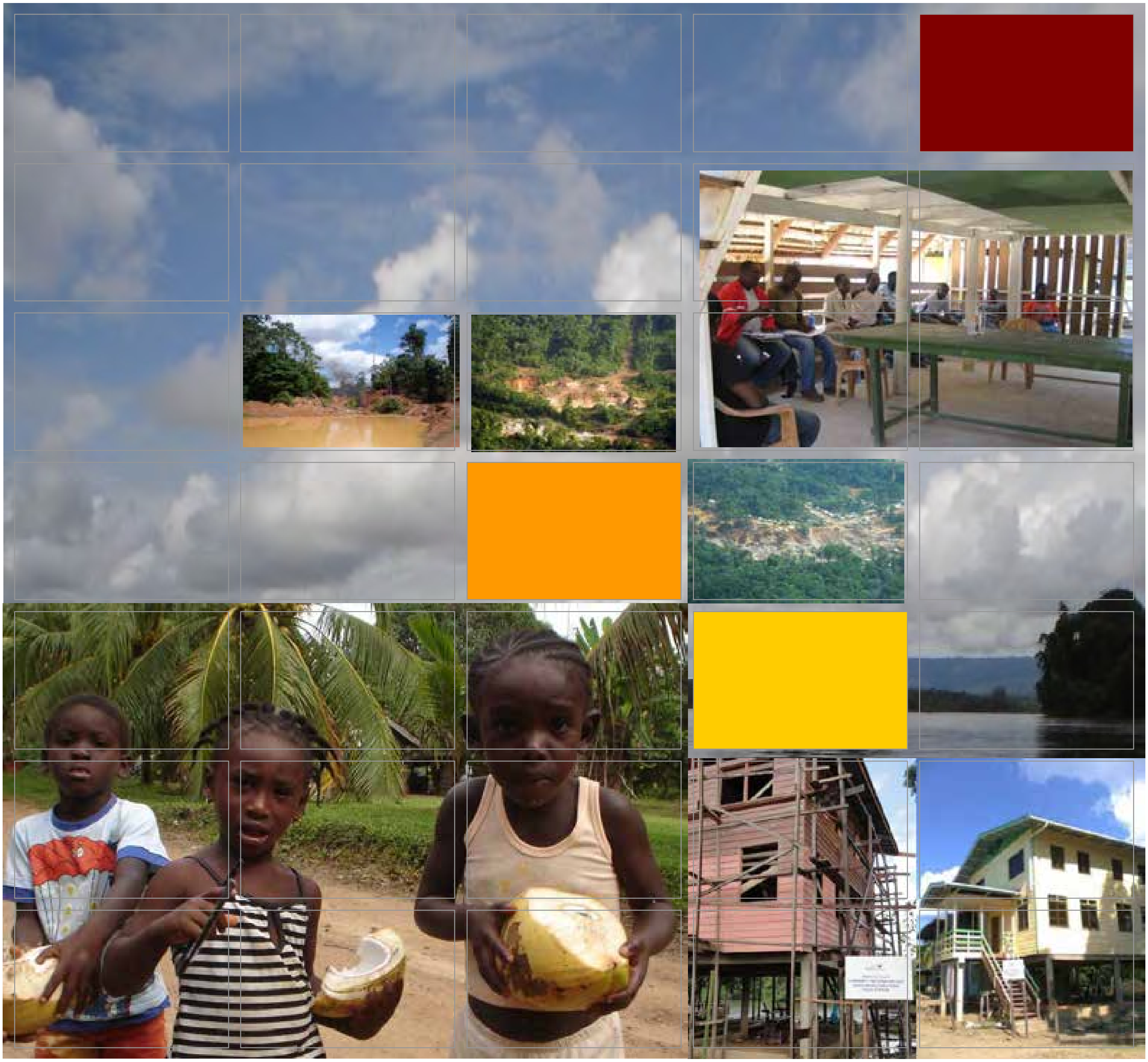

# Merian Project
# Final ESIA Report
# Volume I - Introduction and Environmental and Social Baseline

31 January 2013

ERM

*The world's leading sustainability consultancy*

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| Acronym | Definition |
|---|---|
| AAQ | Ambient Air Quality |
| ABA | Acid Base Accounting |
| ABS | General Bureau of Statistics |
| AERMIC | AMS/EPA Regulatory Model Improvement Committee |
| AERMOD | AERMIC Model |
| AIDS | Acquired immunodeficiency virus |
| ANFO | Ammonium Nitrate/Fuel Oil |
| ANSI | American National Standards Institute |
| ANZECC | New Zealand Environment and Conservation Council |
| ARD | Acid Rock Drainage |
| Area of Influence | Environmental Study Area and a Social Study Area |
| ARI | acute respiratory infections |
| ART | Antiretroviral Therapy |
| ARV | Anti-retroviral |
| As | Arsenic |
| ASM | Artisanal and Small-Scale Mining |
| ATM | Ministry of Labor, Technological and Environment |
| AWA | Alcoa World Alumina LLC |
| BAPP | Biological Acid Production Potential |
| BFA | Bench Face Angle |
| BMP | Best Management Practices |
| BOD | Biological Oxygen Demand |
| BOPH | Bureau of Public Health |
| BPL | below the poverty line |

| Acronym | Definition |
|---|---|
| BSC | Biodiversity Steering Committee |
| BSS | Behavioral Surveillance Survey |
| CBO | Community Based Organizations |
| CC | Climate Change |
| CCD | Counter Current Decantation |
| CCME | Canadian Council Of Ministers of the Environment |
| CDD | Current Decantation |
| CDMP | Caribbean Disaster Management Program |
| CEC | Cation Exchange Capacity |
| CELOS | Center for Agricultural Research in Suriname |
| CFR | Code Of Federal Regulations |
| CH4 | Methane |
| CI | Community Investment |
| CIA | Cumulative Impacts Assessment |
| CIP | Carbon-In-Pulp |
| CITES | Convention on International Trade in Endangered Species |
| CO | Carbon Monoxide |
| CO2 | Carbon Dioxide |
| COD | Chemical Oxygen Demand |
| CN | Cyanide |
| Cr | Total Chromium |
| CR | Community Relations |
| CSNR | Central Suriname Nature Reserve |
| Cyanide Code | Code for the Manufacture, Transport and Use of Cyanide in the Production of Gold |
| dB | Decibels |

| Acronym | Definition |
|---|---|
| dBA | A-Weighted Decibels |
| DBK | Soil Survey Department Of Suriname |
| dBL | Linear-Weighted Decibels |
| DD | Data Deficient |
| DUI | Driving Under the Influence |
| EA | Environmental Assessment |
| EBRD | European Bank for Reconstruction and Development |
| EBS | Energie Berdrijven Suriname |
| EDC | Environmental Design Criteria |
| EHS | Environmental, Health and Safety |
| EMP | Environmental Management Plans |
| EN | Endangered |
| EP | The Equator Principles |
| EP | Evaluation Point |
| EPFI | Equator Principles Financial Institution |
| ERM | Environmental Resources Management |
| ERP | Emergency Response Plan |
| ESIA | Environmental and Social Impact Assessment |
| ESC | Erosion and Sediment Control Plan |
| ESMMP | Environmental and Social Management and Monitoring Plan |
| ESR | Environmental and Social Responsibility |
| ETP | Endogenous Thrombin Potential |
| FGD | Focus Group Discussions |
| FHWA | Federal Highway Administration |
| GDP | Gross Domestic Product |

| Acronym | Definition |
| --- | --- |
| GFR | General Fertility Rates |
| Gg | Gigagrams |
| Gj | Gigajoule |
| GHG | Greenhouse gases |
| GII | The Gender Inequality Index |
| GIS | Geographic Information System |
| GISPLAN | Geografisch-Planologisch Adviesbureau |
| GNI | Gross National Income |
| GoS | Government of Suriname |
| GPS | Global Positioning System |
| GRDC | Global Runoff Data Center |
| H&S | Health & Safety |
| ha | hectares |
| HCS | Highway Capacity Software |
| HCT | Humidity Cell Test |
| HDI | Human Development Index |
| HDR | Human Development Report |
| HFO | Heavy Fuel Oil |
| HIV | Human immunodeficiency virus |
| HR | Human Resources |
| HRS | Human Resources Services |
| HRD | Human Resources Development |
| HSLP | Health, Safety and Loss Prevention |
| HWTA | Hazardous Waste Transfer Area |
| ICMM | International Council of Mining & Metals |
| ICMC | International Cyanide Management Code |

| Acronym | Definition |
|---|---|
| IFC | International Finance Corporation |
| IHDI | Inequality Adjusted HDI |
| ILO | International Labor Organization |
| In / s | Inches per second |
| IPPF | International Planned Parenthood Federation |
| ISO | International Organization for Standardization |
| IUCN | International Union for the Conservation of Nature |
| IPCC | International Panel on Climate Change |
| IRA | Inter Ramp Slope Angles |
| ISEC | International Society for Ecology and Culture |
| IT | Information Technology |
| IZ | Industrial Zone |
| JMP | Joint Monitoring Program |
| JV | Joint Venture |
| KII | Key Informant Interviews |
| km | kilometers |
| KPI | Key Performance Indicator |
| LAeq | A-weighted steady equivalent sound level |
| LBB | Suriname Forest Service |
| LBGO | Lower Vocational Education School |
| LOM | Life of Mine |
| LVV | Ministry of Agriculture, Animal Husbandry and Fisheries |
| masl | meters above sea level |

| Acronym | Definition |
|---|---|
| MDGs | Millennium Development Goals |
| ML | metal leaching |
| MM | Bureau of Public Health, Medical Mission |
| mm/s | millimeters per second |
| MMI | Modified Mercalli Intensity |
| MNH | Ministry of Natural Resources |
| MNH GMD | Geological Mining Service |
| MOH | Ministry of Health |
| Moz | million ounces |
| MRD | Ministry of Regional Development |
| MSD | Malaria Service Delivery |
| MSDS | Material Safety Data Sheets |
| MTI | Ministry of Trade and Industry |
| MW | Megawatts |
| MWE | Megawatts Electricity |
| MWT | Megawatt Thermal |
| N2O | nitrous oxide |
| NAAQS | National Ambient Air Quality Standards |
| NAF | Non-Acid Forming |
| NAG | Net Acid Generation Test |
| NAP | National AIDS Program |
| NAWQA | National Water Quality Assessment |
| NCD | Nature Conservation Division |
| NCD | Non-Communicable Disease |
| NEAP | National Environmental Action Plan |
| Newmont | Newmont Overseas Exploration Limited |

| Acronym | Definition |
|---|---|
| NGO | Non-Governmental Organization |
| Ni | Nickel |
| NIMOS | the National Institute of Environment and Development in Suriname |
| NL | Not listed |
| NL | Netherlands |
| NMR - National Council for the Environment | Nationale Milieuraad |
| NMS | Newmont Metallurgical Services |
| NO2 | Nitrogen Dioxide |
| NPI | Australian National Pollutant Inventory |
| NTFP | Non Timber Forest Products |
| NZCS | National Zoological Collection of Suriname |
| OAS | Organization of States |
| OGS | Ordening Goud Sector |
| OP | Operating Procedure |
| OSHAS | Occupational Health and Safety Advisory Services |
| oz | ounces |
| PAF | Potentially Acid Forming |
| PAG | Potentially Acid Generating |
| PAG | Peroxide Acid Generation |
| PAHO | Pan American Health Organization |
| PAPs | Project Affected Peoples |
| PCS | Petroleum Contaminated Soils |
| PFCs | hydro-fluorocarbons |
| PK | Porknocking |
| PM | Particulate Matter |
| PMF | Probable Maximum Flood |

| Acronym | Definition |
| --- | --- |
| POI | Points of Interest |
| ppbv | parts per billion by volume |
| PPE | Personal Protective Equipment |
| PPP | Purchasing Power Parity |
| PPV | Peak Particle Velocity |
| PVC | Polyvinyl Chloride |
| QA / QC | Quality Assurance / Quality Check |
| REEEP | Renewable Energy and Energy Efficiency Partnership |
| RGD | Bureau of Public Health, Regional Health Service |
| ROM | Run-of-Mine |
| SAG | Semi-Autogenous Grind |
| SBB | Foundation for Forest Management and Production Control |
| SBC | Suriname Business Coalition |
| SCBA | Self-contained Breathing Apparatus |
| SCF | Suriname Conservation Foundation |
| SES | Stakeholder Engagement Strategy |
| SEP | Stakeholder Engagement Plan |
| SF6 | sulfur hexafluoride |
| SIA | Security Industry Authority |
| SMP | Social Management Plans |
| SO2 | Sulfur Dioxide |
| SOC | Species of Concern |
| SOP | Standard Operating Procedures |

| Acronym | Definition |
|---|---|
| SPCC | Spill Prevention and Countermeasures Plan |
| SPLP | Synthetic Precipitation Leaching Procedure |
| SPS | National Planning Office of Suriname |
| STINASU | Foundation for Nature Conservation in Suriname |
| SRH | Sexual and Reproductive Health |
| SRK | SRK Consulting |
| SRD | Surinamese Dollar |
| SRU | Seismic Research Unit |
| SSA | Social Study Area |
| SSSA | Soil Science Society of America |
| STI | Sexually Transmitted Infections |
| STP | Sewage Treatment Plant |
| Surgold or the Company | Suriname Gold Company |
| SW | Surface Water |
| SWM | Surinamese Water Company |
| SWMP | Solid Waste Management Plan |
| TANA | To Assist Needy Animals |
| TB | Tuberculosis |
| TCLP | Characteristic leaching Procedure |
| TDS | Total Dissolved Solids |
| the Project | Merian Gold Project |
| TNM | Traffic Noise Model |
| TNM | Noise Technical Manual |
| ToR | Terms of Reference |
| TRV | Toxicity Reference Values |
| TSF | Tailings Storage Facility |

| Acronym | Definition |
|---|---|
| TSP | Total suspended particulate matter |
| TSS | Total Suspended Solids |
| TWS | Treated Water Storage |
| TWSR | Treated Water Storage Reservoir |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| USDOT | United States Department of Transportation |
| USEPA | United States Environmental Protection Agency |
| USGS` | United States Geological Survey |
| UN | United Nations |
| UNDP | United Nations Development Program |
| UNFCCC | United Nations Framework Convention on |
| UNICEF | United Nations Children’s Fund |
| USACE | United States Army Corps of Engineers |
| USGS | United States Geological Survey |
| UV | Ultraviolet |
| VAC | Vacuum |
| VSB | Suriname Trade and Industry Association |
| VU | Vulnerable |
| WAD | Weak Acid Dissociable |
| WDI | World Development Indicators |
| WHIMIS | Workplace Hazardous Materials Information System |
| WHO | World Health Organization |
| WRD | Waste Rock Disposal |
| WRI | World Resource Institute |
| WSS | Water Supply and Sanitation |

| Acronym | Definition |
|---|---|
| WWF | World Wildlife Fund |
| XRD | X-ray Diffraction |
| XRF | X-ray Fluorescence |
| Zn | Zinc |
| $mg/m^3$ | micrograms per cubic meter |

# 1.0 *INTRODUCTION*

This Environmental and Social Impact Assessment (ESIA) report has been prepared by Environmental Management Resources (ERM) on behalf of the Suriname Gold Company ("Surgold" or the "Company") that operates the Merian Gold Project (the Project) located in the northeastern part of Suriname (Figure 1-1).

## 1.1 *OVERVIEW OF PROPOSED PROJECT*

### *1.1.1 Purpose and Need for Proposed Project*

Surgold holds a Right of Exploration for gold and other minerals for a 25,916 hectare area located in northeastern Suriname, approximately 60 km south of Moengo in the vicinity of Snesse Kondre. The Company began exploration activities at the Merian site in 2004 and has identified an estimated 5 million ounces (Moz) of potentially recoverable gold reserves. The Company applied for a Right of Exploitation Agreement in 2007 (Figure 1-1), the granting of which will be subject to a Mineral Agreement that is currently under review and pending negotiation and approval with the Government of Suriname (GoS). The area delineated in the application as the Right of Exploitation is referred to for the purposes of this document as the Project Area.

If a Right of Exploitation is granted, Surgold will seek to extract and process the identified gold reserves at Merian in order to maximize financial and socio-economic benefits to the Company and local and national economies, while minimizing negative environmental and social impacts.

### *1.1.2 Proposed Project*

Surgold is proposing to develop the Project to extract and process gold ore upon the granting of the Right of Exploitation (Figure 1-1). The proposed Project consists of the construction and operation of a mine with three open pits; processing plant; waste rock and tailings management facilities; water treatment facilities; and other associated facilities for the storage of fuel, power generation, maintenance operations and office and worker accommodations. The Project will require the transport of construction materials and operational supplies to the Project site from the Nieuwe Haven port in Paramaribo via the East-West Highway to Moengo and then the Moengo-Langa Tabiki Road to the site.

The outcome of the ESIA process will inform the feasibility and engineering studies, which are being conducted concurrently with the ESIA process. The ESIA has utilized best available information regarding the Project design. The ultimate design of the Project, however, has yet to be finalized, allowing the results of the concurrent environmental, social, engineering and feasibility studies to be considered in the final Project design. Surgold is pursuing an approval-in-principle based on the Project Description presented in this ESIA, which is considered adequate for the purpose of the ESIA.

*Figure 1-1 Merian Gold Project Location and Transportation Corridor*

### 1.1.3 *Project Proponent, Ownership and Licenses*

In early 1999, the Suriname Aluminum Company LLC ("Suralco") identified the Merian area for its bauxite exploration potential. As part of those exploration activities, gold occurrence was documented, which was further supported by evidence of past gold mining in the area. After acquiring the Merian Right of Exploration, Suralco conducted surface sampling, mapping and drilling activities between 1999 and 2003. During this period, Suralco identified a small gold resource of approximately 170,000 oz. in what is now referred to as the Merian II area.

In 2004, Newmont Overseas Exploration Limited ("Newmont") entered into a joint venture agreement with Suralco's parent company, Alcoa World Alumina LLC ("AWA"), whereby Newmont agreed to conduct exploration within the area of interest on behalf of the joint venture in exchange for equity interests in a company to be established to explore and operate the Project.

The parties established Surgold on 11 February 2004 as a limited liability company under the laws of the State of Delaware, United States of America, and registered with the Chamber of Commerce and Industry of Suriname on 30 March 2004. As of the date of this report, Newmont and AWA each own 50% of the equity interest of Surgold. Under this arrangement, Newmont is the manager of Surgold and Surgold holds the Merian Right of Exploration. Once a feasibility study is completed, Newmont will hold an 80% interest in Surgold and Alcoa will hold the remaining 20% interest. Surgold will become the operator of the Merian Mine.

From 2004 to present, Surgold has conducted extensive exploration activities, which have resulted in the expansion of the Merian II deposit and the discovery of the Maraba deposit. Additional resources were also identified at the Merian I deposit previously identified by Suralco. These areas are included in the Project and the corresponding application for the Mineral Exploitation Agreement filed on behalf of Surgold in 2007.

## 1.2 *OVERVIEW OF THE ENVIRONMENTAL, SOCIAL AND HEALTH IMPACT ASSESSMENT PROCESS*

### 1.2.1 *Purpose of the Environmental and Social ESIA Process*

In accordance with Surgold's internal corporate policies and project development process, and in alignment with the guidelines established by the Nationaal Instituut voor Milieu en Ontwikkeling in Suriname (NIMOS – the National Institute for Environment and Development in Suriname). Surgold has commissioned an integrated ESIA for the Project. The ESIA integrates the assessment of environmental, social and health impacts within a single study. The ESIA process is intended to identify, reduce and avoid negative impacts and promote positive impacts by suggesting the preferred design, mitigation and management measures to fulfill the need and purpose of the proposed Project.

Inherent to the ESIA process is the participation of all identified project stakeholders in order to develop and consider all feasible alternatives to fulfill the need and purpose of the proposed Project. Each phase of the ESIA process seeks to incorporate the participation of a wide range of internal and external stakeholders, including all potentially affected communities, governmental authorities and the general public of Suriname.

The ESIA process is designed to provide decision-makers and the general public with a comprehensive, independent, rigorous assessment of the potential impacts and benefits of the proposed Project and potential alternatives to the Project. The ESIA process provides valuable information to governmental authorities, corporate decision-makers and the public at large upon which informed decisions can be made. The ESIA process does not represent a final decision to develop the Project; it is a tool in the decision making process, without which an informed decision cannot be made.

### *1.2.2 Objective*

The objectives of the ESIA process for the Project are:

- Describe in detail the proposed Project and any feasible alternatives to the Project;
- Describe the existing environment, including all physical, biological, and socio-economic characteristics relevant to the Project;
- Assess in detail the environmental, social, and health impacts that would result from the Project;
- Identify environmental and social mitigation measures to address the impacts identified;
- Develop Environmental and Social Management Plans (EMP and SMP), based on the mitigation measures proposed in the ESIA;
- Inform and engage with positively or negatively affected individuals, communities, governmental authorities and other stakeholders in order to document and address relevant issues and concerns throughout the ESIA process; and
- Inform corporate and public decision-making processes regarding Project investment and approval.

These objectives, and the ESIA process itself, have been designed in alignment with applicable guidelines and regulations established by the Government of Suriname, including those established by NIMOS and the Ministry of Natural Resources, among others. In addition, the ESIA has been developed in alignment with Surgold’s internal corporate policies, values and environmental, social, health and safety standards, with reference to relevant international standards and guidelines such as the the International Cyanide Management Code for the Manufacture, Transport and Use of Cyanide In The Production of Gold (the Cyanide Code) and the Equator Principles.

### *1.2.3 ESIA Phases*

The ESIA study has been carried out in four phases (Screening, Scoping, Impact Assessment, and Review) as prescribed in the NIMOS Environmental Assessment Guidelines (NIMOS, 2009). The ESIA process followed for the Project is summarized in Figure 1-2.

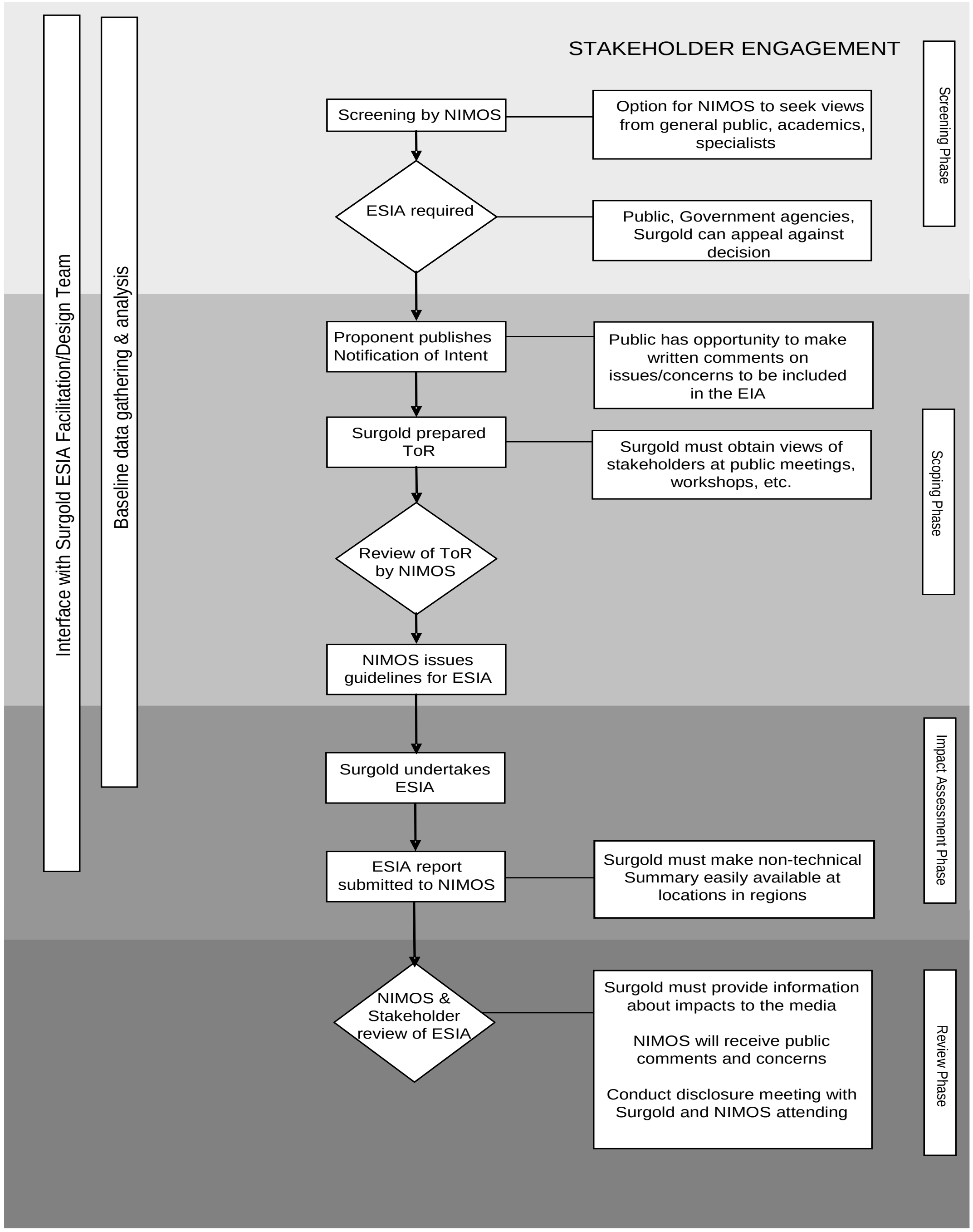


*Figure 1-2 The ESIA Process for the Project*

*Screening Phase*

The Screening Phase is the initial phase of the process outlined in the 2002 Surinamese Draft Environmental Act and recommended by the NIMOS Environmental Assessment (EA) guidelines. The purpose of the Screening Phase is to decide if an EA is required for the proposed Project and determine the extent of the required environmental analysis. The NIMOS EA guidelines identify three Project categories (A, B, and C) and indicate that an EA is mandatory for all Category A projects. Category A projects are those which are "likely to have adverse impacts that may be extensive, irreversible, and diverse.

The extent and scale of the environmental impacts can only be determined after thorough environmental assessment."

Per NIMOS project screening guidelines, any metallic mining project with exploitation affecting more than 10,000 hectares of land is considered a Category A project. All Category A projects require a comprehensive environmental assessment and the development of project-specific mitigation measures and management plans.

The Project has been identified as a Category A project due to the size of the Area of Exploitation and the potential for significant impacts if mitigation and management measures are not implemented. This ESIA is being carried out in fulfillment of the NIMOS requirement to complete an Environmental Assessment commensurate with the size and scope of the proposed Project.

The following activities were held during this phase:

- Kick-off meeting at Merian office at the site exploration camp on 27 April 2011. This included Project team members from Surgold, ERM, and a local subconsultant;
- Initial coordination meetings with NIMOS on 14 June 2011. The meeting included technical personnel from Surgold, Newmont, Golder, G Mining (engineering support), and ERM. Follow up meetings were held between Surgold and NIMOS on 30 June to discuss the plan and Terms of Reference (ToR) for the ESIA; and
- Visit to the Mine Site on 28 June 2011 (visual observation of site, streams, artisanal and small-scale gold mining (ASM) [locally referred to as "porknocking"] activities).

*Scoping Phase*

The Scoping Phase provides additional information on the key issues identified during Screening in order to develop a detailed ToR for the activities and studies to be undertaken as part of the ESIA process. The Scoping Phase consists of desktop analysis, site visits and stakeholder interviews to ascertain whether additional information is needed to evaluate baseline conditions and potential impacts within the Project Area.

The various activities and sources of information / documentation that informed the scoping for the ESIA include:

- Surgold pre-feasibility studies, which include surface and groundwater sampling reports;
- Conference calls with the engineering contractor, Golder, on 20 July 2011 to discuss sampling locations for surface water and groundwater wells.
- Presentation of Draft ToR in public meetings held on 17, 18 and 19 August 2011 at Paramaribo, Moengo and Langa Tabiki to solicit the comments of all stakeholders; and

- Comments received during Public Meetings conducted during August 2011 in Paramaribo, Moengo, and Langa Tabiki.

Scoping activities resulted in the identification of the following issues requiring additional investigation and analysis during the ESIA process:

- Potential for the Project to impact water quality and quantity specifically with respect to:
  - Process plant, tailings and waste rock management;
  - Management of erosion and sediment;
  - Mine water management; and
  - Opportunities to improve environmental conditions of areas impacted by ASM activities.
- Potential for groundwater drawdown from pit dewatering;
- Potential increased risks to the environment related to waste management and the use of cyanide in gold processing and the need to establish a robust environmental management plan;
- Potential for the Project to impact biodiversity since Suriname is a recognized high-biodiversity area;
- Potential for non-routine or uncontrolled releases from the Tailings Storage Facility (TSF) possibly resulting in:
  - Contamination of soils, ground and surface water;
  - Disturbance to flora and fauna and resultant;
  - Impacts to human health; and
  - Impacts to the practice of traditional collection of Non-Timber Forest Products (NTFPs) or hunting activities.
- Potential for the Project to impact fish and aquatic resources through water quality and quantity impacts resulting in:
  - Potential impacts on downstream fisheries; and
  - Potential effects on any subsistence fishing.
- Potential for the Project to impact air quality specifically through:
  - Combustion emissions from heavy fuel oil generators (50 megawatts [MW] Power Plant); and
  - Fugitive dust emissions from surface disturbance at the Mine Site and along the transport roads.
- The need for mine closure and restoration planning; and
- Potential impacts from the transportation corridor specifically regarding:
  - Community health and safety concerns;
  - Existing sensitive receptors;
  - Capacity of existing network to absorb additional traffic; and

- Cumulative impacts from other projects.

The Scoping Phase resulted in the publication of the draft ToR Report, issued on 5 August 2011 and public meetings to disclose the draft ToR was held on 17, 18 and 19 August 2011. Based on comments received, the Draft ToR was revised and the Final ToR was issued on 28 September 2011. NIMOS issued a formal letter on 24 October 2011 citing the conclusion of the scoping phase of the ESIA. The ToR, NIMOS' response, and the outcomes of the Scoping Meetings are available in hardcopy at the NIMOS office and at Surgold's office. They have also been published on-line at www.merianproject.com.

*Impact Assessment Phase*

The Impact Assessment Phase characterizes the existing, or baseline, environment; assesses the significance of the impacts identified, including cumulative effects; and recommends mitigation measures to minimize negative impacts and/or enhance benefits. The physical, biological, and social findings are presented in an integrated ESIA, which is the main document upon which environmental and social decisions regarding the Project will be based. An overall Environmental and Social Management Plan is prepared during the Impact Assessment Phase to assure that environmental and social issues are properly managed during the construction, operation, and restoration phases of the Project.

The Impact Assessment Phase for the Project was conducted in accordance with the integrated approach and activities described in the ToR. A total of nine environmental specialist studies and four socio-economic and human health specialist studies were completed (see Table 1-1)

*Table 1-1 Environmental and Social Studies Completed*

| Environmental Specialist Studies | Socio-Economic and Human Health Studies |
|---|---|
| 1. Groundwater Study | 1. Socio-Economic Baseline Study |
| 2. Surface Water Flow and Quality Study | 2. Community Health Baseline Study |
| 3. Air Quality and Climate Study | 3. Cultural Heritage and Living Cultural Heritage Baseline Study |
| 4. Noise Study | 4. Traffic Study |
| 5. Flora Studies | |
| 6. Soil Study | |
| 7. Aerial Fauna Studies | |
| 8. Terrestrial Fauna Studies | |
| 9. Fish and Aquatic Habitat Baseline Studies | |

*Disclosure Phase*

During the disclosure phase, a draft ESIA was presented to NIMOS and the findings were presented to stakeholders through three meetings in Langa Tabiki, Moengo and Paramaribo. Stakeholders including affected people and NIMOS had the opportunity to comment on the Draft ESIA through the meetings, or via email through the Project's website. This revised ESIA addresses NIMOS' comments and those provided through Stakeholder Engagement.

## 1.3 *ESIA STUDY TEAM*

Surgold has commissioned Environmental Resources Management (ERM), an independent international environmental consultancy, to complete the ESIA. ERM is a recognized leading provider of environmental, health and safety, risk and social consulting services. ERM's expertise is centered in the identification and management of social and environmental risks and ERM has extensive experience preparing world-class environmental and social assessments consistent with international standards and best practice for the mining sector ERM's technical staff and teaming partners assigned to manage and execute mining projects have direct experience working in the mining sector in Suriname and throughout the world, as well as relevant and complementary skills developed in other industrial settings. ERM therefore provides strong capabilities in the identification and management of mining-related environmental and social impacts relevant to the Project, including cultural heritage, archaeology, soils, ecology, socio-economics, water, waste, noise, and air quality.

The ESIA team for the Project is composed of a staff with extensive mining, natural resources assessment, international and Surinamese ESIA experience combined with several well-qualified international and local experts in terrestrial and aquatic ecology, social issues, and geotechnical engineering. Table 1-2identifies the key ERM team members and their respective roles, as well as the local environmental, social, and engineering experts.

*Table 1-2 ESIA Core Team*

| Name | Company | Role and Specialty Study |
|---|---|---|
| David Blaha | ERM | Project Director |
| Emma McKennirey | ERM | Project Manager, Water resources |
| Alistair Gow-Smith | ERM | Social assessment |
| Salomon Emanuels | Equalance Foundation, Suriname | Social assessment |
| Matthew Kuniholm | ERM | Social assessment |
| Sinang Lee | ERM | Health impact assessment |
| Emlen Myers | ERM | Archaeological and historical heritage |
| Joan Huston | ERM | GIS |
| Ben Sussman | ERM | Traffic assessments, land use, and visual resources |
| Yinka Afon | ERM | Air quality and climate, carbon footprint, odors, noise, vibration, and natural hazards |
| Paul Whincup | ERM | Geology, water supply, and water management; DS 1 and 2, and ESS 1 and 2 |
| Gabe Luna | ERM | Geology |
| James Nalven | ERM | Hydrogeology and water management |
| Romina Aramburu | ERM | Environmental management and monitoring plans and due diligence |
| Jason Willey | ERM | Aquatic ecology |
| Sarah Piper | ERM | Terrestrial fauna studies, biodiversity, soils |
| Rutger De Wolf | ESS, Suriname | Forestry and vegetation |
| Bart De Dijn | ESS, Suriname | Wildlife and vegetation |
| Jan Mol | Consultant – University of Suriname | Zoology, biodiversity, and aquatic ecology |
| Paul Ouboter | Consultant – University of Suriname | Zoology and biodiversity |
| Kat Noland | ERM | Social and health impacts |

## 1.4 *SCOPE OF THE ESIA STUDY*

An Environmental Study Area and a Social Study Area (i.e., Area of Influence) were determined to define the boundaries of the ESIA study (Figure 1-3and Figure 1-4). The fieldwork and desktop studies that were undertaken to determine baseline conditions and potential impacts of the Project was conducted within this Environmental and Social Study Area.

The delineation of the Environmental Study Area was based on previous understanding of the Project, Surgold's continued environmental monitoring work, proposed Project footprint (e.g., access roads, tailing area, mine facilities) and stakeholder consultations. Similarly, the determination of the Social Study Areas was based on inputs from stakeholders such as NIMOS and communities, input from Surgold's community engagement program and understanding of the Project footprint and potential impacts on the communities.

*Figure 1-3 Environmental Study Area*

*Figure 1-4 Social Study Area*

## 1.5 *ESIA ORGANIZATION*

This ESIA follows the environmental assessment guidelines issued by the NIMOS and is composed of the following Volumes and Chapters:

### *1.5.1 Volume I: Introduction, Environmental and Social Baseline*

- Chapter 1.0 provides descriptions of the proposed undertaking, the purpose of and need for the proposed undertaking, background of the Project, and the ESIA process.
- Chapter 2.0 summarizes the legal and institutional framework applicable to the environmental assessment process for mining sector projects in Suriname.
- Chapter 3.0 describes the proposed undertaking, including the associated project components like infrastructure and transport corridor.
- Chapter 4.0 describes the evaluation of alternatives of the proposed project.
- Chapter 5.0 describes the Project location and setting.
- Chapter 6.0 describes the baseline air quality.
- Chapter 7.0 describes noise and vibration baseline conditions.
- Chapter 8.0 describes soil conditions at the Project site.
- Chapter 9.0 describes the baseline groundwater and surface water conditions.
- Chapter 10.0 describes the traffic conditions on the transport corridor.
- Chapter 11.0 describes terrestrial ecology.
- Chapter 12.0 describes aquatic ecology.
- Chapter 13.0 provides a discussion on protected areas in Suriname.
- Chapter 14.0 describes the socio-economic baseline setting in the Project Area of influence, including data on governance, administration, demography, education, health, infrastructure, cultural heritage, livelihoods and other socio-economic issues.

### *1.5.2 Volume II: Environmental and Social Impact Assessment*

- Chapter 15.0 describes the impact assessment and rating methodology followed in the ESIA.
- Chapter 16.0 identifies the impacts of the Project on air quality and greenhouse gases.
- Chapter 17.0 identifies the impacts of the Project on noise and vibration.
- Chapter 18.0 identifies the impacts of the Project on the soil.
- Chapter 19.0 identifies the impacts of the Project on the water resources.

- Chapter 20.0 identifies the impacts of the Project on traffic and transportation.
- Chapter 21.0 identifies the impacts of the Project on biological resources.
- Chapter 22.0 identifies the impacts of the Project on land use.
- Chapter 23 identified the social and health related impacts.
- Chapter 24 identifies the cumulative effects related to this and other planned Projects.
- Chapter 25 provides a summary of the ESIA.

### *1.5.3 Volume III and IV: Appendices*

- Volume III includes all appendices associated with the ESIA
- Volume IV: Environmental and Social Management Plan
- The Environmental and Social Management Plan provided in Volume IV provides a framework level management plan that will guide the Project as it develops detailed, operational-level environmental and social management plans.

## 1.6 *REFERENCES FOR CHAPTER 1*

National Institute for Environment and Development in Suriname (NIMOS). Environmental Assessment Guidelines Volume I: Generic 2nd Edition, August 2009.

United Nations Country Team in Suriname, Suriname UNDAF Action Plan 2012-2016, (no date provided)

## 2.0 *LEGAL AND INSTITUTIONAL FRAMEWORK*

The Merian Gold Project is subject to certain Surinamese and international standards. These are a collection of regulatory requirements as well as international best practices to ensure that the Project is conducted in an environmentally and socially responsible manner by minimizing impacts on the ecosystem and human population and maximizing the positive benefits. Surgold is committed to complying with: 1) Surinamese national legislation and Surgold's internal environmental and social standards, as well as being consistent with best practices from international standards, including the International Cyanide Management Code.

The proposed Project will adapt best practices, international standards and treaties to the specific project context to meet sustainability objectives.

Some of the standards described in this chapter are directly related to conducting the ESIA study while others will apply throughout the Project lifecycle especially in managing and mitigating environmental and social impacts.

### 2.1 *SURINAME LAWS AND REGULATIONS*

Suriname is governed according to the 1987 Constitution of the Republic of Suriname. To date, Suriname does not have an approved environmental policy and there is no legislation dealing specifically with environmental management. Environmental legislation, however, is currently being developed and draft regulations for environmental assessment have been released. In addition, there are several government policies that concern sustainable development and biological resources, including the Government Declaration, the Multi-Annual Development Plan, and the National Biodiversity Strategy. The proposed Merian Gold Project will comply with the draft environmental regulations and other relevant existing legislation, including government policy documents. Responsibility for environmental and natural resource management in Suriname is fragmented between different pieces of legislation and amongst different government institutions. Surgold is committed to complying with the draft and promulgated regulations at the time of this project permitting

In addition to Surinamese regulatory requirements, the Project will be developed in a manner consistent with all relevant international standards and requirements. These include international treaties and conventions, to which Suriname is a signatory that deal with biodiversity, climate change and marine pollution.

The legislative, regulatory and institutional requirements guiding the Project are discussed in more detail below. Note that other requirements may pertain to the proposed Project, but identification and interpretation of these is beyond the brief of this study. As such, the list provided below is not intended to be definitive or exhaustive, and serves to highlight key environmental legislation and obligations.

The Republic of Suriname has several Acts, Bills and Regulations dealing with environmental and / or natural resource management; however, there is no national law on environmental management. The Constitution of the Republic of Suriname (1987) supports the creation and improvement of "conditions necessary for the protection of nature and for the preservation of the ecological balance (Chapter III, Article 6)." As such, it provides a legal basis for a national environmental policy. A National Environmental Action Plan (NEAP) was compiled in 1996 and, although it has not been formally approved, some of its proposals have been implemented, such as the establishment of an institutional framework for environmental management and sustainable natural resource use.

The Nationale Milieuraad (NMR - National Council for the Environment) was established in 1997 with a mandate to advise the government of Suriname on the development and implementation of national environmental policies. The NMR consists of a chairperson and 5-10 members representing government, private sector, Amerindian and Maroon communities, labor unions, consumer rights, and other Non-Governmental Organizations (NGOs).

Executive support for the NMR is provided by the Nationaal Instituut voor Milieu en Ontwikkeling in Suriname (NIMOS – the National Institute for Environment and Development in Suriname). NIMOS was originally established in 1998 by Presidential Decree as an entity subordinate to the President's office, and was later ordered by the President to report to the Ministry of Labor, Technological and Environment (ATM) as its technical division in 2001. NIMOS is the main environmental management policy and advisory body and also acts as a research institute. Suriname's Biodiversity Action Plan is being managed by NIMOS under the guidance of Ministry of ATM and the Biodiversity Steering Committee (BSC). NIMOS had a role in the implementation of the Biodiversity Action Plan. A Senior Advisor to the President of Suriname is the focal point for the Biodiversity Action Plan.

Suriname's Multi-Annual Development Plan (2012-2016) (United National Country Team in Suriname) calls for the development and implementation of policy for environmental management, climate change, adaptation and mitigation. This will include the development and implementation of plans and standards in this area and supporting their integrated operationalization. In the absence of dedicated national environmental legislation, the responsibility for environmental (and social) issues remains widely distributed between a number of agencies and departments in other ministries. These agencies and departments, and their role in environmental (and social) issues are described in Table 2-1.

*Table 2-1 Environmental Management Responsibilities of Key Institutions in Suriname*

| Environmental Management Aspects | Institutions | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | ATM | Sectorial Ministries | NIMOS | STINASU | SCF | District Commis-sioners | NCD (LBB) | SBB |
| Nature Conservation and Management | | | Facilitation of National Biodiversity Strategy | Browns-berg Nature Park | CSNR and Sipaliwini Nature Reserve | | Creation of new protected areas, management, and control | Management of forests |
| ESIA processes | | Approval of development projects and enforcement | Guidance and review of reports. Provides advice regarding environmental planning, but the final decision is still the responsibility of permitting agency (NIMOS). | | | | | |
| Industrial Pollution | | | Technical advice; Enforcement | | | Permit approval | Enforcement | |
| Monitoring | | Implementation | Supervision; Enforcement | | | | Implementation | Implementation |
| Environmental Planning (Management Plans) | | Participation in design and plan implementation | Coordination of design and plan implementation | | | | Participation in design and plan implementation | |
| Environmental Regulations | Approval | Enforcement | Drafting and stakeholder consultation | | | | | |
| Forest Development | | | | | | | Permits approval and control of forest management plans | Monitoring of logging activities |

Key:
ATM – Ministry of Labor, Technological Development and Environment; NIMOS – National Institute for Environment and Development in Suriname; CSNR - Central Suriname Nature Reserve; STINASU – Foundation for Nature Conservation in Suriname; SCF – Suriname Conservation Foundation; NCD – Nature Conservation Division; LBB – Suriname Forest Service: SBB – Foundation for Forest Management and Production Control

### 2.1.1 Legal and Institutional Framework

*Introduction*

In addition to national laws and regulations, Suriname is bound by international treaties and conventions that it has signed or to which it has otherwise agreed. International Treaties and Conventions applicable to the Merian Project are summarized in Table 2-2 and include:

- Climate Change / Air Quality - Vienna Convention for the Protection of the Ozone Layer (1985), Montreal Protocol on Substances that Deplete the Ozone Layer (1989), United Nations Framework Convention on Climate Change (UNFCC) (1994), Kyoto Protocol (1997);
- Biodiversity / Protected Areas - Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere (Western Hemisphere Convention 1942), Convention on the International Trade of Endangered Species of Wild Fauna and Flora (CITES), (1973), United Nations Convention on Biological Diversity (1992);
- Forest Management - International Tropical Timber Agreement, (1994) (Tropical Timber 94);
- Indigenous People - American Convention on Human Rights, 1969, United Nations (UN) formulation of Declaration on Rights of Indigenous People, (1994), UN approval of Declaration on Rights of Indigenous People (2007); and
- Labor / Health / Safety - Constitution of the International Labor Organization, Constitution of the Pan American Health Organization.

*Table 2-2 International Treaties and Conventions Related to the Project*

| Agreement/ Convention | Objective | Status | Relevance to Project |
|---|---|---|---|
| **CLIMATE CHANGE/AIR QUALITY** | | | |
| Vienna Convention for the Protection of the Ozone Layer, 1985 | Protection of the ozone layer, came into force in 1988. | Suriname acceded in 1997. | The project will generate greenhouse gas emissions. |
| Montreal Protocol on Substances that Deplete the Ozone Layer, 1989 | Protection of the ozone layer. | Suriname acceded in 1997 but subsequent amendments not yet ratified. | |
| United Nations Framework Convention on Climate Change (UNFCC), 1994 | Control of greenhouse gas emissions. | Ratified by Suriname in 1997. | |
| Kyoto Protocol, 1997 | Greenhouse gas emissions targets. | Ratified by Suriname in 2006. | |

| Agreement/ Convention | Objective | Status | Relevance to Project |
| --- | --- | --- | --- |
| **BIODIVERSITY/PROTECTED AREAS** | | | |
| Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere (Western Hemisphere Convention), 1942 | Provisions to establish a set of protected areas; national parks to provide recreational and educational facilities; strict wilderness areas to be maintained inviolate; co-operation in the field of research between governments; species listed in annex to enjoy special protection and controls to be imposed on trade in protected fauna and flora and any parts thereof. | Signed by Suriname in 1985.<br><br>Suriname has three Western Hemisphere Shorebird Reserves:<br>1. Coppenamernonding<br>2. Bigi Pan<br>3. Wia Wia | Protected fauna and flora exist within the project footprint. |
| Convention on the International Trade of Endangered Species of Wild Fauna and Flora (CITES), 1973 | To ensure that international trade in specimens of wild animals and plants does not threaten their survival and it accords varying degrees of protection to more than 33,000 species of animals and plants. | Ratified by Suriname in 1980. New game regulations to comply with CITES requirements were passed in 2002. | Several species known to occur within the project footprints are listed under CITES. |
| United Nations Convention on Biological Diversity, 1992 | Promotes development of national strategies for the conservation and sustainable use of biological diversity. Often seen as the key document regarding sustainable development. | Ratified by Suriname in 1996. A National Biodiversity Strategy (2006) has been compiled as framework for a National Biodiversity Action Plan. | The project has the potential to affect biodiversity on a local scale. |
| **FOREST MANAGEMENT** | | | |
| International Tropical Timber Agreement, 1994 (Tropical Timber 94) | To ensure that (by the year 2000) exports of tropical timber originate from sustainably managed sources and to establish a fund to assist tropical timber producers in obtaining the resources necessary to reach this objective. | Suriname acceded in 1998. | The project requires clearing of forested areas. |
| American Convention on Human Rights, 1969 | International human rights instrument to establish a system of personal liberty and social justice based on respect for the essential rights of man, within the framework of democratic institutions. The bodies responsible for overseeing compliance are the Inter-American Commission on Human Rights and the Inter-American Court of Human Rights, both of which are organs of the Organization of American States. | Ratified by Suriname in 1987 | The project has the potential to cause social impacts. |

| Agreement/ Convention | Objective | Status | Relevance to Project |
|---|---|---|---|
| **INDIGENOUS PEOPLE** | | | |
| UN formulation of Declaration on Rights of Indigenous People, 1994.<br><br>UN approval of Declaration on Rights of Indigenous People, 2007. | Promotes rights of indigenous people | Ratified by Suriname | The project is committed to protecting human rights of local populations. |
| **LABOR/HEALTH/SAFETY** | | | |
| Constitution of the International Labor Organization | Promotes opportunities for women and men to obtain decent and productive work, in conditions of freedom, equity, security and human dignity. | Suriname member since 1976. | The projects will affect labor and employment patterns in the local communities. |
| Constitution of the Pan American Health Organization | To improve health and living standards of the countries of the Americas. | Suriname member since 1976. | The project will have the potential for socioeconomic effects in the local communities. |

Source: ERM modified from SRK, 2007

## 2.2 *LEGAL FRAMEWORK*

Suriname's legislation at the national level is exercised through Laws or Acts of Parliament (Wet, also called Verordening and Landsverordening prior to 1975), Decrees (Decreet)[1], Government Decree (Staatsbesluit), Presidential Decree (Resolutie), Presidential Orders (Presidentieel Besluit) or Ministerial Orders (Ministeriële Beschikking) targeting various sectors including industry, tourism, nature conservation, etc.

The Hindrance Act (Hinderwet, 1930, 1944, and 1972) defines the permit requirements to control noise and air pollution for industrial development Projects. The permits are issued and enforced by local District Commissioners (Buursink, 2005; SRK, 2007); however, the Act's effectiveness has been negatively impacted by outdated and inadequate regulations concerning *inter alia* pollution standards and waste management, and a lack of sufficient resources to conduct monitoring inspections (Buursink, 2005; SRK, 2007).

The Nature Conservation Act (Natuurbeschermingswet, 1954) defines the procedures to establish and manage conservation areas and protect wildlife. According to the Act, the only allowable activities in the protected areas are

[1] Decrees date from the period of 1980 – 1986 and have the same status as past or present Laws.

activities of scientific, educational or cultural importance. Conservation areas can be established only by Presidential decree and managed by the Nature Conservation Division of the Suriname Forest Service (LBB). The Act does not provide for the protection of sensitive areas outside the established conservation areas.

The Forest Management Act (Wet Bosbeheer 1992) replaced the Timber Act of 1947 as the governing regulation for forest exploitation and conservation. The Act classifies forests in Suriname in three ways: permanent, temporary (maintained for the time being), or one-time exploitation forest (land intended for other future use where tree cover will be completely cleared). Resource exploitation in public forests (domain land) is allowable with a permit or forest site granted by the Ministry of Natural Resources (MNH), which issued regulations for logging, deforestation, and processing-related activities. The Forest Management Act also allows the Surinamese government to establish conservation forests.

The major laws, acts, decrees, and orders concerning environmental management in Suriname are described in Table 2-3.

The 2002 draft Environmental Act, currently under review by the Council of Ministers, defines the rules for environmental conservation, management, and protection while promoting sustainable development. The provisions of the act provide guidance for conducting an ESIA in Suriname including:

- Allowing for the creation and implementation of a comprehensive environmental policy and planning process;
- Establishing the importance of environmental protection and equal consideration of environmental issues with all other considerations;
- Establishing NIMOS as the Environmental Authority in Suriname;
- Giving effect within Suriname to many internationally-accepted principles of Environmental Law, including the principle of precaution, the polluter pays principle and the concept of environmental impact assessment;
- Introducing and giving effect to the Environmental Assessment Guidelines;
- Enshrining the principles of access to information, participation and legal protection for the Surinamese public;
- Allowing for the introduction of suitable regulations to address specific issues of environmental protection; and
- Establishing a framework for enforcement of environmental legislation and regulations, together with penalties.

*Table 2-3 Legal Framework for National Environmental Management in Suriname*

| Title | Objective(s) | Implementing Agency | Comments | Applicability |
|---|---|---|---|---|
| Mineral Resources | | | | |
| Mining Decree 1986 SB. 1986 no. 28 | 1. Governs exploration and exploitation of mineral resources.<br>2. Article 2 stipulates that all raw materials in and above the ground, including the territorial sea, are property of the State. | MNH | 1. Articles 2, 4, 16, 43, 45 are applicable to environmental protection.<br>2. Contains requirements for consideration of affected communities of Indigenous Peoples.<br>3. Several implementation regulations have been issued under this decree. | The Project will have environmental impacts, as explained in this report, including impacts on Pamaka and other communities. |
| Drilling Law G.B. 1952 no. 93 | Provides provisions for drilling in Suriname | Head of MNH | This law does not protect groundwater. | Drilling will occur. |
| **Land/Land Use** | | | | |
| Construction Law 1956 G.B.1 956 no.30 | Provides requirements for the construction of buildings. | Ministry of Public Works | | The proposed Project will include the construction of several buildings (support facilities), which will be in accordance with the requirements of this statute. |
| Police Criminal Law GB. 1915 no. 77 as amended | | Ministry of Justice and Police | Article 39a penalizes the disposal of waste in public places. | The proposed Project will generate several types of waste, which will be disposed in accordance with the requirements of this statute. |

| Title | Objective(s) | Implementing Agency | Comments | Applicability |
|---|---|---|---|---|
| **Air Quality and Noise** | | | | |
| Hindrance Law G.B. 1930 no. 64 as amended (1944, 1972) | Controls industrial pollution (noise and air). | District Commissioners issue permits in consultation with Ministry of Health | Permits are required for industrial development Projects. | This Project is industrial in nature, and will involve impacts to air quality and noise. |
| **Water/Maritime** | | | | |
| Water Supply Law G.B. 1938 no. 33 | Contains prohibitions with respect to water wells, etc. that serve as water supply sources. | MNH, Ministry of Public Health | According to this Law the President is responsible for its implementation, but in practice the ministries assume the role. | Several creeks are occasional sources of potable water for local communities. |
| Water Board Law G.B. 1932 no. 32 as amended | To establish water boards in charge of maintenance of waterways and waterworks within designated areas. | Execution by the water boards, on behalf of the MRD | The manner in which water boards execute their tasks is of importance to the protection, improvement of the living conditions and the maintenance of the quality of the natural environment. | The Project will require the use of public waterways (the Suriname River) to received supplies by ship. |
| Harbors Decree 1981 S.B. 1981 no. 86 | Provisions for harbor activities. | Maritime Authority Suriname and District Commissioners, assisted by the Prosecutors office, the Police and the Ministry of Trade and Industry | Prohibits the discharge of waste, oil, and oil-contaminated water and condemned goods into public waterways and harbors. | The Project will require the use of public waterways (the Suriname River) to received supplies by ship |
| Maritime Safety Law SB. 2004 No. 90 | Provisions for safety of ships and harbors. | Maritime Authority Suriname, Ministry of Trade and Industry, Maritime Safety Council | | The Project will require the use of public waterways (the Suriname River) to received supplies by ship |

| Title | Objective(s) | Implementing Agency | Comments | Applicability |
|---|---|---|---|---|
| Drilling Law GB. 1952 no. 93 | Regulates drilling activities in Suriname. | GMD | Drilling of liquid-containing layers should be done in a manner by which these liquids do not come in contact with both each other and other mineral depositions. | The Project will require drilling. |
| Police Criminal Law GB. 1915 no.77 as amended | | Ministry of Justice and Police | In terms of Article 51 the polluting of a water source or water well is liable to a fine. | Water runoff from Project activities will have to be managed to prevent impacts on potable water availability and surface water quality. |
| Penal Code G.B. 1911 no.1 as amended | | Ministry of Justice and Police | In terms of Articles 224 and 225, contamination of water resources is penalized. | Water runoff from Project activities will have to be managed to prevent impacts on potable water availability and surface water quality. |
| Government Decree on Pesticides G.B. 1974 no. 89 as amended | To implement article 13 of the Pesticides Law | LVV, ATM, Ministry of Public Health | Article 13 Part 2 forbids the removal or destruction of empty containers or remainders of undiluted pesticides in such a manner that water procurement areas or surface waters are polluted. | Water runoff from Project activities will have to be managed to prevent impacts on potable water availability and surface water quality. |
| **Natural Ecosystems (Vegetation, Fish, And Wildlife)** | | | | |
| Forest Management Law S.B. 1992 no.80 (replaced the Timber Law of 1947) | Provides a framework for forest management, exploitation, and related sector activities (e.g. primary processing and export) to guarantee sustainable utilization of forest resources.<br>Provides for establishment of conservation forests. | MNH, SBB | 1. Permits are required for the exploitation of public forests.<br>2. Currently 13 implementing resolutions have been issued under the Law<br>3. The Law also contains a requirement to respect the traditional rights of tribal communities. | The Project will involve impacts on forests. |

| Title | Objective(s) | Implementing Agency | Comments | Applicability |
|---|---|---|---|---|
| Government Decree on Fish Stock Protection<br>GB. 1961 no.144 as amended | Protection of fish stocks in inland waters. | LVV | Permits are required for inland fishing, including for trap and line fisheries in estuaries, gillnet fisheries in pans and swamps, trawling and from the river, and sport fishing (a recreational fishing license), | Some fish species will be impacted by the Project. |
| Game Law 1954 G.B. 1954 no. 25 as amended | Protection of fauna and game management. | MNH | The Economic Offences Law is also applicable. | The Project will have the potential to affect wildlife within and surrounding the proposed mine. Some of these species are hunted on a subsistence basis. Some fish species are found in the creeks that will be impacted by the Project. |
| Hunting Decree 2002 | Provisions for various animal species, including hunting seasons and numbers allowed, | | Protection clause for Indigenous Peoples in the south of Suriname is included. | The Project will have the potential to affect wildlife within and surrounding the proposed mine. Some of these species are hunted on a subsistence basis. |
| **Cultural Heritage** | | | | |
| Law on Historical Monuments GB. 1963 no. 23 | Provisions for the preservation of historical monuments, art and architecture in Suriname. | Ministry of Education & Community Development | | Project will have no impacts on Cultural Resources |
| Law of 7 February 1952 G.B. 1952 no. 14 | Controls the export of objects that have historical, cultural and scientific value. | Ministry of Education & Community Development | A permit is required to export objects of historical, cultural and scientific value. | Project will have no impacts on Cultural Resources |

| Title | Objective(s) | Implementing Agency | Comments | Applicability |
|---|---|---|---|---|
| **Occupational Health & Safety/Public Health** | | | | |
| Occupational Safety Law G.B. 1947 no.142 as amended | To advance safety and hygiene in enterprises so that the chance of accidents and occupational diseases can be reduced to a minimum. | Ministry of Labor | 9 regulations have been issued for the implementation of this Law. | The Project will be accomplished in accordance with all applicable Surinamese health and safety regulations, and in accordance with Newmont's health and safety policies. |
| Labor Inspection Law S.B. 1983 no. 42 | Outlines the tasks and responsibilities of the Labor Inspector. | Ministry of Labor | In cases where the safety of persons is in danger, the Inspector has the authority to close the enterprise in question. | The Project will be accomplished in accordance with all applicable Surinamese health and safety regulations, and in accordance with Newmont's health and safety policies. |
| Water Supply Law G.B. 1938 no. 33 | Establishes prohibitions with respect to water wells, etc. that serve as water supply sources. | MNH, Ministry of Public Health | According to this Law the President is responsible for its implementation, but in practice the ministries assume the role. | The Project will be accomplished in accordance with all applicable Surinamese health and safety regulations, and in accordance with Newmont's health and safety policies. |

| Title | Objective(s) | Implementing Agency | Comments | Applicability |
|---|---|---|---|---|
| Key: MNH (GMD) - Geologische Mijnbouwkundige Dienst (Geological Mining Service); MNH - Ministerie van Natuurlijke Hulpbronne (Ministry of Natural Resources); MRD - Ministry of Regional Development; LVV - Ministerie van Landbouw, Veeteelt en Visserij (Ministry of Agriculture, Animal Husbandry and Fisheries); LBB - Lands Bosbeheer (Suriname Forest Service). | | | | |

## 2.3 *SURGOLD STANDARDS*

Surgold will adopt the Environmental and Social Responsibility (ESR) Standards and Policies of Newmont Mining Corporation for the purpose of developing the Merian Project. A summary of Newmont's Environmental and Social standards is provided in Appendix 2-A. Community consultation and environmental stewardship is an important component of any new project Newmont undertakes anywhere in the world, including the proposed Merian Project.

Surgold has established internal standards that outline the Company's approach to its design and operation of aspects of its business that impact people and the environment that set out minimum requirements such that human health and the environment are protected. These standards have been taken into consideration in conducting the Merian ESIA study and will govern the implementation of the Project moving forward.

The corporate standards address such aspects as:

- Air Quality Management
- Water Management
- Waste Rock Management
- Tailings Management
- Mercury management
- Cyanide Management
- Chemical Management
- Hydrocarbon Management
- Closure and Reclamation Planning
- Social Baseline Studies
- Social Impact Assessment
- Stakeholder Mapping
- Stakeholder Engagement
- Expectation and Commitment Management
- Complaints - Grievance Management
- Monitoring and Evaluation
- Local Community Investment
- Security and Human Rights
- Land Acquisition and Resettlement
- Management of Cultural and Heritage sites

## 2.4 *INTERNATIONAL STANDARDS*

In addition to Surinamese national laws and Surgold ESR Standards, the Project will use international standards and guidelines as resources for social and environmental risk management. These international standards range from general guidelines applicable to private sector projects to industry-specific standards surrounding the use of cyanide in mining and the sustainable development performance of projects in the mining and metals industry.

### *2.4.1 IFC General Environmental, Health and Safety (EHS) Guidelines*

The General EHS Guidelines of the IFC contain performance levels and measures that are considered to be achievable in new facilities at reasonable costs using existing technology. The General Guidelines are used in concert with the industry-specific EHS Guidelines to establish best practices for internationally-acceptable standards of conduct for environment, health and safety. The Guidelines support actions aimed at avoiding, minimizing, and controlling EHS impacts during the construction, operation, and decommissioning phase of a project or facility. The EHS Guidelines have become globally applied references for private sector development.

### *2.4.2 IFC EHS Guidelines for Mining*

The IFC EHS Guidelines for Mining address industry-specific impacts and management for the mining sector. The guidelines present performance levels and measures of Good International Industry Practice (GIIP) that are applicable to underground and open-pit mining, alluvial mining, solution mining, and marine dredging.

### *2.4.3 International Cyanide Management Code*

The International Cyanide Management Code for the Manufacture, Transport and Use of Cyanide in the Production of Gold (the Cyanide Code) establishes principles and standards for the safe management of cyanide that is produced, transported and used for the recovery of gold, and on cyanidation, mill tailings and leach solutions. Surgold's Cyanide Management Standard requires Cyanide Code Certification of the Project within 36 months after mineral processing operations are commissioned. This corresponds with the Cyanide Code's requirement that signatories be certified three years after becoming a signatory. The Cyanide Code's Principles and Standards of Practice are presented below.

### *2.4.4 Principles and Standards of Practice*

Principle 1 - Production: Encourages responsible cyanide manufacturing by purchasing from manufactures who operate in a safe and environmentally protective manner.

Principle 2 – Transportation: Protect communities and the environment during cyanide transport.

Principle 3 – Handling and Storage: Protect workers and the environment during cyanide handling and storage.

Principle 4 – Operations: Manage cyanide process solutions and waste streams to protect human health and the environment.

Principle 5 – Decommissioning: Protect communities and the environment from cyanide through development and implementation of decommission plans for cyanide facilities.

Principle 6 – Worker Safety: Protect workers' health and safety from exposure to cyanide.

Principle 7 – Emergency Response: Protect communities and the environment through the development of emergency response strategies and capabilities.

Principle 8 – Training: Train workers and emergency response personnel to manage cyanide in a safe and environmentally protective manner.

Principle 9 – Dialogue: Engage in public consultation and disclosure.

### 2.4.5 *International Council of Mining & Metals (ICMM) Guidelines*

The ICMM was established in 2001 to improve sustainable development performance in the mining and metals industry. Based on their experience with the ICMM standards, ERM has incorporated the ICMM practives into the proposed mitigation measures. These are listed in Table 2-4 below.

*Table 2-4 ICMM Standards*

| ICMM Standard or Commitment | How ESIA will address standard |
|---|---|
| *Sustainable Development Framework* | |
| 1. Implement and maintain ethical business practices and sound systems of corporate governance. | · Consultation and involvement of NIMOS and other Government of Suriname officials throughout<br>· Involvement of stakeholders in the development of impact ratings and mitigation measures |
| 2. Integrate sustainable development considerations within the corporate decision-making process. | · Consultation of stakeholders throughout ESIA process |
| 3. Uphold fundamental human rights and respect cultures, customs and values in dealings with employees and others who are affected by our activities. | · Dedicated and strategic consultation of local communities with the Project Study Area. |

| ICMM Standard or Commitment | How ESIA will address standard |
|---|---|
| 4. Implement risk management strategies based on valid data and sound science. | · World-class environmental and social scientists involved in baseline research and impact assessment<br>· Consultation of affected stakeholders throughout to assess risks |
| 5. Seek continual improvement of our health and safety performance. | · ESIA subject to same high health and safety standards of Surgold operations themselves<br>· ERM coordination with Surgold expected to include interaction with Health & Safety personnel<br>· ESIA to include assessment of community health impacts |
| 6. Seek continual improvement of our environmental performance. | · ESIA to consider impacts throughout project lifecycle through to closure |
| 7. Contribute to conservation of biodiversity and integrated approaches to land use planning. | · Environmental specialist studies to focus on biodiversity<br>· ESIA to include consultation of and liaison with national and international conservation organizations |
| 8. Facilitate and encourage responsible product design, use, re-use, recycling and disposal of products. | · NA |
| 9. Contribute to the social, economic and institutional development of the communities in which we operate. | · Social Specialist Studies will create a complete and detailed snapshot of communities with the Study Area. |
| 10. Implement effective and transparent engagement, communication and independently verified reporting arrangements with stakeholders. | · ESIA process features nteractions with external stakeholders throughout the ESIA process.<br>· ERM intends to support Surgold regular public dissemination of information throughout the ESIA process. |

## 2.5 *REFERENCES FOR CHAPTER 2*

Buursink Consultants. 2005. Country Environmental Assessment (CEA) - Suriname. Inter American Development Bank. Paramaribo, Suriname. April 2005

SRK Consulting, 2007, Bakhuis Transport ESIA Scoping Phase: PCDP.

# 3.0 *PROJECT DESCRIPTION*

This chapter describes the development, operations and closure of the Merian Gold Project (also referred to as the Project).

The Project is located in the northeastern part of Suriname, approximately 60 kilometers (km) south of Moengo and is accessed by the road from Moengo to Langa Tabiki Road (Figure 3-1). The project site is located at the ridge between the Marowijne and the Commewijne watersheds in a largely undeveloped part of the country. The nearest permanent settlement, approximately 17 km from the Project site by road, occurs on Langa Tabiki Island with a population of approximately 500 people. The area immediately surrounding the Project has been modified to a significant degree by timber cutting and unlicensed artisanal and small-scale mining (ASM).

## 3.1 *GENERAL PROJECT DESCRIPTION*

The proposed Project consists of the development of a gold mine with planned production of approximately 5 million ounces (oz) of gold over 12-14 years and the processing of an estimated 150 million tonnes of ore, 680 million tonnes of waste rock and 150 million tonnes of tailings. Mining will take place over 12 years and processing over 14 years. Exploration at the site is ongoing and will continue during operations. There is potential that additional deposits may be identified over the course of the mine life, although this ESIA addresses the only currently known resource. The construction and operation of the Project requires the development of supporting infrastructure.

The description of the Project hereafter will be divided into two main components, as outlined below:

1. *Merian Mine Site*- this is the immediate operational mine area incorporating:
   - Three open pits (named Merian I, Merian II and Maraba);
   - Five waste rock disposal areas (WRDs) named North, East, Central, South and West;
   - A processing plant , including a CCD circuit and cyanide destruction;
   - Heavy Fuel Oil (HFO) power plant (62.3 MWe maximum installed capacity and 44.5 MWe maximum running capacity);
   - Backup diesel generating station (3.64 MWe)
   - A tailings storage facility (TSF);
   - A Water Treatment Plant (WTP) to treat TSF supernatant and associated Treated Water Storage Reservoir (TWSR);
   - One minor borrow area;

- An air strip;
- An accommodation camp and maintenance shops;
- Fuel and chemical storage;
- Potable water treatment plant;
- Sewage treatment plant;
- Haul roads and other access roads;
- Landfill and waste management facilities; and
- Other on-site infrastructure

2. *Transportation Corridor* – The transportation corridor (Figure 3-1) includes:
    - Use of the existing Nieuwe Haven Port in Paramaribo and the port in Moengo;
    - Use of the existing public road from Paramaribo to Moengo called the East-West Highway (being upgraded by the Government of Suriname at the time of writing - November 2012);
    - Use and upgrade of approximately 60 km of the existing public Moengo Road from Moengo to the North Access Road;
    - Upgrade and extend the Merian Mine Site Access Road (i.e., North Access Road) a 16 km North Access Road (9 km of this extension is privately owned by a Surinamese logging concessionaire, the remaining 7 km is under the Merian Exploration Right) from the Moengo Road to the site, called the North Access Road.

Construction materials and operational supplies will mostly be imported via the Nieuwe Haven port in Paramaribo, though some of the larger equipment and supplies may arrive by barge to Moengo. During operations materials, reagents and other supplies will be trucked from Paramaribo on the East-West Highway to Moengo (or be barged to Moengo) and then along the Moengo Road to the site as shown in Figure 3-1. The final product, gold dore, will be transported from the mine site's airstrip via airplane to the international airport for export to an accredited gold refinery.

Figure 3-1 also shows the Industrial Zone boundary denoted by the yellow line. The Industrial Zone boundary is the area where all the mining, processing, and power generating activities would occur within the Project site. This area has also been demarcated and engaged around with local artisanal and small scale miners as an area where their illegal trespass may represent a health and safety concern.

The major mine components are presented in Figure 3-2. The total disturbed areas of the main mine components are presented in Table 3-1. Key characteristics of the Project are also summarized in Appendix 3-A.

*Table 3-1 Summary of Total Disturbed Area by Major Mine Components*

| *Mine Component* | *Total Disturbed Area (ha) (approximate)* |
|---|---|
| *Pits* | *480* |
| *Waste Rock Disposal areas (WRDs)* | *940* |
| Process Plant | 40 |
| Tailings Storage Facility (TSF) | 1,130 |
| Airstrip | 20 |
| Accommodations Camp | 15 |
| Haul roads | 40 |
| Communications Tower | 10 |
| Other disturbed areas (i.e. ancillary access roads, stockpile and laydown areas, borrow areas, drainage works and sedimentation ponds) | 2,644 |
| Total hectares | 4,965 |

*Figure 3-1 The Project Location*

*Figure 3-2 Merian Gold Project Mine Site Layout*

The mine life has been divided into four phases: Pre-Production, Operations, Closure and Post-Closure. Pre-Production includes all activities required to build the mine and bring the process plant into full operation (60% of name plate capacity). Operation is the phase during which the mine and process plant is producing gold (at over 60% of nameplate capacity). Closure describes the phase after production during which Surgold will stabilize the site so that it can be left in a sustainable state long-term. Post closure is the phase during which Surgold no longer has responsibility of maintaining or managing the site.

Activities during these phases are summarized in the generalized Mine Schedule presented in Table 3-2.

*Table 3-2 Generalized Mine Schedule*

| Year | Activities |
|---|---|
| Early Works (currently underway until December 2012) | · Construction and improvements to access roads<br>· Construction of a Pioneer camp<br>· Commercial tree harvesting |
| Pre-production (Construction, Commissioning and Start Up) January 2013 –December 2014[1] | · Completion of Pioneer Camp<br>· Construction of air strip<br>· Construction of Early Works landfill<br>· Site preparation at the process plant including clearing and leveling<br>· Construction of sediment dams, and site drainage features (ditches, ponds, site diversion channels, re-grading)<br>· Construction of the main haul road between Merian II and the process plant area<br>· Construction of an access road from the process plant to the TSF, Langa Tabiki Road Upgrades, and other minor access roads.<br>· Construction of the TSF Phase 1 starter dams<br>· Preparation of Phase 1 TSF including: felling of remaining trees in the TSF impoundment<br>· Stripping of Merian II pit area, excavation at the Merian II pit and stockpiling of saprolitic ore<br>· Construction of the operations camp<br>· Construction of the process plant, water treatment facilities, power plant and supporting infrastructure<br>· Use of existing ASM alluvial sands at White Sands for concrete production<br>· Commissioning and start-up of process plant |

| Year | | Activities |
|---|---|---|
| | | · Establishment of the West WRD<br>· Construction of operational landfill |
| Operations | Year 1 | · Mining Merian II pit<br>· Operation and beginning of closure of West WRD or central dump (Waste saprolite from Merian II)<br>· Opening of Maraba pit<br>· Establishment of Maraba WRD |
| | Year 2 | · Mining at Merian II pit<br>· Mining at Maraba pit<br>· Operation and beginning of closure of West WRD i.e. concurrent reclamation<br>· Continued operation of North and central WRD |
| | Year 3 | · Mining at Merian II pit<br>· Mining at Maraba pit<br>· Opening of Merian I pit<br>· Establishment of Central and South WRD (Merian II and Maraba saprolite, saprock and fresh rock waste)<br>· Continue operation of North and East WRD |
| | Year 4 | · Mining at all three pits<br>· Operation of East and South WRDs<br>· Beginning of closure at North WRD concurrent reclamation of WRDs. |
| | Year 5-12 | · Mining at all three pits<br>· Concurrent reclamation of WRDS. |
| | Year12-14 | · End of Mining at Merian II<br>· Beginning of closure at East WRD<br>· Continued operation of Process Plant |
| Closure | | · Capping of East, Central and South WRDs with saprolite from North and West WRDs<br>· Re-grading of benches on waste dumps if necessary<br>· Re-vegetation of WRDs and other disturbed areas<br>· Decommissioning of buildings and processing plant |

[1] The Pre-Production months consists of 2 months of initial mobilization of key personnel and equipment (November and December 2012) and 24 months of onsite construction activities (January 2013 to December 2014). The 26 months of construction development excludes the completion of the crusher and the Sewage Treatment Plant . The completion and commissioning of the crusher and Sewage Treatment Plant (STP) will continue for an addition 8 months post commercial production for total project duration of 34 months.

ERM has taken important/significant information to develop this project description from sources such as Merian Gold Project Stage 2D study (Rev B), Merian Gold Project Feasibility Study, November 2012, Final Project

Environmental Design Criteria Rev 1, 23 November 2012 and regular communication from Surgold and GMining from October, 2011 – November 2012 via face-to-face meetings, conference calls, memos and email correspondence with Surgold and GMining.

It should be noted that the following project description is based on GMining's preliminary assessment and the design elements may be subject to further optimization. Moreover, details on the design of mine infrastructure, specifications on equipment or machinery, and logistical plans for the Project are being revised and analyzed by the team.

## 3.2 *EARLY WORKS*

Early works at the site, most of which have already been constructed and include camps, access roads, and drill pads, are permitted under the existing exploration license, include activities up to August 2012, and are not evaluated in this ESIA. Exploration at the Merian site has been underway by Surgold prior to 2004. An exploration camp and access roads have been constructed during exploration. The exploration camp is located 15 km from the mine site and will be gradually eliminated during early works as construction of a new Operations camp progresses. The construction of a new Pioneer Camp is included in Surgold's exploration license as it is needed to support continued definition of the mine resource. The Pioneer Camp will cover approximately 3.5 ha and eventually accommodate 250 workers. The Camp will be used for exploration support and then for workers during the early stages of construction. One of the first construction activities will be to commence building the Operations Camp that will serve to house the large number of workers required during construction and will be transitioned to accommodate workers during operations. The Pioneer Camp will be built near the proposed site for the Operations Camp (Figure 3-2). Both the Pioneer and the Operations Camps will include offices, living accommodations, and maintenance facilities, additionally the pioneer camp will also include a concrete batch plant.

Domestic water (e.g., that used for showering, laundry, dish-washing, etc., but excluding potable water) for the Pioneer Camp will be primarily sourced from rainwater. Other possible sources include groundwater wells or surface water streams. Water will be treated on-site to meet domestic water standards as necessary. Bottled water or suitably treated water will be used for potable water supply. The domestic water treatment plant will be a pre-fabricated unit and will treat water to meet the Project's Environmental Design Criteria (EDC) provided in Appendix 3-B. Domestic water demand at the Pioneer camp is expected to approximate 50 $m^3$/day.

Sewage will be treated by a pre-fabricated rotary-biological treatment system and discharged to the upper-most reaches of North North Fork A3 Creek. The sewage treatment plant will be designed with a 50 $m^3$/day capacity. Treatment will meet discharge standards required by the Project's Environmental Design Criteria (Appendix 3-B). Solid waste generated at camp will be managed according to the Project's Waste Management Plan, which will be finalized prior to construction, and will be based on international and Surgold standards. Power will be generated by two small diesel generators at the beginning of early works construction, with a capacity of 600kWh.

A small landfill within the footprint of the West or Central WRD will be constructed and operated to manage domestic, non-hazardous waste from the camp and Early Works activities.

During Early Works, improvements to an extension of the North Access Road and improvements to the Moengo Road will be completed. Improvements to the North Access Road will include clearing and grubbing of the right-of-way, installation of permanent culverts to manage runoff and the construction of a road bed suitable for the transport of heavy equipment required to construct the mine. Improvements to the Moengo Road include clearing of vegetation to improve lines of sight and the safety of road travel for all users, making a slightly wider right-of-way and surfacing of the road with laterite. Early works will also include upgrading four bridges on the Moengo Road to ensure adequate capacity and width to transport some of the mine's heavier pieces of equipment.

Early Works will also include the construction of the airstrip that will be located near the process plant. The airstrip will be used to support exploration, transport personnel and emergency supplies into site during Pre-Production. It will transition into serving the Project during Operations for the transport of gold and personnel and providing transportation in the event of emergencies. A helipad will also be constructed to support emergency evacuations.

A logging concession has been awarded to an independent third-party for an area that includes the mine facilities. The third-party is currently logging most of the Project area for all commercial wood.

The potential impacts that will continue beyond the Early Works Phase resulting from these early works are discussed in Impact Assessment Chapters of this ESIA.

## 3.3 *MINE SITE*

The proposed mine site will comprise three open pits: Merian I, Merian II and Maraba; a processing plant; waste rock disposal (WRD) facilities and tailings storage facility (TSF); fuel tank farm, power generation plant; water treatment facilities; maintenance facilities; offices and worker accommodations. The mine pits and waste rock stockpiles will be located in the Marowijne River watershed while the processing plant and tailings storage facility will be located in the

Commewijne River watershed. Figure 3-2 shows the location of the site's major components.

The phasing of the disturbance of different areas within the Project area is summarized in Figure 3-3. The disturbance area includes temporary areas such as staging and laydown areas.

*Figure 3-3 Merian Gold Project Disturbance Sequence*

### 3.3.1 *Mine Pits*

Over the life of the Project, the mine will produce 150 M tonnes of ore and 680 M tonnes of waste rock and 150 M tonnes of tailings. Merian II pit will be opened first with Maraba Pit opened at the end of Year 1 and operations beginning at Merian I in Year 2. Ultimately, the three pits are expected to extend approximately 170 meters below ground surface with a collective surface area of approximately 480 hectares (ha). Merian II will be the largest pit and will eventually expand over approximately 260 ha, Maraba pit will grow to an estimated 160 ha and Merian I will be the smallest with a total area of approximately 55 ha.

All mining at the Merian project will be open-pit mining performed using a truck and shovel operation. The Merian site is generally composed of a thick layer of saprolite underlain by a transition layer of saprock overlying more competent bedrock (unweathered rock), which is generally referred to as fresh rock[2]. The differences in the rock properties affect the mining methods and rates. The saprolite is a residual soil that is formed in place by chemical weathering of a parent rock. Saprolite is common in tropical environments and can be found up to depths of 150 m in the Merian Project area. It is generally soft and can be mined without blasting although approximately 25% of this softer saprolitic ore will be hard enough to require blasting. Blasting will be required for fresh rock and some of the harder saprolite. The hardness of the rock and ore increases through the saprock transition zone.

Blasting will be carried out using a blend consisting of 70% emulsion and 30% ANFO to reflect the moisture present in the holes and to ensure sufficient shock energy for fragmentation in relatively low bench heights. Blasting will begin near the end of Year 1 and will be required on average six times weekly or approximately 312 times per year with a drill pattern of about 315 holes/ha in the hard rock.

The pits will be constructed with a maximum average rate of vertical advance by pit stage of 14 x 5m benches per annum for the first 8 to 9 years and a maximum of 20-25 x 5m benches in last 4 to 5 years. This rate is considered achievable due to the planning of blasting two benches together in many instances. Pit slopes will be gradual through the softer rock and steepen in the harder fresh rock. A series of generic stability models were analyzed to determine slope heights and angles to achieve a minimum Factor of Safety of 1.2. For each model, both total stress analyses and effective stress analysis were performed to evaluate stability of saprolite slopes under the short-term condition and end-of-mining condition. The bench geometry is specific to the weathering profile and slope height. Final bench heights are 10 m in all weathering units. The design bench face angle

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[2] More details regarding geology of the site are provided in Chapter 5 Project Setting.

(BFA) is 63°in saprolite, 68°in saprock and 80°in fresh rock. The inter ramp slope angles (IRA) recommended for the feasibility-level design of the Merian 2 Pit are based on the limit equilibrium analyses. Identical IRA angles were applied for the other pits. The catch bench widths were adjusted to achieve the recommended IRA required to meet minimum factor of safety criterion. The pit geometry recommendations are summarized in Table 3-3.

*Table 3-3 Slope Design Configurations Summary*

| Material | Slope Heigh (m) | Bench Face Angle BFA (deg.) | Atch Bench Width (m) | Vertical Bench Height (m) | Inter Ramp Angle IRA (deg.) |
|---|---|---|---|---|---|
| Saprolite | 0-40 | 63 | 12.25 | 10 | 30 |
| | 40-80 | 63 | 14.55 | 10 | 27 |
| | 80-120 | 63 | 17.40 | 10 | 24 |
| Saprock | <40m | 68 | 6.00 | 10 | 45 |
| Fresh Rock | <300m | 80 | 6.50 | 10 | 50 |

*Source: Merian Gold Project – Feasibility Study, Section 9 (Golder 2012)*

### 3.3.2 *Waste Rock Disposal Facilities*

Waste Rock Disposal (WRD) facility locations (Figure 3-2) have been selected to minimize truck travel distances from pits to the WRDs. WRDs heights have been restricted so as to not exceed the surrounding regional topography and to be geotechnically stable. The phasing of the opening and closing of the WRDs is dependent on the sequencing of the pit development. Pit production will begin at Merian II and the first WRD to be established will be the nearby West or Central WRD. A portion of the initial dump will open during Pre-Production to store saprolite stripped from Merian II prior to Production. The North WRD will open in the first year of Production. The remaining WRD facilities will become active in Year 3.

Waste rock from Merian II will be stored in the West WRD for the first three years of Production, after which waste rock will be diverted to the Central WRD for the remaining mine life. The West WRD will consist primarily made of saprolite. The southern part of the West WRD will also store low grade ore stockpiles. The West WRD will also include grubbing waste material from the TSF (if required). The surrounding area will also host ore stockpiles for processing.

Early waste rock (Years 1 – 3) from the Maraba pit will be deposited at the smaller North WRD. The North WRD will also comprise mainly saprolite. Once that facility reaches capacity the waste rock from Maraba will be deposited at the

East WRD. The East WRD will comprise a blend of saprolite, saprock and fresh rock. All waste rock from the Merian I pit will be deposited at the South WRD. The majority of the South WRD will be saprolite. The yearly dump plan by material type for each pit is presented in Table 3-4. The estimated WRD facility capacity is presented in Table 3-5.

*Table 3-4 Yearly Dump Plan by Material Type for each Pit (million tonnes)*

| Material Type per Pit | PP[1] | Y1 | Y2 | Y3 | Y4 | Y5 | Y6 | Y7 | Y8 | Y9 | Y10 | Y11 | Y12 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MER II - SAP | 18 | 37 | 37 | 0.3 | | 21 | 28 | 40 | 13 | 0.02 | | | | 194 |
| MAR - SAP | | 0.1 | 34 | 42 | 5 | 0.01 | | | | | | | | 81 |
| MER I - SAP | | | | 0.04 | 8 | 2 | | 1 | 3 | 35 | 14 | 4 | | 67 |
| MER II - Saprock | | 0.25 | 0.25 | 1 | | | | 2 | 16 | 0.2 | | | | 20 |
| MAR - Saprock | | | | 9 | 11 | 0.5 | | | | | | | | 20 |
| MER I - Saprock | | | | | | | | | | | 0.3 | 0.4 | | 1 |
| MER II - Rock | 0.01 | 0.03 | 0.03 | 12 | 2 | 1 | 0.1 | 0.5 | 25 | 27 | 23 | 10 | 1 | 102 |
| MAR - Rock | | | 0.02 | 3 | 46 | 47 | 41 | 26 | 16 | 7 | 1 | 0.1 | 0 | 187 |
| MER I - Rock | | | | 0 | 0.03 | | | 0 | 0.02 | 0.2 | 1.3 | 0.2 | | 2 |
| Total | 18 | 37 | 71 | 67 | 72 | 72 | 69 | 70 | 73 | 69 | 40 | 15 | 1 | 674 |

SAP – Saprolite

PP – Pre-production year

1 Suitable waste saprolite generated during pre-production will be used for the construction of the tailings dam.

*Table 3-5 Estimated WRD Facility Capacity*

| Dump | Elevation (m.a.g.s) | Volume ($Mm^3$) | Million Tonnes |
|---|---|---|---|
| West | 640 | 52 | 94 |
| Central | 640 | 144 | 223 |
| North | 640 | 89 | 145 |
| South | 640 | 43 | 71 |
| East | 640 | 92 | 145 |
| Total | | 420 | 678 |

Waste material will be deposited at all WRDs in 10 to 20 meter benches. The benches may vary in height in order to facilitate drainage toward the working crest while avoiding ponding of water on top of the WRD. The benches will be built to facilitate drainage toward the working crest of the WRD and avoid ponding at the top of the WRD. At the WRD crests the bench height will be 10 – 12 meters. Depending on operational requirements, the WRDs may be operated on several benches at different elevations. WRDs will be started at the higher ground elevations to avoid pooling of runoff or seepage at the toe of the facilities.

Waste rock has been physically and geochemically characterized as part of the final design process. Additional characterization will be completed during operations. Characterization has included analysis of Acid Rock Drainage (ARD) potential as well as the entrainment of other pollutants, such as nitrates due to blasting. The overall ARD potential of the waste rock and tailings due to sulfide oxidation is low (Merian Gold Project – Feasibility Study, Section 9 [Golder 2012]). Analysis of site materials to date suggests low probability to generate Potentially Acid Forming (PAF) ore or waste (Merian Gold Project – Feasibility Study, Section 9 [Golder 2012]); waste rock will be analyzed for PAF characteristics throughout the mine life. All tailings are considered non-acid forming (NAF), as is the bulk of the waste rock and ore, with PAF material mostly restricted to saprolite and saprock. The fresh rock samples typically yield the highest acid generation potential; however, these samples also contain the highest neutralization potential due to the presence of carbonate minerals.

Static and kinetic leach testing has indicated a potential for low-level leaching of metalloids, specifically arsenic, antimony, selenium and molybdenum, under neutral pH conditions. Release of these metalloids likely occurs in association with sulfide oxidation. Under neutral pH conditions, the mobility of these metalloids is high. Low-level cadmium leaching was also observed during testing. This parameter is identified as a possible constituent of concern due to the very low aquatic water quality standards. Testing of tailings samples, specifically bottle roll testing, indicated a potential for copper leaching under alkaline conditions. It is likely that copper is released into solution during cyanide leaching (Merian Gold Project – Feasibility Study, Section 9 [Golder 2012]).

Concurrent reclamation activities shall be conducted as areas of the waste disposal facility become available. Once the WRD bench has reached its final area limit, interim bench slopes of 1.5 H: 1V will be re-graded to a slope of 2H: 1V with 5 meter benches sloped back to minimize erosion. The overall slope will be 2.5H: 1V. The slopes will be re-vegetated to limit erosive energy. Growth media will be used to cover the WRD faces to facilitate re-vegetation. Growth media includes saprolite and grubbed or felled vegetation. Once the growth media is placed, the available WRD face will be re-vegetated through hydro-seeding or other methods. The focus will be to return the vegetation communities as quickly as possible to a native plant community. Reclamation of these areas shall be undertaken as areas become available.

Project Environmental Design Criteria, Appendix 3-B, requires disturbed areas to be re-contoured to final landform and re-vegetated within two years of becoming available.

Example cross-sections of the WRD facilities are provided in Figure 3-4.

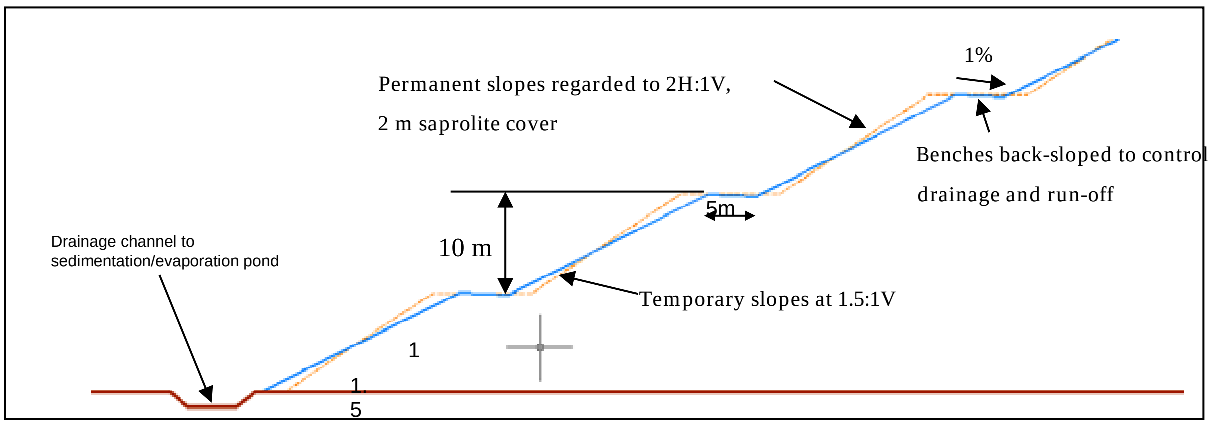



*Figure 3-4 Example Cross-Sections of Waste Rock Disposal Areas*

### *3.3.3 Mining Equipment*

Table 3-6provides a summary of the estimated mining fleet. The manufacturer designations are shown for descriptive purposes only. Equipment from other manufacturers could be used in actual operation. All vehicles will be diesel powered.

*Table 3-6 Summary of Mining Fleet*

| *Description* | *No. of Units* |
|---|---|
| Hydraulic Excavator (Hitachi EX3600 Backhoe Configuration) | 2 |
| Hydraulic Excavator (Hitachi EX3600 Face Shovel | 4 |

| | |
|---|---|
| Configuration) | |
| Caterpillar 785D haul trucks (140t wet payload) | 35 -40 |
| Blast Hole Drill (Atlas Copco DML rotary drills) | 6 |
| Motor Grader (CAT 16H) | 6 |
| Large Track Dozer (CAT D10T) | 6-8 |
| Excavators (CAT 349D(45t)) | 6 |
| Water Trucks (CAT 785D or smaller) | 2-4 |
| Fuel and Lube Trucks (CAT 740B) | 2-4 |
| D-6 Wide Pad Utility Dozers | 1 – 2 |

#### *3.3.4 Process Plant*

The processing of the ore will begin with crushing in the case of fresh rock and simple screening in the case of the saprolitic ore. During the times that the mine is producing both kinds of ore, material from both streams will be fed onto a conveyor and the process plant will run a blend of saprolite and fresh rock. The process plant will be designed with the flexibility to run a throughput ranging from 8 – 16 Mtpa. The throughput will be a function of the ore with the higher throughput realized when the plant is processing only saprolite and the lower throughput when the plant is processing only fresh rock. The ore will be conveyed to a grinding circuit comprised of a SAG mill, a pebble-crusher and a ball mill. Some coarse gold will be recovered from this grinding circuit through a gravity concentrator and sent directly to the refinery. A summary process flow diagram of the process plant is provided in Figure 3-5.

In the grinding circuit, water is added to the ore stream and is pulverized by grinding balls into pieces small enough to expose most of the gold. Coarse and fine ore particles are separated in cyclones, where the fines go with the overflow through a trash screen and are thickened prior to the leaching circuit, while the coarser material is captured in the underflow, re-circulated through the grinding circuit and further pulverized until it is small enough to leave the circuit in the cyclone overflow. Cyanide and lime may be added to the ore in the grinding circuit, in order to initiate the leaching of gold as soon as possible in the process.

The leaching circuit comprises several large leach tanks where additional cyanide and lime are mixed into the ore slurry as required and the gold is dissolved into solution. From the leaching circuit the slurry proceeds to the Carbon-in-Pulp (CIP) circuit where a series of pump cell tanks mix the slurry with activated carbon and the gold adsorbs out of solution and onto the carbon. Once complete, the slurry goes to tailings processing and the carbon goes to elution where the gold is recovered.

In the elution circuit the carbon is first acid-washed to remove lime scale and then the gold is removed from the carbon in an elution vessel with hot cyanide / caustic solution (eluate) at elevated pressures. The barren carbon is transferred to a kiln where it is reactivated prior to returning to the CIP circuit. The eluate solution, which is loaded with gold, is run through an electrowinning circuit where the gold is plated out of solution onto the steel wool cathodes in the form of a gold-laden sludge. The sludge is dried, combined with fluxes, and smelted in a refining furnace to produce gold doré bars.

The tailings from the CIP circuit will be treated using a combination of tailings washing/thickening and an air/sulfur dioxide (Air/$SO_2$) cyanide detoxification system prior to tailings disposal. Reclaimed water from the TSF will be used to wash and dilute the CIP tailings slurry and recover cyanide-containing water for immediate reuse at the process plant, through a single-stage counter current decantation (CDD) circuit. The thickened tailings will be routed to an air/$SO_2$ detoxification circuit, where cyanide levels in the tailings will be further reduced prior to disposal. The cyanide detoxification process (also referred to as cyanide destruction) reduces most of the cyanide species in the tailings to levels below those recommended in the International Cyanide Management Code (ICMC) to protect humans and wildlife that might come into contact with it. Following detoxification, the tailings will be pumped via pipeline to the site's Tailings Storage Facility (TSF). The concentration of cyanide in the tailings at the point of discharge at the TSF will comply with ICMC standards. The Project will complete a design review for Cyanide Code certification before construction and would achieve certification under the schedule specified by the code. This includes an audit within 1 year of receiving cyanide, with verification audits conducted no less frequently than every 3 years. The Project will complete a design review for Cyanide Code certification before construction and would achieve certification under the schedule specified by the code. This includes an audit within one year of receiving cyanide, with verification audits conducted no less frequently than every three years.

*Figure 3-5        Process Flow Diagram*

### 3.3.5 Tailings Storage Facility

The Tailings Storage Facility (TSF) is proposed to be located in the upper reaches of a tributary to the Commewijne River. The facility will be constructed and operated in two phases (Phase 1 and Phase 2). The sequencing of construction and tailings deposition for Phase 1 is complete, while Phase 2 is considered to allow for future expansion. A memo summarizing deposition options is provided in Appendix 3-C. The TSF will require the damming of two sub drainages referred to as A3 Creek and North Fork of A3 Creek as illustrated in Appendix 3-C. Tailings will be deposited via spigotting from the tailings embankment to form a tailings beach that will push ponding water upstream and away from the tailings dams. Spigotting is achieved by depositing the tailings slurry through a perforated pipe as shown in Figure 3-6.

*Figure 3-6 Spigotting underway at mine in Guiana Shield*

Surgold has completed detailed hydrogeological and geochemical modeling and analysis to determine the chemical characteristics of seepage from the TSF as well as the hydrogeological conditions in the affected drainage basins in order to finalize TSF design to ensure it does not degrade the receiving environment, both with respect to groundwater and surface water quality. The TSF will be designed such that if seepage from the TSF is considered to have the potential to degrade the groundwater immediately down-gradient of the facility, mitigation measures will be established to prevent seepage from reaching the receiving environment. Mitigation measures under consideration include collection and treatment of the tailings effluent to remove constituents of concern, enhancement of natural degradation of cyanide in the tailings pond, surface treatment within the TSF that would reduce the flux of seepage to the surrounding environment, cutoff walls within or adjacent to the containment dams and dikes, sand drains for the interception and collection of seepage should it occur, and pumping wells for the return of seepage that is collected. These mitigation measures would be accompanied by monitoring wells located downstream.

Newmont's Environmental Standard, NEM-ENV-S.041, Tailing Management, requires minimum factors of safety of 1.4 and 1.0 for static and pseudo static (seismic analyses), respectively. In addition, the dams must be designed to accommodate the anticipated settlements as well as the dispersive nature of the saprolite. Stability analyses carried out under steady state seepage conditions using phearitic surfaces indicated a factor of safety in excess of 1.7 and 1.5 for static and pseudo seismic analyses (using an acceleration of 0.025 g) conditions, respectively. These results exceed Newmont’s minimum requirements (Technical Memorandum-Preliminary Dam Design and Seepage Collection Systems, Tailings Storage Facility, September 27, 2012 [Golder 2012]). Settlement analysis carried out for selected main dams at completed is presented in Table 3-7.

*Table 3-7 Settlement Analyses Carried Out for Selected Main Dams at Completion*

| Dam Height (m) | Thickness of Foundation Saprolite (m) | Estimated Settlement (mm) |
|---|---|---|
| 10 | 68 | 750 |
| 25 | 55 | 1,400 |
| 35 | 40 | 1,400 |
| 48 | 30 | 1,650 |

Source: Technical Memorandum-Preliminary Dam Design and Seepage Collection Systems, Tailings Storage Facility, 27 September 2012 (Golder 2012)

Due to variations in the thickness of the foundation saprolite, as well as the thickness of the dam fill differential settlements will occur and these have the potential to develop cracks in the dams. To minimize this potential impact, the saprolite fill will be placed at water content above the laboratory optimum for compaction and dam construction will be staged. Internal drainage of the dams to control the phreatic surface and enhance the stability of the downstream face will be provided by constructing a toe drain consisting of a 1-meter thick layer of 25 millimeter crushed rock or well graded sand and gravel having a length equal to dam height and enveloped in a heavy non-woven geotextile such as Geotex 1701 (or equivalent). To permit collection and analysis of any discharge water, the toe drain will be provided with outlets to a sump not connected to the surface water drainage systems. In the event that a crack propagates through the dam, the geotextile beneath the rock protection and around the toe drain will reduce the loss of soil from the dispersive saprolite should water flow through the crack.

The toe drain and rock protection blanket are critical items for long-term performance of the dams and would be carefully inspected during project construction so that these features are protected from potential soil clogging during construction. The internal drainage systems for the large dams will also facilitate tailing consolidation, which will also reduce the phreatic surface of the dams.

### *3.3.6 Labor Force*

The workforce will be housed at the site in worker accommodations during both construction and operations.  Construction is anticipated to start in Q1 2013 with an estimated workforce of approximately 250 employees.  The total construction force will increase as construction progresses to reach a minimum of 750 people (excluding mine operations and exploration groups).  Of the 750 workers, an estimated 600 are expected to be Surinamese nationals and the remaining 150 are expected to be non-Surinamese nationals.  Once the mine begins operations, it will employ approximately 1,200 employees (with approximately half on site at any given time) and will operate 24-hours/day. The Project will strive to hire unskilled labor during construction from local communities such as the Pamaka communities in the area.  It is anticipated that the available labor pool within the local communities will not be large enough to meet the labor needs during construction in which case Surgold will expand recruitment to include more distant communities within Suriname, including Paramaribo.  Unskilled labor requirements will reach approximately 200 workers.

Recruitment and training for positions for operations will be based on a similar approach (i.e., priority placed on local communities and expanded as necessary). The Project is currently exploring training and partnering opportunities with Surinamese organizations to help finalize a resourcing plan as it moves into construction. Hiring will be conducted in established centers including Paramaribo and Moengo.  There will not be any hiring conducted at the Project site.

The construction workforce will work on a fourteen days on and seven days off roster during pre-production, working 11 hours shifts. Operations staff will operate on a fourteen day  and seven day rotation, working 12 hour shifts (day and night shifts will exist).

Technical staff will work the same 14:7 rotor and 12 hour shifts or nine days on, five days off for ten hour shifts however will only work day shifts. Administrative staff will work with 9 days on and five off for 10 hour shifts or five days on and two off for eight hour shifts (daytime shifts only). Expatriate staff (of which there are anticipated to be approximately 7 to 10) will work 23 days on and 19 off or 30 days on and 26 days off.

Typical jobs during construction will include:

- Helpers for all trades,
- Camp support,
- Bush cutters,
- Carpenters,
- Pipefitters,
- Electrical technicians,
- Industrial mechanics,
- Industrial welders,
- Riggers,
- Crane operators, and
- Administrative staff.

During operations, a workforce of 1,200 workers is estimated. An overview of general job types is as follows:

- Administration,
- Legal,
- Accounting/finance,
- Procurement/logistics,
- Human resources,
- IT,
- Engineers,
- Geologists,
- Health and Safety,
- Environmental,
- Community Relations,
- Warehouse,
- Surface Support,
- Mine Operations,
- Earthworks,
- Mine Maintenance,
- Camp support,
- Drill and Blasting,
- Bush cutters,

- Metallurgical lab,
- Security,
- Mill operators,
- Mill electricians, and
- Mill maintenance.

## 3.4 *MINE INFRASTRUCTURE*

### *3.4.1 Power Plant*

Power Supply: The site will include a dedicated Heavy-Fuel Oil (HFO) power plant with a 53.4 MWe running capacity and a 62.3 MWe installed capacity. During the preliminary design stage of this Project, it was anticipated that the plant will initially comprise six (6) HFO 10.5 MWe generators, totaling 63 MWe installed capacity and 52.5 MWe running capacity (assuming one of the generators would be on standby). More recent design indicate the plant will initially consist of six (6) 8.9 MWe generators (with 100 percent plant availability) for a total installed generating capacity of 53.4 MWe or running capacity of 35.6 (assuming two of the generators would be on standby). Given the increased fresh rock feed to the mill from Year 4 and beyond, the plant will need an expansion phase at Year 3 with the addition of one 8.9 MWe unit, bringing the total installed generating capacity of the plant to 62.3 MWe and the total running capacity to 44.5 MWe. The thermal efficiency of the HFO generators, including losses in sludge from processing HFO, is 4.65 kWh / L (Feasibility Study for the Merian Gold Mine Project, Section 12 [GMining 2012]).

Power consumption for the Project is estimated in five categories:

- Crushing and Grinding: - Crushing and grinding energy requirements were determined using the ore types specific energy indexes;
- Fixed Load (Mill): - The energy consumption of the process plant fixed loads were benchmarked against similar projects;
- Fixed Load (Other): - The energy consumption of the fixed loads outside the process plant were benchmarked against similar projects;
- Variable Loads: - Variable loads are functions of the process plant throughput. They were estimated using the project's mechanical list; and

  Power Plant: - The power plant internal energy consumption was benchmarked against similar projects.

The power plant will be designed such that emissions meet those recommended in the IFC EHS Guidelines for Thermal Power Plants (2008). Sulfur emissions (SOx) will be controlled through the use of low-sulfur fuel (approximately <1.5%). Nitrogen oxide emissions (NOx) will be controlled through the tuning of the engines' fuel-air mix during start-up. Particulate matter (PM) controls are currently being designed based on laboratory analysis of the fuel that will be supplied to the Project. During operations indicative monitoring for of SOx, and continuous monitoring of NOx and PM will be completed to monitor stack emissions. Additional control technology will be employed as needed to achieve IFC emission criteria. HFO will be stored at the sites' fuel tank farm as described in Section 3.4.4. The fuel will be transported from Paramaribo regularly via the transportation corridor with an average of four (4) truck deliveries per day. The power plant will provide power for all of the mine's power demands including process plant, tailings and water pumping stations, worker accommodation and offices.

Power Distribution: Power distribution for the Merian project will be implemented at 13.8 kV, 60 Hz and will consist of sub-stations and powerlines. The process plant will have various satellite electrical rooms which will be fed by the HFO power plant. These electrical rooms will serve the following areas:

- Grinding / Gravity / Gold Room;
- Crushing Area;
- CN Detox / Plant Services;
- Pre-Leach / Leach / CIP / Acid Wash / Elution / Carbon Regeneration; and
- Ore Handling.

Power lines out of the HFO power plant will be used to distribute power to other infrastructures such as:

- The Pioneer Camp;
- The Operations Camp / Communication (Telesur);
- The Administration Building / Assay Lab / Gate House;
- The Mine Maintenance Shop / Warehouse / Diesel Fuel Storage / Explosive Plant;
- The various Pollution Ponds;
- Tailings Facility Reclaim Water / Seepage control;
- Water Treatment Plant; and
- Sewage Treatment Plant.

<u>Construction Power / Emergency Backup Power</u>: A small diesel power plant will be installed early in the project in order to supply power during the Pre-Production phase until the commissioning of the HFO power plant. During the preliminary design stages, it was anticipated that this Project will initially comprise three (3) 910 kWe at the process plant site and two (2) 300 kWe diesel power generators at construction camp sites, making a total installed capacity of 3.33 MWe during the construction phase. More recent design indicate the this

facility will include four high speed diesel generators, each having a prime rating of 910 kWe, for a total installed capacity of 3.64 MWe. These generators will produce power at 480 V, 60 Hz and will be connected to the overhead power lines through individual and dedicated 480 V / 13.8 kV transformers. Once the HFO power plant is commissioned and operational, the diesel power plant will be used as peak shaving capacity and backup power in case of a blackout at the main power plant (Feasibility Study for the Merian Gold Mine Project, Section 12 [GMining 2012]).The power plant manpower will be as follows:

- Power Plant General Foremen (2);
- Power Plant Supervisors (3);
- Power Plant Operators (3);
- Power Plant Electricians (3); and
- Power Plant Mechanics (3).

### 3.4.2 *Airstrip*

An airstrip will be constructed on site as shown in Figure 3-2. The airstrip will be designed to accommodate airplanes up to the size of a Twin-Otter or Caravan and will be approximately 700 meters long. The airstrip will be used for export of gold, personnel transport, and health and safety emergencies during all phases of the Project. An average of three or four flights per week is anticipated, which will occur during daylight hours as the airstrip will not be lit. The strip will be unpaved and constructed from laterite. The airstrip will be oriented east-west as required by the sites prevailing winds. Little clearing for the approaches is anticipated as the strip is situated on a ridge and much of the surrounding area will be already disturbed due to other mine development activities.

### 3.4.3 *Borrow Sites*

Borrow sites for aggregate material, laterite and sand have been identified both within the Right of Exploitation and beyond at current third-party operations. The potential borrow material on-site is found in the tailings piles left behind by ASM activities in the White Sands area of Tomulu Creek. There is potential to collect the sands and/or gravels found in these piles using an excavator and dump truck operation, washing and screening the material for use in the making of lower-grade concrete required for the construction of the camp and other ancillary mine facilities and possibly dam drainage filter material.

Rock fill and the remainder of the sand requirements will be sourced from third-party quarries. Currently the following sites listed in Table 3-8 are under consideration:

*Table 3-8 Potential Third-Party Quarries*

| Type of Material | Description | Location | Distance From Site |
|---|---|---|---|
| River aggregate | River sand and gravel mined by Guaya Mining from the Marowijne River | Albina | 127 km |
| River sand | River sand from the Brokopondo Area | Paramaribo | 182 km |
| Crushed aggregate | Crushed aggregate from the mica quarry operated by Dalian International | KM 9 on the MoengoRoad | 68 km |
| Crushed aggregate | Crush aggregate from the Dalian International quarry in Pokigron | Pokigron | 327 km |
| Crushed aggregate | Quarry located east of the Suriname River operated by MNO Vervat | Bridge between Paramaribo and Moengo | 127 km |

In addition to the borrow sites described above, other construction material required during Pre-Production Phase are presented in Table 3-9. During the Operation Phase, the Merian Project will be self-sufficient for backfill, aggregate, and rip rap.

*Table 3-9 Construction Material Required during Pre-Production Phase*

| Type | Gradation (mm) | Volume ($m^3$) |
|---|---|---|
| Riprap - Plating + Sediment Ponds | - | 200,000 |
| Engineering Backfill – Dams + Sedimentation Ponds | 0 to 50 | 1,852,168 |
| Sand – For Sedimentation Ponds | $75 \times 10^{-6}$ to 4.75 | 200,000 |
| Bedding | 0 to 25 | 2,000 |
| Aggregate | 4.75 to 25 | 43,905 |

### *3.4.4 Fuel and Chemical Storage*

There will be two on-site fuel storage locations during operations. One site will be dedicated to HFO with two 2,500 $m^3$ storage tanks. The HFO will be sourced from Staatsolie in Paramaribo or imported from other suppliers and delivered to the site by trucks. It is estimated that the daily consumption of HFO at the power plant will be approximately 140 $m^3$ for four running generators, and 175 $m^3$ for five running generators. In order to maintain the storage reserve in the tanks, four to six 30 $m^3$ tankers will need to be unloaded on site on a daily basis. In order to handle this important volume, the power plant will include a tank farm with an unloading station capable of servicing two HFO tankers at the same time (Feasibility Study for the Merian Gold Mine Project, October 1, 2012 [GMining 2012]).

The unloading station of the power plant will be equipped with pumps to handle the following:

- Delivery of diesel fuel;
- Delivery of fresh lube oil;
- Loading of waste lube oil; and
- Loading of sludge.

The second site will be dedicated to diesel fuel with a storage capacity of approximately 5 million liters for the mining equipment, vehicles, and diesel generators.  The diesel fuel will be sourced from diesel suppliers in Paramaribo and delivered to the site by trucks. The tank farm (HFO and diesel tanks) will be replenished daily and will be designed to meet Surgold standards specific to hydrocarbon management, including the following:

- Hydrocarbon storage tanks shall be designed and constructed above ground (i.e., – not buried).
- Hydrocarbon storage facilities (tanks and piping) shall have a system to detect leaks and recover product (e.g., – visual inspections, active leak detection system, annual integrity testing).
- Bulk hydrocarbon storage and transfer systems, including temporary systems, shall have a secondary containment. Where distribution piping is above ground and visible for inspection secondary containment is not required; however, the distribution piping shall be inspected and documented routinely to verify its integrity.
- The capacity of secondary containment structures shall be capable of containing a minimum of 110% of the volume of the largest tank in the containment area.
- Secondary containment shall have a typical water permeability equivalent to untreated concrete.
- Bulk tanks shall be equipped with engineered overfill/overpressure protection devices.
- Hydrocarbon use, transfer, distribution, and storage facilities shall be designed to control meteoric water, including drainage within and around containment areas.

- The areas around fuel delivery pumps and vehicle refueling points shall be protected against spills and releases using containment and collection systems.

Reagents that could be used on-site and transported daily from Paramaribo include:

- Cyanide,
- Lime,
- Flocculent,
- Caustic,
- Nitric Acid,
- Carbon,
- Antiscalent,
- Sulfuric Acid,
- Peroxide,
- Silica,
- Borax,
- Sodium Nitrate,
- Soda Ash,
- Copper Sulfate,
- Sodium Metabisulfite,
- Sodium Hypochlorite, and
- Iron.

As the process engineering is still under optimization, certain reagent requirements could change.

During Pre-Production fuel with be stored in smaller double-hulled tanks on paved areas designed with secondary containment.

### *3.4.5 Operations Camp*

As shown in Figure 3-2, the mine site will include worker accommodations with a capacity of up to 800 people. The camp will also include ancillary facilities such as kitchen and dining hall, laundry, showers and recreation or general use areas. The design of the accommodations will meet or exceed international standards[3].

[3] Workers' accommodation: processes and standards. A guidance note by IFC and the EBRD.

### 3.4.6 *Waste Management*

The mine operations are expected to generate the following waste streams during construction:

- Construction waste:
  - Pallets and other wood packaging materials
  - Shipping packaging
  - Discarded dry, non-hazardous materials
  - Scrap metal
  - Scrap lumber
- Discarded office supplies
- Discarded food containers
- Putrescible food waste
- Other "household" waste
- Condemned vehicles
- Medical waste
- Solid waste: domestic solid waste or similar industrial waste (non-hazardous and hazardous) including tires, broken and used parts, unused raw concrete, reagent bags, scrap steel
- Liquid waste: un-used chemical waste, solvents, used oil, sewage sludge and supernatant water, and waste water from maintenance shops (non-hazardous and hazardous)

Waste management will follow a hierarchy with the emphasis placed on reuse and recycling. A Waste Management Plan has been prepared to identify what material can be reused and recycled (Volue IV, Environmental and Social Management Plan for the Merian Gold Mine Project). Currently material identified for reuse include: tires (recapping) steel and wood waste if useful to location communities. Materials identified for recycling include: waste lubricants and filters, broken parts, used air filters etc, condemned vehicles, typical household recyclables, batteries, and scrap metals.

<u>Non-Hazardous Waste</u>

Non-hazardous waste for the project during construction is primarily associated with packing material and surplus construction materials. The primary material types are wood (pallets), scrap steel, and cardboard. Smaller volumes of other non-hazardous waste, such as paper and organic food waste, will also be generated. As much as possible, waste will be segregated to facilitate recycling. A reputable, licensed contractor will be hired to handle final disposal of recyclable and saleable waste. The waste storage area will be constructed from impermeable materials. Waste processing and storage areas will be constructed with curbs to prevent runoff to permeable areas. Runoff and leachate will be collected and treated as needed prior to discharge to the environment. Materials that are currently recycled at the Project, includes scrap steel and other metals (aluminum, copper), plastic bottles, and specific shipping containers that can be returned to the supplier. These practices will continue into construction and operations to minimize the non-hazardous waste stream that must be managed.

For non-hazardous materials that cannot be recycled or returned to the suppliers, one or more landfills will be developed to manage the waste. The landfills will be created within the WRD areas and will be constructed and operated to be consistent with best practices, including those of the IFC. This includes aspects such as landfill siting, engineering to minimize infiltration and facilitate leachate collection if needed, tracking of waste streams, and monitoring run-off and leachate generation.

Materials that may be landfilled include tires, broken parts that cannot be recycled, typical non-recyclable waste such as foam, plastic packaging, used equipment and cloth material, un-useable wood materials, and unused concrete.

Oils and lubricants will be reused or otherwise returned to the supplier for recycling or sent to a reputable recycling facility through a trading company authorized to handle recyclable materials. Hydrocarbon-stained soil will be treated on-site using a bio-pile. A bio-pile is similar to conventional land-farming but is designed for areas that receive high amounts of precipitation, such as the Merian site. Aerobic microbial activity that breaks down the hydrocarbon contamination is stimulated by aerating the soil by increase air flow through the pile through slotted or perforated piping. The pile will be constructed on a bunded concrete pad and covered to reduce rainfall onto the pile.

Hazardous Waste

Hazardous material will not be disposed in the site landfill. Hazardous waste generated during the construction and operations will be temporarily stored on site and then disposed of at an approved facility by a licensed contractor. Designated facilities used for the collection and temporary on-site storage of hazardous waste will include fencing, signage, roofing, lighting, and secondary containment.

Existing management protocols are in place for materials including:

- Medical Waste
- Used Batteries

- Used or Residual Oil
- Used Oil Filters
- Hydrocarbon Impregnated Materials
- Light Bulbs, Fluorescent Tubes, and Vehicle Light Lamps
- Printer cartridges

The Environmental and Social Management Plans included in Volume IV provides a framework for expanding the current practices to meet the requirements of construction and operations. The management plan includes procedures for: 1) identifying hazardous waste streams, including the introduction of new ones, 2) collection, 3) temporary storage, 4) transfers to appropriate facilities, and 5) tracking and auditing of the process and ultimate disposal.

Surgold is responsible for ensuring that licensed disposal sites are being operated to acceptable standards. These requirements are incorporated in the Environmental and Social Management Plan (Volume IV) and shall be implemented, adhered to and reviewed / updated regularly or whenever changes to the system are made. The Project EDC Appendix 3-B specifies criteria for hazardous wastes. These criteria have been established based on the IFC EHS Guidelines for Waste Management Facilities, and Newmont Environmental Standard NEM-ENV S.046 – Waste Management (2008. A more detailed environmental design criteria for hazardous waste is included in Appendix 3- D.

## 3.5 *MINE-SITE WATER MANAGEMENT*

The Project will incorporate numerous structural and operational environmental controls designed to manage and minimize potential water resources, including:

- Installation and active management of sediment ponds downstream of all major disturbance areas including construction areas, borrow areas, WRDs and pit disturbance areas. Sediment ponds will provide retention time to facilitate (with addition of flocculants, as necessary) the settling of suspended solids prior to discharge to local streams. Sediment ponds will be equipped with multi-level discharge outlets to manage discharge rates and attenuate peak flows;
- Incorporation of engineering controls in the process plant design, including a single stage counter current decantation (CCD) circuit to re-cycle cyanide into the process, a cyanide destruction circuit prior to discharge into the TSF, keyed dam design to minimize seepage through the surficial alluvial soil unit, and seepage collection and recovery systems described below;
- Installation and operation of an upstream drainage system to be located upstream of the main TSF dams to reduce groundwater piezometric heads, which in turn will reduce the flow of TSF-impacted seepage

through the underlying quartz vein system and saprolite. The internal drainage systems will include pumps to facilitate tailing consolidation, which will further limit seepage;

- Installation of a seepage collection and recovery system along the downgradient perimeter of the TSF to capture a portion of seepage from through and under TSF dams and allow for its return to the TSF supernatant pool. Seepage collection system will include shallow seepage collection drains to capture seepage through the shallower parts of the quartz vein systems and seepage collection wells to capture seepage through the deeper parts of the quartz vein systems and the fractured saprock and fractured bedrock layers. This impact assessment chapter assumes a seepage collection efficiency of 50 percent (i.e., 50 percent of the TSF seepage will be captured and returned to the TSF), though this is thought to be conservative; and
- Installation and operation of Water Treatment Plant (WTP) to treat excess water from the TSF prior to discharge to a constructed Treated Water Storage Reservoir (TWSR) and then to the environment.

Water management at the mine site includes active management, and/or contingency management of the following water streams/issues:

- Sediment control during construction and operations;
- Pit dewatering water;
- Waste rock disposal area runoff;
- Water management at the TSF; and
- Domestic waste water.

The Project EDC Appendix 3-B specifies criteria (Project Discharge Criteria) for sanitary effluent and treated process water effluent. The Project EDC also specifies water quality for designated water uses including drinking water, agriculture and aquatic life. These criteria have been established based on the IFC EHS Guidelines for Mining as well as other internationally-accepted standards such as the Cyanide Code and USEPA guidelines and criteria.

The following chapter provides an overview of the site-wide water management. A more detailed Mine Water Balance is included in Appendix 3-D.

### *3.5.1 Site Drainage and Sediment Control*

Sediment management relies on: 1) run-on controls, 2) source controls near the disturbance, 3) intermediate controls, and 4) perimeter controls. Releases from the perimeter controls must meet effluent limits and achieve ambient criteria at downstream compliance points.

Conditions on site have been disturbed as a result of legacy small-scale mining such that sediment loads in the streams on the mine site have increased dramatically from early 2000s conditions (more detail is provided in Baseline Water Resources Chapter 9). The project will apply sediment control measures prior to discharging to the receiving environment to reduce sediment loads discharging from the site. This includes development of sediment control structures / dams (sediment ponds) downstream of Project-impacted areas prior to start of major earthworks. The sediment control structures are integrated into a surface water management plan that is directed at minimizing run-on flows from undisturbed areas, so that the sediment structures can be managed. The discharges from the sediment control structures will not undergo formal treatment, though flocculants may be added to help precipitate fine clays and reduce retention time needed for Total Suspended Solids (TSS) removal in the ponds. The design discharge criteria for TSS will be based on the EDC and on continuous baseline sediment data collected in the existing streams. The sediment control plan includes in-stream sedimentation basins (with the ability to control / regulate peak flows) with the locations as shown in Figure 3-7.

*Figure 3-7 Mine Site Water Management*

### 3.5.2 *Pit Dewatering*

Pit dewatering is expected to be required at all three pits. Water will be collected in a sump and pumped to a near-by Sediment Pond and then discharged to the environment as shown in Figure 3-7. Based on preliminary geochemistry data and analysis conducted to-date, the water quality of the pit dewatering is expected to meet Project discharge criteria. Pit water will be treated for TSS by routing the water through sediment ponds and then discharged to the receiving environment. Blasting will be controlled to minimize residual nitrogen in the waste rock. It is assumed that controls can be used to limit wastage to 1% or less. This level of wastage would not result in nitrogen levels in waste rock run-off or seepage that would exceed project criteria. Contingency plans for managing nitrogen have been developed in the event wastage is higher than projected. This contingency is described in the Appendices. Similarly, contingency plans for pumping water from sedimentation ponds to the TSF to allow for water treatment have been developed. Water released from the sediment control ponds will meet effluent limits at the point of discharge and ambient water quality criteria for protection of human health and the environment at a downgradient compliance point. Runoff during wet periods is anticipated to meet discharge criteria without treatment. Water quality analysis of pit water will occur during operations to confirm water quality prior to discharge to the environment. Contingency measures for water treatment will be implemented if needed to meet water quality criteria for the discharges. Areas adjacent to pits will be filled and graded to drain away from the pits. The flow diversion arrows in Figure 3-7show where runoff will be routed.

### 3.5.3 *Waste Rock Disposal Area Runoff and Seepage*

Similar to the pit-dewatering water, geochemistry completed indicated that waste rock disposal area runoff and seepage will only require treatment for TSS prior to discharge to the environment. As per the pit water, during operations, water quality analysis of the waste rock disposal area runoff will be conducted prior to discharge and contingency measures will be implemented if monitoring shows that discharge criteria are not met. Figure 3-7 shows the conceptual arrangement of diversion ditches, collection ditches and other conveyance features that feed the sedimentation facilities, prior to discharge to recovery streams.

### 3.5.4 *Tailings Water Management*

The tailing storage facility (TSF) has been designed to meet several criteria, including:

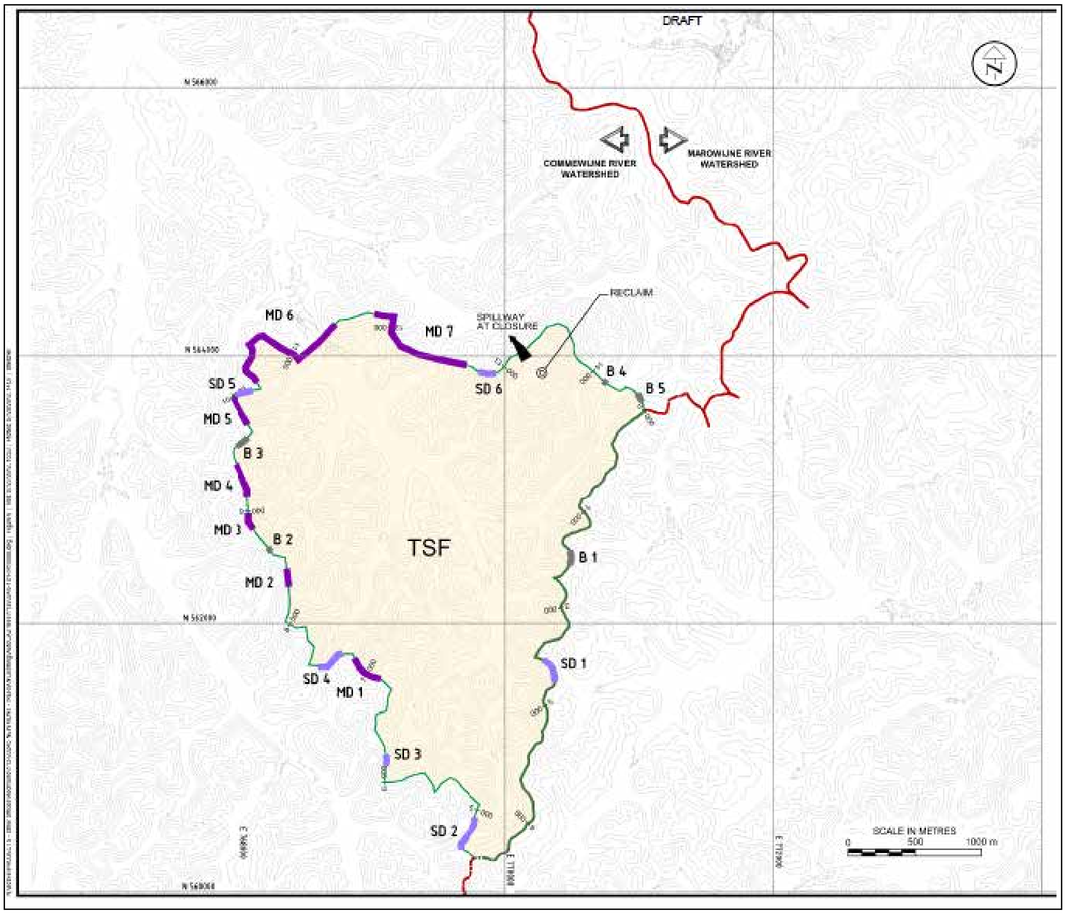
- The facility should be fully located within the single watershed of the Commewijne River.

- The design is based on ore reserves of up to 150 million tonnes (Mt).
- Storage of accumulated water for a dry period of 2 months is required.
- Tailings will be deposited / spigotted off of all dams.
- The maximum basin crest elevation will not exceed elevation 578 meters (masl).
- 45 percent solids are targeted for slurry discharge.
- The milling rate ranges from 8 to 16 Mt per annum.
- The Life of Mine (LOM) is about 12 years.
- During operation, the TSF should have a minimum pond volume of about 2.0 million cubic meters ($Mm^3$) and a maximum of 14 $Mm^3$.
- The facility is to be capable of containing the three day probable maximum flood event (PMF), estimated to be approximately 1,300 mm of rainfall, along with a 1.0 m freeboard.
- Over-topping of the facility during operations is not permitted.
- Access roads will be required around the full perimeter of the facility.
- Starter dams should contain 3 years of tailings production.
- A permanent spillway will be constructed at closure.

The design for TSF Phase 1 provides sufficient storage for the ore reserves of 132 Mt of tailing. There is sufficient capacity in Phase 1 to allow for some expansion. If additional capacity is needed, the TSF can be extended to the north (i.e., Phase 2 - with sufficient storage for an additional 18 Mt of tailings to give a total of 150 Mt of tailings), which would require re-location of the treated water storage pond. TSF Phase 1 and Phase 2 are shown on Figure 3-2.

The development of the TSF requires the construction of a series of dams. For Phase 1 this includes seven large Main Dams (MD1 through MD7) on the east and northeast of the TSF; six smaller Saddle Dams on the south, northwest, and north of the TSF (S1 through S6); and five Berms (B1 through B5) on the west, northeast, and east of the TSF (Figure 3-8).

The major and saddle dams will include internal drainage with a toe drain, a rock protection layer with a geotextile filter on the downstream face, and a key at the base of the dam. The TSF also includes internal drainage systems upgradient of the major dams to minimize head and seepage, as well as to facilitate consolidation of the tailing. Additionally, a series of seepage collection drains and wells to capture groundwater flow from the TSF are designed downgradient of the TSF.

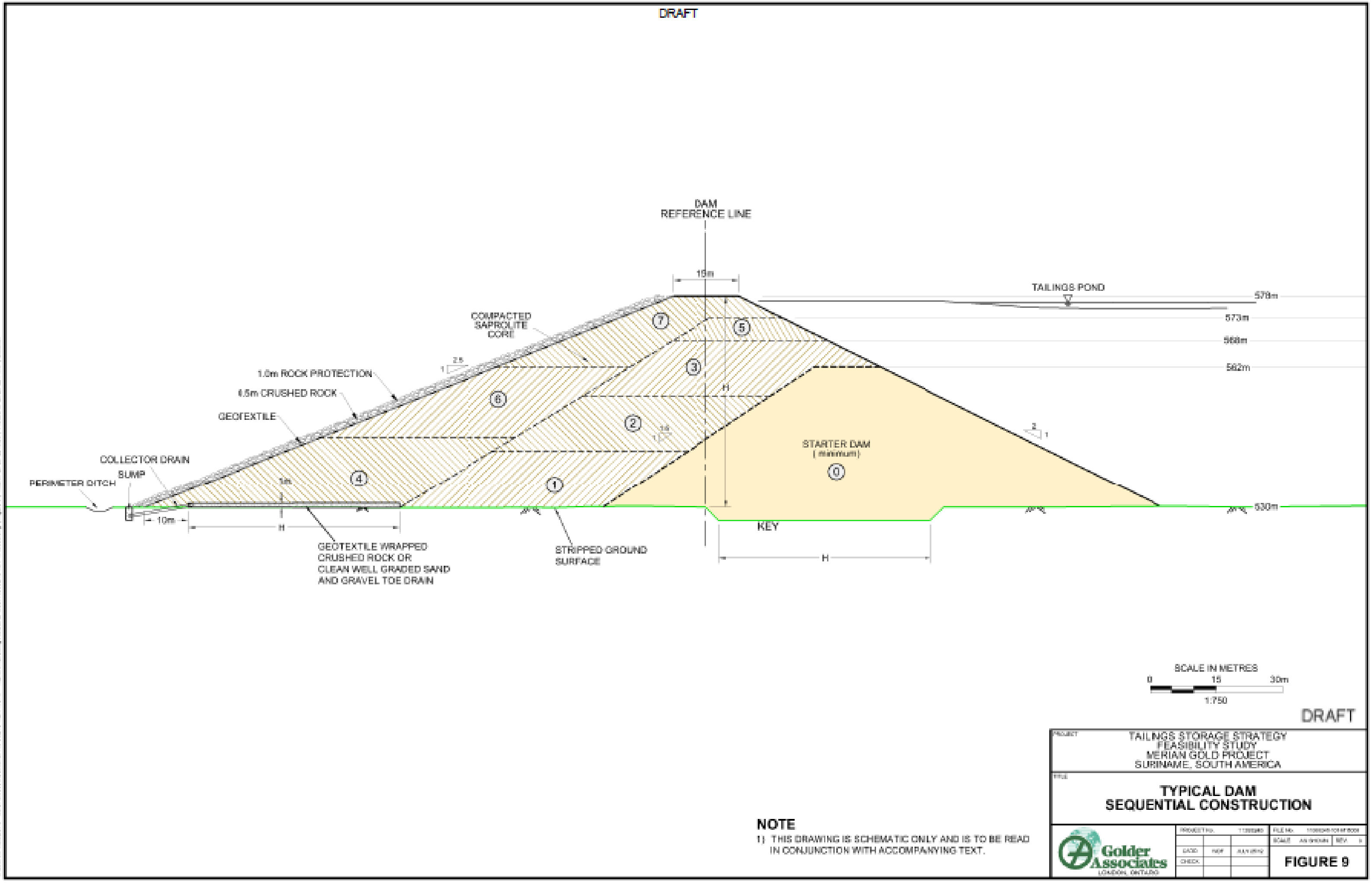



*Source: Merian Gold Mine Project Feasibility Study, Section 14 (Golder 2012).*

*Figure 3-8 Dam Locations at the Tailing Storage Facility*

Based on testing completed on the site soils, it is anticipated that the TSF dams will be constructed using suitable pit waste materials and saprolite materials excavated from within the basin. Special graded sand and gravel will be used in the toe drain and seepage collection features. Work to date has found that only limited sources of sand are available within the Project Area, which will require an external source of these materials during the initial construction. However, after three years of operation, 25 millimeter size crushed rock is expected to be available from fresh rock pit waste, as well as required larger rip rap.

While the saprolite materials are relatively strong with angles of effective shearing resistances of 30 degrees or greater, the foundation saprolites are somewhat compressible and settlement on the order of 1.5 meters could occur for some of the major dams. Settlement, which may be differential, could result in cracking of the compacted saprolite dam cores. To account for this potential, the dam designs include provisions to address possible cracking and the migration of tailings through the dams. An important operational measure to prevent the loss of impounded water is the spigotting of tailing from each of the dams to keep the pond remote from the dams. A typical dam cross section with staged construction sequencing is shown in Figure 3-9.




*Source: Merian Gold Mine Project Feasibility Study, Section 14 (Golder 2012)*

*Figure 3-9 A Typical Dam Cross Section with Staged Construction Sequencing*

As shown in Figure 3-9, the dam consists of a section of homogeneous compacted saprolite core with a geotextile wrapped crushed rock toe drain. The downstream slope is protected by a layer of crushed rock enveloped with geotextile and a layer of rockfill. This cross section controls the development of porewater pressure in the downstream portion of the dam by the use of a filtered toe drain. The drain also provides a defense against the effects of cracking, which is augmented by the layer of geotextile on the downstream face of the dam. Additional seepage collection features will be located downstream of the dams. The starter dams, and berms of less than 5 m height, do not require slope protection or drainage features.

*Tailings Disposal Method*

Tailings will be placed to support the development of dry tailings beaches in front of all of the dams (major and saddle), and to keep the reclaim pond away from the dam faces. The tailings surface slopes are expected to be relatively flat, approximately 0.3 % for the dry slope and 1.3 % for the wet slope.

The initial tailings deposition would be from the dams in the northwest corner of the TSF. As the project progresses, deposition would continue along the remainder of the TSF perimeter such that the open water pond is forced towards the reclaim location. Water reclaim will be accomplished using barge pumps.

As discussed above, the TSF would be capable of containing the three day PMF event, estimated to be approximately 1,300 mm of rainfall, along with a 1.0 m of freeboard. During development of the TSF, sediment ponds will be expanded to allow storage of the PMF precipitation event. At closure, the pond size will be reduced through the placement of a spillway to allow passive flow of run-on water to the receiving drainage, once the water quality has reached acceptable quality.

*Tailings Seepage and Control*

The TSF will be constructed through the damming of A3 Creek and North Fork A3 Creek as shown in Figure 3-2 and Figure 3-7. Therefore, water inputs to the TSF include basin runoff, rainfall over the basin as well as water content of the tailings slurry and any seepage captured through interceptor or collector wells and returned to the TSF's supernatant pond (Figure 3-10).

*Figure 3-10 Water Management Plan Conceptual Flow Diagram*

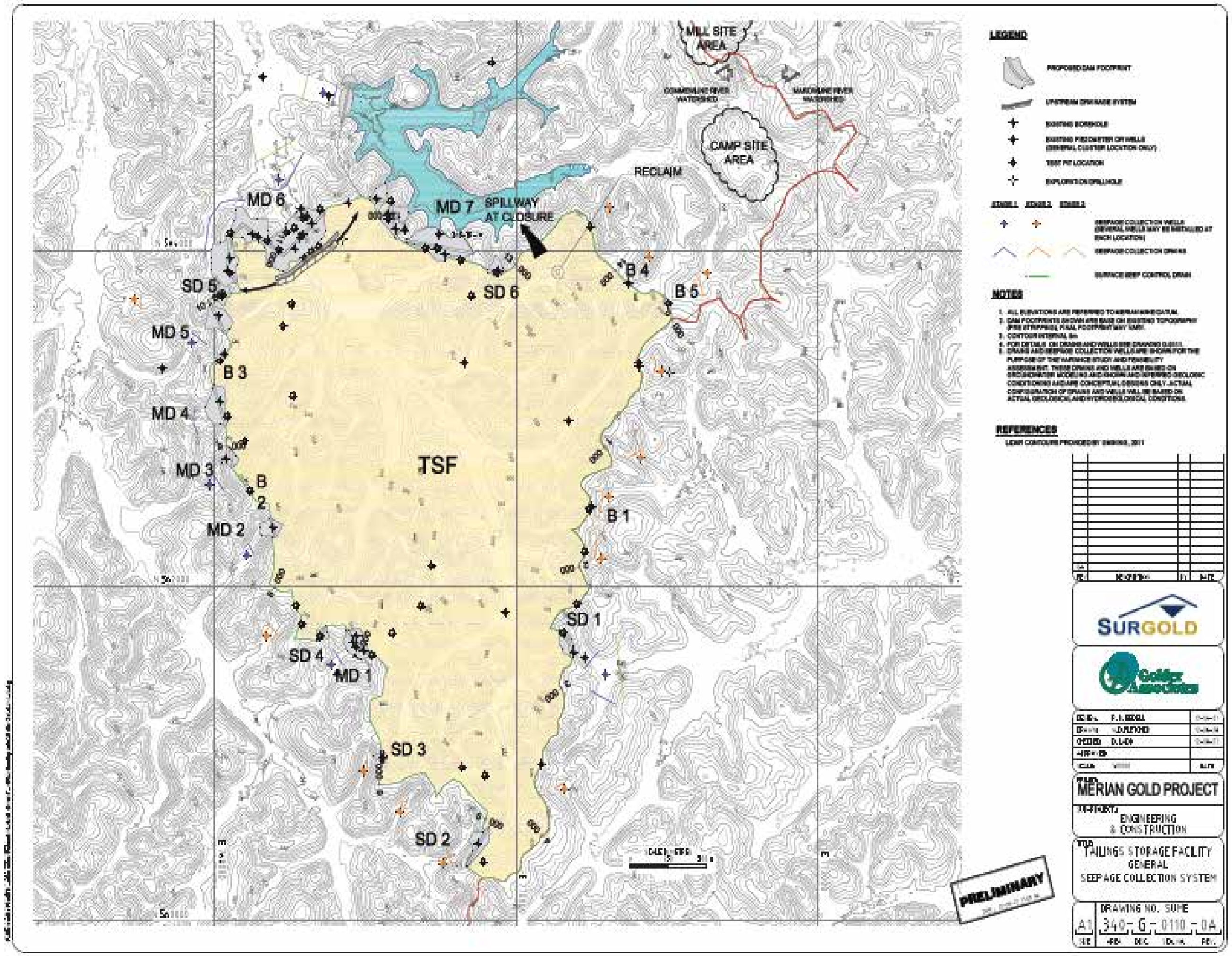
While there is significant occurrence of saprolite in the TSF basin, which serves as a barrier to seepage from the TSF, some seepage is expected to occur both through the saprolite, as well as in isolated quartz vein structures within the saprolite. To effectively manage seepage, the design of the TSF includes both internal drainage and collection systems, and external toe drains and collection wells. These systems will be used to collect seepage so that it can be returned to the TSF and used for process make-up water, or treated by the Water Treatment Plant prior to discharge to the TWSR and then to the environment. The discharged water will meet Project and IFC discharge criteria. Both criteria are summarized in the Project EDC (Appendix 3-B). The internal drainage system will be constructed upstream of the Main Dam, as the characterization and modeling work completed as part of the design process indicates that this area accounts for a significant proportion of the potential seepage.

In general, the designed seepage collection system consists of a simple, multi-staged system that can be readily modified, through adaptive management, as based on the results of the operational monitoring program.

The downstream seepage collection system includes:

- Seepage collection drains
- Seepage collection wells
- Surface seep control drains

The seepage collection components are shown in Figure 3-11:




*Source: Merian Gold Mine Project Feasibility Study, Section 14 (Golder 2012)*

*Figure 3-11 Seepage Collection Systems at the Tailings Storage Facility*

The seepage collection systems shown in Figure 3-11 are located based on groundwater modeling of the TSF at the end of mine operations and other evaluations of groundwater flow. The groundwater modeling indicated that the primary modes of groundwater seepage are: 1) shallow seepage paths through alluvium underlying the main valley floor, 2) relatively rapid seepage through the near-vertical quartz vein systems found within the saprolite, saprock and fractured bedrock, 3) slower seepage paths through saprolite, and 4) slower seepage paths through saprolite and into the underlying saprock and fractured bedrock that functions as a regional underdrain below the TSF. Testing of the attenuation capacity of the saprolite has demonstrated that there is effective retardation and attenuation of metals from the saprolite, though certain constituents, like nitrate, are not effectively attenuated. In general, the seepage collection system is focused on addressing seepage pathway types 1 and 2, as there is less attenuation and more rapid transit in these pathways. To target the primary seepage pathways, the collection system includes:

- Seepage collection drains will capture shallow seepage through the shallower parts of the quartz vein system
- Seepage collection wells will capture seepage through deeper parts of the quartz vein systems and the fractured saprock and fractured bedrock layers

As part of the geotechnical design, the TSF dam keys will be excavated into saprolite, which is effective at cutting off seepage though the shallow alluvium.

Excess water from the TSF will be treated as required by pumping to a Water Treatment facility that will discharge to the Treated Water Storage Reservoir. Excess water from the Treated Water Storage Reservoir will be discharged to the A3 Creek. As indicated earlier, the discharged water will meet Project and IFC effluent discharge criteria as summarized in the Project EDC (Appendix 3-B).

Water quality in the TSF pond will be function of the TSF slurry and natural degradation of cyanide. Cyanide destruction will be implemented at the process plant prior to discharge of the tailings slurry so that the cyanide concentration in the water discharged to the TSF pond meets ICMC criteria. Cyanide concentrations in the pond will further degrade due to natural reactions.

### 3.5.5 *Water Treatment Plant (WTP)*

The Water Treatment Plant (WTP) for excess water from the TSF is the largest treatment plant for mine site discharges. The WTP is designed to treat divalent metals, including copper, and ammonia. The discharges from the WTP will report to the TWSR. Water released from the TWSR will meet the Project's Environmental Design Criteria (Appendix 3-B) for effluent criteria, as well as support compliance with the Project ambient water criteria for protection of human health and the environment at the defined compliance points.

### 3.5.6 *Treated Water Storage Reservoir (TWSR)*

The Treated Water Storage Reservoir (TWSR) will be located in the upper A3 Creek Basin, and will ultimately discharge to the A3 Creek watershed. The TWSR water may serve as make-up water for the mill, if needed.

### 3.5.7 *Fresh Water Supply*

Fresh water for the mine site site is primarily collected from storage of precipitation. For the mill start-up, the initial TSF dams will be constructed early enough that sufficient storage of water is achieved to meet mill start-up needs. Other water required, including for the camp, will be largely met by collection of rainwater. As needed, supplemental water will be supplied by a groundwater well field. Estimated fresh water demand during operation is approximately 72 $m^3$/day. During Pre-Production estimated fresh water demand is expected to double the amount for the Operation Phase. Water will be supplied from a combination of rainwater and groundwater wells. An optional source if needed is surface streams. For collected rainwater, the stored water is treated with ultraviolet (UV) system prior to delivery to the camp. For water from the creeks/surface streams, the water is treated with aluminum sulfate and chlorine. After settling time, the water is treated with the UV system. The water treatment will include removal of iron and manganese, filtration for solids, anion exchange for organic matter, carbon treatment for taste and color, followed by microbial treatment (UV and sodium hypochlorite).

Four boreholes or test wells (GWS-1, GWS-2, GWS-3, and GWS-4) were drilled in June and July 2012, ranging in depths from 62.5 to 89.5 meters below ground surface (m bgs). The purpose of the drilling and testing was to use information from the test wells to identify locations in the vicinity of the Main Camp that had the potential to supply groundwater. Of the four test wells, three (GWS-1, GWS-3, and GWS-4) showed good potential to supply groundwater in quantities suitable for camp needs. GWS-2 would likely not be completed as a groundwater supply well because the water production at this location was relatively low at about 4 to 5 L/min. The currently installed PVC screen and riser assembly at GWS-2 would remain in place for groundwater monitoring purposes. The three production wells would be located within 5 to 10 m of the existing test wells.

Given the potential variability in geology, it is expected that the production wells would demonstrate similar hydraulic properties as the test wells; however, this cannot be confirmed until the well is drilled. The recommended well construction and pump sizing for the three wells is summarized in Table 3-10.

*Table 3-10 Recommended Well Construction and Pump Sizing*

| Well | 7-inch Borehole Depth (m bgs) | PVC Casing Inside Radius (m bgs) | Screened Interval (m bgs) | Filter Pack Interval (m bgs) | ¼-inch Bentonite Chips (m bgs) | Pump Intake Depth (m bgs) | Estimated Pumping Rate (L/min) |
|---|---|---|---|---|---|---|---|
| GWS-1 | 66 | 4 | 44 to 65 | 39 to 66 | 34 to 39 | 43 | 20 to 25 |
| GWS-3 | 86 | 4 | 64 to 85 | 59 to 86 | 54 to 59 | 63 | 10 to 15 |
| GWS-4 | 86 | 4 | 52 to 85 | 47 to 86 | 42 to 47 | 50 | 40 to 50 |

Note: Pumping rate to be confirmed with short step test following completion of each well.
Key:
m bgs = meters below ground surface
L/min = Liters per minute.

### 3.5.8 *Sewage Treatment Plant (STP)*

During Operations, domestic sewage treatment will be provided by a bio-disc reactor and the sludge and effluent discharged to the TSF. The bio-disc reactor will be the same technology used during Pre-Production. The EDC provides the required treatment criteria for the plant. Two permanent or semi-permanent sewage systems are considered during Operations: Mine Camp Sewage Treatment Plant (Mine Site) and the Process Plant Sewage Treatment Plant (Plant Site). The Mine Camp Sewage Treatment Plant will supercede the temporary Construction Camp Sewage Plant used during the Pre-Production Phase. The estimated required capacity for the Mine /Construction Camp Sewage Treatment Plant will be approximately 300 m3of sewage/ grey water daily at maximum occupancy (200 L/day/person), reducing to 160 m3 of sewage/ grey water daily for the operational period after January 2015. The Process Plant Sewage Treatment Plant will supercede the temporary individual portable toilets and multiple mobile toilet trailers with holding tanks used during the Pre-Production Phase. The estimated required capacity for the Process Plant Sewage Treatment Plant will be approximately 60 m3 of sewage/ grey water daily at maximum occupancy (50 L/day/person), reducing to 25 m3 of sewage/grey water daily for the operational period after January 2015.

## 3.6 *TRANSPORTATION CORRIDOR*

As discussed in the introduction to this chapter, most of the Project's supplies will be imported to the Nieuwe Haven Port at Paramaribo or sourced from suppliers in Paramaribo. Supplies will be trucked from Paramaribo to the mine site. It is estimated that 15 – 20 trucks / day will be required to keep the mine supplied in fuel, diesel, reagents, perishables, and other supplies. During construction truck traffic is expected to reach approximately 30 trucks / day. The fuel and diesel trucking will be conducted in caravans while the other supplies will not be organized as they will come from a variety of suppliers. Generally, supplies will leave Paramaribo in the morning and make the return trip in the afternoon to maximize travel during daylight hours. The one-way trip between Paramaribo and the mine site is estimated at 3 hours.

The East-West Highway from Paramaribo to Moengo is currently being upgraded by the Government of Suriname, while the Moengo Road to the Project site is currently being upgraded by Surgold (as described in Section 3.2, Early Works). An existing private 16 km spur road from the Moengo Road to the Merian Project site will be improved as the main access road to site. The route was selected to minimize disturbance by using this previously cleared right-of-way.

During construction and operations certain material may be barged by river to Moengo because of their size (i.e., they may be too large to transport via the Nieuwe Haven bridge, and certain bridges along the East-West Highway) or to improve logistics. Oversize materials would include, but may not be limited to, the main HFO power generators and certain mill components.

## 3.7 *PROJECT PHASES*

### *3.7.1 Pre-Production*

As shown in Table 3-2, Pre-production is scheduled to begin in Q1 2013 and last until December 2014. Pre-Production describes activities required to build the mine infrastructure and start-up the processing plant until it reaches at least 60% of its nameplate capacity. Activities include:

- Recruitment and training;
- Opening of the borrow pits for construction materials;
- Construction of sediment control structures;
- Clearing of the TSF and clearing and grubbing at the Merian II pit site;
- Construction of the main tailings starter dams, earthworks for the airstrip construction;
- Construction of Mine Infrastructure such as roads, stockpiles, ROM pads, etc.
- Preparation of the fuel tank farm;

- Earthworks and surface preparation of the waste management facility and land farm;
- Construction of the main camp including offices and worker accommodations;
- Construction of the process plant and main HFO power plant;
- Import of major pieces of equipment such as mills, excavators, mine trucks, batch plants/crushers/grinders;
- Commissioning and start-up of the process plant; and
- Operation of an interim power plant comprising four high speed diesel generators, each having a prime rating of 910 kWe, for a total installed capacity of 3.64 MWe. These generators will be used for emergency and backup power once the main HFO power plant begins operation.

Pre-Production activities will be done primarily with Surgold equipment but will also utilize contractor equipment when required. As such, much pressure will be placed on the recruitment and training of supervisors, operators and maintenance personnel in order to commence activities in the field as rapidly as possible. It is currently assumed that two months will be required to recruit and train the initial employees to operate and maintain the Surgold equipment, albeit under the direct supervision of seasoned expats.

Access road upgrades and bush clearing will start as soon as the contractors can be mobilized to site which will take approximately two weeks. Once construction earthwork activities commence, the priority will be to complete the north access road to allow transportation of the equipment to site. Simultaneously with the upgrading the access roads, the camp site will be cleared of vegetation and access from the construction camp to the Operations camp will be established. By the third month of construction, a portion of Surgold's mining fleet would have been assembled and ready to work.

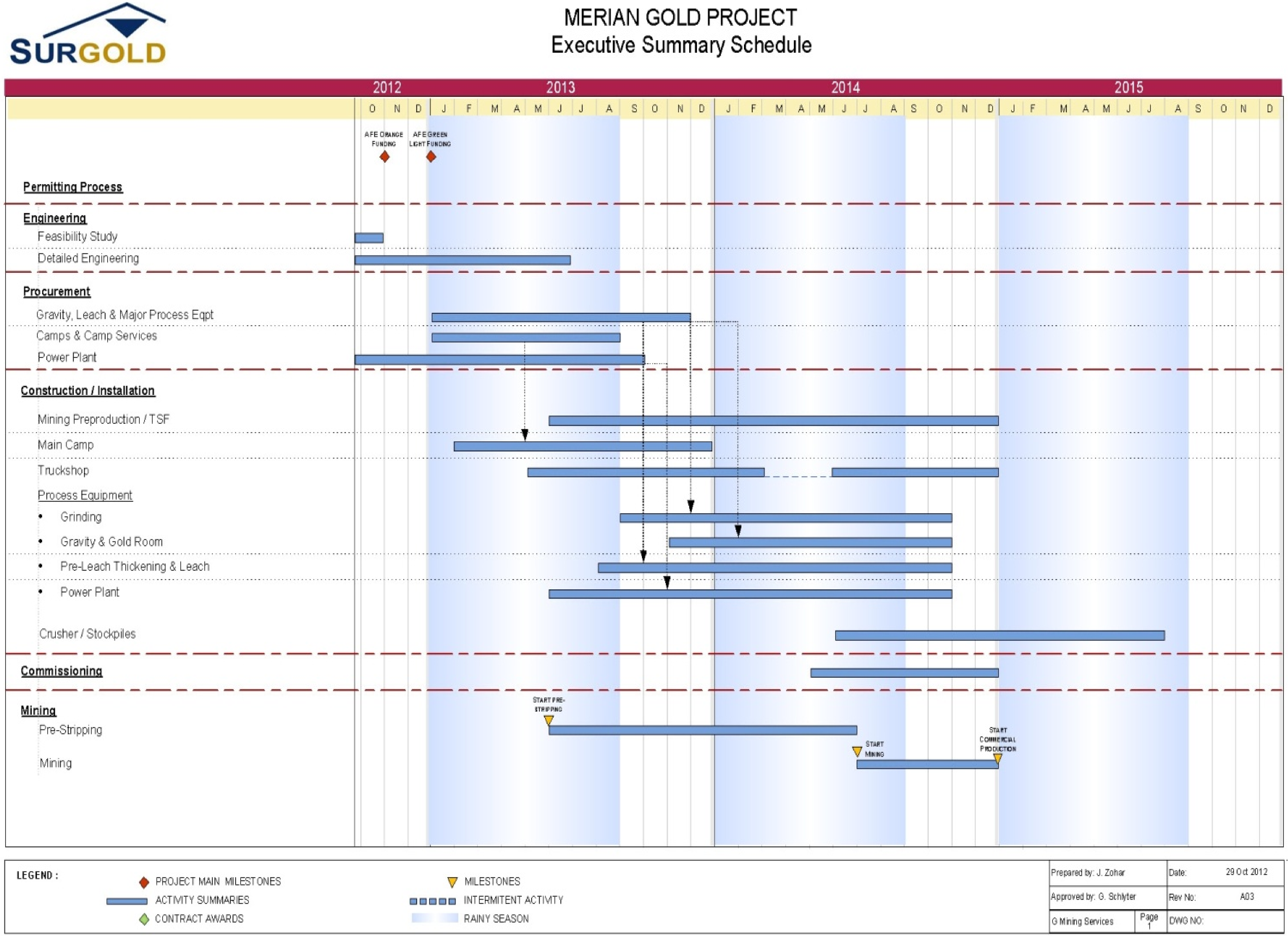
All major cuts will be done with Surgold's main mining fleet (Hitachi EX-3600 BH and CAT 785D Trucks). The smaller fleet will be used for the construction of the temporary sediment ponds downstream of the initial disturbed areas. Part of the smaller fleet will also be working at the camp and mill site pads assisting the construction team with miscellaneous small jobs. The contractors will mainly focus on the access roads working based from a self-sustained camp and clearing and grubbing working from the construction camp.

After the sediment ponds and main pads have been constructed, the focus will shift to establishing roads to the pits where the majority of the waste will be mined to construct haul roads to the TSF. Once the haul roads to the TSF have been completed, waste saprolite can be mined to start constructing the main dams.

All General Services functions will be performed by Surgold Employees. As such, when the project commences, the critical task will be to identify and recruit a Services Manager and departmental superintendents. The General Services departments are generally positions which can be found to a large extent in non-mining environments. As such, administrative, technical and clerical candidates are likely to originate from Paramaribo. Certain General Services departments such as the Camp and Surface support typically do not require skilled labor and are often staffed by individuals from local communities. All General Services departments will have a certain number of expatriate employees. Various General Services departments such as Accounting, Logistics and Human Resources will function out of an office located in Paramaribo. Others will be located on site. During the construction period, a temporary administration building will be located in the Pioneer camp. Once the Administration building is complete, all functions will mobilize to the permanent facilities. Some of the equipment used by the construction team will also be transferred to the General Services departments during the production period.

The construction development schedule leading to commercial production, which excludes the completion of the crusher and the Sewage Treatment Plant, is 26 months, consisting of 2 months initial mobilization of key personnel and equipment and 24 months of on-site construction activities. The completion and commissioning of the crusher and STP will continue for an additional 8 months post commercial production for total project duration of 34 months. Pre-stripping activities is expected to start in mid-2013, but commercial mine production would not start until Q1 of 2015 (Table 3-11).

*Table 3-11 Project Schedule Summary*



### 3.7.2 *Operation*

Operations are considered to begin when the process plant is operating at 60% of the name plate capacity. Operation activities will include:

- Open-pit mining;
- Tailings management;
- Waste rock management;
- Ore processing;
- Operation of accommodations including treatment and delivery of potable water and sewage treatment and domestic waste management;
- Transport of supplies and gold;
- Routine transport of mine employees to and from Paramaribo;
- Waste management;
- Power generation; and
- Progressive reclamation of WRDs.

### 3.7.3 *Closure*

Closure is considered to begin once the process plant is no longer operating. Closure activities will include those required to return the site as much as possible to current conditions with the exception of improvements on the areas currently impacted by ASM. Activities will also be required to ensure public safety related to the TSF and pit areas. A more detailed Conceptual Mine Closure Plan is included in Appendix 3-E.

Closure activities will include:

- Regrading of waste rock disposal area and re-vegetation;
- Pit lake management if necessary;
- Any required site grading to ensure long-term site drainage conditions;
- Stabilization of all slopes through re-grading and re-vegetation;
- Establishment of a long-term water management system at the TSF if necessary; and
- Environmental monitoring.

### *3.7.4 Post-Closure*

Post-closure describes the phase after all closure works are completed and the site can be left in an unmaintained but sustainable state. Activities may include environmental monitoring.

# 4.0 *PROJECT ALTERNATIVES*

The following chapter provides an overview of some of the major project design alternatives that were considered through the course of project planning and the rationale for the selecting the preferred alternatives that are presented in the Project Description (see Chapter 3).

## 4.1 *PLANT LOCATION*

The site selection for the plant site and main accommodation camp is driven by the need to be in close proximity to the ore body. The site selected also lies within the area identified in the application for a right of exploitation.

The location of the plant site is strategic because is between the TSF and the Merian II pit, which is the first pit to be developed and is the largest of the pits. By siting the plant near the pits and TSF, the overall transportation requirements are lessened, which serve to limit greenhouse gas production, the amount of trucks required, and the overall environmental impacts.

An additional advantage of the plant site location is that it is located at a higher elevation than the TSF, which allows for gravity-assisted flow of the tailing; by not requiring pumping, the energy demands of the Project are lowered, which results in less fuel consumption, greenhouse gas emissions, and overall environmental impacts.

## 4.2 *POWER SUPPLY*

A power source of approximately 50 MW is required for the Project. Most of the power generated and supplied in Suriname comes from the Afobaka hydropower station as shown in Figure 4-1. The station was constructed by Suralco under an agreement with the Surinamese government in the 1960s. A large portion of the hydropower output, about 80 - 100 MW of the 189 MW capacity, was effectively granted to the government for use by its distribution utility Energie Berdrijven Suriname (EBS). The power is distributed to the Surinamese at very low prices, such that EBS annually requires subsidies from the government. The total capacity of the national grid meets national demand during regular years but runs the risk of being in an energy deficit during dry years as was the case in 2005. EBS operates Heavy Fuel Oil (HFO) generators in Paramaribo to offset the difference in demand and supply during such times. Generally, these HFO generators are operated infrequently and are only used to supplement the hydro power supply.  Given the situation described above, simply "tying-in" to the national grid is not an option for the Project.

*Figure 4-1 Power Supply Alternatives*

An alternatives risk analysis was conducted that compared four different options:

Option 1. Power supplied from the existing Afobaka hydropower project and conveyed via a 60 km transmission line to the mine. To compensate for the power drawn by the Project, a new thermal power plant located most likely in the surroundings of Paramaribo would need to be constructed. As part of the evaluation process, different potential ownership and operational structures for the constructed facilities were evaluated, including ownership and operations by EBS, Suralco or Surgold. The risks, particularly the environmental and social risks were generally considered equivalent regardless of ownership and operational structure and therefore are presented here as one option. Two variations related to this option are evaluated in the following discussion: construction of a transmission line from Afobaka to the Project supplemented with a Power Purchase Agreement between Surgold and EBS and a power plant constructed by the Project (to offset the Project's energy demands) at Paramaribo and a transmission line from Afobaka.

Option 2. A Surgold power plant built, operated and located at the Mine site with fuel delivered regularly from Paramaribo.

Option 3. A power plant built, operated, and located in Moengo with power conveyed via a 60 km transmission line to the Merian site.

Option 4. A new hydropower project, Grankriki Hydro Project on the Tapanahoni River will be located approximately 45 km south of Merian. The project is currently in a pre-feasibility stage and project sponsors do not anticipate negotiating Power Purchase Agreements until 7 – 10 years from now. Surgold would need to initially build a power plant at the Merian site or source power from Afobaka until Grankriki is operational. The Grankriki project is only anticipated to generate about 15 MW, so it would not meet the full project power demand. The projected costs and the need to ensure back-up supply make this option very expensive for Surgold. Furthermore, there is no guarantee that this project will move ahead to completion. Based on cost and risk, this option was not investigated further.

The alternatives were evaluated based on environmental, economic and construction risks. Environmental risks considered were greenhouse gas emissions, risks related to potential fuel spills on and off-site, impacts to natural habitats, and the necessity to handle operating wastes. Economic criteria were energy costs and their potential volatility, risks associated to interruption of supply chain, operation and maintenance requirements, capital costs, potential for major failure. Construction criteria were potential delays to start-up and health and safety risks.

Each option including sub-options was assessed based on the likelihood and consequences related to each criterion. Definitions of likelihood and consequences are summarized in Tables 4-1 and 4-2. Some assumptions made in developing the risk ratings include:

- Greenhouse gas emissions generated by truck traffic were not considered significant enough to warrant increasing the consequences to Major from Moderate compared to those GHG's generated by a power plant without the trucking activity such as Option 1.
- Potential spills in a river were considered to have graver consequences than a spill during trucking as the contaminant plume moves further more quickly and therefore is considered to have the potential to have more significant adverse effects. Barges are generally compartmentalized and therefore in both the trucking and barging option spill volume would be limited to the volume of the ruptured container.
- Impacts to habitat by trucking were considered minor as the majority of the transportation corridor is already in place and therefore little increase in habitat degradation is anticipated.
- Supply chain was considered to be at risk either through strikes or the interruption of the provision of HFO from the supplier or water availability. The options in which there were alternatives available were considered to have lower consequences than those options where few options were available.

Options 2 and 3 were further developed into sub-options to outline different transportation options to get fuel to either Merian or Moengo as described in Table 4-1.

*Table 4-1 Definitions of Likelihood Ratings Used to Evaluate Power Alternatives*

| Likelihood | Estimated Probability | Rating |
|---|---|---|
| Almost Certain | ≥90% | 0.9 |
| Likely | ≥50% | 0.5 |
| Possible | ≥ 20% | 0.2 |
| Unlikely | ≥ 5% | 0.05 |
| Rare | ≤ 5% | 0.02 |

*Table 4-2 Definitions of Severity of Consequences Ratings Used to Evaluate Power Alternatives*

| | | Definitions | | |
|---|---|---|---|---|
| **Severity** | **Rating** | **Environmental** | **Economic** | **Construction** |
| **Insignificant** | 0.25 | No or negligible environmental impacts; un-measureable and unobservable | < 1 million dollars<br><2% production | Days of start up delay |
| **Minor** | 1 | Affects environmental conditions, species, and habitats over a short period of time, is localized and reversible | > $1 million<br>> 2% production | 1 week start up delay |
| **Moderate** | 5 | Affects environmental conditions, species and habitats in the short to medium term. Ecosystems integrity will not be adversely affected in the long term, but the effect is likely to be significant in the short or medium term to some species or receptors. The area/region may be able to recover through natural regeneration and restoration | > $5 million<br>> 5% production | 2 weeks start up delay |
| **Major** | 10 | Affects environmental conditions, species and habitats for the long term, may substantially alter the local and regional ecosystem and natural resources, and may affect sustainability. Regeneration to its former state would not occur without intervention. | > $10 million<br>> 10% production | 1 month start up delay |
| **Severe** | 20 | Irreversible, regional negative impacts on environment or human health | | 2 months start up delay |

*Table 4-3 Summary of Power Alternatives Evaluation*

| Option | Description | Environmental: Emission of GHGs | Environmental: Potnetial spills in non-confined areas on-site | Environmental: potential spills in unconfied areas off-site | Environmental: Impacts on natural habitats | Economical: Disturbances to Supply Chain | Economical: Energy Inavailability due to O&M | Economical: Major Failure | Economical: Capital Costs Overruns | Construction: Permit Requirements with long lead times | Construction: Delays in Start Up | Construction: Health and Safety Risk | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Option 1**:Construction of a powerline from Afobaka with a PPA with EBS | | Almost Certain | Rare | Rare | Unlikely | Unlikely | Unlikely | Unlikely | Unlikely | Almost Certain | Unlikely | Unlikely | 25.81 |
| | | Moderate | Insignificant | Insignificant | Moderate | Moderate | Moderate | Severe | Minor | Severe | Major | Severe | |
| **Option 1a**: Construction of a Power Plant at Paramaribo by Surgold and transmission line from Afobaka to Merian | Power plant with generators that meet Merian's power demand | Almost Certain | Rare | Rare | Unlikely | Unlikely | Rare | Unlikely | Possible | Almost Certain | Unlikely | Unlikely | 26.53 |
| | | Moderate | Insignificant | Insignificant | Moderate | Moderate | Minor | Severe | Moderate | Severe | Major | Severe | |
| | Power Plant with N generators that exceed Merian's powers demand | Almost Certain | Rare | Rare | Unlikely | Unlikely | Rare | Unlikely | Possible | Almost Certain | Unlikely | Unlikely | 26.53 |
| | | Moderate | Insignificant | Insignificant | Moderate | Moderate | Minor | Severe | Moderate | Severe | Major | Severe | |
| **Option 2**: Construction of a Power Plant on-site | a. Trucking fuel from Paramaribo with a Surgold truck fleet | Almost Certain | Rare | Rare | Unlikely | Unlikely | Rare | Rare | Unlikely | Rare | Unlikely | Rare | 5.75 |
| | | Moderate | Insignificant | Minor | Minor | Minor | Minor | Severe | Minor | Insignificant | Moderate | Severe | |
| | b. Trucking fuel from Paramaribo via contractor | Almost Certain | Rare | Rare | Unlikely | Unlikely | Rare | Rare | Unlikely | Rare | Unlikely | Rare | 5.75 |
| | | Moderate | Insignificant | Minor | Minor | Minor | Minor | Severe | Minor | Insignificant | Moderate | Severe | |
| | c. Barging fuel from Paramaribo to Moengo and transportation of fuel by a Surgold truck fleet to site | Almost Certain | Rare | Rare | Unlikely | Unlikely | Rare | Rare | Unlikely | Unlikely | Unlikely | Rare | 5.995 |
| | | Moderate | Insignificant | Minor | Minor | Minor | Minor | Severe | Minor | Moderate | Moderate | Severe | |
| | d. Barging fuel from Paramaribo to Moengo and transportation of fuel by a contractor | Almost Certain | Rare | Rare | Unlikely | Unlikely | Rare | Rare | Unlikely | Unlikely | Unlikely | Rare | 6.075 |
| | | Moderate | Insignificant | Moderate | Minor | Minor | Minor | Severe | Minor | Moderate | Moderate | Severe | |
| | e. Barging fuel from Paramaribo to Moengo and transportation of fuel via pipeline to site | Almost Certain | Rare | Rare | Unlikely | Unlikely | Rare | Rare | Possible | Likely | Unlikely | Rare | 17.875 |
| | | Moderate | Insignificant | Major | Minor | Minor | Minor | Severe | Major | Severe | Moderate | Severe | |
| **Option 3**: Construction of a Power Plant in Moengo and transmission line to Merian | a. Trucking fuel from Paramaribo by Surgold truck fleet | Almost Certain | Rare | Rare | Rare | Rare | Rare | Unlikely | Possible | Almost Certain | Unlikely | Unlikely | 26.085 |
| | | Moderate | Insignificant | Minor | Minor | Minor | Minor | Severe | Moderate | Severe | Major | Severe | |
| | b. Trucking fuel from Paramairbo via contractor | Almost Certain | Rare | Rare | Rare | Rare | Rare | Unlikely | Possible | Almost Certain | Unlikely | Unlikely | 26.085 |
| | | Moderate | Insignificant | Minor | Minor | Minor | Minor | Severe | Moderate | Severe | Major | Severe | |
| | c. Barging fuel from Paramaribo to Moengo | Almost Certain | Rare | Rare | Rare | Rare | Rare | Unlikely | Possible | Almost Certain | Unlikely | Unlikely | 26.165 |
| | | Moderate | Insignificant | Moderate | Minor | Minor | Minor | Severe | Moderate | Severe | Major | Severe | |

As can be seen be an inspection of Table 4-3, the lowest scoring options, and therefore the one that would pose the least risk to the Project is the option related to a power plant located on site with a supply of HFO trucked in from Paramaribo.

## 4.3 *SITE ACCESS*

Three routes were considered for construction of the access road from the Moengo-Langa Tabiki Road to the Project Figure 4-2:

Option 1. Existing Access Road: the existing access road runs from the Moengo Road to the mine site accessing the site from the south-west. The road is a wide, unpaved, well-maintained road. The road presents a number of sharp grades and tight turns as it travels through varied terrain.

Option 2. North Access Road Route 1: this potential route has a total length of 9 km after the turn-off from the Moengo Road to site. It was identified as a shorter and safer route to access the mine site from the Moengo-Langa Tabiki Road. No road exists on this route currently.

Option 3. North Access Road Route 2: a rough road with a length of approximately 13 km after the turn-off from the Moengo Road to site. It has been built by a third-party who has been awarded commercial logging rights to an area that includes part of the Right of Exploitation application area. The route follows a ridgeline. To use this road, the existing track would require additional clearing and upgrading.

The options were evaluated based a set of desired goals and a ranking system to identify which option met the most goals the most closely. The goals for the road design are summarized in Table 4-4.

*Figure 4-2 Access Road and Airstrip Alternatives*

*Table 4-4 Criteria and Goals used in the analysis of Access Road Alternatives Evaluation*

| Factor | Criteria | Goal | Rationale |
|---|---|---|---|
| Worker Health and Safety | Safety considerations in road design | Select the route that will present the safest possible design. | Safety considerations in road design include grade, line of sight, and turning radius. These are often influenced by the existing terrain. |
| Environment | Number of stream crossings | Limit the number of stream crossings required by the road. | Road crossings introduce the potential for degradation of aquatic habitat during construction and risks to spills or pollution during operations. Crossings that already exist or those that will cross streams that are already disturbed are preferred over crossings of pristine streams. |
| Environment | Total cleared area | Limit the amount of area required for clearing. | Clearing is considered a direct impact on potential ecological habitat. Clearing in already disturbed areas is generally preferred as this habitat is already impacted. |
| Environment | Potential for habitat fragmentation | Limit the potential to fragment large areas of habitat into smaller, less sustainable areas. | Roads or other linear corridors have the potential to reduce the size of habitats and restrict the movement of populations. |
| Economics | Length | Limit the length of the access road. | There are costs associated with clearing, grading, and capping roads as well as maintenance. These increase on a per kilometer basis as do costs related to fuel consumption of trucks moving on and off site, and the accompanying production of emissions and greenhouse gases. |
| Economics | Number of Bridges | Limit the number of bridges required. | Bridges have significant costs associated with construction. |

Each of the three options were ranked from that closest to achieving each desired goal to the option less likely to achieve the goals presented in the above table.

The option most likely to achieve the desired goal was awarded the most points (3) and the option least likely to achieve the desired goal awarded the least points. The highest score is 3 (because there are three options) and the lowest score 1. In the case where the difference between two options was considered negligible, both options were awarded the same score. The option with the highest total score was considered the preferred option, based on the criteria and goals established in Table 4-4.

Option 3 – North Access Road Route 2 was selected as the preferred route. The alternatives analysis is summarized in Table 4-5. The following summarizes considerations that were included in the alternatives analysis:

- Health and Safety: Option 1, the existing route, includes a number of steep grades and tight turns which increase potential for traffic accidents. Both North Access routes follow less rugged terrain and present comparable health and safety risks. Therefore, Option 1 was awarded the least points (1) and the two North Access routes were considered to be equal and safer than Option 1 and therefore awarded 2 points each.
- Stream Crossings: The number of stream crossings from the northern most turn-off from the Moengo-Langa Tabiki Road for each Option were compared. The existing access road includes the most stream crossings including crossing of Merian Creek. Option 2 requires fewer stream crossings and Option 3 does not require any creek crossings.
- Cleared Area: The existing route is considered the option that requires the least amount of clearing as the road currently exists and is wide enough that further improvements are limited. Clearing of the right of way on either side of the road could be required to improve visibility. Option 2 would require the most clearing as there is nothing existing along that route to date. Option 3, although some clearing has been completed would require that the existing track be widened and therefore some clearing would be required.
- Habitat Fragmentation: The existing access route, Option 1, is considered the option to contribute least to the potential for habitat fragmentation as it has been in place for a number of years and therefore is awarded the highest score. Both North Access routes increase the potential for habitat fragmentation as they both create an isolated area of habitat bordered by the Moengo Road, the existing access road and a North Access Road. Option 3 is marginally preferred over Option 2 as a rough road already exists here. If Option 2 were selected and Option 3 remains in use for any reason this habitat area would be further fragmented.
- Bridges: The existing access road crosses Merian Creek. The existing bridge is a small wooden bridge which would need to be substantially improved to accommodate heavy trucks and traffic that any of the access roads will experience. Neither of the other two options

requires any bridge crossings. Therefore, Option 1 is awarded the least points (1) and the other two options are awarded equal points.

*Table 4-5* *Summary of Alternatives Evaluation for Access Road*

| Alternative | Health and Safety | Stream Crossings | Cleared Area | Habitat Fragment-ation | Length | Bridges | Score |
|---|---|---|---|---|---|---|---|
| Option 1 – Base Case | 1 | 1 | 3 | 3 | 1 | 1 | **10** |
| Option 2 – North Access Road Route 1 | 2 | 2 | 1 | 2 | 2 | 2 | **11** |
| Option 3 – North Access Road Route 2 | 2 | 3 | 2 | 1 | 3 | 2 | **13** |

## 4.4 *WORKER ACCOMMODATIONS*

The Project workforce will come from local communities, Moengo and Paramaribo, with only a limited number of expatriate workers for specialty skills that cannot be found locally. The worker accommodation alternatives considered were:

- Staff Village located in Moengo for expatriate workers. All other workers to live in surrounding communities and commute to site each day via a Project bus or other private forms of transportation; and
- An on-site full-service accommodation camp including private accommodations, a full mess-hall style kitchen, recreational facilities, laundry and showers and other amenities.

The two alternatives were considered based on an 8 or a 12-hour shift and the resulting four options were evaluated based on a similar goal and ranking system as applied to the Access Road alternatives analysis. The criteria used to evaluate these alternatives are described in Table 4-6.

*Table 4-6 Criteria and Goals used in the analysis of Worker Housing alternatives evaluation*

| Factor | Criteria | Goal | Rationale |
|---|---|---|---|
| Community Health and Safety | Traffic volume on the Moego – Langa-Tabiki road | Limit the increase to traffic volumes on the Moengo-Langa Tibiki. | It is assumed that less traffic on the Langa Tibiki road will result in fewer accidents so therefore the option that results in the least traffic on the road would be considered the safest option. |
| Worker Health and Safety | Length of work day and Commute time | Achieve a reasonable work-day length that is safe for workers. | The length of the work day should include any commuting time and related health and safety considerations such as driving after a long shift for an extended period of time. |
| Social | Influx | Limit the potential for influx to local communities including Moengo | Influx can put strain on community resources and infrastructure and could require active management by Surgold. Options that would limit influx are preferred to those that could result in the influx. |
| Social | Time away from home | Limit extended periods of time away from home for national workers | Time away from home was been identified through consultation to be an important factor for communities. |
| Economics | Cost of Housing | Limit the cost required for housing and infrastructure required while achieving a standard of accommodations that meets international standards. | Costs associated with housing the workforce will obviously affect the Project's overall economics. |
| Economic | Operational Efficiency | Maximize efficiency of operations | |

The four options were ranked based on which option would most likely meet each desired goal. Similar to the methodology used in ranking access routes, the option considered that most likely to achieve the desired goals was awarded the most points with 4 points being the highest score and 1 point the lowest. The option with the highest total score was considered the preferred option. Based on the criteria and goals established in Table4-7 Option 4, on-site accommodations was selected as the preferred route. The alternatives analysis is summarized in Table 4-7.

*Table 4-7 Summary of Alternatives Evaluation for Worker Housing*

| Alternative | Community Health and Safety | Worker Health and Safety | Influx | Time Away from Home | Housing Costs | Operational Efficiency | Score |
|---|---|---|---|---|---|---|---|
| Option 1 off-site 8 hour shift | 1 | 2 | 1 | 3 | 1 | 1 | 9 |
| Option 2 off-site 12-hour shift | 2 | 1 | 2 | 2 | 2 | 2 | 11 |
| Option 3 on-site 8-hour shift | 3 | 4 | 3 | 1 | 1 | 3 | 15 |
| Option 4 on-site 12-hour shift | 4 | 3 | 3 | 1 | 2 | 4 | 17 |

The following summarizes the rationale for the ranking shown in Table 4-7:

- Community Health and Safety: Considerations around community health and safety focused on potential increases to traffic on the Moengo Road. Eight-hour shifts with accommodation off-site was considered to generate the most traffic as three shifts are required to complete a 24-hour work period as opposed to two 12-hour shifts and off-site accommodations are assumed to generate more traffic on a daily basis as all workers would travel to and from the site daily. Therefore, off-site accommodations were considered less safe with a 12-hour shift being safer than a 8-hour shift as these would generate less traffic.

- Worker Health and Safety: on-site accommodations were generally considered to provide a higher degree of health and safety as workers are not required to drive any distance after a full day of work. Eight-hour shifts were considered safer than 12-hour shifts as fatigue was considered less of a risk.

- Influx: off-site accommodations was considered likely to potentially result in greater influx specifically to the Moengo area as this is the largest community within driving distance of the site. While it is possible that the on-site accommodations may also generate influx to the Moengo area, the Project will provide transportation to workers to Paramaribo to mitigate this potential impact. An 8-hour shift was considered to have a higher potential to create influx as three shifts are required per day compared to two shifts and therefore it is assumed more workers are required.

- Time away from home: off-site accommodations were considered to result in less time away from home for workers than on-site accommodations, however this may be based on perception as a shift rotation in which a worker is at home for a full week without working could be considered to actually result in more time at home.
- Housing Costs: The difference between the two options: on or off-site accommodations when it comes to housing costs was considered negligible because it is anticipated that in the case of an off-site option there would be an expectation that the Project supply additional housing as housing demands increased due to influx. Eight-hour shifts were considered to result in higher cost because it was assumed more workers would be required than in the 12-hour shift scenario and therefore more housing would be required.
- Operational efficiency: 12-hour shifts were considered to result in a higher efficiency than 8-hour shifts, as there is less time lost to crew changes and breaks. Each crew change requires a ramp down of productivity as one crew leaves and a ramp up of productivity as the other crew comes on to the shift.

As shown in Table 4-7, the preferred option is Option 4 on-site accommodation with a 12-hour shift. To off-set the time away from home, which is this option's weakest criterion, the Project is proposing to adopt a 7 days on - 7 days off shift rotation. This rotation is becoming the norm in Suriname and approaches a balance between operational efficiency and time away from the home and community.

## 4.5 *AIRSTRIP*

The Project includes the need for an airstrip. The airstrip will be used for transport of workers, export of gold and for medical emergencies. The alternative locations for an airstrip that were considered are shown in Figure 4-2 and are:

Option 1. Near the Plant Site;

Option 2. Within the Project Area in the "White Sands" area in the Tomolu Creek drainage;

Option 3. Moengo; and

Option 4. Langa Tabiki.

Options 3 and 4 were eliminated early in decision process as they were both considered too far from the site to adequately provide emergency services and transport and because the distance to either location was considered too great to properly secure for the shipment of gold. Siting of an airstrip requires consideration of, but not limited to:

- Visibility during approach,

- Alignment of the strip with prevailing winds, and
- Access and security.

Both remaining options were considered to meet the basic siting requirements. The location closest to the plant site was selected based on the following. The preferred location:

- Requires less clearing as much of the area will be disturbed for construction of the mine components;
- Located closer to main mining components such as process plant, pits and waste rock disposal areas and is therefore more accessible in the case of an emergency;
- Requires a shorter access road which reduces overall costs both related to construction and maintenance; and
- The White Sands location also has a high risk of flooding and becoming inaccessible.

## 4.6 *TAILINGS STORAGE FACILITY*

The location of the Tailings Storage Facility was selected to optimize energy efficiency and minimize footprint. A location with sufficient capacity down-gradient from the process plant is desired as this minimizes pumping requirements, fuel consumption and greenhouse gas emissions. The optimal way to gain storage capacity given the terrain of the Project Area is to use an existing basin and natural contours where possible. Doing so reduces the amount of dams, berms and other structures required to retain the tailings and confine the footprint of the storage facility. The alternative to using an existing storage basin is to build a ring dam to retain the tailings. However, given the terrain at the site potential locations for such a facility are small and would provide limited capacity. Based on these requirements the current location of the TSF presented itself as the evident preferred location.

# 5.0 *PROJECT LOCATION AND SETTING*

This chapter describes the land use and ownership within the Environmental and Social Study Areas and provides a discussion of regional and site-specific climate, geology and topography, and natural hazard conditions.

## 5.1 *LAND USE AND OWNERSHIP*

Figure 5-1 shows land use and concessions within and beyond the Environmental Study Area, including nearby settlements. Surgold holds a Right of Exploration in the area and has filed an application for a Right of Exploitation for the Mine Site and surrounding area, referred to as the Project Area. The area identified in the Right of Exploitation application is approximately 17,000 ha. The Project Area and surroundings are largely forested, though as discussed later, there are significant existing disturbances due to Artisanal and Small scale Mining (ASM). Timber concessions overlap much of the northern portion of the mining concession.

Land in and around the Project Area is designated by the Government of Suriname as Domain Land, which is owned by the Suriname government. Although local residents have no legal title of land within the Project Area (besides timber concessions), traditional land tenure systems identify all of the forest as a communal resource. The general area is currently used on an ad hoc basis for collection of Non-Timber Forest Products (NTFPs) and for hunting activities. Section 14.3.8 (Marowijne Area Livelihoods and Socio-economics) contains further details of the formal and informal land tenure system.

ASM occurs extensively in the southern and central portion of the Project Area and to the South and along the Marjowijne River. This small-scale mining is based on the traditional land tenure system and no legally-designated or registered small scale concessions occur within the exploitation concession. Much of the ASM activity has historically involved alluvial extraction of auriferous soil throughout the network of creeks in the area, though some rudimentary pits have also been established. Section 14.3.9 (ASM) contains further details surrounding ASM livelihoods.

*Figure 5-1 Land Use and Concessions*

## 5.2 *CLIMATE*

### *5.2.1 Regional Climate*

Suriname is an area where both northeast and southeast trade winds may occur. Trade winds are very steady winds that usually blow from the same direction and with the same force every day. Where they converge in the "equatorial trough," they cause an uplifting of the air, which causes clouds to condense and rain to fall if sufficient moisture is available. The equatorial trough, which is influenced by variations in the general circulation of the air, is the most decisive factor in creating the climate of Suriname (SPS, 1988).

In general, Suriname has a tropical climate influenced by year-round trade winds from the northeast with four distinct seasons:

- Short rainy season: mid-December to mid-February;
- Short dry season: mid-February to mid-April;
- Long wet season: mid-April to mid-August; and
- Long dry season: mid-August to mid-December.

The long-term, annual mean rainfall in Suriname (1971 – 1980) varies between approximately 1,450 mm at low-lying areas such as Coronie to 3,000 mm in the mountainous regions such as Tafelberg. For the Sipaliwini District where the Project Site is located, the annual mean rainfall is approximately 2,060 mm, although the on-site meterological station shows a slightly lower amount (see Table 5-1).

The monthly rainfall shows a seasonal cycle, which is caused by the meridional movement of the Inter-tropical Convergence Zone. The higher rainfall in certain parts of the interior results when moist winds are forced up over the mountain slopes to higher, colder altitudes where the water condenses (orographic rains). In Suriname, the monthly rainfall is typically highest in May-June and lowest in September-October. Sibibusi (heavy thunderstorms) normally occur in July and August, but can also occur between September and November. Maximum daily rainfall may rise as high as 100 to 200 mm once every 2 to 3 years (SPS, 1988).

Mean air temperature is 26.2- 28.2° C with January being the coldest month and September and October being the warmest months. The mean wind force or wind speed is 1.3 meters per second (m/s), with a maximum of 1.6 m/s in February and March and a secondary peak of 1.4 m/s in September and October. The minimum wind speed of 1.0 m/s usually occurs in June. Depending on the position of the equatorial trough, the most frequent wind directions vary between east-northeast and east-southeast (SPS, 1988). The relative humidity is high to very high (80 to 90%). The occurrence of hurricanes in Suriname is very rare.

### 5.2.2 *Project Site Climate*

Meteorological data (rainfall, temperature, relative humidity, and wind speed) have been collected at a weather station (Merian Station) installed within the Project Site in December 2005. Table 5-1 presents the annual average rainfall, temperature, relative humidity, and wind speed data for the Merian Station. Figure 5-2 through 5-5 display monthly averages of the meteorological data collected at the station.

*Table 5-1 Annual Average Accumulated Rainfall, Temperature, Relative Humidity, and Wind Speed Data at the Merian Station (December 2005 – December 2011)*

| Station | Annual Average Accumulated Rainfall (mm) | Annual Average Temperature (˚C) | Annual Average Relative Humidity (%) | Annual Average Wind Speed (m/s) |
|---|---|---|---|---|
| Merian | 1,733 | 26.3 | 84.8 | 0.80 |

Key:
mm = millimeters
m/s = meters per second

### 5.2.3 *Rainfall*

Based on the 6 years of rainfall data obtained from the Merian Station, the wettest months are June (210 mm) and December (224 mm) and the driest months are September (60.7 mm) and October (67.7 mm). Rainfall totals for the months of January, May, and July were relatively high (178-193 mm). The maximum daily rainfall (112 mm) was recorded on Friday, 3 July, 2009. Annual mean rainfall recorded during the 6 year monitoring period was 1,733 mm. This annual mean rainfall value is slightly lower than the regional annual rainfall values for Suriname (Section 5.3.2). Figure 5-2 shows the total monthly cumulative precipitation and accumulation for the Project from December 2005 to December 2011.

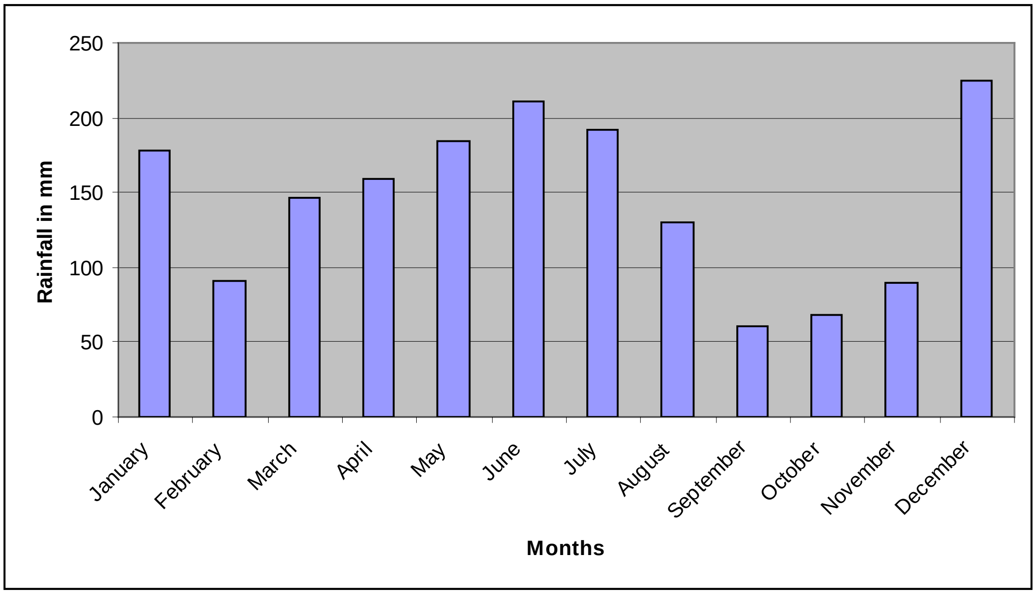



*Figure 5-2* *Average Total Monthly Precipitation – Merian Site Precipitation Gauge December 2005 – December 2011*

An analysis of regional data and Project data was completed to establish long-term estimates for the Project Area (details are presented in Chapter 9, Water Resources Baseline and associated appendices). Data was used from long-term stations at Paramaribo and elsewhere and compared to the site data. A weighting factor for location and time period were established and the long-term estimates of average monthly precipitation are presented in Figure 5-3. Total average long-term annual precipitation for the site based on this analysis is 2382 mm.

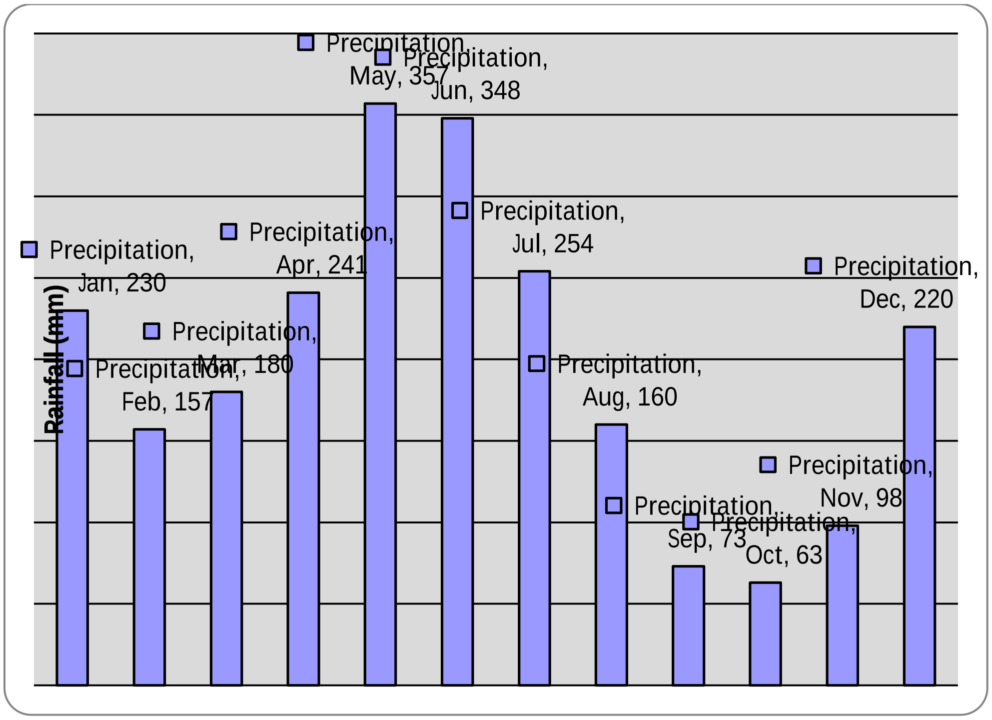



*Figure 5-3 Long-Term Average Monthly Precipitation Estimates for Merian Gold Project*

### *5.2.4 Temperature*

Figure 5-4 shows that temperature values at the Project Site do not vary much throughout the year. Average monthly temperature values recorded at the station range from 25.3° C (February) to 27.2°C (September). These values are within the range of regional annual temperature values for Suriname (Section 5.2.1).

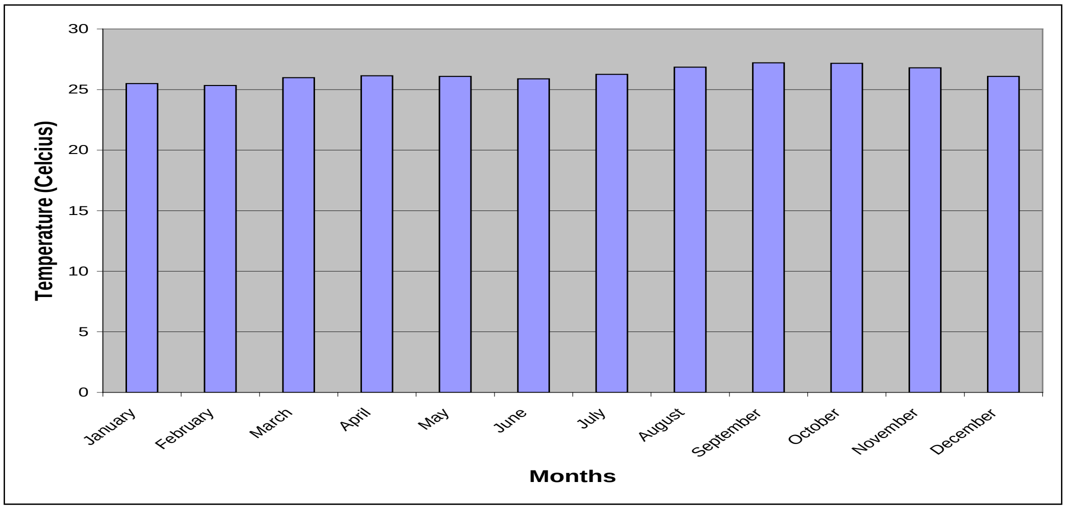



*Figure 5-4* *Monthly Summary of Temperature Values at the Merian Station (December 2005 to December 2011)*

*Relative Humidity*

Figure 5-5 shows that relative humidity values at the Project Site are lowest in October (80.2%) during the dry season and highest in May (89.0%) during the wet season. These values are within the range of regional annual relative humidity values for Suriname (Section 5.2.1).

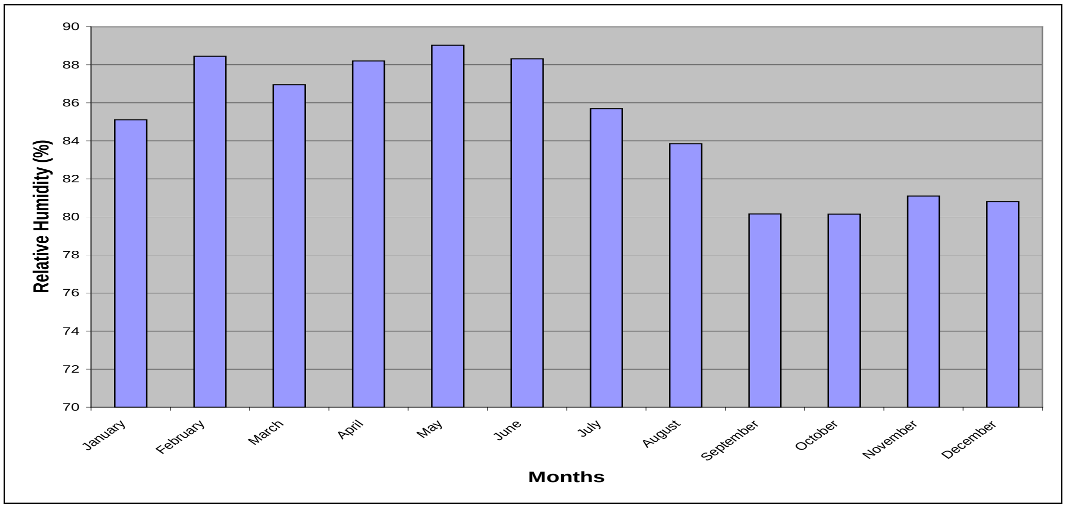



*Figure 5-5* *Monthly Summary of Average Relative Humidity at the Merian Station (December 2005 to December 2011)*

*Wind Speed and Direction*

Figure 5-6 shows that wind speed values at the Project Site are generally low (< 1 m/s). The windiest months at the Project Site are September (0.92 m/s) and October (0.94 m/s). Average wind speeds were lowest in March (0.66 m/s). These values are slightly lower than the regional annual wind speed values for Suriname (Section 5.2.1). Wind directions from the Project Site are primarily from the east and east-southeast, which is similar to the regional wind directions in

Suriname (Section 5.2.1). Figure 5-7 displays a wind rose summary of the data obtained from the Merian Station from December 2005 to December 2011.

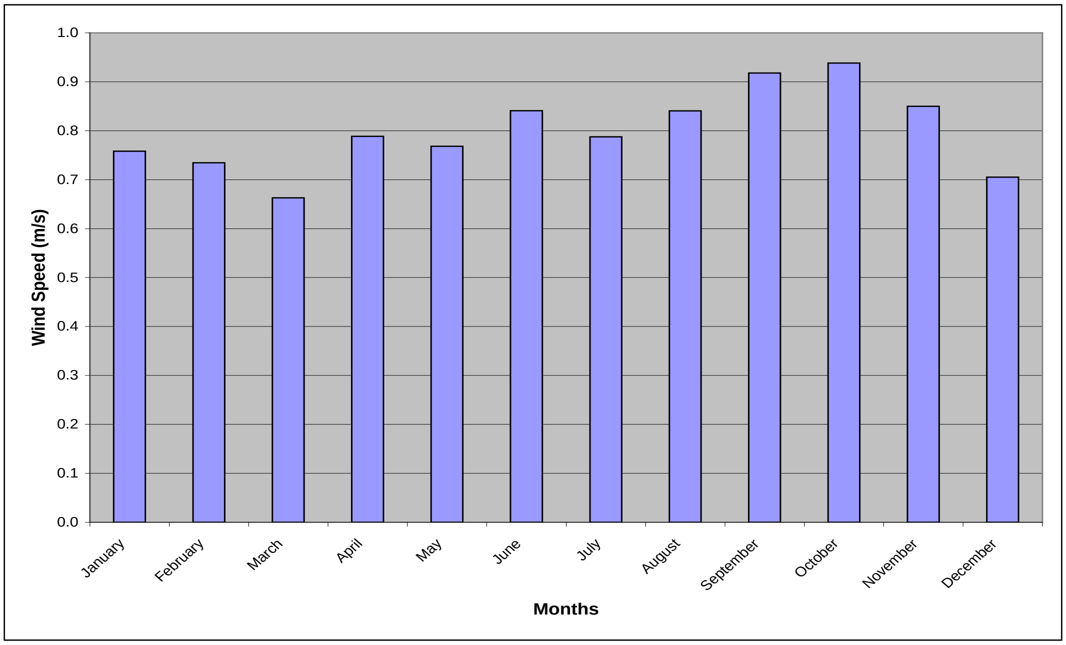



*Figure 5-6 Monthly Summary of Average Wind Speed at the Merian Station (December 2005 to December 2011)*

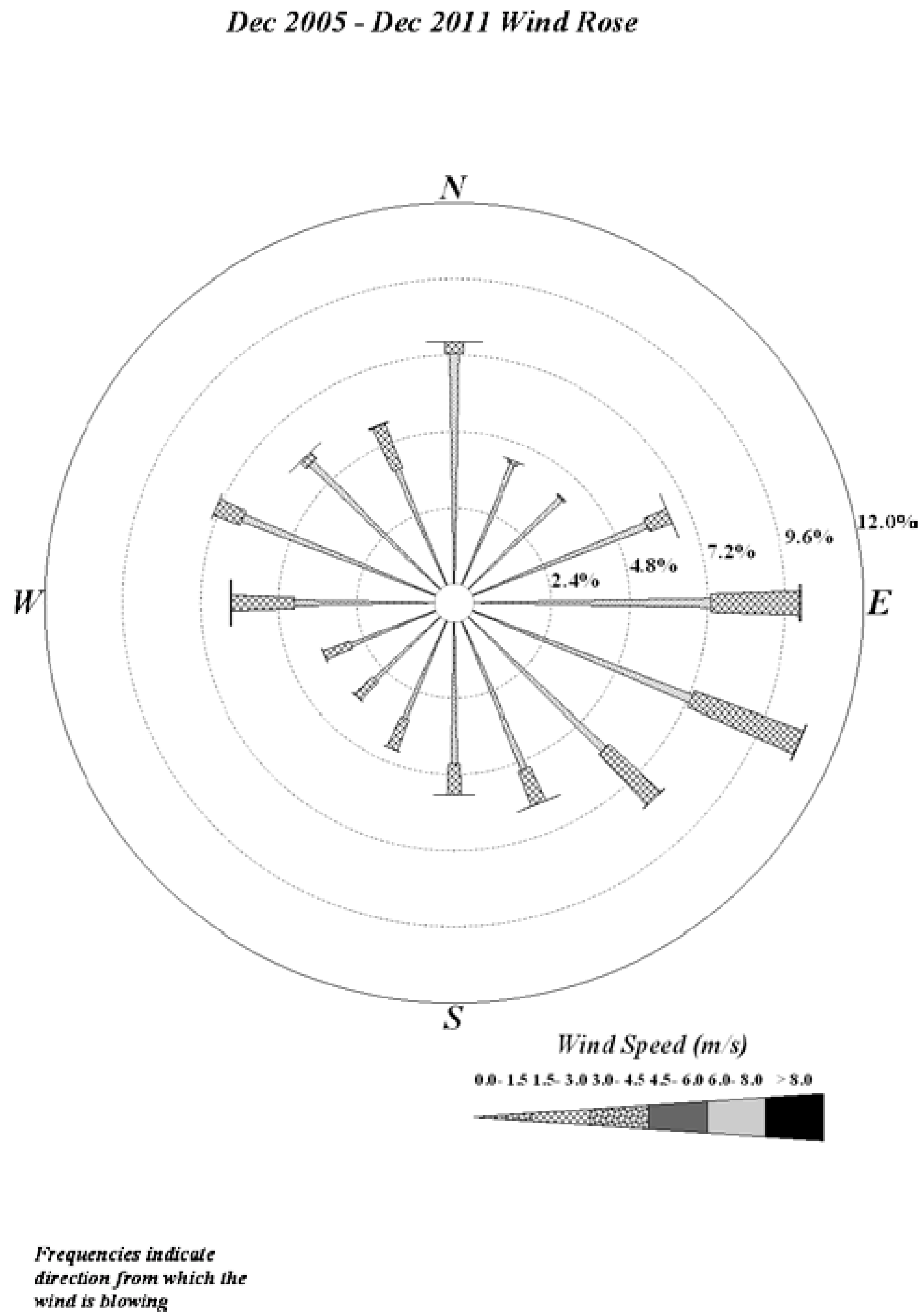



*Figure 5-7 Wind Rose for the Merian Station (December 2005 to December 2011)*

## 5.3 GEOLOGY AND TOPOGRAPHY

### *5.3.1 Regional Geology and Topography*

The physical geography of Suriname is divided into three areas: the Coastal Plain, the Savannah Belt, and the Guiana Shield. The Guiana Shield comprises approximately 80 to 85% of the total land area of Suriname, and extends into French Guiana to the east, Brazil to the south, and Guyana, Columbia and

Venezuela to the west (Figure 5-8). The proposed Project is located within the Guiana Shield.

The Guiana Shield is comprised of distinct, east-west trending belts of low-grade metamorphic rocks that are separated by large areas of granitic rocks and gneisses. The crystalline basement of the Guiana Shield was formed during the Trans-Amazonian Orogenic Cycle approximately 1.8 to 2 billion years ago. The remaining northern portion of Suriname is dominated by rocks of the Marowijne Supergroup, which is comprised of the Rosebel Formation and the underlying Armina Formation. Figure 5-9 provides an overview of regional geology in Suriname.

The Guiana Shield is a mixture of Precambrian granites, gneisses, metasediments, and metavolcanics situated between the Orinoco and Amazon River basins, to the north and south, respectively. The Guiana Shield is comprised of three major tectono-stratigraphic units:

- The intensely-deformed Archean high-grade granite-gneiss complex (Imataca Complex) (3.2 - 2.8 giga-years [Ga]) in the extreme north of the Shield in Venezuela;
- The clastic, volcanic, volcaniclastics and plutonic rocks of the Paleoproterozoic greenstone belts of the Guiana Shield (2.0 - 2.3 Ga), which extend along the Atlantic Coast from Venezuela to Brazil; and
- The continental Roraima Formation conglomerates and sandstones (1.8 Ga), which overlie the Archean Complex and the Paleoproterozoic greenstone belts. The Roraima sediments have been intruded by large dykes, mafic sills and smaller bodies of continental tholeite magma, mostly of Jurassic to Cretaceous age.

The Paleoproterozoic greenstone sequence dominates the central and western portions of the Guiana Shield. The greenstone belts trend roughly northeast-southwest and span a geographic distance of about 200 km between Venezuela and French Guiana. In Suriname and French Guiana, the lower greenstones, comprising the Marowijne and Maroni supergroups, are overlain by the Ston, Rosebel, Armina, and Paramaka Formations, respectively, in probable stratigraphic order (Gibbs and Barron, 1993).

*Figure 5-8 Guiana Shield*

*Figure 5-9 Regional Geology*

The Ston Formation is of fluvial origin from the Mid-Proterozoic Era. The Rosebel Formation consists of metavolvanics, and meta-arenites and metaconglomerates which are probably metamorphosed fluvial sediments representing a molasse-type sequence. The Armina Formation includes quartzite, rhyolitic flows and tuff, aplitic microgranite, polymict basal conglomerate, schist, phyllite, greenish sandstone, and arkosic quartzite. Below these sedimentary formations lies the Paramaka Formation. This Formation is comprised of predominantly mafic volcanic rocks. The uppermost units of the Paramaka Formation consists of mica-schist and aluminous gneiss with dark, interbedded quartzite, iron-formation, and manganese-rich sandstone (Gibbs and Barron, 1993).

### *5.3.2 Project Site Geology*

The area of the Merian Project Area lies within Lower Proterozoic-aged rocks of the Guiana Shield (Figure 5-9). The bedrock geology at the Merian Right of Exploitation consists of folded and faulted, inter-bedded graywackes, mudstones, siltstones, sandstones and minor volcaniclastics of the Armina Formation of Lower Proterozoic age (Surgold 2010). This area has been subjected to weak to moderate, low-grade, greenschist facies regional metamorphism. No known intrusive rocks have been identified on the property to date. A generalized geologic map of the property is shown in Figure 5-10.

*Figure 5-10 Geology Surrounding Right of Exploitation*

Due to prolonged chemical weathering from the surrounding semi-arid, tropical paleo-climate, the laterite / saprolite profile extends on average 80 to 100 meters below the surface. The upper lateritic horizon is generally 2 to 3 meters thick covered by 0.3 to 0.5 meters of soil. Sedimentary rocks of the Armina Formation in the saprolite zone are weathered and oxidized to a mixture of clays such as kaolinite and iron oxides. Primary rock texture is fairly well preserved, and quartz and quartz veining remain intact (Surgold, 2010).

A transition zone of partially-weathered rock, referred to as saprock, occurs below the saprolite. Highly irregular, the transition zone ranges in thickness from 0 to 20 meters. Primary rock fabric such as bedding and folding, as well as partially oxidized pyrite can be readily seen in this zone (Surgold, 2010).

Un-oxidized rock underlies the transition zone. The resource gold mineralization at Merian occurs within saprolite, saprock or un-oxidized rock. The majority of the known deposits and prospects show evidence of recent and historical mining from the laterite and alluvial sources.

A north-west trending, south-east plunging antiform (the Merian Antiform) dominates the structural geology of the property (Surgold, 2010). Second-order folds occur in both limbs of the antifold. These second-order folds generally have a north-west axial trace and wave lengths between a few centimeters to several hundreds of meters.

Northwest-striking moderate-to-steeply dipping faults and shear zones occur along the axial trace and limbs of the Merian Antiform (Surgold, 2010). Gold mineralization in this area is associated with quartz veins, stockworks, and breccias along the north-west trending structural zones. Additionally, a low-angle set of veins occurs throughout the property. It is likely that these veins occupy low-angle imbricate thrust fault zones and may be cross cut by mineralized quartz breccia bodies. North-east and east-west trending faults cross-cut the Merian antiform and may bound or localize mineralization along the north-west striking structural fabric (Surgold, 2010).

### *5.3.3 Regional Site Topography*

The Guiana Shield is characterized by a series of long terraces that are separated by pronounced scarps or cliffs. Areas outside these terraces are mostly low-lying plateaus, with some mountain groups rising over 250 meters above sea level (masl). The border zone with Brazil is higher with elevations ranging from 250 to 500 masl, and summits reaching up to 1,000 masl (Surgold, 2010). Figure 5-11 shows the topography throughout Suriname.

*Figure 5-11 Topography of Suriname*

### 5.3.4 *Project Site Topography*

The Project Site is characterized by undulating hills interspersed with deeply incised streams and creeks. Ground cover at the Project Site consists of heavily vegetated rain forest. Localized site topography has been significantly disturbed by ASM activities that distributed tailings piles in creek valleys, and radically alters stream hydrology and geomorphology. Figure 5-12 shows the topography at the Merian Right of Exploitation (red line) and the Merian Area Environmental Study Area.

*Figure 5-12 Merian Site Topography*

## 5.4 *NATURAL HAZARDS*

### *5.4.1 Seismic*

The US National Oceanic and Atmospheric Administration Earthquake Database, which includes data on a half-million earthquakes indicates no events in recorded history within 300 km of Paramaribo. This search was supplemented by a search of the United States Geological Survey (USGS) for an area defined by latitudes 1.5 to 6.0 North and longitudes 54.0 to 58.0 West, which includes the whole of Suriname. This search also recorded no seismic event in that area between 1471 and 2010. The closest earthquake to the Project area occurred on 8 June 2008 in French Guiana (Magnitude 5.2 earthquake) (USGS, 2011a). Magnitude measures the energy released at the source of the earthquake and is determined from measurements on seismographs. No seismic events have been recorded in the Project area and the seismicity of the Project area is very low, but in spite of the absence of recorded seismic events in proximity to the Project area, the area may still be subject to ground motions caused by earthquake activity elsewhere. Intensity measures the strength of shaking produced by an earthquake at a certain location and is determined by effects on people, human structures, and the natural environment.

Numerous intensity scales have been developed over the past several hundred years to evaluate the effects of earthquake; the one most widely used today is the Modified Mercalli Intensity (MMI) scale. The MMI scale is designated by Roman numerals ranging from I (not felt) to XII (catastrophic destruction) and does not have a mathematical basis; instead it is an arbitrary ranking based on observed effects (USGS 2011b). Table 5-2 shows intensities that are typically observed near the epicenter of earthquakes of different magnitudes.

*Table 5-2 Modified Mercalli Intensities Typically Observed at Locations near the Epicenter of Earthquakes of Different Magnitudes*

| Magnitude [Richter] | Typical Maximum Modified Mercalli Intensity |
|---|---|
| 1.0 - 3.0 | I |
| 3.0 - 3.9 | II - III |
| 4.0 - 4.9 | IV - V |
| 5.0 - 5.9 | VI - VII |
| 6.0 - 6.9 | VII - IX |
| 7.0 and higher | VIII or higher |

Source: USGS 2011b

Description of the abbreviated MMI scale are as follows:

I. Not felt except by a very few under especially favorable conditions.
II. Felt only by a few persons at rest, especially on upper floors of buildings.
III. Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV. Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V. Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI. Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII. Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
XI. Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
XII. Damage total. Lines of sight and level are distorted. Objects thrown into the air.

The Seismic Research Unit (SRU) of the University of the West Indies has developed country-level seismic hazard maps for the Caribbean and part of South America as part of the Caribbean Disaster Management Program (CDMP). The maps show MMIs for several countries, including Suriname.

The map for Suriname indicates an expected MMI event, with a 10% probability of exceedance, in 50 years of magnitude of IV for the area. This is based on the projected occurrence of a magnitude 4.0 earthquake in the area (Figure 5-13) (OAS, 2011). Though the probability of occurrence is low, such a magnitude 4.0 earthquake at the Project area would correspond to a MMI level IV as shown in Table 5-2. Such an event would be felt indoors by many people and outdoors by a few people, but would not result to any building / structural damage.

### 5.4.2 *Flooding*

Coastal areas are regularly flooded by seawater, particularly in the rainy season; however, flood disasters occur infrequently in Suriname (PAHO, 2011). The

Project Area is located on high ground and straddles the ridge line between the Commewijne and Marowijne rivers, so has little potential for flooding.

*Figure 5-13 Mercalli Intensity*

## 5.5 *REFERENCES FOR CHAPTER 5*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# 6.0 *AIR QUALITY AND GREENHOUSE GAS BASELINE*

## 6.1 *EXISTING AIR QUALITY*

Air quality in the Environmental and Social Study Area is generally influenced by natural and anthropogenic sources, such as:

- Dust blown by wind during the dry season;
- Small-scale and artisanal mining (ASM);
- Logging activities;
- Dust created by driving vehicle on unpaved roads;
- Exhaust gases from vehicles; and
- Fuel combustion (wood and hydrocarbons) for home cooking.

The current impacts of these activities on air quality are generally localized and do not contribute substantially to regional degradation of air quality.

### *6.1.1 Air Quality Sampling*

No historical ambient air quality data are available for the Study Area. Surgold established an air monitoring program at the Mine Site and along the Transportation Corridor in November 2011 to obtain baseline data.

Sampling was conducted at three locations; (1) Maraba Pit, (2) location of the future processing plant (Plant Site), and (3) in the vicinity of Pelgrin Kondre near the Moengo Road. The site locations were selected to provide the most representative ambient air concentrations near activities related to the Project. In addition, they provided ease of access and required security for the monitoring equipment and portable generators at each site. The portable generators were used to power the samplers at each site and were placed approximately 40 meters away in the general downwind direction to minimize potential sampling of exhaust gases carried by winds in the area. Figure 6-1 presents a map of the selected sampling locations.

The following constituents were included in the sampling program:

- Total suspended particulate matter (TSP);
- Particulate matter less than 10 microns aerodynamic diameter ($PM_{10}$);
- Particulate matter less than 2.5 microns aerodynamic diameter ($PM_{2.5}$);
- Arsenic (As);

- Total Chromium (Cr);
- Nickel (Ni);
- Nitrogen Dioxide ($NO_2$);
- Sulfur Dioxide ($SO_2$); and
- Carbon Monoxide (CO).

Meteorological data was obtained from the Merian weather station as well as from other instrumentation in the field to accurately characterize weather conditions during each sampling event.

The ambient air sampling program was conducted over the course of two mobilizations. The first mobilization was conducted from 8 November 2011 through 14 December 2011, which is generally considered the end of the long "dry" season. The drier portions of the year were targeted as during this time there is typically an elevated amount of background particulate matter in the ambient air. Target constituents during the first mobilization included TSP, $PM_{10}$, As, Cr, Ni, $NO_2$, and $SO_2$. Due to complications in operation of the equipment, data recovery during the first mobilization (particularly between 14 November 2011 to 23 November 2011) was less than desired and a second mobilization was scheduled for February 2012.

The second mobilization was conducted from 18 February through 1 March 2012 during the short "dry" season and included an expanded list of target analytes, adding $PM_{2.5}$ and CO. The sampling equipment was reassembled at each of the same three locations utilized during the first mobilization.

As expected, no major air pollution sources were identified during sampling (first and second mobilizations) at the Maraba Pit, indicating that ambient baseline conditions were sampled. The sampling at the Plant Site was scheduled so that it did not coincide with any drilling activities associated with Early Works activities. Infrequent vehicular traffic was observed during the sampling at the Plant Site (first and second mobilizations). During the first mobilization, infrequent vehicle traffic was also observed on the Moengo Road (Transportation Corridor) at the Pelgrin Kondre site, but an increase in traffic was observed on the Moengo Road during the second mobilization, possibly due to Early Works at the Project site.

Sampling for TSP and $PM_{10}$ was conducted during both mobilizations and followed the 2011 and 2012 Monitoring Schedules published by the United States Environmental Protection Agency (US EPA) which specify sampling every third day. TSP and $PM_{10}$ sampling followed the procedures outlined under Title 40 Code of Federal Regulations Part 50 (40 CFR 50) Appendix B and 40 CFR 50 Appendix J, respectively. TSP samples were first gravimetrically analyzed for determination of total mass gain and were then transported to an analytical laboratory for analysis of As, Cr, and Ni (metals).

$PM_{2.5}$ was measured at each location as a part of the second mobilization using Met One E-Samplers. The E-Samplers are new technology instruments that utilize light scatter to continuously measure $PM_{2.5}$ concentrations in ambient air. These units provided one-minute average $PM_{2.5}$ concentration data for each sample period which was then reduced to 24-hour averages for comparison to published standards and guidelines.

$NO_2$ and $SO_2$ were sampled during both mobilizations using Radiello passive diffusive tubes. Each sample was collected over a 7-day period concurrent with the other ambient monitoring. Samples were analyzed by the analytical laboratory and reported in units of parts per billion by volume (ppbv) and micrograms per cubic meter ($\mu g/m^3$). CO was measured during the second mobilization using electronic passive personal samplers that record concentration data at one-minute intervals. Data was downloaded during each site visit and reduced to 8-hour and 1-hour rolling averages for comparison to published standards and guidelines.

Table 6-1, Table 6-2, and Table 6-3 present a detailed summary of the results of all constituents measured from 8 November 2011 to 01 March 2012 at the Maraba Pit, Plant Site, and Pelgrin Kondre site, respectively. The tables also show the observed weather conditions during each sampling event.

Table 6-4 through Table 6-8 present summaries of the resultant data of all constituents, except the metals (As, Cr, and Ni), and a comparison to the U.S. EPA's National Ambient Air Quality Standards (NAAQS)[4] and the World Health Organization (WHO) Ambient Air Quality Guidelines (WHO 2005; IFC 2007). Metals were not included in the tables because there are no specific standards or guidelines for metals in the NAAQS and/ or WHO Ambient Air Quality Guidelines.

The tables present data based on the maximum results obtained for each target analyte during both mobilizations for comparison to the published standards and guidelines. Based on the monitoring results, there were no target analytes that exceeded the NAAQS or the WHO Ambient Air Quality Guidelines with the exception of a single PM10 value (98.1 $\mu g/m^3$) measured on 8 November 2011 at the Pelgrin Kondre location[5]. The $PM_{10}$ concentration measured for this 24-hour period exceeded the WHO 24-hour $PM_{10}$ guideline of 50 $\mu g/m^3$ but did not

4 The U.S. EPA NAAQS were taken from 40 CFR Part 50 (CFR = Code of Federal Regulations).

5 The high PM10 concentrations (98.1 $\mu g/m3$) at the Pelgrin Kondre location on 8 November 2011 is likely due to wind-blown dust associated with the dry weather on that day coupled with vehicle traffic on the Moengo Road (though no traffic count was taken during the monitoring period).

exceed the NAAQS 24-hour $PM_{10}$ standard of 150 $\mu g/m^3$. In comparison to Mobilization No. 1, $PM_{10}$ and $PM_{2.5}$ ambient concentrations were higher at Maraba Pit and Plant Site locations during Mobilization No. 2 due to the increase in site activity i.e., increased road traffic associated with the new camp installations during Mobilization No. 2.

Overall, pollutant concentrations obtained from all three locations are representative of good air quality in the Study Area, as expected from a generally undeveloped area.

Detailed information on sampling units and installation, locations, summary of events and results, test procedures, weather data, laboratory data and calculations, equipment calibration, and sampling protocol are included in the Baseline Ambient Air Quality Monitoring Report (Appendix 6-A).

*Figure 6-1 Air Monitoring Locations*

*Table 6-1 Merian Project – Baseline Ambient Air Quality Monitoring – Detailed Summary of Results – Maraba Site*

| Maraba Pit | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Date** | **TSP** | **$PM_{10}$** | **$PM_{2.5}$** | | **Arsenic** | **Chromium** | **Nickel** | **CO** | | | | **$NO_2$** | **$SO_2$** | Weather Conditions[d] |
| | | | **Avg.** | **Peak[a]** | | | | **Avg.** | **Avg.** | **Avg.** | **Peak[a]** | | | |
| | $\mu g/m^3$ | $\mu g/m^3$ | $\mu g/m^3$ | $\mu g/m^3$ | $\mu g/m^3$ | $\mu g/m^3$ | $\mu g/m^3$ | (ppmv) | (ppmv) | (ppmv) | (ppmv) | (ppbv) | (ppbv) | |
| Averaging Period | 24-hr | 24-hr | 24-hr | 5-min | 24-hr | 24-hr | 24-hr | 24-hr | 8-hr | 1-hr | 1-min | | | |
| 11/8/2011 | 12.1 | 10.9 | --- | --- | 0.0014[b] | 0.0004 | 0.0001 | --- | --- | --- | --- | N/A | N/A | Clear |
| 11/11/2011 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | | Clear/Light Rain |
| 11/14/2011 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | | Clear |
| 11/17/2011 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | | Clear |
| 11/20/2011 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | | Clear |
| 11/23/2011 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | | Cloudy |
| 12/2/2011 | 9.6 | 7.3 | --- | --- | 0.0013[b] | 0.0002 | 0.0002 | --- | --- | --- | --- | ND | ND | Clear |
| 12/5/2011 | 11.5 | 6.9 | --- | --- | 0.0014[b] | 0.0010 | 0.0004 | --- | --- | --- | --- | | | Clear |
| 12/8/2011 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | ND | ND | Clear |
| 12/11/2012 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | | Clear |
| 12/14/2012 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | | Cloudy/Periods of Heavy Rain |
| 2/18/2012 | 18.5 | 12.7 | 1.6 | 4.0 | 0.0014[b] | 0.0005 | 0.0002 | 0.0 | 0.0 | 0.1 | 3.0 | ND | ND | Cloudy |
| 2/21/2012 | 24.1 | 21.1 | 4.0 | 9.0 | 0.0014[b] | 0.0003 | 0.0002 | 0.0 | 0.0 | 0.0 | 0.0 | | | Cloudy/Light Rain (~2 hrs.) |
| 2/24/2012 | 26.2 | 20.4 | 4.4 | 10.0 | 0.0014[b] | 0.0002 | 0.0003 | 0.0 | 0.0 | 0.0 | 0.0 | | | Cloudy/Light Rain (~2 hrs.) |
| 2/27/2012 | 17.7 | 13.9 | 6.3 | 13.0 | 0.0014[b] | 0.0000[c] | 0.0003 | 0.0 | 0.0 | 0.0 | 0.0 | ND | ND | Cloudy/Period of Heavy Rain |
| 3/1/2012 | 40.4 | 30.3 | 10.5 | 22.0 | 0.0014[b] | 0.0004 | 0.0008 | 0.0 | 0.0 | 0.0 | 0.0 | | | Cloudy/Period of Heavy Rain |

(a) Peak based on the highest average data point obtained during test period.
(b) Analyte not detected (ND). The method detection limit (MDL) was used for emission calculation purposes.
(c) Analyte detected below blank concentration, zero value is reported.
(d) Weather conditions for 11/8 through 12/11 estimated. No onsite meteorological data was available - field observations for the day prior to and the day after the sample day were utilized along with other local weather data sources for Paramaribo.
ND Compound was analyzed for, but not detected above the laboratory reporting limit.
Avg. Average. 8-hr and 1-hr based on maximum rolling averages.

## *Table 6-2 Merian Project – Baseline Ambient Air Quality Monitoring – Detailed Summary of Results – Plant Site*

| Plant Site | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Date** | **TSP** | **$PM_{10}$** | **$PM_{2.5}$** | | **Arsenic** | **Chromium** | **Nickel** | **CO** | | | | **$NO_2$** | **$SO_2$** | Weather Conditions[e] |
| | | | **Avg.** | **Peak[a]** | | | | **Avg.** | **Avg.** | **Avg.** | **Peak[a]** | | | |
| | mg/m$^3$ | mg/m$^3$ | mg/m$^3$ | mg/m$^3$ | mg/m$^3$ | mg/m$^3$ | mg/m$^3$ | (ppmv) | (ppmv) | (ppmv) | (ppmv) | (ppbv) | (ppbv) | |
| Averaging Period | 24-hr | 24-hr | 24-hr | 5-min | 24-hr | 24-hr | 24-hr | 24-hr | 8-hr | 1-hr | 1-min | | | |
| 11/8/2011 | 13.7 | 9.9 | --- | --- | 0.0014[b] | 0.0014 | 0.0002 | --- | --- | --- | --- | --- | --- | Clear |
| 11/11/2011 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | | Clear/Light Rain |
| 11/14/2011 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | | Clear |
| 11/17/2011 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | | Clear |
| 11/20/2011 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | | Clear |
| 11/23/2011 | 11.4 | 11.4 | --- | --- | 0.0014[b] | 0.0002 | 0.0001 | --- | --- | --- | --- | | | Cloudy |
| 12/2/2011 | 14.0 | --- | --- | --- | 0.0014[b] | 0.0028 | 0.0004 | --- | --- | --- | --- | ND | ND | Clear |
| 12/5/2011 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | | Clear |
| 12/8/2011 | 35.1 | --- | --- | --- | 0.0015[b] | 0.0093 | 0.0003 | --- | --- | --- | --- | 3.2 | 1.9 | Clear |
| 12/11/2012 | 14.7 | --- | --- | --- | 0.0014[b] | 0.0014 | 0.0003 | --- | --- | --- | --- | | | Clear |
| 12/14/2012 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | | Cloudy/Periods of Heavy Rain |
| 2/18/2012 | 18.0 | 10.8 | 1.4 | 9.0 | 0.0014[b] | 0.0022 | 0.0002 | 0.0 | 0.0 | 0.0 | 4.0 | ND | ND | Cloudy |
| 2/21/2012 | 18.4 | 15.0 | 3.0 | 11.0 | 0.0014[b] | 0.0003 | 0.0002 | 2.5 | 3.5 | 3.6 | 6.0 | | | Cloudy/Light Rain (~2 hrs.) |
| 2/24/2012 | 20.8 | 16.0 | 3.7 | 12.0 | 0.0014[b] | 0.0002 | 0.0002 | 3.2 | 3.6 | 3.7 | 6.0 | | | Cloudy/Light Rain (~2 hrs.) |
| 2/27/2012[c] | 35.0 | 15.1 | 7.0[d] | 18.0[d] | 0.0020[b] | 0.0063 | 0.0007 | 3.4 | 3.6 | 3.8 | 6.0 | ND | ND | Cloudy/Period of Heavy Rain |
| 3/1/2012 | 39.7 | 28.6 | 11.8 | 57.0 | 0.0013[b] | 0.0010 | 0.0009 | 3.5 | 3.7 | 3.9 | 6.0 | | | Cloudy/Period of Heavy Rain |

(a) Peak based on the highest average data point obtained during test period.
(b) Analyte not detected (ND). The method detection limit (MDL) was used for emission calculation purposes.
(c) Sample on 2/27/2012 was operated for 17 hours only due to power outages caused by a faulty circuit breaker on the generator. CO was sampled for the entire 24-hour period.
(d) Due to data loss caused by the power outages, replacement data for the missing time periods on 2/27/2012 was obtained by resuming the sampling on 2/29/2012 during the same time periods as the missing data.
(e) Weather conditions for 11/8 through 12/11 estimated. No onsite meteorological data was available - field observations for the day prior to and the day after the sample day were utilized along with other local weather data sources for Paramaribo.
ND Compound was analyzed for, but not detected above the laboratory reporting limit.
Avg. Average. 8-hr and 1-hr based on maximum rolling averages.

## *Table 6-3 Merian Project – Baseline Ambient Air Quality Monitoring – Detailed Summary of Results – Pelgrin Kondre*

| Pelgrin Kondre | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Date** | **TSP** | **$PM_{10}$** | **$PM_{2.5}$** | | **Arsenic** | **Chromium** | **Nickel** | **CO** | | | | **$NO_2$** | **$SO_2$** | Weather Conditions[d] |
| | | | **Avg.** | **Peak[a]** | | | | **Avg.** | **Avg.** | **Avg.** | **Peak[a]** | | | |
| | mg/m$^3$ | mg/m$^3$ | mg/m$^3$ | mg/m$^3$ | mg/m$^3$ | mg/m$^3$ | mg/m$^3$ | (ppmv) | (ppmv) | (ppmv) | (ppmv) | (ppbv) | (ppbv) | |
| Averaging Period | 24-hr | 24-hr | 24-hr | 5-min | 24-hr | 24-hr | 24-hr | 24-hr | 8-hr | 1-hr | 1-min | | | |
| 11/8/2011 | --- | 98.1 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | Clear |
| 11/11/2011 | --- | 40.0 | --- | --- | --- | --- | --- | --- | --- | --- | --- | | | Clear/Light Rain |
| 11/14/2011 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | | Clear |
| 11/17/2011 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | | Clear |
| 11/20/2011 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | | Clear |
| 11/23/2011 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | | Cloudy |
| 12/2/2011 | 50.7 | 23.6 | --- | --- | 0.0014[b] | 0.0083 | 0.0024 | --- | --- | --- | --- | ND | ND | Clear |
| 12/5/2011 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | | Clear |
| 12/8/2011 | --- | --- | --- | --- | 0.0015[b] | --- | --- | --- | --- | --- | --- | ND | ND | Clear |
| 12/11/2012 | --- | --- | --- | --- | 0.0014[b] | --- | --- | --- | --- | --- | --- | | | Clear |
| 12/14/2012 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | | Cloudy/Periods of Heavy Rain |
| 2/18/2012 | 67.3 | 27.3 | 3.2 | 41.0 | 0.0014[b] | 0.0106 | 0.0005 | 0.0 | 0.0 | 0.0 | 0.0 | ND | ND | Cloudy |
| 2/21/2012 | 21.0 | 17.6 | ---[c] | ---[c] | 0.0013[b] | 0.0003 | 0.0005 | 0.0 | 0.0 | 0.0 | 0.0 | | | Cloudy/Light Rain (~2 hrs.) |
| 2/24/2012 | 47.1 | 23.1 | ---[c] | ---[c] | 0.0014[b] | 0.0069 | 0.0005 | 0.0 | 0.0 | 0.0 | 0.0 | | | Cloudy/Light Rain (~2 hrs.) |
| 2/27/2012 | 10.7 | 8.1 | ---[c] | ---[c] | 0.0014[b] | 0.0017 | 0.0012 | 0.0 | 0.0 | 0.0 | 0.0 | ND | ND | Cloudy/Period of Heavy Rain |
| 3/1/2012 | 53.4 | 38.0 | 4.9 | 41.0 | 0.0014[b] | 0.0025 | 0.0010 | 0.0 | 0.0 | 0.0 | 0.0 | | | Cloudy/Period of Heavy Rain |

(a) Peak based on the highest average data point obtained during test period.
(b) Analyte not detected (ND). The method detection limit (MDL) was used for emission calculation purposes.
(c) Heavy rain caused the $PM_{2.5}$ analyzer to malfunction. Missing data for 2/21, 2/24, and 2/27.
(d) Weather conditions for 11/8 through 12/11 estimated. No onsite meteorological data was available - field observations for the day prior to and the day after the sample day were utilized along with other local weather data sources for Paramaribo.
ND Compound was analyzed for, but not detected above the laboratory reporting limit.
N/A Not Applicable
Avg. Average. 8-hr and 1-hr based on maximum rolling averages.

*Table 6-4 Merian Project - Maximum $PM_{10}$ and $PM_{2.5}$ Monitoring Results and Comparison to Published Standards and Guidelines*

| *Mobilization No. 1 (Nov.-Dec. 2011)* | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Location** | **Date** | **$PM_{10}$** | | | | **Location** | **Date** | **$PM_{2.5}$** | | | | |
| | | **Max Result** | **NAAQS** | **WHO** | | | | **Max Result** | **NAAQS** | | **WHO** | |
| | | μg/m$^3$ | μg/m$^3$ | μg/m$^3$ | μg/m$^3$ | | | μg/m$^3$ | μg/m$^3$ | μg/m$^3$ | μg/m$^3$ | μg/m$^3$ |
| | | Averaging Period | | | | | | Averaging Period | | | | |
| | | 24-hr | 24-hr | 24-hr | Annual | | | 24-hr | 24-hr | Annual | 24-hr | Annual |
| Maraba Pit | 11/8/2011 | 10.9 | 150 | 50 | 20 | Maraba Pit | n/a | n/a | 35 | 15 | 25 | 10 |
| Plant Site | 11/23/2011 | 11.4 | 150 | 50 | 20 | Plant Site | n/a | n/a | 35 | 15 | 25 | 10 |
| Pelgrin Kondre | 11/8/2011 | 98.1[(a)] | 150 | 50 | 20 | Pelgrin Kondre | n/a | n/a | 35 | 15 | 25 | 10 |
| *Mobilization No. 2 (Feb.-Mar. 2012)* | | | | | | | | | | | | |
| **Location** | **Date** | **$PM_{10}$** | | | | **Location** | **Date** | **$PM_{2.5}$** | | | | |
| | | **Max Result** | **NAAQS** | **WHO** | | | | **Max Result** | **NAAQS** | | **WHO** | |
| | | μg/m$^3$ | μg/m$^3$ | μg/m$^3$ | μg/m$^3$ | | | μg/m$^3$ | μg/m$^3$ | μg/m$^3$ | μg/m$^3$ | μg/m$^3$ |
| | | Averaging Period | | | | | | Averaging Period | | | | |
| | | 24-hr | 24-hr | 24-hr | Annual | | | 24-hr | 24-hr | Annual | 24-hr | Annual |
| Maraba Pit | 3/1/2012 | 30.3 | 150 | 50 | 20 | Maraba Pit | 3/1/2012 | 10.5 | 35 | 15 | 25 | 10 |
| Plant Site | 3/1/2012 | 28.6 | 150 | 50 | 20 | Plant Site | 3/1/2012 | 11.8 | 35 | 15 | 25 | 10 |
| Pelgrin Kondre | 3/1/2012 | 38.0 | 150 | 50 | 20 | Pelgrin Kondre | 3/1/2012 | 4.9 | 35 | 15 | 25 | 10 |

(a) = exceedance of the WHO 24-hr emisison standard.
n/a = not applicable
NAAQS = EPA National Ambient Air Quality Standards
WHO = World Health Organization, Air Quality Guidelines (2005)

*Table 6-5 Merian Project - Maximum CO Monitoring Results and Comparison to Published Standards and Guidelines*

| *Mobilization No. 2 (Feb.-Mar. 2012)* | | | | | |
|---|---|---|---|---|---|
| | | **CO** | | | |
| **Location** | **Date** | **Max Result** ppmv | **NAAQS** ppmv | **Max Result** ppmv | **NAAQS** ppmv |
| | | Averaging Period | | | |
| | | 8-hr | 8-hr | 1-hr | 1-hr |
| Maraba Pit | 2/18/2012 | 0.0 | 9 | 0 | 35 |
| Plant Site | 3/1/2012 | 3.7 | 9 | 4 | 35 |
| Pelgrin Kondre | all sample days | 0.0 | 9 | 0 | 35 |

NAAQS = EPA National Ambient Air Quality Standards
WHO = World Health Organization, Air Quality Guidelines (2005)

*Table 6-6 Merian Project - Maximum $NO_2$ Monitoring Results and Comparison to Published Standards and Guidelines*

| *Mobilization No. 1 (Nov.-Dec. 2011)* | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | **$NO_2$** | | | | | |
| | | **Max Result** | **NAAQS** | | **Max Result** | **WHO** | |
| **Location** | **Date** | ppbv | ppbv | ppbv | μg/m$^3$ | μg/m$^3$ | μg/m$^3$ |
| | | Averaging Period | | | | | |
| | | 7-day | 1-hr | Annual | 7-day | 1-hr | Annual |
| Maraba Pit | all sample days | ND | 100 | 53 | ND | 200 | 40 |
| Plant Site | 12/8 - 12/14/2011 | 3.2 | 100 | 53 | 6.0 | 200 | 40 |
| Pelgrin Kondre | all sample days | ND | 100 | 53 | ND | 200 | 40 |
| *Mobilization No. 2 (Feb.-Mar. 2012)* | | | | | | | |
| | | **$NO_2$** | | | | | |
| | | **Max Result** | **NAAQS** | | **Max Result** | **WHO** | |
| **Location** | **Date** | ppbv | ppbv | ppbv | μg/m$^3$ | μg/m$^3$ | μg/m$^3$ |
| | | Averaging Period | | | | | |
| | | 7-day | 1-hr | Annual | 7-day | 1-hr | Annual |
| Maraba Pit | all sample days | ND | 100 | 53 | ND | 200 | 40 |
| Plant Site | all sample days | ND | 100 | 53 | ND | 200 | 40 |
| Pelgrin Kondre | all sample days | ND | 100 | 53 | ND | 200 | 40 |

ND = Not Detected
NAAQS = EPA National Ambient Air Quality Standards
WHO = World Health Organization, Air Quality Guidelines (2005)

*Table 6-7 Merian Project - Maximum $SO_2$ Monitoring Results and Comparison to Published Standards and Guidelines*

| *Mobilization No. 1 (Nov.-Dec. 2011)* | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Location** | **Date** | **$SO_2$** | | | | | |
| | | **Max Result** | **NAAQS** | | **Max Result** | **WHO** | |
| | | ppbv | ppbv | ppbv | $\mu g / m^3$ | $\mu g / m^3$ | $\mu g / m^3$ |
| | | Averaging Period | | | | | |
| | | 7-day | 1-hr | 3-hr | 7-day | 24-hr | 10-min |
| Maraba Pit | all sample days | ND | 75 | 500 | ND | 20 | 500 |
| Plant Site | 12/8 - 12/14/2011 | 1.9 | 75 | 500 | 5.1 | 20 | 500 |
| Pelgrin Kondre | all sample days | ND | 75 | 500 | ND | 20 | 500 |
| *Mobilization No. 2 (Feb.-Mar. 2012)* | | | | | | | |
| **Location** | **Date** | **$SO_2$** | | | | | |
| | | **Max Result** | **NAAQS** | | **Max Result** | **WHO** | |
| | | ppbv | ppbv | ppbv | $\mu g / m^3$ | $\mu g / m^3$ | $\mu g / m^3$ |
| | | Averaging Period | | | | | |
| | | 7-day | 1-hr | 3-hr | 7-day | 24-hr | 10-min |
| Maraba Pit | all sample days | ND | 75 | 500 | ND | 20 | 500 |
| Plant Site | all sample days | ND | 75 | 500 | ND | 20 | 500 |
| Pelgrin Kondre | all sample days | ND | 75 | 500 | ND | 20 | 500 |

ND = Not Detected

NAAQS = EPA National Ambient Air Quality Standards

WHO = World Health Organization, Air Quality Guidelines (2005)

*Table 6-8 Merian Project - Summary of Background Ambient Air Quality*

| Pollutant | Averaging Period | Measurement Units | Measured Values | | | Background Concentration | USEPA NAAQS | WHO |
|---|---|---|---|---|---|---|---|---|
| | | | Maraba Pit | Plant Site | Pelgrin Kondre | | | |
| $PM_{10}$ | 24-hour | ug/m3 | 20.6 | 20.0 | 68 | 21.10 | 150 | 50 |
| | Annual | ug/m3 | - | - | - | 15.35 | - | 20 |
| $PM_{2.5}$ | 24-hour | ug/m3 | 10.5 | 11.8 | 4.9 | 7.00 | 35 | 25 |
| | Annual | ug/m3 | - | - | - | 5.37 | 15 | 10 |
| $NO_2$ | 1-hour | ug/m3 | - | 15.0 | - | 16.77 | 188.7 | 200 |
| | Annual | ug/m3 | - | - | - | 6.02 | 100 | 40 |
| $SO_2$ | 10-min | ug/m3 | - | - | - | 13.85 | - | - |
| | 1-hour | ug/m3 | - | 23.0 | - | - | 196 | - |
| | 3-hour | ug/m3 | - | - | - | - | 1,300 | - |
| | 24-hour | ug/m3 | - | - | - | 4.97 | - | 20 |
| CO | 1-hour | ug/m3 | - | 4,580 | - | 4,066.25 | 40,000 | - |
| | 8-hour | ug/m3 | - | 4,237 | - | 4,066.25 | 10,000 | - |

Notes:

1. If more than one sample is available, average of the measured values is reported.

2. For $SO_2$ and $NO_2$, 7-day averaged sample value is used to represent 1-hour averaged; a scaling factor of 0.4 is used.

## 6.2 *GREENHOUSE GASES*

Greenhouse gases (GHGs) are gases that warm up the earth's atmosphere by absorbing solar radiation reflected from the earth's surface. The five main greenhouse gases are carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), hydro-fluorocarbons (PFCs), and sulfur hexafluoride ($SF_6$).

Scientific evidence indicates a trend of increasing global temperature over the past century due to an increase in GHG concentrations in the atmosphere caused by human activities, particularly fossil fuel combustion. The resulting increase in GHG concentrations in the atmosphere have likely increased the amount of heat that is retained by Earth's atmosphere, thus contributing to increased global temperatures. There is concern that such increase in global temperatures could have many consequences for the environment. The magnitude and significance of these consequences are currently subject to debate, but there is general consensus in the scientific community that these consequences will occur more quickly and could have adverse effects on human health and the environment. Such effects may include human health problems from exposure to extreme heat and declining air quality, reduction in agricultural production, and severe flooding from frequent heavy downpours and sea-level rise.

Due to the potential effects of global warming from human activities, the United Nations Framework Convention on Climate Change (UNFCCC) initiated the Kyoto Protocol, an international and legally binding agreement to reduce GHG emissions worldwide. The protocol was initially adopted for use on 11 December 1997 in Kyoto, Japan and entered into force on 16 February 2005. As of March 2012, over 180 countries including Suriname, have ratified and signed the Kyoto Protocol. The Kyoto Protocol expires in 2012 and it is expected that its successor will be negotiated at the next United Nations Climate Change Conference.

In Suriname, there are currently no policies, laws, or measures in place to reduce or mitigate the effects of GHG emissions. The most currently available estimate of GHG emissions for Suriname, which is 2003, indicated approximately 8,802 Gigagrams (Gg) of $CO_2$ equivalents were emitted annually. The total $CO_2$ removals (GHG sinks) via land-use change and forestry equal 3,862 Gg of $CO_2$ equivalents, making the net GHG emissions in Suriname equal to 5,040 Gg of $CO_2$ equivalents (Suriname, 2005).

## 6.3 *REFERENCES FOR CHAPTER 6*


Suriname. 2005. Republic of Suriname – First National Communication to the United Nations Framework Convention on Climate Change, National Institute for Environment and Development in Suriname (NIMOS), 2005.

WHO. 2005. WHO 2005 Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide, and Sulfur Dioxide – Global Update 2005.

International Finance Corporation (IFC). 2007. General Environmental Health and Safety Guidelines, World Bank Group, April 30, 2007.

# 7.0 NOISE AND VIBRATION BASELINE

This chapter addresses existing noise and vibration conditions at the Mine Site and Transportation Corridor, including a description of ambient noise monitoring/ field activities at the Mine Site. The chapter also includes a brief introduction to noise and vibration concepts and terms.

Noise is generally defined as unwanted sound. Sound can be perceived as pleasant or annoying, and as loudness/ intensity, in terms of decibels (dB). Changes in loudness are described on a logarithmic scale (decibel scale) because the human ear can hear such a wide variety of sound levels. Since the decibel scale is logarithmic, it means noise levels do not add up or change according to simple linear arithmetic. For example, adding two equal noise sources results in a doubling of sound energy, which gives a combined noise level that is 3 dB higher than the individual levels. So 70 dB plus 70 dB equals 73 dB (not 140 dB). Sound measurement is further refined by using an A-weighted scale that emphasizes the range between 1,000 and 8,000 cycles per second (hertz) which are the sound frequencies most audible to the human ear. Therefore, unless otherwise noted, all decibel measurements presented in this report are A-weighted (dBA) on a logarithmic scale. A sound increase of 3 dBA is barely perceptible to the human ear while a 5 dBA increase is clearly noticeable and a 10 dBA increase is heard as twice as loud. Noise emissions diminish or attenuate with distance from the source. One of the most commonly used noise metrics for outdoor noise is the A-weighted steady equivalent sound level (LAeq) that contains the same acoustic energy as the time varying noise level over the same time period. The letter 'A' denotes that 'A'-weighting has been used and the 'eq' indicates that an equivalent level has been calculated.

Vibration is defined as regularly repeated movement of a physical object about a fixed point. Blasting is an activity associated with mining that could result into vibration. There are two types of vibration associated with mine blasting: ground vibration and air vibration or airblast overpressure. The magnitude of ground vibration is expressed in terms of Peak Particle Velocity (PPV) and is measured in inches per second (in/s) or millimeters per second (mm/s). Airblast overpressure is measured in Linear-weighted decibels (dBL).

## 7.1 EXISTING NOISE CONDITION

### 7.1.1 Mine Site

*Nearest Noise Receptors*

The Mine Site is located in a sparsely populated rural region in eastern Suriname. Site visits indicate that there are some settlements within a 6 km radius of the Mine Site (Figure 7-1). However, the majority of settlements in close proximity are transient ASM camps that are not occupied on a permanent basis[6]. The largest permanent settlement near the Project is Langa Tabiki (with a population of approximately 500 people), which is approximately 2.5 km from the closest edge of the Exploitation Boundary and 17 km southeast of the Mine Site. A smaller permanent settlement, Akaati, is located approximately 16 km from the Mine Site.

*Ambient Noise Monitoring*

To document the baseline noise levels, ambient noise surveys were conducted over a one-hour period during the daytime at two locations within or near the Mine Site. As illustrated in Figure 7-2, the two monitoring locations selected to measure baseline noise levels are as follows:

- L1 – Eastside of Maraba Pit, 1 km from the North Access Road, near Mine Site ; and
- L2 – Security Gate 1 near one of the ASM camps, 4 km from the Exploration Camp.

The monitoring locations L1 and L2 were chosen because they would represent baseline noise at the Mine Site and nearest receptor (a temporary ASM camp), respectively. Photographs of the two monitoring locations are shown on Figure 7-3 and Figure 7-4. Measurements were recorded on 28 June 2011 using the following instruments:

- Quest 2900 Type 2 Integrating/Logging Sound Level Meter;
- Quest QC-10 Acoustic Calibrator (114dB-1000Hz); and
- Remote microphone.

[6] Some of the small scale ASM camps are occupied for more than a year but they are still not considered permanent camps for the purpose of this study.

*Figure 7-1 Nearest Noise Receptors*

*Figure 7-2 Noise Monitoring Locations*

SSource: ERM

*Figure 7-3 Noise Monitoring Location L1 near Maraba Pit*

SSource: ERM

*Figure 7-4 Noise Monitoring Location L2 at Security Gate 1*

The Quest 2900 Sound Level Meter is a precision instrument designed for use in performing sound level surveys for commercial, industrial and environmental situations. This instrument conforms to the following standard: ANSI S1.4-1991 - Specification for Sound Level Meters. For this study, the sound level meter was set to a "Fast" response time, '3dB' exchange rate, and weighting on the 'A' weighting frequency scale. The microphone was positioned at a height of approximately 1.5 m above ground level away from solid structures and was equipped with a windscreen to prevent measurement errors caused by high winds. The instruments were calibrated before and after the study to ensure that the instrument was functioning within the specified range (114 dB at 1,000 hertz).

Table 7-1includes the one-hour average LAeq measurements recorded during daytime hours at each location as well as meteorological conditions and dominant noise sources observed during the monitoring period. Nighttime noise surveys were not taken (2200h-0700h). Since human-related noise would not occur at night (only wildlife noises), the nighttime noise levels at both locations (L1 and L2) are assumed to be 5 dBA less than the measured daytime noise levels.

*Table 7-1 Noise Survey Results*

| ID | Receptor Description | Survey Period / Hour[1] | Measured Ambient LAeq Levels (dBA) | Meteorological Conditions | Dominant Noise Source |
|---|---|---|---|---|---|
| L1 | Eastside of Maraba Pit, approximately 1 km from the North Access Road, near Mine Site | 0837h – 0937h | 42.6 | Light breeze with wind speeds less than 1 m/s and temperature and relative humidity of approximately 27˚C and 85%, respectively. | Some exploration activities a few kilometers away (drilling) and wildlife noises |
| L2 | Security Gate 1, near one of the informal ASM camps | 1156h - 1256h | 46.4 | Light breeze with wind speeds less than 1 m/s and temperature and relative humidity of approximately 27˚C and 85%, respectively. | Infrequent vehicle traffic; security guards talking; and wildlife noises |

[1] Under IFC noise guidelines, daytime period represents any one-hour period between 0700h and 2200h; nighttime period represent any one-hour between 2200h and 0700h. Only daytime measurements were taken during the survey. For the purpose of this study, nighttime noise levels at the Mine Site are assumed to be 3 dBA less than the measured daytime noise levels.

There is no permanent population or settlements within a 14 km radius of the Mine Site so ambient noise monitoring was not conducted at permanent settlements outside the Mine Site. As illustrated in Figure 7-1, the nearest permanent settlements are located approximately 14 - 22 km east of the Mine Site (along the Marowijne River).

Due to lack of major noise sources at the nearby permanent settlements along the Marowijne River, baseline daytime levels at these settlements were assumed to be 5 dBA lower than ambient noise measurements taken at the Mine Site (L1). In other words, baseline daytime levels at the settlements were assumed to be 37.6 dBA (42.6 dBA minus 5 dBA). As indicated above, nighttime measurements were not taken at the Mine Site and were assumed to be 5 dBA lower than measured daytime levels. Therefore, baseline nighttime levels at the settlements were also assumed to be 5 dBA lower than the presumed nighttime levels at the Mine Site (i.e., 37.6 dBA minus 5 dBA equals 32.6 dBA).

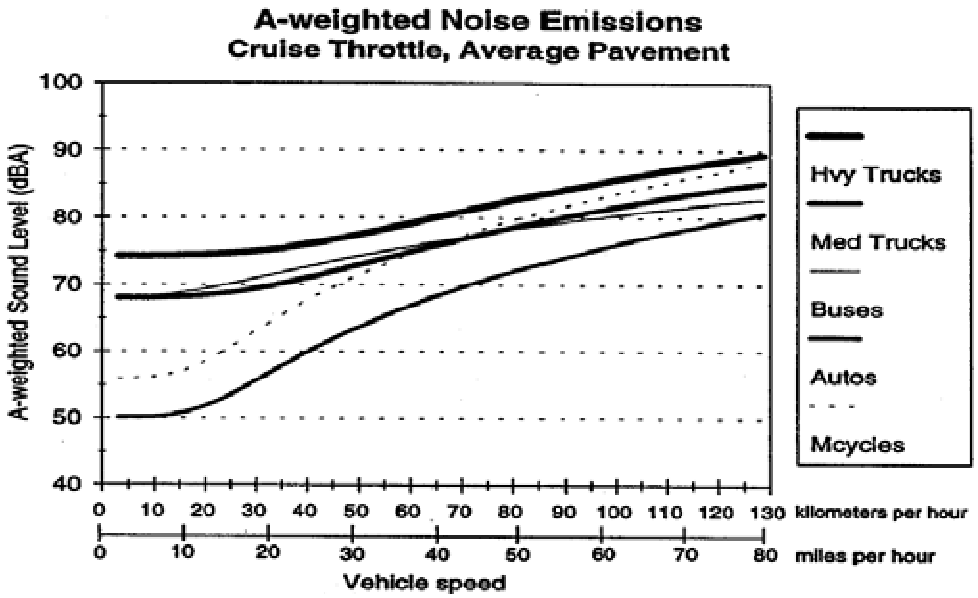
### *7.1.2 Transportation Corridor*

Roadside settlements are commonly found along the Transportation Corridor (particularly the western portion of the East-West Highway, between Paramaribo and the Commewijne River). Residential homes, commercial establishments, houses of worship, schools, and government/public buildings are located within 20 m of the roadway. As shown in Figure 7-1, the villages along the Transportation Corridor between the Mine Site and Moengo include Patamaka, Casaba Ondro, Ovilonoloi, Mora Kondre, Pelgrin Kondre, Akalikondre, and Moengo. The villages between Moengo and Paramaribo include Perica, Potribo, Mon Pere, Tamaredjo, and Meerzorg.

To characterize the existing noise environment along the Transportation Corridor, hourly traffic counts for different vehicle types (automobiles, light/medium trucks, heavy trucks, and motorcycles), were collected at three locations along the East-West Highway (Bosje Brug, Tamanredjo, and Abadu Kondre) and at one location along the Moengo Road (Mora Kondre) (see Chapter 10 – Traffic and Transportation Safety Baseline).

To determine the variation in traffic volumes on different days of the week, traffic counts were taken on a weekend (Saturday, 10 September 2011) and a weekday (Tuesday, 13 September 2011) at each location. Since vehicle traffic is the dominant noise source along the Transportation Corridor, baseline hourly LAeq levels have been calculated using the traffic volumes collected by vehicle type at each traffic count location. Total hourly LAeq levels for all vehicle types at 15m from center of roadway were calculated in accordance with the United States Department of Transportation (USDOT) methodology for estimating traffic noise from highways and transit sources (USDOT 2006). The USDOT noise calculation parameters include each vehicle's reference sound levels at 50 miles per hour (80 km/hr) and at 50 feet (15 m) from center of roadways; daytime and nighttime hourly volumes of vehicles; average vehicle speed; and a speed constant for each vehicle type. Site visits indicate the average vehicle speeds observed along the East-West Highway and Moengo Road were approximately 55 km/hr. Figure 7-5 shows the reference sound levels for various vehicle types at 15 m from roadways and at various vehicle speeds, including the reference vehicle speed of 80 km/hr used in the USDOT calculation methodology. The figure also shows that heavy trucks generate the loudest noise while automobiles generate the least amount of noise. Table 7-2and ***Table***

7-3 show the baseline hourly noise levels along the Transportation Corridor during weekends and on weekdays, respectively.




Source: Federal Highway Administration (FHWA). 1998. Traffic Noise Model (TNM) Noise Technical Manual, FHWA-PD-96-010, DOT-VNTSC-FHWA-98-2, Final Report, February 1998 (FHWA 1998).

*Figure 7-5* *A-weighted Sound Exposure Levels at 15 m from Roadways for Vehicles at Various Speeds*

*Table 7-2 Calculated Baseline Hourly Noise Levels along the Transportation Corridor during Daytime and Nighttime on Weekends*

| | | Peak Hour Traffic Volume (Total, All Directions) | | | | | Hourly LAeq at 15 m from center of Roadway (dBA) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Location | Peak Hour | Auto-mobiles | Light/ Medium Trucks | Heavy Trucks | Motor-cycles | Total Traffic Volume | Auto-mobiles | Light/ Medium Trucks | Heavy Trucks | Motor-cycles | Total Hourly LAeq for all Vehicles |
| Daytime | | | | | | | | | | | |
| Bosje Brug | 1900h - 2000h | 779 | 87 | 18 | 64 | 948 | 61.3 | 60.3 | 57.5 | 56.5 | 65.4 |
| Tamanredjo | 1900h - 2000h | 363 | 44 | 16 | 53 | 476 | 58.0 | 57.4 | 57.0 | 55.7 | 63.1 |
| Abadu Kondre | 1600h - 1700h | 95 | 20 | 13 | 0 | 128 | 52.2 | 53.9 | 56.1 | 0 | 59.1 |
| Mora Kondre | 1330h - 1430h | 13 | 5 | 9 | 3 | 30 | 43.6 | 47.9 | 54.5 | 43.2 | 55.9 |
| Nighttime | | | | | | | | | | | |
| Bosje Brug | 0600h - 0700h | 221 | 34 | 21 | 24 | 300 | 55.9 | 56.2 | 58.1 | 52.2 | 62.1 |
| Tamanredjo | 0600h - 0700h | 29 | 12 | 5 | 11 | 57 | 47.1 | 51.7 | 51.9 | 48.8 | 56.3 |
| Abadu Kondre | 0600h - 0700h | 29 | 15 | 11 | 2 | 57 | 47.1 | 52.7 | 55.3 | 41.4 | 57.7 |
| Mora Kondre | 0600h - 0700h | 2 | 0 | 3 | 1 | 6 | 35.4 | 0 | 49.7 | 38.4 | 50.2 |

Notes:

[1] Vehicular traffic is the dominant noise source along the Transportation Corridor so baseline hourly noise levels were estimated based on existing vehicular traffic volume on the corridor. On Saturday, 10 September 2011 (weekend), existing vehicular traffic along the Transportation Corridor was counted at three locations on the East-West Highway (Bosje Brug, Tamanredjo, and Abadu Kondre) and one location on the Moengo Road (Mora Kondre). See Chapter 10 - Traffic.

2 Under the IFC noise guidelines, daytime periods are defined as any hour between 0700h - 2200h while nighttime periods are defined as any hour between 2200h and 0700h. Traffic counts were taken for 14 hours (0600h - 2000h) at each location and hourly noise levels were based on peak hour traffic volumes during daytime and nighttime. For this assessment, daytime peak hour traffic volumes were determined using the highest hourly traffic counts from 0700h - 2000h while nighttime peak hour traffic were determined based on traffic counts from 0600h - 0700h.

| Location | Peak Hour | Peak Hour Traffic Volume (Total, All Directions) | | | | | Hourly LAeq at 15 m from center of Roadway (dBA) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Auto-mobiles | Light / Medium Trucks | Heavy Trucks | Motor-cycles | Total Traffic Volume | Auto-mobiles | Light / Medium Trucks | Heavy Trucks | Motor-cycles | Total Hourly LAeq for all Vehicles |

3 Total hourly LAeq for all vehicle types at 15m from center of roadway was calculated in accordance with the FTA methodology for estimating traffic noise from highways and transit sources (USDOT 2006). The calculation parameters include each vehicle's reference sound levels at 50 miles per hour and (80 km / hr) at 15 m from roadways, daytime and nighttime hourly volumes of vehicles, observed roadway vehicle speeds, and a speed constant for each vehicle type. Speed constant for automobiles were assumed for motorcycles as well.

*Table 7-3 Calculated Baseline Hourly Noise Levels along the Transportation Corridor during Daytime and Nighttime on Weekdays*

| Location | Peak Hour | Peak Hour Traffic Volume (Total, All Directions) | | | | | Hourly LAeq at 15 m from center of Roadway (dBA) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Auto-mobiles | Light / Medium Trucks | Heavy Trucks | Motor-cycles | Total Traffic Volume | Auto-mobiles | Light / Medium Trucks | Heavy Trucks | Motor-cycles | Total Hourly LAeq for all Vehicles |
| Daytime[2] | | | | | | | | | | | |
| Bosje Brug | 1730h - 1830h | 713 | 62 | 42 | 91 | 908 | 61.0 | 58.8 | 61.1 | 58.0 | 66.0 |
| Tamanredjo | 0700h - 0800h | 242 | 32 | 24 | 98 | 396 | 56.3 | 56.0 | 58.7 | 58.3 | 63.5 |
| Abadu Kondre | 1400h - 1500h | 41 | 21 | 15 | 0 | 77 | 48.6 | 54.1 | 56.7 | 0 | 59.0 |
| Mora Kondre | 1400h - 1500h | 8 | 5 | 15 | 2 | 30 | 41.5 | 47.9 | 56.7 | 41.4 | 57.4 |
| Nighttime[2] | | | | | | | | | | | |
| Bosje Brug | 0600h - 0700h | 375 | 41 | 34 | 54 | 504 | 58.2 | 57.0 | 60.2 | 55.8 | 64.1 |
| Tamanredjo | 0600h - 0700h | 155 | 31 | 20 | 43 | 249 | 54.3 | 55.8 | 57.9 | 54.8 | 62.0 |
| Abadu Kondre | 0600h - | 26 | 10 | 7 | 0 | 43 | 46.6 | 50.9 | 53.4 | 0 | 55.9 |

| Location | Peak Hour | Peak Hour Traffic Volume (Total, All Directions) | | | | | Hourly LAeq at 15 m from center of Roadway (dBA) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Auto-mobiles | Light/ Medium Trucks | Heavy Trucks | Motor-cycles | Total Traffic Volume | Auto-mobiles | Light/ Medium Trucks | Heavy Trucks | Motor-cycles | Total Hourly LAeq for all Vehicles |
| | 0700h | | | | | | | | | | |
| Mora Kondre | 0600h - 0700h | 5 | 3 | 3 | 3 | 14 | 39.4 | 45.7 | 49.7 | 43.2 | 52.0 |

Notes:

1 Vehicular traffic is the dominant noise source along the Transportation Corridor so baseline hourly noise levels were estimated based on existing vehicular traffic volume on the corridor. On Tuesday, 13 September 2011 (weekday), existing vehicular traffic along the Transportation Corridor was counted at three locations on the East-West Highway (Bosje Brug, Tamanredjo, and Abadu Kondre) and one location on the Moengo Road (Mora Kondre). See Chapter 10 - Traffic.

2 Under the IFC noise guidelines, daytime periods are defined as any hour between 0700h - 2200h while nighttime periods are defined as any hour between 2200h and 0700h. Traffic counts were taken for 14 hours (0600h - 2000h) at each location and hourly noise levels were based on peak hour traffic volumes during daytime and nighttime. For this assessment, daytime peak hour traffic volumes were determined using the highest hourly traffic counts from 0700h - 2000h while nighttime peak hour traffic were determined based on traffic counts from 0600h - 0700h.

3 Total hourly LAeq for all vehicle types at 15m from center of roadway was calculated in accordance with the USDOT methodology for estimating traffic noise from highways and transit sources (USDOT 2006). The calculation parameters include each vehicle's reference sound levels at 50 miles per hour and (80 km/hr) at 15 m from roadways, daytime and nighttime hourly volumes of vehicles, observed vehicle speeds, and a speed constant for each vehicle type. Speed constant for automobiles were assumed for motorcycles as well.

Table 7-2 and Table 7-3 indicate that baseline daytime and nighttime noise levels along the Transportation Corridor were highest at Bosje Brug on weekdays (66.0 dBA at daytime and 64.1 dBA at nighttime) and weekends (65.4 dBA at daytime and 62.1 dBA at nighttime) due to the high vehicle traffic volumes at that location. Baseline noise levels along the corridor were generally higher during the weekdays than on weekends because of the higher heavy truck volumes on weekdays.

Some residential homes are very close to the Transportation Corridor, although commercial buildings are more prevalent along the road. As shown in the tables, baseline noise exceeds the IFC residential limit for night (45 dBA) and day (55 dBA) but just under the IFC limit of 70 dBA for the commercial buildings (70 dBA). This shows that the residential homes along the corridor are currently being impacted without the proposed project.

## 7.2 *EXISTING VIBRATION CONDITION*

Currently, no ground or air-vibrating sources or activities (i.e. mine blasting, piling, locomotives, etc) are present at the Mine Site or along the Transportation Corridor. In addition, rubber tired vehicles such as those that use the Transportation Corridor, do not generate any significant amount of ground vibration (USDOT 2006). Like noise emissions, ground and air vibration effects diminish with distance from the source, so baseline levels of vibration at the Mine Site, Transportation Corridor, and surrounding communities are expected to be negligible.

## 7.3 *REFERENCES FOR CHAPTER 7*

Federal Highway Administration (FHWA). 1998. Traffic Noise Model (TNM) Noise Technical Manual, FHWA-PD-96-010, DOT-VNTSC-FHWA-98-2, Final Report, February 1998.

United States Department of Transportation (USDOT). 2006. Transit Noise and Vibration Impact Assessment, Federal Transit Administration, FTA-VA-90-1003-06, May 2006.

# 8.0 *LANDSCAPE AND SOILS BASELINE*

Four major physiographical provinces can be distinguished in Suriname. From North to South, these include:

- The Young Coastal Plain;
- The Old Coastal Plain;
- The Savanna Belt; and
- The Precambrian Guiana Shield.

The Project site is entirely situated within the Guiana Shield physiographic zone. The surface of this shield has been shaped during billions of years of tectonic movements, weathering, denudation, and deposition under a range of different climates, and it can thus be characterized as a landscape of very old age. The current land surface is dominated by low hills, with a multi-convex topography. Above this hilly lowland, some higher residual hills, plateaus, and mountains arise, which often form prominent features in the landscape. These higher parts are often covered with a duricrust of laterite or bauxite (Noordam, 2007).

The regolith in which the soils of the Guiana Shield have developed is often deep and intensively weathered. The soils that were formed have been eroded several times during periods of strong denudation, coinciding with drier periods. After such periods of intense denudation, the soil formation process often had to start over again on the newly exposed regolith. The soils usually possess a good structure and a low to very low fertility. The nutrients are mostly concentrated in the biomass, the litter layer and the humic topsoil (Plantprop, 2003).

In general, the soils found within the Project Area can be characterized as dark and light brown sandy loams over clay, gravelly and rocky throughout on hilltops, terraces, and side slopes. These soils are mostly hard, dry, and predominantly well-drained, although poorly drained soils are found in riverine, valley bottom, and foot-slope landscapes.

Information on the landscapes and the soil types found at the Project Area was taken from the Soil Map of Suriname (DBK, 1977), which distinguished 9 soil map units in the area (see Table 8-1 and Figure 8-1).

*Table 8-1 Landscapes and Soil Map Units Found in the Vicinity of the Project Area — Suriname North of the 5th Degree of Latitude*

| Landscape | Landscape Element | Soil Map Unit (see Figure 8-1) | Soil Description |
|---|---|---|---|
| Terraces | Plateau and Slope Soils | 31 | Well and moderately well drained medium and coarse sand and (sandy) loam to sandy clay loam and (sandy) clay. |
| | | 33 | Imperfectly and poorly drained bleached medium and coarse sand. |
| | Valley Bottom and Foot-slope Soils | 34 | Poorly drained medium or coarse sand, loam, or clay. |
| Tibiti Landscape | Plateau and Hill-Top Soils | 43 | Moderately well and imperfectly drained sandy (clay) loam, often over sandy clay; locally gravelly clay. |
| | Plateau and Slope Soils | 44 | Moderately well and imperfectly drained sandy (clay) loam and (sandy) clay; locally with gravelly surface. |
| | Valley Bottom and Foot-Slope Soils | 46 | Poorly drained sand, sandy loam to clay. |
| Tempati Landscape | Hill-Top Soils | 64 | Well drained gravelly clay. |
| | Slope Soils | 65 | Moderately well drained gravelly soils. |
| | Valley Bottom and Foot-Slope Soils | 66 | Poorly drained loam to clay. |

Source: DBK, 1977.

To characterize the soils, soils at 10 locations within the study area from the same transect locations where the vegetation communities were characterized (see Chapter 11, Terrestrial Biolological Resources Baseline) were sampled on 15-18 January 2012 and described qualitatively based on their position on the landscape (see Figure 8-2 and Table 8-2). The locations were selected to sample representative landscapes and vegetative communities within the study area. As shown in Table 8-2, in general the soils have thin organic layers, with the depths of the leaf litter and humic layers (O-horizon) that ranged from 1 to 5 centimeters (cm) and from 0 to 5 cm, respectively. Furthermore, the topsoil layers (A/B horizons) are also relatively thin, with depths that ranged from 1 to 20 cm. In the northern part of the study area, the soils are sandy loams or mixed loams with gravel. In the southern part, the soils sampled tend to have a finer texture and are characterized primarily as silt loams, mixed with clays and gravel (see Table 8-2).

Since the topsoil resources in the study area are not significant, the preservation or salvage of this resource during construction activities of the mine facilities is not considered to be critical.

*Figure 8-1 Soil Map of the Project Area*

*Figure 8-2 Soil Sampling Locations*

*Table 8-2 Description of Soils in the Project Area*

| Location in Figure 8-2 | Landscape/ Topography / Drainage | Vegetation Type/Community | Soil Profile Surficial Layers Depths (cm) Leaf Litter | Humus | Topsoil[a] | Soil Description |
|---|---|---|---|---|---|---|
| M1 | Plateau, dry, and level terrain. Natural area (undisturbed) within a forested patch surrounded by previous ASM miner activity; recently felled trees; mostly level terrain within an upland community; dry; moderately drained soils. | Mixed tall forest (dryland). Ridge foreest | 2-3 | 1-4 | 1-3 | Lateritic soils; gravelly sandy loam; light brown color with many rocks, stones, gravel and pebbles and roots within the plot |
| M2 | Plateau, dry, and level terrain. Disturbed area; however, the sampling station is located within a naturally dense-shrub-dominated closed canopy area; mostly level terrain; within an upland community; dry; moderately to well drained soils. | Secondary Forest (dryland). | 1 | 0-1 | 1 | Lateritic soils; loamy gravelly sand; dark upper horizon underlain by a lighter sub-soil; much gravel and pebbles within sample; little root material. |
| M5 | Natural area within a forested area; dry, moderately sloping terrain, adjacent to recently cleared area; moderately drained. | Tall forest (dryland). Ridge forest | 2-3 | 2-5 | 1-4 | Loamy sand; very rocky and gravelly, much root-material, difficult to break through; bright brown colors. |
| M6 | Natural area perpendicular to existing road, steep slope; dense vegetation; poor to moderate drained. | Tall forest (dryland). Slope forest | 1-3 | 0-1 | 1-6 | Lateritic soils; gravelly sandy loam; clayey; many rocks, gravel, and pebbles; bright brown soils; little root material. |

| Location in Figure 8-2 | Landscape/ Topography / Drainage | Vegetation Type/Community | Soil Profile Surficial Layers Depths (cm) | | | Soil Description |
|---|---|---|---|---|---|---|
| | | | Leaf Litter | Humus | Topsoil[a] | |
| M8 | Disturbed area within previously ASM miner activity, floodplain with exposed soils, flat area with lots of rocks; little vegetation; poorly drained. | Secondary herbal vegetation | NA | NA | NA | Mixed loamy gravelly sand; silty; rocky. |
| R1 | Plateau to lowlands. Natural area within forested area; level terrain; very dry; two inches plus of leaf detritus and fibric material; moderately to well drained. | Tall forest (dryland). Slope ridge forest | 1-5 | 1-5 | 1-9 | Loose, fine sandy loam; many rocks, gravel, pebbles, and root material. |
| T2 | Plateau to lowlands. Natural area located on a steep slope in a densely vegetated area; moderately to well drained soils. | Tall forest (dryland). Slope forest | 1-3 | 1-2 | 2-20 | Fine sandy loam; many roots; little rocks within sample. |
| T3 | Lowland. Disturbed area located between two streams in densely vegetated area; undulated topography; saturated at the surface; water stained leaves; poorly drained. | Tall forest (dryland) | 1-4 | 0-1 | 20 | Fine silt loam with some clay (sticky); thin dark layer at surface; redoximorphic features (concentration and depletions) and oxidized rhizospheres; little rocks; water in pit at 15cm, seeping water at 10-12cm. |
| T4 | Lowlands. Disturbed area within lowland, seasonally flooded area (water stained leaves); flat terrain with thin leaf litter; poorly drained soils. | Secondary forest | 3-5 | 0-1 | 20 | Fine sandy loam or silt loam; fine sediment; at least two gray colored horizons/layers within plot. |

| Location in Figure 8-2 | Landscape/ Topography / Drainage | Vegetation Type/Community | Soil Profile Surficial Layers Depths (cm) | | | Soil Description |
|---|---|---|---|---|---|---|
| | | | Leaf Litter | Humus | Topsoil[a] | |
| T5 | Lowlands. Natural area within forested area; located on a moderately steep slope, adjacent to small depression; canopy is moderately open, much light reaches ground; moderately to well drained soils. | Tall forest (dryland) | 2-5 | 1-6 | 3-4.5 | Loamy fine sand; many small rocks, gravel, and pebble; much root material. |

[a] = Mineral surficial layers (topsoil) found on top of hard / rock layer.

Key:
M = Sample station located within the proposed mine and stockpiles areas.
T = Sample station located within the proposed tailing areas.
R = Sample station located within the proposed access roads.

## 8.1 *SOIL QUALITY AND PRODUCTIVITY*

Existing soil information available from the Soil Survey Department of Suriname does not include data on soil quality and productivity for the study area (DBK, 1977). Therefore, soil samples to assess the physical and chemical characteristics of the soils were collected from a depth of 0-20 cm from the 10 study plots described above in Figure 8-2. The results of the chemical characterization are presented in Table 8-3. Figure 8-3 shows a view of sample station during sampling located in an ASM impacted area.

As shown in Table 8-3, despite the often favorable physical properties of these soils (e.g., the soil texture of the soils are generally loams and clays), soil fertility is low. The cation exchange capacity (CEC) is low for all soils (average 3.8 milliequivalent per 100 grams of soil [meq/100 g]). Soils with a CEC below 10 meg/100g typically exhibit low fertility. This indicates that the soils can only adsorb a few cations, among which are nutrients. The average pH of the soils shows little variability, pH ranges from 4.2 to 5.3, indicating acid soils conditions. The total nitrogen and phosphorus and available phosphorus is also low, indicating that the availability of these nutrients is very low.

Comparison of the total metal levels measured in the soils sampled with common ranges of metal elemental composition levels observed for typical soils showed that most metals are within typical ranges and levels, with the exception of cadmium and molybdenum, which are high (see Table 8-3; Linday, 1979). Cadmium and molybdenum levels also exceeded the averaged metal levels from soils sampled in the nearby Nassau Plateau area. Molydenum is considered a plant micronutrient and it is only phytotoxic at high concentrations (usually >10 mg/kg) in alkaline soils, and soils rich in organic matter (SSSA, 1972; Kabata-Pendias and Kabata, 1972).

It should be noted that some degree of mercury, primarily associated with historical porknocking activities, may be present in the Project area that will require management. The Environmental Liability Assessment prepared for Surgold by TetraTech (May 2011) indicated raised levels of mercury in isolated areas of soils and perhaps in fish tissues as a result of illegal artisanal mining activities. It was reported that mercury ‘hotspots’ were recorded where artisanally mined material was processed.

*Figure 8-3 Soil Sampling Station M8 – an ASM Disturbed Area*

*Table 8-3 Summary of Chemical and Physical Characteristics of Soil found within the Study Plots and Comparison Background Soils*

| | Sample Station (see Figure 8-2 for Location of Stations) | | | | | | | | | | | | Common Range | Nassau |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **Unit** | **M1** | **M2** | **M5** | **M6** | **M8** | **R1** | **T2** | **T3** | **T4** | **T5** | **Mean** | **in Solis b** | **Plateau Soils c** |
| **Metals a** | | | | | | | | | | | | | | |
| Antinomy | mg/kg | 17.2 | 17.9 | 36.5 | 21.7 | ND | 19.2 | 11.3 | 12.4 | 18.3 | 15.5 | 17.0 | NR | 18.1 |
| Arsenic | mg/kg | 17.1 | 45.8 | 72.7 | 84.2 | 56.8 | 56.6 | 59.5 | 48.9 | 58.3 | 67.2 | 56.7 | 1-50 | 53.7 |
| Barium | mg/kg | 301.8 | 231.4 | 349.1 | 359.1 | 210.2 | 93.9 | 268.7 | 314.5 | 82.1 | 293.3 | 250.4 | 100-3,000 | 42.9 |
| Beryllium | mg/kg | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | 0.1-40 | ND |
| Bismuth | mg/kg | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | NR | ND |
| Cadmium | mg/kg | 33.0 | 44.4 | 55.3 | 53.1 | 36.1 | 25.0 | 11.5 | 5.4 | 2.8 | 25.3 | 29.2 | 0.01-0.70 | 18.4 |
| Calcium | mg/kg | 544.3 | 578.5 | 874.0 | 419.3 | 602.2 | 468.6 | 402.3 | 667.4 | 388.9 | 629.3 | 557.5 | 7,000-500,000 | 596.4 |
| Chromium | mg/kg | 437.2 | 599.7 | 813.9 | 866.1 | 485.3 | 530.7 | 424.4 | 464.5 | 278.1 | 520.1 | 542.0 | 1-1,000 | 667.0 |
| Lead | mg/kg | 58.9 | 66.5 | 60.5 | 58.0 | 70.1 | 44.7 | 46.5 | 46.7 | 42.8 | 50.3 | 54.5 | 2-200 | 35.8 |
| Magnesium | mg/kg | 888.8 | 606.9 | 1064.4 | 626.1 | 285.7 | 706.0 | 766.9 | 868.2 | 407.2 | 1018.0 | 723.8 | 600-6,000 | 397.6 |
| Mercury | µg/kg | 244.7 | 235.0 | 159.5 | 353.2 | 356.7 | 176.6 | 100.1 | 286.9 | 160.5 | 237.4 | 231.1 | 10-300 | 386.3 |
| Molybdenum | mg/kg | 4.8 | 9.2 | ND | ND | 34.6 | 2.5 | 17.6 | 10.2 | 12.3 | 16.6 | 10.8 | 0.2-5 | 7.1 |
| Nickel | mg/kg | 104.7 | 77.8 | 151.9 | 201.6 | 256.0 | 255.7 | 90.3 | 87.9 | 69.1 | 114.9 | 141.0 | 5-500 | 92.5 |
| Phosphorus | mg/kg | 177.1 | 330.9 | 129.6 | 129.4 | 586.7 | 230.9 | 246.5 | 109.8 | 81.7 | 176.2 | 219.9 | 200-5,000 | 537.6 |
| Selenium | mg/kg | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | 0.1—2 | ND |
| Silver | mg/kg | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | 0.01-5 | ND |
| Strontium | mg/kg | 125.4 | 122.2 | 102.8 | 155.6 | 100.1 | 47.3 | 111.7 | 125.1 | 61.3 | 142.4 | 109.4 | 50-1,000 | 29.3 |
| Vanadium | mg/kg | 324.1 | 526.5 | 547.7 | 645.9 | 304.7 | 338.7 | 163.9 | 78.5 | 39.8 | 276.2 | 324.6 | 20-500 | 1,954.7 |
| Yttrium | mg/kg | 42.8 | 35.6 | 16.9 | 28.3 | 11.9 | 8.1 | 14.8 | 18.6 | 12.8 | 30.9 | 22.1 | 25-250 | 9.3 |
| Zinc | mg/kg | 54.8 | 36.4 | 41.1 | 40.4 | 48.3 | 48.5 | 51.8 | 14.9 | 10.2 | 73.3 | 42.0 | 10-300 | 49.4 |
| Zirconium | mg/kg | 332.7 | 301.5 | 375.6 | 517.4 | 252.9 | 452.0 | 401.8 | 382.6 | 370.6 | 477.8 | 386.5 | 60-2,000 | 1,275.6 |
| **Nutrients d** | | | | | | | | | | | | | | |
| Total Nitrogen | % | 0.27 | 0.30 | 0.41 | 0.38 | 0.21 | 0.34 | 0.02 | 0.21 | 0.13 | 0.43 | 0.3 | — | 0.46 |
| Total Phosphorus | mg/kg | 58 | 93 | 86 | 91 | 65 | 91 | 40 | 96 | 64 | 151 | 83.5 | — | 274 |
| Available Phosphorus | mg/kg | 0.6 | 2.8 | 1.4 | 1.0 | 0.6 | 1.4 | 0.9 | 3.7 | 1.3 | 2.7 | 1.7 | — | 1.17 |
| **Other Soils Parameters d** | | | | | | | | | | | | | | |
| pH | Standard Units | 4.2 | 4.2 | 4.2 | 4.5 | 5.3 | 4.3 | 4.2 | 4.9 | 4.4 | 4.2 | 4.4 | — | 4.3 |
| Organic Carbon | % | 3.96 | 4.54 | 7.55 | 5.11 | 0.11 | 5.74 | 3.14 | 2.74 | 1.86 | 5.54 | 4.0 | — | 7.91 |
| Cation Exchange | meq/100 g | 3.85 | 5.02 | 5.90 | 4.73 | <0.1 | 4.14 | 2.13 | 1.78 | 0.78 | 5.60 | 3.8 | — | 3.92 |

| | Sample Station (see Figure 8-2 for Location of Stations) | | | | | | | | | | | Common Range in Solis b | Nassau Plateau Soils c |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **Unit** | **M1** | **M2** | **M5** | **M6** | **M8** | **R1** | **T2** | **T3** | **T4** | **T5** | **Mean** | | |
| Capacity (CEC) | | | | | | | | | | | | | | |
| Exchangeable Aluminum | meq/100 g | 3.31 | 3.44 | 4.09 | 2.87 | 0.07 | 3.49 | 2.25 | 0.90 | 1.66 | 4.18 | 2.6 | — | 3.17 |
| **Particle Size d** | | | | | | | | | | | | | | |
| 2 - 0.063 (Sand) | mm | 45.9 | 32.2 | 36.4 | 42.0 | 69.7 | 41.0 | 34.3 | 40.0 | 46.4 | 37.4 | 42.5 | — | — |
| 0.063 - 0.002 (Silt) | mm | 13.8 | 12.4 | 16.2 | 13.5 | 24.1 | 16.7 | 35.2 | 41.2 | 42.8 | 13.3 | 22.9 | — | — |
| < 0.002 (Clay) | mm | 40.2 | 55.4 | 47.4 | 44.5 | 6.2 | 42.3 | 30.5 | 18.8 | 10.8 | 49.3 | 34.5 | — | — |
| > 2 (Gravels) | mm | 60.60 | 51.99 | 70.32 | 74.13 | 49.23 | 23.69 | 19.21 | 1.89 | 0.75 | 23.95 | 37.6 | — | — |
| Soil Texture | — | Sandy Clay | Clay | Clay | Clay | Sandy Loam | Clay | Loam | Loam | Loam | Clay | — | — | — |

a Samples analyzed at Suralco Chemical Laboratory in Paranan.

b From Lindsay, W. (1979); common range for soils.

c Suralco (2011); mean values from 16 soils soil samples collected at the Nassau Plateau, Suriname.

d Samples analyzed at the Anton de Kom University of Suriname Soils Testing Laboratory in Paramaribo.

Key:

ND = Not Detected (Below detection limit).

NR = Not Reported.

## 8.2 *REFERENCES FOR CHAPTER 8.0*

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# 9.0 *WATER RESOURCES BASELINE*

The following Chapter addresses water resources in the Project Area and region and includes a discussion of both surface water and groundwater resources. The surface water discussion addresses surface water quantity, quality and streambed sediment quality and is presented by watershed. The hydrogeology discussion addresses groundwater occurrence, groundwater movement and flow paths and groundwater quality. Surface waters and groundwater are influenced by local and regional climate, topography, soils, land use and geology, which were topics addressed in detail in Chapter 7 of this ESIA. This water resources Chapter provides an overview of the influence of these characteristics on surface water and groundwater resources.

The Chapter is organized as follows:

- Overview of climate;
- Surface Water characteristics of the Commewijne watershed on a regional and project-specific basis, including delineation of site drainage basins and streamflow characteristics, flow paths, water quality and sediment quality;
- Surface water characteristics of the Marowijne watershed: on a regional and project-specific basis, including delineation of site drainage basins and streamflow characteristics, flow paths, water quality and sediment quality;
- Regional hydrogeology focused on groundwater occurrence, general groundwater quality and water uses; and
- Project-specific hydrogeology, including discussion of site-specific detail regarding groundwater occurrence, groundwater elevations, flow paths and groundwater quality.

This Chapter is supported by a series of technical studies performed by Golder Associates, Inc. (Golder), which are provided in Appendices to this ESIA. These include:

- Merian Site-Wide Water Balance Model (Appendix 3-D);
- Merian Climate Summary (Appendix 9-A);
- Merian Baseline Hydrology Report (Appendix 9-B); and
- Merian Hydrogeology Baseline Report (Appendix 9-C); and
- Merian Baseline Water Quality Summary Report (Appendix 9-D).

These baseline studies and technical evaluations provide more comprehensive and detailed information regarding the issues summarized in this Chapter and should be referenced as needed.

The Project is located in an inland region of Suriname, approximately 90 km from the Atlantic Ocean Coast on the divide between two major rivers (Figure 9-1). The Project Area is a densely forested region with large steep hills leading down to incised valleys. A series of smaller creeks descend from the upland areas to larger regional rivers which transfer flow from the watershed to the coastal area before it discharges to the ocean.

The eastern portion of the Study Area (approximately 70% of the disturbance footprint of the Project) is located in the lower Marowijne River watershed. The Marowijne River is one of the largest rivers in Suriname. The river flows to the north east and discharges to the Atlantic Ocean near Mana, approximately 90 km downstream of the Project Area. The western portion of the disturbance footprint of the Project (approximately 30% percent of the site) is located in the upper reaches of the Commewijne River watershed. The Commewijne River, although one of the major rivers of Suriname, is much smaller than the Marowijne. The river flows to the west-northwest and discharges to the Atlantic Ocean near Paramaribo, approximately 100 km northwest of the Project Area. The branch of the Commewijne downstream of the Project and its many tributaries is often referred to collectively as Tempati Creek. For the purposes of this ESIA the river is referred to as the Commewijne River and the name Tempati Creek has been used to describe a much smaller tributary within the Study Area.

The Project Area is subject to an equatorial climate and is hot, humid, and, generally receives rainfall throughout the year, although it has established wet and dry seasons. Average annual precipitation in the Project Area is estimated at 2,382 mm (based on conservative estimations using figures from the Sipaliwini District and the on-site meteorological station). Runoff and streamflow varies throughout the year in response to precipitation patterns. Highest runoff and streamflow is in the wetter months. During the drier months (September and October), streamflows are less and a large proportion of the streamflow is composed of groundwater discharge to streams (baseflow).

Surface water quality in the Interior of Suriname is variable but generally slightly acidic, low-hardness, with high dissolved oxygen and low nutrient levels. ASM activities in the Interior are common and are known to significantly increase sediment loads and potentially other contaminant concentrations associated with ASM mining activities. In the Project Area, ASM hydraulic mining has been active for many years and has extensively impacted the main creeks and tributaries and downstream waters mainly through disturbance to creek valleys and streambeds resulting in a substantially increased sediment load. Over the past year an “Industrial Zone” controlled by Surgold has been re-established by the Surinamese government in which ASM mining is not allowed; however, the ASM mining is continuing outside the Surgold Industrial Zone and within the Project Area and Study Area.

The hydrogeology in the Study Area is a function of the underlying geological conditions, topography, and climatic conditions. The area is underlain by four primary stratigraphic units: alluvium, saprolite, saprock, and bedrock. Relatively thin and unconsolidated alluvial sediments are present in the valley areas along and adjacent to the stream channels.

*Figure 9-1 Regional Watersheds*

The topographic conditions influence the thickness of the surficial saprolite unit. The saprolite is thickest below the higher elevation areas and thinnest in the valley bottoms. The saprolite is predominately silt (with varying proportions of sand and clay) derived from the underlying metasedimentary bedrock (siltstone/sandstone units). The saprolite is overlain with a veneer of thin organic litter topsoil. The saprolite, saprock and bedrock include near-vertical quartz veins which extend to ground surface subcropping below the thin soil cover. In the ore zones (areas planned for the open pits), the quartz veining density is greatest.

Groundwater is found in all stratigraphic units. Groundwater elevations are highest below the hill tops and lowest in the valley bottoms. Groundwater flow is from higher to lower elevations, discharging as baseflow to streamflow. With the exception of the thin quartz veins, the geological units encountered in the Project Area are of relatively low permeability. Groundwater flow occurs within the saprolite, saprolite quartz vein systems, fractured saprock, and fractured bedrock. There is little groundwater flow in unfractured saprock or bedrock because of its very low permeability. Quartz veins (and occasional zones of highly fractured bedrock) are the most permeable units in the Project Area.

Water use in the Project Area is limited in part due to the very small population in the entire region. There are no known uses or users of groundwater. Surface water and rain water provide water for domestic use. Streams and rivers are used for transportation and fishing. The closest communities to the Study Area are Langa Tabiki (17 km to the southeast), Akaati (16 km to the southeast), and the nearest town is Moengo (60 km to the north). In Langa Tabiki and Akaati, rain water is collected from roofs to small barrels and stored for domestic needs. Similarly, ASM miners in the area either collect rain water for domestic supplies or transport water from larger urban centers. Moengo has a water treatment plant that treats water from the Cottica River for distribution. The Cottica River lies outside the Project's area of influence and, therefore, is not discussed further.[7]

## 9.1 *CLIMATE*

As discussed in greater detail in the Merian Climate Summary (Appendix 9-A), the climate of Suriname is characterized by two short and two long wet and dry seasons. The short wet season is from December to January followed by the short dry season from February to April. The long wet season is considered to be from April to August and the long dry season between August and November.

Precipitation data were collected on-site (Merian site gage) from 2005 - 2011 and are summarized in Chapter 5 Project Setting. Regional precipitation data were obtained from the Surinamese government for six sites in the northeastern part of the country. The gage with the most complete data set, approaching 100 years of data (1905-2010), is the Alliance gage located approximately 90 km northwest

[7] Base on local knowledge collected during Social Baseline studies.

of the Project Area near Paramaribo. The gage closest to the Project site is the Langa Tabiki gage (23 years of record). The Langa Tabiki gage, located approximately 10 km southeast of the Project Area, provides the best estimate of precipitation with respect to proximity while the Alliance gage provides the best long-term estimates.

Because the Merian site precipitation record is short, both gages (Langa Tabiki and Alliance) as well as site data were used as a basis for estimating long-term site average precipitation (detailed analysis is provided in Appendix 9-A). The actual simultaneous precipitation at Langa Tabiki and the Merian site frequently differ. Simultaneous precipitation from these two gages is poorly correlated (correlation coefficient =0.33), which indicates that individual precipitation events are often localized and can vary substantially over distances as short as 15 km. However the mean monthly precipitation and mean annual precipitation at these two locations is very similar, suggesting that given enough time the two gages produce statistically similar data.

Similarly, the relationship between Alliance and Langa Tabiki rain gage data shows that individual months and years of precipitation have a poor correlation but the mean monthly and mean annual precipitation for both gage's are very similar. Therefore data from Langa Tabiki and Alliance were adjusted for period bias and geography bias and the resultant data was used to develop a mean monthly estimate of precipitation at the Merian site. Details regarding the methodology used to establish precipitation conditions at the site are provided in Appendix 9-A. Average long-term total rainfall for the Project Area is estimated to be 2,382 mm/year.

While the above value demonstrates that the Project Area receives substantial rainfall, only a portion of the precipitation enters local creeks and rivers as runoff. The remainder of the water is lost directly to the atmosphere by evaporation, is indirectly returned to the atmosphere via vegetation uptake/transpiration (referred to as evapotranspiration), or infiltrates to become shallow interflow or move deeper into the soil profile to eventually recharge the groundwater system.

Evaporation rates are affected by numerous factors, but mainly by air temperature, humidity and wind speed. Evaporation data were collected at the Merian site using an evaporation pan; however inspection of the data collected at Merian indicates extensive time periods with either missing data or data that are unrealistic, suggesting possible equipment malfunction. Consequently, evaporation data from the Rosebel Gold Mine site (located in Suriname, approximately 50 km west of the Project site) were applied for the purposes of this study. The Rosebel data are considered representative of regional conditions, because evaporation data usually do not vary significantly across a region if the elevation and climatic conditions are similar.

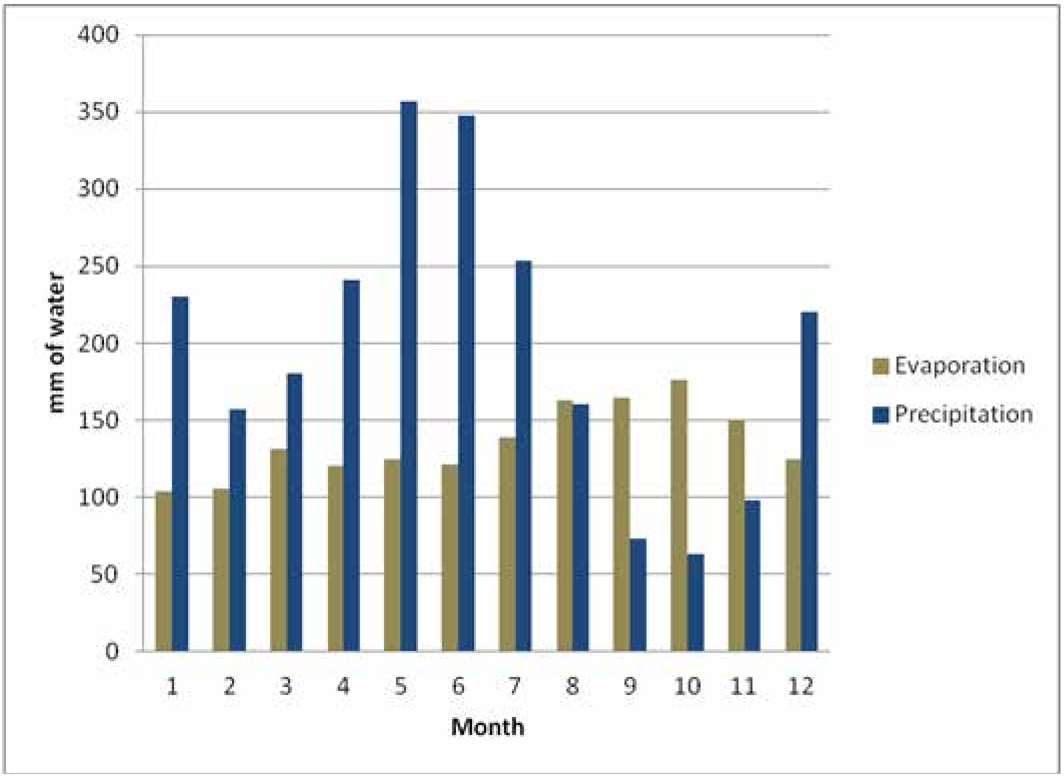
Evaporation from the Rosebel Mine are available from 2006 – 2011 and the average annual evaporation reported (prior to adjustment for a Class A pan) is 1623.7 mm. Regional evaporation data are available for four stations: Jarikaba, Zorg en Hoop, Nickerie, and Kwamalasamutu. The period of record covered by these stations is 1973-1990 (not all stations report data for all years). The range of average annual evaporation of these four stations is 1013.2 mm – 1801 mm.

All four of the stations are located some distance from the Merian site. Jarikaba and Zorg en Hoop are located on the coast, between 90 to 120 km from the Merian site; Nickerie is in the far west of the country and located in the Interior approximately 250 km west of the Merian site; and Kwamalasamutu is located in the far south of the country on the border Brazil, approximately 400 km southwest of the Merian site. Given that Rosebel is located closer to the Merian Site than any of these regional stations and given that the Rosebel data fall within the range of the other evaporation stations, applying Rosebel data is considered acceptable.

Pan evaporation provides an estimate of evaporation and is typically adjusted to better represent actual evaporation by applying a coefficient established through calibration. Calibration work at Rosebel suggests a coefficient between 0.5 and 0.6.

The distribution of the Merian site's estimated long-term average monthly precipitation and evaporation (not adjusted with the pan coefficient) rates are presented in Figure 9-2. These estimates show that monthly precipitation rates vary more significantly than do monthly evaporation rates, which indicates that precipitation has a greater effect on runoff and streamflow than does evaporation. For most of the year precipitation exceeds evaporation, even in the short-dry season between February and April. The months of September to November in the long dry season can be expected to have the lowest streamflows. During this season flow in the smaller creeks and streams will mainly be supplied by baseflow from groundwater.

A site-wide water balance including precipitation, evaporation, and runoff is presented in Appendix 3-D.




Source: Climate Summary (Appendix 9-A)

*Figure 9-2 Mean Monthly Precipitation and Evaporation (mm) long-term estimates at Merian*

## 9.2 SURFACE WATER

Suriname is divided into three (sometimes four) main physiographic zones or provinces: the Interior (also referred to as the Interior Precambrian Shield), which is by far the largest zone, the Savannah Belt, and the Coastal Plain (the Coastal Plain is sometimes divided into two distinct zones: the New and the Old Coastal Plains). These zones have distinct topography, geology and soils that influence hydrologic conditions. Figure 9-3 shows the geographic extent and characteristics of the three zones as defined by the United States Army Corps of Engineers (USACE) (USACE, 2001).

*Figure 9-3 Surface Water Resources of Suriname (USACE 2001)*

The Project is situated in the Interior physiographic zone (province) on the divide of two major watersheds: the Marowijne and Commewijne (Figure 9-1). Table 9-1 presents each river's total catchment (watershed) area, mean discharge as reported by the USACE (2001) for the total watershed and the percentage of each watershed located in each of the country's three physiographic zones (provinces). Table 9-1 clearly demonstrates that the Marowijne River watershed is primarily within the Interior zone, whereas the Commewijne River watershed, while in the Interior zone in the Project Area, has predominant Coastal Plain zone features further downstream.

*Table 9-1 Catchment Areas of Major Rivers within Project Area*

| River | Total Catchment Area (km2) | Mean Discharge (m3/s) | Interior (%) | Savannah Belt (%) | Coastal Plain (%) |
|---|---|---|---|---|---|
| Commewijne | 6,600 | 169 | 36.4 | 11.5 | 52.1 |
| Marowijne | 68,700 | 1791 | 99.45 | 0.05 | 0.5 |

### 9.2.1 *Commewijne River Watershed*

As shown in Figure 9-1, approximately 30% of the Project Area is located in the upper reaches of the Commewijne River watershed. The Commewijne River flows to the Suriname River just before the Suriname River discharges to the Atlantic Ocean. The vast majority of the Commewijne River watershed is uninhabited and undeveloped. While approximately half of the Commewijne River watershed lies in the Coastal Plain, the Project Area is located in the upper reaches of the Commewijne where flows are dominated by the characteristics of the Interior Precambrian Shield. The Project will disturb the surface area of approximately 0.8% of the Commewijne's total drainage area and approximately 5% of the surface area of the headwaters of the Commewijne. The Commewijne River and its tributaries support a variety of aquatic life and fishing is common on the river throughout the watershed although the population that uses the river is quite small. The river in the region is also used during cultural celebrations.

Streamflow has not been historically measured on the Commewijne, therefore, a regional analysis is required to predict streamflows on the river. Within Suriname streamflow data for nine regional stream gages are available through the Global Runoff Data Center (GRDC), including two stations located on the Marowijne River: one located at Langa Tabiki in Suriname and one located near Langa Tabiki but in French Guiana. The measured drainage basins for the nine stations range in size from 4,930 $km^2$ to 63,700 $km^2$. The period of record of measurements made at these regional stream gages are short and mainly limited to the late 1970s. Given the short and dated periods of record these data can only provide estimates of long term streamflow conditions in the region. One station on the Marowijne River at Langa Tabiki in French Guiana provides a longer and more current period of record (1951-1996).

A detailed analysis of regional streamflow characteristics was completed by Golder (2012) and is included in Appendix 9-B. Figure 9-4 shows the location of the regional streamflow stations for which historic data was available. Average monthly discharge rates per unit area ($m^3/s$ per $km^2$) were calculated based on streamflow data from all nine stations and are presented in Table 9-2.

*Table 9-2 Regional Stream Gage Monthly Summary*

| Parameter | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Unit Discharge Average (m3/s/km2) | 0.017 | 0.018 | 0.026 | 0.040 | 0.049 | 0.052 | 0.040 | 0.031 | 0.016 | 0.009 | 0.007 | 0.014 |
| Water Yield (cm) | 4.7 | 4.3 | 6.9 | 10.3 | 13.2 | 13.5 | 10.8 | 8.3 | 4.3 | 2.5 | 1.8 | 3.9 |
| Percent of Annual Flow | 5.0 | 4.9 | 7 | 10.7 | 14.6 | 17.5 | 15 | 11.8 | 5.8 | 2.9 | 1.8 | 3.0 |

Source: Baseline Hydrology Report (Appendix 9-B)

From the data presented in Table 9-2, the average monthly streamflow rates in the Commewijne can be estimated by multiplying the average unit discharge/$km^2$ by the drainage area upstream of each identified point of interest. Three evaluation points on the Commewijne have been identified as relevant to the ESIA (as shown in Figure 9-5). Commewijne at Las Dominicanas Creek, the Commewijne at Poithede and the Commewijne at Java. The Commewijne at Las Dominicanas Creek is the location at which the potentially impacted Las Dominicanas Creek discharges to an upper branch of the Commewijne River. The Commewijne at Poithede is the first named point on the river downstream of the Project. While Poithede is not inhabited it was a settlement prior to the Surinamese civil war. People left the area after the war but retain a tie to the land and use the area at time for fishing, agriculture and ceremonies. The Commewijne at Java is the first point downstream of the Project that impacts may reach the main stem of the Commewijne River. Table 9-3 presents estimated streamflow rates at these three locations.

*Figure 9-4 Regional Stream Gage Locations*

*Figure 9-5 Regional Hydrology Points of Interest*

*Table 9-3 Estimated Commewijne River Watershed Monthly Average Streamflow (m3/sec)*

| Point of Interest | Drainage Area (km2) | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Commewijne at Las Dominicanas Creek | 448 | 8 | 8 | 12 | 18 | 22 | 23 | 18 | 14 | 7 | 4 | 3 | 6 |
| Commewijne at Poithede | 854 | 15 | 15 | 22 | 34 | 42 | 44 | 34 | 26 | 14 | 8 | 6 | 12 |
| Commewijne at Java | 1572 | 27 | 28 | 41 | 63 | 77 | 82 | 63 | 49 | 25 | 14 | 11 | 22 |

### *9.2.2 Study Area Streamflow - Commewijne River Watershed*

The Study Area, like all of Suriname, is densely forested and is underlain by saprolitic soils derived by the deep tropical weathering of the underlying bedrock. The Study Area is located in an area of steep hills and incised valleys. The local topography results in the concentration of runoff into numerous small headwater creeks which enter larger creeks flowing within the wider main valley bottoms. The dense tree canopy results in elevated rates of evapotranspiration. Water is either taken up by vegetation and lost to the atmosphere through transpiration or stored in the forest canopy and lost to the atmosphere through evaporation. The steep slopes and low permeability of the near surface saprolite create conditions for high runoff once water reaches the ground surface. Some shallow interflow (flow in the unsaturated zone) occurs within the thin soil layer and uppermost pisolithic saprolite zone. However, because of the relatively low permeability of the saprolite (silt), the overall rate of groundwater recharge is low. There is the potential for greater recharge where zones of more permeable quartz veins outcrop at the surface or below the thin soil cover.

The main creeks in the Study Area are shown in Figure 9-6. The Las Dominicanas Creek watershed is the main tributary subwatershed that is directly impacted by the Project footprint within the larger Commewijne River watershed. The total drainage area of the Las Dominicanas Creek is 54 $km^2$ and the creek flows from south to north to discharge to the Commewijne. The total Project footprint within the Las Dominicanas drainage area is 1,550 ha or 30% of the total Las Dominicanas drainage basin. Sub drainage basins in the Las Dominicanas watershed are:

- North Fork A3 Creek (surface water monitoring location SW-35);
- South Fork A3 Creek (surface water monitoring location SW-38);
- Upper Las Dominicanas Creek (surface water monitoring location SW-30); and
- Tempati Creek (surface water monitoring location SW-36).

Within the Las Dominicanas Creek watershed the creeks range in width from <1m to larger creeks with widths of approximately 10 to 15 m. During dry periods many of the creeks are only 10 to 30 cm deep in places. During wetter periods the larger creeks can often not be crossed by fording or wading across the streams. Water depths of nearly 2 m have been measured at the Las Dominicanas Creek stream gage. The small tributary creeks that are present on the steep hill sides have relatively straight channels. Once in the valley bottom areas, the creek gradient flattens and meanders develop. A3 Creek and Tempati Creek are both currently subject to active ASM mining. Signs indicate that ASM mining is also active on the main stem of Las Dominicanas Creek. ASM activity significantly alters the hydrologic regime of the drainages, and based on antedoctol information, the hydrology will remain altered for several decades unless active intervention is made.

*Figure 9-6 Project Creeks and Basins*

Figure 9-7 and Figure 9-8 show a small un-named tributary to A3 Creek and Las Dominicanas Creek (at SW-27[8]) respectively, as examples of creek dimensions in the drainage basin. Also of note in these two photos is the difference in turbidity of the two streams. The high turbidity in Las Dominicanas Creek at SW-27 is attributed to disturbances from ASM activities higher up in the drainage basin. Las Dominicanas Creek at SW-27, where this photo was taken, was mined out shortly after the photo was taken and there is no longer a creek as shown here at this location.

*Figure 9-7 Small Tributary to A3 Creek*

[8] SW-## connotation is used to identify surface water monitoring stations in the Project baseline environmental monitoring program. These are further described in the following section.

*Figure 9-8 Las Dominicanas Creek at SW-27 (August, 2012) before 2012 Disturbance by ASM mining*

Streamflow characteristics for the Project were studied through on-site stream gage stations established in late 2011 (see Baseline Hydrology Report, Appendix 9-B for additional details). The locations of these stations are shown in Figure 9-9 and summarized in Table 9-4. Most of these stations remain in place and continue to collect data. The notes in the table demonstrate the difficulties associated with operating continuous streamflow stations in an area being actively mine by ASM miners. The creeks in the immediate area of the two of the gaging stations were dug up by ASM activities only a short time after being instrumented. Stream gage station locations were selected to measure streamflow downstream of critical mine infrastructure and also to provide streamflow data from a range of basin sizes and types.

*Figure 9-9 Surface Water Monitoring Locations*

*Table 9-4 Summary of Project Streamflow Gaging Stations*

| Watershed | Site ID | Creek | Drainage Area (km2) | Period of Record | Notes |
|---|---|---|---|---|---|
| Las Dominicanas Creek (Commewijne) | SW-35 | North Fork A3 Creek at Log Bridge crossing | 2.8 | 1 Sep 2011 to 22 Aug 2012 | The period of record and range of manual flow measurements provides good estimates of low flows/baseflows and rough estimates of total runoff |
| Las Dominicanas Creek (Commewijne) | SW-38 | South Fork A3 Creek at proposed Phase 1 dam site | 7.03 | 11 Oct 2011 to 16 Nov 2011 | Gage was removed due to channel disturbance (i.e. ASM mining) |
| Las Dominicanas Creek | SW-36 | Upper Tempati Creek | 1.26 | 30 Aug 2011 to 5 Nov 2011 | Gage was removed due to encroachment of active ASM mining |
| Las Dominicanas Creek (Commewijne) | SW-30 | Upper Las Dominicanas | 20.6 | 23 Nov 2011 to 29 July 2012 | The period of record and the range of manual flow measurements allows for estimating low flows and baseflows only |
| Las Dominicanas Creek (Commewijne) | SW-27 | Lower Las Dominicanas Creek | 38.7 | Gage not installed due to active ASM mining at proposed location | |
| Merian Creek (Marowijne) | SW-4B | Tomulu Creek at 4 Km Bridge | 19.6 | 1 Sep 2011 to 22 Aug 2012 | The period of record and range of manual flow measurements provides good estimates of low flows/baseflows and rough estimates of total runoff |
| Merian Creek (Marowijne) | SW-34 | Lower Merian Creek | 87.8 | 1 Dec 2011 to 23 Aug 2012 | The period of record and range of manual flow measurements provides good estimates of low flows/baseflows and rough estimates of total runoff |

Data collected at a streamflow station consist of continuous water level data collected by a pressure transducer and data logger and periodic streamflow measurements collected by field personnel. Streamflow and water level are assumed to have a unique relationship at each gaging station. This relationship (called a rating curve) is used to estimate streamflow for any measured water level by the pressure transducer. Streamflow measurements are required for a range of flow conditions in order to establish a relationship that predicts streamflow for the entire range of water levels measured at the station location. In some cases, for stations in the Study Area, access and other obstacles have limited the number of streamflow measurements such that a rating curve could not be accurately established for the gaging station. Efforts continue to collect these data so that flow records can be improved. Runoff models and the water balance calculations will be refined based on improved streamflow data.

Generally, streamflow within the Study Area shows very quick responses in the streams to precipitation events, which is to be expected in steep terrain, small basins, and relatively impermeable soil. An increase in baseflow, or groundwater contributions to streamflow, can be observed in the wetter months as groundwater levels gradually rise and more groundwater is discharged to surface water.

As described in Table 9-4, the gage reporting streamflow data over the widest range of flows in the Las Dominicanas basin is SW-35 on the North Fork of A3 Creek. Figure 9-10 shows the creek at the gaging station.

Streamflow measurements at the SW-35 gage (for a period from September 2011 to February 2012) are presented in Figure 9-11. Also included are daily precipitation data measured at the Merian climate station. As can be seen in the Figure, the creek responds very quickly to precipitation events and recedes just as quickly. Figure 9-12 presents an extended record of streamflow data measured at SW-35 (through September 2012) shown on the log scale so that lower flows are more easily reviewed. Baseflow, or groundwater contributions, have been estimated and are shown on the Figure. Average monthly unit area discharge volumes ($m^3/sec/km^2$) are estimated for the months of record and are presented in

Table 9-5. These show the lowest flow months to be September – December, which coincide with the more regional flow patterns where the lowest flows of the year occur through October – December. Even though SW-35 has the most robust rating curve of the Las Dominicanas stations, some measured water levels are above the highest measured water level for which a streamflow rating curve has been developed and therefore, these peak flows remain best estimates.

*Figure 9-10 Looking Upstream at SW-35 (North Fork A3 Creek - August 2011)*

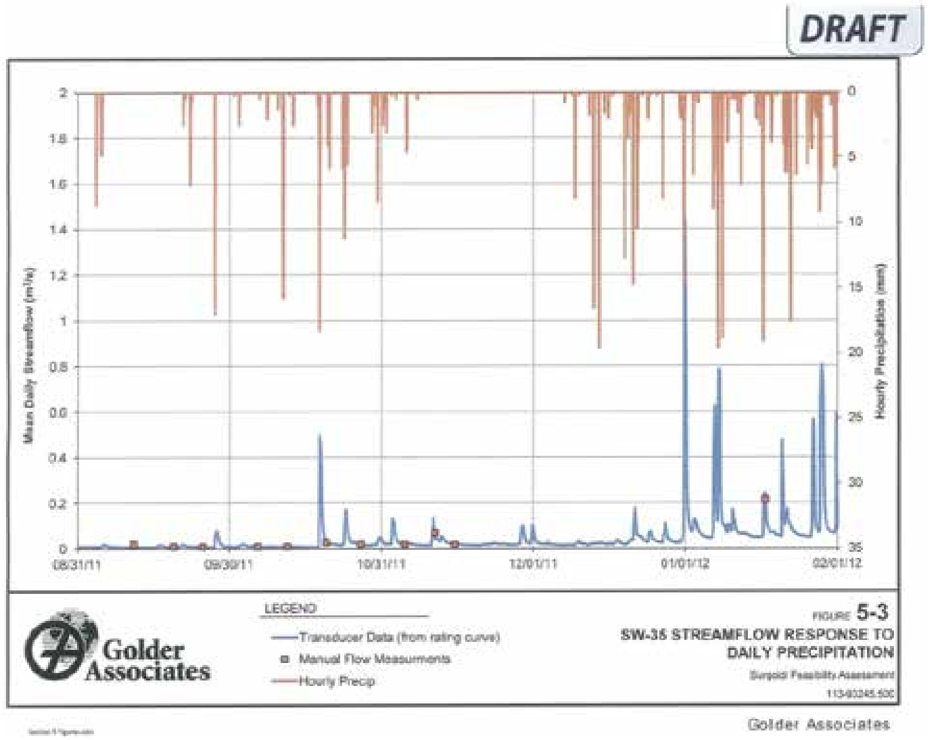



*Figure 9-11 SW-35 (North Fork A3 Creek) Streamflow Response to Daily Precipitation*

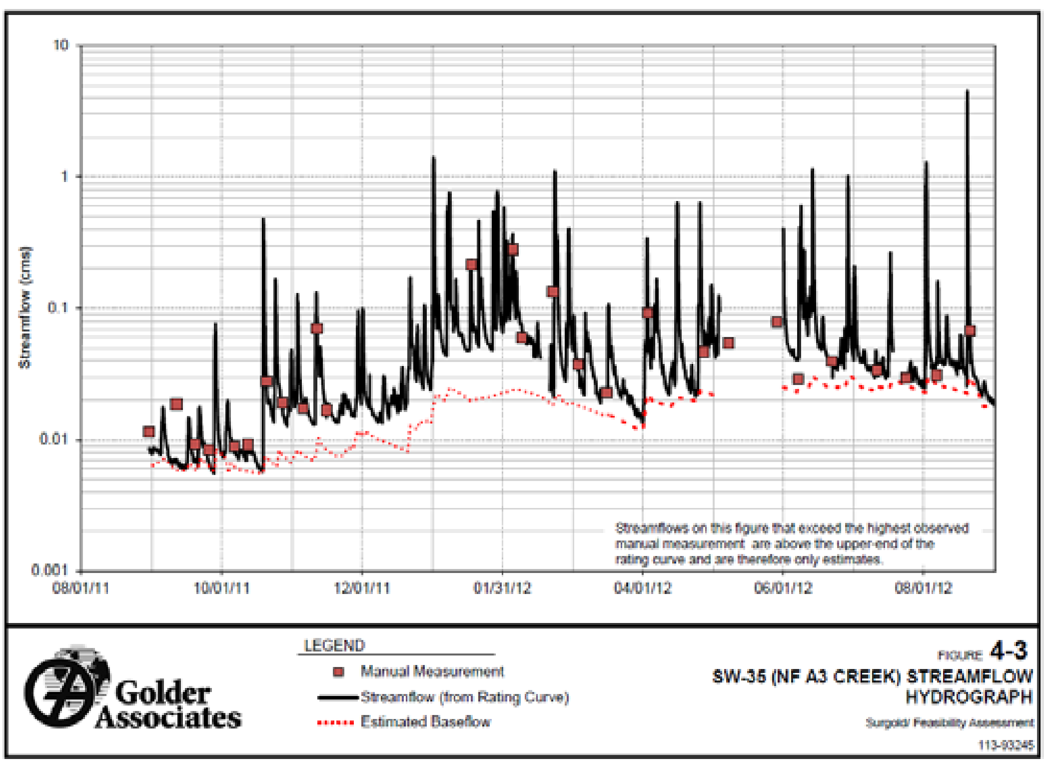



*Figure 9-12 SW-35 (North Fork A3 Creek) Streamflow Hydrograph*

Despite difficulty establishing high-flow rating curve data, low flows have been generally well measured and the data are considered to reflect measured conditions. However, these low flow estimates are based solely on one season of data and therefore can only provide a very preliminary estimate of streamflow characteristics in the dry season. Baseflows, or groundwater contribution, have been estimated by Golder (Baseline Hydrology Report, Appendix 9-B). A summary of monthly streamflow data collected at SW-35 is provided in Table 9-5. Streamflow was greatest during the wettest months of January and February 2012, a period of high runoff and baseflow rates. Streamflow was lowest during the dry month of September 2011, with baseflow providing the greatest contribution during this period.

*Table 9-5 Monthly Streamflow and Baseflow Summary North Fork A3 Creek (SW-35)*

| | 2011 | | | | 2012 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Param.** | **Sep** | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** |
| Average Monthly Flow (m3/sec) | 0.01 | 0.02 | 0.03 | 0.03 | 0.14 | 0.11 | 0.03 | 0.07 | -- | 0.11 | 0.04 | 0.12 |
| Average Monthly Unit Area Discharge (m3/sec per km2) | .004 | .009 | .009 | .012 | .049 | .040 | .012 | .027 | -- | .040 | .016 | .043 |
| Total Runoff (cm) | 1.0 | 2.4 | 2.4 | 3.2 | 13.1 | 10.1 | 3.1 | 6.9 | -- | 10.3 | 4.2 | 11.4 |
| Average Monthly Baseflow (m3/sec) | .007 | .006 | .008 | .011 | .022 | .022 | .015 | .020 | -- | .026 | .026 | .024 |
| Average Monthly Unit-Area Baseflow (m3/sec per km2) | .0024 | .0023 | .0030 | .0039 | .0078 | .0078 | .0056 | .0072 | .-- | .0094 | .0093 | .0086 |
| Total Baseflow (cm) | 0.61 | 0.63 | 0.78 | 1.04 | 2.08 | 1.96 | 1.49 | 1.85 | -- | 2.45 | 2.48 | 2.31 |
| Percent Baseflow (compared to Total Runoff) | 64% | 26% | 33% | 32% | 16% | 19% | 48% | 27% | -- | 24% | 59% | 20% |

Source: Baseline Hydrology Report (Appendix 9-B)

Streamflow patterns in other creeks in the Las Dominicanas watershed are expected to exhibit patterns similar to those reported at SW-35 due to the relatively uniform nature of the soils, vegetation cover and relief in the drainage basin. A probabilistic model (GoldSim©) has been developed for the Project Area. Details regarding model development are provided in Appendix 3-D. The model provides streamflow estimates based on topography, soils, vegetation and climate records and was refined based on streamflow data collected in the field. The streamflow estimates for the main creeks in the Las Dominicanas watershed under normal precipitation conditions (as defined in Appendix 3-D) are provided in Table 9-6. The exact "evaluation points" on each creek at which flows are estimated are show on Figure 9-9.

*Table 9-6 Summary of Predicted Streamflows in Las Dominicanas Watershed*

| GoldSim© evaluation point ID | Creek | Drainage Area (km2) | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EP-A0 | Las Dominicanas Creek at the Study Area Boundary | 49.5 | 1.12 | 0.85 | 0.84 | 1.32 | 2.29 | 2.36 | 1.35 | 0.64 | 0.25 | 0.25 | 0.33 | 0.92 |
| EP-A2 | A3 Creek downstream of Project impacts | 12.8 | 0.09 | 0.07 | 0.07 | 0.11 | 0.20 | 0.21 | 0.11 | 0.05 | 0.02 | 0.02 | 0.02 | 0.08 |
| EP-A3 | Tempati Creek downstream of Project impacts | 3.6 | 0.33 | 0.24 | 0.24 | 0.40 | 0.71 | 0.73 | 0.41 | 0.19 | 0.07 | 0.07 | 0.10 | 0.30 |

Source: Merian Site-Wide Water Balance Model – Technical Memorandum (Appendix 3-D)

### *9.2.3 Marowijne River Watershed*

As discussed previously, part of the Project Area is located within the Marowijne River watershed, a large 68,700 km$^2$ watershed that extends from the border with Brazil in the south and flows over 725 km north and discharges to the Atlantic Ocean. The Project area is located in the lower reach of the watershed to the west of the river. The largest community along the river in close proximity to the Project site, Langa-Tabiki, is situated on Langa-Tabiki Island approximately 17 km from the Project Area and upstream of where potential impacts from the Project would discharge to the Marowijne River. The Marowijne River watershed is very sparsely inhabited and undeveloped. The main tributary to the Marowijne River potentially impacted by the Project has been named Merian Creek for the purposes of this project, although it may be that another local name exists.

Historic streamflow data for the Marowijne River have been recorded near Langa Tabiki at two different stations: one operated by the French Guiana government and one operated for a shorter duration by Suriname. The streamflow station located in French Guiana has a longer period of record and therefore is preferred as a data source to provide streamflow estimates in the Marowijne River. Average monthly streamflows calculated based on the data collected at the French Guiana gage are reported in Table 9-7.

Estimated drainage area measured at the station is 60, 930 $km^2$. The exact location of the regional gage on the Marowijne at Langa Tabiki (French Guiana) and the delineated drainage basin is not available. Given the large size of the drainage basin and the relatively small difference in drainage area expected between the gage site and the confluence of Merian Creek and the Marowijne River, the streamflow measurements at the regional Langa Tabiki gage are assumed to provide adequate estimates of flow rates in the Marowijne River at Merian Creek.

*Table 9-7 Estimate Monthly Average Streamflow at Regional Points of Interest ($m^3$/sec)*

| Point of Interest | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Majowijne at Langa Tabiki[1] | 1180 | 1550 | 2025 | 2538 | 3322 | 3295 | 2328 | 1560 | 871 | 489 | 378 | 639 |

Source: Streamflow gage records Marowijne at Langa Tabiki (1951 – 1996) provided in Hydrology Baseline Hydrology Report (Appendix 9-B).

### 9.2.4 *Study Area Streamflow – Marowijne River Watershed*

The Merian Creek watershed is the main tributary watershed that could be impacted by the Project within the Marowijne River watershed. The total drainage area is 180 $km^2$. The total Project disturbance footprint within the Merian Creek watershed is 3387.4 ha or approximately 18% of the Merian Creek drainage area. It is important to note that much of the projected footprint has already been disturbed from the extensive ASM activities in the drainage.

Potentially impacted sub drainage basins of interest in the larger Merian Creek drainage basin are:

- (Upper) Merian Creek (SW-34); and
- Tomulu Creek (SW-4B).

The headwater streams of Merian Creek within the Study Area have been extensively disturbed by ASM mining and the main stem of the upper reaches of Merian Creek at SW-34 is heavily laden with sediment (Figure 9-13). Within the portion of the Merian Creek watershed impacted by the Project, the creeks range in width from 2 – 3 m to larger creeks approximately 10 – 15 m.

Similar to the Las Dominicanas watershed, during dry periods many of the creeks are very shallow in places and many of the smaller tributaries are ephemeral. During wetter periods these same creeks are likely not passable and Merian Creek within the Study Area regularly overtops its banks in flatter areas of the valley.[9] Water depths in excess of 3 meters have been measured during storm events at the stream gage on Merian Creek. Tomulu Creek has been extensively mined by ASM miners. Figure 9-13 and Figure 9-14 show conditions on Merian Creek and Tomulu Creek in August, 2011. Both figures show the high levels of turbidity in the creeks. Tomulu Creek also shows areas of sediment deposited along the current creek banks and bottom.

*Figure 9-13 Merian Creek at SW-34*

[9] Based on local knowledge of Surgold employees

*Figure 9-14 Tomulu Creek at SW-4b*

Streamflow measurements at the SW-4b gage (Tomulu Creek) are presented in Figure 9-15. A summary of monthly streamflow data collected at SW-4b is provided in Table 9-8. As shown in the Figure, manual measurements are not yet available for high flow, mainly due to access issues during high water, and therefore, high flows are only estimated in the hydrograph. Based on the data collected to date, Tomulu Creek responds quickly to rain events with an increasing average flow rate building in the months of January to March. Streamflow was greatest during the wettest months of January and February 2012, a period of high runoff and baseflow rates. Streamflow was lowest during the driest months of September and October 2011, with baseflow providing the greatest contribution during this period. This pattern is similar to observed flows in Las Dominicanas Creek and regionally. While high flows remain very approximate estimates, low flows for the one dry season have been generally well measured and baseflow characteristics can be estimated given the data available. These low flow estimates are based solely on one season of data and therefore can only provide a very preliminary estimate of streamflow characteristics in the dry season.

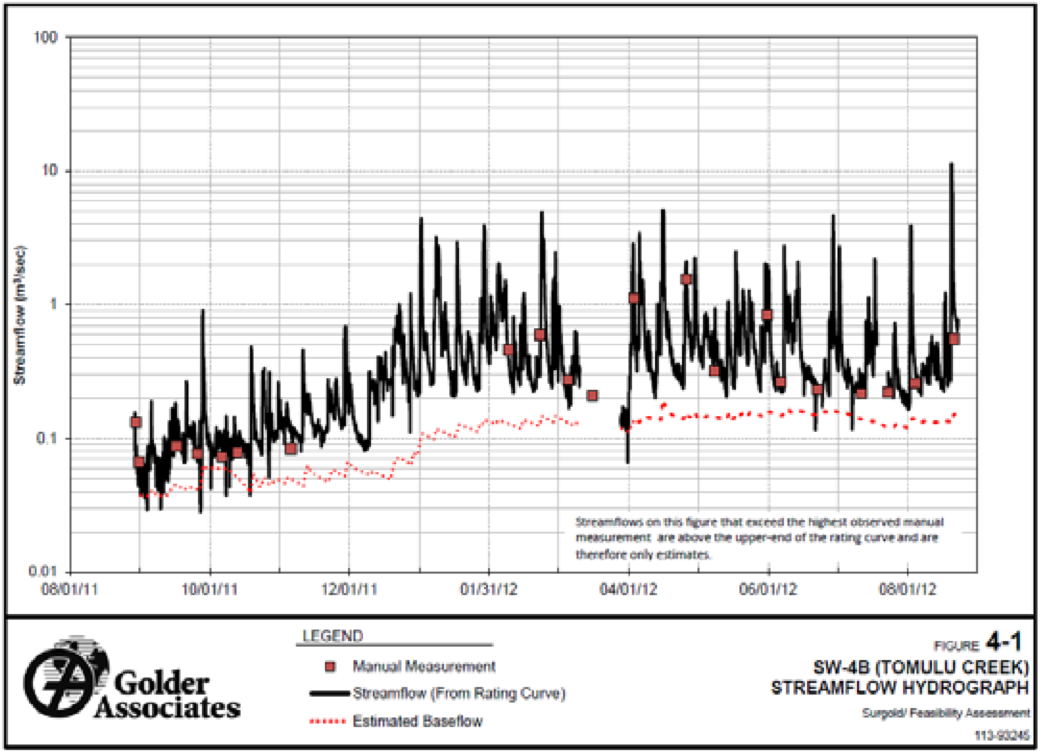



*Figure 9-15 SW-4b (Tomulu Creek) Streamflow Hydrograph*

*Table 9-8 Monthly Streamflow and Baseflow Summary Tomulu Creek (SW-4b)*

| | 2011 | | | | 2012 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Param.** | **Sep** | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** | **Msy** | **Jun** | **Jul** | **Aug** |
| Average Monthly Flow (m3/sec) | 0.10 | 0.12 | 0.16 | 0.30 | 0.78 | 0.76 | -- | 0.79 | 0.58 | 0.61 | 0.38 | 0.73 |
| Average Monthly Unit Area Discharge (m3/sec per km2) | .005 | .006 | .008 | .015 | .040 | .039 | -- | .040 | .030 | .031 | .020 | .037 |
| Total Runoff (cm) | 1.3 | 1.6 | 2.1 | 4.1 | 10.6 | 9.7 | -- | 10.4 | 8.0 | 8.1 | 5.2 | 9.9 |
| Average Monthly Baseflow (m3/sec) | .043 | .052 | .052 | .061 | .115 | .132 | .129 | .145 | .147 | .156 | .137 | .135 |
| Average Monthly Unit-Area Baseflow (m3/sec per km2) | .0022 | .0026 | .0026 | .0031 | .0058 | .0067 | .0066 | .0074 | .0075 | .0079 | .0070 | .0069 |
| Total Baseflow (cm) | 0.57 | 0.70 | 0.69 | 0.83 | 1.56 | 1.68 | 1.77 | 1.92 | 2.00 | 2.06 | 1.87 | 1.84 |
| Percent Baseflow (compared to Total Runoff) | 44% | 45% | 32% | 20% | 15% | 17% | -- | 18% | 25% | 25% | 36% | 19% |

Source: Baseline Hydrology Report (Appendix 9-B)

Streamflow measurements at the SW-34 gage (Merian Creek) are presented in Figure 9-16. As shown in the Figure, manual measurements are not yet available for high flow, mainly due to access issues during high water, and therefore, high flows are only estimated in the hydrograph. Based on the data collected to date, Merian Creek shows the same quick response to rain events observed on Las Dominicanas Creek with a similar increasing average flow rate building in the months of January to March. While high flows remain very approximate estimates, low flows have been well measured and baseflow characteristics can be estimated given the data available. These are summarized in Table 9-9. Streamflow was greatest during the wettest months of January and February 2012, a period of high runoff and baseflow rates. Data was not available for the driest months of September and October 2011, however during the driest month with available data (November 2011), streamflow was the lowest, with baseflow providing the greatest contribution during this month (as compared to wetter months).

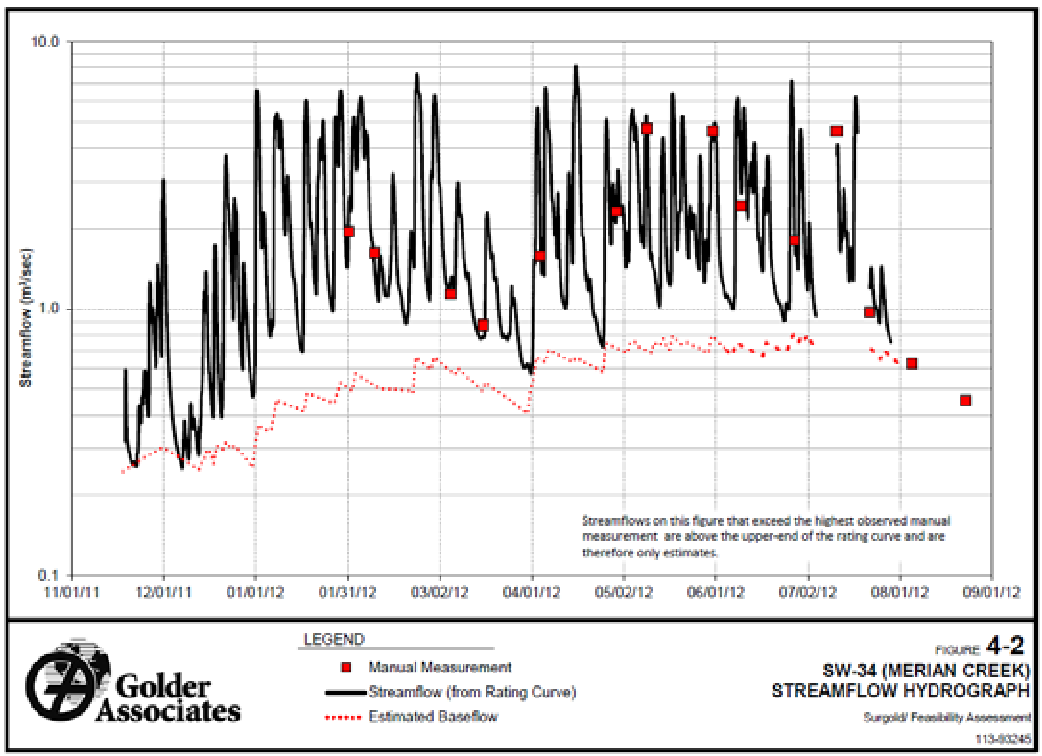



*Figure 9-16 SW-34 (Merian Creek) Streamflow Hydrograph*

*Table 9-9 Monthly Streamflow and Baseflow Summary Merian Creek (SW-34)*

| | 2011 | | | | | | | 2012 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Param.** | **Sep** | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** | **Msy** | **Jun** | **Jul** | **Aug** |
| Average Monthly Flow (m3/sec) | -- | -- | 0.58 | 0.92 | 2.77 | 2.77 | 1.29 | 2.53 | 2.66 | 2.46 | -- | -- |
| Average Monthly Unit Area Discharge (m3/sec per km2) | -- | -- | .007 | .010 | .032 | .032 | .015 | .029 | .030 | .028 | -- | -- |
| Total Runoff (cm) | -- | -- | 1.7 | 2.8 | 8.4 | 7.9 | 3.9 | 7.5 | 8.1 | 7.3 | -- | -- |
| Average Monthly Baseflow (m3/sec) | -- | -- | .272 | .283 | .435 | .541 | .520 | .649 | .728 | .724 | -- | -- |
| Average Monthly Unit-Area Baseflow (m3/sec per km2) | -- | -- | .0031 | .0032 | .0050 | .0062 | .0059 | .0074 | .0083 | .0083 | -- | -- |
| Total Baseflow (cm) | -- | -- | 0.80 | 0.86 | 1.33 | 1.54 | 1.59 | 1.92 | 2.22 | 2.14 | -- | -- |
| Percent Baseflow (compared to Total Runoff) | -- | -- | 47% | 31% | 16% | 19% | 40% | 26% | 27% | 29% | -- | -- |

Source: Baseline Hydrology Report (Appendix 9-B)

Similar to the creeks in the Las Dominicanas watershed, the streamflow estimates for the main creeks in the Merian watershed are provided in Table 9-10.

*Table 9-10 Summary of Predicted Streamflows in Merian Creek Drainage Basin*

| Creek | Drainage Area | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EP-B1 Merian Creek upstream of SW-34 | 57.7 km2 | 1.68 | 1.20 | 1.21 | 1.95 | 3.45 | 3.54 | 1.99 | 0.95 | 0.36 | 0.34 | 0.48 | 1.43 |
| EP-B0 Merian Creek at SW-34 | 87.8 km2 | 2.60 | 1.84 | 1.86 | 3.03 | 5.40 | 5.53 | 3.09 | 1.45 | 0.55 | 0.51 | 0.72 | 2.20 |
| EP-C0 Tomulu Creek at SW-4b | 19.6 km2 | 0.62 | 0.45 | 0.45 | 0.71 | 1.23 | 1.25 | 0.73 | 0.36 | 0.14 | 0.13 | 0.19 | 0.53 |

*Source: Merian Site-Wide Water Balance Model – Technical Memorandum (Appendix 3-D)*

## 9.3 WATER QUALITY

The water quality in the Precambrian Shield Province of Suriname as characterized by USACE (2001) has pH levels from 6.5 to 7.3 and relatively low specific conductance. Waters are soft to moderately hard with low to very low salinity and low turbidity. The waters in this region are high in dissolved oxygen (55% to oversaturated) because of the number of waterfalls and rapids. Some streams have locally high levels of hardness because these flow through areas of exposed rocks, which contribute large amounts of total dissolved solids. The region is classified as “Fresh Water Seasonally Available,” which is further defined as, “seasonally intermittent stream sand creeks” with “meager to very small quantities of fresh water are seasonally available. Other regional studies for water quality in the Precambrian Shield report lower pH and lower dissolved oxygen values (Ouboter, 1993).

### *9.3.1 Artisanal and Small Scale ASM Mining*

Water quality throughout Suriname is affected by ASM mining. Both the USACE and Oubuter (1993) refer to the regional effects on water quality. Furthermore, specific studies have been conducted to better understand water quality impacts of ASM mining.

Many of the creeks in the Study Area have been heavily disturbed by local small-scale ASM mining activities. ASM mining involves the excavation of alluvial sediments forming the creek beds and valleys and sluicing to separate the material by grain size. Figure 9-17 and Figure 9-18 are photographs taken in

August 2011 and illustrate resulting degradation from ASM mining to creek valleys in the Study Area. Small-scale mining was present as early as 2002. An increase in the number of active operations in the Project Area occurred in January 2010. Over the past year an "industrial zone" controlled by Surgold has been re-established by the Surinamese government in which ASM mining is not allowed; however, the ASM mining is continuing outside the Surgold Industrial Zone and within the Project Area and Study Area.

*Figure 9-17 Active Small-scale ASM Mining Operation in A3 Creek Valley (Aug 2011)*

*Figure 9-18 Stream Valley in Study Area after Small-scale Mining (Aug 2011)*

ASM mining leaves a series of flooded pits within the creek valley and results in extremely high levels of total suspended solids (TSS) in the creeks. Most ASM operations use mercury to extract the gold (mercury amalgamation) and only a portion of the mercury used in the process is recovered, with the remainder released to the local environment. As a result, mined creeks often exhibit elevated mercury concentrations. In the case of the Project Area, mercury is not typically detectable in the surface water (with the exception of one sampling location in November 2011 in the Las Dominicanas watershed and 4 samples in the Merian Creek watershed).

In 2011, Surgold commissioned an Environmental Liability Assessment (Tetra Tech, 2011) to assess the current conditions associated with the history of small scale mining in the Project Area. Mercury was found at detectable levels in the soil in areas used for sluicing operations of the ASM mining and also in creek sediments (Tetra Tech, 2011). Other impacts to water resources from ASM mining include increases in anthropogenic contaminants in the streams such as nutrients from sewage and waste disposal and hydrocarbons. The study identified numerous areas of soil contaminated with hydrocarbons and mercury.

The areas within the Study Area that have been disturbed by small-scale ASM mining based on aerial photo interpretation of 2010 imagery are shown in Figure 9-19.

### *9.3.2 Project Surface Water Quality*

Water quality sampling began in the Project Area in 2003. Samples were collected generally twice per year and samples were sent to an accredited laboratory in the United States. During the more recent monitoring program samples with very short holding times were sent for analysis to the University of Suriname (analytes included Biological Oxygen Demand (BOD), orthophosphate, TSS, and TDS). The monitoring network has been refined over time as the Project layout and design developed; with some early stations abandoned and other, new stations added. As a result not all locations were sampled during every sampling mission and some sampling locations were only added recently as part of the most-recent ESIA study. Implementation of the surface water monitoring program will continue through Pre-Production to continue to build an extended record of existing conditions. Once pre-production activities begin, monitoring will continue in order to quantify the environmental effects of the Project.

Water quality data collected at the site are comparable to other data collected on creeks within the Interior physiographic province as reported by USACE (2001). These are characterized by low hardness, nutrients, and salinity and often high dissolved oxygen. Local creeks exhibit lower pH than reported regionally (i.e. measured pH in the creeks within the Project Area ranged from approximately 4.5 to 7.5 whereas regional reported pH are 6.5 – 7.3 (USACE, 2001) and 5.7 -6.6 (Oubeter, 1993). As can be expected given the ASM activities in the Study Area, creeks in the Study Area have higher observed levels of turbidity and TSS than regionally reported. Typically Interior province streams have low turbidity and carry little sediment load (Ouboter, 1993).

The water quality results from 2005 – 2011 have been tabulated based on drainage basin to provide a water quality overview. Records of data collected prior to 2005 were not sufficient to include in this analysis. Statistical descriptors, maximum, minimum, average and standard deviation, have been calculated for each drainage basin based on all data collected to-date. The locations of the historic and current sampling locations are shown in Figure 9-20. A summary of sampling dates, locations, and lab analysis methods as well as details regarding sampling collection are provided in the Baseline Water Quality Summary Report (Appendix 9-D).

In some cases, analysis methodologies changed between sampling events, as did detection limits for certain parameters. The suite of parameters for which analysis was performed varied over the years and therefore some parameters have more data than others. Furthermore, QA/QC was performed on the data after each field mission based on field duplicates. Duplicate data was compared and parameters for which the relative percent difference was greater than accepted limits data were qualified as estimates only.

*Figure 9-19 Existing Disturbed Areas within Study Area*

*Figure 9-20 Historic and Current Surface Water Monitoring Locations*

Water quality data are presented by physical characteristics, nutrients, major ions and metals. The following are some notes regarding the parameters and history of sampling:

- Nutrient data were collected starting in 2008. Nutrients for which samples were analyzed include nitrogen in various forms and phosphates. Efforts were made to collect samples for chlorophyll –a analysis; however, due to difficulties in meeting holding times and the requirement to keep the filtrate frozen, the analysis was not reliable and, therefore, the results are not included. Improvements have been made to the Sampling Analysis Plan and efforts have been made to measure chlorophyll-a using a field meter during sampling rounds beginning in 2012.

- Carbonate and Bicarbonate Alkalinity, and Total Alkalinity as $CaCO_3$ were analyzed. Chemical Oxygen Demand (COD) and Hardness were only analyzed in 2011. Hardness can be calculated for the remainder of the data based on Ca and Mg concentrations.

- For most of the sampling program only dissolved metals analysis was performed with the exception of analysis of the total fraction for iron (Fe) and manganese (Mn). Total metals for the full suite of metals were included later in the program in 2011.

- Sediment samples were sieved and particles less than 2 mm were used in the chemical analysis. In 2011, a smaller sieve size was added to the analysis (no. 230 or 64 µm).

- The water quality data set includes data from different laboratories and in some cases includes results based on different methodologies. These data have been treated as comparable and analyzed without differentiating different methodologies. This approach can skew statistical results, for example if high detection limits are not exceeded. Effort has been made to identify specific cases where changes in detection limits affect results within the discussion of the data.

- The majority of TSS data was analyzed using method SM 2540D, however, a different method was used in 2006 (EPA method 160.1) and an unknown method in earlier years. The detection limits for the EPA 160.1 method and the SM 2540 is 5 mg/L and the detection limit for the unknown method is 10 mg/L. For the purposes of this report all TSS data are reported regardless of method.

- Average concentrations have been calculated for two scenarios: an average that did not include any samples for which concentrations were below detection limits and an average the included non-detect samples assuming the detection limit as the concentration.

The Project has established criteria for the protection of aquatic life as presented in the Environmental Design Criteria (Appendix 3-B[10]) as well as criteria for sewage effluent and drinking water standards. Water quality is compared against the criteria for aquatic life in dissolved fraction for the purposes of this Project[11].

*Las Dominicanas Water Quality*

The following Table 9-11 presents the range of parameters measured in the Las Dominicanas Drainage Basin between 2005 and 2011.

*Table 9-11 Summary of General Chemistry in Las Dominicanas Watershed*

| PARAMETER | UNITS | MIN | AVG(ONLY DETECTS) | AVG (INCL NON DETECTS) | MAX | # DETECTS | # SAMPLES | STDEV |
|---|---|---|---|---|---|---|---|---|
| pH, Field | pH units | 4.69 | 5.60 | 5.63 | 6.65 | 20 | 23 | 0.48 |
| Temperature, Field | deg C | 24.03 | 25.9 | 25.9 | 28.6 | 20 | 20 | 1.4 |
| Conductivity, Field | uS/cm | 17 | 27 | 27 | 45 | 20 | 20 | 8 |
| Dissolved oxygen, Field | mg/l | 1.17 | 5.21 | 5.21 | 9.99 | 20 | 20 | 2.32 |
| Turbidity, Field | NTU | 0 | 10 | 10 | 21 | 21 | 21 | 6 |
| | | | | | | | | |
| Total Alkalinity | mg/l | 1 | 4.4 | 3.6 | 7.2 | 20 | 26 | 2.0 |
| Chemical oxygen deman | mg/l | 5 | 32.4 | 28.4 | 70.9 | 6 | 7 | 22.4 |
| Hardness | mg/l | 3.01 | 7.11 | 7.11 | 9.98 | 7 | 7 | 2.36 |
| Total dissolved solids | mg/l | 10 | 79 | 77 | 660 | 33 | 34 | 147 |
| Total suspended solids | mg/l | 5 | 99 | 75 | 1440 | 26 | 35 | 257 |
| | | | | | | | | |
| Chloride | mg/l | 2.79 | 5.11 | 5.11 | 8.06 | 29 | 29 | 1.27 |
| Fluoride | mg/l | 0.1 | | 0.1 | 0.1 | 0 | 7 | 0.0 |
| Sulfate | mg/l | 0.3 | 0.60 | 0.57 | 1.91 | 26 | 29 | 0.34 |
| Calcium | mg/l | 0.195 | 0.86 | 0.86 | 1.44 | 7 | 7 | 0.43 |
| Magnesium | mg/l | 0.613 | 1.20 | 1.20 | 1.55 | 7 | 7 | 0.33 |
| Potassium | mg/l | 0.5 | 0.93 | 0.59 | 1.55 | 6 | 29 | 0.25 |
| Sodium | mg/l | 2.06 | 2.85 | 2.85 | 4.15 | 29 | 29 | 0.48 |
| | | | | | | | | |
| Ammonia as N | mg/l | 0.03 | 0.092 | 0.077 | 0.304 | 22 | 29 | 0.066 |
| Nitrite + Nitrate as N | mg/l | 0.02 | 0.2 | 0.2 | 0.5 | 16 | 29 | 0.2 |
| Phosphorus | mg/l | 0.01 | 0.245 | 0.073 | 0.512 | 4 | 29 | 0.106 |
| Total organic carbon | mg/l | 1.46 | 5.4 | 5.4 | 10.9 | 27 | 27 | 2.6 |

Field measurements for, alkalinity and hardness are generally in keeping with expected water chemistry for fresh surface water, while pH is relatively low, but

[10] The Project's Environmental Design Criteria (EDC) is presented in Appendix 3-B to the Chapter 3 Project Description. The EDC presents effluent, drinking water and ambient water quality criteria. These have been developed on the IFC EHS Guidelines, WHO drinking water standards, the International Cyanide Code and other internationally recognized standards such as those set forth by the USEPA.

[11] High sediment loads can result in high total concentrations such that potential project impacts may not be detectable, therefore the dissolved fraction has been used to compare baseline conditions to criteria. This is considered to be a conservative approach.

similar to reported regional values. Of note are the TDS, TSS, and Turbidity measurements. Figure 9-21 shows historic TSS data collected at SW-27 and SW-29 since 2006. As can be seen in the Figure, TSS concentrations prior to 2011 were quite low and typically less than 50 mg/L. ASM mining in A3 and Tempati Creeks began in 2010 and has proceeded in 2011. TSS and turbidity results in 2011 show a dramatic change in each creek's sediment load. In addition to the routine semi-annual/seasonal sampling data, continuous turbidity data have been collected at SW-37, a small relatively undisturbed tributary to A3 Creek and Las Dominicanas Creek upstream of the Project influence (SW-30). Access to SW-30 was cut off shortly after the gage was installed; therefore, data at this location is not currently available. Turbidity readings at SW-37 ranged from 1.3 to 338 NTU and calculated TSS (based on a site-specific turbidity-TSS relationship) ranged from 1 – 195 mg/L with a mean of 25 mg/L. More details regarding turbidity and TSS monitoring are provided in the Baseline Hydrology Report (Appendix 9-B) and the Baseline Water Quality Summary Report (Appendix 9-D).

Nutrients at both SW-29 and SW-27 are plotted in Figure 9-22 and Figure 9-23.

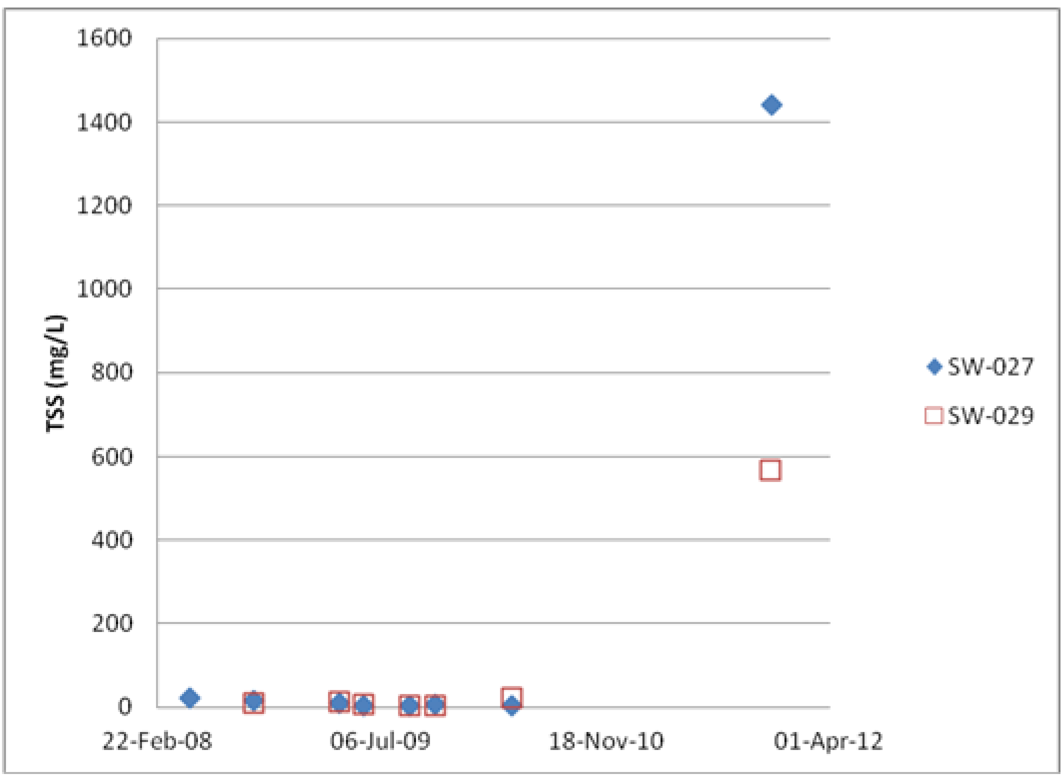



*Figure 9-21 TSS Concentrations at SW-27 and SW-29 2006-2011*

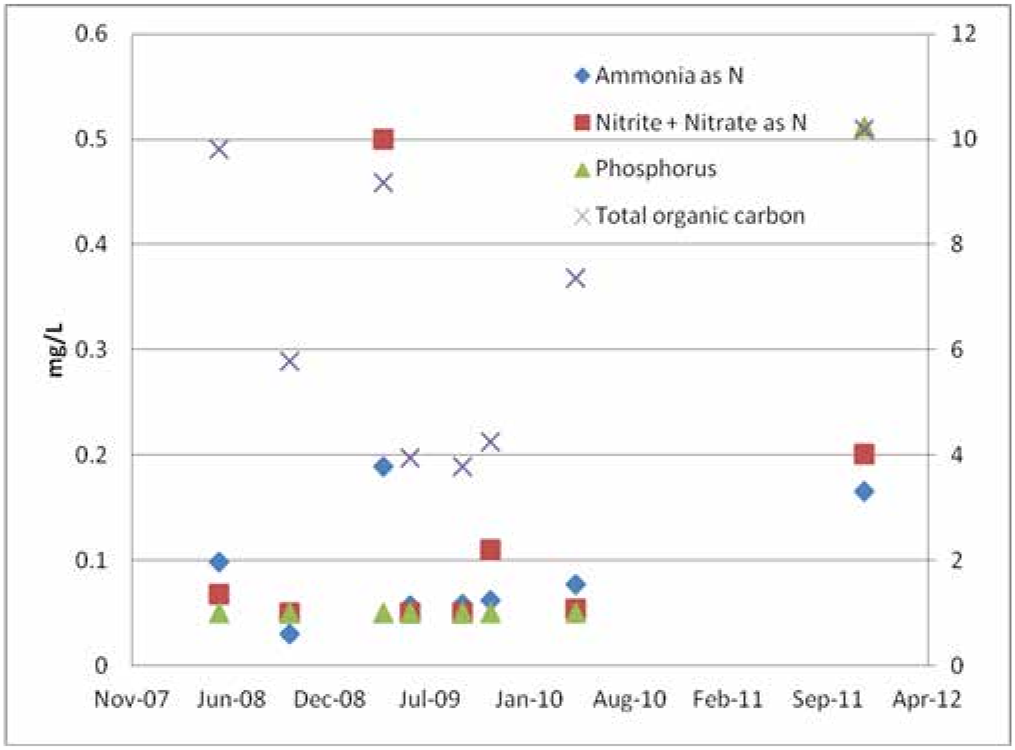



*Figure 9-22 Nutrient Concentrations at SW-27 (Las Dominicanas Creek d/s of A3Creek) (mg/L) (TOC results are plotted on secondary axis)*

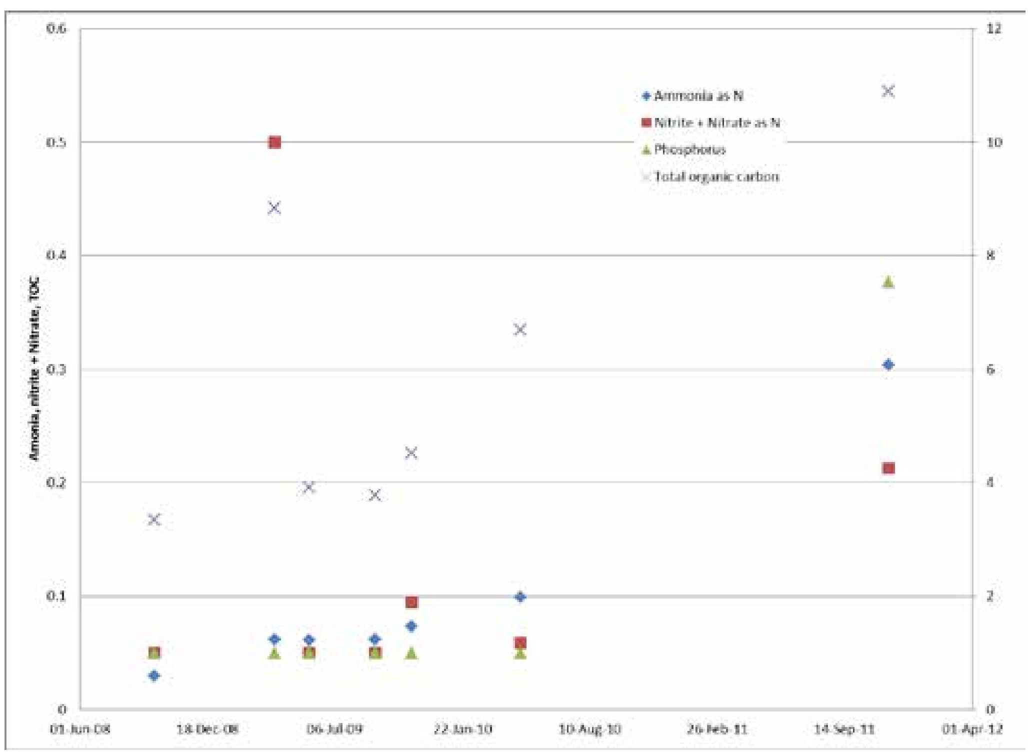



*Figure 9-23 Nutrient Concentrations at SW-29 (Tempati Creek) (mg/L)*

Nutrient concentrations, particularly at SW-29, appear to have increased since 2010. This could be due to increased anthropogenic activities within the basin. Increased ASM activity in the area has been observed by local Surgold staff and during field missions. November 2011 was the first sampling event in which phosphorous levels were above detection limits. Prior to 2011 the detection limit for phosphorous was 0.05 mg/L. In 2011 the detection limit dropped to 0.01 mg/L due to a change in the analysis method at the laboratory. Not all detects are attributed to this change in detection limit. Phosphorous above 0.05 mg/L was reported for the first time in 2011 at SW-27, SW-29, and SW-30.

*Metals*

Table 9-12 provides a summary of the dissolved metals analysis completed for samples collected in the Las Dominicanas watershed.

*Table 9-12 Summary of Dissolved Metals Las Dominicanas Watershed (mg/L)*

| PARAMETER | UNITS | MIN | AVG(ONLY DETECTS) | AVG (INCL NON DETECTS) | MAX | # DETECTS | # SAMPLES | STDEV |
|---|---|---|---|---|---|---|---|---|
| Aluminum | mg/l | 0.03 | 0.098 | 0.081 | 0.101 | 5 | 29 | 0.012 |
| Antimony | mg/l | 0.0012 | | | 0.02 | 0 | 29 | |
| Arsenic | mg/l | 0.002 | | | 0.025 | 0 | 29 | |
| Barium | mg/l | 0.0021 | 0.0041 | 0.0041 | 0.0057 | 7 | 7 | 0.0012 |
| Beryllium | mg/l | 0.002 | | | 0.002 | 0 | 29 | |
| Boron | mg/l | 0.04 | | | 0.04 | 0 | 29 | |
| Cadmium | mg/l | 0.002 | | | 0.002 | 0 | 29 | |
| Chromium | mg/l | 0.006 | | | 0.006 | 0 | 29 | |
| Cobalt | mg/l | 0.006 | 0.0091 | 0.0062 | 0.0111 | 2 | 29 | 0.0010 |
| Copper | mg/l | 0.01 | | | 0.01 | 0 | 29 | |
| Iron | mg/l | 0.061 | 0.88 | 0.88 | 3.25 | 29 | 29 | 0.70 |
| Lead | mg/l | 0.0075 | | | 0.0075 | 0 | 29 | |
| Manganese | mg/l | 0.0095 | 0.026 | 0.026 | 0.126 | 29 | 29 | 0.024 |
| Mercury | mg/l | 0.0002 | | | 0.0002 | 0 | 23 | |
| Molybdenum | mg/l | 0.008 | | | 0.008 | 0 | 29 | |
| Nickel | mg/l | 0.01 | | | 0.01 | 0 | 29 | |
| Selenium | mg/l | 0.001 | | 0.02 | 0.04 | 0 | 29 | 0.02 |
| Silver | mg/l | 0.005 | | | 0.005 | 0 | 29 | |
| Thallium | mg/l | 0.001 | | | 0.001 | 0 | 7 | |
| Titanium | mg/l | 0.005 | | | 0.005 | 0 | 7 | |
| Vanadium | mg/l | 0.005 | | | 0.005 | 0 | 29 | |
| Zinc | mg/l | 0.01 | | | 0.01 | 0 | 29 | |

Iron and manganese are routinely detected in the dissolved fraction as is barium. Samples were not analyzed for barium until 2011 which is why the total number of samples is smaller than other parameters. Iron and manganese have been detected in every sample collected to-date and these same parameters are also prevalent in the total fraction. Aluminum and cobalt were detected at a range of sampling locations in wet and dry seasons. No trends are immediately apparent in the locations or times that aluminum was detected.

Based on the data presented in Table 9-12, the average baseline aluminum concentrations (when detected) exceed recommended criteria (0.087 mg/L). This criteria is applicable in a pH range from 6.5 -9.0[12]. Other standards provide pH dependent criteria; for example, Canadian Council of Ministers of the Environment (CCME) recommends 0.005 mg/L for pH less than 6.5[13]. Given the range of pH reported for Las Dominicanas Creek as well as the baseline concentrations above the established criteria, establishing a site-specific criterion for aluminum may be required. Iron concentrations observed in the watershed can exceed Project criteria (aquatic life) (1 mg/L)); however, the average of observed concentrations falls below the Project criteria. Generally, concentrations of iron as SW-29 and SW-27 are greater than 1 mg/L. A site-specific criterion for iron is likely required depending on continued baseline data collection results.

Table 9-13 provides a summary of the total metals analysis completed for samples collected in the Las Dominicanas watershed.

*Table 9-13 Summary of Total Metals Las Dominicanas Watershed (mg/L)*

| PARAMETER | UNITS | MIN | AVG(ONLY DETECTS) | AVG (INCL NON DETECTS) | MAX | # DETECTS | # SAMPLES | STDEV |
|---|---|---|---|---|---|---|---|---|
| Aluminum | mg/l | 0.086 | 6.36 | 6.36 | 20.7 | 7 | 7 | 9.22 |
| Antimony | mg/l | 0.003 | | | 0.003 | 0 | 7 | |
| Arsenic | mg/l | 0.003 | | | 0.003 | 0 | 7 | |
| Barium | mg/l | 0.005 | 0.046 | 0.046 | 0.137 | 7 | 7 | 0.062 |
| Beryllium | mg/l | 0.002 | | | 0.002 | 0 | 7 | |
| Boron | mg/l | 0.04 | | | 0.04 | 0 | 7 | |
| Cadmium | mg/l | 0.002 | | | 0.002 | 0 | 7 | |
| Chromium | mg/l | 0.006 | 0.076 | 0.036 | 0.123 | 3 | 7 | 0.048 |
| Cobalt | mg/l | 0.006 | 0.0137 | 0.0071 | 0.0137 | 1 | 7 | 0.0029 |
| Copper | mg/l | 0.01 | 0.05 | 0.02 | 0.052 | 2 | 7 | 0.02 |
| Iron | mg/l | 0.504 | 4.29 | 4.29 | 29 | 29 | 29 | 6.30 |
| Lead | mg/l | 0.0075 | 0.0170 | 0.0102 | 0.0226 | 2 | 7 | 0.0056 |
| Manganese | mg/l | 0.0112 | 0.033 | 0.033 | 0.227 | 29 | 29 | 0.040 |
| Mercury | mg/l | 0.0002 | 0.00113 | 0.00023 | 0.00113 | 1 | 29 | 0.00017 |
| Molybdenum | mg/l | 0.008 | | | 0.008 | 0 | 7 | |
| Nickel | mg/l | 0.01 | 0.04 | 0.02 | 0.05 | 2 | 7 | 0.02 |
| Selenium | mg/l | 0.003 | | | 0.003 | 0 | 7 | |
| Silver | mg/l | 0.005 | | | 0.005 | 0 | 7 | |
| Thallium | mg/l | 0.001 | | | 0.001 | 0 | 7 | |
| Titanium | mg/l | 0.005 | 0.0410 | 0.0204 | 0.0547 | 3 | 7 | 0.0230 |
| Vanadium | mg/l | 0.005 | 0.060 | 0.029 | 0.108 | 3 | 7 | 0.041 |
| Zinc | mg/l | 0.01 | 0.0347 | 0.0171 | 0.0443 | 2 | 7 | 0.0133 |

Averages of samples that reported concentrations above the detection limits for the following total metals exceed Project established criteria for the protection of aquatic life as presented in the Environmental Design Criteria (Appendix 3-B).

- Aluminum;

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[12] Ambient Water Quality Criteria for Aluminum – 1988, US EPA 440/5-86-008

[13] Canadian Environmental Quality Guidelines, Canadian Water Quality Guidelines for the Protection of Aquatic Life, Canadian Council of Ministers of the Environment (1999) http://ceqg-rcqe.ccme.ca/

- Cobalt[14];
- Copper;
- Chromium [15];
- Iron;
- Mercury; and
- Lead.

With the exception of iron and manganese total metals were measured only during the 2011 sampling round. Aluminum was reported at concentrations exceeding criteria at every sampling location.

Mercury (total) was detected at SW-29 in November of 2011 (0.00113 mg/L). This was the first time mercury was detected in the water column in the Las Dominicanas watershed in the Merian sampling programs. This concentration of mercury exceeds the recommended criteria for aquatic life (0.0008 mg/L).

A summary of surface water quality at SW-27 for all parameters with Project criteria for aquatic life (per the Project EDC Appendix 3-B) is presented in Table 9-14. Exceedances in concentrations in the dissolved fraction compared to the Project criteria are highlighted. SW-27 is located downstream of predicted Project discharges. The dissolved fraction is considered appropriate for the Project because the high TSS concentrations have the potential to skew results.

*Table 9-14 Summary of Water Quality at SW-27 compared to Project Criteria for Aquatic Life[1]*

| Parameter | | MIN | AVG (only detects) | AVG (incl non detects) | MAX | No. of samples | No. of detects | No. of exceedances |
|---|---|---|---|---|---|---|---|---|
| pH | | 4.69 | 5.56 | 5.56 | 6.14 | | | |
| BOD | | No data | | | | | | |
| COD | mg/L | 44.6 | 44.6 | 44.6 | 44.6 | 1 | 1 | 0 |
| TDS | mg/L | 21 | 46.2 | 46.2 | 80 | 5 | 5 | 0 |
| TSS | mg/L | 7 | 36.6 | 36.6 | 1440 | | | |

[14] Cobalt is a drinking water criteria and not relevant with respect to the protection of aquatic life. TSS

[15] Cr concentrations were analyzed for total Chromium. Project criteria specify a criterion for hexavalent chromium. Total chromium concentrations have been compared to criteria for hexavalent chromium, which is a conservative approach.

| Parameter | | MIN | AVG (only detects) | AVG (incl non detects) | MAX | No. of samples | No. of detects | No. of exceedances |
|---|---|---|---|---|---|---|---|---|
| Cyanide,WAD | mg/L | - | - | - | - | 1 | 0 | 0 |
| Cyanide, Free | mg/L | - | - | - | - | 1 | 0 | 0 |
| Cyanide, Total | mg/L | - | - | - | - | 8 | 0 | 0 |
| Phenols | mg/L | Did not sample | | | | | | |
| Nitrate + nitrite as N | mg/L | 0.05 | 0.11 | 0.14 | 0.5 | 4 | 8 | 0 |
| Ammonia as N | mg/L | 0.03 | 0.10 | 0.09 | 0.189 | 7 | 8 | 0 |
| Sulfate | mg/L | 0.38 | 0.79 | 0.79 | 1.91 | 8 | 8 | 0 |
| Aluminum | mg/L | 0.08 | 0.099 | 0.082 | 0.099 | 8 | 1 | 1 |
| Barium | mg/L | 0.0057 | 0.0057 | 0.0057 | 0.0057 | 1 | 0 | 0 |
| Chromium | mg/L | 0.006 | | 0.006 | 0.006 | 8 | 0 | 0 |
| Cobalt | mg/L | 0.0060 | 0.0111 | 0.0066 | 0.0111 | 8 | 1 | 1 |
| Copper | mg/L | - | - | - | - | 8 | 0 | 0 |
| Iron | mg/L | 0.53 | 1.24 | 1.24 | 3.25 | 8 | 8 | 4 |
| Lead | mg/L | - | - | - | - | 8 | 0 | 1 |
| Manganese | mg/L | 0.013 | 0.043 | 0.043 | 0.126 | 8 | 8 | 0 |
| Nickel | mg/L | - | - | - | - | 8 | 0 | 0 |
| Titanium | mg/L | - | - | - | - | 8 | 0 | 0 |
| Uranium 238 | mg/L | - | - | - | - | 8 | 0 | 0 |
| Zinc | mg/L | - | - | - | - | 8 | 0 | 0 |

[1] Metals results provided in dissolved fraction

Based on the 2011 data it appears that existing conditions exceed guidelines for the protection of aquatic life for iron on a semi-regular basis. Other metals such as aluminum only reported one exceedance thus far and cannot be assumed to regularly exceed criteria .

*Las Dominicanas Watershed Sediment Quality*

Sediment samples were collected at various locations in the Las Dominicanas watershed in 2008, 2009, and 2011. Data are presented in Table 9-15.

*Table 9-15 Summary of Sediment Quality Las Dominicanas Watershed (mg/Kg)*

| PARAMETER | UNITS | MIN | AVG (ONLY DETECTS) | AVG (INCL NON DETECTS) | MAX | # DETECTS | DETECTS | STDEV |
|---|---|---|---|---|---|---|---|---|
| Paste pH | pH units | 4.42 | 4.88 | 4.88 | 6.08 | 6 | 6 | 0.636323 |
| Total organic carbon | % | 0.09 | 1.01 | 0.96 | 6.34 | 19 | 20 | 1.403455 |
| Total Organic Matter | % | 0.15 | 1.73 | 1.65 | 10.9 | 19 | 20 | 2.413538 |
| | | | | | | | | |
| Aluminum | mg/kg | 167 | 2175 | 2175 | 5720 | 20 | 20 | 1945.873 |
| Antimony | mg/kg | 2 | | 2 | 2 | 0 | 6 | 0 |
| Arsenic | mg/kg | 0.3 | 0.9 | 1.3 | 2.5 | 13 | 20 | 0.908335 |
| Beryllium | mg/kg | 0.2 | | 0.2 | 0.2 | 0 | 6 | 3.33E-09 |
| Boron | mg/kg | 4 | | 4 | 4 | 0 | 6 | 0 |
| Cadmium | mg/kg | 0.1 | | 0.13 | 0.2 | 0 | 20 | 0.047016 |
| Chromium | mg/kg | 0.75 | 14.164 | 14.164 | 39.7 | 20 | 20 | 11.59743 |
| Cobalt | mg/kg | 0.6 | | 0.6 | 0.6 | 0 | 6 | 0 |
| Copper | mg/kg | 1 | 6.2 | 5.2 | 14.5 | 16 | 20 | 4.310911 |
| Iron | mg/kg | 991 | 7822 | 7822 | 18300 | 13 | 13 | 5441.157 |
| Lead | mg/kg | 0.1 | 2.5 | 2.0 | 7.18 | 15 | 20 | 1.872829 |
| Manganese | mg/kg | 2.25 | 33.2 | 33.2 | 165 | 13 | 13 | 46.02841 |
| Mercury | mg/kg | 0.033 | 0.234 | 0.164 | 0.99 | 13 | 20 | 0.225793 |
| Molybdenum | mg/kg | 0.8 | | 0.8 | 0.8 | 0 | 6 | 1.33E-08 |
| Nickel | mg/kg | 1 | 4.4 | 3.1 | 13.5 | 12 | 20 | 3.370795 |
| Selenium | mg/kg | 0.3 | 1.0 | 1.8 | 4 | 10 | 20 | 1.635369 |
| Silver | mg/kg | 0.05 | | 0.2 | 0.5 | 0 | 20 | 0.211573 |
| Thallium | mg/kg | 0.1 | | 0.1 | 0.1 | 0 | 14 | 1.46E-09 |
| Vanadium | mg/kg | 0.98 | 10.8 | 10.8 | 28 | 20 | 20 | 8.484906 |
| Zinc | mg/kg | 1 | 5.6 | 5.1 | 14.5 | 18 | 20 | 4.35908 |
| | | | | | | | | |
| Cyanide | mg/kg | 0.5 | | 0.5 | 0.5 | 0 | 14 | 0 |
| Cyanide, Free | mg/kg | 1 | 1.34 | 1.31 | 5 | 1 | 14 | 1.065912 |
| WAD CN | mg/kg | 0.5 | | 0.5 | 0.5 | 0 | 14 | 0 |

Mercury was detected in 13 of 20 samples. In 2008, mercury was detected at SW-28 (upper reaches of Upper Las Dominicanas Creek) and in 2009, at SW-27. Sediment samples were sieved and particles less than 2 mm (no. 10 sieve) were used in the chemical analysis. In 2011, a smaller sieve size was added to the analysis (no. 230 or 64 µm).

Mercury was detected in the no. 10 sieve (2 mm) sample at SW-27, SW-29, SW-37, and SW-38 with concentrations ranging from 0.03 – 0.164 mg/L. Concentrations in the sample sieved through the no. 230 (64 µm) were higher than those reported for the sample run through the no. 10 sieve, indicating that mercury is found in higher concentrations in the fine sediment.

*Merian Creek Water Quality*

Merian Creek data has been broken down into the upper reaches of Merian Creek and Tomulu Creek for the purposes of reporting average water quality results. Upper Merian Creek summary data includes data collected at all of the Merian Creek tributaries (labeled Merian Creek Tributary #1 - #4 on Figure 9-20). SW-34 was only added to the sampling program in 2011 and, therefore, a record of water quality data at this location is only beginning to be compiled. SW-34 results are included in Merian Creek summaries. Tomulu Creek summaries comprise mainly results reported at SW-4b and a small number of samples collected further upstream in earlier years of the sampling program.

Table 9-16 summarizes general chemistry recorded at Merian Creek.

*Table 9-16 Summary of General Chemistry Merian Creek*

| PARAMETER | UNITS | MIN | AVG(ONLY DETECTS) | AVG (INCL NON DETECTS) | MAX | # DETECTS | # SAMPLES | STDEV |
|---|---|---|---|---|---|---|---|---|
| pH, Field | pH units | 4.69 | 5.93 | 5.93 | 7.34 | 67 | 68 | 0.44 |
| Temperature, Field | deg C | 24.4 | 28.0 | 28.0 | 37.4 | 67 | 67 | 2.3 |
| Conductivity, Field | umhos/cm | 18 | 30 | 30 | 46 | 66 | 66 | 8 |
| Dissolved oxygen, Field | mg/l | -0.05 | 5.75 | 5.75 | 10.87 | 66 | 66 | 2.35 |
| Turbidity, Field | NTU | 1 | 90 | 90 | 1000 | 67 | 67 | 208 |
| | | | | | | | | |
| Total Alkalinity | mg/l | 1.5 | 6.1 | 6.1 | 14.9 | 65 | 65 | 3.1 |
| Biochemical oxygen demand, 5 Days | mg/l | 2.28 | 4.146 | 4.146 | 5.04 | 5 | 5 | 1.09 |
| Chemical oxygen demand | mg/l | 5 | 24.3 | 21.5 | 44.6 | 12 | 14 | 10.0 |
| Hardness | mg/l | 4.6 | 10.3 | 10.3 | 14.6 | 14 | 14 | 2.5 |
| Total dissolved solids | mg/l | 10 | 70 | 68 | 782 | 90 | 92 | 107 |
| Total suspended solids | mg/l | 5 | 83 | 75 | 1440 | 83 | 92 | 253 |
| | | | | | | | | |
| Chloride | mg/l | 1.99 | 4.97 | 4.97 | 9.08 | 89 | 89 | 1.26 |
| Fluoride | mg/l | 0.01 | 0.0 | 0.1 | 0.1 | 4 | 14 | 0.0 |
| Sulfate | mg/l | 0.3 | 0.82 | 0.80 | 3.18 | 79 | 89 | 0.58 |
| Calcium | mg/l | 0.48 | 1.31 | 1.31 | 1.77 | 14 | 14 | 0.40 |
| Magnesium | mg/l | 0.42 | 1.40 | 1.40 | 1.99 | 14 | 14 | 0.40 |
| Potassium | mg/l | 0.5 | 0.83 | 0.74 | 2.59 | 64 | 89 | 0.37 |
| Sodium | mg/l | 2 | 3.02 | 3.02 | 5.85 | 89 | 89 | 0.70 |
| | | | | | | | | |
| Ammonia as N | mg/l | 0.03 | 0.3 | 0.2 | 1.4 | 81 | 84 | 0.2 |
| Nitrite + Nitrate as N | mg/l | 0.02 | 0.145 | 0.147 | 0.684 | 54 | 84 | 0.161 |
| Phosphorus | mg/l | 0.01 | 0.100 | 0.056 | 0.512 | 11 | 84 | 0.052 |
| Total organic carbon | mg/l | 2.35 | 7.4 | 7.4 | 14.9 | 81 | 81 | 3.2 |

Similar to the data collected in the Las Dominicanas Creek, nutrient concentrations in Merian Creek show potentially increasing trends apparently in response to increased anthropogenic activities in the area. Despite potential recent increases, these concentrations remain below guidelines for the protection of aquatic life (Figure 9-24).

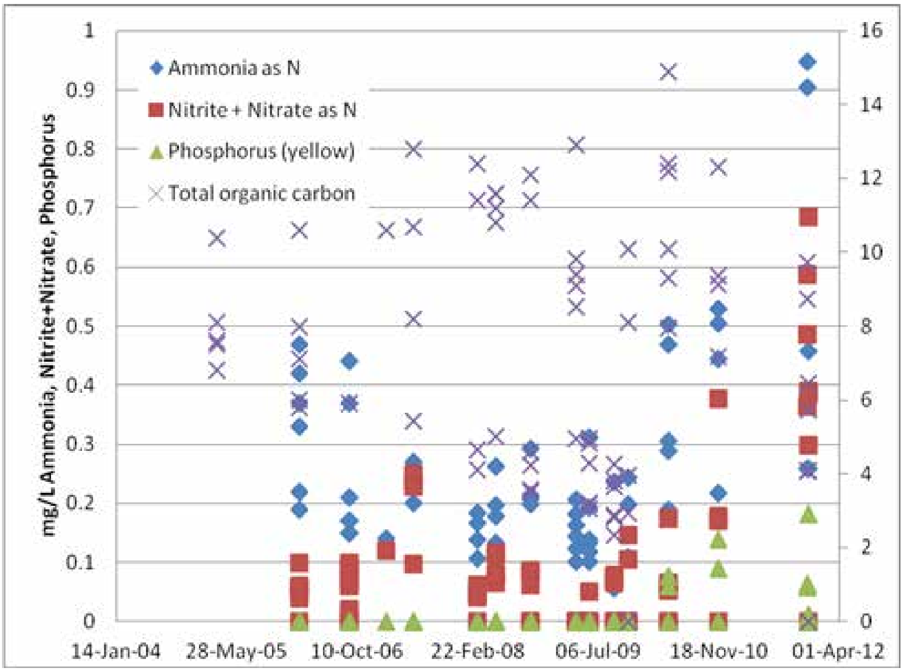


*Figure 9-24 Nutrient concentrations in Merian Creek Drainage Basin (TOC Results are plotted on secondary axis*

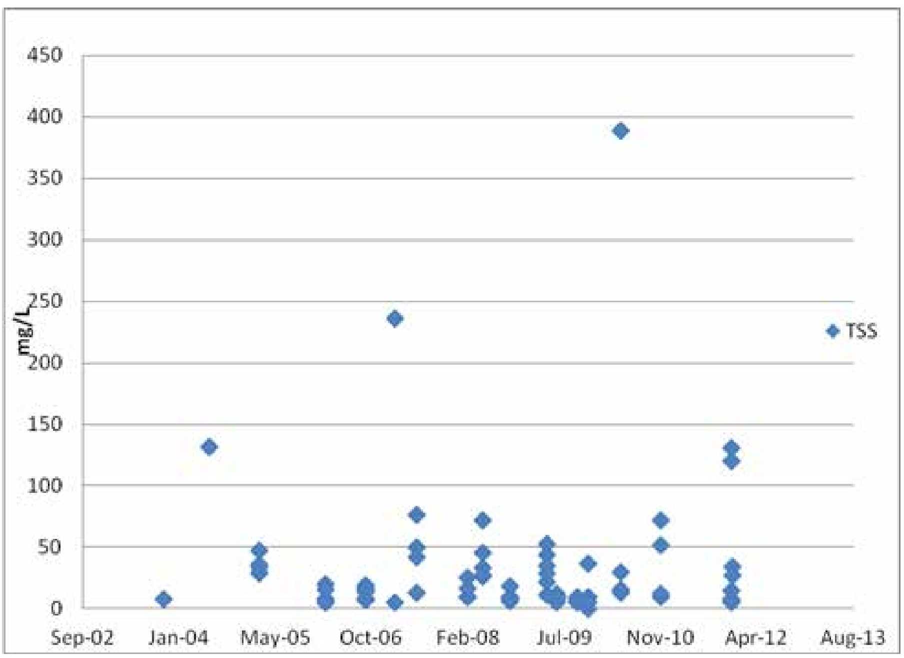


*Figure 9-25 TSS Concentrations in the Merian Creek Drainage Basin*

TSS data in the Merian Creek tributaries range generally from below detection limits to up to almost 400 mg/L with the exception of two measurements over 1400 mg/L that were recorded in April, 2010. As shown in Figure 9-25, concentrations were often below 50 mg/L and only exceeded 150 mg/L on a few occasions (April 2010 concentrations, not shown here, may be a result of significant flooding that occurred during this field mission (Tetra Tech 2010) rather than activities in the watershed). In addition to the routine semi-annual/seasonal sampling data, continuous turbidity data have been collected on Merian Creek at SW-34. Data is available from November, 2011 to January, 2012. Turbidity readings at SW-34 ranged from 19.2 to 1197 NTU and calculated TSS (based on a site-specific turbidity-TSS relationship) ranged from 17 – 347 mg/L with a mean of 92 mg/L. More details regarding turbidity and TSS monitoring are provided in Appendix 9-C Baseline Hydrology Report, Golder (2012).

Dissolved metals data collected in the upper Merian Creek Drainage Basin (i.e. above the confluence with Tomulu Creek) are presented in Table 9-17.

*Table 9-17 Summary of Dissolved Metals Concentrations in Merian Creek Drainage Basin*

| PARAMETER | UNITS | MIN | AVG(ONLY DETECTS) | AVG (INCL NON DETECTS) | MAX | # DETECTS | # SAMPLES | STDEV |
|---|---|---|---|---|---|---|---|---|
| Aluminum | mg/l | 0.01 | 0.10 | 0.08 | 0.18 | 23 | 89 | 0.03 |
| Antimony | mg/l | 0.001 | | | 0.02 | 0 | 89 | |
| Arsenic | mg/l | 0.001 | 0.001 | 0.017 | 0.025 | 1 | 89 | 0.011 |
| Barium | mg/l | 0.002 | 0.04 | 0.04 | 0.11 | 13 | 14 | 0.05 |
| Beryllium | mg/l | 0.002 | | | 0.002 | 0 | 84 | |
| Boron | mg/l | 0.015 | | | 0.04 | 0 | 89 | |
| Cadmium | mg/l | 0.0002 | | | 0.002 | 0 | 89 | |
| Chromium | mg/l | 0.001 | 0.002 | 0.006 | 0.006 | 1 | 89 | 0.001 |
| Cobalt | mg/l | 0.001 | 0.0084 | 0.0061 | 0.0129 | 13 | 89 | 0.0017 |
| Copper | mg/l | 0.001 | | | 0.01 | 0 | 89 | |
| Iron | mg/l | 0.08 | 0.99 | 0.99 | 3.65 | 89 | 89 | 0.54 |
| Lead | mg/l | 0.001 | | | 0.0075 | 0 | 89 | |
| Manganese | mg/l | 0.004 | 0.043 | 0.043 | 0.275 | 89 | 89 | 0.039 |
| Mercury | mg/l | 0.00002 | 0.0000 | 0.0002 | 0.0002 | 4 | 80 | 0.0000 |
| Molybdenum | mg/l | 0.002 | 0.008 | 0.008 | 0.008 | 1 | 89 | 0.001 |
| Nickel | mg/l | 0.001 | | | 0.01 | 0 | 89 | |
| Selenium | mg/l | 0.001 | 0.00 | 0.03 | 0.04 | 2 | 89 | 0.02 |
| Silver | mg/l | 0.001 | 0.015 | 0.005 | 0.015 | 1 | 89 | 0.001 |
| Thallium | mg/l | 0.001 | | | 0.001 | 0 | 9 | 0 |
| Titanium | mg/l | 0.001 | | | 0.005 | 0 | 14 | 0.002 |
| Vanadium | mg/l | 0.001 | | | 0.005 | 0 | 89 | 0.001 |
| Zinc | mg/l | 0.01 | 0.0147 | 0.0104 | 0.0164 | 2 | 89 | 0.0014 |

Similar to observations in the Las Dominicanas Creek data, iron and manganese are pervasive and are detected in all samples. Similarly barium is present in all samples for which it was analyzed. Aluminum and cobalt occur in some samples. Also detected in the dissolved fraction in a very small number of samples are:

- Arsenic;
- Mercury;
- Zinc; and
- Selenium.

Occurring only once in 89 samples were:

- Chromium (SW-14, 2005); and
- Silver (SW-05, 2005).

Concentrations of the above dissolved metals are compared to Project criteria for the projection of aquatic life. Average concentrations of aluminum exceed criteria (0.087 mg/L) similar to Las Dominicanas Creek. The one sample in which silver was detected the concentration also exceeded criteria (0.0001 mg/L). As with Las Dominicanas Creek, the pH range recorded in Merian creek ranges from 4.69 – 7.34. This overlaps with the recommended range for which the aluminum criterion applies. A site-specific criterion for aluminum is recommended. Continued baseline data collection will indicate if silver is a constituent of concern. Average of dissolved iron concentrations are quite close to the Project criterion for the protection of aquatic life (1 mg/L). Exceedances of the criterion for iron are most common in the small tributaries of Merian Creek (SW-15, SW-21, SW-23, SW-25, and SW-26). A site-specific criterion for iron is likely also required.

Total metals data collected in the Merian Creek Drainage Basin are presented in Table 9-18.

*Table 9-18 Summary of Total Metals Concentrations in Merian Creek*

| PARAMETER | UNITS | MIN | AVG(ONLY DETECTS) | AVG (INCL NON DETECTS) | MAX | # DETECTS | # SAMPLES | STDEV |
|---|---|---|---|---|---|---|---|---|
| Aluminum | mg/l | 0.119 | 3.3 | 3.3 | 20.7 | 9 | 9 | 6.6 |
| Antimony | mg/l | 0.003 | | | 0.003 | 0 | 9 | |
| Arsenic | mg/l | 0.003 | | | 0.003 | 0 | 9 | |
| Barium | mg/l | 0.0037 | 0.0237 | 0.0237 | 0.137 | 9 | 9 | 0.0427 |
| Beryllium | mg/l | 0.002 | | | 0.002 | 0 | 9 | |
| Boron | mg/l | 0.04 | | | 0.04 | 0 | 9 | |
| Cadmium | mg/l | 0.002 | | | 0.002 | 0 | 9 | |
| Chromium | mg/l | 0.006 | 0.031 | 0.020 | 0.123 | 5 | 9 | 0.039 |
| Cobalt | mg/l | 0.006 | 0.0137 | 0.0069 | 0.0137 | 1 | 9 | 0.0026 |
| Copper | mg/l | 0.01 | 0.05 | 0.01 | 0.052 | 1 | 9 | 0.0 |
| Iron | mg/l | 1.53 | 7 | 7 | 39 | 89 | 89 | 6 |
| Lead | mg/l | 0.0075 | 0.0226 | 0.0092 | 0.0226 | 1 | 9 | 0.0050 |
| Manganese | mg/l | 0.0127 | 0.053 | 0.053 | 0.328 | 89 | 89 | 0.052 |
| Mercury | mg/l | 0.0002 | | | 0.0005 | 0 | 84 | |
| Molybdenum | mg/l | 0.008 | | | 0.008 | 0 | 9 | |
| Nickel | mg/l | 0.01 | 0.05 | 0.01 | 0.05 | 1 | 9 | 0.01 |
| Selenium | mg/l | 0.003 | | | | 0 | 9 | |
| Silver | mg/l | 0.005 | | | | 0 | 9 | |
| Thallium | mg/l | 0.001 | | | | 0 | 9 | |
| Titanium | mg/l | 0.005 | 0.020 | 0.015 | 0.0524 | 6 | 9 | 0.0150 |
| Vanadium | mg/l | 0.005 | 0.027 | 0.017 | 0.108 | 5 | 9 | 0.034 |
| Zinc | mg/l | 0.01 | 0.04 | 0.01 | 0.0443 | 1 | 9 | 0.0114 |

As seen in Las Dominicanas Creek, iron and manganese are above detection limits across all sampling locations and sampling missions. Aluminum and barium are present in all samples for which they were analyzed. Metals with averages greater than Project criteria are:

- Aluminum;
- Chromium[16];
- Cobalt[17];
- Copper;
- Iron; and

[16] Cr concentrations were analyzed for total Chromium. Project criteria specify a criterion for hexavalent chromium. Total chromium concentrations have been compared to criteria for hexavalent chromium, which is a conservative approach.

[17] Cobalt is a drinking water criteria and not relevant with respect to the protection of aquatic life.

· Lead.

Copper and lead concentrations were only observed in one sample. Further baseline data will confirm if these are actually constituents of concern. As with Las Dominicanas Creek, aluminum and iron both exceed the Project criteria regularly. Similar to Las Dominicanas Creek data for total solids, high precipitation events can result in high levels of TSS that increase metals baseline concentrations such that Project impacts may not be reliably detectable.

Sediment concentrations measured in Merian Creek are reported in Table 9-19.

*Table 9-19 Sediment Quality in Merian Creek*

| PARAMETER | UNITS | MIN | AVG(ONLY DETECTS) | AVG (INCL NON DETECTS) | MAX | # DETECTS | # SAMPLES | STDEV |
|---|---|---|---|---|---|---|---|---|
| Paste pH | pH units | 4.47 | 5.25 | 5.25 | 6.55 | 10 | 10 | 0.72 |
| Total Organic Matter | % | 0.15 | 0.91 | 0.83 | 2 | 25 | 28 | 1 |
| | | | | | | | | |
| Aluminum | mg/kg | 157 | 2517 | 2517 | 7160 | 33 | 33 | 1832 |
| Antimony | mg/kg | 2 | 3 | 2 | 3 | 1 | 15 | 0 |
| Arsenic | mg/kg | 0.3 | 11.2 | 4.7 | 92.6 | 11 | 33 | 15.9 |
| Barium | mg/kg | 2 | 12 | 10 | 28 | 4 | 5 | 10.59717 |
| Beryllium | mg/kg | 0.2 | | | 0.2 | 0 | 10 | |
| Boron | mg/kg | 2 | | | 4 | 0 | 15 | |
| Cadmium | mg/kg | 0.1 | | | 0.2 | 0 | 33 | |
| Chromium | mg/kg | 2 | 22.0 | 22.0 | 44.2 | 33 | 33 | 13.7 |
| Cobalt | mg/kg | 0.6 | 7.6 | 1.9 | 10 | 2 | 15 | 3 |
| Copper | mg/kg | 1.54 | 9.71 | 9.48 | 22.5 | 32 | 33 | 7.1 |
| Iron | mg/kg | 990 | 12937 | 12937 | 33800 | 33 | 33 | 9377 |
| Lead | mg/kg | 0.394 | 2.927 | 2.739 | 5.44 | 29 | 33 | 1.38 |
| Manganese | mg/kg | 0.72 | 39.94 | 38.79 | 673 | 32 | 33 | 115 |
| Mercury | mg/kg | 0.033 | 0.152 | 0.421 | 2 | 25 | 33 | 1 |
| Molybdenum | mg/kg | 0.8 | 6.0 | 2.1 | 13 | 3 | 15 | 3 |
| Nickel | mg/kg | 1 | 3 | 2 | 5.88 | 20 | 33 | 1.28 |
| Selenium | mg/kg | 0.3 | 1.0 | 1.9 | 4 | 13 | 33 | 2 |
| Silicon | mg/kg | 5 | 200 | 161 | 300 | 4 | 5 | 112 |
| Silver | mg/kg | 0.05 | 3.02 | 0.63 | 7 | 3 | 33 | 1 |
| Thallium | mg/kg | 0.1 | | 0.1 | 0.1 | 0 | 18 | |
| Vanadium | mg/kg | 1.89 | 20.74 | 20.74 | 64 | 33 | 33 | 14 |
| Zinc | mg/kg | 1.29 | 5.85 | 5.85 | 15 | 33 | 33 | 3 |
| | | | | | | | | |
| Cyanide | mg/kg | 0.5 | 1 | 0.61 | 1 | 2 | 23 | 0 |
| Cyanide, Free | mg/kg | 1 | 1.46 | 1.08 | 2.19 | 3 | 18 | 0.28 |
| WAD CN | mg/kg | 0.5 | | 0.5 | 0.5 | 0 | 18 | 0 |

*Tomulu Creek Water Quality*

The following data summaries are based on samples collected at SW-4B, SW-10, and SW 12 (Table 9-20). Data from SW-10 and SW-12 are limited to 2005 and 2006.

*Table 9-20 Summary of General Chemistry Tomulu Creek*

| PARAMETER | UNITS | MIN | AVG(ONLY DETECTS) | AVG (INCL NON DETECTS) | MAX | # DETECTS | # SAMPLES | STDEV |
|---|---|---|---|---|---|---|---|---|
| pH, Field | pH units | 5.6 | 6.07 | 6.05 | 6.89 | 19 | 20 | 0.39 |
| Temperature, Field | deg C | 27.4 | 30.09 | 30.09 | 35.51 | 19 | 19 | 2.90 |
| Conductivity, Field | uS/cm | 20 | 39 | 39 | 116 | 19 | 19 | 20 |
| Dissolved oxygen, Field | mg/l | 3.22 | 6.92 | 6.92 | 11.4 | 19 | 19 | 2.1 |
| Turbidity, Field | NTU | 16 | 235 | 235 | 1000 | 17 | 17 | 310 |
| | | | | | | | | |
| Total Alkalinity | mg/l | 1.5 | 5.5 | 5.5 | 7.9 | 9 | 9 | 2.6 |
| Biochemical oxygen demand, 5 Days | mg/l | 2.58 | 3.24 | 3.24 | 3.81 | 3 | 3 | 0.62 |
| Chemical oxygen demand | mg/l | 5 | 46 | 46 | 111 | 4 | 4 | 46 |
| Hardness | mg/l | 9.68 | 10.1 | 10.1 | 10.6 | 4 | 4 | 0.4 |
| Total dissolved solids | mg/l | 11 | 92 | 92 | 436 | 19 | 19 | 105 |
| Total suspended solids | mg/l | 0 | 536 | 512 | 2900 | 21 | 22 | 831 |
| | | | | | | | | |
| Chloride | mg/l | 3.02 | 4.80 | 4.80 | 6.3 | 18 | 18 | 0.9 |
| Fluoride | mg/l | 0.017 | 0.019 | 0.0514 | 0.1 | 3 | 5 | 0.0 |
| Sulfate | mg/l | 0.38 | 0.72 | 0.77 | 1.57 | 15 | 18 | 0.33 |
| Calcium | mg/l | 0.48 | 0.86 | 0.86 | 1.21 | 4 | 4 | 0.31 |
| Magnesium | mg/l | 1.2 | 1.305 | 1.305 | 1.62 | 4 | 4 | 0.21 |
| Potassium | mg/l | 0.57 | 0.83 | 0.83 | 1.47 | 17 | 17 | 0.27 |
| Sodium | mg/l | 2.37 | 3.12 | 3.12 | 3.73 | 17 | 17 | 0.36 |
| | | | | | | | | |
| Ammonia as N | mg/l | 0.08 | 0.22 | 0.22 | 0.35 | 14 | 14 | 0.09 |
| Nitrite + Nitrate as N | mg/l | 0.03 | 0.10 | 0.15 | 0.5 | 11 | 14 | 0.2 |
| Phosphorus | mg/l | 0.05 | 0.212 | 0.073 | 0.366 | 2 | 14 | 0.084 |
| Total organic carbon | mg/l | 3.36 | 7.41 | 7.23 | 10.1 | 13 | 14 | 2.1 |

Tomulu Creek may be the most heavily mined creek in the area. TSS concentrations are presented in Figure 9-26.

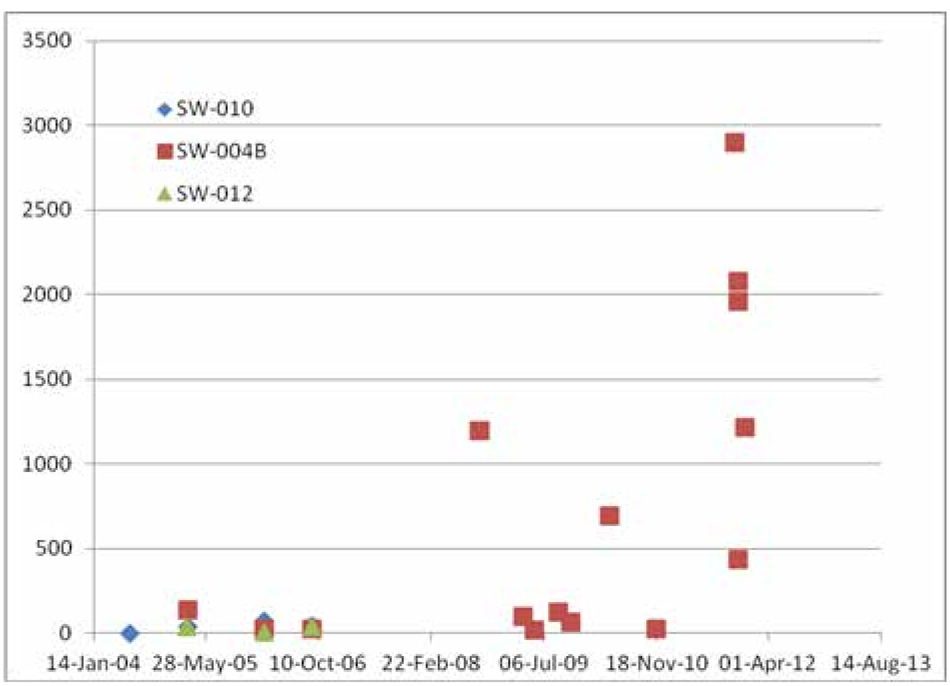


*Figure 9-26 TSS Concentrations in Tomulu Creek (mg/L)*

Table 9-21 presents the dissolved metals concentrations recorded in Tomulu Creek.

*Table 9-21 Summary of Dissolved Metals Concentrations Tomulu Creek*

| PARAMETER | UNITS | MIN | AVG(ONLY DETECTS) | AVG (INCL NON DETECTS) | MAX | # DETECTS | # SAMPLES | STDEV |
|---|---|---|---|---|---|---|---|---|
| Aluminum | mg/l | 0.01 | 0.080 | 0.059 | 0.137 | 5 | 17 | 0.036 |
| Antimony | mg/l | 0.001 | | | 0.02 | 0 | 17 | 0.01 |
| Arsenic | mg/l | 0.001 | 0.002 | 0.015 | 0.025 | 2 | 17 | 0.012 |
| Barium | mg/l | 0.0031 | 0.08 | 0.08 | 0.13 | 4 | 4 | 0.05 |
| Beryllium | mg/l | 0.002 | | | 0.002 | 0 | 14 | |
| Boron | mg/l | 0.015 | | | 0.04 | 0 | 17 | |
| Cadmium | mg/l | 0.0002 | | | 0.002 | 0 | 17 | |
| Chromium | mg/l | 0.001 | 0.001 | 0.005 | 0.006 | 1 | 17 | 0.002 |
| Cobalt | mg/l | 0.001 | 0.0094 | 0.0055 | 0.0115 | 2 | 17 | 0.0025 |
| Copper | mg/l | 0.001 | | | 0.01 | 0 | 17 | |
| Iron | mg/l | 0.16 | 0.61 | 0.61 | 1.59 | 17 | 17 | 0.41 |
| Lead | mg/l | 0.001 | | | 0.0075 | 0 | 17 | |
| Manganese | mg/l | 0.013 | 0.0363 | 0.0363 | 0.0689 | 17 | 17 | 0.0170 |
| Mercury | mg/l | 0.00002 | 0.0000 | 0.0002 | 0.0002 | 2 | 16 | 0.0001 |
| Molybdenum | mg/l | 0.002 | | | 0.008 | 0 | 17 | |
| Nickel | mg/l | 0.001 | 0.00 | 0.01 | 0.01 | 1 | 17 | 0.00 |
| Selenium | mg/l | 0.001 | | | 0.04 | 0 | 17 | |
| Silver | mg/l | 0.001 | | 0.0042941 | 0.005 | 0 | 17 | |
| Thallium | mg/l | 0.001 | | | 0.001 | 0 | 1 | |
| Titanium | mg/l | 0.001 | | | 0.005 | 0 | 4 | |
| Vanadium | mg/l | 0.001 | | | 0.005 | 0 | 17 | |
| Zinc | mg/l | 0.01 | | | 0.015 | 0 | 17 | |

As in the other watersheds, iron and manganese are ubiquitous. Similar to the other two watersheds, aluminum and iron are reported as exceeding Project criteria for the protection of aquatic life occasionally however aluminum was only detected in a small number of samples. Recurring metals detected in the dissolved fraction are barium, iron, and manganese.

Table 9-22 presents the total metals concentrations recorded in Tomulu Creek. Since total metals were collected only in 2011 (with the exception of iron and manganese) these data mainly present the November 2011 results for SW-4B.

*Table 9-22 Summary of Total Metals Concentrations Tomulu Creek*

| PARAMETER | UNITS | MIN | AVG(ONLY DETECTS) | AVG (INCL NON DETECTS) | MAX | # DETECTS | # SAMPLES | STDEV |
|---|---|---|---|---|---|---|---|---|
| Aluminum | mg/l | 22 | 22 | 22 | 22 | 1 | 1 | |
| Antimony | mg/l | 0.003 | | 0.003 | 0.003 | 0 | 1 | |
| Arsenic | mg/l | 0.0042 | 0.0042 | 0.0042 | 0.0042 | 1 | 1 | |
| Barium | mg/l | 0.0785 | 0.0785 | 0.0785 | 0.0785 | 1 | 1 | |
| Beryllium | mg/l | 0.002 | | | 0.002 | 0 | 1 | |
| Boron | mg/l | 0.04 | | | 0.04 | 0 | 1 | |
| Cadmium | mg/l | 0.002 | | | 0.002 | 0 | 1 | |
| Chromium | mg/l | 0.145 | 0.145 | 0.145 | 0.145 | 1 | 1 | |
| Cobalt | mg/l | 0.006 | | | 0.006 | 0 | 1 | |
| Copper | mg/l | 0.061 | 0.061 | 0.061 | 0.061 | 1 | 1 | |
| Iron | mg/l | 3.37 | 12.1 | 12.1 | 36.9 | 17 | 17 | 10.5 |
| Lead | mg/l | 0.0129 | 0.0129 | 0.0129 | 0.0129 | 1 | 1 | |
| Manganese | mg/l | 0.027 | 0.061 | 0.061 | 0.255 | 17 | 17 | 0.053 |
| Mercury | mg/l | 0.0002 | 0.00052 | 0.00025 | 0.00058 | 2 | 14 | 0.00012 |
| Molybdenum | mg/l | 0.008 | | | 0.008 | 0 | 1 | |
| Nickel | mg/l | 0.027 | 0.027 | 0.027 | 0.027 | 1 | 1 | |
| Selenium | mg/l | 0.003 | | | 0.003 | 0 | 1 | |
| Silver | mg/l | 0.005 | | | 0.005 | 0 | 1 | |
| Thallium | mg/l | 0.001 | | | 0.001 | 0 | 1 | |
| Titanium | mg/l | 0.0426 | 0.0426 | 0.0426 | 0.0426 | 1 | 1 | |
| Vanadium | mg/l | 0.097 | 0.097 | 0.097 | 0.097 | 1 | 1 | |
| Zinc | mg/l | 0.0316 | 0.0316 | 0.0316 | 0.0316 | 1 | 1 | |

Total TSS at SW-4b in November 2011 was around 2000 mg/L, which explains the high number of total metals detected and in some cases above Project criteria (copper and iron). Mercury has been sampled in this creek over the course of the baseline sampling period. Mercury was detected at SW-10 in 2006.

Sediment quality in Tomulu Creek is reported in Table 9-23.

*Table 9-23 Sediment Quality Tomulu Creek*

| PARAMETER | UNITS | MIN | AVG(ONLY DETECTS) | AVG (INCL NON DETECTS) | MAX | # DETECTS | # SAMPLES | STDEV |
|---|---|---|---|---|---|---|---|---|
| Total organic ca | % | 0.18 | 0.23 | 0.23 | 0.268 | 3 | 3 | 0.05 |
| Total organic ca | g/kg | 1 | 1 | 1 | 1 | 1 | 3 | 0 |
| | | | | | | | | |
| Aluminum | mg/kg | 500 | 2111 | 2111 | 4520 | 6 | 6 | 1695 |
| Antimony | mg/kg | 2 | | 2 | 2 | 0 | 4 | 0 |
| Arsenic | mg/kg | 2 | 13.5 | 7.9 | 22.7 | 3 | 6 | 9.1 |
| Barium | mg/kg | 4 | 7 | 7 | 10 | 3 | 3 | 3 |
| Beryllium | mg/kg | 0.2 | | 0.2 | 0.2 | 0 | 1 | |
| Boron | mg/kg | 2 | | 2.5 | 4 | 0 | 4 | 1 |
| Cadmium | mg/kg | 0.1 | | 0.2 | 0.2 | 0 | 6 | 0.1 |
| Chromium | mg/kg | 4 | 29 | 29 | 72.5 | 6 | 6 | 32.3 |
| Cobalt | mg/kg | 0.6 | | 1.65 | 2 | 0 | 4 | 1 |
| Copper | mg/kg | 2 | 12 | 12 | 28.8 | 6 | 6 | 11.5 |
| Iron | mg/kg | 1700 | 14445 | 14445 | 38000 | 6 | 6 | 17575 |
| Lead | mg/kg | 1.07 | 4.39 | 3.60 | 7.13 | 4 | 6 | 2.34 |
| Manganese | mg/kg | 3 | 29 | 29 | 74 | 6 | 6 | 33 |
| Mercury | mg/kg | 0.05 | 0.16 | 1.08 | 2 | 3 | 6 | 1 |
| Molybdenum | mg/kg | 0.8 | | 1.7 | 2 | 0 | 4 | 1 |
| Nickel | mg/kg | 1 | 9.2 | 5.4 | 12.5 | 3 | 6 | 5.0 |
| Selenium | mg/kg | 0.431 | 0 | 2 | 4 | 2 | 6 | 1 |
| Silver | mg/kg | 0.05 | | 1.1 | 2 | 0 | 6 | 1 |
| Thallium | mg/kg | 0.1 | | 0.1 | 0.1 | 0 | 2 | 0 |
| Vanadium | mg/kg | 3 | 13.0 | 13.0 | 29.9 | 6 | 6 | 12.6 |
| Zinc | mg/kg | 2.61 | 9.9 | 9.9 | 18.7 | 6 | 6 | 6.9 |
| | | | | | | | | |
| Cyanide | mg/kg | 0.5 | | 0.8 | 1 | 0 | 5 | 0 |
| Cyanide, Free | mg/kg | 1 | | 1 | 1 | 0 | 2 | 0 |
| WAD CN | mg/kg | 0.5 | | 0.5 | 0.5 | 0 | 2 | 0 |

## 9.4 *REGIONAL HYDROGEOLOGY*

Suriname contains two hydro-geologically distinct provinces: the Interior Precambrian Shield of crystalline rocks, comprising 80% of the country and the Coastal Plain basin, comprising the remaining 20%. The Interior, where the Project is found, is mainly located in the Interior Precambrian Shield. Here, groundwater resources are considered limited because the main geologic formations have low permeability.

In the region of the Project, the area is classified by the USACE to have "Fresh Water Locally Plentiful," which is defined as "meager to large quantities of freshwater available locally from fractured and weathered zones in Precambrian age sedimentary, metaclastic and carbonate rocks. Depth to aquifer is less than 70 m." Meager is defined as >0.25 to 1 L/s. In the Project region groundwater is typically found in fractured and weathered zones within the bedrock. The highest groundwater yields are available from large fracture zones.

Groundwater found in the region through these fractured bedrock aquifers is generally fresh[18]. Expected yields fall between 0.25 – 50 L/s.

[18] USACE Water Resources of Suriname.

Figure 9-27 illustrates the country's groundwater resources as defined by the USACE.

## 9.5 *PROJECT HYDROGEOLOGY*

A preliminary groundwater investigation was conducted in 2009 and further investigations proceeded in 2011 and 2012 conducted by Golder Associates Inc. The investigations included the following:

- Borehole drilling followed by the installation of piezometers, monitoring wells or test wells (22 piezometers at 10 locations installed in 2009, and 90 piezometers, 7 test wells, and 3 monitoring wells at 40 locations installed in 2011 – 2012);
- Permeability testing;
- Pumping tests;
- Falling-head tests;
- Groundwater level monitoring at piezometers, test wells, and monitoring wells to characterize groundwater elevations, flow directions, hydraulic gradients, and seasonal fluctuation in water level at the site; and
- Details regarding field investigations are reported in two Golder reports (2009, 2012). Golder's 2012 Hydrogeology Baseline Report is included as Appendix 9-C.

Figure 9-28 shows the location of the borehole locations and wells. A summary table of all of the boreholes and wells is provided in Appendix 9-C.

The data collected in 2011 and 2012 have refined the understanding of the site's hydrogeologic units:

- Alluvium (In-situ and Reworked)
- Saprolite
- Quartz Vein Units Within Saprolite
- Saprock
- Bedrock

Cross sections depicting the stratigraphy across the site are presented in Appendix 9-D Figures 4 –11 to 4 – 17.

*Figure 9-27 Groundwater Resources of Suriname (reproduced from USACE, 2001)*

*Figure 9-28 Piezometer and Well Locations*

### *9.5.1 Project Hydrogeologic Units*

*Alluvium*

Unconsolidated materials are found primarily in stream valleys across the site. The unconsolidated materials include native alluvial deposits consisting of sand and silt, and materials reworked by ASM mining activities. The reworked materials have been re-deposited in the stream channels, and consist of quartz gravels and sands in a silty matrix. Based on test pits in the TSF area, alluvial materials are 1 to 4 meter thick.

Groundwater occurs in the alluvium unit under unconfined conditions and is likely in direct hydraulic continuity with surface water. Groundwater in the alluvium unit is recharged by direct precipitation and infiltration of runoff from adjacent saprolite hillsides, and from discharge of groundwater from underlying hydrogeologic units in areas where an upward component of hydraulic gradient occurs. Groundwater may also be recharged from surface water during peak streamflow events when for a short time the surface water elevation is higher than the surrounding groundwater elevation. Groundwater in the alluvium discharges to the adjacent streams. The alluvium appears to provide storage and sustain baseflow in the streams between storms and during the dry season, though smaller streams go dry during prolonged dry times, which indicates that the alluvial baseflow is limited.

*Saprolite*

Saprolite is formed by the prolonged chemical weathering of bedrock during a humid, tropical paleo-climate. Weathering has resulted in a laterite/saprolite profile that extends on average 80 to 100 m below the ground surface. The saprolite sequence across the project site exhibits local variation in thickness ranging from less than 10 to 175 meters, with a few very small areas of even thicker saprolite. The laterite profile is generally 2 – 3 meters thick covered by 0.3 to 0.5 meters of soil. Below the laterite is a strongly weather and clay-rich saprolite.

Figure 9-29 shows the predicted saprolite depths across the Project Site. The thinnest areas of saprolite are generally found in the stream valleys and other low-lying areas, and the thickest areas are generally found in the upland areas. In the Merian II and Maraba areas, a significant thickness of saprolite was removed by ASM mining. The prominent geological structure within the saprolite is relict foliation or bedding from the original sedimentary rock structure. There are also remnant quartz veins in the saprolite. These quartz veins may be relatively intact or broken with a gravelly appearance.

Saprolite is typically of low hydraulic conductivity, which is a measure of a material's ability to transmit water. Groundwater occurrence in the saprolite sequence is primarily associated with the quartz veins and is characterized by semi-confined to unconfined conditions. Precipitation on the local hilltops recharges the groundwater in the saprolite.

*Figure 9-29 Saprolite Isopach*

Saprolite quartz veining has been found in the ore zones, in saprolite below the WRD facilities and in saprolite underlying the TSF.  The highest density of quartz veining is associated with the ore zones in the Merian and Maraba pit areas.  There appears to be less quartz veining in the saprolite below the TSF and the WRD areas.  The quartz veins in the saprolite are often oxidized and heavily weathered and appear to strike to the northwest and dip steeply, similar to vein orientations in the underlying bedrock.  These quartz vein features influence the movement of groundwater in the saprolite.  The hydraulic conductivity associated with the quartz veins is significantly greater than the saprolite.  This means that groundwater flows more readily through the quartz veins.  Figure 9-30 shows the range of measured hydraulic conductivities in the different stratigraphic units present at the site, the remaining units are discussed below. Groundwater is found under semi-confined to confined conditions in the quartz veins with the static water level rising above the top of the quartz vein unit. Saprolite acts as the confining layer.

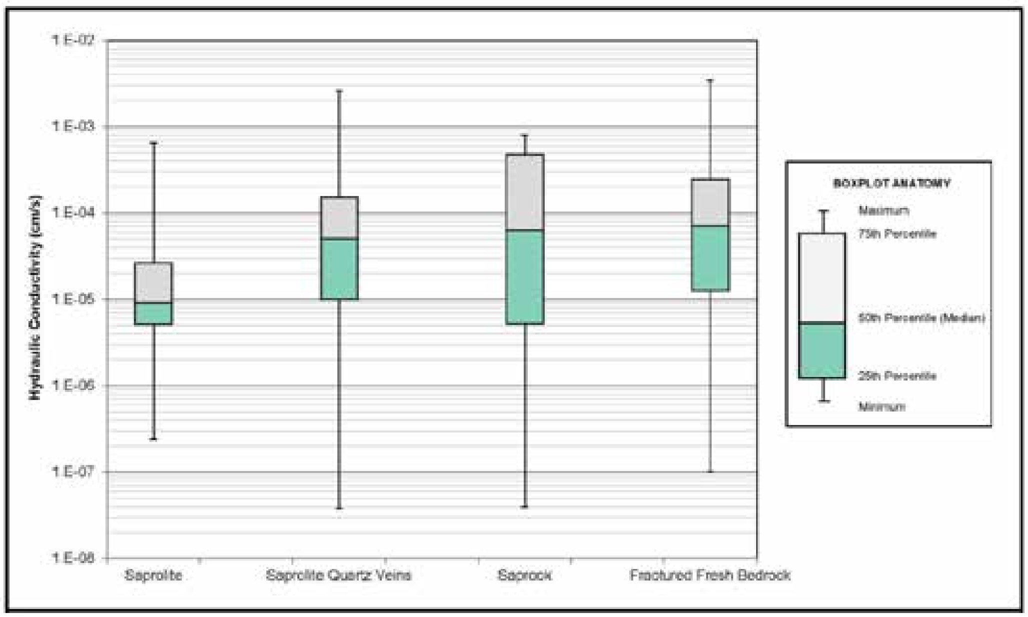


*Figure 9-30 Hydraulic Conductivity of Geologic Units for Entire Site*

*Saprock*

Saprock is partially weathered or oxidized rock.  The transition zone between the saprolite and the fresh bedrock can be highly irregular and ranges in thickness from 0 – 80 meters.  Below the saprock lies the bedrock.  It is difficult to characterize groundwater occurrence in the saprock given its variability however it is inferred that locally higher permeability zones may be found within the saprock transition zone.  The mean hydraulic conductivity of the saprock underlying the TSF area is greater than the mean hydraulic conductivity in the mine and pit area.  The saprock in the mine area may be more silicified or altered than the saprock underlying the TSF area, resulting in lower permeability.

*Bedrock*

The bedrock is comprised of poorly sorted, interbedded, weakly metamorphosed sedimentary package, which ranges from feldspathic sandstone to mudstone. The sedimentary package has been deformed into a series of discontinuous folds and lithologic units. Closely-spaced foliation fractures can be observed in weathered, weak and fresh rock core, where fractures developed preferentially along foliations. Foliation describes a fine layering structure that can be observed in metamorphic rocks.

The overall geotechnical quality of the bedrock is considered to be fair to good, which means there are few fractures and it is structurally competent. However, zones of highly fractured areas are suggested by drilling and pumping tests resulting in possible localized areas of higher permeability.

Quartz breccia and quartz veining (carrying mineralization) in the mine area formed along fold hinges during regional compression and faulting. The orientation of the breccia is irregular but thought to be connected to extensional or sheet veins that generally dip 30 degrees to 40 degrees northeast along cross shears. The quartz breccia and quartz veins within bedrock (below the upper weathered zone) are massive with no natural fracture systems and few voids are evident. This means that the quartz veins in the bedrock do not transmit groundwater in the same manner that they do in the saprolite.

Groundwater occurs in the bedrock under confined conditions as a result of the overlying low-permeability saprolite and saprock.

*Groundwater Elevations, Hydraulic Gradients and Flow Paths*

Groundwater levels have been measured at the site in wells located at the TSF and the Mine Site over the past several months. Piezometers installed in 2008 have also been monitored routinely on a weekly to monthly basis from the end of 2008 to mid-2010. Groundwater levels have been observed either very close to the surface or even under artesian conditions in the lowland areas in the valley bottoms. Groundwater levels in the higher topographical areas are approximately 20 – 25 meters below ground surface (m bgs) and extend to almost 50 m bgs in some upland areas of the TSF. Water level data are summarized in Appendix 9-D and presented in Figure 9-31 to Figure 9-33.

*Figure 9-31 Saprolite Groundwater Elevations*

*Figure 9-32 Saprock Piezometric Surface Map*

*Figure 9-33 Bedrock Piezometric Surface Map*

Figure 9-34 to Figure 9-36 show changes in groundwater levels at the TSF and in the pit areas in the saprolite and quartz vein systems as well as the bedrock. Each figure depicts water levels measured at a number of different depths measured in different hydrogeologic units. These figures also show changes in water level (stage) at surface water gaging stations located in proximity to the piezometers and test wells. Table 9-24 summarizes the data presented in the figures.

Groundwater levels in the valley bottom near the main dam in the TSF area (borehole location TSF-PZ-2) in a quartz vein system in saprolite respond rapidly to precipitation and changes in the water levels in the local creek. There is a short lag time between the peak in water level in the creek (stream stage) and peak in groundwater level in the quartz vein piezometer. This short lag-time suggests a strong hydraulic communication between surface water and the groundwater. In the deeper quartz veins found in the saprock at this same valley bottom location (TSF-PZ-7), groundwater levels also respond to stream stage and precipitation; however, these responses are not as fast as those observed in the saprolite quartz veins. This indicates thate there is a hydraulic connection with surface water and precipitation and groundwater levels in saprock and bedrock, but they are not as well-connected as the saprolite quartz vein system.

Elsewhere within the TSF area (higher elevation hill top areas), groundwater monitoring in piezometers completed in saprolite quartz veins shows that groundwater levels respond much slower to recharge. This indicates that the saprolite quartz veins found below the hilltops are not well connected to surface water or surface precipitation-driven recharge.

In the mine pit areas of Merian II and Maraba (MA-PZ-3), groundwater elevations vary in response to seasonal changes in recharge. Groundwater elevations also respond to periods of increased precipitations, such as in June 2009 when groundwater elevations in MA-PZ-3_SQ and –SR increased by about 0.3 m.

Short-term (diurnal), rhythmic fluctuations in groundwater levels (between 1 and 5 cm) have been observed in piezometers and wells in all formations across the site. These diurnal rhythmic fluctuations have been attributed to earth tides and the groundwater system’s response to earth tides suggests that it is a well-confined system.

*Table 9-24 Summary of Data Presented in Figure 9-34, Figure 9-35 and Figure 9-36*

| Figure | ID | Location | Hydrogeologic Unit |
|---|---|---|---|
| Figure 9-34 | TSF-PZ-2-SQ (S) | TSF | Saprolite quartz vein – shallow |
| | TSF-PZ-2-SQ (D) | TSF | Saprolite quartz vein - deep |
| | TSF-PZ-2-BR | TSF | Bedrock |
| | TSF-TW-2 | TSF | Saprolite quartz vein test well - shallow |
| | TSF-TW2/2R | TSF | Saprolite quartz vein test wells -shallow |
| | SW-38 | North North Fork A3 Creek | Surface water station |
| Figure 9-35 | TSF-PZ-7-BQ | TSF | Bedrock quartz vein |
| | TSF-PZ-7-BR | TSF | Bedrock |
| | TSF-PZ-7-SR | TSF | Saprock |
| | TSF-TW-7 | TSF | Bedrock quartz vein test well |
| | SW-35 | North Fork A3 Creek | Surface water station |
| Figure 9-36 | MA-PZ-3-SR | Maraba | Saprock |
| | MA-PZ-3-BR | Maraba | Bedrock |
| | MA-PZ-3-SQ | Maraba | Saprolite quartz vein |

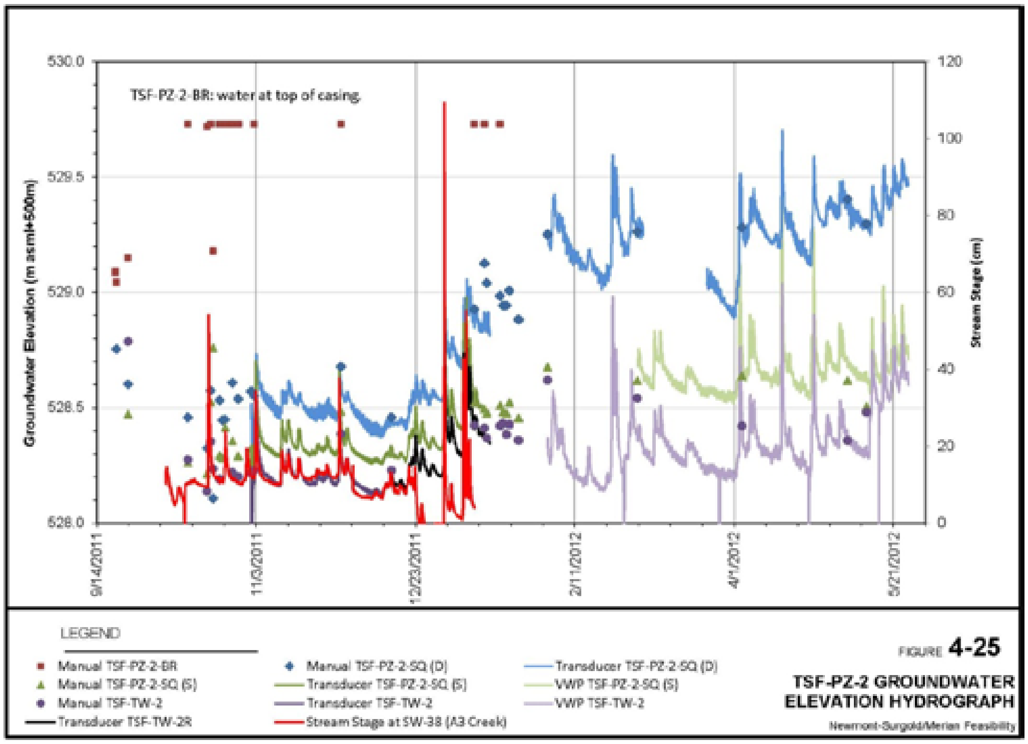


*Figure 9-34 TSF-PZ-2 Groundwater Elevation Hydrograph*

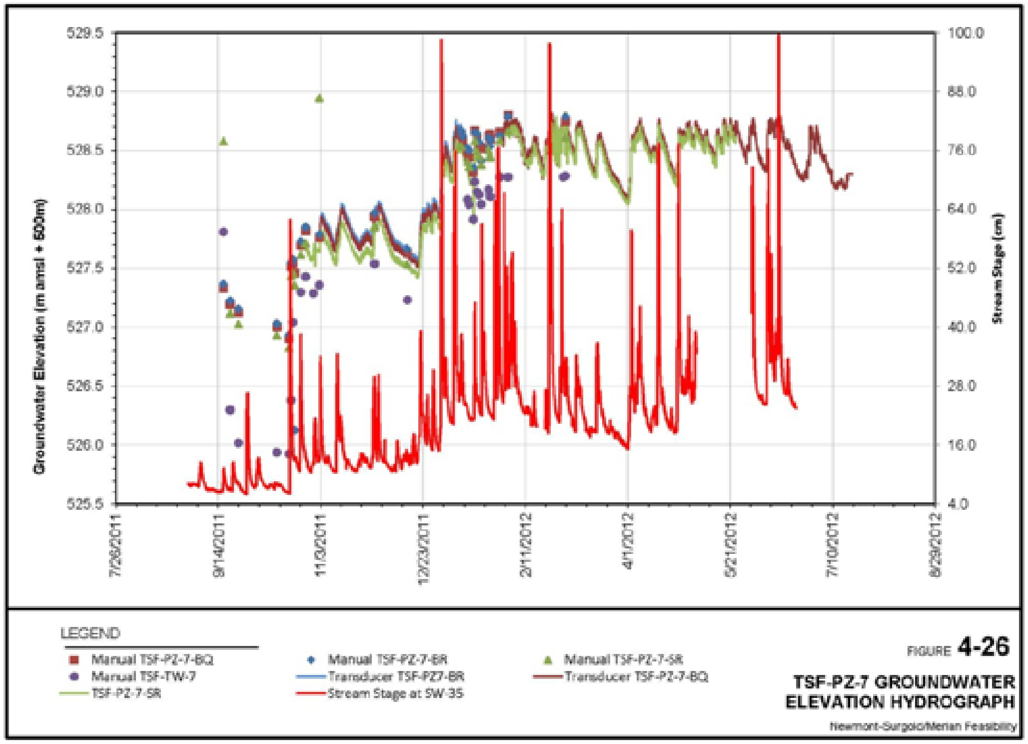


*Figure 9-35 TSF-PZ-7 Groundwater Elevation Hydrograph*

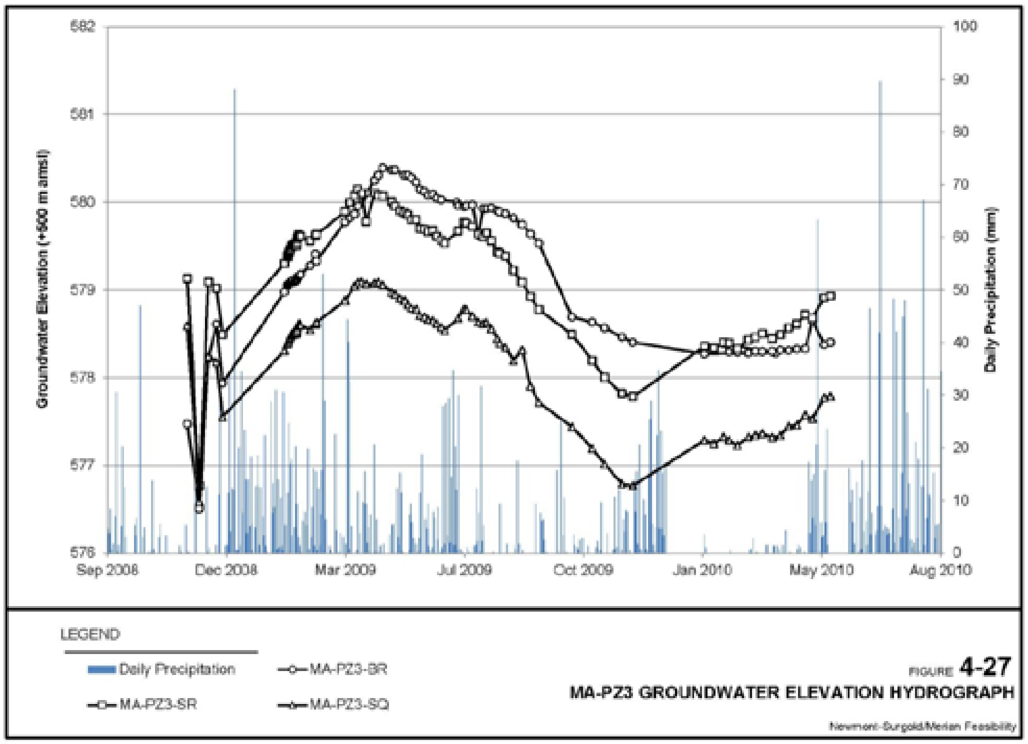


*Figure 9-36 MA-PZ-3 Groundwater Elevation Hydrograph*

The hydraulic gradient is the change in groundwater elevation over distance along a groundwater flow line. It represents the slope of the water table (unconfined aquifer) or the piezometric surface (confined aquifer). For a given value of hydraulic conductivity, a steeper hydraulic gradient indicates a greater volume of groundwater flow per unit cross-sectional area of aquifer.

There are both horizontal and vertical components of hydraulic gradient. The horizontal component of hydraulic gradient across the site generally reflects the topographic conditions. Horizontal components of hydraulic gradient are generally relatively low. The horizontal component of hydraulic gradient in the saprolite ranges from about 0.030 m/m north of TSF Phase 2 to about 0.006 m/m south and east of Merian II. The horizontal component of hydraulic gradient in the saprock ranges from about 0.020 m/m north of TSF Phase 2 to about 0.006 m/m south and east of Merian II . In the bedrock, the horizontal component of hydraulic gradient ranges from about 0.030 m/m north of TSF Phase 2 to about 0.005 m/m south and east of Merian II.

The vertical component of hydraulic gradient indicates the potential for upward or downward groundwater flow. Downward, or negative components of hydraulic gradients, indicate recharge to groundwater and upward, or positive, components of hydraulic gradient indicate areas where groundwater may discharge to creeks or to overlying aquifers. Data collected to date indicate that while vertical components of hydraulic gradients are variable, predominantly upward gradients occur in low-lying areas adjacent to surface water bodies and downward gradients are predominant in the upland areas.

Hydraulic gradients can be interpreted based on groundwater elevation contours such as those depicted in Figure 9-31and Figure 9-32. Contour lines spaced closely together represent steeper hydraulic gradients and contour lines that are spaced far apart from each other represent shallower hydraulic gradients.

### *9.5.2 Groundwater Quality*

Groundwater quality is a function of the geological composition of the hydrogeologic unit, residence time in the subsurface, and recharge rate. The chemistry of groundwater located in the alluvium is not available, though there is a strong connection to surface water, so the chemistry is expected to be quite similar to surface water. However, it is anticipated that groundwater in this unit is similar to surface water given the connectivity between the two. Groundwater samples have not been collected from the saprolite formation as this formation produces little groundwater.

Groundwater baseline conditions are compared to the Site-Specific Standards for determined points of interest in the Project's Environmental Design Criteria (EDC) Appendix 3-B (Table 4-2). The groundwater chemistry is benchmarked to the criteria in the EDC for Drinking Water Points of Interest (POI). Although there are no wells currently used in the Project Area, drinking water is considered a potential future use for groundwater and therefore the most relevant criteria.

*Saprolite Quartz Vein Unit*

Groundwater quality in the saprolite quartz veins is characterized by a low pH (4 to 6 standard units) and low conductivity (10 to 130 µS/cm). The groundwater in this unit has low levels of dissolved solids and non-detectable concentrations for most metals. The following total metals were detected in filtered samples:

- Aluminum;
- Barium;
- Beryllium
- Boron;
- Cobalt;
- Copper;
- Iron;
- Manganese;
- Molybdenum
- Silicon; and
- Zinc.

Only two of these metals (aluminum and zinc) were detected at concentrations that exceeded drinking water standards identified in the Project's EDC in some but not all samples. Aluminum exceeded the EDC in two of eight samples and zinc in two of eight samples.

*Saprock*

Groundwater quality data from the saprock is limited to wells in the TSF area. The groundwater is characterized by a relatively neutral pH (6.5) and a specific conductance of 160 to 200 µS/cm. Total dissolved solids range from 80 to 210 mg/L and hardness ranges from 35 to 100 mg/L as CaCO3. The following total metals were detected in filtered samples:

- Aluminum;
- Arsenic;
- Barium;
- Copper;
- Iron;
- Manganese;
- Lead;
- Molybdenum;
- Silicon;
- Titanium; and
- Zinc.

Aluminum, iron, manganese and zinc concentrations exceeded drinking water standards identified in the Project's EDC in some but not all samples. With respect to iron, six of nine samples exceeded the 1 mg/L EDC, but just one reported concentrations greater than 2 mg/L (2.1 mg/L at TSF-MW-1 December 2011). TSF-MW-1 is located on A3 Creek downstream of what will likely be the main dam of Phase 1 of the TSF. With respect to zinc only two sample out of nine reported concentrations greater than the EDC, with the highest concentration 0.529 mg/L at TSF-TW-5 October 2011. Aluminum was detected at concentrations exceeding the EDC in four of nine samples and manganese was detected in excess of the EDC in one of nine samples. Groundwater quality monitoring is continuing on a monthly basis to increase the baseline data set. Data will be reviewed to determine if existing groundwater quality exceeds the Project-specific criteria.

*Bedrock*

Groundwater quality in the fractured bedrock and the bedrock quartz veins is presented together since they represent a single unit. The groundwater is generally neutral (pH ranges from 6.3 to 7.4 s.u.) and has a specific conductance ranging from 230 to 440 µS/cm. The groundwater is harder than groundwater found in the saprolite quartz veins with hardness ranging from 130 to 270 mg/L CaCO3. The following total metals were detected:

- Aluminum;
- Arsenic
- Barium;
- Copper
- Iron;
- Manganese;
- Molybdenum;
- Silicon; and
- Zinc.

Aluminum, iron and manganese concentrations exceeded drinking water standards identified in the Project's Environmental Design Criteria in some but not all samples. There were a total of 7 exceedances of the iron criteria out of 31 samples (23% of samples) and exceedances were reported at 3 out of 5 wells. Iron criteria was exceeded three times at M2-PZ1-TW-1 location out of 10 samples and confirmed in one field duplicate. The one other iron measurement exceeding the criteria (0.88 mg/L) was reported at MA-PZ1-TW1 at Maraba Pit. Both of these wells were completed in 2008. Aluminum was detected in only 2 of 30 samples, both collected at TSF-TW-7 and exceeding the EDC. Manganese exceeded EDC in 6 of 32 samples.

Monthly sampling of groundwater is ongoing. The number of wells and samples that have been collected as well as the full suite of parameters analyzed and results are presented in Appendix 9-D.

### *9.5.3 Conceptual Model of Groundwater Conditions*

Groundwater flow at the Merian site is primarily a subdued reflection of topographic controls (i.e. groundwater flow moves away from recharge areas below hilltops and ridges to converge and discharge in the valley bottoms to surface water and as evapotranspiration from vegetation). Downward components of hydraulic gradient are found below the hilltops and hill sides that are groundwater recharge areas and upward components of hydraulic gradient are found in the valley bottoms where groundwater discharge occurs.

The overall direction of groundwater flow in the Commewijne watershed is to the northwest and west. In the Marowijne watershed, the overall direction of groundwater flow is to the east. A groundwater divide separates the two watersheds running below the topographical basin divide. Groundwater flow from the Commewijne watershed does not enter the Marowijne watershed under present conditions.

Overall, most of the groundwater flow at the Merian site is most likely to occur in the saprolite quartz vein system and in the saprock and upper 20 to 30 m of the bedrock. Groundwater flow paths through quartz vein systems would be the most rapid because of the higher permeability and low effective porosity of the veins. However, the limited thickness and occurrence of the veins means that the total quantity of groundwater flowing through them may not be substantial from a basin-water balance perspective.

Below the saprolite, most groundwater flow occurs within the saprock and upper 20 to 30 m of the bedrock because of the higher permeability of these materials. Groundwater velocities are higher in the quartz veins than in the saprolite because of the lower effective porosity of the saprock and bedrock.

Groundwater flow through saprolite is relatively slow because of the low permeability and high effective porosity. Groundwater flow in fresh un-fractured bedrock is also relatively slow because of the low permeability as a result of fracture and vein healing with depth and closure from lithostatic pressure.

There is hydraulic interaction between surface water and groundwater, particularly where quartz vein systems are present within (or underlying) the alluvial deposits. There is a rapid response of groundwater levels to precipitation and stream stage increases in saprolite quartz vein piezometers in the main dam area of the Phase 1 and Phase 2 TSF area indicate good hydraulic communication between surface water and the saprolite quartz vein groundwater system. There is also a response to surface water stage changes in bedrock and bedrock quartz veins where the overlying saprolite cover is thin, such as in the TSF drainages on the north side of TSF Phase 1.

There is limited interaction between surface water and groundwater where there is a thick, low permeability saprolite sequence without the presence of quartz veins.

Groundwater quality data in the saprolite quartz vein system indicates that the groundwater has had limited time for interaction with the geologic materials. The slightly acidic pH, low specific conductance, and low hardness and total dissolved solids indicate the groundwater is recharged rapidly, and groundwater flow rates are relatively high to limit chemical interaction with the quartz vein material.

In the deeper saprock and bedrock groundwater, the pH is near-neutral and the specific conductance, dissolved solids, and hardness are greater than in the quartz veins. This indicates the groundwater residence time in the deeper saprock and bedrock is greater than in the shallower aquifers allowing more geochemical interaction between groundwater and the deeper aquifer material.

## 9.6 *REFERENCES FOR CHAPTER 9*

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# 10.0 *TRAFFIC AND TRANSPORTATION SAFETY BASELINE*

This chapter summarizes baseline traffic characteristics (e.g., traffic volume, types of vehicles, non-vehicular movements) and traffic safety concerns along the Transportation Corridor. The primary Transportation Corridor associated with the Project will stretch from the Nieuwe Haven port in Paramaribo, across the Suriname River Bridge, along the East-West Highway to Moengo, and then south along the Moengo Road to the Project site.

The East-West Highway is a paved, two-lane road (one lane in each direction), with no paved shoulders. It is generally straight, with good visibility, and a cleared or low-brush right-of-way. Intersections are relatively sparse, although private driveways are frequent in populated areas west of the Commewijne River. The Moengo Road is unpaved and has numerous sharp turns that limit visibility. Some materials, especially during construction, may also arrive by barge to Moengo, and proceed from there down the Moengo Road, and thus would not travel the full corridor.

## 10.1 *TRAFFIC CHARACTERISTICS*

Existing vehicular and pedestrian traffic along the Transportation Corridor was counted at four locations (see Figure 10-1) on 10 September (Saturday) and 13 September (Tuesday) 2011 in order to measure both weekday and weekend traffic patterns. The locations included:

- On the East-West Highway, east of the Suriname River Bridge (Bosje Brug);
- On the East-West Highway, at Tamanredjo (Alkmaar Road intersection);
- On the East-West Highway, west of Abadu Kondre; and
- On the Moengo Road, north of Mora Kondre (south of Moengo).

These locations were selected to model the type and extent of potential interactions between baseline traffic and Project-related traffic along the entire Transportation Corridor. Predicted traffic impacts at these locations (described in Chapter 17) can be generalized to the remainder of the corridor.

As shown in Figure 10-2, the East-West Highway is a paved road, approximately 8m wide with no paved shoulders and no passing lanes. Much of the road is newly paved, or is in the process of being upgraded by the Surinamese government. Building setbacks from the East-West Highway vary, but are as little as 5 m in developed areas. The observed speed limit on the East-West Highway is typically approximately 55 km/h. The Moengo Road is a variable-width laterite road with typical observed speeds of 45-55 km/h. The road tends to deteriorate during the rainy season.

*Figure 10-1 Traffic Survey Locations*

*Figure 10-2 The East-West Highway, East of Tamanredjo*

During the traffic studies, traffic was counted over a 14-hour period between 0600h and 2000h. Table 10-1 summarizes the peak hours of traffic activity at each of these locations, on each day. Appendix 10-A contains the full traffic count data. Vehicles were classified in four groups:

- Automobiles: Standard passenger automobiles, pickup trucks, and SUVs (2 axles);
- Light trucks: Two-axle vehicles primarily designed to carry cargo;
- Heavy Vehicles: Any vehicle with three or more axles, as well as all buses; and
- Motorcycles.

Also included in the study were:

- Pedestrian and
- Bicycle travelers.

*Table 10-1 Baseline Traffic Volumes*

| Location | Peak Hour | Peak Hour Traffic (Total, All Directions) Number/Percent of Total | | | | |
|---|---|---|---|---|---|---|
| | | Automobiles | Light Trucks | Heavy Trucks | Motorcycles | Total Vehicles |
| Saturday, 10 September 2011 | | | | | | |
| Bosje Brug | 1900h – 2000h | 779 / 82% | 87 / 9% | 18 / 2% | 64 / 7% | 948 |
| Tamanredjo | 1900h – 2000h | 363 / 76% | 44 / 9% | 16 / 3% | 53 / 11% | 476 |
| Abadu Kondre | 1600h – 1700h | 95 / 75% | 20 / 16% | 13 / 10% | 0 | 128 |
| Mora Kondre | 1330h – 1430h | 13 / 43% | 5 / 17% | 9 / 30% | 3 / 10% | 30 |
| Tuesday, 13 September 2011 | | | | | | |
| Bosje Brug | 1730h – 1830h | 713 / 77% | 62 / 7% | 42 / 5% | 91 / 10% | 927 |
| Tamanredjo | 0700h – 0800h | 242 / 61% | 32 / 8% | 24 / 6% | 98 / 25% | 396 |
| Abadu Kondre | 1400h – 1500h | 41 / 53% | 21 / 27% | 15 / 19% | 0 | 77 |
| Mora Kondre | 1400h – 1500h | 8 / 27% | 5 / 17% | 15 / 50% | 2 / 7% | 30 |

The highest traffic volumes observed were at the survey locations closest to Paramaribo, the nation's capital. The lowest traffic volumes observed were on the Moengo Road, where volumes were significantly less than even the lightest volumes observed on the East-West Highway. The vast majority of vehicles on both roads are automobiles and light trucks, although motorcycle traffic is also a substantial component of overall volume. Heavy trucks, comparable to the size and weight of trucks that would haul materials to and from the Project site, comprise approximately five to six percent of total traffic in Bosje Brug and Tamanredjo. Heavy trucks comprise a higher percentage of total traffic near Abadu Kondre and Mora Kondre, although the total number of trucks in these more remote locations is still relatively low.

Figure 10-3 and Figure 10-4 show the variation in total traffic volumes at all four survey locations throughout the course of the survey period. Total traffic volumes were somewhat higher on Saturday; and Saturday traffic volumes remained relatively constant throughout the day. By comparison, Tuesday traffic displayed morning and evening traffic peaks more typical of work-day commuting patterns.

Based on the data described above and illustrated in the Figure 10-3 and Figure 10-4, the Transportation Corridor has sufficient capacity to accommodate typical traffic. The East-West Highway in the vicinity of Bosje Brug had by far the highest traffic volumes among survey locations, but still carried only one-third of its potential maximum volume.[19] During peak hour, traffic volumes are heavier, and congestion is likely to occur. While traffic is still likely to flow during these periods, movement is likely to be considerably slower than off-peak hours, particularly through congested intersections. Volumes along other segments of the Transportation Corridor were far lighter. The Tamanredjo intersection appears to operate with only moderate delay during peak hours.

Bicycle and pedestrian activity occurs along inhabited segments of the Transportation Corridor throughout the day. At Tamanredjo, approximately 55-65 pedestrian and bicycle movements were observed at Tamanredjo during the peak hour. At the Bosje Brug location, 75-100 bicycle and pedestrian movements were recorded during the afternoon peak hour, while more than 150 movements were recorded during the weekday morning peak hour (perhaps reflecting children walking to school).

[19] Capacity calculations performed using Highway Capacity Software (HCS 2010). See Appendix 10-A for detailed calculations.

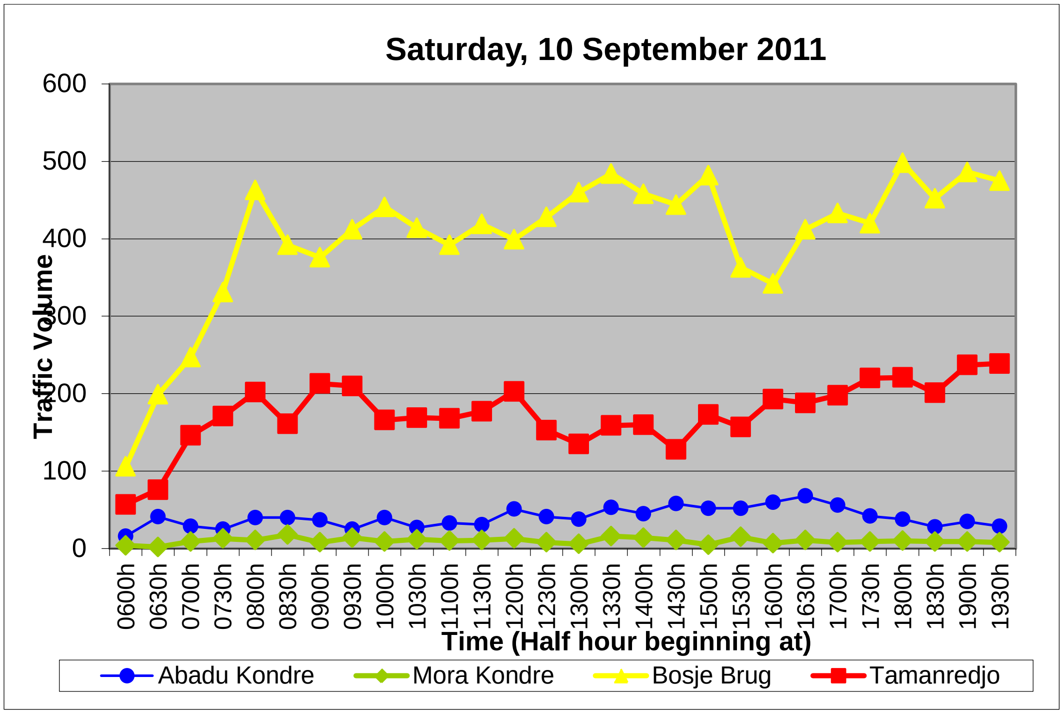


*Figure 10-3* *Distribution of Traffic Volumes at Transportation Corridor Count Locations, Saturday, 10 September 2011*

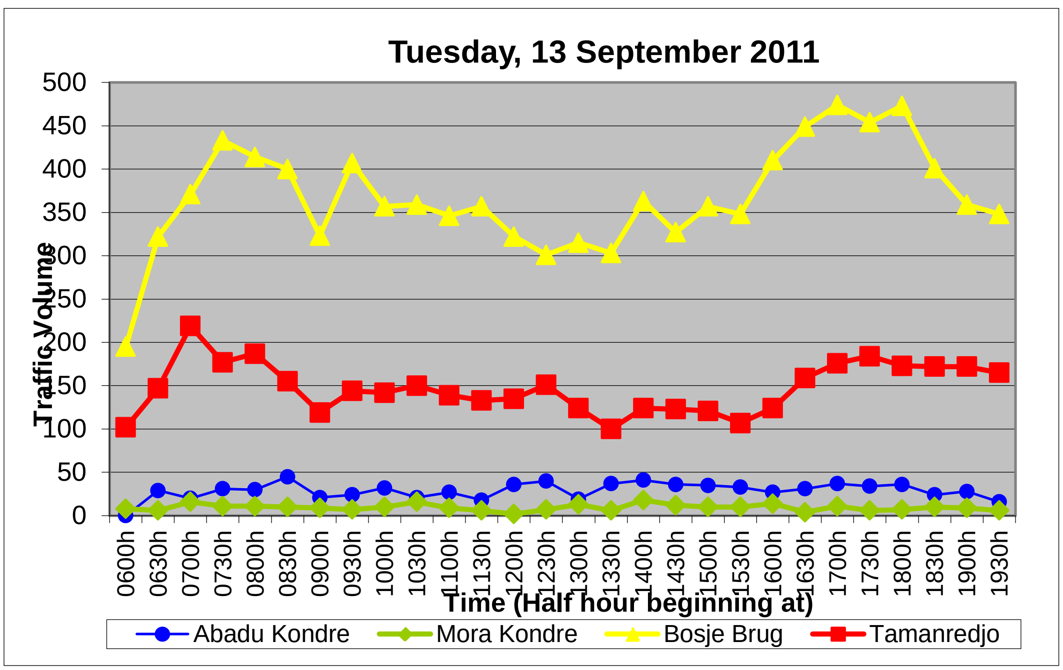


*Figure 10-4* *Distribution of Traffic Volumes at Transportation Corridor Count Locations, Tuesday, 13 September 2011*

## 10.2 *SAFETY CONSIDERATIONS*

The Transportation Corridor, particularly the East-West Highway segment, passes through settlements of various sizes. This chapter discusses concerns about safety along the corridor, including the potential for vehicular crashes and accidents involving pedestrians or cyclists.

### *10.2.1 East-West Highway*

The western portion of the East-West highway, between Paramaribo and the Commewijne River, is the most densely inhabited portion of the Transportation Corridor. Along this segment, roadside settlements are nearly continuous, with some buildings very close to the road (for example, at the Tamanredjo intersection).

Table 10-2 summarizes the vulnerable locations observed along the East-West Highway in late 2011, while Figure 10-5 and Figure 10-6 illustrate some of these locations. Although not uncommon in Suriname, the proximity of inhabited areas and individual buildings to the Transportation Corridor carries with it an elevated risk of traffic accidents, particularly between vehicles and pedestrians.

Since 2007, there have been approximately 10 traffic-related deaths per year in the Commewijne and Marowijne districts (which cover the area between the Suriname and Marowijne Rivers, including the East-West Highway and a portion of the Moengo Road). East of the Commewijne River, the East-West Highway averages approximately 100 accidents per year.

The risk of accidents on the East-West Highway is compounded by the relative scarcity of paths specifically designated for pedestrians (although a path network does exist in the vicinity of Moengo and some areas west of the Commeweijne River). Most pedestrians wishing to travel along the East-West Highway or Moengo Road must use the road itself, thus placing themselves at risk from traffic, much of which moves at high speed.

There are no traffic signals, stop signs, or other traffic controls along the Transportation Corridor (west of the Suriname River), nor are there any designated pedestrian crossings (e.g., crosswalks). This lack of traffic control increases the risk of accidents, especially at intersections. Drivers often try to take advantage of any available gap in traffic, rather than waiting for a safer opportunity.

*Table 10-2 Vulnerable Locations on East-West Highway*

| Road Segment | Description (number) | Typical Distance from Road (m) |
|---|---|---|
| Bosje Brug to Tamanredjo | Commercial Establishments (8) | 3-5 |
| | Houses of Worship (3) | 15 |
| | Schools (1) | 20 |
| | Government / Public Buildings (3) | 5-10 |
| | Other | 3-5 |
| Tamanredjo to Moengo (excluding Potribo) | Commercial Establishments (9) | 5-10 |
| | Houses of Worship (2) | 5-10 |
| | Government / Public Buildings (7) | 5-10 |
| | Schools (1) | 10 |
| Potribo Area | Commercial Establishments (2) | 5+ |
| | Houses of Worship (6) | 10 |
| | Schools (3) | 10-20 |
| | Other | 15 |

*Figure 10-5 Sewrajsing School, East of Bosje Brug, Approximately 20m from the East-West Highway*


*Figure 10-6 Tamanredjo Police Station, Approximately 5m from the East-West Highway*

### *10.2.2 Moengo Road*

Although the Moengo Road is narrower and unpaved, it is also more sparsely settled and less-traveled, significantly reducing the risk of accidents and injuries. Only a few settlements are located within 100 meters of the road. ERM observed one makeshift speed bump constructed in the road near Mora Kondre, near where schoolchildren typically wait for their bus; this may be evidence of concern about traffic speeds. However, as described in Chapter 14, few traffic accidents have been reported on the Moengo Road in recent years.

# 11.0 BIOLOGICAL RESOURCES BASELINE

This chapter describes the baseline condition of biological resources in the Merian Study Area in both a regional and a project specific context. Several biological surveys were conducted to identify and characterize the site-specific biological resources that could be impacted by the Project. Specifically this chapter:

- Describes the general ecological setting for the Project;
- Describes the methodologies used for each of the baseline studies;
- Maps and characterizes the significant biological resources in the Study Area;
- Identifies special status species and habitats in the Study Area; and
- Provides a comprehensive summary of the habitats and populations within the Study Area.

## 11.1 ECOLOGICAL SETTING

Suriname is located entirely within the north-eastern portion of the Guiana Shield. The Guiana Shield is a large (2.5 million km$^2$) plain in the northern part of the South American continent that is bordered by the Orinoco, Rio Negro, and Amazon Rivers. Suriname's human population is primarily concentrated in the coastal plain in the northern part of the country, leaving the central and southern portions of the country with largely intact forests. Suriname has the highest proportion of intact natural forest (80%) of any country in the world. The Environmental Study Area is located in the northeastern portion of that contiguous forest block, near the transition zone between the forested interior and Suriname's north-central savanna belt.

The Study Area has been extensively mined by ASM miners (as discussed previously in Chapter 9 and shown in Figure 9-19). Their operations have had widespread impacts across the Study Area. Until recently their activities were concentrated in the eastern portion of the Study Area in the Marowijne River watershed, but they are now active in the western portion of the Study Area in tributaries of the Commewijne River as well, approximately 35 kilometers west of the village of Langa Tabiki. Although the biological impacts of their operations are most significant in the aquatic environment, they also cause widespread impacts on terrestrial ecosystems, particularly in riparian areas.

### *11.1.1 Vegetation Setting*

Most of the vegetation in the Project Area is dryland forest, although other forest types such as savanna, and disturbed / ruderal areas also exist. Table 11-1 summarizes the vegetative composition of the Study Area by major community type.

*Table 11-1 Vegetative composition of the Study Area*

| Vegetative Community | Total Hectares within Study Area | Percent of Total Study Area |
|---|---|---|
| Primary Mine Site Ecosystems | | |
| High Dryland Forest | 16,089 | 77% |
| Creek Forest | 1,898 | 9% |
| Open Savannah Forest | 1.65 | <1% |
| Savanna Forest | 33.10 | <1% |
| Secondary / Successional Ecosystems | | |
| Secondary vegetation / Disturbed Areas | 2,901 | 14% |
| Total | 20,923 | 100% |

Corridors of creek forest separate adjacent upland blocks of dryland forest on the slopes and ridges. Dryland forest is a general term for several types of dry forest that occur across Suriname and the interior Guiana Shield. Describing dryland forest is problematic because the forest is extremely heterogeneous in different parts of Suriname; the species compositions of the various types of dryland forest are poorly documented; and there are few, if any, plant species that are known to be universally characteristic of all the varieties of dryland forest across the Guiana Shield.

### *11.1.2 Faunal Setting*

This subchapter provides a brief description of the birds, insects, mammals, herpetofauna, and aquatic fauna of the Guiana Shield. Each of these major taxonomic groups was studied in detail in the Environmental Study Area to support the ESIA's baseline assessment. This subchapter provides a regional ecological context for the site-specific information discussed later in the biological baseline chapter.

*Birds*

The forests of Suriname are contiguous with those of its neighboring countries (French Guiana to the east, Guyana to the west, and Brazil to the south). This regional continuity presents few barriers to wildlife movement, especially for birds. As a result, the avifauna of Suriname and its neighboring countries are similar, and no bird species are known to be endemic to Suriname. (Ottema et al. 2009) list 739 bird species known to occur in Suriname, compared to approximately 803 in Guyana and 704 in French Guiana (Thiollay 2002). Of the approximately 90 known species of birds endemic to the Guiana Shield, 44 occur in Suriname.

*Insects*

As is typical in the neotropics, insects of the Guiana Shield in general are poorly known despite the key ecological roles they play in nutrient cycling, pollination, and their potential utility as indicators of functional integrity in tropical ecosystem (de Dijn and de Wolf, 2012). Two exceptions to this generalization include the Nymphalidae (butterflies and moths), and the Euglossine bees (orchid bees). Both groups are widespread in Suriname and have a critical role in the forest ecosystem as pollinators. Both groups are also relatively conspicuous, easy to collect, and occur in the Environmental Study Area.

*Mammals*

Although the larger charismatic mammals such as monkeys and cats are relatively well-known to the general public, the much smaller and obscure bats, rats, and opossums comprise approximately 75% of the mammalian species in tropical lowland South America (Lim et al., 2005). They are critical seed dispersers and flower pollinators, have important roles in insect control, and often have high species diversity and relative abundance. In contrast, many of the large mammals are naturally rare, and many are considered as species of conservation concern by the International Union for the Conservation of Nature (IUCN) or under the Convention on International Trade in Endangered Species (CITES), often due to hunting pressures and / or habitat loss. Approximately 194 mammal species have been reported from Suriname (Lim et al., 2005; Lim and Catzeflis, 2012), the vast majority of which can be expected to occur in the Project Area because it encompasses lowland rainforest habitats typical of much of the Guiana Shield (Lim et al., 2012).

*Amphibians and Reptiles*

Approximately 270 amphibians and 300 reptiles are known to occur on the Guiana Shield. Frogs (tree frogs in particular) and toads dominate the amphibian fauna and snakes dominate the reptiles, accounting for over 90% and approximately 50% of the total species in their respective categories. Unlike the birds of the Guiana Shield, the herpetofauna (reptiles and amphibians) of the Guinana Shield are distinct from the herpetofauna of the rest of South America. Of the roughly 270 amphibians in the region, approximately 100 occur in Suriname and 145 (54%) are endemic to the Guiana Shield. Slightly over half of the Guiana Shield's reptiles (176 or 57%) occur in Suriname. Amphibians are regarded as good indicators of general ecological conditions, and reptiles are important intermediates in the food chain, often fulfilling predator and prey roles.

*Aquatic wildlife*

Very little data is available on the aquatic macroinvertebrates of Suriname and the Guiana Shield in general. By comparison, the fish fauna of Suriname is better studied. The Guiana Shield is known to be home to nearly 1,200 species of freshwater fish and well over 300 of these species are known from Suriname

(Vari et al., 2009). Both numbers have increased rapidly over the past ten years as more focused efforts have been devoted to cataloging the freshwater biodiversity of the neotropics, and more species will undoubtedly continue to be discovered in the future. Aquatic macroinvertebrates play an important trophic role as nutrient recyclers and a prey base for higher-order predators in freshwater systems, much the same as terrestrial insects do on land. Certain groups are highly intolerant of degraded water quality and/or habitat conditions. They also have relatively short generation times so their populations react to changes in environmental conditions quickly, making them good bioindicators of near-term trends in environmental conditions. Like aquatic macroinvertebrates fish are also useful indicators of overall environmental conditions, but their comparatively longer lifespans means their populations are slower to react to environmental changes and they are better indicators of long-term trends in aquatic ecological health.

## 11.2 *BASELINE DATA COLLECTION*

All data collection and data compilation efforts had the same goals:

- To identify and describe the biological resources of the Environmental Study Area in the context of Suriname and the Guiana Shield;
- To assess the relative abundance, richness, and diversity of species in the Study Area; and
- To identify species restricted to specific habitats or areas within the Study Area.

Field data were collected in 2011 and 2012 for vegetation (flora), birds, and aquatic fauna. Mammals have been studied via an ongoing camera trapping survey in the Study Area since 2007, and were surveyed again using supplemental methods in January 2012. Insects, herpetofauna, and mammals were also surveyed in January 2012. Table 11-2summarizes the data collection efforts for each of these biological groups (taxa). Terrestrial biological data were collected at transects, defined as groups of small sampling areas within a larger area of approximately 1 ha. For the purposes of this Chapter, "sites" are defined as smaller areas not directly associated with transects where supplemental biological data were collected. Not all taxa were sampled at every transect and/or site (Table 11-2). Fish, macroinvertebrates, and phytoplankton were collected from several sites on the Commewijne and Marowijne Rivers and their tributaries within and downstream of the Study Area.

*Table 11-2 Summary of field sampling*

| Taxon | Dates of sampling | Sampling areas | Number of large plots/transects/areas | Number of small sites |
|---|---|---|---|---|
| Terrestrial resources | | | | |
| Vegetation | November 2011; January 2012 | M1, M2, M3, M4, M5, M6, M7, M8, T1, T2, T3, T4, T5, U1, U2, U3, U4, R1, Sites 1 - 19 | 18 large vegetation plots (2011 individual counts; 2012 species presence data only) | 19 total, 11 outside of established transects |
| Mammals | November 2011 for interviews, mist netting, trapping, scat observations, and tracking. Five years (2007-2011) of camera trapping data. | M1, T4, U2 | 3 | N/A |
| Birds (avifauna) | November/December 2011 and late January 2012 | U2, T1, T2, M3, M5, M6, U1, T5, R1 | 9 (8 for both field events) | N/A |
| Insects | January 2012 | M3, M5, M6, M8, R1, T2, T3, T5, U1, U2 | 10 | 30 (within the 10 larger transects) |
| Herpetofauna | January 2012 | Transects 1-9 | 9 | 19 (within the 9 larger transects) |
| Aquatic resources | | | | |
| Fish | November/December 2011; January 2012 | Commewijne River; Marowijne River | N/A | 9 |
| Macroinvertebrates | November/December 2011; January 2012 | Commewijne River; Marowijne River | N/A | 9 |
| Plankton | November/December 2011; January 2012 | Commewijne River; Marowijne River | N/A | 9 |

Transect and site locations were selected to be representative of the various habitat types present in the Study Area and to provide site-specific data on flora and fauna within the footprint of the proposed Project's various components. The sampling design considered land form, vegetation types, and the design of the proposed Project. Sampling locations (transects and sites) were selected to include coverage of all the following features in the Study Area:

- The primary landforms of the Environmental Study Area including: 1) well drained ridgetops, 2) well drained slopes between ridges and valleys (including gullies), and 3) lowland creek valleys consisting of wet and level terrain;
- The main vegetation types expected in the Environmental Study Area including: 1) high dryland forest, 2) creek forests, 3) secondary forest, and 4) non-forested secondary vegetation in disturbed areas (previously cleared areas and old trails);
- The three primary components of the proposed Project including: 1) the mining area in the center and north-east parts of the Study Area, including the mine pits, waste rock facilities, and Plant Site; 2) the tailing facility in the west part of the Study Area; and 3) the access road area in the north-east part of the Study Area; and
- Portions of the Study Area that will remain relatively undisturbed because they have not been impacted by ASM to date and are outside the footprints of the Project.

Table 11-3 summarizes the vegetation type/landform and taxa surveyed at each transect.

*Table 11-3 Transects and corresponding habitats from terrestrial studies*

| Transect | Vegetation type/Landform | Taxa collected |
|---|---|---|
| M1 | Ridge forest | Vegetation, Mammals |
| M2 | Secondary forest (trail) | Vegetation |
| M3 | Slope forest | Vegetation, Birds, Insects |
| M4 | Secondary forest (mine) | Vegetation |
| M5 | Ridge forest | Vegetation, Birds, Insects |
| M6 | Slope forest | Vegetation, Birds, Insects |

| Transect | Vegetation type / Landform | Taxa collected |
|---|---|---|
| M7 | Secondary open vegetation | Vegetation |
| M8 | Secondary open vegetation | Vegetation, Insects |
| T1 | Creek forest | Vegetation, Birds |
| T2 | Slope forest | Vegetation, Birds, Insects |
| T3 | Natural disturbed forest | Vegetation, Insects |
| T4 | Secondary forest (agriculture) | Vegetation, Mammals |
| T5 | Ridge forest | Vegetation, Birds, Insects |
| U1 | Creek forest | Vegetation, Birds, Insects |
| U2 | Ridge forest | Vegetation, Mammals, Birds, Insects |
| U3 | Secondary open vegetation | Vegetation |
| U4 | Secondary open vegetation | Vegetation |
| R1 | Slope / ridge forest (logged) | Vegetation, Birds, Insects |

### 11.2.1 *Data collection and analysis methodology*

The methods used to collect data varied by taxon, and affected how the data were compiled and analyzed. Certain sites were chosen because they overlap with areas that are planned to be impacted, while others were selected to represent areas within the Study Area that would not be directly impacted by the Project.

Figure 11-1 depicts the vegetation sample areas and the vegetation types mapped in the Environmental Study Area. Figure 11-2 depicts the terrestrial flora and fauna sampling areas.

*Figure 11-1 Vegetation Communities and Sample Locations*

*Figure 11-2 Terrestrial Flora and Fauna Sampling Locations*

## 11.3 TAXONOMIC DISCUSSION OF BASELINE BIOLOGICAL CONDITIONS

For each biological taxon, a number of assessments were completed on the data. These included: summary of number of species, number of families, and in some cases orders of species; species richness (number of unique species) per transect or sampling area as well as cumulative richness; a diversity analysis using the Shannon Weaver index on either individuals, species, or families and species (depending on the type of data collected); an analysis of the similarities between transects; and a species accumulation analysis showing the incremental and cumulative number of species identified with successive transects. The following sections summarize these analyses by taxon.

### *11.3.1 Vegetation*

Vegetation data were collected at 18 transects in 2011 and supplemental data were collected in 2012 at 19 sites, 11 of which overlapped with the 2011 transects.

The 2011 and 2012 surveys identified a total of 613 species of plants in 102 families in the Study Area and on the planned road route. Table 11-4 summarizes the total species and families documented in both surveys. Due to the differences in type of data between 2011 and 2012, this analysis also compares the 2011 data (individual counts) to the cumulative 2011-2012 data set.

*Table 11-4 Summary of 2011 and 2012 Studies*

| Year | Transects | Sites | Families | Species |
|---|---|---|---|---|
| 2011 | 18 | 0 | 84 | 314 |
| 2012 | 0 | 19 (total); 11 sites inside 2011 transects | 18 additional (12 inside 2011 transects) | 299 additional (244 inside 2011 transects) |
| Cumulative | 18 | 19 | 102 | 613 (558 inside 2011 transects) |

Table 11-5 lists the ten most commonly detected species in the Study Area in 2011. Table 11-6 summarizes the ten most commonly detected species in the Study Area in the cumulative 2011-2012 data set.

*Table 11-5 Most Common and Most Numerous Flora Species (2011 counts)*

| Family | Genus species | Individuals found | Transects occurring |
|---|---|---|---|
| Cyperaceae | *Diplasia karataefolia* | 14 | 14 |
| Caesalpiniaceae | *Eperua falcate* | 141 | 13 |
| Poaceae | *Olyra cf latifolia* | 13 | 13 |
| Bignoniaceae | *Bignoniaceae sp.* | 71 | 12 |
| Lecythidaceae | *cf Eschweilera sp.1* | 54 | 9 |
| Fabaceae | *Bocoa prouacensis* | 52 | 10 |
| Lecythidaceae | *Lecythis sp.1* | 48 | 10 |
| Fabaceae | *Machaeruim sp.* | 46 | 12 |
| Caesalpiniaceae | *Dicorynia guianensis* | 44 | 10 |
| Menispermaceae | *Abuta sp.* | 40 | 11 |

*Table 11-6 Most Common Flora Species (2011 and 2012 Cumulative Counts)*

| Family | Genus species | Number of transects found |
|---|---|---|
| Cyperaceae | *Diplasia karataefolia L.C. Rich.* | 15 |
| Araceae | *Astrocaryum paramaca Mart.* | 14 |
| Araceae | *Astrocaryum sciophilum (Miq.) Pulle* | 14 |
| Cyperaceae | *Diplasia karataefolia* | 14 |
| Cyperaceae | *Bisboeckelera microcephala (Bock.) T. Koyama* | 13 |
| Caesalpiniaceae | *Eperua falcata* | 13 |
| Poaceae | *Olyra cf latifolia* | 13 |
| Poaceae | *Olyra spp.* | 13 |

*Diplasia karataefolia* was the most widespread species in both the 2011 and cumulative flora data set. The three most widespread species in 2011 (*Diplasia karataefolia, Eperua falcate*, and *Olyra cf latifolia*) were also in the top 10 most widespread species in the cumulative dataset, but the remaining seven most widespread species were different in the 2010 and cumulative datasets.

Table 11-7 summarizes the diversity (Shannon Index[20]) and richness for each transect. The Shannon Index is a composite index, so both richness and distribution must be considered when interpreting Shannon Index values for a particular site. The range of potential values depends on richness at each site, so each site has a different theoretical maximum. The cumulative theoretical Shannon Index maxima[21] in Table 11-7 were calculated assuming that all species documented across the entire Study Area were also uniformly distributed across the Study Area. The actual cumulative Shannon Index maxima were within 80% of the theoretical maxima for the 2011 and combined 2011-2012 data sets, indicating that the different vegetation species are spread more or less evenly throughout the Study Area (although the Shannon Index values for the combined 2011-2012 dataset are lower than for 2011, which indicates that additional sampling in 2012 revealed a less uniform distribution than was initially apparent in 2011). One notable exception is transect U1 which had relatively high species richness but low Shannon Index scores, indicating an uneven or "clustered" distribution of species within the transect. In the 2011-2012 dataset transect U2 illustrates the opposite effect. It ranked 10th out of 18 sites in terms of richness, but it ranked 5th for diversity because the comparatively few species that were present were very evenly distributed within the transect.

Table 11-7 also allows comparison of the cumulative Shannon Index and richness values and a theoretical cumulative maximum value for the Shannon Index and richness in the 2011 and cumulative 2011-2012 vegetation datasets. This comparison illustrates important similarities between the two datasets. The same sites tend to be near the top and bottom of both lists, respectively, which indicates that relative species richness and diversity tended to be similar in both years. The three most diverse sites in 2011 (T2, T3, and M3) were the 1st, 3rd, and 4th most diverse sites in the cumulative data set. The three least rich and diverse sites were also the same in the 2011 and cumulative datasets (M2, M8, and U4). Although Table 11-4 through Table 11-6 illustrate the difficulty in determining exactly how many total plant species are actually present in the Environmental Study Area, the comparison presented in Table 11-7strongly suggests that the area around transects T2 and T3 contains high vegetative biodiversity and the areas around M2, M8, and U4 contain low vegetative biodiversity relative to the

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[20] The Shannon diversity index measures diversity as a function of richness and distribution of species. High numbers of species with even distributions score the highest Shannon values; low numbers of species with patchy or clumped distributions score low Shannon values. The Shannon is therefore a composite index that considers both richness and distribution of species.

[21] The range of potential Shannon index scores varies depending on richness. The theoretical maximum Shannon index value for a site or area with perfectly even distribution of all species would be equal to the richness at that site or area.

rest of the Study Area. The consistency in the species richness and diversity rankings between the 2011 and cumulative datasets also suggests that these rankings would not change significantly with more sampling.

*Table 11-7 2011 and Cumulative 2011-2012 Vegetation Diversity and Richness by Site*

| **2011 based on individuals and species** | | | | **2011 and 2012 combined based on species and families** | | | |
|---|---|---|---|---|---|---|---|
| Transect | Shannon Index (H) | eH | Richness (S) | Transect | Shannon Index (H) | eH | Richness (S) |
| T2 | 4.10 (4.30) | 60.2 | 74 | T3 | 3.52 | 33.6 | 156 |
| T3 | 3.97(4.34) | 53.2 | 77 | M6 | 3.47 | 32.2 | 134 |
| M3 | 3.92(4.26) | 50.4 | 71 | T2 | 3.46 | 31.8 | 127 |
| T1 | 3.89(4.20) | 48.8 | 67 | M3 | 3.34 | 28.2 | 91 |
| M1 | 3.84 (4.16) | 46.4 | 64 | U2 | 3.29 | 26.8 | 80 |
| M6 | 3.83(4.32) | 46.3 | 75 | M5 | 3.25 | 25.7 | 92 |
| U1 | 3.80(4.26) | 44.8 | 71 | T1 | 3.25 | 25.8 | 90 |
| R1 | 3.73 (4.14) | 41.7 | 63 | M1 | 3.20 | 24.4 | 89 |
| M5 | 3.61(3.93) | 37.0 | 51 | T4 | 3.18 | 24.0 | 52 |
| U2 | 3.55(4.11) | 34.9 | 61 | U1 | 3.18 | 24.1 | 132 |
| M7 | 3.42(3.43) | 30.6 | 31 | R1 | 3.18 | 24.1 | 86 |
| M4 | 3.30(3.53) | 27.2 | 34 | T5 | 3.05 | 21.1 | 84 |
| T4 | 3.17(3.52) | 23.9 | 34 | M7 | 3.04 | 20.9 | 63 |
| U3 | 2.94(2.94) | 19.0 | 19 | M4 | 2.83 | 16.9 | 51 |
| T5 | 2.80(3.09) | 16.4 | 22 | U3 | 2.72 | 15.2 | 44 |
| M2 | 2.75 (2.77) | 15.7 | 16 | U4 | 2.24 | 9.4 | 14 |
| M8 | 2.71(2.71) | 15.0 | 15 | M8 | 2.12 | 8.3 | 40 |
| U4 | 2.04(2.08) | 7.7 | 8 | M2 | 2.09 | 8.1 | 19 |
| Cumulative | 4.83 | 124.8 | 314 | | 3.95 | 51.8 | 558 |

| 2011 based on individuals and species | | | | 2011 and 2012 combined based on species and families | | |
|---|---|---|---|---|---|---|
| Theoretical maximum | 5.75 | 314.0 | unknown | 4.56 | 96.0 | unknown |

There are some minimally impacted forest blocks in the Environmental Study Area, but most areas in the Study Area have either been previously affected by logging, road construction, clearing or mineral prospecting in the past, or are near an area that has been or continues to be affected by one or more of these activities. Effects have tended to be most severe in the lowlands along creeks where ASM has been concentrated. In spite of the significant historical disturbances that have occurred in the past, the data shows no clear relationship between landscape position and vegetative diversity. This may be because certain pioneer or ruderal species are more common in the disturbed areas, while undisturbed areas contain more species that are typical of mature or climax forest communities. Although the survey did not include clearcuts or other recently denuded sites it did include numerous previously disturbed sites and the data show no clear relationship between historical disturbance and vegetative diversity. This suggests that the forest in the Environmental Study Area can regenerate under favorable conditions, and that vegetative diversity can remain high even in areas that are very near disturbances or have been historically disturbed.

Table 11-8 shows for paired transects the combined number of species, the number of common species, and the percentage of common species based on the combined species totals by paired transects[22]. Combined species counts by paired transect ranged from 33 (6% of total species in transects) to 234 (42% of total species in transects) with T3/T2 being the richest pair as with the 2011 data. Commonality of species across transects ranged from 0 to 71 species and 0% to 42.4% of combined species by pairs of transects with U1/T3 having the most species in common and M8/U3 having the highest percentage of species in common. Thirteen (13) transects or 8.5% of pairs had no species in common. Transect U4 remained the most different from other transects with most pairings having no species in common, however it also has the lowest species richness value.

[22] Species richness is compared between transects as a measure of similarity between transects.

*Table 11-8 Comparison of Transects (2011 and 2012 Cumulative Data)*

| Total species by pairs of transects | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M2 | M3 | M4 | M5 | M6 | M7 | M8 | T1 | T2 | T3 | T4 | T5 | U1 | U2 | U3 | U4 | R1 |
| M1 | 95 | 139 | 127 | 147 | 168 | 145 | 120 | 147 | 179 | 206 | 116 | 152 | 178 | 138 | 123 | 103 | 133 |
| M2 | | 99 | 65 | 99 | 143 | 80 | 59 | 100 | 136 | 163 | 65 | 97 | 137 | 92 | 62 | 33 | 93 |
| M3 | | | 125 | 152 | 178 | 148 | 124 | 142 | 176 | 202 | 112 | 156 | 176 | 135 | 129 | 105 | 136 |
| M4 | | | | 129 | 174 | 108 | 84 | 122 | 163 | 188 | 89 | 118 | 158 | 112 | 90 | 64 | 122 |
| M5 | | | | | 190 | 152 | 124 | 144 | 185 | 205 | 126 | 152 | 178 | 139 | 129 | 106 | 145 |
| M6 | | | | | | 192 | 167 | 189 | 202 | 233 | 160 | 189 | 218 | 178 | 169 | 148 | 168 |
| M7 | | | | | | | 91 | 150 | 183 | 211 | 106 | 136 | 188 | 138 | 88 | 73 | 145 |
| M8 | | | | | | | | 120 | 160 | 185 | 83 | 112 | 157 | 111 | 59 | 52 | 116 |
| T1 | | | | | | | | | 186 | 202 | 123 | 155 | 175 | 139 | 127 | 104 | 134 |
| T2 | | | | | | | | | | 234 | 145 | 177 | 213 | 169 | 163 | 141 | 168 |
| T3 | | | | | | | | | | | 181 | 209 | 217 | 203 | 192 | 170 | 200 |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T4 | | | | | | | | | | | | 120 | 157 | 106 | 86 | 66 | 115 |
| T5 | | | | | | | | | | | | | 184 | 146 | 119 | 95 | 149 |
| U1 | | | | | | | | | | | | | | 175 | 166 | 146 | 172 |
| U2 | | | | | | | | | | | | | | | 115 | 94 | 128 |
| U3 | | | | | | | | | | | | | | | | 52 | 122 |
| U4 | | | | | | | | | | | | | | | | | 100 |
| Common species by transect pairs | | | | | | | | | | | | | | | | | |
| | M2 | M3 | M4 | M5 | M6 | M7 | M8 | T1 | T2 | T3 | T4 | T5 | U1 | U2 | U3 | U4 | R1 |
| M1 | 13 | 41 | 13 | 34 | 55 | 7 | 9 | 32 | 37 | 39 | 25 | 20 | 43 | 31 | 10 | 0 | 42 |
| M2 | | 11 | 5 | 12 | 10 | 2 | 0 | 9 | 10 | 12 | 6 | 5 | 14 | 7 | 1 | 0 | 12 |
| M3 | | | 17 | 31 | 47 | 6 | 7 | 39 | 42 | 45 | 31 | 18 | 47 | 36 | 6 | 0 | 41 |
| M4 | | | | 14 | 11 | 6 | 7 | 19 | 15 | 19 | 14 | 16 | 25 | 19 | 5 | 1 | 15 |
| M5 | | | | | 36 | 3 | 8 | 38 | 34 | 43 | 18 | 23 | 46 | 33 | 7 | 0 | 33 |
| M6 | | | | | | 5 | 7 | 35 | 59 | 57 | 26 | 28 | 48 | 36 | 9 | 0 | 52 |
| M7 | | | | | | | 12 | 3 | 7 | 8 | 9 | 10 | 7 | 5 | 19 | 4 | 4 |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M8 | | | | | | | | 10 | 7 | 11 | 9 | 11 | 15 | 9 | 25 | 2 | 10 |
| T1 | | | | | | | | | 31 | 44 | 19 | 18 | 47 | 31 | 7 | 0 | 42 |
| T2 | | | | | | | | | | 49 | 34 | 33 | 46 | 38 | 8 | 0 | 45 |
| T3 | | | | | | | | | | | 27 | 30 | 71 | 33 | 8 | 0 | 42 |
| T4 | | | | | | | | | | | | 15 | 27 | 26 | 10 | 0 | 23 |
| T5 | | | | | | | | | | | | | 31 | 17 | 8 | 2 | 20 |
| U1 | | | | | | | | | | | | | | 37 | 10 | 0 | 46 |
| U2 | | | | | | | | | | | | | | | 9 | 0 | 38 |
| U3 | | | | | | | | | | | | | | | | 6 | 8 |
| U4 | | | | | | | | | | | | | | | | | 0 |
| Percent of common species by transect pairs | | | | | | | | | | | | | | | | | |
| | M2 | M3 | M4 | M5 | M6 | M7 | M8 | T1 | T2 | T3 | T4 | T5 | U1 | U2 | U3 | U4 | R1 |
| M1 | 13.7% | 29.5% | 10.2% | 23.1% | 32.7% | 4.8% | 7.5% | 21.8% | 20.7% | 18.9% | 21.6% | 13.2% | 24.2% | 22.5% | 8.1% | 0.0% | 31.6% |
| M2 | | 11.1% | 7.7% | 12.1% | 7.0% | 2.5% | 0.0% | 9.0% | 7.4% | 7.4% | 9.2% | 5.2% | 10.2% | 7.6% | 1.6% | 0.0% | 12.9% |
| M3 | | | 13.6% | 20.4% | 26.4% | 4.1% | 5.6% | 27.5% | 23.9% | 22.3% | 27.7% | 11.5% | 26.7% | 26.7% | 4.7% | 0.0% | 30.1% |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M4 | | | | 10.9% | 6.3% | 5.6% | 8.3% | 15.6% | 9.2% | 10.1% | 15.7% | 13.6% | 15.8% | 17.0% | 5.6% | 1.6% | 12.3% |
| M5 | | | | | 18.9% | 2.0% | 6.5% | 26.4% | 18.4% | 21.0% | 14.3% | 15.1% | 25.8% | 23.7% | 5.4% | 0.0% | 22.8% |
| M6 | | | | | | 2.6% | 4.2% | 18.5% | 29.2% | 24.5% | 16.3% | 14.8% | 22.0% | 20.2% | 5.3% | 0.0% | 31.0% |
| M7 | | | | | | | 13.2% | 2.0% | 3.8% | 3.8% | 8.5% | 7.4% | 3.7% | 3.6% | 21.6% | 5.5% | 2.8% |
| M8 | | | | | | | | 8.3% | 4.4% | 5.9% | 10.8% | 9.8% | 9.6% | 8.1% | 42.4% | 3.8% | 8.6% |
| T1 | | | | | | | | | 16.7% | 21.8% | 15.4% | 11.6% | 26.9% | 22.3% | 5.5% | 0.0% | 31.3% |
| T2 | | | | | | | | | | 20.9% | 23.4% | 18.6% | 21.6% | 22.5% | 4.9% | 0.0% | 26.8% |
| T3 | | | | | | | | | | | 14.9% | 14.4% | 32.7% | 16.3% | 4.2% | 0.0% | 21.0% |
| T4 | | | | | | | | | | | | 12.5% | 17.2% | 24.5% | 11.6% | 0.0% | 20.0% |
| T5 | | | | | | | | | | | | | 16.8% | 11.6% | 6.7% | 2.1% | 13.4% |
| U1 | | | | | | | | | | | | | | 21.1% | 6.0% | 0.0% | 26.7% |
| U2 | | | | | | | | | | | | | | | 7.8% | 0.0% | 29.7% |
| U3 | | | | | | | | | | | | | | | | 11.5% | 6.6% |
| U4 | | | | | | | | | | | | | | | | | 0.0% |

There is a weak relationship between richness and similarity; there is a greater similarity among species-rich sites than among species-poor sites. If this relationship actually exists, it is only weakly shown by the data. Figure 11-3 plots species richness against percentage of species in common for paired transects. The resulting scatterplot suggests a weak relationship between richness and similarity.

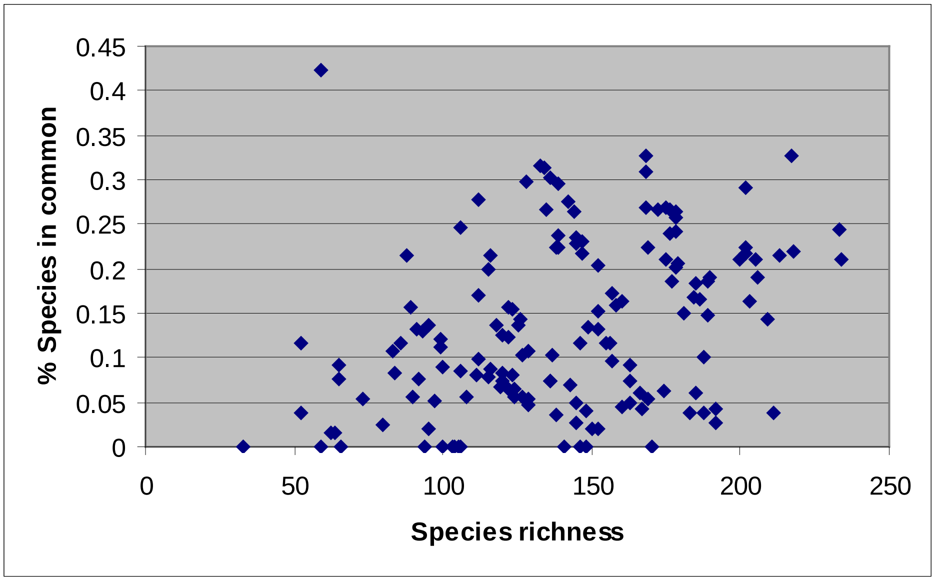


*Figure 11-3 Species richness versus percentage of species in common for paired transects*

In 2003, Dekker and de Graaf identified *Dendrobangia boliviana*, *Dicorynia guianensis*, and *Lecythis corrugate* as indicators of climax rainforest and *Goupia glabra*, *Inga alba*, and *Cecropia spp*

[23] as pioneer species in Suriname's rainforests. Regressing abundance of these species groups against diversity and richness helps to explain the weak relationship shown in Figure 11-3. Figure 11-4 shows diversity regressed against climax tree abundance and pioneer tree abundance. Figure 11-5 shows richness regressed against climax tree abundance and pioneer tree abundance. Considering that these figures illustrate single-variable relationships, these figures show a clear relationship between the abundance of both the climax species and pioneer species and richness. Climax species are more common in species-rich communities, and the pioneer species are more common in depauperate communities. The relationship is strongest between species richness and climax species abundance.

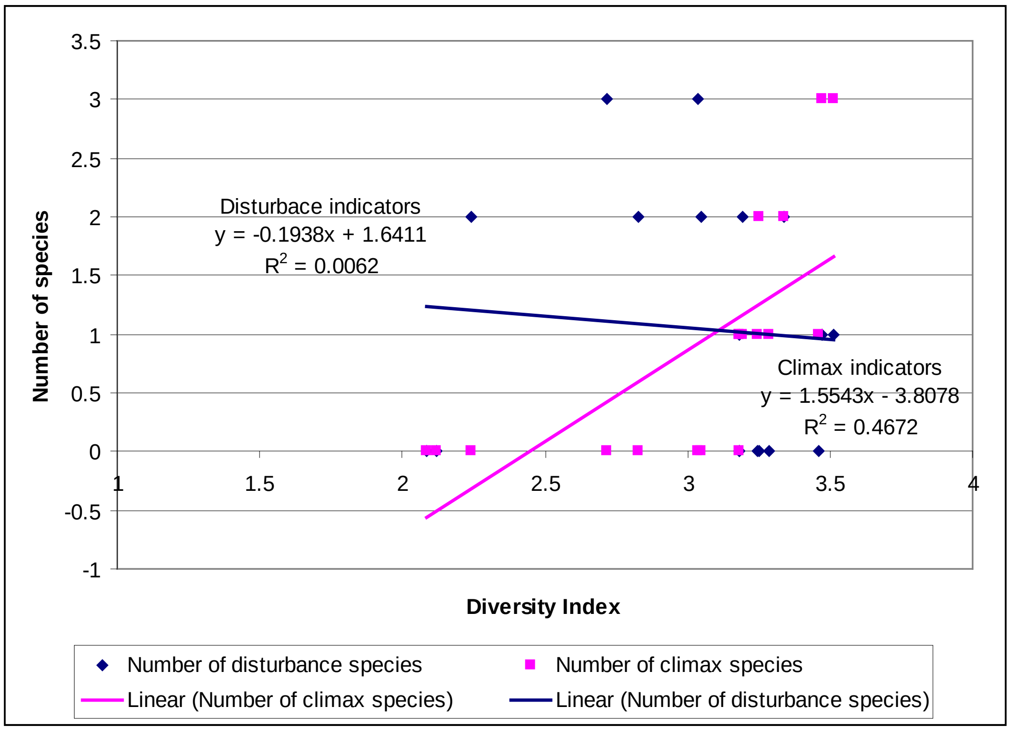


*Figure 11-4 Vegetative Species Diversity Versus Abundance of Climax and Pioneer (disturbance) Species*

[23] Spp. is scientific shorthand for a monophyletic group of unspecified species. In this case it refers to all species of the genus *Cecropia* naturally found in Suriname.

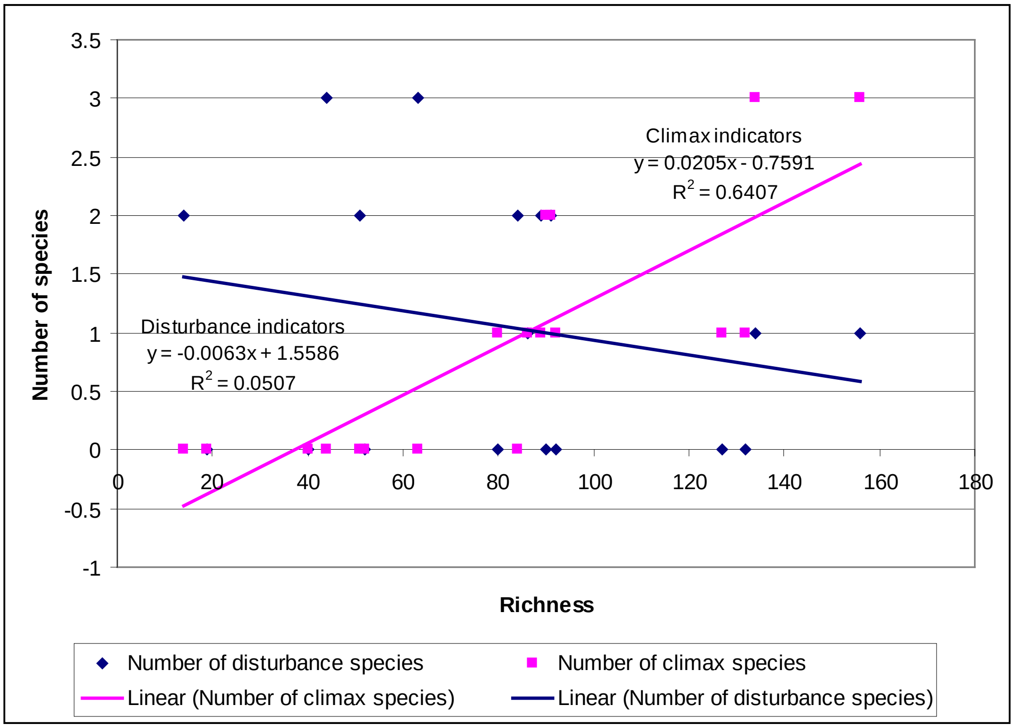


*Figure 11-5 Vegetative Species Richness Versus Abundance of Climax and Pioneer (disturbance) Species*

These results strongly indicate that

- Depauperate or highly impacted vegetation communities are often very different from each other in terms of species composition;
- Not all climax vegetation communities in the Study Area have identical species composition but they tend to be more similar to each other than depauperate communities, and
- Even though species composition varies in both rich and poor communities in the Study Area, there are subsets of species whose abundance is closely related to relative species richness and are therefore good indicators that a given stand is either species rich- or species-poor. Tracking these species over time will provide a good indication of how vegetative richness is changing in the Study Area.

Repetitive sampling of an area typically produces diminishing records of novel species because as more sampling is completed, more species are identified up to some maximum number of species actually present[24]. Each new site surveyed for the first time in 2012 added an average of slightly more than one new family and 16 species to the total number of taxa known to occur in the Study Area.

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24 Species accumulation curves illustrate this effect by plotting sampling effort against total number of species recorded.

Considering that 11 of the 19 sites surveyed in 2012 were within transects previously surveyed in 2011 and that the 2012 surveys documented numerous novel families and species, the surveys to date may not have detected all the species in the Study Area, however, the rate of discovery of new species would probably decline progressively with additional sampling. Figure 11-6 illustrates the vegetation species accumulation curve for both 2011 and 2012 in the Environmental Study Area. The slope of the line represents the rate at which new species were documented as new sites were surveyed. The slope is slightly less steep toward the right end of the graph. This indicates that the rate of discovery of new species decreased slightly toward the end of the field surveys. This slight flattening of the curve suggests that relatively few vegetation species remain to be documented within the Study Area, and the sampling conducted to date is sufficient to generally characterize the vegetation in the Study Area.

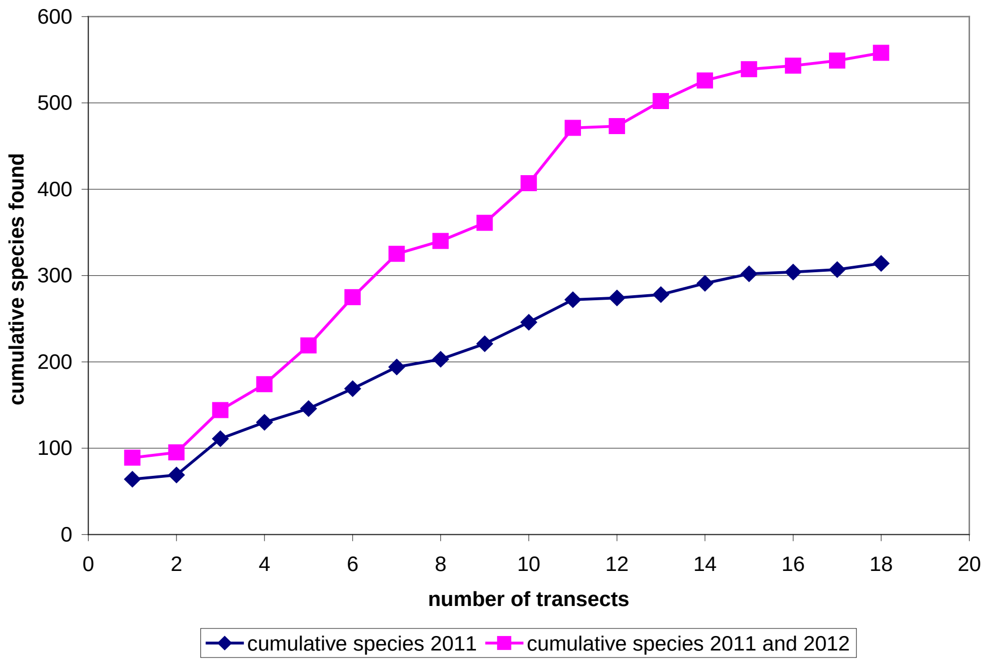


*Figure 11-6 Vegetation Species Accumulation with Successive Transects*

### *11.3.2 Mammals*

At total of 75 mammal species in 21 families have been recorded from the Environmental Study Area to date. Species groups commonly associated with the neotropics are all present, including ungulates (hoofed mammals), wild cats, bats, opossums, primates, rodents, and anteaters, and sloths.

As described below, mammals were surveyed using several methods over several years. Due to differences in the methodologies used to detect mammals not all data can be compared so reporting raw abundance and detection rates for species is not as useful for mammals as it is for some of the other taxa surveyed for this baseline. Instead, Table 11-9 provides a summary of mammal orders and families documented from the Study Area. Some broad conclusions can be taken from the data presented in Table 11-9:

- Bats and rodents, which are ubiquitous in the neotropics, are characteristically abundant in the Study Area. Bats were the most dominant species group, accounting for 56% of all species across all transects, and the Phyllstomidae (leaf nose bats) were the most dominant family. The Phyllstomidae accounted for 84% of all bat species and 47% of all mammal species detected in the Study Area. The next most abundant species group were the rodents, accounting for 7 (16%) of the total mammal species in the Study Area.
- Other species groups are conspicuously depauperate by comparison. Most species groups were represented by only one or two species. Five of the 12 families documented in the Study Area are known on the basis of a single species.
- Several species that could be considered “charismatic megafauna” including three cat species and five primate species are known to be present in the Study Area. Two other cat species are thought to be present based on interviews with knowledgeable local residents and workers in the Study Area, but their presence has not been verified.

*Table 11-9 Mammal Taxa Known from the Environmental Study Area*

| Order | Common name | Number of species found |
|---|---|---|
| Artiodactyla | Not applicable | 5 |
| Carnivora | | 13 |
| Chiroptera | | 25 |
| Cingulata | | 5 |
| Didelphimorpha | | 3 |
| Perissodactyla | | 1 |
| Pilosa | | 4 |
| Primates | | 8 |
| Rodentia | | 10 |
| Xenarthra | | 1 |
| Total species | | 75 |
| Family | Common name | Number of species found |

| | | |
|---|---|---|
| Bradypodidae | Three toed sloths | 1 |
| Callitrichidae | Marmosets and Tamarins | 1 |
| Cebidae | Capuchins and squirrel monkeys | 7 |
| Cervidae | Deer | 3 |
| Cricetidae | Rats and mice | 3 |
| Cuniculidae | Pacas | 1 |
| Dasypodidae | Armadillos | 5 |
| Dasyproctidae | Agoutis and acouchis | 2 |
| Didelphidae | Opossums | 3 |
| Echimyidae | Spiny rats | 2 |
| Emballonuridae | Sac-winged bat | 4 |
| Erethizontidae | Porcupines | 1 |
| Felidae | Wild cats | 6 |
| Hydrocharidae | Capybaras | 1 |
| Megalonychidae | Two toed sloths | 1 |
| Myrmecophagidae | Anteaters | 2 |
| Mustelidae | Weasels | 4 |
| Phyllostomidae | Leaf-nosed bats | 21 |
| Procyonidae | Raccoons, coatis, kinkajous, etc. | 3 |
| Tapiridae | Tapirs | 1 |
| Tayassuidae | Peccaries | 2 |
| **Total species** | | **74*** |

*The family level totals do not include the one Xenarthran species, as the family-level taxonomy of Xenarthra is unresolved.

Field surveys for mammals (using several different techniques) were completed at three different sites. Site 1 was located in the mining pit area in the vicinity of vegetation transects M1 and M2. Site 2 was located in the proposed TSFarea in the vicinity of vegetation transects T3 and T4. Site 3 was located in the vicinity of vegetation transects U2 and U3. The number of species (richness) by transect was fairly consistent. Mammal Site 1 had 23 species, Site 2 had 25 species, and Site 3 had 29 species[25]. Only 10 species were common to all three transects. Table 11-10 summarizes the commonality of species between and across transects. The similarity of Site 2 to the other two sites is somewhat unexpected given that Site 2 is bisected by a wide corridor of creek forest habitat, which would be expected to include some unique species, while both of the other transects are entirely or nearly entirely composed of dryland forest and disturbed areas or nearly so. This finding suggests that factors other than habitat type (e.g.; disturbance) may be driving the distribution of mammal species in the Environmental Study Area.

*Table 11-10 Commonality of species*

| | Sites 1 and 2 | Sites 1 and 3 | Sites 2 and 3 | All 3 Sites |
|---|---|---|---|---|
| Species in common | 11 | 14 | 17 | 10 |

Species diversity based on individual counts was similar across all transects with Shannon indices ranging from 2.41 to 2.59. Table 11-11 compares the Shannon Index values and richness for each site. It also presents a theoretical maximum value for the Shannon Index and richness based on a hypothetical, perfectly uniform distribution of species across all transects.

*Table 11-11 Diversity and Richness Summary*

| Area | Shannon Index (H) | Richness (S) |
|---|---|---|
| Site 1 | 2.59 | 23 |
| Site 2 | 2.59 | 25 |
| Site 3 | 2.41 | 29 |
| Cumulative | 2.82 | 45 |
| Theoretical maximum | 3.81 | Unknown |

[25] Total species counts for individual transects (and the accompanying richness and diversity metrics in Table 11-8 and Table 11-9 and Figure 11-9) were based on provisional data and will be updated when final verified species counts are available.

Figure 11-7 shows the species accumulation curve for mammals.

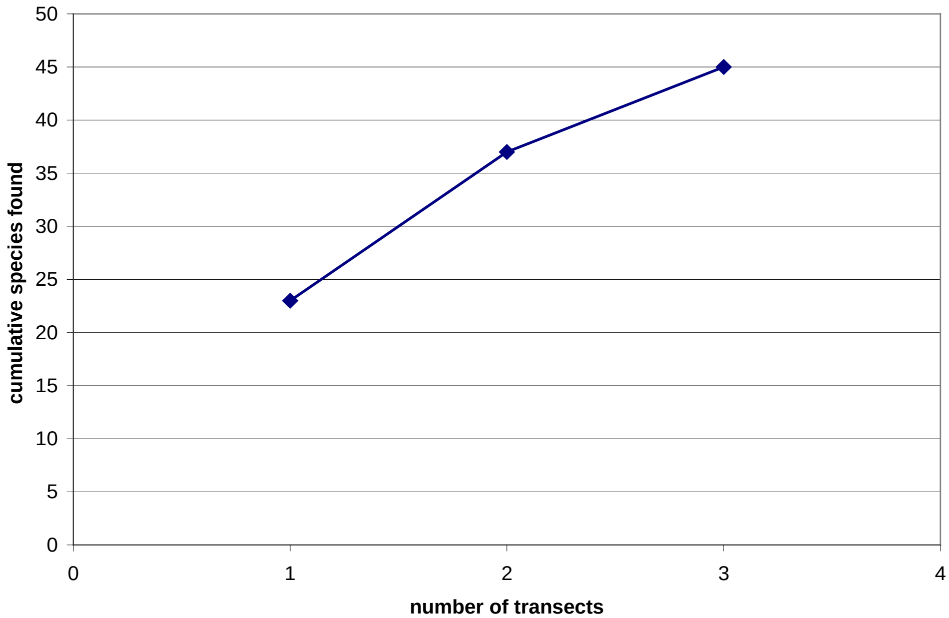


*Figure 11-7 Mammal species accumulation with successive transects*

Bats, small mammals, and large mammals were detected using different techniques that were appropriate to each group (e.g.; mist nets for bats; nets and traps for small mammals; and a combination of opportunistic sightings, interviews, camera trapping, tracks, and scat identification for large mammals). Each of these collection methodologies has potentially different detection rates, so separate analyses of each group were warranted to assess the effectiveness of the mammal data collection program as a whole. Separate species accumulation curves were prepared for bats, small mammals, and large mammals and the curves were extrapolated to predict the theoretical maximum number of species within each group present in the Environmental Study Area. Figure 11-8 through Figure 11-10present the species accumulation curves for bats, small mammals, and large mammals, respectively.

Species accumulation curves for Sites 2 and 3 overlapped more with each other than with Site 1, which occupied the lower quadrant of the graph, indicating lower species diversity and abundance (Figure 11-8). Extrapolation of the curves suggests that less than 50% of the bat species present at Site 1 were detected as opposed to >60% for the other sites[26]. Extrapolation of the entire data set suggests that the survey documented 82% of the species present in the Study Area (Lim et al., 2012).

[26] Mammal species richness was extrapolated using the Michaelis-Menton asymptote function, which uses several different statistical estimators to predict the number of species that would be eventually be detected given enough sampling. This type of analysis was conducted for bats, small mammals, and large mammals.

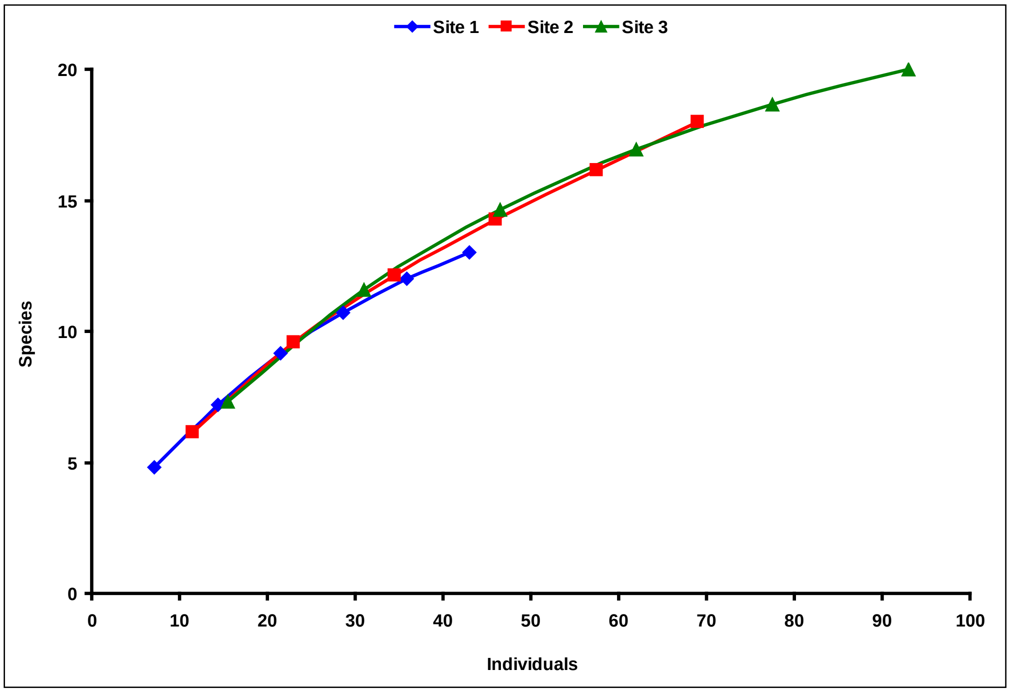


*Figure 11-8* *Species Accumulation Curves for Bats at 3 Sampling Sites in the Environmental Study Area*

A total of 205 bats were captured representing 25 species in 2 families. The short-tailed fruit bat (*Carollia perspicillata*) was the most common species and accounted for 42% of total captures. This species is an indicator of disturbed sites (Lim et al., 2012), particularly forest fragmentation and clearing. The next most common were 3 species of large fruit-eating bats in the genus Artibeus (*A. lituratus*, *A. obscurus*, and *A. planirostris*), but these species together represented only 22% of total captures. Fruit bats also occupied the next 2 positions in order of abundance (*Sturnira lilium* and *Rhinophylla pumilio*) before the first nectar-feeding bat (*Glossophaga soricina*) and insect-feeding bat (*Saccopteryx bilineata*). In contrast, there were 8 species that were caught only once, of which 1 was a fruit-eating bat (*Chiroderma villosum*).

Site 1 had both the lowest number of species and individuals captured whereas Site 3 had the highest values, despite the fact that less surveying effort was expended at Site 3. Site 2 was intermediate in terms of effort and species detected. This pattern among sites continued in terms of unique species detected; Site 3 had four unique species, Site 2 had three unique species, and Site 1 had two unique species. Ten species were caught at all three sites. Similarity indices between pairs of sampling sites were in general high, but Site 3 was more similar to the other two sites than Site 1 was to Site 2.

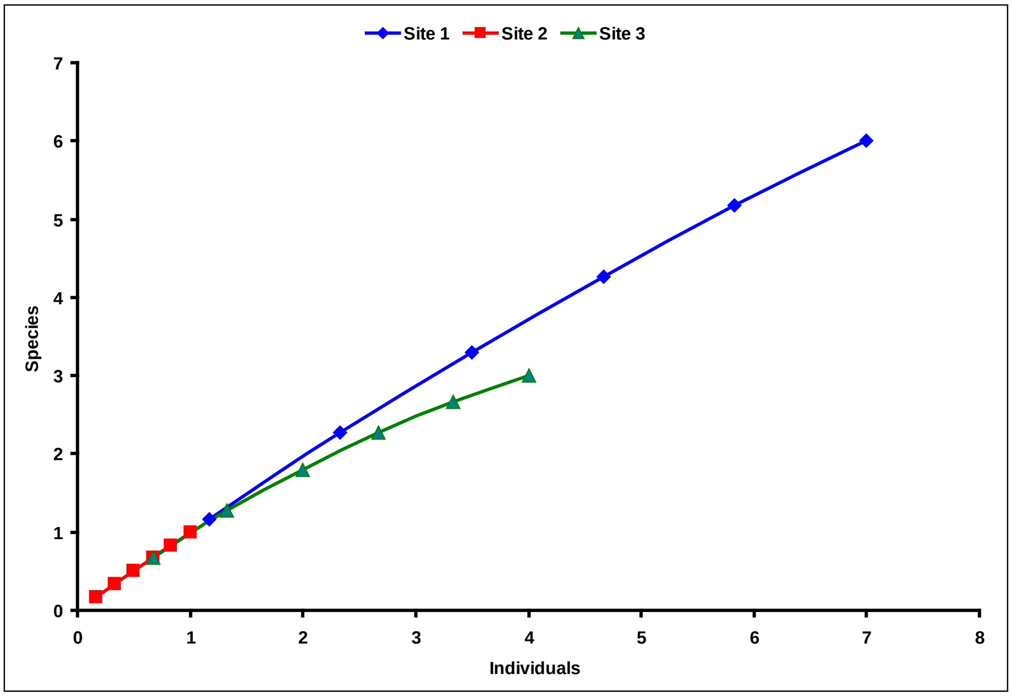


*Figure 11-9 Species Accumulation Curves for Small Mammals at 3 Sampling Sites in the Environmental Study Area*

The small mammal species accumulation curves were different with no overlap between Site 1, which was essentially a straight line, and the other 2 sites (Figure 11-9). Extrapolation estimated that detection rates ranged approximately from 17% of species actually present at Site 1 to 30% at Site 3. Site 2 had no asymptote value because only 1 individual was documented. Extrapolation of the entire data set estimates that the survey documented 43% of the small mammal species present in the Study Area.

Multiple types of data were collected for large mammals that were not collected for bats or small mammals, including interviews with local workers familiar with the Study Area and tracks. The camera traps were also only used for large mammals and had a much longer period of record than the bat or smaller mammal surveys. This required the large mammal data to be compiled and analyzed differently than the bat and small mammal data. Different types of data on large mammals were pooled for all years that data were collected. Observed species richness was plotted against recorded individuals, and the Michaelis-Menton asymptote function was used to predict total species present in the Project Aarea. This analysis differs from the species accumulation analyses for small mammals and bats because it assesses the Study Area as a whole rather than in discreet transects. Extrapolation predicted that between 19 and 25 species of large mammals would eventually be expected to be detected given enough sampling in the Environmental Study Area, depending on the statistical estimator used. Figure 11-10 suggests that the mammal survey has reached the point of diminishing new detections per unit of survey effort, but this may be partially due to an unexpectedly high actual detection rate in the first year of the camera trapping effort, which has a damping effect on the trajectory of the observed species curve.

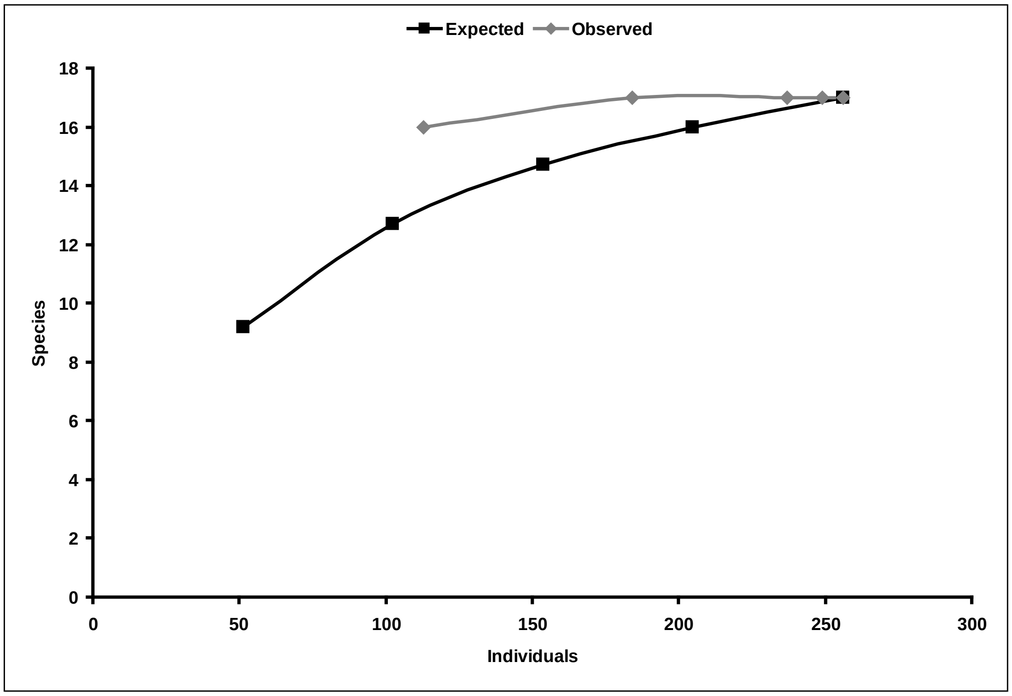


*Figure 11-10 Species Accumulation Curves for Large Mammals at 3 Sampling Sites in the Environmental Study Area*

The camera trapping data was conspicuously rich in terms of large mammal detections. Interviews also produced many records of large mammals in the Study Area, but information from interviews is not as reliable as a verifiable camera trap record. There may be several reasons for the comparative effectiveness of camera trapping including the minimally invasive nature of the technique, the secretive nature of many of the large mammal species in the Study Area, and the period of record of the camera trapping program relative to the other survey methods. Regardless of the cause, camera trapping has provided most of the directly verifiable large mammal records from the Study Area to date. Table 11-12 summarizes the mammal records from the camera traps for the entire period of record from 2007 to 2011.

*Table 11-12 Mammals Detected by Camera Traps*

| Taxa | Year | | | | |
|---|---|---|---|---|---|
| | 2007 | 2008 | 2009 | 2010 | 2011 |
| Didelphidae (Opossums) | | | | | |
| *Didelphis marsupialis* | 17 | 7 | | | |
| *Metachirus nudicaudatus* | 5 | 1 | | | |

| Taxa | Year | | | | |
|---|---|---|---|---|---|
| | 2007 | 2008 | 2009 | 2010 | 2011 |
| Myrmecophagidae (Anteaters) | | | | | |
| *Tamandua tetradactyla* | 1 | | | | |
| Dasypodidae (Armadillos) | | | | | |
| *Dasypus novemcinctus* | 2 | 8 | 5 | | |
| Felidae (Wild Cats) | | | | | |
| *Leopardus pardalis* | 1 | 1 | | | 1 |
| *Puma concolor* | 2 | 2 | 2 | 1 | 1 |
| *Panthera onca* | 5 | 5 | 1 | | |
| Mustelinae (Weasels) | | | | | |
| *Eira barbara* | 1 | | | 1 | |
| Procyonidae (Raccoons, coatis, kinkajous, etc.) | | | | | |
| *Procyon cancrivorus* | 1 | | | | |
| Tapiridae (Tapirs) | | | | | |
| *Tapirus terrestris* | 3 | 6 | 4 | 1 | |
| Tayassuidae (Peccaries) | | | | | |
| *Pecari tajacu* | 11 | 10 | 6 | | |
| Cervidae (Deer) | | | | | |
| *Mazama americana* | 9 | 3 | 3 | 6 | 1 |
| Hydrochaeridae (Capybaras) | | | | | |
| *Hydrochoeris hydrochaeris* | 1 | | | | |
| Dasyproctidae (Agoutis and acouchis) | | | | | |
| *Dasyprocta leporina* | 39 | 18 | 19 | | 3 |

| Taxa | Year | | | | |
|---|---|---|---|---|---|
| | 2007 | 2008 | 2009 | 2010 | 2011 |
| *Myoprocta acouchy* | 5 | | | | |
| Cuniculidae (Pacas) | | | | | |
| *Cuniculus paca* | 10 | 9 | 13 | 3 | 1 |
| Echimyidae (Spiny rats) | | | | | |
| *Proechimys cuvieri* | | 1 | | | |
| Total taxa detected per year | 16 | 12 | 8 | 5 | 5 |

Table 11-12 demonstrates that most large mammals known from the Study Area were detected by the camera traps. It also shows a clearly decreasing trend in the number of taxa detected from 2007 to 2011. The abundance data for some of the large and medium-sized mammals including deer, tapirs, and armadillos do not show any clear trend over the period of record, but others (e.g.; opossums, agoutis, peccaries, puma, and jaguar) have declined. The rate of detections has not increased for any of the mammal species detected by the camera traps over the period of record.

In summary, the results of the mammal study suggest that none of the major species groups have been completely documented to date, but enough data has been collected to 1) identify some general patterns in the distribution of species across the Study Area and 2) determine that prior disturbances have had an effect on the mammal population in the Study Area. Extrapolation from our sampling study estimated that 82% of the bat species, 43% of the small terrestrial mammal species, and 80% of the large mammal species present in the Study Area have been documented. Camera-trapping indicated a trend of decreasing species diversity and relative abundance in large mammals since 2007 when data camera trapping began. The disturbance to the area is also exhibited by the high frequency of occurrence of the short-tailed fruit bat (*Carollia perspicillata*), which is an indicator of disturbed habitat and accounted for 42% of the total bat captures. Patterns of decreasing species diversity of mammals and increasing relative abundance of species indicative of disturbance confirmed the negative impacts on mammals from ASM in the Study Area, including the clearing of forest (Lim et al., 2012).

Site 1 was located adjacent to the mining pit area and had the lowest species diversity and relative abundance for bats. Site 2 was in the TSF area and for small terrestrial mammals documented only 1 species during the sampling period. Site 3 near an old camp clearing and pit area had the highest bat diversity and abundance.

### *11.3.3 Birds*

Bird data were collected in November/ December 2011 at 8 transects (U2, T1, T2, M3, M6, U1, T5, and R1). In 2012, the 2011 data were supplemented with opportunistic observations at various locations throughout the Study Area. The 2011 and 2012 surveys documented a total of 237 species in 41 families. Table 11-13 summarizes bird families across all transects.

*Table 11-13 Bird families known from the Merian Study Area*

| Family | Number of species | Common name/example |
|---|---|---|
| Accipiteridae | 9 | Hawks and eagles |
| Alcedinidae | 3 | Kingfishers |
| Apodidae | 3 | Swifts |
| Ardeidae | 1 | Herons |
| Bucconidae | 4 | Puffbirds |
| Caprimulgidae | 2 | Nightjars |
| Cardinalidae | 2 | Cardinals |
| Cathartidae | 2 | Vultures |
| Columbidae | 5 | Pigeons and doves |
| Cuculidae | 4 | Cuckoos |
| Cotingidae | 7 | Cotingas |
| Cracidae | 4 | Chachalacas and curassows |
| Emberizidae | 1 | New World sparrows |
| Eurypygidae | 1 | Sunbitterns |
| Falconidae | 5 | Falcons and caracaras |
| Fringillidae | 3 | Finches |
| Formicariidae | 2 | Ground antbirds |
| Furnariidae | 11 | Ovenbirds |
| Galbulidae | 4 | Jacamars |

| Family | Number of species | Common name / example |
|---|---|---|
| Grallariidae | 2 | Antpittas |
| Hirudinidae | 1 | Swallows and martins |
| Icteridae | 4 | Orioles and blackbirds |
| Momotidae | 1 | Kingfishers and bee-eaters |
| Nyctibiidae | 2 | Potoos |
| Odontophoridae | 1 | New World quail |
| Parulidae | 2 | New World warbler |
| Picidae | 10 | Woodpeckers |
| Pipridae | 5 | Manakins |
| Pipridae* | 1 | Manakins |
| Psittacidae | 12 | Parrots |
| Psophiidae | 1 | Trumpeters |
| Rallidae | 2 | Rails, coots, etc. |
| Ramphastidae | 5 | Toucans |
| Scolopacidae | 1 | Sandpipers |
| Strigidae | 4 | Owls |
| Thamnophilidae | 24 | Antbirds |
| Thraupidae | 18 | Tanagers |
| Tinamidae | 4 | Tinamous |
| Tityridae | 5 | Tityras and becards |
| Trocholidae | 9 | Hummingbirds |
| Troglodytidae | 3 | Wrens |
| Trogonidae | 4 | Trogons and quetzals |

| Family | Number of species | Common name / example |
|---|---|---|
| Turdidae | 1 | Thrushes |
| Tyrannidae | 33 | Tyrant flycatchers |
| Vireonidae | 14 | Vireos |
| Total species | 237 | |

*The taxonomic status of the Wing-barred Piprites (Piprites chloris) is currently unclear. It was formerly placed in Pipridae but this assignment is currently considered uncertain (IT IS, 2012)

Tyrant flycatchers were the most common family with 33 different species, or 14% of all bird species, found. The next most common families were antbirds with 24 species, or 10% of all bird species, found, followed by tanagers, parrots, and ovenbirds with 18, 12 and 11 species from each family, or 8%, 5% and 5% of all bird species, found, respectively. This distribution is mostly typical of forested habitats across the Guiana Shield, where antbirds, ovenbirds, and tyrant flycatchers are usually the dominant families. The most commonly documented species were *Crypturellus variegates* (variegated tinamou), *Glyphorhynchus spirurus* (wedge-billed woodcreeper) and *Thamnophilus murinus* (mouse-colored antshrike), which were found at all eight transects. The cumulative dataset shows that the avifauna at the Environmental Study Area is very rich as a whole but the number of species (richness) varied substantially by transect from 19 species at U2 to 40 species at U1. Creek forest transects (U1 and T1) had conspicuously high richness and the highest number of unique species. Bird counts did not include individuals so to complete a diversity assessment, families and species were used. Diversity using this approach ranged from 2.28 to 2.95 with a cumulative value (all transects) of 3.05 compared with a theoretical maximum of 3.4. Table 11-14 summarizes the indices (exponents), transformed exponents, and comparison to the cumulative diversity and theoretical maximum (all species equally represented).

*Table 11-14 Diversity and Richness Summary*

| Transect | Shannon Index (H) | Richness (S) |
|---|---|---|
| U2 | 2.48 | 19 |
| T1 | 2.96 | 38 |
| T2 | 2.32 | 20 |
| M3 | 2.28 | 22 |
| M6 | 2.38 | 23 |
| U1 | 2.89 | 40 |

| Transect | Shannon Index (H) | Richness (S) |
|---|---|---|
| T5 | 2.71 | 28 |
| R1 | 2.55 | 29 |
| Cumulative | 3.05 | 83 |
| Theoretical maximum | 3.40 | Unknown |

Combined species counts by paired transect ranged from 29 (35% of total species) to 59 (71% of total species). Commonality of species across transects ranged from 6 to 19 species and 17.6% to 48.3% of combined species by pairs of transects with T1 and U1 having the most species in common and T2 and M6 having the highest percentage of species in common. Table 11-15 shows for paired transects the combined number of species, the number of common species, and the percentage of common species based on the combined species totals by pair.

*Table 11-15* *Comparison of Transects*

| Total species by pairs of transects | | | | | | | |
|---|---|---|---|---|---|---|---|
| | T1 | T2 | M3 | M6 | U1 | T5 | R1 |
| U2 | 44 | 33 | 34 | 33 | 48 | 36 | 36 |
| T1 | | 46 | 46 | 45 | 59 | 49 | 50 |
| T2 | | | 31 | 29 | 51 | 39 | 38 |
| M3 | | | | 32 | 49 | 40 | 43 |
| M6 | | | | | 49 | 39 | 39 |
| U1 | | | | | | 52 | 55 |
| T5 | | | | | | | 43 |
| Common species by transect pairs | | | | | | | |
| | T1 | T2 | M3 | M6 | U1 | T5 | R1 |
| U2 | 13 | 6 | 7 | 9 | 11 | 11 | 12 |
| T1 | | 12 | 14 | 16 | 19 | 17 | 17 |
| T2 | | | 11 | 14 | 9 | 9 | 11 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Total species by pairs of transects | | | | | | | |
| M3 | | | | 13 | 13 | 10 | 8 |
| M6 | | | | | 14 | 12 | 13 |
| U1 | | | | | | 16 | 14 |
| T5 | | | | | | | 14 |
| Percent of common species by transect pairs | | | | | | | |
| | T1 | T2 | M3 | M6 | U1 | T5 | R1 |
| U2 | 29.5% | 18.2% | 20.6% | 27.3% | 22.9% | 30.6% | 33.3% |
| T1 | | 26.1% | 30.4% | 35.6% | 32.2% | 34.7% | 34.0% |
| T2 | | | 35.5% | 48.3% | 17.6% | 23.1% | 28.9% |
| M3 | | | | 40.6% | 26.5% | 25.0% | 18.6% |
| M6 | | | | | 28.6% | 30.8% | 33.3% |
| U1 | | | | | | 30.8% | 25.5% |
| T5 | | | | | | | 32.6% |

Comparison of the similarity and richness/diversity distributions reveals some similar trends to those documented in the vegetation assessment, but it is not clear whether an actual relationship exists between richness and similarity in the bird data. Transects T1 and U1 were the richest pair as well as the most similar pair in terms of number of species shared; however, M6 shared a higher percentage of its species with T2 and M3 and all three of these sites had lower richness than T1 or U1. U2 had the fewest species of any transect, and shared relatively few species in common with transects T2 and M3 which also had relatively few species. Figure 11-11 plots species richness against percentage of species in common for paired transects, and suggests little or no relationship between richness and similarity in the bird data.

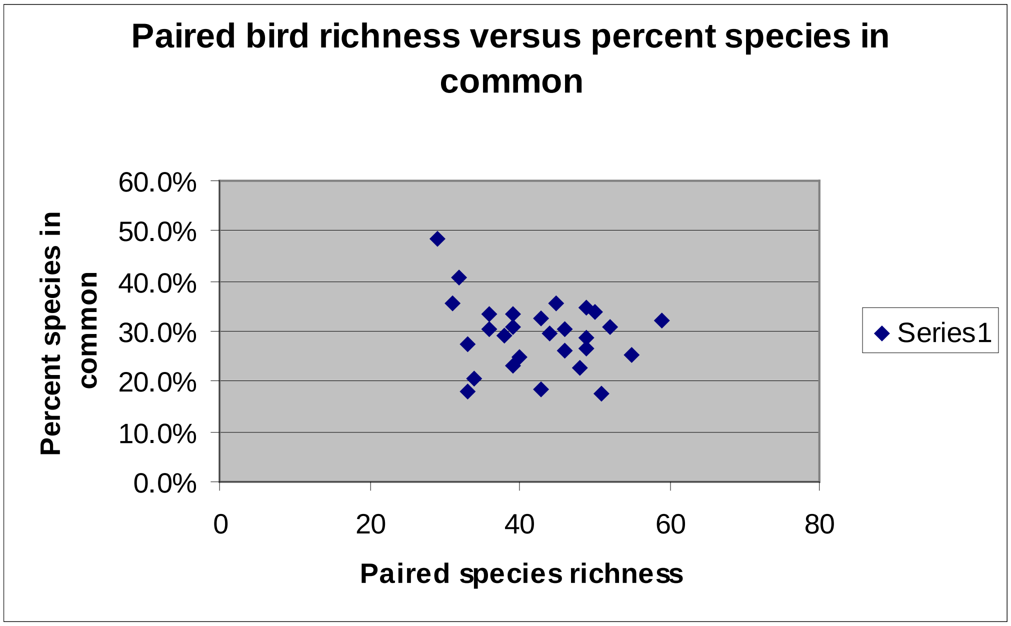


*Figure 11-11 Paired Bird Richness versus Percent Species in Common*

Several species of large game birds occur in the Study Area, including Great Tinamou (*Tinamus major*), Black Curassow (*Crax alector*), White-headed Piping-Guan (*Pipile cumanensis*), and Gray-winged Trumpeter (*Psophia crepitans*). These species are sensitive to exploitation by subsistence and market hunting. They can be considered indicators of good habitat integrity because they tend to disappear from regions with extensive human settlement and habitat fragmentation. They are also particularly important seed dispersers for large-seeded trees, which rely on these and other large vertebrates to disperse their seeds (O'Shea, 2012).

Several species of parrots were found in the Environmental Study Area despite the short sampling period. Parrots are highly sought for the cage bird trade and trappers often capitalize on new road construction to reach previously inaccessible areas. Trappers can deplete populations quickly by taking young parrots from their nest cavities (O'Shea, 2012). Their diversity in the Environmental Study Area indicates that human activity has had minor impacts on their presence within the Study Area to date.

Figure 11-12 presents the bird species accumulation curve for the Environmental Study Area. The curve offers no clear indication of the adequacy of the bird surveys to date. Most of the species that occur in Suriname are known or expected to occur at the Environmental Study Area based on location and habitat conditions in the Study Area. A basic understanding of avian diversity in the region is beginning to emerge through recent field surveys in Guyana (Braun et al. 2003; Robbins et al. 2004, 2007; O'Shea et al. 2007), Suriname (O'Shea 2005), and Brazil. The results of these inventories, as well as species lists accumulated over the years at particular sites (e.g., tourist lodges), indicate that local diversity is typically between 350-450 species (O'Shea, 2012) in minimally impacted areas. Habitat conditions in and around the Study Area suggests that up to 111 more species of bird species may actually occur at Merian, which would put the total species present in the Environmental Study Area near the lower end of the typical range for avian richness in Suriname (O'Shea 2012). It is unlikely that this many species actually remain to be documented at Merian because the substantial amount of ASM activity in the Study Area constitutes more than "minimal" disturbance. Considering that 237 bird species have already been documented in the Study Area and that an additional 111 species would be considered likely if the Study Area's habitat were less disturbed, it is likely that most bird species present in the Study Area have been documented, even if the species accumulation curve does not clearly indicate this conclusion

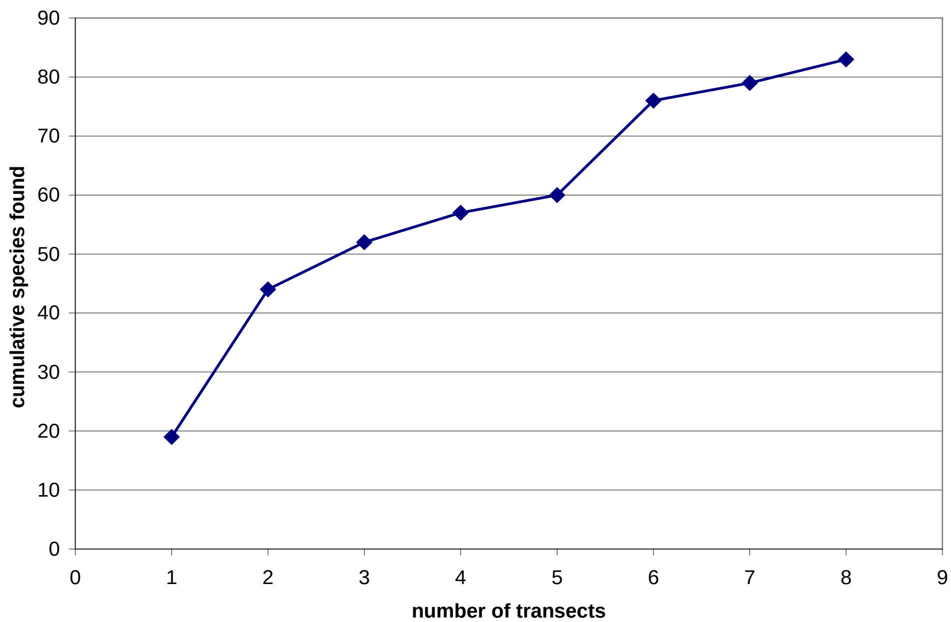


*Figure 11-12 Bird Species Accumulation with Successive Transects*

### *11.3.4 Insects*

Insect data was collected at 10 transects (M3, M5, M6, M8, R1, T2, T3, T5, U1, and U2). The field surveys were focused on two specific groups, bees and butterflies/moths (orders Hymenoptera and Lepidoptera, respectively). These taxa were targeted because:

- Bees (particularly the Euglossinae or orchid bees) have been relatively well described and are easily detectable; and
- Lepidopterans are common and diverse, relatively well known taxonomically, geographically, and are easily detectable.

The identified species consisted of 103 species in 2 orders (Hymenoptera and Lepidoptera) and 2 families (Apidae and Nymphalidae). Table 11-16 provides a summary of insect orders and families across all transects.

*Table 11-16 Insect Orders and Families*

| Order | Family | Number of species | Common name/example |
|---|---|---|---|
| Hymenoptera | Apidae (Euglossinae) | 36 | bees |
| Lepidoptera | Nymphalidae | 67 | butterflies and moths |
| Total species | | 103 | |

Three species of bees and one species of butterfly were found at all 10 transects and three species of bees were the most numerous (201, 116 and 250 individuals each). Cumulatively, the three species of bees constituted 47% of all individuals found across all transects. Table 11-17 summarizes the most commonly found and most numerous species.

*Table 11-17 Most Common and Most Numerous Insect Species*

| Order | Family | Genus species | Individuals found | Transects occurring |
|---|---|---|---|---|
| Hymenoptera | Apidae | *Euglossa amazonica* Dressler, 1982 | 29 | 10 |
| Hymenoptera | Apidae | *Euglossa augaspis* Dressler, 1982 | 201 | 10 |
| Hymenoptera | Apidae | *Euglossa hemichlora* Cockerell, 1917 | 116 | 9 |
| Hymenoptera | Apidae | *Euglossa stilbonota* Dressler, 1982 | 250 | 10 |
| Lepidoptera | Nymphalidae | *Chloreuptychia chlorimene* (Hübner, [1819]) | 21 | 10 |

The number of species (richness) varied from 16 species at M8 to 43 species at T3. Table 11-18 summarizes species richness by transect.

*Table 11-18 Insect Species Richness by Transect*

| Transect | M3 | M5 | M6 | M8 | R1 | T2 | T3 | T5 | U1 | U2 | Cumulative |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of species | 25 | 32 | 35 | 16 | 31 | 32 | 43 | 37 | 31 | 25 | 103 |

Combined species counts by paired transect ranged from 24 (23% of total species) to 49 (48% of total species) with T3/U1 being the richest pair. Commonality of species across transects ranged from 4 to 16 species and 11.4% to 48.4% of combined species by pairs of transects with T2/M5, T3/M6, T3/R1 and T3/T2 having the most species in common and R1/M6 having the highest percentage of species in common. Table 11-19 shows for paired transects the combined number of species, the number of common species, and the percentage of common species based on the combined species totals by pair.

*Table 11-19 Comparison of Insect Diversity by Paired Transects*

| Total species by pairs of transects | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | M5 | M6 | M8 | R1 | T2 | T3 | T5 | U1 | U2 |
| M3 | 28 | 29 | 24 | 29 | 33 | 39 | 35 | 33 | 26 |
| M5 | | 32 | 29 | 32 | 35 | 42 | 38 | 41 | 31 |
| M6 | | | 28 | 31 | 37 | 39 | 36 | 41 | 36 |
| M8 | | | | 29 | 30 | 33 | 33 | 35 | 25 |
| R1 | | | | | 37 | 39 | 37 | 41 | 30 |
| T2 | | | | | | 43 | 39 | 44 | 34 |
| T3 | | | | | | | 45 | 49 | 39 |
| T5 | | | | | | | | 45 | 34 |
| U1 | | | | | | | | | 36 |
| Common species by transect pairs | | | | | | | | | |
| M3 | 12 | 10 | 4 | 10 | 10 | 9 | 8 | 10 | 9 |
| M5 | | 15 | 7 | 15 | 16 | 14 | 13 | 10 | 12 |
| M6 | | | 7 | 15 | 13 | 16 | 14 | 9 | 10 |
| M8 | | | | 6 | 9 | 11 | 6 | 4 | 6 |
| R1 | | | | | 13 | 16 | 13 | 9 | 12 |
| T2 | | | | | | 16 | 15 | 10 | 12 |
| T3 | | | | | | | 14 | 10 | 12 |
| T5 | | | | | | | | 9 | 12 |
| U1 | | | | | | | | | 10 |

| Percent of common species by transect pairs | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| M3 | 42.9% | 34.5% | 16.7% | 34.5% | 30.3% | 23.1% | 22.9% | 30.3% | 34.6% |
| M5 | | 46.9% | 24.1% | 46.9% | 45.7% | 33.3% | 34.2% | 24.4% | 38.7% |
| M6 | | | 25.0% | 48.4% | 35.1% | 41.0% | 38.9% | 22.0% | 27.8% |
| M8 | | | | 20.7% | 30.0% | 33.3% | 18.2% | 11.4% | 24.0% |
| R1 | | | | | 35.1% | 41.0% | 35.1% | 22.0% | 40.0% |
| T2 | | | | | | 37.2% | 38.5% | 22.7% | 35.3% |
| T3 | | | | | | | 31.1% | 20.4% | 30.8% |
| T5 | | | | | | | | 20.0% | 35.3% |
| U1 | | | | | | | | | 27.8% |

Diversity indices ranged from 2.44 to 3.03 with a cumulative value (all transects) of 3.23 compared with a theoretical maximum of 4.63. Table 11-20 summarizes the indices (exponents), transformed exponents, and comparison to the cumulative diversity and theoretical maximum (all species equally represented).

*Table 11-20 Diversity and Richness Summary*

| Area | Shannon Index (H) | eH | Richness (S) |
|---|---|---|---|
| M3 | 2.64 | 14.0 | 25 |
| M5 | 2.96 | 19.2 | 32 |
| M6 | 2.96 | 19.3 | 35 |
| M8 | 2.47 | 11.8 | 16 |
| R1 | 2.58 | 13.2 | 31 |
| T2 | 3.03 | 20.8 | 32 |
| T3 | 2.98 | 19.8 | 43 |
| T5 | 2.44 | 11.5 | 37 |
| U1 | 3.23 | 25.4 | 31 |
| U2 | 2.53 | 12.6 | 25 |

| Area | Shannon Index (H) | eH | Richness (S) |
|---|---|---|---|
| Cumulative | 3.23 | 25.2 | 103 |
| Theoretical maximum | 4.63 | 103 | unknown |

An effect of sampling an area is that as more sampling is completed, more species are identified up to some maximum number of species actually present. Figure 11-13 shows this effect with the three transects and indicates the new species identified with successive transects.

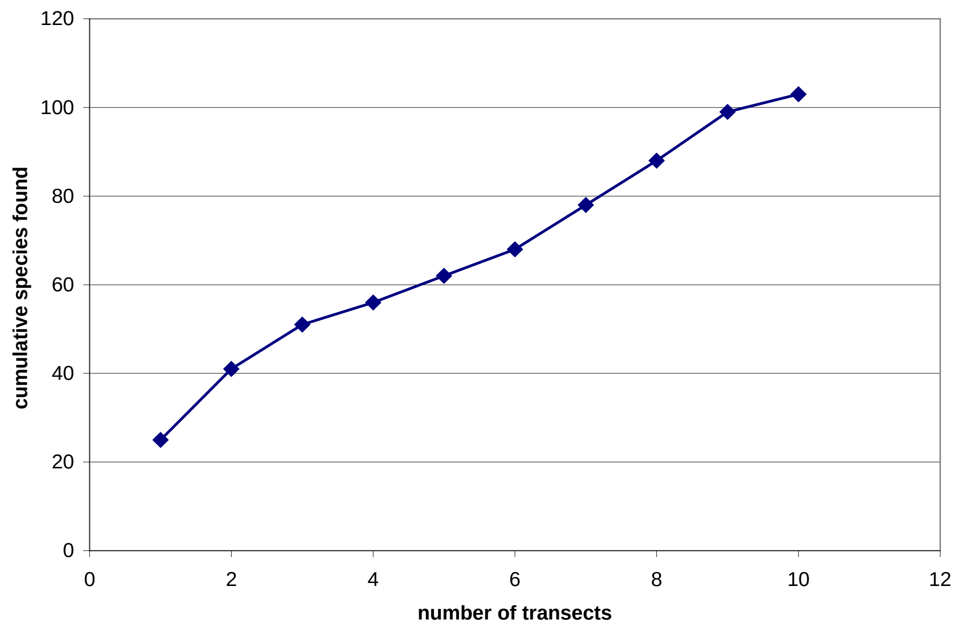


*Figure 11-13 Nymphallidae and Euglossine Species Accumulation with Successive Transects*

Most of the Nymphallid butterfly species recorded at the Environmental Study Area were typical of undisturbed forest. This is an artifact of the sampling design, which favored areas that had experienced comparatively minor levels of recent disturbance. In contrast, transect M8 was heavily disturbed and was dominated by ruderal vegetation. This site had almost none of the butterfly species typical of undisturbed forest, but did have several species in abundance that typically occur in both disturbed and undisturbed forest. The overall scarcity of butterfly species indicative of heavy disturbance likely reflects the fairly recent history of large-scale conversion of forest habitats in the Merian area; i.e.; these species may not have had sufficient time and opportunity to colonize areas that have only recently been disturbed. It also probably indicates the heterogeneity of impacts across the Study Area.

The butterfly community in transects near the proposed location for the TSF was generally richer in species than in the mine pit / fill area. This may mean that the tailing pond area is generally less disturbed than the mine pit / fill area. It should, however, be noted that location U1, the marsh forest that is not expected to be impacted by the Project, was very rich in Nymphalid species. The high species diversity at locations T1 and U1 be related to the proximity of these transects to marsh forest habitat.

The two most abundant Euglossine bee species recorded at Merian are very different in their known relation to disturbance: *Euglossa stilbonota* can be considered a dense forest species, while *E. augaspis* prefers converted habitats and forest margins and is known as an indicator of disturbed conditions. The high abundance of both species likely reflects the fact that both dense forest and forest margins are present in the Study Area, and were sampled at most of the insect sampling transects. The comparatively low numbers of *E. stilbonota* collected at location M8 (a previously disturbed area) is consistent with its status as a sensitive species, but our data do not support the status of *E. augaspis* as an indicator of disturbed conditions. The low numbers of *E. cordata* and the absence of *Eulaema nigrita* despite the presence of ASM-related disturbance of the Merian area are unexpected. These species are typically quite rare in uninhabited areas, while in urban and rural settings with high levels of human activity these species are often very common. Their absence/rarity in the Study Area may be due to the scarcity of permanent man-made structures in the Merian area (the Surgold camp being an exception); both species have frequently been observed to nest in houses elsewhere, in particular in the capital city of Suriname, Paramaribo (De Dijn pers. obs.).

### *11.3.5 Herpetofauna*

Herpetofauna (reptiles and amphibians) were sampled at nine sites in 2011. The survey documented 61 species in 18 families in the Study Area. Table 11-21 summarizes the families and species of herpetofauna known to occur to date in the Environmental Study Area. The herpetofaunal study was one of the last surveys to be conducted and some transects that were used for the other studies described in this chapter had been cleared prior to the herpetofaunal survey, so some of the herpetofaunal sites are located in different areas than the other faunal or vegetative transects. The herpetile survey locations are referred to as “sites” rather than “transects” to avoid confusion.

*Table 11-21 Herpetofauna species by family*

| Family | Number of species found | Common name/example |
|---|---|---|
| Alligatoridae | 2 | Alligators and caimans |
| Allophrynidae | 1 | Tree frogs |
| Aromobatidae | 4 | Poison dart frogs |
| Bufonidae | 4 | Toads |
| Centrolenidae | 2 | Glass frogs |

| Family | Number of species found | Common name / example |
|---|---|---|
| Chelidae | 1 | Side neck turtles |
| Colubridae | 2 | Non-viper snakes |
| Dendrobatidae | 1 | Poison dart frogs |
| Dipsadidae | 2 | Rear-fang snakes |
| Gekkonidae | 3 | Geckos |
| Gymnophthalmidae | 2 | Spectacled lizards |
| Hylidae | 20 | Tree frogs |
| Leptodactylidae | 7 | Frogs |
| Microhylidae | 1 | Narrow mouthed frogs |
| Polychrotidae | 2 | Anoles |
| Teiidae | 4 | Whiptail lizards |
| Tropiduridae | 2 | Iguanas |
| Viperidae | 1 | Viper and pit viper snakes |
| Total species | 61 | |

*Anomaloglossus baeobatrachus* (a species of poison dart frog) was the most dominant species with 22% of all individuals across all sites. *Allobates femoralis* (another species of poison dart frog) and *Osteocephalus oophagus* (a species of tree frog) were the most common species with each found at seven of the nine sites. None of the species occurred at all nine sampling sites. Weather conditions observed during the survey may have affected detection rates for reptiles during the January survey. Conditions were very wet, which is favorable for detecting amphibians but sub-optimal for detecting lizards, so the apparent lack of lizards in the data set is likely an artifact of field conditions during the survey.

The number of species (richness) by site was variable and ranged from 31 species at Site 8 to four species at Site 9. Table 11-22 summarizes the number of individuals and species richness by site.

*Table 11-22 Individuals and Species Richness by Site*

| Site | Individuals | Richness (S) |
|---|---|---|

| Site | Individuals | Richness (S) |
|---|---|---|
| Site 1 | 98 | 22 |
| Site 2 | 60 | 16 |
| Site 3 | 133 | 22 |
| Site 4 | 167 | 26 |
| Site 5 | 67 | 14 |
| Site 6 | 44 | 5 |
| Site 7 | 83 | 29 |
| Site 8 | 130 | 31 |
| Site 9 | 10 | 4 |

Sites were compared by pairs for cumulative species richness and number of species in common. Sites 7 and 8 had the highest cumulative richness with 49 species or 80% of all herpetofauna species found across the Study Area. Sites 6 and 9 had the lowest with 9 species. Sites 1 and 4, Sites 3, and 4, and Sites 4 and 8 shared the most number of species at 14. Site 9 shared the fewest species with any site with no species in common with most other sites, 1 species in common with Site 1, and 3 in common with Site 7. Site 9 also had the lowest species richness with only 4 species. Sites 1, 3, and 4 were all very similar. Sites 1 and 3 had the highest percentages of common species with 41.9% of species shared between them. Site 4 shared a slightly smaller percentage of species (41.2%) with both Sites 1 and 3. Table 11-23 summarizes the commonality of species between and across sites.

*Table 11-23 Commonality of Species*

| Total species by pairs of sites | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Site 2 | Site 3 | Site 4 | Site 5 | Site 6 | Site 7 | Site 8 | Site 9 |
| Site 1 | 27 | 31 | 34 | 27 | 22 | 39 | 40 | 26 |
| Site 2 | | 29 | 34 | 27 | 20 | 39 | 38 | 20 |
| Site 3 | | | 34 | 26 | 23 | 41 | 39 | 26 |
| Site 4 | | | | 29 | 26 | 42 | 42 | 29 |
| Site 5 | | | | | 14 | 35 | 35 | 17 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Total species by pairs of sites | | | | | | | | |
| Site 6 | | | | | | 31 | 31 | 9 |
| Site 7 | | | | | | | 46 | 30 |
| Site 8 | | | | | | | | 34 |
| Common species by site pairs | | | | | | | | |
| | Site 2 | Site 3 | Site 4 | Site 5 | Site 6 | Site 7 | Site 8 | Site 9 |
| Site 1 | 11 | 13 | 14 | 8 | 5 | 12 | 12 | 0 |
| Site 2 | | 9 | 8 | 2 | 1 | 6 | 8 | 0 |
| Site 3 | | | 14 | 9 | 4 | 10 | 13 | 0 |
| Site 4 | | | | 10 | 5 | 13 | 14 | 1 |
| Site 5 | | | | | 4 | 7 | 8 | 0 |
| Site 6 | | | | | | 3 | 4 | 0 |
| Site 7 | | | | | | | 13 | 3 |
| Site 8 | | | | | | | | 0 |
| Percent of common species by site pairs | | | | | | | | |
| | Site 2 | Site 3 | Site 4 | Site 5 | Site 6 | Site 7 | Site 8 | Site 9 |
| Site 1 | 40.7% | 41.9% | 41.2% | 29.6% | 22.7% | 30.8% | 30.0% | 0.0% |
| Site 2 | | 31.0% | 23.5% | 7.4% | 5.0% | 15.4% | 21.1% | 0.0% |
| Site 3 | | | 41.2% | 34.6% | 17.4% | 24.4% | 33.3% | 0.0% |
| Site 4 | | | | 34.5% | 19.2% | 31.0% | 33.3% | 3.4% |
| Site 5 | | | | | 28.6% | 20.0% | 22.9% | 0.0% |
| Site 6 | | | | | | 9.7% | 12.9% | 0.0% |
| Site 7 | | | | | | | 28.3% | 10.0% |
| Site 8 | | | | | | | | 0.0% |

Figure 11-14 plots cumulative species richness against percent of species in common by site pair. Unlike the vegetation and bird data, which suggested weak or non-existent relationships between site richness and similarity in those groups, the herpetofauna data suggests a relatively strong relationship between species richness and the percentage of species shared between site pairs. The reason for this difference in the datasets is unclear, but it suggests that the herpetofauna may be unique in that there may be particular groups of reptile and amphibian species that are characteristic of diverse or depauperate communities, and that certain species may be useful indicators of general richness in the Environmental Study Area's herpetofauna community.

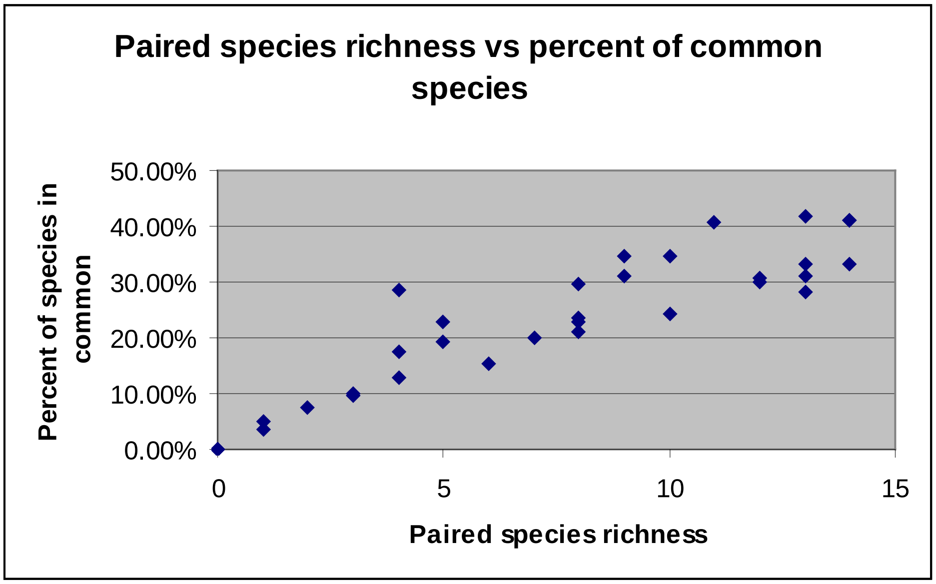


*Figure 11-14 Paired Species Richness vs. Percent of Common Species*

Species diversity based on individual counts was similar across all sites with Shannon indices ranging from 1.08 (Site 6) to 2.83 (Site 1) compared with a cumulative (all sites) of 3.25 and theoretical maximum (all species equally represented) of 4.11. Table 11-24 summarizes the indices (exponents), transformed exponents, and comparison to the cumulative diversity and theoretical maximum.

*Table 11-24 Diversity and Richness Summary*

| Site | Shannon Index (H) | Richness (S) |
|---|---|---|
| Site 1 | 2.83 | 22 |
| Site 2 | 2.35 | 16 |

| | | |
|---|---|---|
| Site 3 | 2.25 | 22 |
| Site 4 | 2.74 | 26 |
| Site 5 | 2.25 | 14 |
| Site 6 | 1.08 | 5 |
| Site 7 | 2.82 | 29 |
| Site 8 | 2.83 | 31 |
| Site 9 | 1.28 | 4 |
| Cumulative | 3.25 | 61 |
| Theoretical maximum | 4.11 | Unknown |

As discussed above, one of the effects of sampling an area repetitively is that as more sampling is completed, more species are identified up to some maximum number of species actually present. Figure 11-15 shows this effect for all herpetofauna species in the Environmental Study Area and indicates the new species identified with successive sites.

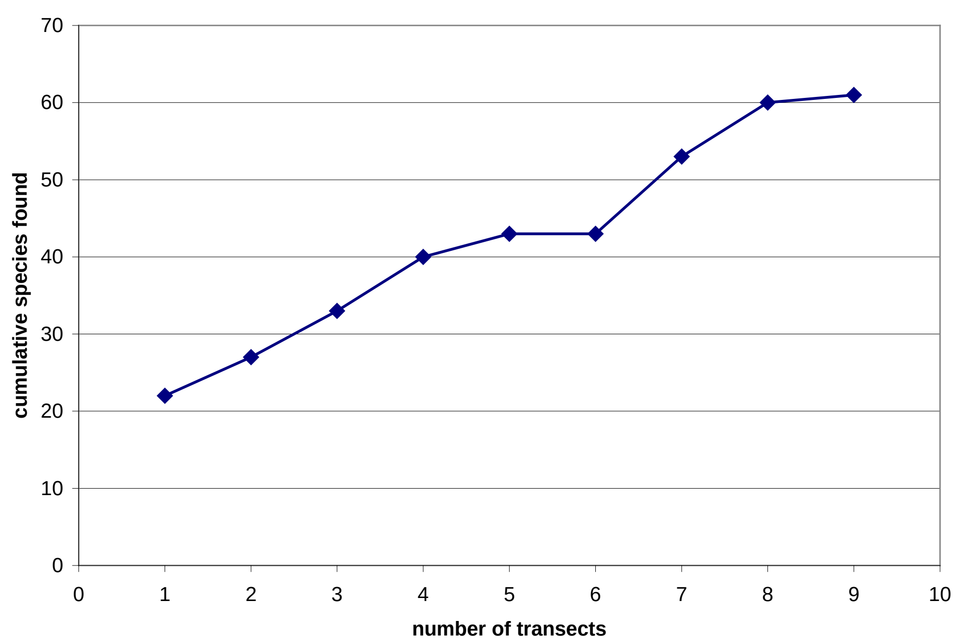


*Figure 11-15 Cumulative Herpetofauna Species Accumulation with Successive Sites*

Much like the species accumulation curves presented previously for the various faunal groups surveyed to date, the species accumulation curve for all the herpetofauna pooled together in Figure 11-15 is more linear than asymptotic, indicating that the rate of new species discoveries did not decrease significantly over the course of the survey. This suggests that there may be significant numbers of herpetofauna remaining to be discovered in the Environmental Study Area.

Although the Study Area's herpetofauna community as a whole may remain partially documented, a separate species accumulation curve for treefrogs presented in
Figure 11-16 suggests that the documentation of treefrog richness to date has been comparatively thorough. As stated at the beginning of this subchapter, weather conditions may have reduced detections of reptiles during the herpetile field survey. Treefrogs accounted for just over half of the total amphibian species documented and are, therefore, a reasonable proxy for the group as a whole. Comparison of the treefrog and cumulative herpetofauna species accumulation curves clearly indicates different sampling efficiencies for the two groups, and substantiates the hypothesis that reptile detections may have been disproportionately compromised during the field survey.

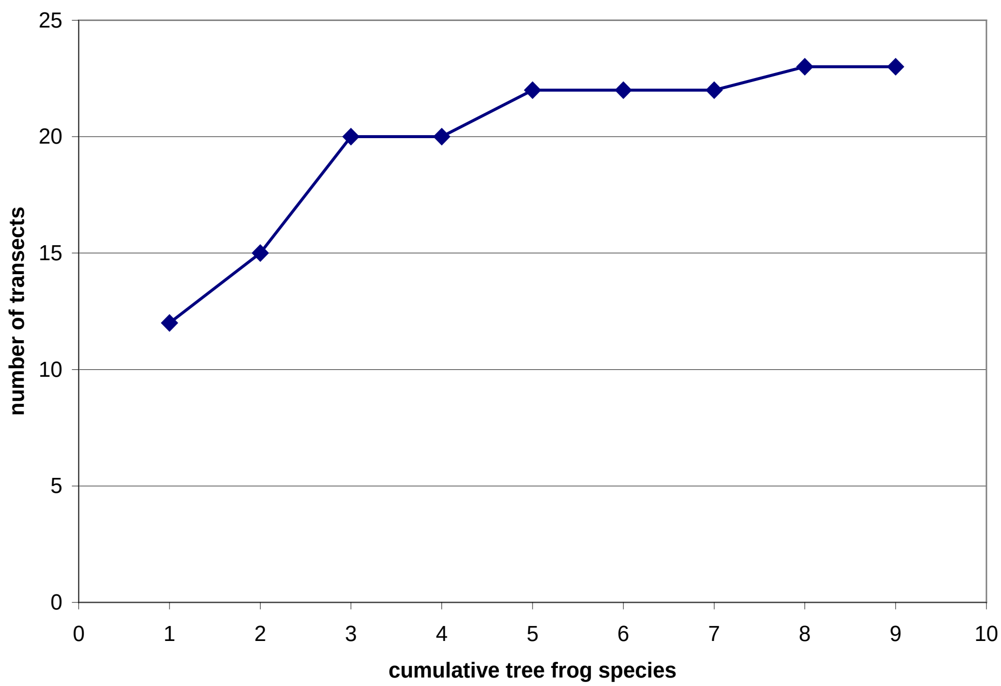


*Figure 11-16 Cumulative Treefrog Species Accumulation with Successive Sites*

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# 12.0 *AQUATIC RESOURCES BASELINE*

Aquatic biodiversity was evaluated based on the richness and distribution of fishes, macroinvertebrates, and plankton within and downstream of the Study Area in both the Commewijne and Marowijne watersheds. This subchapter includes separate discussions of all three species groups. Sampling stations were chosen after a reconnaissance survey in November 2011. Several factors were considered in the selection of sampling stations, including catchment (Commewijne and Marowijne/Merian), degree of porknocker disturbance, and stream size. Samples were taken in both the Commewijne and Marowijne catchments, including the Commewijne and Marowijne rivers themselves and tributaries, and samples were taken both within the Project boundary, and downstream of the Project boundary in both catchments. Figures 12-1 and Figure 12-2 illustrate the locations of each sample site. The specific methodologies used to assess water quality, habitat, phytoplankton, fish, and macroinvertebrates are described below.

Water temperature, conductivity, pH, and dissolved oxygen were measured in the field at each sample site. Water transparency was measured with a Secchi disc. Sampling and analysis followed standard methods (Clesceri *et al.* 1998). Aquatic habitat was further described qualitatively based on stream width (m), water depth (cm), canopy covery (%), aquatic macrophytes, streambed substrate, banks, and current velocity. Photographs were taken of each sampling station.

Phytoplankton and periphyton samples were collected by filling a 0.7-litre polyethylene bottle with surface water and fixated by addition of 5 ml 37% formaldehyde. In the laboratory, phytoplankton and periphyton samples were analyzed by Mrs Asha Haripersad of Hydraulic Research Division (WLA) of the Ministry of Public Works with a Reichert MeF2 inverted microscope. Phytoplankton was identified to the species level with Prescott (1955), Huber-Pestalozzi (1962) and Fott (1971).

Fishes and macroinvertebrates were collected by several gear types. Fishes were collected with trammel nets (length 30 or 50 m, depth 2.5 m; knot-to-knot mesh size of inner net 2.5 and of outer nets 9.5 cm) and a small 3 x 1.2 m seine (2 mm mesh size) (Table 12-1). Seines were used primarily for small fish and macroinvertebrates, and the trammel nets for medium to large fish. Trammel nets were set, left to soak overnight, and checked for fish after 24 hours. Seines were used in day light only. Specimens were initially fixed in 4% formaldehyde, later transferred to 70% ethanol for long term storage at the National Zoological Collection of Suriname (NZCS) of the Anton de Kom University of Suriname, Paramaribo. A selected number of large, piscivorous fishes were deep-frozen for analysis of heavy metals (including total mercury) in their muscle tissues.

Fishes and macro-invertebrates were identified, counted and weighed to the nearest 0.1 g. Identifications were made to the lowest taxonomic level possible. For fish this usually meant to species. Publications used to identify the fishes included regional monographs like Eigenmann (1912), Planquette *et al.* (1996), Keith *et al.* (2000), Le Bail *et al.* (2000) and taxonomic surveys specific to Suriname like Boeseman (1968), Nijssen (1970), Mees (1974) and Kullander & Nijssen (1989) and many others. Decapoda were identified with Holthuis (1959) and aquatic insects with Edmondson (1960) and Borror & De Long (1976).

## 12.1 *PLANKTON*

This subchapter focuses on phytoplankton (the vegetative portion of the plankton) because only one species of zooplankton (*Lecane sp.*) was found in the Study Area as opposed to over 50 species of phytoplankton, and the significance of phytoplankton as bioindicators in Surinamese freshwaters is comparatively well understood. In Suriname the abundance and species composition of freshwater phytoplankton can be used as a general indicator of trophic status. Relatively unimpacted sites tend to have low abundance of phytoplankton due to a general scarcity of nutrients in the water column, but at sites where significant numbers of planktonic organisms occur diversity tends to be high. As nutrient loads increase, nutrient availability increases, primary productivity increases, and general phytoplankton abundance increases (Haripersad-Makhanlal and Ouboter, in Ouboter, 1993).

Phytoplankton species composition also changes with increased nutrient enrichment. Chrysophyta (otherwise known as diatoms), which are mostly found on stream bottoms, require clear water to photosynthesize and are, therefore, most common in clear, unpolluted systems. Chlorophyta (in particular the Desmidiacea) also tend to be common and diverse in these systems. In turbid / polluted systems, diatoms become less abundant, and Euglenophyta and Cyanophyta (known as blue-green algae or cyanobacteria) generally constitute a more significant component of the phytoplankton community (Haripersad-Makhanlal and Ouboter, in Ouboter, 1993).

Table 12-1 presents the phytoplankton data generated during the freshwater baseline surveys. The generally low phytoplankton abundance in both the Marowijne watershed and the Commewijne watershed are indicative of low levels of impairment as a whole. The phytoplankton community was too impoverished at the Commewijne watershed sites to draw meaningful conclusions from the species composition data, but the differences in species composition between the Marowijne watershed sites may indicate different levels of impairment in particular places in that watershed. The relative composition of Chrysophyta, Chlorophyta (Desmidiacea), Euglenophyta, and Cyanophyta in the Marowijne River watershed are graphed in Figure 12-3. There had been relatively little disturbance in the vicinity of SW 21 compared to SW 34 and SW 4A at the time these sites were surveyed (see Figure 12-3). The relatively intolerant Chrysophyta and Chlorophyta constituted a much larger proportion of the phytoplankton community at SW 21 than at SW4A, and were much more common at SW21 than at either of the other sites. Both Marowijne River sites also had more intolerant than tolerant phytoplankton taxa but not nearly as many intolerant taxa as SW21. This likely reflects the river's much greater capacity to dilute contaminated inputs compared with the smaller creeks at SW 21, SW34, and SW4A.

*Figure 12-1 Aquatic Fauna Sampling Locations*

*Figure 12-2 Downstream Aquatic Fauna Sampling Locations*

*Table 12-1 Diversity and Richness Summary*

| Taxon (species) | Phytoplankton | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Marowijne River System | | | | | | Commewijne River System | | |
| | SW34 | SW4 A | SW2 1 | MaD1 | MaU1 | MaU2 | Tempati Creek | Klein Commewijne River | Lower Mapane Creek |
| CHRYSOPHYTA (diatoms) | | | | | | | | | |
| *Cyclotella sp.* | | | | | A | | | | |
| *Eunotia asteriolloides** | | | | A* | | | | | |
| *Frustuliia rhomboides* | | | | | | A | | | |
| *F. rhomboids var. .saxofona* | | | A | | | | | | |
| *Gomphonema longiceps var. gracillis* | | | A | | | | | | |
| *Gyrosigma wansbeckii* | | | | | | | A | | |
| *Pinnularia sp.* | | | A | | | | | | |
| *Navicula agnite* | | | A | | | | | | |
| *Navicula sp.1* | | | A | | | | | | |
| *Navicula sp.2* | | | A | | | | | | |
| *Navicula sp.3* | | | | A | | | | | |

| Taxon (species) | Phytoplankton | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Marowijne River System | | | | | | Commewijne River System | | |
| | SW34 | SW4 A | SW2 1 | MaD1 | MaU1 | MaU2 | Tempati Creek | Klein Commewijne River | Lower Mapane Creek |
| *Navicula sp.4* | | | | A | | | | | |
| *Navicula sp.5* | | | | | | A | | | |
| *Melosira granulata* | | | | A | A | A | | | |
| *Surirella engleri* | | | | | | A | | | |
| *Surirella engleri var.subleavis* | | | | | | A | | | |
| *Surirella.sp* | | | | | A | | | | |
| *Surirella celebesiana* | | | | | | A | | | |
| *Surirella tenuissima* | | | | | | | | | A |
| CHLOROPHYTA (Desmidiaceae) | | | | | | | | | |
| *Closterium longicauda* | A | | | | | | | | |
| *Closterium dianea* | A | | | | | | | | |
| *Closterium praelongum var. breavis* | A | | | | | | | | |
| *Closterium setaceum* | | | | A | | | | | |
| *Closterium nematodas* | | | | A | | | | | |

| Taxon (species) | Phytoplankton | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Marowijne River System | | | | | | Commewijne River System | | |
| | SW34 | SW4 A | SW2 1 | MaD1 | MaU1 | MaU2 | Tempati Creek | Klein Commewijne River | Lower Mapane Creek |
| *Cosmarium zonatum var. latum* | | | A | | | | | | |
| *Cosmarium reniforme* | | | A | | | | | | |
| *Cosmarium praemorsum* | | | | A | | | | | |
| *Cosmarium sublatum* | | | | A | | | | | |
| *Cosmarium .inaequalinotatum* | | | A | | | | | | |
| *Cosmarium paramense* | | | | A | A | | | | |
| *Cosmarium ralfsii var. spinigerum* | | | A | | | | | | |
| *Cosmarium sp.1* | | | A | | | | | | |
| *Cosmarium sp.2* | | | A | | | | | | |
| *Cosmarium sp.3* | | | | A | | | | | |
| *Cosmarium quadrum var. sublatum f.dilatutum* | | | A | | | | | | |
| *Pleurotaenium minutum* | | | C | | | | | | |
| *Pleurotaenium minutum var elongatum* | | A | A | | | | | | |
| *Pleurotaenium .tracecula var. rectum* | | | C | | | | | | |

| Taxon (species) | Phytoplankton | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Marowijne River System | | | | | | Commewijne River System | | |
| | SW34 | SW4 A | SW2 1 | MaD1 | MaU1 | MaU2 | Tempati Creek | Klein Commewijne River | Lower Mapane Creek |
| *Pleurotaenium coroniferum var. multinodosum* | | | A | | | | | | |
| *Euastrum incavatum* | | | A | | | | | | |
| *Euastrum verrucosum* | | | | | A | | | | |
| *Euastrum verrucosum alatum* | | | | | A | | | | |
| *Staurastrum sp.* | | | A | | | | | | |
| *Mougeotia sp.* | | | A | | | | | | |
| *Spondylosium desmidiiforme var. tenuous* | | | A | | | | | | |
| *Desmidium swartzii var. amblydon* | | | A | | | | | | |
| *Oedogonium sp.* | | | | | | | | A | |
| *Xanthidium concinnum var. americanum* | | | A | | | | | | |
| CYANOPHYTA (cyanobacteria) | | | | | | | | | |
| *Anabaena sp.* | | | A | | | | | | |
| *Oscillatoria sp.* | | | | | | | | A | |
| EUGLENOPHYTA | | | | | | | | | |

| Taxon (species) | Phytoplankton | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Marowijne River System | | | | | | Commewijne River System | | |
| | SW34 | SW4 A | SW2 1 | MaD1 | MaU1 | MaU2 | Tempati Creek | Klein Commewijne River | Lower Mapane Creek |
| *Euglena sp1* | A | | | | | | | | |
| *Euglena acus* | | | | | | | A | | |
| *Strombomonas verrucosa var. zwiemika* | | A | | | | | | | |
| *Lepocinclis ovum var. angustata* | | | | | | | A | | |

Note: A = 0-5, B=6-20, C =21-50, D=51-100, E >100 individuals / liter.

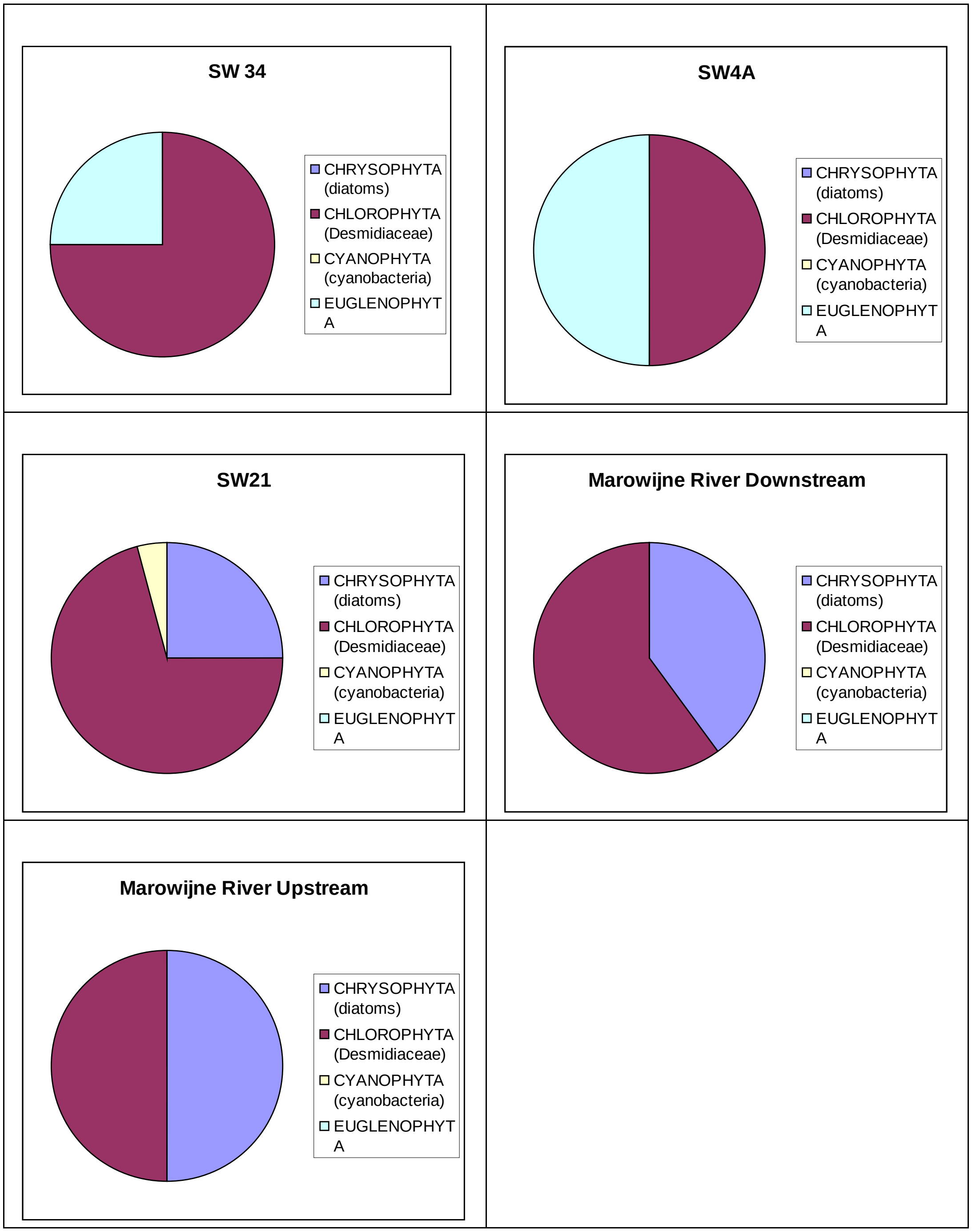


*Figure 12-3 Phytoplankton Species Composition at the Marowijne River Watershed Sampling Sites*

## 12.2 AQUATIC FAUNA

### *12.2.1 Macroinvertebrates*

Macroinvertebrates were collected from eight of the aquatic sampling sites surveyed. The sites were split evenly between the Marowijne and Commewijne watersheds and headwater streams as well as main river channels were sampled in both watersheds. Table 12-2 presents the results of the aquatic macroinvertebrate survey.

*Table 12-2* *Aquatic Macroinvertebrate Survey Results*

| | Marowijne River System | | | | Commewijne River System | | | |
|---|---|---|---|---|---|---|---|---|
| | SW21 | SW34 | SW4A | MaU | SW30 | SW35 | LT | KC |
| Decapoda | | | | | | | | |
| *Macrobrachium sp.* | 1 | 19 | 9 | | 40 | 12 | | |
| *Palaemonetes carteri* | 49 | 19 | 41 | | 21 | 3 | 4 | 2 |
| *Potamocarcinus latifrons* | | | | 1 | | | | |
| *Pseudothelphusa denticulata* | | | | | 1 | | | |
| Insecta | | | | | | | | |
| *Belostoma sp* | | | 1 | | | | | |
| *Gerridae sp.1* | | x | | | 9 | | | |
| *Gerridae sp.2* | | x | | | 1 | | | |
| *Ranatra sp* | | | | | 1 | | | |
| *Coleoptera sp.1* | | | | | 1 | | | |
| *Coleoptera sp.2* | | | | | 1 | | | |
| *Plecoptera sp.* | 1 | | | | | | | |
| Gastropoda | | | | | | | | |
| *Pomacae sp.* | | | | | | | | x |

Note: X=observed but not counted

Most of the aquatic macroinvertebrates captured during the field surveys are habitat generalists, so comparison of the species composition data from the various sites sampled reveals relatively little about the condition of the benthic communities at these sites or their likely sensitivity to Project-related impacts. The plectopteran (stonefly) captured at SW 21 may be a minor exception to this generalization because most (but not all) stoneflies are moderately to highly sensitive to physiochemical habitat degradation, but the presence of a single individual does not constitute a significant result.

### 12.2.2 Fish

Fish data were collected from two major areas: the Marowijne River (Merian Creek) catchment and the Commewijne River catchment. The fish survey documented a total of 105 species in eight orders and 33 families. Table 12-3 summarizes the fish taxa collected from the Study Area.

*Table 12-3 Fish species by order and family*

| Order | Family | Number of species |
|---|---|---|
| Characiformes | Acestrorhynchidae | 1 |
| Characiformes | Anostomidae | 5 |
| Characiformes | Characidae | 28 |
| Characiformes | Chilodontidae | 1 |
| Characiformes | Curimatidae | 2 |
| Characiformes | Cynodontidae | 1 |
| Characiformes | Erythrinidae | 3 |
| Characiformes | Gasteropelecidae | 1 |
| Characiformes | Lesbiasinidae | 3 |
| Characiformes | Prochilodontidae | 2 |
| Chondrichthyes | Potamotrygonidae | 1 |
| Clupeiformes | Engraulidae | 2 |
| Cyprinodontiformes | Poeciliidae | 2 |
| Cyprinodontiformes | Rivulidae | 1 |
| Gymnotiformes | Apteronotidae | 2 |
| Gymnotiformes | Gymnotidae | 3 |
| Gymnotiformes | Hypopomidae | 2 |
| Gymnotiformes | Sternopygidae | 2 |
| Perciformes | Cichlidae | 4 |
| Perciformes | Crenuchidae | 2 |

| Order | Family | Number of species |
|---|---|---|
| Perciformes | Eleotridae | 1 |
| Perciformes | Polycentridae | 1 |
| Perciformes | Sciaenidae | 2 |
| Siluriformes | Auchenipteridae | 5 |
| Siluriformes | Callichthyidae | 2 |
| Siluriformes | Cetopsidae | 2 |
| Siluriformes | Doradidae | 3 |
| Siluriformes | Heptapteridae | 3 |
| Siluriformes | Loricariidae | 11 |
| Siluriformes | Pimelodidae | 3 |
| Siluriformes | Polycentridae | 1 |
| Siluriformes | Pseudopimelodidae | 1 |
| Siluriformes | Trichomycteridae | 1 |
| Synbranchiformes | Synbranchidae | 1 |

Characids (tetras and relatives) were the most common species found across the entire Study Area, accounting for 28 species or 27% of all species captured. This is typical of lowland stream systems in Suriname and in much of northern South America; Characidae is one of the largest and most diverse families of fish on the Guiana Shield. The second most common group were Loricariids (suckermouth armored catfish) with 11 species or 10% of all species. This is also not unusual; the Loricariidae are also a large and diverse family. They are exclusively from northern South America and represent the largest family of catfishes (Siluriformes) in the world.

Forty-six species were captured in the Marowijne and 78 species were captured in the Commewijne watershed. The two areas had only 19 species in common. Table 12-4 shows a list of all the species common to both catchments.

*Table 12-4 Species common to both catchments*

| Order | Family | Species |
|---|---|---|
| Characiformes | Anostomidae | *Leporinus friderici* |
| Characiformes | Anostomidae | *Schizodon fasciatus* |
| Characiformes | Characidae | *Astyanax bimaculatus* |
| Characiformes | Characidae | *Charax pauciradiatus aff.s* |
| Characiformes | Characidae | *Pristella maxillaris* |
| Characiformes | Characidae | *Serrasalmus rhombeus* |
| Characiformes | Characidae | *Tometes lebaili* |
| Characiformes | Curimatidae | *Curimata cyprinoides* |
| Characiformes | Gasteropelecidae | *Gasteropelecus sternicla* |
| Cyprinodontiformes | Poeciliidae | *Micropoecilia bifurca* |
| Gymnotiformes | Sternopygidae | *Eigenmannia sp.* |
| Gymnotiformes | Sternopygidae | *Sternopygus macrurus* |
| Perciformes | Crenuchidae | *Microcharacidium eleotrioides* |
| Perciformes | Sciaenidae | *Plagioscion squamosissimus* |
| Siluriformes | Auchenipteridae | *Ageneiosis inermis* |
| Siluriformes | Auchenipteridae | *Trachelyopterus galeatus* |
| Siluriformes | Loricariidae | *Hypostomus gymnorhynchus* |
| Siluriformes | Loricariidae | *Hypostomus plecostomus* |
| Siluriformes | Loricariidae | *Loricaria cataphracta* |

Individual counts were not available, so diversity was calculated from family and species counts. Using this method, the Shannon indices were 2.72 for the Marowijne watershed and 2.87 for the Commewijne watershed. Table 12-5 summarizes the diversity indices for each area, the combined areas and the cumulative theoretical maximum. As described in Chapter 11.3.1, the Shannon Index is a composite index of richness and distribution of species. It measures diversity as a function of richness and distribution of species. High numbers of species with even distributions score the highest Shannon values; low numbers of species with patchy or clumped distributions score low Shannon values. In the case of the fish data in Table 12-5, the Shannon Index values for the Commewijne and Marowijne watersheds are similar but the Commewijne watershed yielded approximately 70% more species than the Marowijne watershed, despite the fact that equal sampling effort was expended in both watersheds (5 sample sites in each watershed). This result clearly shows the effect that distribution of species has on the Shannon Index, and indicates that the species in the Commewijne watershed are more unevenly distributed than in the Marowijne watershed.

*Table 12-5 Diversity and Richness Summary*

| Area (Watershed) | Shannon Index (H) | Richness (S) |
|---|---|---|
| Marowijne | 2.72 | 46 |
| Commewijne | 2.87 | 78 |
| Cumulative | 2.96 | 105 |
| Theoretical maximum | 3.49 | Unknown |

Figure 12-4 illustrates the variability in species richness between and within the two watersheds. When the five transects in each watershed are paired according to species richness, the Commewijne watershed sites are richer than the Marowijne watershed sites in every pair. There is also more variability in the number of species at each site in the Commewijne (24 more species at the richest site than at the poorest site) than in the Marowijne (13 more species at the richest site than at the poorest site).

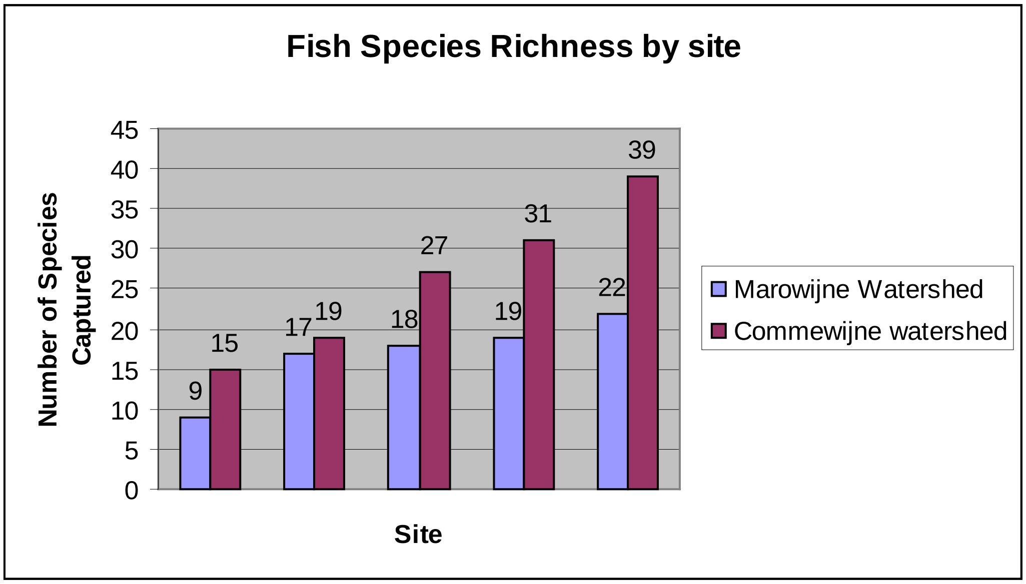


*Figure 12-4 Fish Species Richness in the Marowijne and Commewijne Watersheds by Site*

### *12.2.3 Aquatic habitat*

The Project Area has historically been disturbed by ASM activities. Until recently, ASM in the Project Area had been more widespread in the Marowijne watershed portion of the Study Area than in the Commewijne watershed, but in 2010 ASM began in Las Dominicanas Creek and A3 Creek. Since that time is has spread within both the Marowijne and Commewijne watersheds.

Artisinal gold mines in Suriname are typically placer mines, and as it is practiced in Suriname the activity is extremely destructive to aquatic habitats. Exhausted artisinal mines are often simply abandoned, leaving a series of silty, highly turbid pools that are heavily loaded with fine sediment. Mol and Ouboter (2004) compared undisturbed rainforest stream habitat to streams affected by artisanal gold mining and documented numerous negative physical effects on aquatic habitat downstream of artisanal gold mines, including a decline in instream habitat due to structural changes in the impacted stream channels, loss of coarse substrate that is important for spawning and foraging due to accumulation of fine sediment, decreased light transmission due to increased turbidity, and declining availability of biologically derived habitat elements such as leaf litter banks and exposed root wads. These effects are readily apparent in many of the streams in the Study Area. In some areas the natural stream channel has been nearly completely eliminated and replaced with a series of silty, highly turbid basins (see Figure 12-5 and Figure 12-6).

*Figure 12-5 ASM Activity on A3 Creek South of SW-37, Commewijne River Watershed (August, 2011)*

*Figure 12-6 Instream Habitat at SW 4b-Tomulu Creek, Marowijne River Watershed*

Figure 12-5 depicts excavation of a stream channel within an artisanal gold mine. Figure 12-6 illustrates a stream in the early stages of recovery from typical impacts from artisanal gold mining, including eroding streambanks, artificial berms and other barriers to movement, sedimentation, and elevated turbidity. Impacts such as these are widespread in the Study Area. As a result, aquatic habitat value is generally low.

Mercury (locally known as “quick” or “kwik”) is used by ASM miners to precipitate the gold in an amalgam, and is then burned off at the streamside. Tailings contaminated with mercury are released directly to the stream, and atmospheric deposition from the burnt amalgams exacerbates this effect. Mercury and other metals can be particularly harmful to the aquatic ecosystem because many are highly toxic even in low concentrations, they are readily taken up by organisms at the lowest trophic ranks, and they tend to biomagnify up the trophic ranks. Once released to the environment, metals can become a persistent and significant problem in the aquatic ecosystem.

To assess the current status of metal contamination in the aquatic foodweb, fish tissue samples (muscle) were taken from the aquatic sites illustrated in Figure 12-7 and analyzed for twelve different metals: aluminum, arsenic, cadmium, chromium, copper, lead, magnesium, mercury, molybdenum, selenium, vanadium, and zinc. These metals were selected based on their prevalence in areas historically impacted by unregulated placer gold mining in Suriname, and known potential for their negative effects on aquatic biota. Four sites were located north of the Study Area within the Commewijne River, two sites east of the Study Area within the Marowijne River, and six sites on streams within the Study Area.

The muscle tissue samples were collected by catching fish with a trammel net, and then weighing the fish and muscle tissue sample to the nearest gram. All samples were labeled according to species, time, date and location, then placed into a Ziploc style bag and stored in a freezer until shipment under chain-of-custody to Alpha Analytical Inc. in Mansfield, MA, USA. Preparation / analysis followed EPA Method 3051 / 1,6020A for all metals except Hg and EPA Method 7474 / 1,7474 for mercury.

*Figure 12-7 Sites with Special Status Species*

When evaluating the ecological risk posed by environmental contaminants, it is standard practice to compare sampled concentrations to levels that have been documented to produce observable effects in a known proportion of the population; however, there are no Surinamese baseline screening levels for fish tissue analysis. The Toxicity Reference Values (TRVs) in

Table 12-6 are taken mostly from Hinck et al., 2009, and were developed based on reviews of data from 111 sites in large river basins across North America. They are composite thresholds indicating the level at which toxicity can be expected to occur in fish and wildlife, and are expressed in terms of dietary intake of metals per kilogram of receptor's body weight per day. They are intended to protect both fish and piscivorous wildlife and are expressed in terms of wet weights (Hinck et al., 2009). The specific TRVs cited in this ESIA have been developed for Bald eagle (*Haliaeetus leucocephalus*) and North American mink (*Neovison vison*) and are included in this ESIA as proxies for TRVs for similar piscivorous species that might feed on the fish in or downstream of the Study Area.

In order to calculate the risk to wildlife associated with exposure to fish tissue contaminated with metals, the amount of fish that selected representative piscivorous species would have to eat per day to experience negative effects (referred to hereafter as the minimum observed effect dose) was compared to their predicted daily intake to fish. The minimum observed effect dose was derived by multiplying the TRV by the body weight of the selected representative species to calculate the quantity of metal that would have to ingested daily to cause an effect, and then multiplying that value by the concentration of the metal observed in the fish at the Project Site. The predicted daily intake for giant river otter (*Pteroneura brasiliensis*) was taken from the literature and used to represent generalized intake of fish by mammals. There are no readily available daily intake values in the literature for the piscivorous birds at the Project Site. The daily intake rate for the North American belted kingfisher (*Ceryle alcyon*) was used as a proxy because the belted kingfisher is similar to some of the kingfishers and small herons at the Project Site in terms of life history, body size, and hunting behavior.

Aluminum, cadmium, molybdenum, and vanadium were not detected anywhere in the Study Area (

Table 12-6). Magnesium is the only metal that was detected in fish tissue in the Study Area for which Hinck et al., 2009 does not provide a TRV, but it does not likely represent a major risk to aquatic life because it is actually an important micronutrient and an essential element to the formation of biological structures such as bone and scales. The remaining seven metals were detected in varying concentrations, but according to the body size and intake rates used in this analysis and presented in Table 12-26, most (including arsenic, chromium, copper, lead, and zinc) were detected at levels that do not represent a significant toxicological threat to piscivorous wildlife (Table 12-6). This does not necessarily mean that fish at the site are universally safe as forage, but it does mean that piscivorous wildlife would have to consume large quantities of fish tissue, in many cases several kilograms per day even for small animals over a prolonged period, to experience toxic effects from ingesting the arsenic, chromium, copper, lead, and zinc in the tissues of fish from the Study Area.

There is considerable variability in the concentrations of selenium and mercury in fish tissue at the Project Site. The upper end of the observed range of concentrations for these metals (1.23 mg/kg) is higher than all other metals detected in fish tissue at the Project Site except zinc and magnesium, and selenium and mercury both tend to be toxic at lower concentrations than the other metals detected. The analysis summarized in Table 12-6 is conservative in the sense that it uses the upper range of observed concentrations for metals in fish tissues and the lower end of the body weights for adult piscivorous species. Nevertheless it indicates that at current cocentrations, the mercury and selenium in fish tissue at the Project Site poses potential risks to adult piscivorous mammals and birds. Arsenic may also pose a small risk to birds, although the concentrations observed in fish tissues at the Project Site are very close to the risk threshold as shown in Table 12-6. These risks are likely higher for immature animals due to their smaller body size, and in the case of piscivorous birds, their higher fish consumption rates as a proportion of body weight.

*Table 12-6 Metal concentrations in fish tissue (wet weight concentrations) and associated exposure to piscivorous wildlife in the Study Area*

| Metals | Observed Range in Merian Samples (mg/kg) | Toxicity Levels for Bald eagles (mg/kg/day) | Body weight of adult kingfishers (mg)[1] | Minimum observed effect dose (mg) | Dietary intake of fish per day[1] (mg) |
|---|---|---|---|---|---|
| Arsenic | 0.418 | 2.24 | 130 | 696.65 | 650 |
| Chromium | 0.161-0.373 | 2.66 | 130 | 927.08 | 650 |
| Copper | ND-0.227 | 4.05 | 130 | 2,319.38 | 650 |
| Lead | ND-0.019 | 1.63 | 130 | 11,152.63 | 650 |
| Magnesium | 266-343 | * | 130 | N/A | 650 |
| Mercury | 0.066-1.23 | 0.5 | 130 | 52.85 | 650 |
| Selenium | 0.0784 – 1.23 | 0.4 | 130 | 42.27 | 650 |
| Zinc | 1.71 – 3.98 | 14.49 | 130 | 473.29 | 650 |
| **Metals** | **Observed Range in Merian Samples (mg/kg)** | **Toxicity Levels for North American mink (mg/kg/day)** | **Body weight of adult giant otters (mg)[2]** | **Minimum observed effect dose (mg)** | **Dietary intake of fish per day (mg)[2]** |
| Arsenic | 0.418 | 1.04 | 22,000 | 54,736.80 | 3,000 |
| Chromium | 0.161-0.373 | 2.40 | 22,000 | 141,554.90 | 3,000 |
| Copper | ND-0.227 | 5.60 | 22,000 | 542,731.30 | 3,000 |
| Lead | ND-0.019 | 4.7 | 22,000 | 5,442,105.30 | 3,000 |
| Magnesium | 266-343 | * | 22,000 | N/A | 3,000 |
| Mercury | 0.066-1.23 | 0.05 | 22,000 | 894.30 | 3,000 |
| Selenium | 0.0784 – 1.23 | 0.154 | 22,000 | 2,754.50 | 3,000 |
| Zinc | 1.71 – 3.98 | 123 | 22,000 | 679,899.49 | 3,000 |

Note: Aluminum, Cadmium, Molybdenum, and Vanadium were not detected at the reporting limit (RL) for the sample.

[1] USEPA, undated.

[2] Carter and Rosas, 1997.

### *12.2.4 Special Status Species*

Special status species are species that are either endemic to a specific area, new to science, or species that are recognized by the scientific community as being in need of conservation. In accordance with international best practice, this ESIA considers species listed by the IUCN as Vulnerable, Endangered, or Critically Endangered as being in need of conservation. Table 12-7 lists the species currently known from the Study Area that meet the IUCN listing criteria described above or are either endemic to Suriname (or in the case of aquatic species, endemic to the Marowijne River), or are new to science. Figure 12-7 and Figure 12-8 depict the distributions of sites where special status species were located within the Study Area. The special status species that are known to occur in the Study Area based on interviews or other non-site specific data are also listed at the bottom of Figure 12-7.

*Table 12-7 Special Status Species*

| Scientific Name | IUCN Status* | Endemicity | New to Science | Habitat** | Comment |
|---|---|---|---|---|---|
| Fish | | | | | |
| *Ancistrus sp.* (reticulate) | NL | Possibly endemic to Saramacca, Suriname and Commewijne Rivers | Yes | Commewijne River | Presence verified |
| *Cetopsis sp.* | NL | Possibly endemic to Commewijne River | Yes | Commewijne River | Presence verified |
| *Corydoras oxyrhynchus* | NL | Endemic to Saramacca, Suriname and Commewijne Rivers | No | Commewijne River | Presence verified |
| *Corydoras punctatus* | NL | Endemic to Suriname and Commewijne Rivers | No | Commewijne River | Presence verified |
| *Cynodon meionactis* | NL | Endemic Marowijne River | No | Marowijne River | Presence verified |
| *Geophagus harreri* | NL | Endemic to Marowijne River | No | Marowijne River | Presence verified |
| *Lithoxus surinamensis* | NL | Endemic to Suriname | No | Commewijne River | Presence verified |
| *Loricariichthys maculatus* | NL | Possibly Endemic to Suriname | No | Commewijne River | Presence verified |
| *Panaque cf dentex* | NL | Possibly Endemic to Marowijne and Commewijne Rivers | Yes | Marowijne River; Commewijne River | Presence verified |

| Scientific Name | IUCN Status* | Endemicity | New to Science | Habitat** | Comment |
|---|---|---|---|---|---|
| *Peckoltia sp.* | NL | Possibly Endemic to Marowijne and Commewijne Rivers | Yes | Marowijne River; Commewijne River | Presence verified |
| *Platydoras sp.* | NL | Possibly endemic to Marowijne River | Yes | Marowijne River | Presence verified |
| *Potamotrygon marinae* | DD | Endemic to Marowijne River | No | Marowijne River | Presence verified |
| *Pseudancistrus barbatus* | NL | Endemic to Marowijne River | No | Marowijne River | Presence verified |
| *Semaprochilodus varii* | NL | Endemic to Marowijne River | No | Marowijne River | Presence verified |
| Plants | | | | | |
| *Oenocarpus sp. aff. O. bacaba Mart.* | NL | Endemic to northeast Suriname | Yes | High Dryland Forest, Disturbed / Secondary Vegetation Area | Possibly a subspecies of *Oenocarpus bacaba*, Presence verified |
| *Virola surinamensis* (Rolander) Warb. | EN | Native to Suriname | No | Disturbed / Secondary Vegetation Area | Presence verified |
| *Vouacapoua americana* | CR | Native to Suriname | No | High Dryland Forest, Disturbed / Secondary Vegetation Area | Presence verified |
| Mammals | | | | | |
| *Ateles paniscus* | VU | Endemic to Guiana Shield | No | High Dryland Forest, Creek Forest | Presence inferred from interviews |
| *Leopardus tigrinus* | VU | Native to Suriname | No | Muliple, generally forested | Presence inferred from interviews |

| Scientific Name | IUCN Status* | Endemicity | New to Science | Habitat** | Comment |
|---|---|---|---|---|---|
| *Leopardus wiedii* | NT | Native to Suriname | No | Multiple, generally forested | Presence inferred from interviews |
| *Myrmecophaga tridactyla* | VU | Native to Suriname | No | Multiple, generally forested | Presence inferred from interviews |
| *Panthera onca* | NT | Native to Suriname | No | High Dryland Forest | Presence verified |
| *Priodontes maximus* | VU | Native to Suriname | No | Primary rainforest; Creek Forest | Presence inferred from interviews |
| *Pteronura brasiliensis* | EN | Endemic to Guiana Shield | No | Creek Forest | Presence inferred from interviews |
| *Tapirus terrestris* | VU | Native to Suriname | No | Creek Forest and Wetlands | Presence inferred from interviews |
| *Tayassu pecari* | NT | Native to Suriname | No | Multiple, generally forested | Presence inferred from interviews |
| Birds | | | | | |
| *Amazona dufresniana* | NT | Endemic to Guiana Shield | No | High Dryland Forest | Presence verified |
| Herpetiles | | | | | |
| *Anomaloglossus surinamensis* | NL | Endemic to eastern Suriname | No | Secondary Vegetation, High Dryland Forest | Presence verified |
| *Atelopus hoogmoedi nassaui* | VU | Endemic to eastern Suriname | No | Creek Forest | Presence verified, listed as A. spumarius in IUCN Red list |

*The IUCN Red List of Threatened Species Status:

The IUCN Red List of Threatened Species is widely recognized as the most comprehensive, objective global approach for evaluating the conservation status of plant and animal species.

CRITICALLY ENDANGERED (CR) - A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future.

ENDANGERED (EN) - A taxon is Endangered when it is not Critically Endangered but is facing a very high risk of extinction in the wild in the near future.

| Scientific Name | IUCN Status* | Endemicity | New to Science | Habitat** | Comment |
|---|---|---|---|---|---|

VULNERABLE (VU) - A taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future.

DATA DEFICIENT (DD) A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and / or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and / or distribution is lacking. Data Deficient is therefore not a category of threat or Lower Risk. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate.

NOT LISTED (NL) Not listed by the IUCN.

*Figure 12-8 Downstream Sites with Special Status Species in the Commewijne River Watershed*

Most of the special status species currently known within the Study Area are fish. Most of the fish are included due to endemicity within the Marowijne and/or Commewijne River watersheds. Very few if any fishes (with the possible exception of *Cetopsis sp.*) are restricted to the Study Area. The fish are relatively evenly distributed between the Commewijne River and Marowijne River watersheds, but the Commewijne River species would likely be more susceptible to impacts from the Project because the Commewijne River is much smaller than the Marowijne River (and therefore would not dilute effluent from the Project Area as rapidly as the Marowijne River). Furthermore, all of the special fishes captured during the field surveys for this ESIA in the Marowijne River watershed except *Potamotrygon marinae* were captured upstream of the Study Area as well as downstream of potential Project impacts. Their presence up and downstream indicates that many of these species are widespread in the Marowijne and portions of their populations within the river would not be exposed to impacts from the Project. Conversely, all the special status species known from the Commewijne River water watershed are downstream of the Study Area and would therefore be susceptible to impacts from the Study Area without mitigation actions. Some species such as *Panaque cf dentex*, *Peckoltia sp.*, and *Corydoras punctatus* were not documented during this study but have been documented from the Marowijne and/or Commewijne Rivers from other unpublished studies.

The only special status fishes currently known to occur within the Study Area boundary are *L. surinamensis* and *Cetopsis sp.* Neither of these species have been found to date within the proposed footprint of mine infrastructure, but they are both known to occur in close proximity to areas that would be directly impacted by the Project. *L. surinamensis* in particular has the potential to occur elsewhere within the Study Area in headwater streams in the Commewijne catchment due to its affinity for small streams. *Cetopsis sp.* is new to science and little is known about its habitat requiremnets, so it is impossible to speculate whether it is likely to occur elsewhere in the Study Area. The other special status fishes are located downstream of the Study Area and would not be expected to move upstream into headwater streams within the Study Area due to a general tendency among these species to occur in larger waterbodies, although it is possible that some of the species from the Marowijne River ascend a short distance into the lower reaches of Merian Creek, particularly during the wet season.

Based on the data available to date, the three special status plant species are the most widespread special status species in the Project Area and the most threatened: two of the three species are listed as endangered or critically endangered. The three species are somewhat different in terms of habit. *Oenocarpus sp. aff. O. bacaba* Mart [IUCN-NL] is a medium sized palm tree that occupies the understory in a variety of forest types in the Study Area. *Virola surinamensis* (Rolander) Warb [IUCN-EN] is a medium sized broadleaf evergreen that is known to have medicinal value to some Native Amerindian, although it is not known whether it isused for medicinal purposes in Suriname. *Vouacapoua americana* [IUCN-CE] is the largest of the special status plant species and is known primarily as a timber species. It is the only species in the entire Study Area to be ranked as Critically Endangered by the IUCN, mainly on the basis of habitat loss elsewhere in its range. IUCN lists Suriname as the only country where it is still relatively common (IUCN, 2012).

Several special-status mammal species occur in the Study Area. Most are large, conspicuous species that travel readily across large areas, e.g.; the Guiana spider monkey (*Ateles paniscus*) [IUCN-VU], oncilla (*Leopardus tigrinus*) [IUCN-VU], jaguar (*Panthera onca*) [IUCN-VU], and margay (*Leopardus wiedii*) [IUCN-VU]. These species should be considered to occur at low densities across most if not all of the Study Area. The only mammal species considered to be Endangered is the giant otter (*Pteronura brasiliensis*). It is listed as endangered due to an inferred future population decline attributed to habitat loss and exploitation. IUCN also cites bioaccumulated mercury in fish as a potential threat to this species, particularly in areas where ASM occurs due to the use of mercury amalgamation.

The only special status bird species is the blue cheeked Amazon parrot (*Amazona dufresniana*) [IUCN-NT]. It is listed by the IUCN mainly due to habitat loss and hunting/trapping for the pet trade. It is wide ranging across the Guiana shield and is characteristic of humid forest, but has also been found in savanna habitats in Venezuela (IUCN, 2012).

There are two special-status herpetile species known to occur in the Study Area as well. *Anomaloglossus surinamensis* [IUCN-NL] is a small frog often found in low hanging vegetation or on the ground. It is only known from one site within the Study Area, near the northern boundary of the Study Area. *Atelopus hoogmoedi nassaui* [IUCN-VU] is a range-restricted subspecies of harlequin toad that is almost exclusively terrestrial and only found on Nassau plateau and the surrounding lowland areas. Both species would be susceptible to changes in surface water quality in their ranges within the Study Area and/or changes in insect populations.

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# 13.0 *PROTECTED AREAS BASELINE*

## 13.1 *INTRODUCTION*

This chapter describes protected areas, as well as the characteristics of biodiversity in the Guiana Shield, and their relationship to the Merian Gold Project. Although the Project does not directly affect protected areas in Suriname, it is important to note that most of Suriname, including the Project, falls within the Guiana Shield which is recognized as an internationally important region of conservation concern. This chapter is useful for understanding the on-going conservation programs in Suriname and potential opportunities for the Project to offset any potential impacts to natural or critical habitats[27], and ensure a net positive impact on the ecology of the Study Area.

## 13.2 *INTERNATIONAL GUIDANCE ON PROTECTED AREAS*

The IUCN, a leading organization on natural resource conservation, has developed protected areas management categories which distinguish different protected areas according to their distinct management objectives. The seven major categories are considered the "global standard for defining and recording protected areas," and are used by the United Nations and many national governments to define protected areas (IUCN, 2012). A summarized definition of each category follows.

- Category Ia, Strict Nature Reserve. Protected areas falling under Category Ia are the most protected, given the presence of exceptional native ecosystems, biodiversity, or geodiversity that could be adversely, and possibly irreversibly, impacted by even mild human interactions.
- Category Ib, Wilderness Area. Wilderness areas are often larger than Category Ia protected areas, are not significantly inhabited by humans, and are characterized by a high percentage of original ecosystems and biodiversity. These areas are protected to preserve their natural conditions, and are free of modern infrastructure. Areas have very controlled levels of access to visitors, but indigenous communities are allowed to maintain their traditional ways of life here.
- Category II, National Park. National parks are large natural areas which conserve "large-scale ecological processes" and populations of native species, especially those with wide-ranging migration routes, while allowing for scientific, educational, spiritual, and recreational uses of the environment.
- Category III, Natural Monument or Feature. Category III protected areas conserve exceptional natural or culturally-influenced natural features,

[27] As defined by the industry best practice.

along with associated biodiversity and spiritual values. Natural Monuments or Features are often small in area, as they tend to protect unusual features or biodiversity, and are heavily visited by tourists.

- Category IV, Habitat / Species Management Area. Category IV protected areas are focused on conserving a particular species or habitat and require active management to properly maintain these species or habitats. These areas have already undergone substantial modification and require additional measures to maintain remaining natural habitat or species.
- Category V, Protected Landscape / Seascape. Category V protected areas are areas with "significant ecological, biological, cultural and scenic" value for people that have been created through the human and natural interface. These protected areas aim to maintain a balance between human and natural systems, between biological conservation and cultural values and socioeconomic activities in the area.
- Category VI, Protected Area with Sustainable Use of Natural Resources. These protected areas are generally large areas that conserve ecosystems, habitats, and biodiversity, while simultaneously allowing for low-level, non-industrial, sustainable use of natural resources in the area. The sustainable use of natural resources in Category VI protected areas serves as a means to achieving nature conservation.

## 13.3 *PROTECTED AREAS IN SURINAME*

### *13.3.1 Internationally Recognized Protected Areas in Suriname*

Suriname's Nature Protection Commission was established in 1948 to study conservation problems and propose conservation legislation. The Commission proposed the Game Act (Government Bulletin 1954 No. 25) and the Nature Preservation Law (Government Bulletin 1954, No. 26), which allows for the establishment of nature reserves; both laws are enforced by the Forest Service (Baal, 2005). The Forest Service is responsible for overall management of protected areas, while the Nature Conservation Division within the Forest Service is responsible for daily management activities (STINASU, 2008). The Foundation for Nature Conservation in Suriname (STINASU) has been appointed by the Forest Service to manage educational and tourism aspects of the protected areas (STINASU, 2008).

Article 2 of the Nature Preservation Law states that an area must meet the following requirements to be considered a nature reserve in Suriname:

- it deserves protection by the Government because of its varied nature and scenic beauty; and / or because of the presence of - from a scientifically or culturally significant point of view – important flora, fauna, or geological objects (Baal, 2005).

Suriname contains 11 nature reserves, one nature park, and four multiple-use management areas, covering approximately 13% of the total land area of the country (Chapter 13).  These are listed below and are shown in Figure 13-1.

Galibi Nature Reserve.  The Galibi Nature Reserve is an IUCN Category IV Reserve which was established in 1969 (Baal, 2005).  The reserve is located along the north-east coast in the Marowijne district covering approximately 4,000 hectares (ha) (STINASU, 2008).

Wia Wia Nature Reserve.  The Wia Wia Reserve is an IUCN Category IV Reserve which was established in 1966 (Baal, 2005).  It is also located in the Marowijne district, just west from Galibi and covers an area of 36,000 ha (STINASU, 2008).

Copenamemonding Nature Reserve.  The Copenamemonding Reserve and Western Hemisphere Shorebird Reserve is an IUCN Cateogry IV Reserve established in 1966 (Baal, 2005).  The Reserve was also designated as a Wetland of International Importance (Ramsar site No. 304) in accordance with the Ramsar Convention on Wetlands (Ramsar, 2000).  The 12,000 ha reserve is located in the Saramacca district along the coast, near the Coppename River (STINASU, 2008).

Peruvia Nature Reserve.  This IUCN Category IV Reserve was established in 1986 (Baal, 2005).  The 31,000 ha reserve is located in the Coronie district, near the coast and along the freshwater part of the Coppename River (STINASU, 2008).

Hertenrits Nature Reserve.  This is an IUCN Category III reserve that was established in 1972 (Baal, 2005).  The smallest reserve in Suriname covering only 100 ha, the reserve is located in the Nickerie district (STINASU, 2008).

*Figure 13-1 Protected Areas in Suriname*

Wanekreek Nature Reserve. The Wanekreek Reserve is an IUCN Category IV Reserve established in 1986 (Baal, 2005). The reserve is located in the Marowijne district near Wanekreek and covers an area of 45,000 ha (STINASU, 2008).

Copi Nature Reserve. This IUCN Category IV Reserve was established in 1986 (Baal, 2005). The reserve is located in the Para district near the Casawinicakreek and covers an area of 28,000 ha (STINASU, 2008).

Boven-Cosewijne Nature Reserve. This IUCN Category IV Reserve was established in 1986. The reserve is located along the Cosewijne River and covers 27,000 ha (STINASU, 2008).

Brinckheuvel Nature Reserve. The Brinckheuvel Reserve is an IUCN Category IV Reserve, which was established in 1966 (Baal, 2005). The reserve is located in the Brokopondo district between the Suriname and the Saramacca Rivers and covers and area of 6,000 ha (STINASU, 2008).

Central Suriname Nature Reserve. The Central Suriname Nature Reserve was listed as a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Site in December 2000 (Baal, 2005). The reserve is an IUCN Category Ib Reserve which was established in 1998 with the integration of the pre-existing Raleighvallen, Tafelberg, and Eilerts de Haan Nature Reserves, covering an area of 1.6 million (ha) (Baal, 2005).

Sipaliwini Nature Reserve. This IUCN Category IV Reserve was established in 1972. The reserve is located in the Sipaliwini district, in the south of Suriname along the border with Brazil, encompassing 100,000 ha (Baal, 2005; STINASU, 2008).

Brownsberg Nature Park. The Brownsberg Nature Park is an IUCN Category II Reserve that was established in 1970 and later expanded in 2002 for a total area of 12,200 ha (Baal, 2005). The park is located in the Brokopondo district, 130 km south of Paramaribo (STINASU, 2008).

Multiple-Use Management Areas. Suriname has four multiple-use management areas including the Bigi Pan, North Coronie, North Saramacca, and North Commewijne-Marowijne. All of these are estuarine zones that are protected due to their important aquatic fauna diversity (STINASU, 2008).

## 13.4 *PROTECTED AREAS NEAR THE MERIAN GOLD PROJECT*

The closest protected area to the Merian Gold Project is the Copi Reserve, which is located approximately 33 km northwest of the Merian Gold Project along the Casawincakreek and approximately 20 km south of the East-West Highway. The Wia Wia Nature Reserve is located north of the Project along the Atlantic Ocean coastline. The Wia Wia Nature Reserve is located approximately 73 km from the Project.

Both the Wanakreek Nature Reserve and the Galibi Nature Reserves are located to the northeast of the Project along the Maroni River. The Wanakreek Nature Reserve is 50 km northeast of the Project, while the Galibi Nature Reserve is 80.5 km northeast of the Project.

## 13.5 *OTHER IMPORTANT BIODIVERSITY AREAS*

The Guiana Shield is a unique bio-geographic region that covers 250 million ha of land extending from Colombia in the west to the State of Amapá in Brazil in the east, and including nearly all of Suriname, Guyana, French Guiana, and the Venezuelan states of Delta Amacuro, Amazonas and Bolívar (Guiana Shield Initiative, 2012). It is a 2 billion year-old geological formation that includes large mountain plateaus and rainforests. The Shield is characterized by distinctive table-top mountains or plateaus called tepuis. Tepuis are sandstone sediments which overlay crystalline rocks that have eroded over a billion years (Funk et al., 2007).

According to the Guiana Shield Initiative, the region contains between 10 and 15% of all of the world's freshwater resources. The region is also said to sequester large quantities of carbon dioxide and is, therefore, important in controlling climate change (Guiana Shield Initiative, 2012). The varied topography of the Shield supports the "largest complex of uninterrupted and intact primary tropical forest on earth" (Guiana Shield Initiative, 2012). The Shield is characterized by exceptionally high biodiversity, including approximately 20,000 species of vascular plants, 1,000 species of birds, and 1,100 species of freshwater fish, with approximately 40% endemism for both flora and fauna (Conservation International, 2012; Smithsonian Institution, 2012). The region supports several types of ecosystems, some of which are unique to the region, including tepuis, white sand vegetation, savannas, coastal swamp forests, riparian flooded forests, and tropical rain forests (Guiana Shield Initiative, 2012). Tepuis are isolated geological formations that are characterized by cooler temperatures and higher rainfall on top, while their bases support tropical forests and humid climates. Species endemic to tepuis habitat can occur at elevations as low as 300 masl, with greater diversity associated with increases in elevation (Funk et al., 2007).

Even though there is a high level of cultural diversity in the region, with several indigenous groups inhabiting the Guiana Shield, the region has benefited from isolation and inaccessibility; studies have found that approximately 70% of the vegetation in the Shield is still undisturbed by humans (Funk et al., 2007). Threats to the region are increasing, however, as logging, mining, agricultural expansion, and other infrastructure projects are beginning to increase in the region (Guiana Shield Initiative, 2012). As noted in other chapters of this document, the immediate area around the Merian Gold Project has experienced extensive impacts due primarily to small-scale and artisanal mining. Conservation of the Guiana Shield within Suriname has mainly occurred on a national level through the creation of national protected areas.

There is currently no official regional framework in place for transboundary conservation; however, several international organizations have come together to promote conservation solutions for the region. One of the major programs in place includes the Guiana Shield Initiative which is coordinated by the United Nations Development Programme (UNDP) in Guyana and the IUCN National Committee of the Netherlands (NL). Donor organizations for the Initiative include the European Union, the Dutch Embassy in Bogotá, the UNDP, and the IUCN NL. Partner organizations include Conservation International and the World Wildlife Fund as well as the Institute for Environmental Security (Guiana Shield Initiative, 2012). The Initiative was started in 1993 with the objective of developing a program for payment mechanisms as a way to support local owners and users of the region and counter threats to conservation (Guiana Shield Initiative, 2012).

Other programs include the Biological Diversity of the Guiana Shield Program sponsored by the Department of Botany of the National Museum of Natural History of the Smithsonian Institution. Since 1983, the Program has brought together over 300 scientists from around the world to research and share information on the Shield in order to promote conservation of biological diversity of the region (Smithsonian Institution, 2012).

The Merian Gold Project is located within the Guiana Shield as shown in Figure 13-2.

*Figure 13-2 The Guiana Shield (Smithsonian Institution, 2012).*

## 13.6 *CONCLUSION*

The Merian Gold Project does not directly impact protected areas, and there are not protected areas in the nearby vicinity of the Project. The closest protected areas located in the region of the Project are the Copi and Wanakreek Nature Reserves, both of which are several kilometers away. The Project falls within the Guiana Shield,which is in general a high biodiversity area of international conservation concern. Biodiversity in the immediate area of the project has been reduced due to the disturbance from ASM activiites, including the secondary changes associated with bush meat hunting by the ASM miners. As discussed in later sections, the project has the potential for improving local biodiversity conditions by 1) restoring the hydrology of some of the damaged drainages, 2) improving ASM practices in conjunction with the governmen, 3) completing reclaimation of the mine disturbance, and 4) improving environmental practices in the area through education and engagement with the other users of the forest.

IUCN 2012
http://www.iucn.org/about/work/programmes/gpap_home/gpap_quality/gpap_pacategories/ accessed 10 April 2012

Baal 2005 http://www.unesco-suriname.org/natural%20heritage%20in%20suriname.htm accessed 12 April 2012

STINASU 2008 http://www.stinasu.com/protected_areas.html accessed 10 May 2012

Conservation International 2012
https://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=8&cad=rja&ved=0CE4QFjAH&url=https%3A%2F%2Flibrary.conservation.org%2FPublished%2520Documents%2FRAP%252063%2520Kwamala%2520Suriname_full%2520report_lores.pdf&ei=cDt0UPbHHMGq0QWjvoGYBw&usg=AFQjCNG2Mj-kwiPvUxyxL1e6qQvKBaU44Q accessed 23 March 2012

Smithsonian 2012
https://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=8&cad=rja&ved=0CE4QFjAH&url=https%3A%2F%2Flibrary.conservation.org%2FPublished%2520Documents%2FRAP%252063%2520Kwamala%2520Suriname_full%2520report_lores.pdf&ei=cDt0UPbHHMGq0QWjvoGYBw&usg=AFQjCNG2Mj-kwiPvUxyxL1e6qQvKBaU44Q accessed 15 May 2012

Funk, R., H.I. Reuter, C. Hoffmann and W. Engel 2007: Effect of moisture on fine dust emission of soils and its relevance for the derivation of emission factors. Earth Surface Processes and Landforms, submitted.

# 14.0 *SOCIAL BASELINE*

## 14.1 *INTRODUCTION*

This chapter provides an overview of the existing characteristics of the defined Social Study Area (SSA) of the Merian Gold Project. This includes a summary of the demographic, socio-economic, health and socio-cultural conditions, archaeological and living heritage resources, the existing infrastructure and services, and stakeholder perceptions and expectations.

The social baseline seeks:

- To provide a benchmark of pre-Project conditions from which changes and impacts can be predicted;
- To provide an understanding of known and unknown archaeological sites sites that could be impacted by project ativities;
- To identify the presence and specific sensitivities around traditional or living heritage sites that are of value to the communities in the SSA;
- To provide comparative data, so that Project affected areas can be compared to national and regional averages and, where appropriate, each other to better understand the local context, potential vulnerabilities and stakeholder perceptions;
- To provide comparative data, so that Project affected areas can be compared to national and regional averages and, where appropriate, each other to better understand the local context, potential vulnerabilities and stakeholder perceptions;
- To understand the existing environmental and socio-economic context to help inform impact predictions (positive and negative), and assessments of the ability of receptors and stakeholders to benefit from, adapt to and accept change;
- To understand the existing development context and the extent to which the Project supports and is aligned with local development and environmental protection objectives, and any potential alignment opportunities in future;
- To identify individual stakeholders and stakeholder organizations that may have roles and responsibilities with regard to Project implementation (e.g., local administrators and politicians) as well as stakeholders who are sensitive to the Project or able to support in the implementation of information disclosure and mitigation measures;
- To inform the Project on how best to disseminate information and collect feedback from stakeholders, including vulnerable groups of interests;

- To provide a context for understanding feedback from stakeholders, specifically verifying what is reported by stakeholders and beginning to understand the differences between stakeholders' perceptions of impacts and actual impacts;
- To feed into the design and tailoring of mitigation measures; and
- To provide a basis for monitoring from which to evaluate actual impacts and the success of mitigation measures following implementation.

### 14.1.1 Socio-Economic Indicators

Table 14-1 summarizes some of the key socio-economic indicators for Suriname.

*Table 14-1 Suriname - Key Socio-Economic Indicators*

| Socio-Economic Indicator | National Level | Source |
|---|---|---|
| Population | 524,624 | World Bank Development Indicators Database, 2010 |
| Life Expectancy at birth (years) | 70 | World Bank Development Indicators Database, 2009 |
| HDI index Value* | 0.674 | United Nations Development Program (UNDP) Human Development Index (HDI), 2010 |
| Gender Inequality Index** | 0.68 | UNDP HDI, 2011 |
| Gross Domestic Profit (GDP) per capita (current US$) per annum*** | 6,255 | World Bank Development Indicators Database, 2009 |
| School enrolment, primary (% net) | 90 | World Bank Development Indicators Database, 2008 |

| Socio-Economic Indicator | National Level | Source |
|---|---|---|
| Adult Literacy Rate**** | 95 | World Bank Development Indicators Database, 2008 |
| Proportion of Total population served with improved water source (% of population with access) | 93 | World Bank Development Indicators Database, 2008 |
| Inequality Adjusted HDI | 0.518 | Human Development Report 2011 |

* The Human Development Index (HDI) is a summary measure of human development. It measures the average achievements in a country in three basic dimensions of human development: a long and healthy life, access to knowledge, and a decent standard of living. The HDI is the geometric mean of normalized indices measuring achievements in each dimension. 1 shows high human development whilst 0 shows low human development.

** The Gender Inequality Index (GII) reflects women's disadvantage in three dimensions—reproductive health, empowerment, and the labor market—for as any countries as data of reasonable quality allow. The index shows the loss in human development due to inequality between female and male achievements in these dimensions. It ranges from 0, which indicates that women and men fare equally, to 1, which indicates that women fare as poorly as possible in all measured dimensions

***GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars. Dollar figures for GDP are converted from domestic currencies using single year official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used.

**** Adult Literacy Rate is the percentage of people aged 15 and above who can, with understanding, read and write a short simple statement on their everyday life.

With a small population, but high literacy, school enrolment, access to improved water and life expectancy, Suriname displays the characteristics of a society with comparatively high levels of inequality. This analysis is based on the Human Development Index (HDI) Value, which gives Suriname a ranking comparable to nations such as China, Turkey, or Thailand. This HDI score is below the regional Latin American and Caribbean average of 0.731 and may indicate that, despite some percentage of the population benefitting from development efforts, a portion of the country experiences low income and access to services.

It should be noted that the 2010 Human Development Report (HDR) introduced the 'inequality adjusted HDI (IHDI), which takes into account inequality by discounting each dimension's average value according to its level of inequality. The HDI can be viewed as an index of 'potential' human development and IHDI as an index of actual human development. The 'loss' in potential human development due to inequality is given by the difference between the HDI and the IHDI, and can be expressed as a percentagei.

Suriname's HDI for 2011 is 0.674; however, when the value is discounted for inequality, the HDI falls to 0.518, a loss of 23.8%. The average loss due to inequality for medium HDI countries is 23.7 percent and for Latin America and the Caribbean it is 26.1 percent. This indicates that although some portions of society in Suriname have benefitted from development efforts disparity within the country is comparatively high.

### *14.1.2 Historical Overview of Suriname*

Geographically, Suriname lies between two very large river drainages, the Orinoco to the northwest and the Amazon to the southeast. Suriname and the Guyanas generally have been overshadowed prehistorically by cultural and political developments in these two adjacent areas. Recent archaeological study of Suriname has considered that country's archaeology as part of the Guyanas, essentially the coastal and inland zone between the mouths of the Orinoco and the Amazon. Human occupation of Suriname dates back at least five thousand years, and probably much earlier. Ethno-historical data indicate that in the late pre-colonial period *Arawak*-speaking peoples were living on the coast while the *Caribe*-speaking people were living in the inland areas. During the colonial period Suriname was also populated by runaway or escaped African slaves who established independent communities referred to as *Maroon* communities. There are Maroon communities, most notably the Pamaka, who live within the vicinity of the Merian Site.

Suriname was colonized in 1650 by Lord Francis Willoughby, who owned several plantations in Barbados. The first plantation owners were British, and they were soon joined by Portuguese-Jews who left Brazil (1650 and 1664). The focus of the plantation activities were on the Upper Suriname River, but also on higher grounds, including along the Para Rivers. A map of 1667 shows the Para River already populated by numerous plantations. Sugar has always been the mainstay of the Suriname colonial economy, followed by coffee, cacao, cotton, tobacco and timber. The upriver plantations were usually reserved for timber harvesting and they supplied the plantations as well as the rest of the country with the required timber resources.

In 1667 Admiral Abraham Crijssen sailed to Suriname taking the area from the British and making Suriname a Dutch colony. The focus of plantation development then shifted to the lowlands along the Commewijne River, as dikes and sluices, a technology familiar to the Dutch, were used to manage irrigation in that area. During the fourth quarter of the 18th century the plantation development peaked at 500 estates and then decline set in, only to accelerate during the 19th century. On the eve of the abolition of slavery in 1863, only 200 plantations were still in operation. By 1900 this number dropped to 82. In 1950 there were 24 plantations left and during the 1970s the last plantation shut down.

Suriname gained independence from the Netherlands in 1975. Its history as a Dutch plantation colony is reflected in today's population, the majority of which is made up of descendants from African slaves (Maroons and Creoles) and Indonesian or Indian migrants. There are eight major ethnic groups in total. Each group has preserved its own culture and there is little inter-ethnic integration beyond the economic sphere, with many institutions, including political parties, tending to follow ethnic lines. It should be noted that the ethnic divisions do not generally manifest themselves in everyday life and the majority of nationals seem happy to live and interact.

The majority of the population lives along the coastal region in and around the capital Paramaribo, with only Maroon and Amerindian groups typically living in the tropical rainforest (the interior), which makes up more than 80%of the total land area of Suriname.

During the colonial period, the Surinamese economy relied mainly on agricultural crops: sugar, coffee, and cocoa and later bananas, rice and citrus fruits. Exploitation of bauxite reserves and production of alumina began following World War I and until recently dominated the Surinamese economy. Other major sources of income come from the oil and gold sectors, agriculture, tourism, and remittances from abroad.

There were several challenges to domestic affairs in the years following independence, including two military coups and a civil war, which led to severe economic stagnation. Since 2000, the economy has stabilised and industrial growth has resumed. According to the 2011 UN Human Development report, Suriname's Gross National Income (GNI)[28] per capita increased by about 41% between 1980 and 2011.

*Maroons in Suriname*

Maroons in Suriname are descendants of escaped African slaves who fled from the plantations in the 18th and 19th centuries and succeeded in establishing

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28 GNI consists of the personal consumption expenditures, the gross private investment, the government consumption expenditures, the net income from assets abroad (net income receipts), and the gross exports of goods and services, after deducting two components: the gross imports of goods and services, and the indirect business taxes.

viable communities in the interior of the country. Traditionally, Maroon groups in Suriname live in ‘kin’ or family ordered societies in which the matrilineal descent is the dominant principle of social organization. Typically, Maroon societies are organized into extended families, which together form lineages, which in turn, are grouped into clans at a higher level. Together the clans form one of the six Maroon societies including the Pamaka (most relevant to this Project), the Saramaka, the Ndjuka (also referred to as the Aucaan), the Kwinti, the Aluku, and the Matawai. The Pamaka territory was established in approximately 1830 by escaped slaves from the Commewijne and Tempati area who settled near the Marowijne River. The first Pamaka settlement was in Nason and still exists today. As escaped slaves, the Pamaka community had an outlaw status, but its people have been at peace with the government and missionaries since the 1800s.

### *14.1.3 Project Social Study Area*

As indicated within the Project Description, the Project will involve a series of infrastructure developments and activities including a Mine Site and associated infrastructure and facilities, and a Transportation Corridor from Paramaribo to the Project, including improved port facilities.
Figure 14-1 shows the geographic distribution of the Project and associated Transportation Corridor in relation to the capital Paramaribo and the nearest sizeable town, Moengo.

Due to its size and remote location, the Project does not involve the types of direct socio-economic effects characteristic of large mining projects. Artisanal and small-scale mining (ASM) is a key livelihood activity around the Mine Site and the illegal artisanal and small scale miners (ASM miners), typically move frequently and establish small exploitation camps wherever they go.

The only settlements within the areas defined by the Right of Exploitation are transient small-scale mining camps. In 2010, the GoS, at the request of Surgold, enforced a previously negotiated Industrial Zone (IZ) within which no ASM activities are allowed so that Surgold could continue its exploration activities safely and securely. This area includes the Gowtu Bergi pit located where the Merian II deposit has been identified. In addition there are several fluid settlement functioning as ASM camps in proximity to the Project facilities.

The social baseline study area was developed looking at the areas where possible interactions and impacts of the Project on settlements were likely to occur. For example, the employment opportunities from the Project may attract influx into the town of Moengo thereby qualifying as one of the impacts of the Project.

Because of the geographic distances between Project infrastructure and other associated activities, the SSA extends from Paramaribo to the Pamaka villages along the Marowijne River based on the prediction of impacts during the scoping phase of the ESIA.

Figure 14-2 shows the extent of the SSA including the proposed project location and relevant settlements. Due to the extent of the SSA, the social baseline has been divided into the following distinct geographic study areas as shown in Figure 14-2.

- **Marowijne Area**: includes the area surrounding the Mine Site and the villages along the Marowijne River (the nearest permanent human settlements). This area is included based on proximity to the Project Area and the prediction that human populations in this area risk being directly affected by socio-economic or health related project impacts;
- **Moengo Area:** Includes the town of Moengo where project related migration influx is a risk and could lead to indirect socio-economic or health impacts in the area;
- **Tempati and Commewijne Area:** includes the river corridor downstream of the TSF including the populated areas along the Commewijne River. This area is included based on the risk of releases of tailings downstream; and
- **Transportation Corridor:** includes the linear area along the East-West Highway between Paramaribo and Moengo and the Langa Tabiki Road that runs from Moengo to the area on the bank of the river opposite Langa Tabiki. This includes the small communities south of Moengo including the villages of Mora Kondre and Pelgrim Kondre along the Moengo - Langa Tabiki road. This area is included based on the risk of traffic related disturbances and health and safety risks caused by project vehicles.

It should be noted that the archaeological component of the social baseline is based on relativley limited knowledge of Suriname’s pre-colonial past. Further, there is no broadly recognized historical connection between Surname’s contemporary communities and its archaeological past. Archaeology is therefore addressed on a broader geographic scale, rather than in a community-focused manner. The distribution of known terrestrial archaeological sites is considered for the area of northwestern Suriname surrounding and including the Project Site. This broader geographic view, which includes a review of the national-level archeological site inventory, is used to address impacts to known and unknown sites witin the Project site.

*Figure 14-1 Social Study Area Overview*

*Figure 14-2 Social Study Area*

### 14.1.4 *Structure of the baseline chapter*

The social baseline has been structured to include baseline conditions across the distinct geographic division in the SSA. Where relevant, the social baseline characterizes conditions separately for each of these distinct areas.

The baseline will not describe all aspects of social conditions for each of the geographically distinct areas within the SSA. Instead it will attempt to focus on those aspects of the socio-economic environment relevant to the impact scoping, impact assessment, mitigation and management process, or the stakeholder engagement process.

For example, the baseline for each of the distinct areas of the SSA may not discuss education, and will summarize conditions only where relevant to the impact assessment, mitigation and management process, or the stakeholder engagement process.

In addition, the social baseline includes regional and national level commentary to provide comparative data, allowing Project affected areas to be compared to national and regional averages and, where appropriate, each other to better understand the local context, potential vulnerabilities, and stakeholder perceptions.

For ease of reading, some data has been removed from the main component of the text and included within Appendix 14-A. The data collection methodology for the social and health baseline has been included within Appendix 14-B.

The social baseline for each of the separate area of the SSA contains the following sections where relevant:

- Governance and Administration;
- Demography;
- Education;
- Health;
- Social Infrastructure and Services;
- Living Cultural Heritage;
- Livelihoods and Socio-Economics;
- Human Rights and Vulnerability; and
- Stakeholder Perceptions, Expectations and Attitudes.

Table 14-2 describes which topics will be discussed for each distinct geographic study area.

*Table 14-2 Topics discussed according to geographic study area*

| *Topic* | *Geographic Study Area* | | | | |
|---|---|---|---|---|---|
| | *National Overview* | *Marowijne Area* | *Moengo Area* | *Tempati and Commewijne Area* | *Transportation Corridor* |
| Governance and Administration | **Included:** Relevant to all other geographic areas and important for stakeholder engagement<br><br>**Relevance: HIGH** | **Included:** Potential area of impact and important for Stakeholder Engagement<br><br>**Relevance: HIGH** | **Not included:** No expected project impacts<br><br>**Relevance: NONE** | **Included:** Important for stakeholder engagement<br><br>**Relevance: Low** | **Not Included:** No expected project impacts<br><br>**Relevance: NONE** |
| Demography | **Included:** Reference for other areas and important for stakeholder engagement<br><br>**Relevance: MODERATE** | **Included:** to understand extent of potentially impacted human receptors and risk of project induced population changes. Also important for stakeholder engagement<br><br>**Relevance: HIGH** | **Included:** to understand extent of potentially impacted human receptors and risk of potential project induced population changes. Also important for stakeholder engagement<br><br>**Relevance: MODERATE** | **Included:** to understand extent of potentially impacted human receptors. Also important for stakeholder engagement<br><br>**Relevance: MODERATE** | **Included:** to understand extent of potentially impacted human receptors.<br><br>**Relevance: MODERATE** |

| Topic | Geographic Study Area | | | | |
|---|---|---|---|---|---|
| | *National Overview* | *Marowijne Area* | *Moengo Area* | *Tempati and Commewijne Area* | *Transportation Corridor* |
| Education | **Included:** reference for other areas<br><br>**Relevance: MODERATE** | **Included:** potential area of impact; relevant to assessing local development status/needs and potential for local employment<br><br>**Relevance: HIGH** | **Included:** For reference and potential area of indirect impact from potential project related in-migration to Moengo<br><br>**Relevance: MODERATE** | **Not Included:** No expected project impacts<br><br>**Relevance: NONE** | **Not included:** No expected project impacts<br><br>**Relevance: NONE** |
| Health | **Included:** national health profile reference for other areas and national health infrastructure also relevant to all areas.<br><br>**Relevance: HIGH** | **Included:** potential area of impact and to determine local health related development status/needs<br><br>**Relevance: HIGH** | **Included:** For reference and potential area of indirect impact from potential project related in-migration to Moengo<br><br>**Relevance: MODERATE** | **Not included:** No expected project impacts<br><br>**Relevance: NONE** | **Included:** Potential area of impact in case of unforeseen event e.g. traffic accident<br><br>**Relevance: MODERATE** |

| Topic | Geographic Study Area | | | | |
|---|---|---|---|---|---|
| | *National Overview* | *Marowijne Area* | *Moengo Area* | *Tempati and Commewijne Area* | *Transportation Corridor* |
| Social Infrastructure and Services | **Included: r**eference for other areas and national level provision of social infrastructure and services also relevant to all areas.<br><br>**Relevance: MODERATE** | **Included:** Potential area of impact and to determine local development status/needs<br><br>**Relevance: HIGH** | **Included:** For reference and potential area of indirect impact from potential project related in-migration to Moengo<br><br>**Relevance: MODERATE** | **Included:** For reference and to determine local development status/needs<br><br>**Relevance: LOW** | **Not included:** No expected project impacts<br><br>**Relevance: NONE** |
| Living Cultural Heritage | **Not included:** No expected impacts to cultural heritage at a national level and national level living cultural heritage profile not relevant for other areas<br><br>**Relevance: NONE** | **Included:** Potential area of impact and important for Stakeholder Engagement<br><br>**Relevance: HIGH** | **Not included:** No expected project impacts<br><br>**Relevance: NONE** | **Included:** Important for stakeholder engagement<br><br>**Relevance: LOW** | **Included:** For reference although there are no expected project impacts<br><br>**Relevance: LOW** |

| *Topic* | *Geographic Study Area* | | | | |
|---|---|---|---|---|---|
| | *National Overview* | *Marowijne Area* | *Moengo Area* | *Tempati and Commewijne Area* | *Transportation Corridor* |
| Archaeological Cultural Heritage | **Included :** No expected impacts to Archaeological cultural heritage at a national level and national level cultural heritage profile not relevant for other areas<br><br>**Relevance: MODERATE** | **Included:** Ground disturbing Construction and Operation phase activities could cause impacts, if they overlap with known or as yet undiscovered archaeological resources.<br><br>**Relevance: MODERATE** | | | |
| Livelihood and Socioeconomics | **Included:** Reference for other areas<br><br>**Relevance: LOW** | **Included:** Potential area of impact, relevant to assessing local development status/needs and local recruitment potential<br><br>**Relevance: HIGH** | **Included:** For reference and potential area of indirect impact from potential project related in-migration to Moengo<br><br>**Relevance: LOW** | **Included:** Potential project impact if unforeseen event occurs. Also important for stakeholder engagement due to economic value placed on area by local stakeholders<br><br>**Relevance: LOW** | **Included:** For reference although there are no expected project impacts<br><br>**Relevance: LOW** |

| *Topic* | *Geographic Study Area* | | | | |
|---|---|---|---|---|---|
| | *National Overview* | *Marowijne Area* | *Moengo Area* | *Tempati and Commewijne Area* | *Transportation Corridor* |
| Human Rights and Vulnerability | **Included:** Reference for other areas<br><br>**Relevance: LOW** | **Included:** Potential area of impact and important for stakeholder engagement<br><br>**Relevance: HIGH** | **Not included:** No expected project impacts<br><br>**Relevance: NONE** | **Not included:** No expected project impacts<br><br>**Relevance: NONE** | **Not included:** No expected project impacts<br><br>**Relevance: NONE** |
| Stakeholder Perceptions, Expectations and Attitudes | **Included:** Important for stakeholder engagement<br><br>**Relevance: HIGH** | **Included:** Important for stakeholder engagement<br><br>**Relevance: HIGH** | **Included:** Important for stakeholder engagement<br><br>**Relevance: HIGH** | **Included:** Important for stakeholder engagement<br><br>**Relevance: HIGH** | **Included:** Important for stakeholder engagement<br><br>**Relevance: HIGH** |

## 14.2 *NATIONAL AND REGIONAL SUMMARY*

In order to provide context and to allow comparison of the SSA this section describes the national and regional socio-economic conditions. Some further detail of the socio-economic baseline at a national and regional level is included in Appendices C and D.

### *14.2.1 National and Regional Governance Systems*

Suriname is a functioning constitutional democratically representational republic, governed by a 51 member unicameral National Assembly. The National Assembly is elected by secret ballot every five years; simultaneous elections are held for Resort Councils, from which District Councils are formed. Suriname has been a functioning democracy since its independence in 1975 (bar two periods of military rule) and since 1987, elections have been reported as largely free of violence. In addition, political activity is reported to be free and equal in accessii.

The Project is located within Sipaliwini District of Suriname; the largest district within the country at approximately 130,567 km2; approximately 80% of the total area of Suriname. Within Sipaliwini, the Project is located in the Pamaka Resort, which covers approximately 3,850 km2. This resort was created in 1983 by dividing the northern part of the former Tapanahony Resort of the Sipaliwini District.

The northern border of Pamaka Resort runs from the Armina Falls on the Marowijne River to Java on the Commewijne River. The Carolina Resort and the northern part of the Sara Kreek Resort form the western boundary. The southern boundary runs east to west, starting at the Ampoma Fall in the Marowijne River. The east boundary is formed by the section of the Marowijne River between the Armina and Ampoma Falls.

The other areas of SSA are within a range of different Resorts and Districts:

- The Marowijne Area lies within the Pamaka resort of the Sipaliwini District;
- The Moengo area is within the Moengo and Patamaka Resorts of Marowijne District and Sipaliwini District, respectively;
- The Tempati and Commewijne Area is within Patamaka Resort of Sipaliwini District, the Carolina Resort of Para District and the Meerzord Resort of the Commewijne Districts; and
- The Transportation Corridor is within the Districts of Marowijne and Commewijne including the resorts of Moengo (Marowijne), Tamaredjo, Alkmaar and Nieuw Amsterdam (Commewijne).

### 14.2.2 *Indigenous and tribal peoples' land rights*

According to the Constitution of Suriname, all land and subsoil resources within the country belong to the state and the Government of Suriname (GoS) does not recognize the individual or group property rights of traditional land tenure.iii

Consultation as part of the development of an Indigenous and Tribal Land Rights Act has been announced and is underway, however, the process is behind schedule. A date for a legal ruling on indigenous and tribal peoples' land rights is unknown.

### 14.2.3 *National Demography Overview*

Suriname's most recent census was applied in 2004 and was published in 2005 and 2006. The census is administered by the Algemeen Bureau voor de Statistiek (ABS – General Bureau of Statistics) and is planned every five / six years. Collection of data for 2010 has not yet been completed and is planned for mid-2011 although it is believed to have been delayed. The World Bank World Development Indicators DataBank has developed population and demographic estimates based on basic assumptions and increased rates.

The national demographic statistics and the demographic statistics for the Sipaliwini District are presented below in Table 14-3. A more detailed explanation of these figures is provided in Appendix 14-E.

*Table 14-3 National Demographic Statistics*

| Statistic | National Statistics | Sipaliwini Statistics |
|---|---|---|
| Total Land Area | 163,820 $km^2$ | 130, 567 $km^2$ |
| Population | · ABS 2004 census: 492,829<br>· World Bank projected figure 2011: 524,636 | 34,136 (approximately 7% of total population) |
| Population Growth Rate | 0.91 % (World Bank estimate 2010) | 0.91 % (2010) |
| Estimated Out Migration rate | 0.23% (World Bank estimate 2010) | Unknown |
| Ethnic Groups (largest to smallest) | Hindustani<br>Creole<br>Javanese<br>Maroon<br>Chinese<br>Amerindian | Maroon<br>Amerindian<br>Other (Creole, Hindustani, Javanese, Chinese) |
| Population density | 3.0 | 0.26 |
| Religious groups (largest to smallest | Christian<br>Hinduism<br>Islam<br>Other (traditional beliefs, non-religious people, Judaism) | Christian<br>Traditional religion and others<br>Hinduism |

Source: ABS 2004, World Bank Data Bank 2011

### 14.2.4 *National Education Overview*

Surinamese law recognizes and guarantees the rights of all citizens to education and offers equal opportunities in education. The law states that it is the duty of the state to guarantee obligatory and free general basic education, and to guarantee durable education and eliminate illiteracy.[iv] Education is compulsory from the age of 7 to 12.

According to the 2004 census data, the adult literacy rate (defined as the population over 15 years who can read and write) at national level is 89.6%.

Adult males have a slightly higher literacy rate of 92% compared to adult females who have a literacy rate of 87.2%. According to UN data, the youth (15-24) literacy rate is higher than the adult literacy rate, and there is less gender disparity within the younger population with a male youth literacy rate of 96% and a female youth literacy rate of 95%v.

According to a recent report discussing gender equality in Surinamevi, girls in Suriname stay in education longer than boys. At pre-school, attendance of boys and girls is said to be approximately equal, however, in the higher classes of elementary school the share of boys begins to drop. This trend continues through secondary school and at the tertiary level only one third (34.7%) of students are male.

The government promotes adult education for those who had limited access to education when they were younger. Classes are available in basic literacy, preparatory elementary school for adults, Elementary school for adults and Secondary education for adults. Each course runs for a year and participants receive a certificate upon successful completion.

### 14.2.5 *National Overview of Health Status*

Certain indicators can be used as indicators of the overall health status of a population, these include life expectancy (how long an individual from a certain population is expected to live), mortality rates, and disease prevalence. Table 14-4 summarizes some of the key health indicators for Suriname compared to the averages for WHO Region of The Americas (WHO, 2011vii).

Compared to The Americas Region, Suriname has a lower life expectancy and higher mortality rates, with a higher burden from HIV and tuberculosis. In respect to malaria status, Suriname has performed above the Americas Region, having reached the Millennium Development Goal. However, this is understood to vary considerable across the country and in the interior, approximately 16% of the country's population, remain at risk for malaria.

*Table 14-4 Suriname - Key Health Indicators*

| Health Indicator (data year) | Suriname | The Americas Region* |
|---|---|---|
| Life expectancy at birth (years), Male / Female (2009) | 68 / 75 | 73 / 79 |
| Probability of dying in adulthood (15-59) (per 1000 adults), Both sexes (2009) | 172 | 125 |
| Probability of dying under 5 (per 1000 live births), Both sexes (2009) | 26 | 18 |
| Maternal mortality ratio (per 100,000 live births) (2009) | 100 | 66 |

| Health Indicator (data year) | Suriname | The Americas Region* |
|---|---|---|
| Prevalence of HIV (per 1000 adults 15-49 years) (2009) | 10 | 5 |
| Prevalence of tuberculosis (per 100,000 population) (2009) | 208 | 38 |
| % of population in high risk areas for malaria (2010) | 16 | -- |

Source: WHO Global Health Observatory Data Repository, 2011

* WHO Region of the Americas covers North America, Latin America and the Caribbean.

In Suriname, chronic diseases are the leading causes of death. In 2010, chronic diseases (including cardiovascular diseases, cancers and diabetes) account for an estimated 71% of all deaths in the countryviii. These national statistics reflect the burden of chronic diseases among the majority of the population living in the urban coastal region; however, these lifestyle-related diseases may be increasing among the rural and interior populations, including the Moengo and Marowijne Areas, whom (according to interviews conducted by ERM) are already suffering from higher rates of water and sanitation-related infectious diseases than the urban population.

Communicable or infectious diseases encompass a wide variety of health conditions, including acute respiratory infections (ARIs), diarrheal or gastro-enteric diseases, vector-borne diseases (e.g., malaria, dengue fever, cutaneous leishmaniasis) and sexually transmitted infections (STIs, including HIV/AIDS). There are some differences in the burden of certain communicable disease between the interior region and the urban coastal region. For example:

- **Diarrheal Diseases** are a major cause of death among children (one to four years) in the interior. Poor sanitary conditions and personal hygiene practices, as well as limited access to safe water sources, especially during dry seasons, are the leading contributors to the high incidence of diarrheal diseases in Suriname's interior[ix].

- **Malaria** has been completely eliminated in the coastal region and, according to information gathered from interviews with the Ministry of Health (MoH), since the Global Malaria Fund Program began in 2005, malaria is now nearly under control among the Surinamese villages in the interior. However, the risk for malaria transmission still remains in the eastern part of the interior of Suriname near the neighboring border with French Guiana, and among the mobile foreign ASM communities in the forest areas. Based on information gathered from interviews with the MoH, approximately 70% of all malaria cases are among small-scale gold miners from French Guiana.

- **Dengue Fever** is primarily reported from the densely populated urban coastal areas, particularly in areas that are favorable for mosquito breeding (e.g., where household water storage is common and where solid waste disposal services are inadequate).

- **HIV/AIDS** has a national prevalence of 1% among the adult population; and based on interviews with the MoH, the incidence of new HIV cases in the country has slightly declined since 2007. However, rates of HIV infections are higher among the high-risk populations, such as Men-having-Sex-with-Men (6-7%) and commercial sex workers (7%)[x]. Foreign ASM miners in the interior are considered among the high risk populations given their association with commercial sex workers at the camps; however, no prevalence data are available for this population[xi].

In 2010, injuries account for 11% of all deaths in Suriname. Among unintentional injuries, road traffic accidents were the top cause of death. In 2000, Suriname was ranked as having a medium level of risk for traffic accidents based on rates of traffic accidents compared to other countries in the Americas region[xii]. In 2007, the Ministry of Justice and Police (Department of Traffic Information Education and Statistics) reported 90 road traffic fatalities (75% males, 25% females) with the highest percentage among riders on motorized 2-or 3- wheelers, followed by drivers of 4-wheelers and then pedestrians[xiii].

### 14.2.6 *National Overview of Social Infrastructure, Resources and Services*

According to the WHO / UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation (WSS) 2010 report on the Estimate of Improved Drinking Water Sources in Suriname, 97% of the urban population and 79% of the rural population has access to improved water sources. Of the urban population, 81% have access to a household water connection, compared to only 46% of the rural population.

The total installed electricity capacity for Suriname is 389 MW indicating the maximum potential demand. At present approximately 125 MW of energy is available from the power grid emphasizing the energy shortfalls and the reliance on generators. There are three energy producers: the *Energie Bedrijven Suriname* (EBS), Suralco, and Staatsolie Power Company. The most significant source of energy for the country is hydroelectricity, which supplies 95% of the country’s electricity generation requirements. Approximately 26% of the total national energy supply is generated by the hydropower system at Brokopondo. The national grid covers the districts of Paramaribo, Wanica, Commewijne, and the communities between Afobakka and Paramaribo. The majority of other areas rely mainly on diesel generators for the production of electricity. According to the Renewable Energy and Energy Efficiency Partnership (REEEP), the estimated electrification rate was 85% in 2006[xiv]. Primary energy demand is increasing at approximately 7.4% per annum[xv].

### 14.2.7 *National Livelihoods and Socio-Economics Overview*

Suriname was ranked as a Medium Human Development country in the 2011 United Nations Human Development report, ranking 104th out of 186 countries ranked [xvi].

The Statistical Yearbook (2006) states that for a standard family of two adults and two children in Suriname, the projected poverty line as calculated for the 2nd quarter of 2007 is approximately SRD 1,049 per month or SRD 12,588 per year. This is approximately equal to US $322.77 per month or US $3,873.23 per year.

## 14.3 *NATIONAL AND REGIONAL ARCHAEOLOGICAL CULTURAL HERITAGE*

### 14.3.1 *Introduction*

Archaeological sites represent a scientific and cultural record of past human activity, and in places such as Suriname where no pre-colonial documentary record exists, these sites are the only historical and scientific record of the people who occupied them. Archaeological resources are unique and fragile, and although they may have highly variable levels of importance, they are all susceptible to irreversible physical damage from ground disturbing construction and operation activities. Although archeological remains may also have special historical or spiritual value for local traditional communities, it appears that this is not the case as local communities in the Merian area have little knowledge of the precolonial archaeological heritage of Suriname. Living cultural heritage issues, which are of importance to local communites, are addressed in *Section 14.4.6*. The primary stakeholders for archaeological heritage in Suriname are the national and international scientific communities and the the national government.

Our baseline research confirmed that there is relativley sparse archaeological literature for Suriname which revealed no specific mention of archaelogical survey of the Merian Project Site. Lacking specific site information, our approach to the archaeological baseline was to review what is known about Suriname broadly and then apply aspects of this broad pattern to the task of understanding archaeological conditions at the Merian Project Site. In this archaelogical section of the social baseline we begin with a regional overview and general archaeological chronology of Suriname and then apply this information to the task of understanding site specific conditions.

### 14.3.2 *Precolonial Cultual Context for Suriname*

The following cultural context is applicable to the Guayanas as a whole, including surname.

*Savannah Hunter Peoples*

These are the earliest cultures of the area of Suriname. Sites are most commonly found in savannah areas that developed in the late-Pleistocene. These pleistocene and early holocene sites have not yet been found in Suriname, although evidence strongly suggests that they are present. The Tupuken Site, a find in Venezuelan Guyana dating to 13,000 BC, is the best known example. Some investigators suggest that these early foraging cultures in the area may date to much earlier time periods. Areas with significant potential for such sites are in southern Suriname, some distance from the Merian Area.

*Shell and Mound Peoples*

Sites relating to these cultures are found in coastal areas west of the Essequibo River in Guyana and in Brazil to the southeast of the Amazon's mouth. These shellfish-dependent cultures were not present in Suriname due to the absence of the dense shellfish populations that supported them. These village sites typically date between 6,000-1,300 BC and usually belong to what is called the Alaka Phase in Guyana. During this same time period there is a gap in archaeological evidence in Suriname.

*Early Farmers*

These were the peoples responsible for the rise of the so called Tropical Forest Cultures in the Guyanas. The period of early farming began in approximately 3,600 BC according to C-14 dates from Kaurikreek Site in western Suriname. The first evidence of early farmers in Suriname consists of Saladoid-style pottery artifacts. Pottery technology and probably agricultural technology (principally bitter manioc cultivation and processing) came from the Amazon region, via the Rio Negro and Casiquiare Canal, and was carried to the upper reaches of the Orinoco River and from there into the Guyanas. The Tropical Forest farming pattern was common among pre-colonial peoples throughout the wooded tropical regions of South America. The people of this tradition lived in villages ranging in size from a few dozen inhabitants up to large villages with hundreds of residents. They possessed knowledge and technology associated with manioc cultivation and practiced shifting cultivation. Most of their tools and structures were made of perishable materials that are not preserved archaeologically. However, they made and used ground-stone tools, and pottery that was often decorated. Pottery shards, which preserve well and were left in abundance by these groups, is what archaeologists use to characterize and identify sites of the many different groups of the Tropical Forest Cultures. Sites relating to these cultures are found throughout Suriname, though in varying density, apparently depending on various geographic factors. The forest culture subsistence tradition and way of life persisted throughout the remaining pre-colonial period and, with cultural admixture and technological borrowings over the years, persist into the present in the lifestyles of Suriname's traditional peoples.

*Mound and Ridge Peoples*

Highly favorable freshwater conditions in coastal plain between AD 300 and 1000 gave rise to this culture. The Mound and Ridge culture were the most advanced and socially complex societies of Suriname's pre-colonial period, involving cultivation of natural sand ridges and the construction of ceremonial mounds. They originated in the coastal areas of eastern Suriname and spread westward. This period saw the introduction of the Amazonian traditional of permanent agriculture, involving the excavation of canals and construction of other water control structures to allow year round cassava cultivation. One archaeological example of the Mound and Ridge tradition is the Buckleburg site which dates to approximately AD 300. Mound and Ridge sites are limited to the coastal areas of Suriname and are not expected in the Merian Project Site.

*Later Cultures from the Interior*

After the onset of the Mound and Ridge phenomena on the coast of Surname, life in the interior continued in the traditional Tropical Forest pattern with many different cultural variants developing, each characterized by its own pottery style. Many such sites are known from the interior and they are typically found on high creek banks and at savannah-edge locations. The Brownsberg culture, dating from approximately AD 1000 to 1500, is an example of a Tropical Forest culture from this period. The Brownsberg sites are at the northeast edge of V. Blommenstein Lake, approximately 60 km Southwest of Merian. The Koriabo Culture is another group from this period, which appears to have moved into Suriname from the south and had a relatively long lasting and widespread prsensence in Suriname compared to other contemporary cultures of the late Pre-Colonial period, such as the Kwatta and Barbakoeba cultures. All three of these cultures are found in the general region of the Merian Project Site.

*Petroglyphs and Stone Rows*

Carvings in natural stone outcrops and structures are found throughout Suriname and although they are understood to be pre-colonial, it is usually impossible to relate them to any particular culture or developmental period. They are often associated with water bodies and savannah edges, the same locations in which village-sites and other settlements are most often found in Suriname. The most notable assemblages of these pre-colonial stone features are found along the Sapliwini Savannah far to the south of the Project Area. These rock features are also found along the Corantijn River and along the Marowijne River, east of the Merian Project Site.

*Contact Period Cultures*

Most of the Caribe and Arawak speaking Ameridians that lived in Suriname at the time of the first European arrival declined fairly rapidly from disease and the effects of enslavement after contact with Europeans. The Sapoyers and Paracotten goups did not survive the early colonial period.

The British and later the Dutch brought the practice of slavery to Suriname in the seventeenth century importing African slaves as the Indians died out. Most plantations and European settlements were on the coast, so as Africans began to escape, they moved inland into the forest where they began to form what are known as Maroon communities.

### 14.3.3 *Known and Potential Archaeological Sites in the Region Around the Merian Area*

Specific site locations and general patterns emerging from the Pre-colonial culture history outlined above can be used to define currently known baseline conditions in the Merian area. Most importantly, river drainages are shown to have had a major pre-colonial importance for travel and communication, as well as for political organization. Pre-colonial sites are typically hard to find due to dense overgrowth and to poor preservation due to tropical soil and moisture conditions. Sites typically consist of preserved remains of traditional villages, including primarily non-organic artifacts such as ceramics, rock artifacts, shell and calcined, burnt bone, as well as soil features including middens (concentrations of cultural refuse) that consist of decomposed organic material and leave traces of much darker soil often referred to by archeologists as "black soils." For most of the pre-colonial period, people in the area lived in relatively small villages practicing shifting agriculture focused on manioc, supplemented by fishing and hunting. Earlier Pre-agricultural peoples had a more mobile lifestyle with smaller, less permanent settlements than those of the agricultural period. Sites would be of various ages including small to large villages (100-1000 inhabitants), smaller camp sites, and petroglyphs sites. Village and camp sites are hard to find, poorly preserved, and research has been limited. Larger village sites are easier to find and account for the highest proportion of the known inventory of sites. Sites are often subject to stream erosion, burial under alluvium, and burial under live and decomposing undergrowth. Sites can be indicated by low mounds, and dark anthropogenic soil deposits containing ceramics and stone artifacts, as well as partially preserved food remains; however, some sites also occur without these "black soils".

The combined research efforts of Versteeg and Boomert over the past four decades has been published in a monograph entitled *Surname before Columbus* (Versteeg 2003). Lacking a government inventory of Surname's archaeological resources, the list, map and associated explanatory text represents a semi-official archaeological inventory for Suriname. The site list, map and descriptive text provide information on the more than 400 known precolonial sites in Suriname. Figure 14-3 shows the locations of the 109 known pre-colonial archaeological sites in the region of Project Site in northwest Suriname.[1]

[1] The map accompanying Versteeg 1993 was georeferenced by ERM against the Merian Project basemap to in order to approximate the centerpoint of each site. Site IDs shown on the map and following table. The site IDs used in this document correspond to those given in Appendix 1 of the mentioned publication.

### 14.3.4 *Archaeological Sensitivity of the Project Site*

Review of Figure 14.3 indicates that 16 of the 109 known archaeological sites within the mapped region around the Merian Project Site lie either in or near at least one of the Project components. Three of these are in or near the the Mine and Base Camp area and the remaining 13 lie along the Transportation Corridor. The three sites may actually lie within the boundary of the Mine and Base Camp area, while the 13 sites appear to be near the transport corridor but not within it. Map locations are approximate and will required field checking by an archaeologist.

The three sites that appear to lie within the Mine and Base Camp date to the Pre-Colonial Period and are of unknown cultural affiliation. They are: Sur-367, Sur-378 and Sur-388).

The 13 sites associated with the Transportation Corridor should be considered to be near to or within the Project Site. These sites have a wider range of cultural and temporal affiliations. All appear to be Pre-Colonial settlement sites, one with associated Graves (Sur-33). Seven are associated with the Koriabo Culture (Sur-12, Sur-13, Sur-34, Sur-99, Sur-160, Sur-379, and Sur-380), one affiliated with the Kwatta culture (Sur-33) and five are of unknown affiliation (Sur-76 , Sur-112, Sur-113, Sur-368, and Sur-369). The Kriabo and Kwatta Cultures are of the late Pre-Colonial post dating AD 1200, as described in the cultural context above.

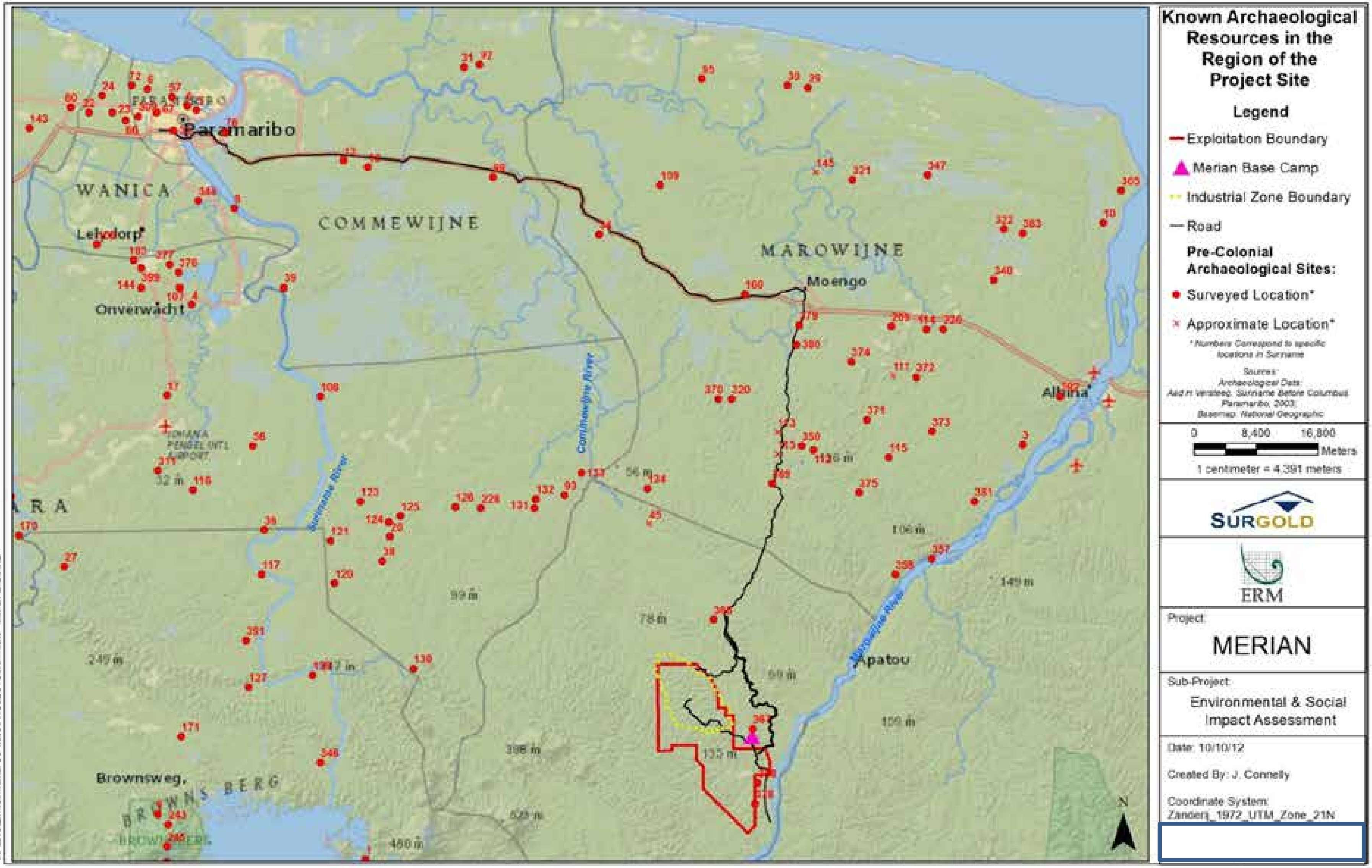



*Figure 14-3 Known Archaeological Sites in Northwestern Suriname*

Overall, the Merian Project Site is considered to have a moderate to high potential for significant undiscovered archaeological remains. In Suriname there is a notable clustering of known archaeological sites along the coast and near coastal banks of major rivers and along rivers in the band of highly productive agricultural land approximately 50-75 km inland from the coast. The Merian area lies at the southern edge of this high potential zone, some 50 km inland. High potential areas within the Project Site would be well-drained level ground along river courses and near other water bodies. Lower potential areas would, in general, be those areas on poorly drained land subject to frequent inundation. It should also be noted that localized drainage conditions can change significantly over time, thereby making areas of high and low potential harder to recognize based on current conditions. Further definition of archaeological baseline conditions will be accomplished with additional more detailed desk study along with aerial image review followed by field investigation, focusing on those areas of the Project Site that will be subject to ground disturbing activity.

*Table 14-5 List of Known Pre-Colonial Archaeological Sites in or Near the Project Site*

| ID | Name | Description | Location |
|---|---|---|---|
| Sur-12 | Commetewane-1 | Pre-Colonial Settlement Site; Koriabo culture | Former Commewijne district; near the East-West Verbinding or Merian transport corridor |
| Sur-13 | Commetewane-2 | Pre-Colonial Settlement site; Koriabo culture | Former Commewijne district; near the East-West Verbinding transport corridor |
| Sur-33 | Paramaribo Waterkant / De Mirandastraat | Pre-Colonial Settlement with graves; Kwatta Culture | Former Paramaribo district; near or within East-West Verbinding transport corridor |
| Sur-34 | Peprepasi | Pre-Colonial Settlement Site; Koriabo culture | Former Marowijne district; near the East-West Verbinding transport corridor |
| Sur-76 | Jachtlust | Pre-Colonial Settlement Site; culture unknown | Former Commewijne district; near the East-West Verbinding transport corridor |
| Sur-99 | Moricokreek | Settlement site, Koriabo culture | Former Commewijne district; near the East-West Verbinding transport corridor |
| Sur-112 | Patamaccakreek-1 | Settlement site; culture unknown | Former Marowijne district; near the transportation corridor |
| Sur-113 | Patamaccakreek-2 | Settlement site; culture unknown | Former Marowijne district; near the transportation corridor |
| Sur-160 | Moengo Boesmanhill | Settlement site; Koriabo culture | Former Marowijne district; near the East- |

| ID | Name | Description | Location |
|---|---|---|---|
| | | | West Verbinding transport corridor |
| Sur-367* | Meriankreek | Settlement site; culture unknown | Former Marowijne district; near or within south-western boundary of project area. |
| Sur-368 | Atijékreek | Settlement site, culture unknown | Former Marowijne district; near or within transportation corridor |
| Sur-369 | Boven Cottica-1 | Settlement site; culture unknown | Former Marowijne district; near transportation corridor |
| Sur-378* | Tomatoekreek-1 | Settlement site; culture unknown | Former Marowijne District; near or within the western boundary of project area |
| Sur-379 | Ingitoetoekreek-1 | Settlement site; Koriabo culture | Former Marowijne district; near the transportation corridor |
| Sur-380 | Ingitoetoekreek-2 | Settlement site; Koriabo culture | Former Marowijne district; near the transportation corridor |
| Sur-388* | Tamatoekreek-2 | Settlement site; culture unknown | Former Marowijne district; near or within south-western boundary of project area |

**Appears to lie within the Project Site*

## 14.4 MAROWIJNE AREA

The Marowijne Area is shown in Figure 14-4.

*Figure 14-4 Marowijne Area*

Based on the scoping process, the Marowijne Area has been included within the social baseline due to the presence of Maroon villages near to the Project Area and the use of natural resources within the Marowijne Area.

Based on the scoping process, the baseline for the Marowijne Area has been structured to consider all topics relevant to potential Project-related impacts, perceptions and relevant considerations for stakeholder engagement and potential Community Investment opportunities.

### *14.4.1 Traditional Pamaka Governance*

The Marowijne Area, and much of the Interior, operates within a dual governance structure maintaining both traditional and formal leadership. In addition to the formal governance system described previously, a traditional hierarchy exists in the Marowijne Area based around the customary Maroon system found throughout Suriname. This includes an overall Paramount Chief or Gaanman, a series of Head Captains (senior advisors representing different clans within the Marowijne Area), Captains (settlement heads), and Basjas (assistants).

Each Maroon clan in Suriname has a paramount leader or Gaanman. This title is passed down in a matrilineal fashion; meaning the Gaanman's nephew (the male child of his sister) inherits the role upon his death. The role of Gaanman is intrinsically linked with mysticism and traditional beliefs; each Gaanman is believed to be a reincarnation of the spirit of the previous and possessing magical powers. The Gaanman's decisions are widely respected and it was reported that he has the 'final word' on decisions.

Figure 14-5 shows a meeting held between ERM and the current Gaanman Forster.

*Figure 14-5 Meeting with Pamaka Gaanman Forster*

Each village within the Pamaka territory was reported to ideally be represented by at least one male and one female Captain who administer the village. Female Captains do not inherit their role, but are elected by the village and formally appointed by the Gaanman. They focus mainly on women's issues and defer to the male Captain for final decision-making and opinion on matters relating to the whole village. The Village Captains are supported by approximately four Basjas (reported to be ideally two of each gender) who are appointed by the Captains. It should be noted that these numbers vary considerably and the gender balance of these traditional leaders is not always equal. The allocation of numbers of Captains and Basjas was reported to be dependent on the size of the village and the clan or lineage.

The formal and customary governance structures operate in parallel to each other and are not formally linked in hierarchy or reporting. There is no legally established division of responsibility or jurisdiction and this appears to create a level of tension between formal and traditional hierarchies. The Gaanman is unofficially recognized by the formal authority as the de facto governance mechanism within Maroon society in the Interior and are consulted to a degree on significant governance decisions relevant to Maroons. The traditional system, therefore, appears to hold more influence in local decision making in the study area, however, the formal local government ultimately has the power to make more general planning decisions for the area without the inclusion of the Gaanman.

It is reported that the GoS is promoting a decentralization process for government services and has completed a building project, which will house the regional government offices on the mainland across from Langa Tabiki, the seat of the Gaanman. This planned administrative outpost of the central government, which will fall under the Ministry of Regional Development, will tend to the various central government responsibilities in the resort, including social services the government provides in the resort. Currently the building is not in use by government and is being used as a police base.

*Local Perceptions of the Traditional Authority*

The current traditional governance system was reported to be experiencing a period of uncertainty which is impacting community decision making, unity and perceptions of the Project. The power of the Gaanman as the paramount traditional authority in the region persists; however, divisions between Pamaka factions were reported.

This is particularly pronounced when we consider divisions between the Upper (Akati and Langa Tabiki) and Lower Pamaka (Nason, Tabiki Ede, Pakira Tabiki, Skin Tabiki, Atemsa, and Loka Loka) Areas. Since 2010, divisions between the Upper and Lower Marowijne Areas have become increasingly pronounced and statements were made that this has been exacerbated by the presence of Surgold and Suralco.

The focus of social investment initiatives by Surgold on Langa Tabiki (the island where the Gaanman lives), have further exacerbated these divisions between the Upper and Lower Pamaka people.

*Pamaka Clans*

The dominant traditional descent amongst Pamaka Maroons ideology is matrilineal and divided into clans and lineages. Political leaders and customary priests are appointed on the basis of descent groups which occupy the various villages.

Under the overall leadership of the Gaanman the Pamaka people are split into Lo; a matrilineal clan of family groups. Each Lo has at least one Head Captain who serves as an advisor to the Gaanman. The role of Head Captain is a lifelong position and passed down through the matrilineal line (a Head Captain passes down to his sister's son). The Lo are divided in Bee or extended family groups.

The Pamaka people are split in three Lo: the Molo, the Antoosi, and the Asaiti, which are divided in Bee or extended families. Currently the Molo are represented by one Head Captain and the Antoosi (from which the Gaanman originates) and Asaiti by two Head Captains.

It should be noted that during the data collection it became obvious that there are divisions between and within villages. The Pamaka clan appears to be divided into three geo-political units based around the villages of Langa Tabiki, Nason, and Loka Loka. These were the earliest villages to be established, have the most territory, and have the most influence. Tensions between these three areas are broadly associated with local power politics.

Despite the tensions between the Pamaka clans and territories, participants in Focus Group Discussions (FGDs) made clear that the Pamaka are united.

*Decision Making and Leadership amongst the Pamaka*

Decision-making at a village level appears to be at the discretion of the Captain; however, several Captains did mention that where there is a group of elders in a village, the group will be consulted to form a decision together (in a meeting called a krutu). The roles of a Captain are fairly typical of those of a village leader and were explained as maintaining order and administering the village, this includes the arbitration of local conflicts. According to information gathered during the data collection process, information shared with the traditional leadership is not necessarily shared with all village residents.

It was reported that important decisions are made during council meetings by the community members, but with particular input from the chiefs, male elders, senior women, and youngsters. It was reported that people with a good education hold a lot of respect in the community and their input in decision making is often sought after and highly valued. Regional and tribal councils are held from time to time to make decisions about matters affecting a region or the entire tribe.

*Pamaka Judiciary Structure*

The traditional or customary legal system awards the traditional authority the responsibility for conflict resolution and maintenance of law and order. This system, similar to governance and land tenure, functions in parallel to the formal legal system and is recognized by local residents as being as important as formal law making.

It was reported that a Captain can adjudicate minor offences, but more serious infractions are dealt with by several chiefs or a village council. There is no clear separation of powers in tribal communities of Suriname, which can at times complicate matters. The village Captain or the village council functions as judge and jury. If a given person has a conflict with a chief, the chance of getting a fair trial is not always good. During FGDs it was reported that more serious crimes that involved violence or high value theft would be reported to the formal police.

Security within ASM camps is typically dealt with internally. ASM miners that come to work in a camp commit to a verbal agreement not to fight or steal. Any incidents are reported by camp security to the land boss, who administers justice. Punishment can range from fines for petty thefts, to suspension for higher value thefts or fighting. More serious crimes are brought to the police. According to Key Informant Interviews (KIIs), crimes within ASM camps are rare and people generally respect the rules of the camp while they work there.

A new government body, the Ordening Goud Sector (OGS – roughly translated as the Gold Sector Restructuring Commission) was established in January 2011 with the task of regulating the gold sector. The main aim of this body is to make the illegal, small-scale mining sector a part of the formal, tax paying economy. Included in this remit is provision of assistance to the military police in supervising the small-scale mining activities in the Interior.

*Pamaka Land Tenure*

Similar to the local governance structure, the Marowijne Area surrounding the Project operates under a dual system of formal land rights and traditional land use. In the traditional land tenure system, land and other natural resources are regarded as a gift from the creator allocated through the ancestors. The Pamaka belief system stipulates that people may manage and use land, leaving it in a reasonable state for the next generations.

Land can be possessed through occupation and the principle of 'first cleaning[30],' but it remains under the greater 'ownership' of ancestors. Land, therefore, traditionally belongs to a vast family of which many are dead, few are living, and countless numbers are still unborn. Traditional authorities (including family elders, village heads, and religious specialists) are responsible for the management and supervision of the use of the forest and the land as a group possession. They may do so because they are the custodians of cultural identity and group values, and the mediators between the supernatural (the ancestors) and living relatives.

Every extended family unit (or Bee) retains access to some traditional ancestral land within the village or tracts of uncleared forest, which is passed down according to the matrilineal system. Typically, agricultural plots are on the Suriname side of the Marowijne River and land tenure traditionally extends inland from these plots as needed or expanded. The land of each village or clan is then subdivided into pieces, which individuals or household use to plant and build houses.

[30] Which refers to clearing of the jungle for plots of land.

The forest is considered communal land and is used by the community for hunting and collecting of forest products. All individual Pamaka people have the right to use it and no individual has the right to prevent communal use of any land allocated to any particular individual. In this way, the community is described as the owner of land, while the individual is described as a user of the land. The traditional land system is not closed and village Captains can award land where requested and deemed suitable by the village hierarchy to Pamaka people, other Maroons, or migrants to the area.

Residents in need of a piece of land to build a house must seek permission from the elders of his or her clan. The clan elders can give approval and can designate where to build or act as mediator. In cases involving the territory of other villages or the founding of new villages, the permission of the Gaanman and the neighboring village Captains must be sought.

The traditional land tenure system in the area is the root of claims of land ownership and rights of land access for many Pamaka Maroon stakeholders. This system of land tenure is particularly important in relation to artisanal and small-scale miners in the area. During the data collection various stakeholders professed that it is their right to continue to mine gold on their ancestral lands, as has historically been the case. The traditional land system facilitates the role of Landboss within the dynamics of artisanal and small-scale mining (ASM). The Landboss controls mining activities within areas to which he claims traditional access to ancestral lands. This situation has established traditional land use as an important factor in the economic success of many individuals, both ASM laborers and Landbosses. As a result the reverence for ancestral lands has become as much an economic as a cultural tenet. The importance of access to ancestral lands is significant not only for its traditional value, but also as a pragmatic socio-economic desire to maintain access to ASM as a viable income generating activity.

Formal land ownership in the area is represented through mining or lumber concessions, of which Alcoa / Suralco and Surgold represent the significant landholders. It was reported that no or very few local residents have legal title of land and according to local residents there are no formal land use rights administered by the national government within the villages surveyed.

#### *14.4.2 Demography in the Marowijne Area*

The total population of the Marowijne Area is approximately 1,136 persons in the ten villages along the Marowijne River. Table 14-4 and Table 14-6 show the distribution of these residents by gender and settlement.

*Table 14-6 Marowijne Area Population Estimate*

| Name of Village/ Location | Households Surveyed | Population Surveyed (58.8% of estimated total) | | | Est. Total Population 2010[a] |
|---|---|---|---|---|---|
| | | Total | Men | Women | |
| Akaati | 3 | 3 | 2 | 1 | *5* |
| Atemsa | 10 | 45 | 19 | 26 | *77* |
| Bada Tabiki | 5 | 13 | 7 | 6 | *22* |
| Kiki Mofo | 16 | 96 | 52 | 44 | *163* |
| Langa Tabiki | 33 | 154 | 88 | 66 | *262* |
| Loka Loka | 20 | 97 | 54 | 43 | *165* |
| Nason | 24 | 120 | 63 | 57 | *204* |
| Pakira Tabiki | 6 | 25 | 15 | 10 | *43* |
| Skin Tabiki | 11 | 68 | 29 | 39 | *116* |
| Tabiki Ede | 8 | 47 | 23 | 24 | *80* |
| Sub-total (Households) | 136 | 668 | 352 | 316 | *1136* |

[a] Note: Estimated total population is based on the assumption that the sample size is 58.8% of total permanent residents. See Appendix 14-B for further details.

The three largest villages in the Marowijne Area are Langa Tabiki, Nason, and Loka Loka. These three largest villages were also reported as oldest villages, from which the founders of other smaller villages are reported to have originated. For comparative purposes, Figure 14-6 indicates the estimated total population of each village in the study area.

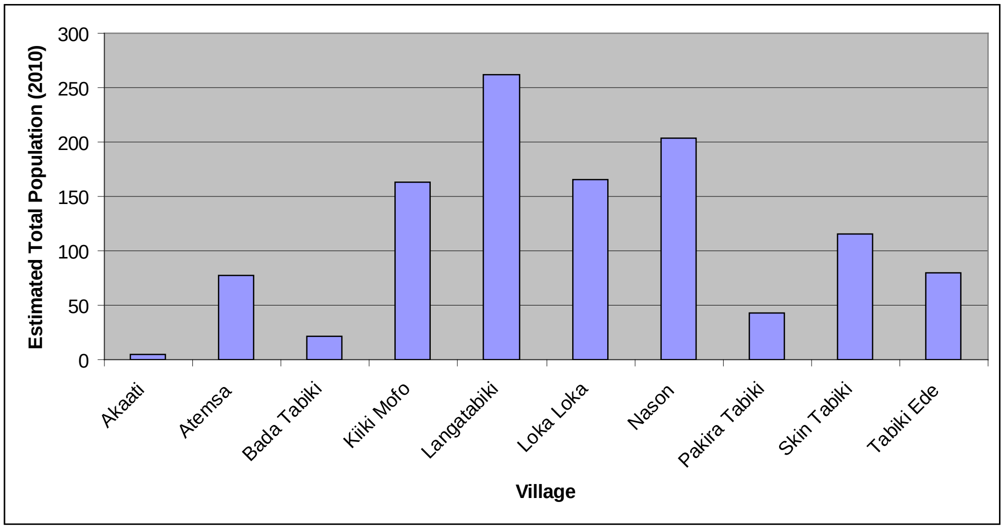



*Figure 14-6 Estimated Pamaka Village Populations*

The 2010 household survey reported an estimated 395 household structures in the Pamaka villages surveyed. However, approximately half of all existing household structures were reported as abandoned by families who have relocated to Paramaribo, other interior areas of Suriname, Albina, or French Guiana. Figure 14-7 compares the number of abandoned and occupied household structures in each of the ten villages.

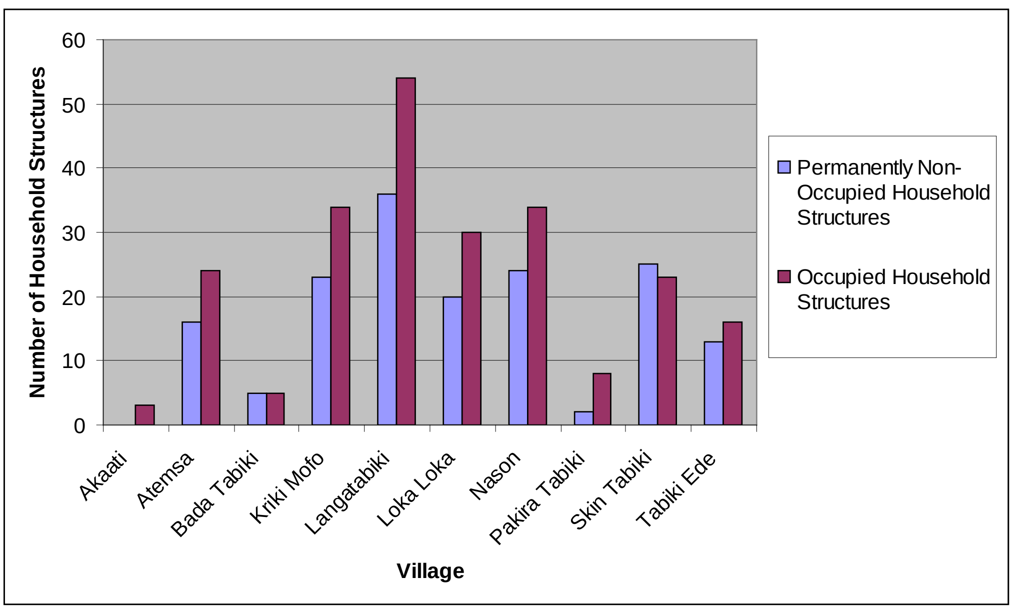



*Figure 14-7 Distribution of Occupied and Abandoned Household Structures in the Marowijne Area*

Langa Tabiki was reported to have the maximum number of occupied households. Skin Tabiki, Bada Tabiki, and Tabiki Ede were reported to have similar numbers of abandoned households as occupied households. It should be noted that since the household survey was undertaken the Gowtu Bergi Area no longer has an ASM presence and some of these people may have returned to the Marowijne Area reducing the numbers of unoccupied structures. Anecdotal evidence based on visits in 2010 and 2011 (before and after the access to Gowtu Bergi Area was restricted[31]) indicates an increase in the number of young men in the Pamaka villages.

Ethnically the Marowijne Area was indicated within the household survey to be fairly homogenous. Approximately 97% of all households indicated they are Pamaka Maroons, 2.9% indicated they are Ndjuka Maroons, and only one household surveyed was reported to be mixed Brazilian / Maroon ethnicity. This homogeneity was corroborated in the household survey results by the data on primary languages spoken in the household. Approximately 92.7% of respondents indicated Pamaka was the primary language in the household, with Dutch the second most prevalent language at 3.7%.

Multiple religious traditions and Christian denominations were reported to be prevalent in the Marowijne Area and these were reported to be actively practiced through attendance at church ceremonies, recognition of holidays, etc. Approximately 70.6% of the population stated Roman Catholicism was the principle religion in the household, with 11.8% stating Evangelism, and 11% Moravian. Traditional beliefs were reported to be the principle religion in only 3.7% of households despite the presence of ancestral shrines in many of the Pamaka Villages (see Figure 14-8)

According to the results of the household survey, religious groupings at the village level were stated to be fairly homogenous. Figure 14-8 illustrates the different religions that are stated to be primary belief structures within the household according to the 10 Pamaka villages surveyed.

[31] The Gowtu Bergi area was one of the largest PK mining areas within the study area. Surgold requested that the GoS ordered PKs to leave the area which was vacated in 2011. This area, within Surgold's potential exploitation license will potentially be the main focus of mining and industrial activities and is referred to as the (planned) Industrial Zone.

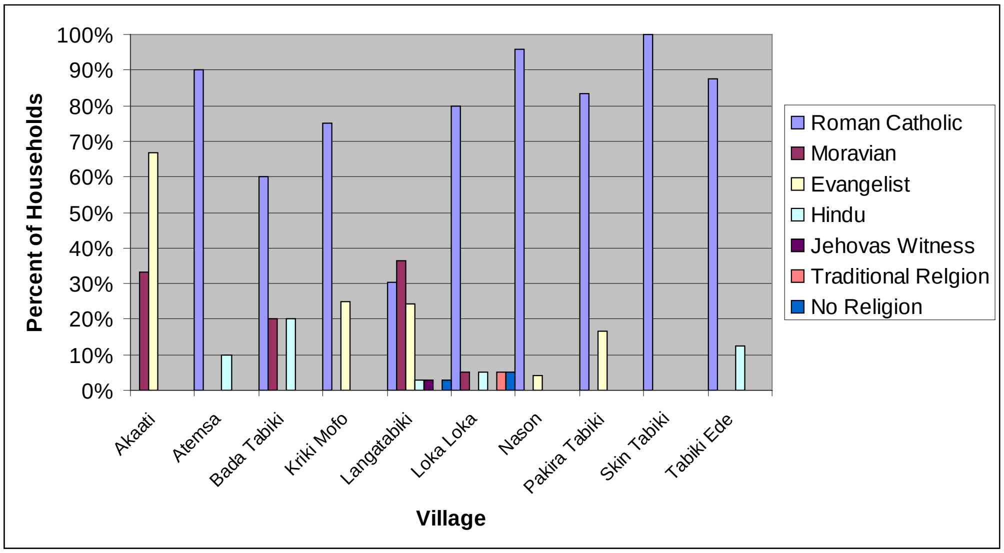
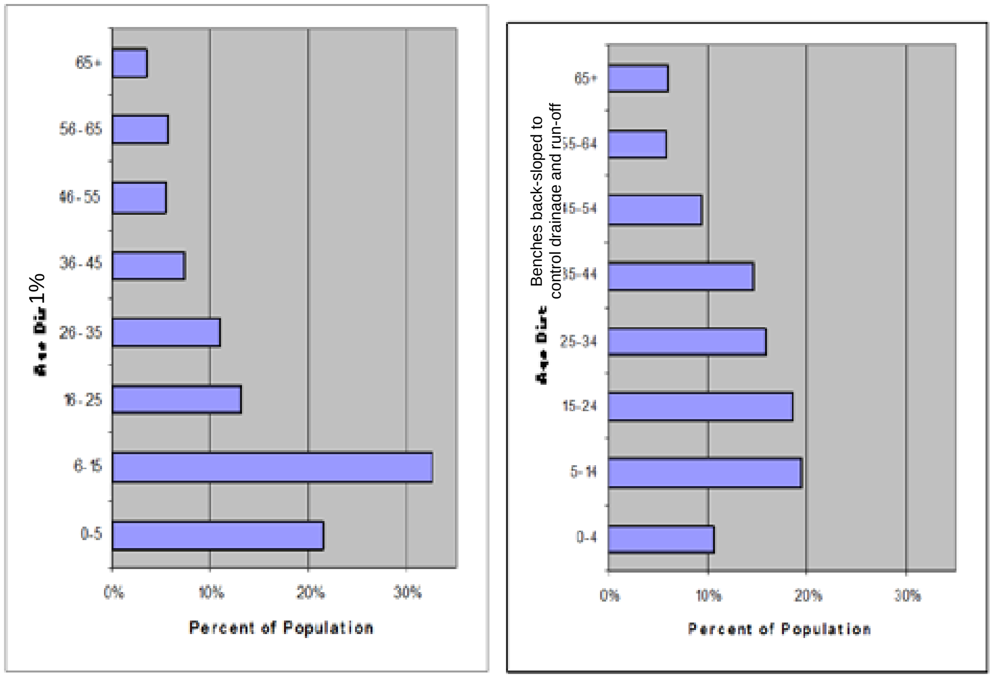



*Figure 14-8 Distribution of Primary Religion in the Households in the Marowijne Area*

Differences in the distribution of religious belief may be the result of the activities of religious missionaries, which arrived in the late 1800s and eventually set up religious schools and churches. The missionaries typically established themselves in certain villages and spread their faith locally. The activities of these missionaries were reported to have fostered division between residents of different denominations in FGDs. Residents suggested that these divisions continue to cause animosity between villages of different religious traditions.

Based on the household survey the youth population (between the ages of 0 – 15) represent more than half of the total population (54%) in the Marowijne Area. This is markedly different to the national data where only 30% of the population is below the age of 15. In addition, the proportion of the population aged between 16 and 65 years old, often considered the working age, is 43% in the Marowijne Area. The age distribution in the Marowijne Area and the national distribution are presented in Figure 14-9.




Source: ERM (left); General Bureau of Statistics, Suriname. Statistical Yearbook, 2006 (right).

*Figure 14-9 Age Distribution: Marowijne Area (left) and National (right)*

Residents suggested that this comparatively youthful population, with a large drop in ‘adult residents’, can be explained by employment induced emigration, high birth rates, and lower than average life spans.

The household survey and FGDs indicated some discrepancy between perceived and actual gender balance within the Marowijne Area. Statements regarding ‘shortages’ of men did not corroborate with the household survey results which indicating 352 men and 316 women within the sample. Figure 14-10 shows the gender distribution in the villages within the Marowijne Area.

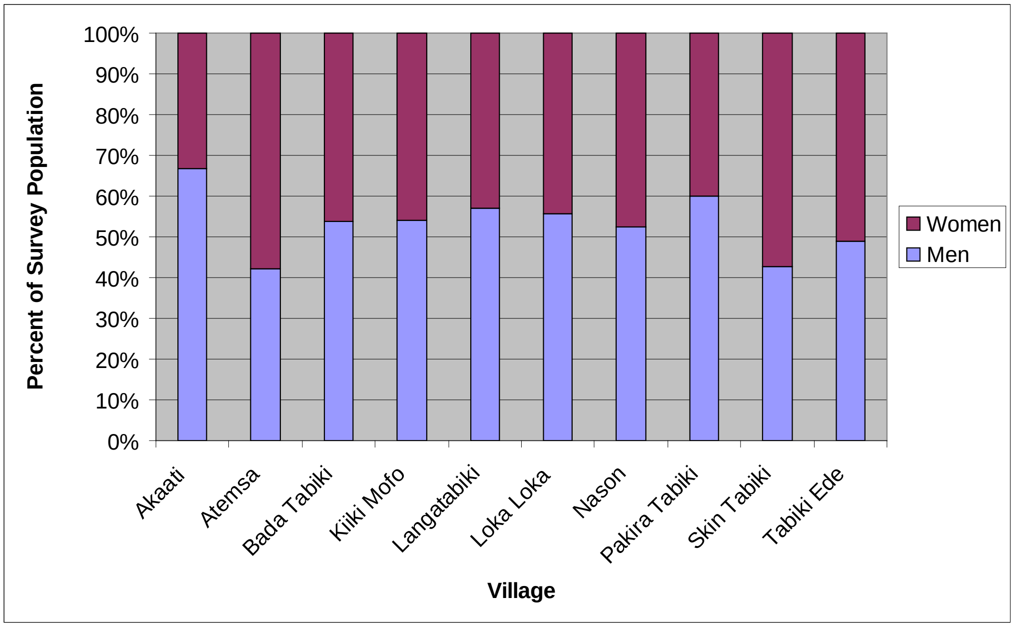



*Figure 14-10 Gender Ratio in Villages in the Marowijne Area*

All villages except Tabiki Ede, Skin Tabiki, and Atemsa have more men than women; however, there does not appear to be a significant correlation between the villages with lower gender ratios and the location or primary economic activity of the village.

It should be noted that the household survey was applied while the Project Area was still illegally used by ASM miners and this may have affected the gender ratio in the Marowijne Area. The use of Gowtu Bergi for ASM may have increased the numbers of men who respondents classified as living in the Marowijne Area, but resided in the jungle. This situation may have increased the numbers of men indicated within the household survey, but absent from the village on a daily basis. Anecdotal evidence gathered during fieldwork in October 2011 indicated that large numbers of ASM miners have left the area and although some Pamaka men may have returned to their villages others have left the Marowijne Area in search of alternative ASM sites or other livelihood options.

*Population Change in the Marowijne Area*

Quantitative and qualitative data gathered in the Marowijne Area indicates that the population has decreased in the past ten years. Based on estimates from the Regional development plan the total decrease since 1995 is estimated to be approximately 29%.

Table 14-7 and Figure 14-11 summarizes the distribution of these population changes.

*Table 14-7 Estimated Population Change in the Marowijne Area*

| Name of Village | Estimated Total Population | | Estimated Percentage Change |
|---|---|---|---|
| | 1995 *(Regional Development Plan Estimates)* | 2010 *(ERM Estimate Based on Household Survey)* | |
| Akaati | 33 | *5* | *-84.85%* |
| Atemsa | 139 | *77* | *-44.60%* |
| Bada Tabiki | 138 | *22* | *-84.06%* |
| Kiki Mofo | 22 | *163* | *640.91%* |
| Langa Tabiki | 389 | *262* | *-32.65%* |
| Loka Loka | 237 | *165* | *-30.38%* |
| Nason | 299 | *204* | *-31.77%* |
| Pakira Tabiki | 66 | *43* | *-34.85%* |
| Skin Tabiki | 146 | *116* | *-20.55%* |
| Tabiki Ede | 136 | *80* | *-41.18%* |
| Total | ~1605 | *~1137* | *-29.16%* |

Source: ERM, 2010 and Streekontwikkelingsplan Paramakaans Stamgebied (Regional Development Plan Paramaka Tribal Area). Geografisch-Planologisch Adviesbureau GISPLAN, October 1995.

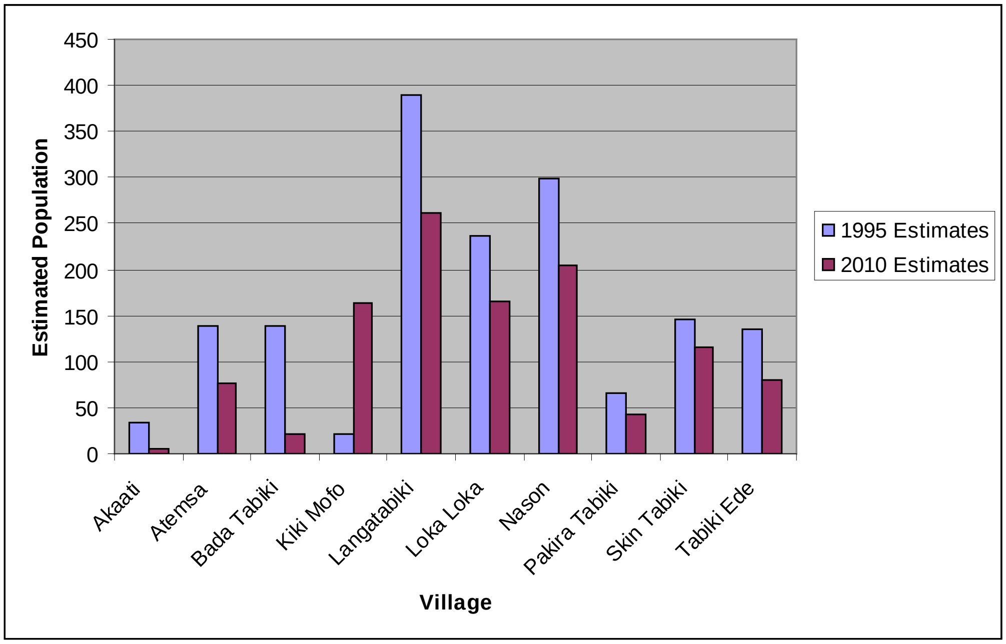



*Figure 14-11 Estimates Population Change in the Marowijne Area*

All of the Pamaka villages show a decrease in population in excess of 20% except for the village of Kiki Mofo, which is the only village estimated to increase in size. The expansion of Kiki Mofo may be explained by its status as the newest Pamaka village however the rate of increase (approximately 641%) is substantially more than would be expected due to natural increase (crude birth rate minus crude death rate).

During the data collection process it was mentioned during FGDs that the drivers for outmigration included:

- Absence of adequate infrastructure and services (e.g., health and education);
- Erosion of the Pamaka cultural identity associated with livelihood change from 'hunter-gathering agriculture' to ASM;
- Absence of income generating opportunities;
- Relocation to be closer to family who have already moved out of the area; and
- Appeal of migration to nearby French Guiana due to preferable social benefits regime and higher standard of living.

Corroborating evidence for this population change is available within the household survey where the results indicate that the majority (51%) of respondents stated that over the last five years the population of their community has decreased significantly and an additional 21.3% say that population has slightly decreased.

Figure 14-12 illustrates the perceived population change in each village in the Marowijne Area based on results from the household survey. The survey results suggest that some residents of Kiki Mofo, Langa Tabiki, and Loka Loka perceive that the population of their villages has increased; however, the majority of residents in all villages suggest that population has decreased.

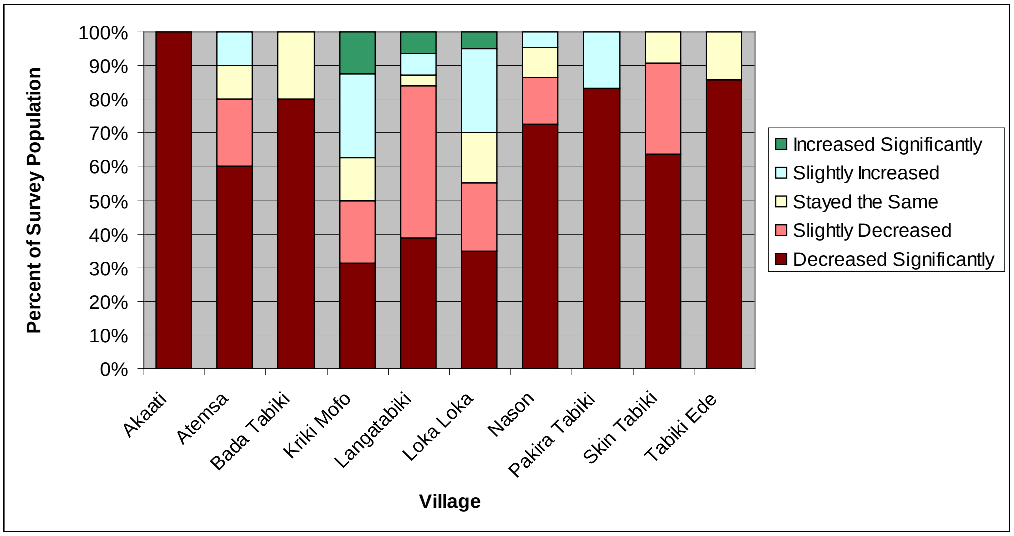



*Figure 14-12 Perceived Population Change in the Marowijne Area*

Results from Kiki Mofo corroborate the estimated population increase demonstrated in Table 14-7 and Figure 14-11. A comparatively higher percentage of respondents in Langa Tabiki indicate a significant increase may be explained by the villages' relative proximity to the Project and the ASM camps in the Project Area and along the road from Langa Tabiki to the Project camp.

The household survey results indicate that the majority of households in the Marowijne Area have resided in their 'home village' for their entire lives. Figure 14-13 demonstrates the length of residency of households within the Marowijne Area.

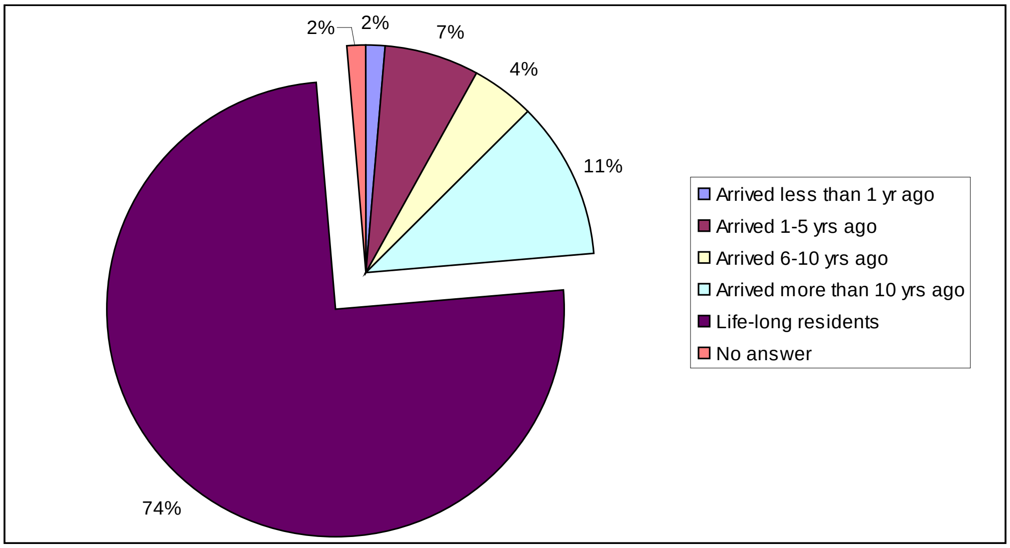



*Figure 14-13 Length of Residency within the Marowijne Area*

An estimated 74% of the total population reported they were originally from the communities where they currently live. Figure 14-13 illustrates that only a small number of households (9%) have moved to their current residences within the last five years. Most of these households reported that they relocated from within the region from other Pamaka villages, indicating that there is very little in-migration of outsiders into the villages.

Although a large majority of households reported that they were 'year-round' residents in their village, anecdotal evidence indicates that some degree of seasonal or temporary migration is common, particularly of young men. Of the households who reported that the head of the household left their villages for three months or more in the last year, the most common causes for seasonal migration were employment (34%), education and employment (12%), and education only (12%). The distributions of these responses are demonstrated in Figure 14-14.

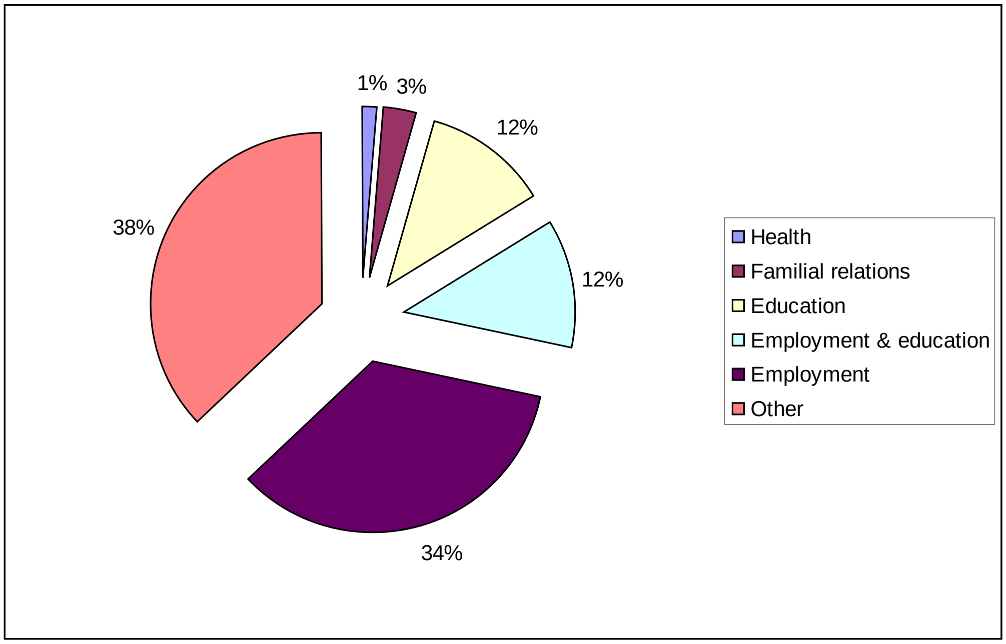



*Figure 14-14 Reported Causes for Seasonal Migration by Heads of Households*

It should be noted that the most common response was that there were multiple causes for seasonal migration, including ASM, forest activities, and visiting family in Paramaribo or French Guiana. According to the household survey the most common destinations for seasonal migration were elsewhere in Sipaliwini, Paramaribo, and French Guiana.

### *14.4.3 Education in the Marowijne Area*

*Education Infrastructure*

It was reported by stakeholders that educational infrastructure in the Marowijne Area is limited and an improved educational service was cited by many stakeholders as one of the key development needs in the area. Forty-five percent (45%) of respondents to the household survey stated that access to educational facilities are 'bad' or 'very bad,' while only 17% state that they are 'good' or 'very good'. Teachers and school directors reported that they consider the educational facilities inadequate and the lack of post-primary school education was cited as one of the key reasons that people leave the Marowijne Area.

There are currently three primary schools in the Marowijne Area located in Langa Tabiki, Nason, and Loka Loka. (See Table 14-8 for further details). The schools are run by the Monrovian church, the Catholic Church, and the government, respectively. The school in Loka Loka was built by the government and Surgold rebuilt three classrooms destroyed during the May- June 2006 flooding. Each school receives a government subsidy of SRD 10 (~ US $3) per child. Nationally all schools follow the same curriculum, which is set at a national level. The official graduation age from primary school is 11xvii; however, teachers interviewed in one school indicated that some students stay well beyond this age, in one case until the age of 18, due to academic shortcomings.

*Table 14-8 Education Facilities*

| Location | Administration | Type | Students | Graduates (2009) | Teachers | Annual tuition / fees |
|---|---|---|---|---|---|---|
| LangaTabiki | Roman Catholic Monrovian | Primary (K-6) | 93 | 11 | 4 | Tuition: 95 SRD<br><br>Fees: 6-12 SRD |
| Nason | Roman Catholic | Primary (K-6) | 104 | 3 | 6 | Tuition: 150 SRD<br><br>Fees: 25 SRD (boat) |
| Loka Loka | Public School | Primary (K-6) | 145 | 5 | 8 | Tuition: 15 SRD<br><br>Fees: 25 SRD (boat) |

Schools in the Marowijne Area were reported to underperform in comparison to schools in the capital. They are limited by funding for basic supplies or maintenance and have minimal access to resources such as computers, radio, or television. The school in Loka Loka has one computer lab with a dozen computers but due to lack of electricity supply these cannot be utilized. The three schools also have limited classroom space or accommodation for additional teachers. In addition, it is difficult to find and recruit qualified teachers that are willing to live and work in the interior.

Access to schools is difficult because none of the schools have adequate docking facilities and they are all affected by regular flooding. Women in Loka Loka reported that there are several months a year during which children cannot go to school because the river is too dangerous after heavy rain. They suggested that this was one of the reasons for high numbers of school failures.

Finally, language is a major challenge for schools in the study area; the official teaching language is Dutch, but students do not have any exposure to the Dutch language outside the classroom and teachers are generally poorly trained to teach students a second language.

There are no secondary schools, vocational training programs or adult education programs in the Marowijne Area. The nearest secondary school is located in Albina, a four-hour boat ride from Nason. For those who can afford it, the preferred option for secondary education is to go to Paramaribo, where students can either go to boarding school or stay with relatives.

Students from the Marowijne Area pursuing secondary education in the capital face significant challenges due to lack of support available for them when living away from home, comparatively lower levels of academic ability upon entering secondary school, and language and cultural barriers. It was reported that boys often drop out of education due to the appeal of generating income from odd-jobs around the capital or to join the small scale mining sector, while many girls drop out due to teenage pregnancy[32].

The Head of Interior Education indicated that there are no plans to alter the current education facilities in the study area. The decision not to build a secondary school is based on the low level of students graduating from primary school and difficulties faced in finding subject teachers that are qualified and willing to teach in the interior. There is a plan to build a boarding school in Albina, which would have the capacity to accommodate all secondary level students within a catchment area from Albina down to Loka Loka. Adequate government funding for such a project is not currently available.

Tuition fees are slightly lower in the Marowijne Area than in Moengo, at SRD 60 for primary and SRD 100-150 for secondary; all other education costs are similar. From 2010 the government has provided assistance with tuition fees, covering approximately 50% of the cost and donating SRD 28 (~ US $8.50) per year per child for school boat fees. Despite this payment it was stated during data collection that several parents in the area struggle to afford the costs associated with education, particularly at secondary level. With limited cash available from alternative sources, children must instead be sponsored by a family living in Paramaribo or Albina should they wish to pursue secondary education.

Surgold have begun to address the issue of access to education through support to the TANA Foundation to provide child tutoring and sponsorship of high performing students and schools in the area. Under the Surgold Scholar Program,

[32] A law was recently introduced to address the problem of teenage pregnancy, which states that pregnant students should stay in school.

six Pamaka students graduating from primary school will receive funding each year to continue into secondary school education. In the first year of the program, two students were selected by teachers from each Pamaka school district; Langa Tabiki, Loka Loka and Nason.

*Educational status*

Due to limited educational infrastructure and challenges facing students and parents, educational achievement in the Marowijne Area is extremely limited. Quantitative data from the household survey indicates that the literacy rate (defined as the proportion of individuals over the age of ten who can read and write) is 49% among households surveyed, compared to a national average of 95%, with higher literacy rates among the youth and lower rates among the adults and elderly. Only 12% of households in 2010 had a member with an education level to at least secondary level, and only 3% had a member who had reached junior college. This compares to a national average of 62.2% of the population that have attained education to secondary level or above.

The highest education level attained by any household member not currently enrolled in school is primary school for 61% of households surveyed, secondary schools for 9% and junior college for 3% (four individuals). In approximately 27% of households surveyed, all household members not currently enrolled in school have no formal education.

Household survey results indicate that the enrolment rate in the 10 villages in the study area is 87% (see Figure 14-24). School administrators, however, estimate that the enrolment rates among the total school age population in the study area are between 50-75%, less than the survey results indicate. The lower enrolment rates are confirmed by comparison of the first and sixth grade classes. In Loka Loka, for example, there were 32 students enrolled in the first grade in 2009 but only 5 in the sixth grade. Assuming the same total class size, this suggests the dropout rate throughout primary school is approximately 85%. The dropout rate is similar in the other two schools.

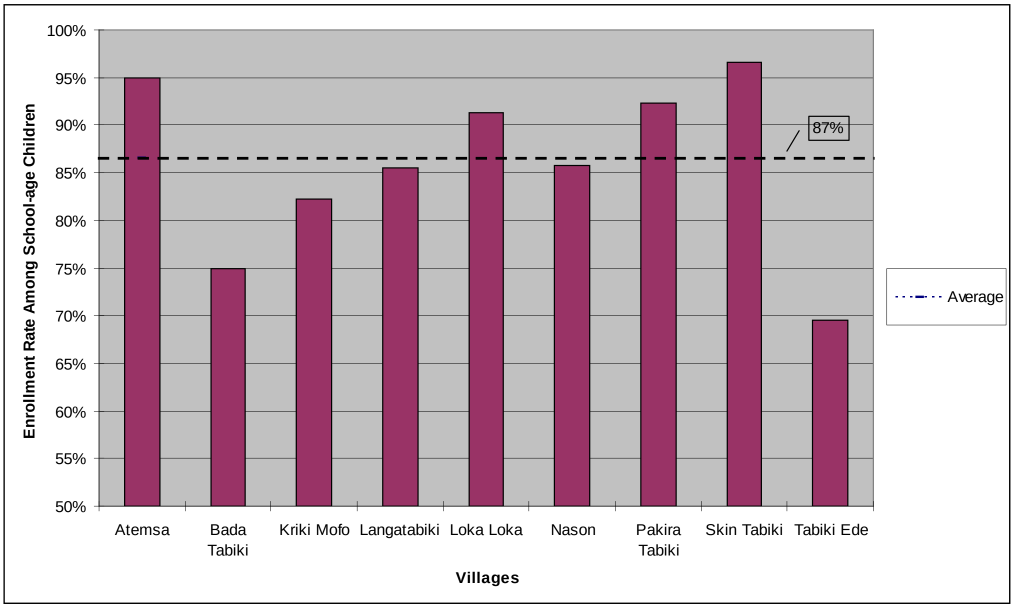



*Figure 14-15 Enrollment rate among school going age children*

Based on these assumptions, the enrolment rate among first year students is close to 100% and the dropout rate increases with each progressive year of schooling. According to the household survey, the primary reasons that school age children are not enrolled in school are the difficulties faced accessing educational facilities (12.5%), high cost of education (12.5%), need to work or help with family activities (6.2%), lack of interest (3.1%) and other reasons such as seasonal migration, health problems, disabilities, etc. (see Figure 14-16).

During stakeholder interviews it was noted that girls stay in education relatively longer than boys. While this is partly due to decreasing demands for girls to help with the household economy, the main reason was hypothesized to be the appeal for boys to leave education to begin working in the ASM sector.

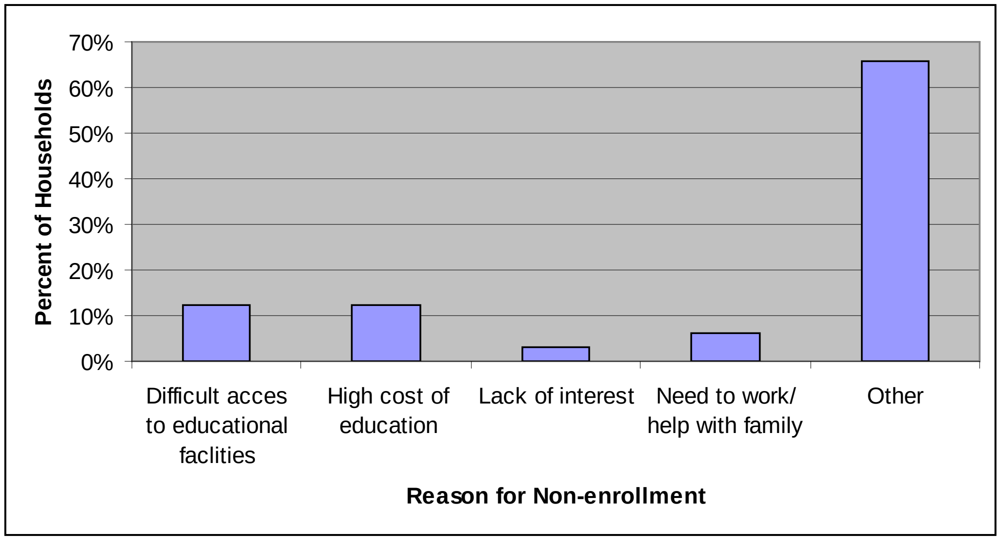



*Figure 14-16 Reason for non-enrollment*

Among the few students graduating primary school, very few children from these villages continue further education (post-elementary and / or technical schools) due to the challenges of cost, lack of support, and language and cultural barriers. Based on interviews held with teachers in Nason, of the approximately 19 students who graduated from the three primary schools in 2009, five enrolled in secondary school in Paramaribo or Albina, two enrolled in schools in French Guiana and two enrolled in technical schools.

The value placed on education was stated to be high during FGDs and the overall number of parents sending their children to school is said to be increasing due to greater awareness of the opportunities that education can provide. An education was also stated to be a means of increasing standing and influence within the community and educated community members are given greater input into village decision making.

During FGDs it was reported, however, that those who gain higher education seldom return to their village of origin because of the lack of opportunities for skilled workers. The practical value and economic advantage of higher education in the villages is, therefore, still perceived as low; teachers and local residents stated that there is no difference in the jobs available to educated and uneducated people in the village.

### *14.4.4 Marowijne Area Health Profile*

The following section summarizes the general health status and health services available in the Marowijne Area including the area surrounding the Project and the villages along the Marowijne River.

*Chronic Diseases*

Between 2009 and 2011, there were 14 deaths in the Marowijne Area. Among the top two causes of deaths were accidents and injuries (four deaths) and chronic diseases (five deaths), including malignancies (cancer), diabetes mellitus, and heart diseasexviii. Based on ERM's 2010 household survey in the Marowijne Area, high blood pressure, diabetes, and anemia were the top three self-reported chronic diseases.

Chronic diseases were reported to be a growing concern in the Marowijne Area. The health providers from the Nason and Langa Tabiki Medical Mission (MM) Clinics consider high blood pressure and diabetes as a growing health problem. High blood pressure was reported to be particularly common among men and women over 40, but the providers have diagnosed adults as young as 35 with the disease. It was reported that the Nason MM Clinic registers approximately 10 patients with diabetes each month. Figure 14-17 shows the reported chronic diseases in the Marowijne Area from the household survey.

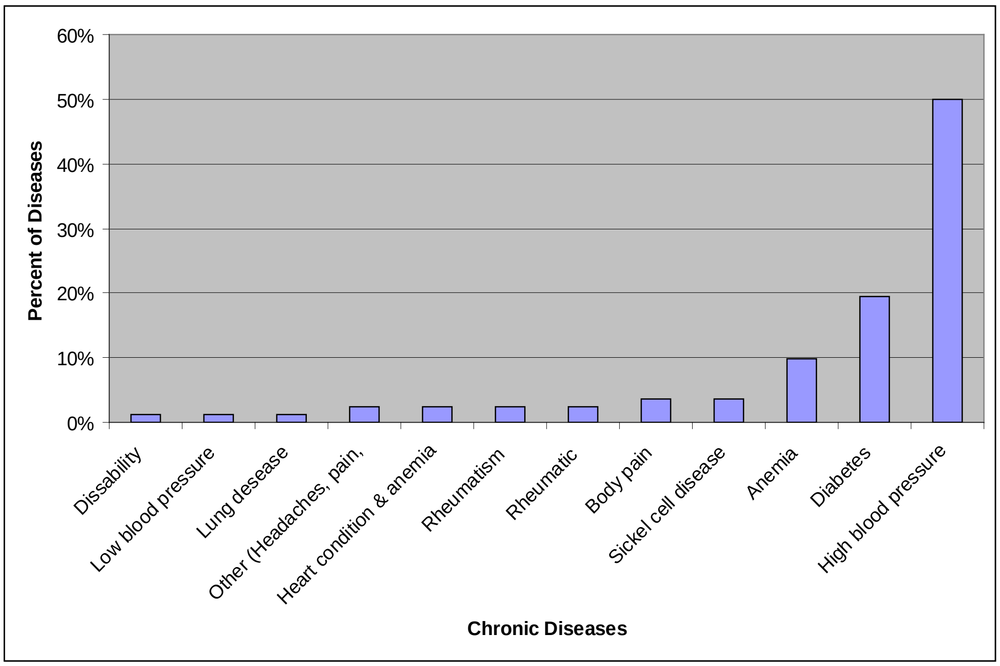



*Figure 14-17 Self-Reported Chronic Diseases in the Marowijne Area, 2010*

Although heart conditions were not a commonly reported health issue in the household survey, clinic admission records from the Langa Tabiki MM Clinic and the Nason MM Clinic indicate it is among the top four causes of morbidity in the area (see Table 14-9).

*Table 14-9 Main Causes of Morbidity in Nason, 2009-2010*

| **Nason (% of Clinic Admissions)** | **Langa Tabiki (% of Clinic Admissions)** |
|---|---|
| 1. Digestive tract diseases (21%) | 1. Digestive tract diseases (24%) |
| 2. Respiratory diseases (18%) | 2. Accidents and trauma (17%) |
| 3. Skin diseases (13%)<br>Cardiovascular (13%) | 3. Respiratory diseases (16%) |
| 4. Leishmaniasis (12%) | 4. Cardiovascular (14%) |
| 5. Nervous system diseases (10%) | 5. Skin diseases (13%) |
| 6. Accidents and trauma (7%) | 6. Leishmaniasis (8%) |
| 7. Urine and reproductive tract infections (4%) | 7. Nervous system diseases (5%) |
| 8. Other (2%) | 8. Other (2%) |
| | 9. Urine and reproductive tract infections (1%) |

*Water and Sanitation-Related Diseases*

Based on health records from the Medical Mission clinics, digestive tract diseases are most common causes of morbidity in the Marowijne Area, with respiratory diseases ranking second and third in Langa Tabiki and Nason, respectively (see Table 14-9). These infectious diseases are major causes of morbidity and mortality among young children in the interior. Leishmaniasis (a parasitic infection) is another common infectious disease in the Marowijne Area. Many of these infectious diseases are related to poor sanitary conditions and personal hygiene practices, as well as limited access to safe water sources. ERM's 2010 household survey found one of the main barriers to being and staying healthy in the Marowijne Area is the lack of clean drinking water. According to the health provider at the Nason MM Clinic, children tend to get diarrheal disease after drinking water from the local creeks and rivers, particularly during the periods of change from dry to rainy season. For the villages susceptible to regular flooding (three times a year between March to December), the clinic has observed spikes in illnesses (including diarrheal diseases) during the three-week long flooding periods. The heavy rains and flooding may free sewage backup and contaminate the water.

During ERM's 2010 household survey in the Marowijne Area, fever was the most common self-reported illness that affected about 40% of the households surveyed (see Figure 14-18). Fever can be attributed to various health conditions, particularly the seasonal flu that commonly occurs during the rainy season.

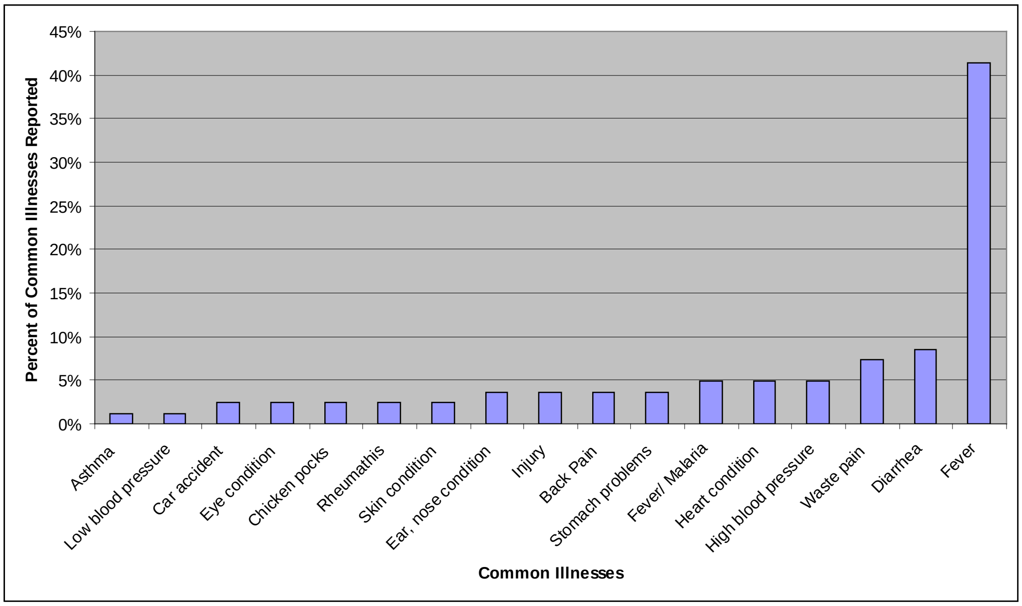



*Figure 14-18 Self-Reported Health Problems in the Marowijne Area, 2010*

*Sexually Transmitted Infections (STIs, including HIV/AIDS)*

The MM clinics do not consider sexually transmitted infections (STIs) including HIV/AIDS to be common among the service population, with a few cases of chlamydia reported in the past three years. However, the local prevalence of STIs (including HIV/AIDS) is difficult to ascertain given the lack of surveillance data on the local population. Both of the local MM clinics provide HIV testing, and the tests are sent to the central laboratory in Paramaribo for analysis. Any confirmed cases are treated in Paramaribo and test results are not shared with the local clinic.

Furthermore, the health records of the MM clinics do not capture the mobile population of foreign ASM miners and commercial sex workers since they typically do not access care there. Although the prevalence of STIs, including HIV/AIDS, of the ASM camp population is not known, it is expected based on examples of other small-scale mining camps and anecdotal evidence to be increasing in this high-risk population.

*Malaria*

It was reported during interviews with the Ministry of Health (MOH) Malaria program and during FGDs that malaria is no longer a major issue in the Pamaka villages following the success of the government's malaria control campaign in these villages. The last malaria case in Langa Tabiki area was recorded one year ago, whereas according to the Langa Tabiki MM Clinic three years ago the clinic had approximately 30 to 40 cases per day. It should be noted that the risk for malaria remains high. The transmission risk for malaria is associated with the movement of foreign ASM miners, particularly from Brazil and French Guiana. According to the MOH National Malaria Program, Brazilian gold miners may contract malaria during the journey through the forest from Brazil into Suriname. When infected, many of these foreign miners are believed to not access the local health clinics for proper treatment for malaria. Instead, they purchase Artecom at shops, which suppresses the symptoms, but does not clear the infection.

*Accidents and Injuries*

According to the Sipaliwini Police, which has jurisdiction over part of the road to Project, specifically from Pakira Kondre to the Marowijne River, traffic accidents are not common. There were no traffic accidents in 2011 and only a few small accidents in 2010; and no reports on traffic-related fatalities over the past couple of years.

Compared to Nason, accidents and trauma (injuries) appear to be more of an issue in Langa Tabiki, where it ranks second as a major cause of morbidity in the area. Based on interviews with the clinic in Langa Tabiki, children receive training about safety in school and there are occasional accidents involving children (mainly broken bones). Overall, accidents and trauma appear to have declined over the years as the population declined in the villages.

*Community Sense of Safety and Mental Well-Being*

According to the MM Pamaka Regional Manager, marijuana and alcohol use is increasing in the villages, particularly among young men. Related to substance abuse is the possible increase in psycho-social issues, such as increased aggression and conflict. Mental health conditions in the area are not well understood and the MM plans to begin monitoring mental health conditions in the future.

In the Marowijne Area it was stated during FGDs that residents have observed an increase in theft cases following the removal of ASM miners at the Project site by the Government of Suriname.

*Mercury Exposure*

According to local health workers, the local residents in the Marowijne Area are aware of the health risks associated with exposure to mercury. Furthermore, residents are aware that the Marowijne River is highly contaminated by mercury related to small-scale gold mining activities. While the local clinics are not able to diagnose or treat mercury poisoning, they report that multiple academic studies have confirmed high levels of mercury contamination in the region[xix].

*Medical Mission Health Clinics – Langa Tabiki and Nason*

The Medical Mission has two basic healthcare clinics located in Langa Tabiki and Nason (see Table 14-10 for details). All services are free of charge for registered citizens of Suriname. Non-citizens living in the area, such as Brazilian ASM miners, must pay a small fee for care.

*Table 14-10 Healthcare Facilities in Marowijne Area*

| Health Facility | Services | Service Population | Staff | Patient Visits per day |
|---|---|---|---|---|
| Langa Tabiki Medical Mission | Basic primary care, including maternal and child health, dental extractions, minor surgery (e.g., gunshot wound), vaccination, dispensary | < 900<br>Between Akaati at the North to Bada Tabiki in the south | 1 nurse<br>1 health assistant<br>1 on-call physician | 10 |
| Nason Medical Mission | Basic primary care. including maternal and child health, dental extractions, minor surgery (e.g., gunshot wound), vaccination, dispensary | < 600<br>Between Bada Tabiki at the North to the villages south of Loka Loka | 2 health assistants | 25 |

The services and facilities of both clinics are basic. The Langa Tabiki clinic is housed in a single structure with four rooms with two patient beds. The Nason Clinic is housed in a single structure with two beds (one for observation and one for prenatal care). The lack of hospital beds in the Langa Tabiki and Nason clinics present difficulties when large number of patients require overnight treatment (such as during infectious disease outbreaks).

Both clinics are equipped with limited diagnostic means (blood sugar, urine proteins, Sickle cell disease diagnostic, HIV 1&2 rapid diagnostic tests)[xx]. There is one health assistant at each clinic who is a trained microscopist who exclusively carries out malaria smear readings. If required, the nurse or health assistant at the clinics can receive advice from an on-call doctor by phone or radio. The recent expansion of the telecommunication coverage in the local area has improved the reliability of telemedicine.

For more serious injuries or ailments, the local population seek treatment in hospitals in Paramaribo (approximately 200 km from the Project area), or Saint Laurent, in French Guiana (four or five hours from the Marowijne Area by boat). The average time that local residents travel to reach the closest medical facility is 34 minutes.

Patients requiring treatment or services not offered by the local clinics are referred to the Medical Mission's Diakonessenhuis Hospital in Paramaribo. In cases of emergencies or critical injures patients may be transported by family or friends to more advanced medical facilities in French Guiana. As with other parts of the interior, the logistics for emergency transport of a patient out of the Marowijne Area are difficult and very expensive.

The number of users of the MM clinics is believed to be substantially less than the number of registered residents. Many of the registered persons no longer live in the area and may have moved to Paramaribo and French Guiana, where they can access health services more freely.

Although both clinics have adequate prenatal care, very few local residents chose to give birth at the local clinic, and prefer to go to Saint Laurent, Albina, or other areas of French Guiana. There is a strong tendency to use the health facilities in French Guiana to deliver children as a means to secure French citizenship for the new-born, even if the parents are Surinamese citizens. Residents clearly state that the incentive for this is the financial benefits associated with the French social security system.

According to the household survey, the local clinic is the first choice for medical care for most of the respondents (84%), followed by self-medication (1%). Only a small number of households (1.5%) seek a spiritual or traditional healer as their first choice for care (see Figure 14-19).

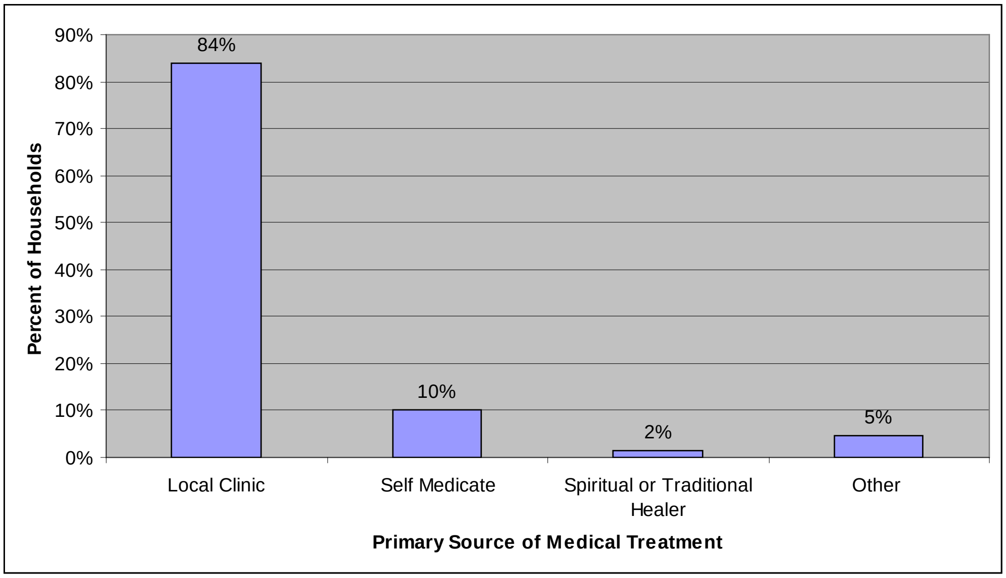



*Figure 14-19 Self-Reported Primary Source of Medical Care*

According to the household survey, many respondents are dissatisfied with the availability (47%) and the quality (39%) of the local healthcare services. With no public transportation in the area, certain residents may have difficulties accessing the local clinic, particularly for non-mobile residents (elderly and people with disabilities). If they do not own a boat, they have to wait for transport passing on the Marowijne River and / or pay a boatman to transport them to the clinic. As a result, many local villagers wait to go to the doctor until their condition is critical. According to the household survey, this lack of adequate medical facilities is among the most significant barriers to being healthy and staying healthy.

*Traditional Healing Practices*

In addition to healthcare provided by clinics and hospitals, the Maroon population also relies on traditional medicine. Most residents stated during FGDs that they were aware of ancestral knowledge of medicinal plants and gather them in the forest. Additionally, the local population stated that they visit the traditional healer in Kiki Mofo to receive traditional treatments.

There is a traditional healer in Kiki Mofo who serves all of the Marowijne Area. The traditional healer is believed to hold magical powers and was reported to be able to cure a series of health issues that formal medicine struggles to rectify. These include HIV / AIDS, complications during pregnancy, and issues related to unsuccessful fertility. Figure 14-20 show a focus group in Kiki Mofo in which the traditional healer (second from right) participated.

*Figure 14-20 Focus Group in Kiki Mofo*

Although it was mentioned that he is the only Pamaka traditional healer who has mystical healing powers, most Pamaka people retain a pragmatic rudimentary knowledge of traditional healing techniques, including specific herbs and products to treat common ailments. Residents suggest that some plants and herbs are only available deep within the forest or on top of the Plateau, but more concrete data regarding types of plants or locations was not offered.

### 14.4.5 *Social Infrastructure, Resources and Services in the Marowijne Area*

Social infrastructure and access to basic services, such as potable water, electricity, sanitation, and telecommunications, is very limited in the Marowijne Area. There are also limited emergency services, few recreational facilities and few active community based groups or associations. Table 14-11 summarizes the levels of social infrastructure and services available in the 10 Pamaka villages.

*Table 14-11 Summary of Marowijne Area Infrastructure*

| Village | PRIMARY SCHOOL | POTABLE WATER | PUBLIC SANITATION SYSTEM | COMMUNITY ELECTRICITY | | IMPROVED DOCK | AGRIC. EXTENSION | POSTAL AGENCY | POLICE STATION | MARKET | HEALTH CLINIC | GUEST HOUSE/TOURIST RESORT | CHURCH BUILDING | SHOPS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Akaati | | | | X | X | | | | | | | | | |
| Bada Tabiki | | | | X | X | | | | | | | | | |
| Tabiki Ede | | | | X | | | | | | | | | | |
| Pakira Tabiki | | | | X | | | | | | | | | | |
| Langa Tabiki | 1 | | | X | X | X | | | | | X | | X | ~5 |
| Nason | 1 | | | X | | | | | | | X | | X | ~5 |
| Kiki Mofo | | | | X | | | | | | | | | X | |
| Skin Tabiki | | | | X | | | | | | | | | | |

| Village | PRIMARY SCHOOL | POTABLE WATER | PUBLIC SANITATION SYSTEM | COMMUNITY ELECTRICITY | | IMPROVED DOCK | AGRIC. EXTENSION | POSTAL AGENCY | POLICE STATION | MARKET | HEALTH CLINIC | GUEST HOUSE/TOURIST RESORT | CHURCH BUILDING | SHOPS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Atemsa | | | | X | | | | | | | | X | X | |
| Loka Loka | 1 | | | X | | | | | | | | | X | ~4 |
| Sneis Kondre | | | | | | | | | X | | | | | ~2 |

*Water and Sanitation*

None of the households in the Marowijne Area have access to piped water. According to the results of the household survey, 64.2 % of households use a combination of rainwater, river and creek water as their primary source of water for drinking and cooking. The remaining 33.6% use rainwater as their primary water source, 1.5% use only creek water, and 0.7% use only river water (see Figure 14-21).

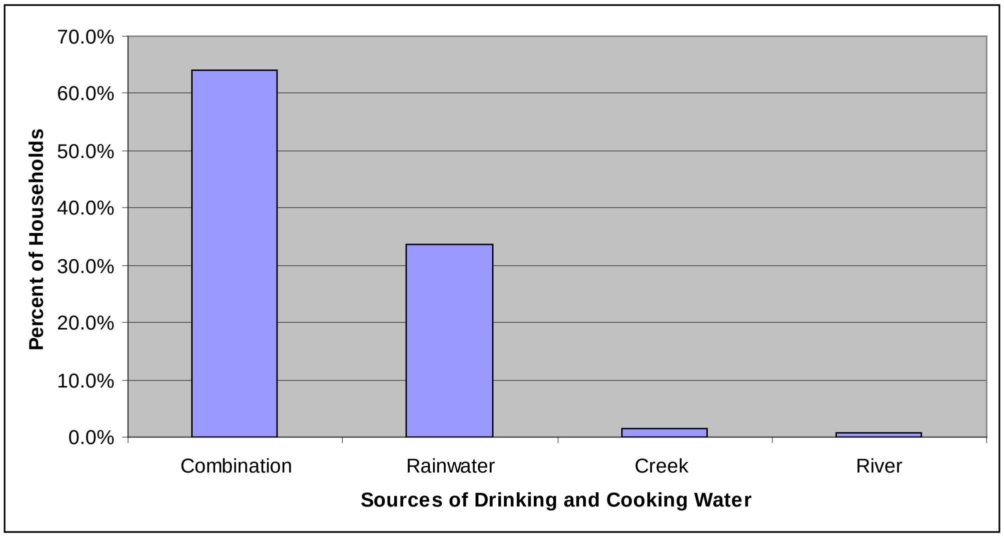



*Figure 14-21 Primary Sources of Drinking and Cooking Water*

According to the World Bank's World Development Indicators (WDI), 'access to improved water sources' refers to:

*"reasonable access to an adequate amount of water from an improved source, such as a household connection, public standpipe, borehole, protected well or spring, and rainwater collection"*[xxi]

Based on this definition, 73% of the rural population in Suriname has access to an improved source of water.[xxii] Survey results indicate that 98% of survey respondents in the local study area have access to some form of rainwater collection system, and therefore have 'access to an improved water source'. However, rainwater collection systems are very basic and rainwater is not purified in any way. In addition, several respondents during FGDs commented that access to clean water is a problem during the dry season. Figure 14-22 shows a typical rainwater collection system in Kiki Mofo.

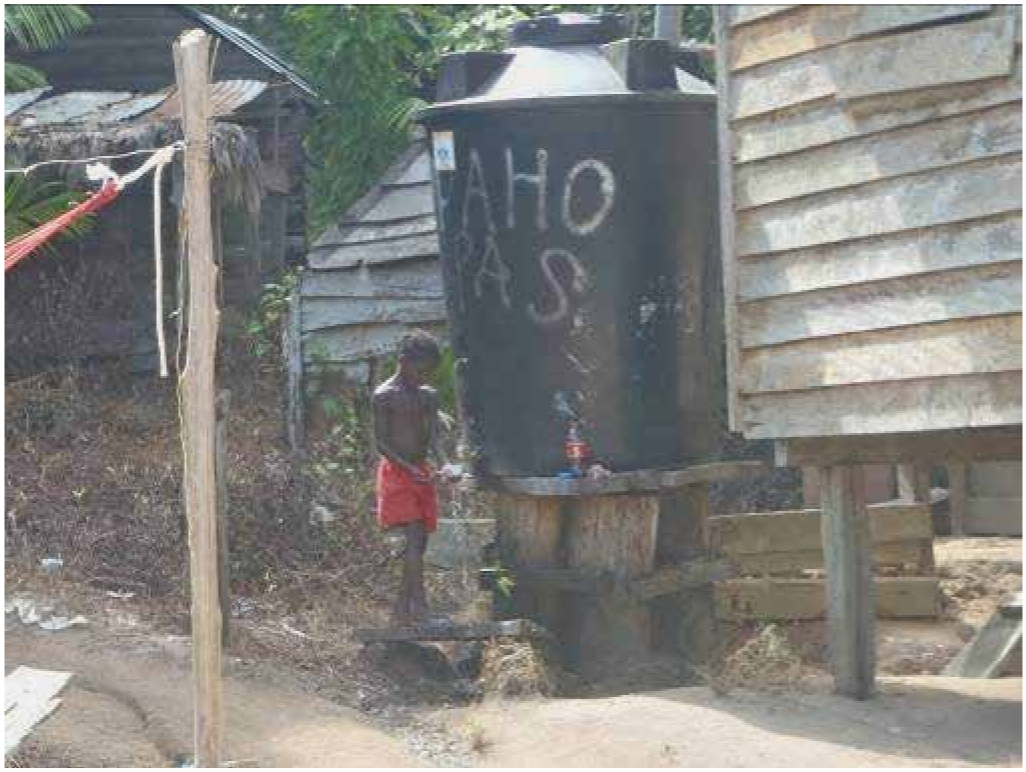


*Figure 14-22 Water Collection in Kiki Mofo*

During FGDs many residents reported that they rely on water from local creeks (usually in French Guiana) and the Marowijne River for cooking and washing. However, it was noted that a considerable number of creeks are not suitable for human consumption due to pollution from ASM activities. In addition, it was mentioned that many of the creeks are seasonal and run dry during the dry seasons. Figure 14-23 shows a map of water sources highlighted during data collection and indications as to their potability and/ or contamination.

Both subsistence and income-generating activities in the Marowijne Area are highly dependent on the waterways in the area. The rivers and creeks are also used for fishing, hunting, transport, ASM, access to agricultural fields, bathing, and washing.

Several creeks are also important sites of cultural heritage and are considered sacred by the Pamaka people. This is discussed in greater detail in section 14.8

No households reported using any form of water purification prior to drinking or cooking with river and creek water and they are, therefore, highly dependent on rainwater and clean water from local creeks, typically those in the foothills of the Nassau Plateau.

*Figure 14-23 Marowijne Creeks*

There is no public sanitation infrastructure in any of the villages in the region. The most common sanitation facilities in the villages are basic outhouses. 44.1% of households respondents indicated in the survey that they utilize outhouses, 15.4% use the river or creek, 12.5% use open pits or holes, 5.9% have access to flush toilets and septic systems, 3.7% have no access to sanitation facilities, and the remaining households use a combination of the above mentioned facilities (see Figure 14-24).

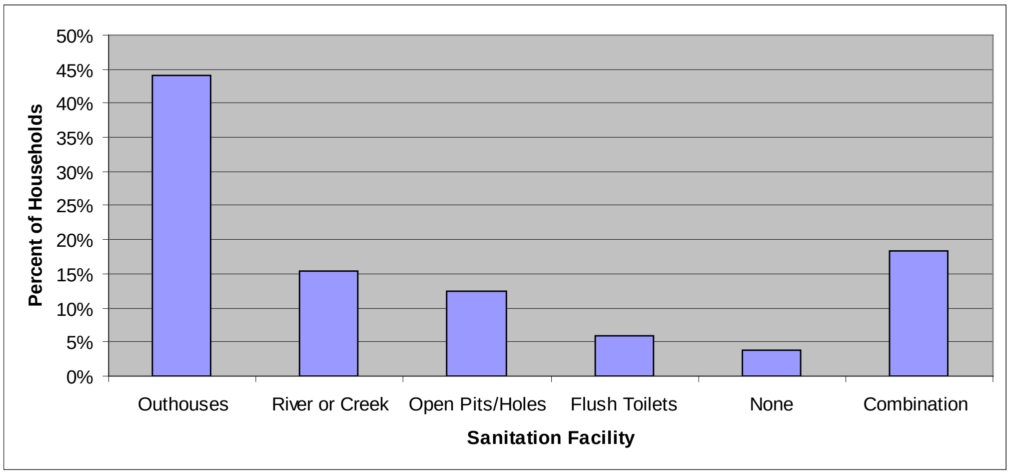



*Figure 14-24 Access to Sanitation Facilities in the Marowijne Area*

*Electricity*

Each village in the study area apart from Akaati has a village-level electrical generator and grid, which is provided by the Government. Approximately 72% of all households surveyed are connected to the village electric system, 24% have no electricity, and approximately 2% have their own generator (2% did not respond).

Figure 14-25 indicates the source of electricity for each of the villages in the study area. One hundred percent (100%) of household survey respondents in Bada Tabiki, Kiki Mofo, and Nason are connected to the village electrical grid. The villages with the highest percentage of households not connected to the village electrical grid include Tabiki Ede (38% with no electricity), Atemsa (30%), Langa Tabiki (25%), and Pakira Tabiki (17%).

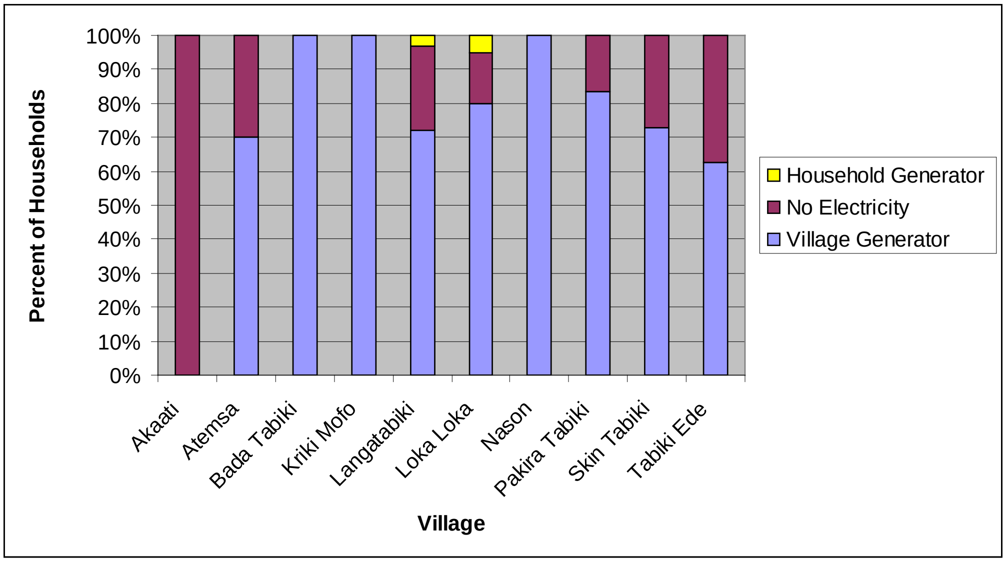



*Figure 14-25 Source of Electricity in the Marowijne Area*

The electricity grid is powered exclusively by diesel generators. Fuel to power the generators is supplied by the government. Each village is supposed to receive between five and 10 barrels of fuel on a bi-monthly basis; however, it was reported that this supply is not regular and only allows for a few hours of power generation per day, usually between six and 10 pm. During FGDs, participants stated that this is inadequate and they would prefer a constant reliable power supply specifically for certain cultural events such as funeral ceremonies. During power shortages the majority of households reported that they rely on kerosene lamps for lighting.

The lack of a good electricity supply was cited as a critical issue in multiple villages and was listed amongst the key reasons that people do not want to stay in the area. It was reported that there has been minimal effort from the government to address this issue and the fuel they supply for diesel generators was irregular and unreliable. In Pakira Tabiki, for example, residents decided to purchase their own generator using profits from ASM after repeated requests to the government failed. The village reported that they maintained the generator and purchased their own fuel for four years before receiving any support from the government.

*Communication*

Communication infrastructure is limited in the Marowijne Area. There is no land line telephone and the cellular phone connection to the Telesur, Digicel, and Uniqual networks are irregular and unreliable. Although the cellular phone reception is unreliable it is available throughout the Upper and Lower Pamaka regions. The villages also receive radio signal and satellite TV reception and there is some use of CB radios.

While some residents have cellular phones, very few have televisions, computers or other electrical items; inhibiting fast communication of news and events throughout the Marowijne Area. The lack of communications was stated to be a significant issue during FGDs and the household survey; 88% of residents state that the quality and availability of telecommunications is 'bad' or 'very bad;' only 12% state that it is satisfactory or more. Teachers and village leaders suggested during FGDs that the lack of communications has a negative effect on the education status of the region as students without access to news and information are not able to answer current events and Surinamese culture questions, which are part of the national standardized testing. Health staff also commented that lack of adequate IT facilities makes it more cumbersome to register patients and to keep good and updated medical records.

*Transportation*

The primary means of transportation in the Marowijne Area is dugout canoe powered by outboard motors. Besides river transport, the main access out of the area is via road from the docks opposite Langa Tabiki, and in Snesi Kondre, which leads to the Langa Tabiki Road. There is also an airstrip in Langa Tabiki, which can be used to airlift patients to hospitals in a medical emergency but is rarely used otherwise.

The main transportation requirements in the Marowijne Area are for daily commuting of women to agricultural fields, for men to go fishing or hunting, for children to go to school, and for journeys to seek medical care at one of the clinics.

There is no public transportation within the Marowijne Area. Private boat owners are hired to transport people and goods within the region. Transport to and from Albina costs approximately SRD 250 (~US $75) or payment in kind, i.e., fresh produce or gasoline. The three schools in the study area each have a boat to transport school children at a fee of approximately SRD 2.50 (~ US $0.80) per month per person.

Fuel supplies to the area are limited and locating and obtaining adequate fuel for a boat journey can often be a challenge and cause severe delays. Fuel is often bought from Moengo or Albina and driven into the Marowijne Area although it is available in a series of small shops along the river. It was reported that the prices of fuel locally fluctuates frequently but that it is considerably more expensive than in Paramaribo. It was reported that male Captains also receive three barrels of fuel every three months from the GoS. This is intended for journeys to meet with the Gaanman and the rest of the Traditional Authority, but it was claimed the men use the fuel for their own purposes.

The only improved (concrete) docks are located in Langa Tabiki, Snesi Kondre, and the health clinic in Nason. A new dock is also being built by the residents of Tabiki Ede; however, during data collection it was yet to be complete. The majority of docks consist of makeshift wooden stairways, tree roots, or designated areas on the riverbank. There are no adequate docks at any of the three schools in the region.

According to respondents to the household survey public perception of the adequacy of local and regional transportation facilities in the study area is very low; 64% of households surveyed state that local transportation facilities are 'bad' or 'very bad,' and 79% consider regional transportation to be 'bad' or 'very bad.' Only 36% of households state that local transportation is more than satisfactory.

Difficulties accessing transport was cited during FGDs as a problem for residents in the area, particularly for the elderly, women and children, who typically rely on men for boat transportation. The residents of Akaati (two male and one female, all elderly) noted that difficulties accessing transportation accounted for poor communications with other villages. Women in Loka Loka also claimed that during previous public meetings hosted by Surgold, women were excluded from attending because they did not receive any boat engine fuel and the men refused to transport them without payment. Several women in the study area also noted during women's FGDs that difficulties accessing transport caused problems in emergency situations. Similarly, the doctor in Nason stated that poor transportation infrastructure limits the provision of health service in the area as he does not have any means of visiting patients in their villages. The lack of affordable transport infrastructure was cited as inhibiting entrepreneurial activities, limiting for example the potential for women to sell excess agricultural produce outside the village or in markets.

River transportation is, however, an important driver to the local economy, driven mainly by the demand for supply and transportation of materials for the small-scale mining sector. Large canoes, sometimes joined together to form pontoons, are regularly seen transporting fuel, machinery, and even cars and construction equipment up and down the Marowijne River.

It was stated that boats are also seen as a status symbol in the area and profits from the ASM industry have previously been used to buy bigger, more powerful boats.

*Emergency Services*

There are no structured emergency services in the Marowijne Area. There are two police officers stationed in an outpost in Snesi Kondre, who are supported by eight military personnel, covering the western border area of the Sipalawini Region. These personnel are provided by central administration in Paramaribo and are assigned to the area for two month periods. They deal mainly with surveillance of the ASM sector but can also intervene in village issues if requested to do so by the traditional authority. This usually happens in cases of theft and in serious cases of violence.

The health clinics in Nason and Langa Tabiki are available twenty-four hours a day to deal with minor emergencies. However, as mentioned above, due to lack of transportation patients must be taken either to the clinic or to pick up a health assistant to visit a patient. For medical cases that cannot be dealt with locally, the medical mission is contacted and asked to send a plane for the patient to be evacuated to Paramaribo from the airstrip in Langa Tabiki.

Responses to large-scale emergencies such as the flooding that occurred in 2006 and 2008 are managed in partnership with the Surinamese Government, through the National Coordination Centre for Disaster Management, and several donor agencies and relief organizations.

*Commercial Infrastructure*

The commercial infrastructure in the Marowijne Area is limited to a number of small stores selling basic foodstuffs and household goods. Langa Tabiki, Nason, and Loka Loka each have approximately five small stores. There is also one bakery in Nason. Commercial infrastructure in other villages is limited to the sale of basic goods from a room of a house or shed rather than a designated store. The largest store in the study area is located across from Nason near the Health Clinic. It is run by Chinese owners and caters to the needs of Brazilian ASM miners. Local residents state that high prices deter them from patronizing the store. During FGDs residents stated that prices in the area are considerably higher than elsewhere in Suriname due to costs associated with the transport of materials to the Marowijne Area.

There are no designated agricultural markets in the region. Agricultural produce is either sold to boatmen on an ad hoc basis, or transported to Albina, Paramaribo, or French Guyana for sale. Residents suggest that the lack of adequate market facilities is a significant deterrent to the development of a more productive agricultural sector.

*Recreational Infrastructure*

The Marowijne River is used for recreational swimming, but other recreational facilities are very limited. The schools in Nason and Langa Tabiki have no recreational facilities.

Residents mention the lack of recreational facilities as a weakness of their communities. In the household survey, the majority of residents (52%) stated they are dissatisfied with the availability of recreational activities in the area, while only 48% state that recreational facilities are satisfactory or better. In the absence of healthy recreational activities, it could be hypothesised that there is more of a tendency towards substance abuse

Before the last general election, some of the national political parties built a permanent shed structure in several of the villages, which can be used for village meetings and gatherings.

*Natural Resources*

The natural resources supplied by the forests and waterways in the Marowijne Area are of central importance to both the livelihoods and the cultural identity of the Pamaka people.

It was stated during FGDs that in the past the Pamaka people could live off the forest. More recently, however, the availability, quality of and access to these resources (wild foods, game etc.) have reportedly deteriorated markedly. These changes were perceived to be caused by a combination of factors including increased pollution from ASM activities; climate change causing increased flooding; increased human presence in the area; and the arrival of industrial mining companies (Surgold and Suralco). Reduced productivity of hunting and fishing activities was reported to have made people more dependent on bought foodstuffs and, therefore, more reliant on cash-based livelihood activities.

Forests and the natural resources within them are described by local residents as their 'supermarket.' The forest is used for hunting, clearing agricultural fields, collecting Non Timber Forest Products (NTFPs), firewood, and timber for house and boat construction. Non Timber Forest Products are collected from the forest, typically between 1-5 km from the point of entry, on a daily basis, however, it was reported that NTFPs are no longer readily available close to inhabited areas. NTFPs frequently collected include fruits such as *patawa* and *comoe*, and medicinal plants and herbs. Knowledge of the location and uses of these products is passed between generations but is not shared with outsiders. Loss of this knowledge is a concern to Pamaka participants who participated in FGDs, particularly due perceived fears that the presence of Suralco and Surgold will result in loss of access to certain parts of the forest.

> *'The things we have lost are much more than minerals – we have lost all herbs and woods in the forest too. The company will take all the knowledge about herbs but won't pay for the forest.'*
>
> - Elderly lady, Atemsa

Hunting typically occurs within 5-10 km from the point of entry into the forest. On designated hunting trips, however, this may range up to a distance of two days walking or more into the interior of the forest west of the Marowijne River and the Nassau Mountain area. During FGDs several villagers reported that restricted access to the forest has affected hunting activities. A story about a man that was removed by the police and military from the Merian Industrial Zone for carrying a shotgun was cited several times as proof for this. People could not understand why he was removed, although it a was a straightforward health and safety decision by Surgold made to prevent any accidents;

'*for the Pamaka people, carrying a shotgun is a must when entering the forest*' - elderly man, Bada Tabiki

The use of rivers and creeks for fishing was reported to be less productive in recent times, particularly in the Marowijne River. This is thought to be due primarily to pollution from ASM.

There were also some claims that in addition to overall depletion of fish stock in the rivers and creeks, certain types of fish such as 'kumalu' could no longer be found in the river.

During the data collection participants were asked to rank the relative importance of natural resources. The activity was conducted separately with groups of men and women to determine any difference in importance. The resource importance matrix demonstrates that despite the increased demand and reliance on purchased processed foodstuff, all natural resources and activities derived from natural resources are perceived to be of the utmost importance to both men and women.The local population view access to the natural resources in the area as a significant aspect of what it means to live freely. Any restrictions on this access, whether perceived or actual and regardless of scale, are seen as disturbing their traditional way of life and identity;

> "*If Surgold takes away the forest from the Pamaka people we will not survive.*"
> -Elderly man, Akaati.

In extreme cases, some respondents in FGDs stated that the loss of access to the forest could be perceived as an attempt to enslave the Pamaka people again (*Chapter 14.1.2)*.

*Community Groups and Associations*

Apart from religious associations, very few active community groups or associations exist within the Marowijne Area. Local stakeholders recognize the absence of a strong community organization that could represent the collective opinion of the Pamaka people to the government and mining companies as a significant weakness.

> '*The company is willing to negotiate with the Pamaka people, but the people themselves do not stand in unity.*'
> Male, Atemsa

Attempts have been made by Surgold to address this issue by creating, with the cooperation of Gaanman Levy (the previous Gaanman), a Community Platform and with the cooperation of Gaanman Forster, an ASM Commission. The specific foci of these organizations were to improve the stakeholder engagement and social investment process and to discuss the issue of ASM respectively. To date, neither organization exists.

*Community Platform*

The Community Platform was set up in March 2008 and met regularly until December 2009, when it didn't meet for 8 months, until it reconvened again in September 2010. It has not met regularly since then, with the most recent meeting in October 2010. The Platform was formed from representatives of the Pamaka villages and other relevant stakeholders as outlined in *Box 14-1*.

*Box 14-1 Platform Members*

The Platform includes:

- Male and Female representatives of all Pamaka villages;
- Representatives of the Entrepreneurs Group;
- Representatives of the church;
- The Overseers;
- Local NGOs and Community Based Organizations (CBOs) including Anamakani and the traditional authority);
- Teachers from the three schools in Loka Loka, Nason and Langa Tabiki;
- Three representatives of the Women's Federation; and
- Representatives from the Youth Federation.


*Figure 14-26 Platform Meeting in October 2010*

*Development Organizations*

There are almost no active development organizations in the Marowijne Area. Efforts are underway to identify and engage development organizations and non-governmental organizations as potential partners in Surgold's community development initiatives.

### *14.4.6 Cultural Heritage in the Marowijne Area*

*Social History*

There is very little historical information available on the foundation of the Pamaka, however, according to oral tradition, the group originated from escaped slaves from the Commewijne and Tempati area and manifested themselves as a group with their own identity around 1830. It was reported that while fleeing from slave masters, the ancestors of the Pamaka hid in and around the Nassau Mountains and the creeks in the vicinity. From there the ancestors travelled down the Nassau Mountains along Pamaka Creek before they settled along the Marowijne River. From a strategic point of view, the islands of the Marowijne River were the ideal location of the first villages in that area; providing an extended line of sight and therefore advanced warning if enemies were approaching. These oral traditions report Nason to be the first Pamaka settlement that is still standing.

It has been reported that Pamaka first contact with the colonial government was made in 1871, when a group led by the Captain Frans Kwaku journeyed to Paramaribo. Contact steadily increased and Petrus Apensa of the Antoosi *Loh* (clan), who inherited the title of Captain in 1881, was recognized by the colonial government and pronounced Gaanman (Paramount Chief) in 1901.

Since the 1800s, the Gaanman and Pamaka people have been at peace with the government and agreed to provide free access to missionaries seeking to carry out religious activities and teaching. In 1896, the Moravian Church baptized Gaanman Apensa, and Langa Tabiki received a teacher and evangelist from the Moravian Church.

Gaanman Apensa died in 1923 and was succeeded by Gaanman Abunawooko (deceased in 1947), who paired Catholicism with traditional African and Pamaka beliefs.

*Sacred Sites*

During data collection, several areas were identified as being of particular cultural, traditional, and socio-economic significance to the Pamaka community. These include:

- The Gran Creek: a sacred site of traditional ceremonial and mystical value;
- The Nassau Plateau: a sacred site associated with the ancestral spirits and the origins of the Pamaka people;
- The village of Kiki Mofo: the first place where the Pamaka ancestors arrived after leaving Nassau. Kiki Mofo is a new village, but is recognized as representative of the first village of the Pamaka people; and
- Pamaka Creek: a sacred site due to its proximity to the traditional Pamaka cemetery; Figure 14-27 indicates the approximate locations of these sites within the Marowijne Area.

*Figure 14-27 Pamaka Cultural Heritage Sites*

Pamaka Creek and its tributaries, including the entire Nassau Plateau area, were reported to be of emotional and cultural significance to the Pamaka Tribe because of the historical connection with their ancestors' escape from slavery. The Nassau Plateau was reported to be one of the first sites that escaped slaves came to in the area before they moved down the Pamaka Creek to the islands on the Marowijne River

The confluence of the Pamaka Creek and the Marowijne was also mentioned as a sacred site of religious importance as it is the site of the cemetery, which continues to be used by all Pamaka communities. This cemetery was one of the first established Pamaka sites and was reported to be sacred to the community.

There is anecdotal evidence that the Pamaka people hold spiritual beliefs surrounding the forest and the presence of forest spirits. Although it is not often openly discussed it was reported that the Pamaka traditional beliefs esteem the forest for its integrated spiritual (as well as economic and subsistence) value as home to these forest spirits.

In the Maroon societies (including Pamaka groups in the Marowijne Area and Saramaka groups in the Tempati and Commewijne area), ancestor worship was reported to be a significant spiritual belief and commonly held. Each clan, lineage, or extended family typically has its own religious shrines, and may have a special relationship to one or more spirits. These spirits are typically honored with 'sacrifices' of alcohol or food; overproof rum can be seen surrounding the base of the shrine.

This linkage and reverence to the ancestors is also the driver for spirituality associated with Maroon lands and natural resources. The concept of ancestor encompasses spiritual knowledge in the past, present and future. Ancestor explains all life, the connections between people, land and spirit, and is expressed as a continuing journey of growth and learning. There are always more secrets and special knowledge to gain within traditional Maroon beliefs as one grows older.

The ancestors carry the responsibility to protect and preserve the spirit of the tribal group and the life forms that are part of it. These ancestors influence codes of behavior, law, family structure, sacred duties, and responsibilities.

Maroons regard land as sacred,. Different groups have different specific beliefs but they all share in the common belief that their ancestors created the environment around them. The traditional Maroons' belief system stipulates that the land is alive with the power of Ancestors who live (buried) in it. As long as the forest and the land live, so do the Ancestors, and therefore the land is the core of all spirituality.

### 14.4.7 *Marowijne Area Livelihoods and Socio-Economics*

During the data collection process, it was stated on several occasions that opportunities to generate income in the area are limited. Subsistence agriculture appears to be widespread, with excess produce sold in local markets; however, other livelihoods and income generating activities are fairly limited. ASM was mentioned as the only and most significant opportunity to generate income and was mentioned as being the most viable activity for approximately the last 100 years. Other economic activities mentioned or witnessed include lumber harvesting, small-scale trading, and boat transportation; however, these were not widespread.

According to the results of the household survey the primary occupations among households in the Marowijne Area include subsistence and non-subsistence agriculture, ASM, fishing, forestry, hunting, formal employment (as teachers, health workers or mining company employees), and other sources of temporary, informal paid labor. Figure 14-28 shows the distribution of primary occupation of households.

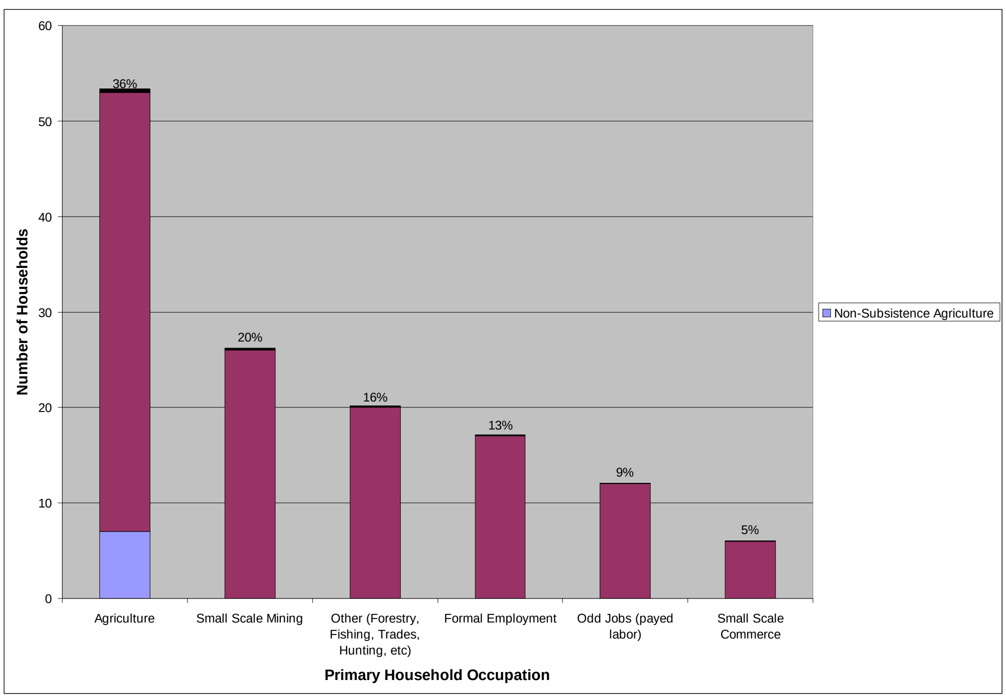



*Figure 14-28 Primary Occupation of Households within the Marowijne Area*

Agricultural activities (both subsistence and non-subsistence) were reported to be the primary occupation of 36.2% of households surveyed. Despite this large prevalence of agriculture as a livelihood activity only 5.6% of the respondents indicated that this agriculture was non-subsistence. Small-scale mining or ASM was reported to be the second most common primary occupation, representing 20.5% of households surveyed. A significant number of households stated they consider their primary occupation to be multiple 'odd jobs,' understood to mean any type of informal paid labor including transportation services or other temporary or irregular sources of employment.

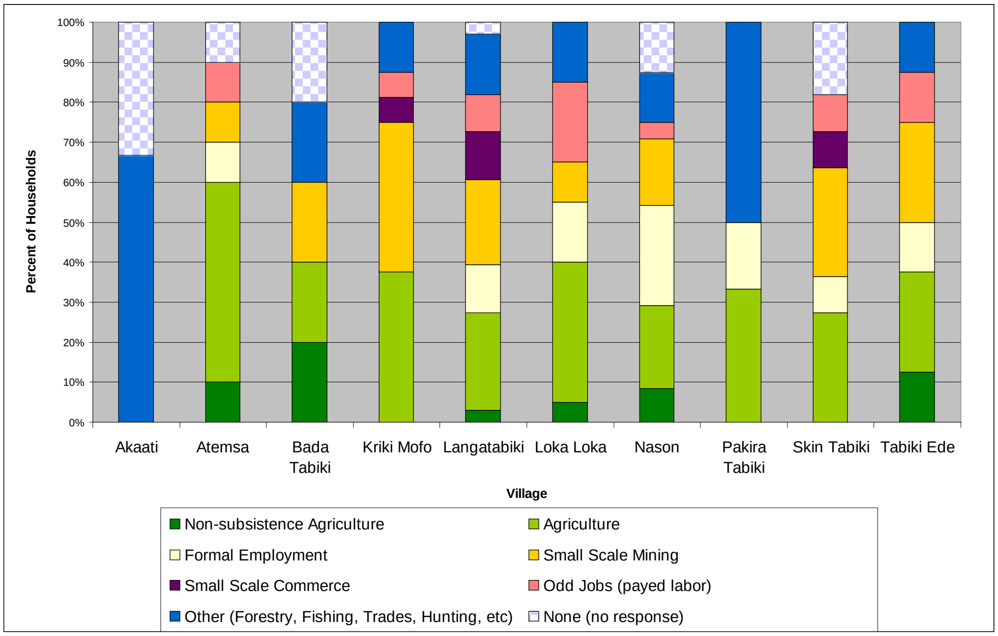



*Figure 14-29 Primary Household Occupation Distribution by Village in the Marowijne Area*

As indicated in Figure 14-29, agriculture is a significant livelihood in every village except Akaati. This may be explained by the age of residents in the village who stated during a FGD that they were too old and infirm to work in the fields.

Formal employment was reported to be a more significant livelihood in the more populous villages of Nason (25%), Loka Loka (15%), and Langa Tabiki (12%), which may indicate that opportunities for income generation are more pronounced in larger settlements. This may be associated with the presence of education and health services, or simply that employers look to the larger villages for their workforce.

ASM is a significant occupation across all of the villages (excluding Akaati for reasons discussed), but particularly in Kiki Mofo (38%), Skin Tabiki (27%), and Tabiki Ede (25%). It was not evident why these villages particularly were focused on ASM; however, the high average involvement in ASM (21%) indicates that it is a common livelihood across the area. .

Small scale trading and commerce appears to be most common in Langa Tabiki (12%), which is corroborated by the number of shops evident in the village.

In addition to quantitative data collection surrounding primary occupations, qualitative information regarding perceived importance was also gathered through a livelihood importance matrix. Table 14-12 presents the results of the livelihood importance matrix, which ranks the relative importance of livelihoods according to voted results from men and women.

*Table 14-12 Marowijne Area Livelihood Importance Matrix*

| **Value to Household►**<br><br>**Activity ▼** | **Income** | **Subsistence Food** | **Household Products/ Uses** | **Cultural Value** | **Total** | **Combined Ranking** |
|---|---|---|---|---|---|---|
| Agriculture | | | | | | 2nd (34) |
| -men | 5 | 5 | 0 | 5 | 15 | |
| -women | 5 | 5 | 4 | 5 | 19 | |
| Animal Husbandry | | | | | | 4th (29) |
| -men | 3 | 3 | 0 | 5 | 11 | |
| -women | 3 | 5 | 5 | 5 | 18 | |
| Fishing | | | | | | 3rd (32) |
| -men | 5 | 5 | 0 | 4 | 14 | |
| -women | 4 | 5 | 4 | 5 | 18 | |
| Hunting | | | | | | 4th (29) |
| -men | 4 | 4 | 0 | 4 | 12 | |
| -women | 3 | 5 | 4 | 5 | 17 | |
| Small Scale Mining | | | | | | 6th (22) |
| -men | 5 | 3 | 0 | 0 | 8 | |
| -women | 5 | 5 | 4 | 0 | 14 | |
| Professional Labor | | | | | | 5th (28) |

| Value to Household► <br> Activity ▼ | Income | Subsistence Food | Household Products/ Uses | Cultural Value | Total | Combined Ranking |
|---|---|---|---|---|---|---|
| -men | 5 | 3 | 0 | 0 | 8 | |
| -women | 5 | 5 | 5 | 5 | 20 | |
| Collecting Forest Products (wood, herbs, etc) | | | | | | 1st (39) |
| -men | 5 | 4 | 5 | 5 | 19 | |
| -women | 5 | 5 | 5 | 5 | 20 | |

Table 14-12 indicates that collecting forest products including wood and NTFPs was ranked as the most important livelihood overall. The significance of the forest and collecting NTFPs was mentioned several times within FGDs as the primary source of cultural and subsistence 'survival'. The importance of collecting forest products is consistent with the local perception that the resources found in the forest could meet all the needs of the village residents. The forest is the source of agricultural land, hunting and fishing areas, potable water sources, and subsistence materials. Therefore, it is not surprising that the perceived importance of collecting forest products is greater than any other individual livelihood activity.

During FGDs, several participants noted that many people were losing the skills needed to source their subsistence needs from the forest or fields. It was mentioned that purchased food was increasingly a necessity for villages in the Marowijne Area and the shift towards a monetary economy and purchasing food has become pronounced.

Surprisingly, ASM was scored as the least important livelihood overall despite being recognized as significant for income generation. Interestingly, none of the respondents rated ASM as significant for its cultural value. The results of the livelihood importance scoring are incongruous with statements made within the FGDs where ASM was referred to as the most significant livelihood (Akati) and the preferable livelihood (Langa Tabiki).

Further analysis of the Livelihood Importance Matrix reveals that all livelihood categories scored at least three out of five for income generation, indicating that even the most basic agricultural produce, game and fish, mining products and forest products can be sold for a profit. In addition, all livelihood categories also have scored at least three out of five as value for subsistence food. This may indicate that food requirements are commonly fulfilled through subsistence activities such as hunting and fishing, but also through food purchasing from income earned from income generating activities, such as small-scale mining and professional labor. Specifically, professional labor may be seen to have value for subsistence food given that household members employed in these occupations are typically provided food while working.

Only women perceive the value of agriculture, hunting, fishing, and other activities to supply household products. According to female respondents, agricultural by-products, animal bones, materials used in ASM, and even supplies for professional labor add value to household livelihood. This suggests that women are more aware of the value of subsistence products to household livelihood than men. Men do not consider any activity except the use of forest products to have any value related to subsistence level products or uses.

The following sections briefly discuss the most common livelihoods in the Marowijne Area.

*Agricultural Livelihoods*

Agricultural activities represent the most commonly practiced livelihood and subsistence activity in the region. Agricultural activities are practiced predominantly at the subsistence level; however, non-subsistence production of several key crops and products also contributes a small amount of income to the majority of households surveyed. Typically, surplus crops are sold locally to generate further income.

Agricultural activities are considered the primary occupation for 36% of households surveyed. However, a large percentage of the population is involved in agricultural activities as a secondary occupation or additional livelihood activity. Approximately 68% of the local population has agricultural land and is engaged in some form of scale agricultural activity. The main crop grown locally is cassava, from which women produce *kwaka*, a dry cereal. Other crops grown locally include plantain, sweet potatoes, taya, peanuts, and dry rice.

The majority of households (67%) involved in agriculture have only one agricultural plot, 23% have two plots, and 9% have three to five plots.

Agricultural plots are located on the mainland, predominantly on the Surinamese side within 2 km from the Marowijne River, creeks, or roads. The agricultural plots of elderly residents tend to be in the most accessible location; youth tend to utilize less accessible areas. There are no formal restrictions on where agricultural plots can be established as long as they are within the territory of the resident's village. Residents are aware of the boundaries of the village territory and are also aware of the locations of other villagers' agricultural plots.

Slash and burn agriculture is the most common technique for preparing land to be planted with cassava or other crops. One new plot is typically cleared and planted each season to create an on-going supply of cassava harvest. Cassava is harvested approximately one year after it is planted. On several occasions during FGDs it was mentioned that repeated use of 'gardens' is not productive.

With the exception of Nason, there are very few agricultural plots or vegetable gardens surrounding the households on island communities due to the high frequency of flooding. Only 13% of households who responded to the survey consume 100% of their harvest each year, indicating that these households are primarily subsistence based agriculturalists. The majority of households, however, use their harvest for both household consumption and sale: 21% consume three quarters of their harvest, 25% consume half, 30% consume a quarter of their harvest, and the remaining 11% consume less than a quarter of their harvest. The portion of the harvest not consumed by the household is typically sold.

*Kwaka*, the primary commercialized product, is sold in Albina, Paramaribo, or French Guiana. The produce is transported by boat to French Guiana or Albina (and then by bus from Albina to Paramaribo). The net revenue from the sale of *kwaka* and other produce is often limited due to the high transportation costs. The cost of transporting 200 liters of produce from the villages to Albina is approximately SRD 250 (~ US $76.92) one way and an additional SRD 50 (~ US $15.38) to Paramaribo, while the population generally sells 200 liters of kwaka for SRD 600-700 (~ US $186.61-215.38).

Animal husbandry is not a significant subsistence or livelihood activity in the region. Only 23.5% of households surveyed kept any type of animal: 3 households own cows, 28 own chickens and 2 others own small fowl or other animals. Animals are primarily used for household consumption or cultural and traditional uses.

*Fishing*

Fishing is an important subsistence activity in all the villages in the Marowijne Area, and is described by local residents as their 'fast food.' The majority (55%) of all households surveyed fish for their own consumption or sale. Of the households reporting that they fish regularly, 70% go fishing more than once a week; 16% go fishing once a week; and 8% go fishing once every two weeks or more (6% did not answer).

The majority of households (77%) consume all fish caught. Only 6% sell the fish, and 17% consume a portion and sell a portion of fish caught. Households that sell fish do so locally, transport it themselves by boat to Albina and Saint Lauren, or sell it to middlemen (or "mobile vendors") who stop regularly in every village to buy the fish from the villagers and take it to Albina. The fishing industry is a loosely organized industry in the sense that the mobile vendors do not inform the local population which days they will stop in the village. As the villages do not have electricity, the fishermen cannot keep the fish until the mobile vendor stops in their village. There is no smoking or preserving of fish done in any other form. The export of fish is thus limited.

It was reported in FGDs that most people fish in the Marowijne River, , in Gran Creek, Ijskreek, and multiple small creeks on both sides of the River, such as Cicilia Creek and Musinga Creek. Some of the interviewees mentioned that Ijskreek was a privileged area for fishing – as well as hunting and bathing, because of the high quality of the water source. It was mentioned frequently that ASM miner activity has impacted the viability of fishing in many of the creeks and they are now too polluted to use as fishing areas.

*Hunting*

Very few residents consider hunting their primary or secondary source of income or livelihood. Nevertheless, hunting occurs regularly on an informal manner, and designated multiple-day hunting trips are occasionally organized prior to large community events. Only 14% of households surveyed hunt on an infrequent basis. Only 7.3% report having hunted at least an average of once a week.

It was reported during FGD that hunting typically occurs on an iterative basis during trips through the forest. This often occurs during trips to and from agricultural plots and during trips to collect NTFPs. The range of designated multiday hunting trips is much wider, covering the foothills east of the Nassau Mountain to forest areas several days walk west of the mountain, as well as in the interior, on the foot hills of the Nassau Mountain. There are multiple hunting trails in the Nassau Mountain area.

Occasionally hunters sell game to Albina and Saint Laurent. Similar to the fishing industry, the export of meat is limited by the lack of organization, electricity and transportation costs.

*Formal Employment*

Approximately 13% of households surveyed state that their primary household occupation is formal employment. Formal employment in the study area is restricted to a limited number of jobs in the governmental, education, healthcare, and the formal mining industry. Governmental jobs include several representatives of the Ministry of Regional Planning, public school teachers in Loka Loka, and village leaders. The government is supposed to provide village chiefs and the local council members a small stipend every month, but according to those officials, the stipend is very irregular and ranges between SRD 200 – 1,640 (US $61.54 – 504.62) per month depending on the position.

Households involved in formal employment are centered in Langa Tabiki, Nason, and Loka Loka. There are 18 teachers and five healthcare workers (nurses) working in the private schools in Langa Tabiki and Nason and the health clinics in Langa Tabiki and Nason. These positions are supported jointly by the Roman Catholic Diocese, the Moravian Church, the Medical Mission, and the Government of Suriname.

In addition, approximately 13% of all households surveyed indicate that either Surgold or Suralco employed one or more household members at the time of the survey. An additional 6% of households reported that members of their households had worked for either of the two companies in the past. Survey results indicate that households with the most individuals currently or formerly employed by Surgold are Langa Tabiki, Bada Tabiki, and Skin Tabiki. Residents of villages further upriver have much lower rates of employment with Surgold and Suralco.

*Gender and Livelihoods*

There are clear gender roles in the villages in the Marowijne Area. Women are primarily responsible for domestic or primary care tasks, caring for children and processing *kwaka*. Women are also responsible for the household's agricultural production; they decide the location of the agricultural plot, when to clear it, what to plant and when, and how the yields will be used. Furthermore, as a matrilineal society, land is passed on through the lineage of the women.

The role of men in the local study area consists of economic and productive activities such as hunting, fishing, boat-making, transport services, small-scale mining and other economic initiatives. Men also assist women in agricultural labor, particularly in the clearing and maintenance of agricultural land. Women in the Marowijne Area do combine to form cooperatives to harvest and produce cassava; however, the economic productivity of these activities was not clear.

*Income Generation and Expenditure*

Basic data on household income and expenditure was collected during the household survey. All data is based on estimates from survey respondents and should be understood as a general estimate rather than exact figures. Data on income and expenditure is notoriously unreliable and the associated cultural nuances and pressures associated with financial wellbeing means that income and expenditure levels may not be accurate.

The average annual household income throughout the total study area was reported to be SRD 9,243.28 (US $2,844.09[xxiii]). Figure 14-30 showed the reported average household income and expenditure levels in Suriname Dollars (SRD).

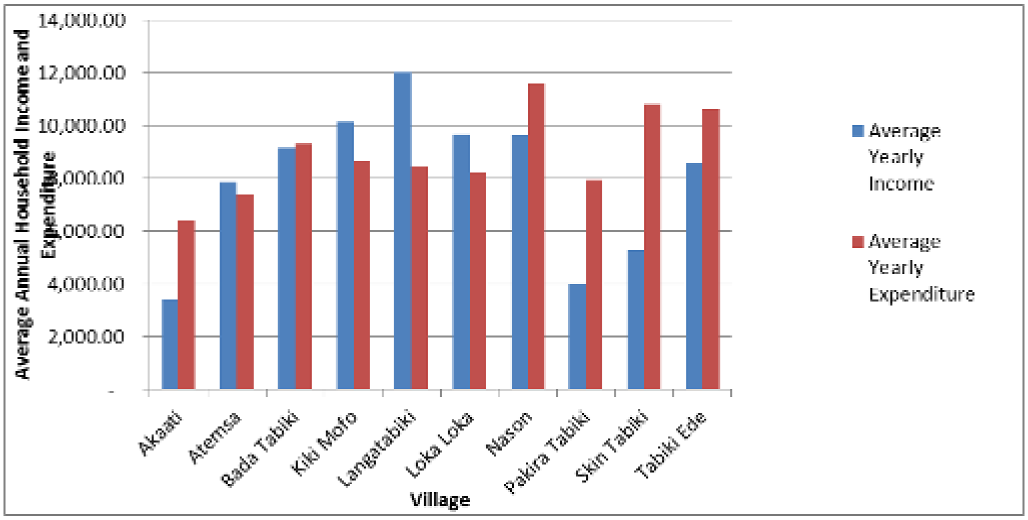



*Figure 14-30 Distribution of Average Household Income and Expenditure (SRD)*

The villages with the highest average annual household income are Langa Tabiki (SRD 12,028.15, ~ US $3,700.97), Kiki Mofo (SRD 10,155.08, ~ US $3,124.64), Loka Loka (SRD9 695, ~ US $2,983.08), Nason (SRD9 655, ~ US $2,970.77), and Bada Tabiki (SRD9 160, ~ US $2,818.46.15). The villages with the lowest average annual income are Akaati (SRD3 400, ~ US $1,046.15) and Pakira Tabiki (SRD 4,011, ~ US $1,234.15).

The average annual household expenditure throughout the study area is SRD 9,212.00 (US $ 3,390.50). Average annual income was reported to be higher in the larger villages of Nason, Langa Tabiki, and Loka Loka supporting the hypothesis that paid employment may be easier to access from those locations.

Expenditure rates were stated to be higher than income in six villages indicating a consumptive economy with an absence of savings and support networks. This may result in potential vulnerabilities to economic change. It should be noted that even in those villages where income was stated to be higher than expenditure the difference was generally not significant.

Based on the results of the household survey the greatest household expenditure is on food, clothing and basic domestic necessities which on average households reporting spending SRD 6,296.20 (~ US $1,937.29). Figure 14-31 shows the amounts spent on average each year on various items.

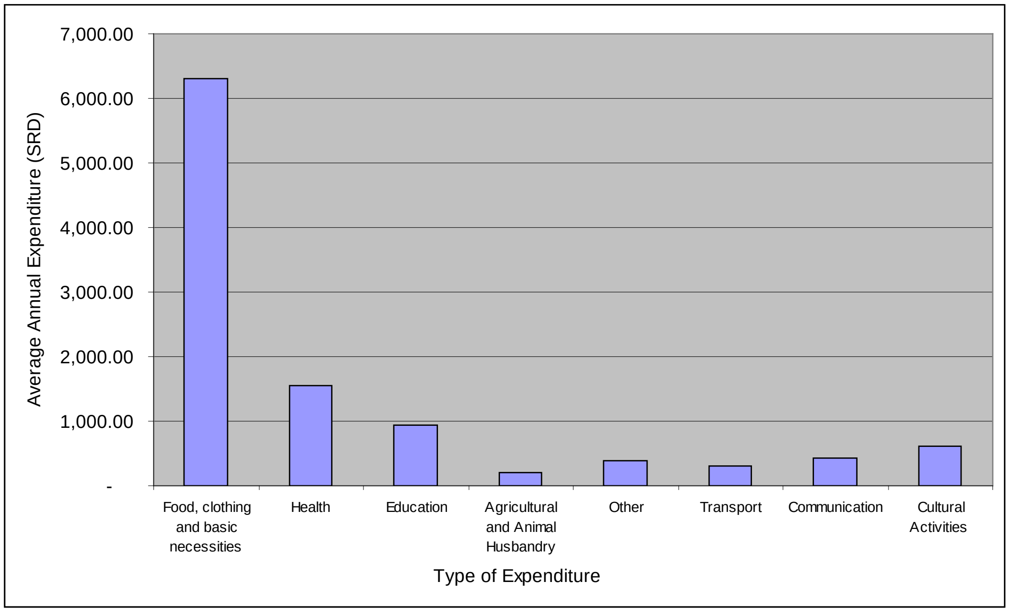



*Figure 14-31 Distribution of Average Household Expenditure (SRD)*

The output on food and necessities is a significant proportion of annual expenditure indicating that food and other necessities are regularly purchased throughout the year. As a generalization, it appears that expenditure may be commonly limited to basic goods and the output on luxury goods was reported to be low.

It should be noted that the expenditure on healthcare (the second largest cost) is higher than expected. Healthcare is reportedly free of charge in the three clinics in the study area and expenditures on healthcare may, therefore, be related to the purchase of medicine, transportation to local and regional medical facilities, and treatment at traditional healers if primary healthcare providers are perceived to be inadequate.

*Remittances and Social Welfare*

According to FGDs, a significant source of income for many of the households in the Marowijne Area includes remittances and social welfare payments from the Governments of Suriname and French Guiana. Anecdotal evidence indicates that the social services in Suriname pay elderly people approximately SRD 400 per month (~ US $123.07) and families receive SRD 30 (~ US $9.23) per month for their first child. In French Guiana, it was stated that the social services are considerably higher and families receive up to €250 (~ US $325.22) per month to help support their first child. Social services from French Guiana are only available to those registered as citizens and this, combined with an increased availability of free education and healthcare were mentioned as drivers for migration over the border.

### 14.4.8 *Artisanal and Small-Scale Mining (ASM)*

ASM (often of gold) is practiced throughout Suriname. Nationally, estimates of the number of small-scale gold miners vary between 20,000 and 25,000[xxiv]. Within the Marowijne Areas, including the Nassau Mountains region, between 500 and 1,500 miners are estimated to operate. Approximately half of these are thought to be local Pamaka people with the remaining half made up from other areas of Suriname, Brazil, and British or French Guiana. It should be noted that these numbers are estimates based on discussions held with local ASM miners, but are difficult to quantify, due to the fluid nature in which people enter and exit the sector. This is particularly the case since ASM has ceased within the Merian Industrial Zone and the miners have dispersed throughout the surrounding environment.

ASM has been a livelihood activity within Suriname for many years and the history of ASM is discussed in *Box 14-2.*

Although small-scale mining is widespread throughout Suriname, the majority of the activities are illegal. Anecdotal evidence gathered through interviews indicates that although approximately 20,000 – 40,000 people are estimated to be involved in ASM, there are only approximately three licensed ASM sites nationally.

## *Box 14-2 History of "ASM"*

Since the colonial period Suriname has been renowned for gold deposits of almost mythical proportions. Early Dutch colonists sent exploration expeditions to the interior of the country in the late seventeenth century and the *Sociëteit van Suriname* (Society of Suriname) opened a gold mine on the Suriname River in the early eighteenth century.[xxv] However for the colonial economy sugar became a much more rewarding commodity and gold mining was essentially dormant until the mid-nineteenth century.

The abolition of slavery and discovery of large deposits in French Guiana sparked a 'mini gold rush' and gold production in Suriname rapidly increased. These early gold mining ventures initially involved minimal Maroon and Amerindian involvement [xxvi] and instead the inhabitants of the Interior specialized in transportation along the river network and work as guides. Between 1879 and 1910 gold production increased from 475 kilograms (kg) to a peak of 1,200 kg; however the onset of World War I arrested this progress and post-war the exploitation of bauxite proved to be more profitable. From the 1930s gold mining in the interior existed on a small scale and was primarily the domain of exploratory entrepreneurs; gold production slipped to around 300 kg in the 1930s and 200 kg after World War II, eventually dropping to just a few dozen kilograms in the 1970s.

In February 1980, less than five years after Suriname's independence, a group of sergeants staged a coup and in the months that followed Desi Bouterse assumed political power. In July 1986 the *Surinaams Nationaal Beverijdingsleger* (the Surinamese National Liberation Army – otherwise known as the Jungle Commandos) carried out the first of several raids against the government and industry, sparked by Maroon unrest in the interior of the country. In the following years the relationship between Maroons in the Interior and the Government worsened and the conflict escalated to civil war status. Six years of war devastated the Interior; education came to a halt, many salaries went unpaid, income support disappeared and the public sector virtually disappeared.

During the data collection several people mentioned that the lack of access to education and damage to the economy of Suriname helped to dramatically increase ASM as a viable livelihood option for many people. ASM miners from Asaweki and Langa Tabiki stated that due to a gap in educational services available during the Civil / Interior War an entire generation lost out on opportunities for self-development. To paraphrase these ASM miners: *"For us ASM is all we know and our only way to make money."*

The separation of much of the Interior from Paramaribo meant that new trade routes were forged and the east of Suriname became increasingly tied to French Guiana. Allegations have been made that the Jungle Commandos funded much of their conflict with revenues from gold mining, and gold replaced hard currency, increasing mining activity. Post 1992, Brazilian garimpeiros (the term by which artisanal and small scale miners are referred to in Lusophone countries) began to move to the Interior as the Brazilian government awarded concessions to timber and mining businesses and increasingly policed illegal mining. The influx of these experienced ASM workers increased the industrialization of ASM and Maroons began to work with Brazilians to extract gold in larger quantities over larger area[xxvii].

Changes to the Mining Law in Brazil and a clampdown on garimpeiros led to increases in Brazilians migrating to Suriname to pursue mining opportunities. The reportedly porous borders between Suriname, French Guiana and Brazil facilitates the easy movements of individuals and combined with the perceived absence of government censure and monitoring of mining operations, the numbers of Brazilians operating garimpagem (the term for artisanal mine sites in Lusophone countries) within Suriname has increased steadily since the mid-1990s. Current estimates predict that approximately 20,000 Brazilians are involved in ASM within Suriname and accompanying service economy, with an additional 10,000 Maroons also engaged within the ASM miner industry[xxviii].

*Box 14-3* outlines the legal structure of ASM in Suriname and the context to which small-scale mining is possible.

*Box 14-3 Legal Structure of ASM in Suriname*

Mining in Suriname is governed by the Mining Decree of 1986, 'Containing General Rules for Exploration and Exploitation of Minerals', which regulated both large and small scale mining operation. The Mining Decree is based on Article 41 of the Constitution of the Republic of Suriname, which states:

*"Natural riches and resources are property of the Nation and shall be used to promote economic, social and cultural development. The Nation shall have the inalienable right to take complete possession of the natural resources in order to apply them to the needs of the economic, social and cultural development of Suriname"* [xxix]

Under this Decree, all mining activity requires some type of involvement and permission from the Government. The Decree continues to stipulate:

*"The right to small-scale mining can be granted to persons who wish to conduct mining activities on a small scale, using rudimentary techniques and equipment for an area no larger than 200 hectares, for a period of two years (article 36.6). This term can be extended (article 38). The right to small-scale mining includes the right to reconnaissance, exploration as well as exploitation (article 39). Under the other provisions of the Mining Decree (article 36.3), small-scale mining rights cannot be granted in areas which have already been issued for large-scale mining."* [xxx]

These criteria for legal ASM concessions are often unfeasible; requirements for offices in Paramaribo and concessions for two years mean that small-scale concessions are a great inconvenience for ASM miner Financiers. In addition, the absence of significant regulatory bodies means that small-scale concessions are deemed unnecessary. The Ministry of Natural Resources, responsible for the all mining activities in Suriname, does not have the capacity and resources to police the Interior of the country.

### *ASM in the Marowijne Area*

Specifically within the Marowijne Area, ASM is the primary income generating activity of 20% of households, according to survey respondents. While the collection of NTFP is the most important livelihood and sustenance activity, small-scale mining represents the most obvious source of income in the region. Materials and supplies for small-scale mining operations are regularly seen daily being transported up and down the Marowijne River (see Figure 14-32).

The transportation sector, small-scale commercial sector and the majority of new construction (housing, camps, and other structures) are believed to directly relate to ASM. Thus, the majority of households in the study area are directly or indirectly involved in ASM. This belief was largely supported during FGDs where it was stated that *"gold drives the local economy"* (Pamaka ASM miner in Langa Tabiki).

*Figure 14-32 Materials Transported up the Marowijne River*

ASM tends to be fairly rudimentary placer mining, semi-mechanized or unmechanized alluvial extraction of gold-bearing sands or soils and processing. *Box 14-4* summarizes the common techniques and processes used.

*Box 14-4 Alluvial ASM*

The main form of mining in the area involves the alluvial extraction and processing of auriferous sands and gravels, also known as placer mining. This is common and widespread throughout the Project area. This often starts with rudimentary exploration or prospecting; digging several shallow holes and processing the contents with a batea or small circular metal pan. Often site selection will be based on previously mined areas, areas previously explored by the Company or informed by local religious / belief systems. When directly questioned ASM miners stated that there are no areas that are ritually forbidden for mining activities, however it was mentioned that many of the creeks have been over-mined and that the hills are now more suitable.

Once a site has been selected and cleared a pit is dug to remove top layers of sand and clay either by hand or, where available, using backhoes, excavators or other equipment. The auriferous sands and gravels are extracted through a generator powering two hoses; one to divert high pressure water to loosen gold bearing soil, and the other to suck water mixed with auriferous sands and gravels, spraying it across a sluice box. Gold particles and other heavy minerals are trapped behind riffles and/or a metal screen and in a fine mat that covers the bottom of the sluice box. Tailings, including gravel, sands and clays mixed with large amounts of water often flow into abandoned pits or into the adjacent forest.

Once a suitable amount of material has been collected the matting from the sluice box is 'washed' with water and mercury, which chemically binds with the gold. The solid mercury-gold amalgam is sieved and then separated through evaporation, burning the amalgam to reduce the mercury and other impurities. The resultant product is gold, separated from the mercury in nugget or dust form.

Placer mining techniques have been carried out throughout the Marowijne Area for some time along the creeks where an accessible source of water is available. Figure 14-33 shows satellite imagery of the Merian Creek and the ASM miner tailings along it and its tributaries.


Source: Google Earth

*Figure 14-33 ASM Tailings in the Merian Creek ASM Governance*

ASM in the Marowijne Area is typically administered by Landbosses who traditionally 'own' the mineral resources in certain areas due to ancestral divisions of land. These titles are unrelated to formal land ownership but widely respected in the Marowijne Area. Landbosses typically maintain supervisors who manage the mining process and the individual mining teams on their land. Specifically they supervise the collection of sluice mats and the processing of the minerals recovered; weighing and recording the total gold recovered so that they can calculate the Landbosses dues and requirements.

At designated ASM camps, rules are typically enforced by the relevant landboss and his team of supervisors. Penalties may include fines, bans or expulsions and can be issues for theft or fighting. Where crimes are more serious or violent it was reported that the police will be involved.

ASM operations tend to be conducted by a team of six to eight people funded by a machine operator, investor, or Landboss who provides food, shelter and equipment for the laborers while they carry out mining operations. The team usually also contains a cook who will provide meals and supplementary services. Investors may be absent machine owners and not from the local area; however, several mining projects are managed by Pamaka Landbosses who have traditional land tenure in the area and fund mining operations on their land.

*ASM miner Economics*

According to one Landboss near the Merian Project, a weekly production total of 40 g may have been seen as a success in the past, however, current mechanized techniques mean that one site operating four teams may generate between 1-3 kg. In the two weeks prior to the interview, a Landboss stated that production at his site included 800 g and 600 g respectively.

As a generalization, it was explained that profits from mining operation are distributed as follows:

- Laborers share approximately 20-40% of the gold recovered;
- Machine operators, cooks, security, and transporters will receive a fixed salary from a Landboss or investor; and
- The Landboss or investor will claim the remaining 60-70% of the gold recovered.

According to a Landboss who was interviewed, common profits on his investment may range between 50 and 200 g per week. The common expenses experienced by the investor may include the cost to buy/rent/repair equipment, supplies and materials, subsistence costs for laborers and any necessary contributions to traditional or formal authorities.

For laborers it was stated that the common expenses include alcohol, marijuana, sex workers and other recreational activities. It was stated that many laborers save a portion of their wages.

Figure 14-34 shows a team of ASM miners working just outside of Surgold's IZ.

*Figure 14-34 ASM Just Outside the Surgold IZ*

*Drivers of ASM*

ASM serves as an attractive livelihood for young men in remote rural communities for a number of reasons.

For many ASM laborers, the level of risk perceived by engaging in ASM activities is considerably less than pursuing employment within formal sectors or traditional livelihoods such as agriculture. For an ASM laborer, the Landboss or investor supplies all the upfront investment and assumes much of the risk profile for the mining team. Laborers are provided with food and shelter during the mining activities and, although they may lose out on potential wages, the risk of failed exploration / exploitation activities are assumed by the Landboss / investor. Other significant income generating activities such as lumber harvesting require significant start-up costs and equipment, more even than ASM, and this risk is shared evenly amongst employees. The combination of 'security' against loss and the 'get-rich-quick' or 'gambling' mentality of mining acts as a driver for increased involvement in ASM, particularly for young men who see traditional livelihoods as unable to generate the cash income required for modern amenities.

Possibly the most significant driver for ASM however is simple economics; although the income can vary greatly according to the success of mining activities, mining is perceived as generating a greater economic return than other income generating activities. During interviews with local Pamaka employees at the Base Camp several stated that on average they previously earned more money from ASM. This is backed up by research undertaken by Heemskerk and van der Kooye (unknown date) who stated that:

*"In 2002, low and unskilled workers in the city (Paramaribo etc.) made approximately US $100 per month, and college-educated professionals, such as nurses made about US $200 per month… among surveyed pit workers, 39% had earned between 20-40 g/month in the month prior to the interview… Over a quarter (27%) had earned less than that."*

According to gold prices at the time of study (US $51.40 – 3rd January 2011) this would amount to between US $1028 and US $2056 per month for 39% of pit laborers involved in ASM. Although surveys covering income are notoriously unreliable and this survey was of Ndjuka ASM miners, even if these estimates are halved the income from ASM, particularly in an area with limited opportunities for income generation is substantial.

*Identities in ASM Communities*

It should be recognized that in many of the local communities the roles within the ASM environment are fluid and not fixed. This means that while someone might retain an identity as a ASM miner, he / she works as a laborer on an ASM site, is a Landboss or investor who funds mining activities, is a cook at an ASM site, or indeed even a service provider within a ASM camp. Usually these roles are not fixed and people can act as one or all of them simultaneously, or changing month to month.

The ASM workers in the region can be divided in to three categories that need to be distinctly identified:

- Pamaka Maroons from the local area that are involved in ASM for the purposes of income generation;

- Other Surinamese from outside of the Marowijne Area who have migrated to the region to practice ASM; and
- Outsiders or foreigners including garimpeiros from Brazil and other artisanal miners from French Guiana who have migrated to the area to practice ASM.

For the Pamaka Maroon, ASM tends to represent a temporary income generating activity that supplements other household livelihoods and income generating activities. This does not mean that all Pamaka Maroon ASM miners are temporary miners, but that the majority appear to practice mining as an intermittent activity, returning to their household or home village for 'rest and recuperation periods.' Commonly an ASM site will operate for around four months depending on how long the financing and supplies last, or how much resource is recovered.

The non-Pamaka ASM miners in the area appear to operate on the fringes of the traditional land tenure and respect systems. An ASM miner near to the Surgold base camp, involved in mining since 1988, explained that approximately 50% of non-Pamaka mine operators seek permissions and pay 'dues' to Landbosses (traditional land owners or captains) and the traditional authority.

As a generalization, the vast majority of ASM miners involved directly in laboring and mining activities are men, while women tend to operate within the supplementary service sectors. This includes the provision of food and drink, sex work, and cleaning. Further research is required to improve the understanding of the role of gender within ASM.

*Risk Attitudes in ASM Communities*

The accepted logic in much of the literature surrounding ASM infers that the absence of safe practices by miners is directly related to the lack of knowledge and information about the risks associated with mining. The accepted representation of ASM sites as the 'Wild West' where people exist in an unmonitored 'finders-keepers' social environment is not always entirely reliable. In fact the management of risk profile by ASM miners is evaluated by fairly conventional risk-reward calculations.

This management of risks by ASM miners can be evidenced by rudimentary H&S and social techniques used to balance the work program. Most ASM miners adjust their labor regime to allow for a break from mining after rigorous activities: mining in areas where ASM miners hold kinship ties and other social relations can help to provide an improved working environment; traditional herbs and medicines, dietary supplements, and taboo systems help to improve the perceived local health profile; and social support networks can provide assistance during difficult times. These techniques help to illustrate the extent of the comprehension that mining work contains certain risk; however, these risks are deemed acceptable if managed. The absence of other viable alternatives for income generation mean that although ASM is understood to be a dangerous activity in the long term, failing to mine gold will endanger their immediate economic well-being[xxxi].

## 14.5 *MOENGO AREA*

The Moengo area is shown in Figure 14-35.

Based on the impact scoping and prediction process, the Moengo area has been included within the social baseline due to the potential for in-migration into the area because of perceived opportunities.

Based on the impact scoping and prediction process, the baseline for the Moengo area has been structured to consider all topics relevant to potential impacts that may be experienced, perceptions, and relevant considerations for stakeholder engagement and potential Community Investment (CI) opportunities. For this area, this means that topics that are not predicted to be impacted are not discussed.

### *14.5.1 Demography in the Moengo Area*

Marowijne District, in which Moengo falls, has a population of 16,641 according to the 2006 census[xxxii]. Moengo itself is a resort within the Marowijne District and has a population of 9,662.

Census data, including the distribution of religions and use of language in the household, reflects the ethnic make-up: 58.8% of households reported that Ndjuka was the most commonly used language in the house, with Dutch (18.8%), Sranan Tongo (11.3%), and Javanese (6.8%) representing the other significant languages spoken (i.e. greater than 3%)[xxxiii]. This dominance of Ndjuka (a Maroon language) leads to a hypothesis that Maroons are the largest ethnic group in Moengo; this is supported by the dominance of Christianity, the typical Maroon belief system, as the most common religion (59.4%) compared to Hinduism (1%) and Islam (10.9%), the typical beliefs of Javanese or Hindustani groups[xxxiv].

Anecdotal evidence gathered during qualitative data collection indicated that the population in Moengo was growing in size due to the presence of seasonal workers and the expansion of the household size (estimated to be in excess of five). The General Fertility Rates (GFR)[xxxv] in Moengo is almost double the national level, (121.9 and 77.6 respectively[xxxvi]), indicating a population that may be growing. However, it should be noted that anecdotal evidence was contradictory and some stakeholders indicated that the expansion of the population may be to be limited due to high levels of migration out of the Moengo.

### 14.5.2 *Education in the Moengo Area*

There are eight primary schools in Moengo and two secondary schools. Three of these schools are privately run and the rest are public. The average student to teacher ratio in Moengo schools is 19:1, and on average, there are approximately 28 students per classroom.

In addition to primary and secondary education facilities, evening adult education and secondary school classes are publicly available in Moengo. There are also a teacher training school, training for head teacher qualification, pre-schooling, and some vocational training courses. Vocational training is provided both publicly through the Lower Vocational Education School, (*Lager Beroepsgericht Onderwijs* or LBGO), and through non-profit organizations such as STEPS, who focus mainly on agricultural training. Other vocational training options include beautician, computer repairs, hairdressing, baking, administration, nursery school teaching, and welding. According to the Director of Steps, numbers registering for these courses are increasing; until 2010, 241 people had registered for training whereas in 2011 approximately 910 people were registered. Some extracurricular activities (e.g., music, art and sports) are provided by individuals in the community. Education was cited as one of the main reasons that people from nearby villages relocate to Moengo.

The estimated annual costs associated with attending school are SRD 350 (US $107) for secondary school and SRD 200 (~US $61) for primary school. This fee includes tuition, between SRD 20 and SRD 60 per school year (~ US $6 – 18); school transport, between SRD 60-70 (~ US $18 – 21) per month for the private school bus, SRD 2.50 (~ US $0.60) per month for the public school bus and SRD 2.50 per month for the school boat (this cost doesn't apply to students who walk, cycle or drive); and uniforms, textbooks and writing materials.

*Figure 14-35    Moengo Social Study Area*

Teaching facilities were reported to be better in Moengo than in the Marowijne Area, although still below standards in Paramaribo. The schools typically have multimedia centers (although not all have teachers qualified to use these), sports facilities, and Information Technology (IT) classes are available in one of the secondary schools. It was reported during interviews with stakeholders that an absence of specialist teachers means that there is little to no music or art taught in schools.

Educational achievement is reported to be higher in Moengo than in the Marowijne Area, although still below standards in Paramaribo. It was reported during FGDs with local school principals and the Moengo Education Inspector that the literacy rate in Moengo is approximately 70%, with the elderly making up the majority of those who cannot read or write. It was further reported that the average age that students leave school is 15 (consistent with the minimum age), and that as in the Marowijne Area, girls tend to stay in education longer than boys.

During FGDs, it was noted that challenges facing students in Moengo include difficulties learning in a second language (Dutch), affordability of education, difficulties connecting education to employment opportunities and lack of follow-up education. Technical vocational training programs that were said to be relevant to the area include agricultural training, forestry, mining, and training to be an electrician and car mechanic.

### *14.5.3 Moengo Area Health Profile*

The following summarizes the general health status and health services available in the Moengo Area.

*Chronic Diseases*

Moengo faces many of the chronic diseases that are typical across the country including heart disease, high blood pressure (hypertension), and diabetes. According to the Moengo RGD Clinic and the Suralco Polyclinic, chronic diseases are among the top health issues in the area, primarily affecting the adult population (age 40 and older), particularly among the Maroon. The levels of prevalence and incidence on the local population are difficult to ascertain given that many residents receive health care outside of Moengo, including in French Guiana.

Poor nutrition / diet, obesity, and physical inactivity are major risk factors for diabetes and other preventable chronic diseases. Based on interviews with the Suralco Polyclinic it was reported that many residents in the Moengo area lack the knowledge on how to reduce their risk of chronic diseases, such as improving their nutrition and diet. According to the health providers interviewed, even with preventative health education, there are cultural barriers to adopting healthier lifestyle choices, such as a preference for a '*wonder pill to cure their hypertension*'. It was also reported that overweight women do not want to diet for fear of looking '*sickly and unattractive to men*'.

*Anemia*

Of particular interest in the Moengo area is the issue of anemia, which has been a long term cause of morbidity in the local population, particularly among the Maroon residents. The vast majority of anemia and iron deficiency cases in the Moengo area are among younger children and pregnant women; however, men have also been diagnosed with anemia[xxxvii].

It was reported by the director of the Moengo RGD Clinic that the frequency of cases of anemia was too high for it to be entirely related to the issue of malnutrition. The causes of anemia are usually multifaceted and can depend on several factors, such as iron deficiency, infections such as HIV and malaria, (intestinal) worms such as hookworm, sickle cell anemia, thalassemia, and other red blood cell diseases.[xxxviii] Socioeconomic factors such as food shortages, overcrowding, family size, and short intervals between births may also increase the risk of suffering from anemia.

*Water and Sanitation-Related Diseases*

In Moengo, the most common infectious diseases primarily afflict children and include diarrheal disease, ARIs, and seasonal colds or influenza. Poor sanitary conditions and personal hygiene practices, as well as limited access to safe water sources are the leading factors for these infectious diseases.

*STIs including HIV/AIDS*

There have been no recent outbreaks in STIs (including HIV/AIDS) in Moengo and it was reported at the Moengo RGD clinic that the HIV prevalence among tested pregnant women in the Moengo area is low. Although HIV testing is available locally, it was reported to be underutilized by the general population. Based on the lack of testing it is impossible to estimate the accurate prevalence and incidence of HIV / AIDS among the local population.

*Teen Pregnancies*

According to the RGD Clinic in Moengo, there is a high prevalence of teen pregnancies in Moengo, especially among girls of Maroon descent. A 2007 study by MOH/ProHealth showed that approximately 50% of all sexually active girls, aged 15-19 years, in Moengo reported at least one pregnancy.[xxxix] Of these girls, 89% stated that the last pregnancy was unintended. Socio-economic status and cultural conditions as well as restrictive attitudes of health workers were stated to be the main barriers in the access and utilization of contraceptive services. Despite national government policy of keeping pregnant girls in schools, it was reported that many school principals remove pregnant girls.

*Malaria and Dengue Fever*

Malaria is not considered a major concern in Moengo due its geographic location within the coastal district of Marowijne north of latitude 5°N, where transmission risk is low or negligible;[xl] however, dengue fever is still considered a risk in these coastal districts.

*Traffic Accidents and Injuries*

The risk of accidents and injuries related to road traffic is higher for residents living in Moengo, where the East-West Highway passes near to the town.

The Moengo Police reported that in 2010, approximately 100 traffic accidents occurred along the East-West Highway from the Commewijne and Marowijne district border to the town of Moengo. Twenty-one of these traffic accidents resulted in injuries treated at the Moengo RGD Clinic and one Driving Under the Influence (of drugs or alcohol, DUI) related fatality occurred within the town of Moengo. As of November 2011, 84 traffic accidents were reported with two fatalities occurring within the town of Moengo. Both fatalities involved pedestrians killed by vehicle drivers.

The risk of traffic accidents and injuries within Moengo has been particularly high given the re-routing of all traffic through the town as part of the East-West Highway Rehabilitation Project. Only recently, a pedestrian footpath was established along part of the main road in the town. The busiest time for vehicle and pedestrian traffic in the town of Moengo is during the early weekday morning commute (7:00-8:30 am) and after school lets out (1:30 pm).

According to the Moengo Police, some of the main risk factors for traffic accidents are:

- Speeding, particularly by taxi drivers and Brazilian ASMs miners;
- Driving under the influence of alcohol;
- Mechanical problems with vehicles (e.g., break failure on trucks);
- Driver fatigue (i.e., sleeping behind the wheel);
- Poor driver visibility due to dust on the roads; and
- Bad road conditions (e.g., water pooling due to improper drainage).

Following the completion of the East-West Highway Rehabilitation Project from Paramaribo to Albina, the Moengo Police expect traffic will increase because of improved access between towns and speeding and night-time driving will increase due to the improved paved road surface. The road currently experiences some heavy truck traffic with heavy cargo (e.g., logging trucks) and dangerous goods (e.g., gasoline trucks). Aside from the road through Moengo, not many pedestrians and bicyclists traverse the East-West Highway and the common routes include footpaths that connect settlements along the road.

*Community Sense of Safety and Mental Well-Being*

In Moengo, theft, burglary, and robbery are considered common occurrences, and interviews with the Moengo Police estimated occurrences at approximately three to 10 incidents per week.

Domestic violence is reported to be a growing concern in Suriname. The true extent of the problem in the Moengo area is not well understood. It was reported during an interview with the Suralco Polyclinic that cultural constructs, social controls, and lack of confidentiality mean it is likely that domestic violence victims are discouraged to go to the police. According to the police in Moengo, only one to two domestic violence cases are reported each year, which may indicate that it is underreported.

Drug use, particularly marijuana, is reported to be common among young males (15-24) in the Moengo area (MOH / ProHealth 2006). While there have been arrests of several young men for drug possession (cocaine and marijuana), it was reported by the Moengo Police that the issue is not as common compared to Paramaribo.

Health providers in Moengo stated during interview that they have noticed indications of mental health issues, such as stress, depression, and anxiety, among their patients. In particular, healthcare providers have identified that Suralco mine contractors living in Moengo are experiencing stress from the long work shift schedule that separates them from their families. Uncertainty of the future of their work at the Suralco mine was reported to increase this stress.

*Local Health Services*

Three main health facilities provide primary health services in Moengo and the surrounding area: RGD Clinic, Suralco Polyclinic, and Lobi Foundation. These facilities are described in Table 14-13.

*Table 14-13 Health Facilities in the Moengo Area*

| Health Facility | Services | Service Population Size | Staff | Patient Visits per day |
|---|---|---|---|---|
| RGD Clinic (includes 2 Community Health Centers) | Curative care<br>Preventative care<br>Maternal & child health<br>HIV/AIDS testing & treatment<br>School health programs<br>Midwifery<br>Diabetic screening<br>Pharmacy | 6,000 | 3 physicians<br>4 nurses<br>3 midwives<br>1 pharmacy assistant<br>1 assistant<br>2 ambulance drivers<br>1 care assistant | 90-135 |
| Suralco Polyclinic | Primary healthcare<br>Occupational health | 500 | 1 physician<br>2 nurses<br>1 pharmacist | 20-25 |
| Lobi Foundation | Preventative women's health and family planning | 6,000 | 1 nurse | 10 |

*Source: ERM Interviews, 2012*

During the key informant interviews, all the providers at the local health facilities in Moengo identified the lack of preventative health education in the communities as a barrier to improving health. With the focus on delivery of services, the health care providers lack the capacity (human resources and/or funding) to implement effective preventative health promotion campaigns among the communities.

*RGD Clinic*

The RGD Clinic in Moengo is the main health facility that services the general population in Moengo and the surrounding communities. The RGD Clinic also operates two small aid clinics in Ofia Olo and Wanhatti, where doctors visit twice a month. The clinic receives visiting specialists including an eye surgeon twice a year and a psychiatric counselor every six weeks.

In the event of an emergency, the RGD clinic has one ambulance and coordinates with the Academic Hospital for any necessary transfer. Complications with pregnancy are among the common reasons that require a transfer to the Academic Hospital in Paramaribo (approximately two hours' drive). The RGD clinic also coordinates with the Moengo Police on other medical emergency incidents in the communities, such as public road accidents and injuries.

With three full-time doctors on staff, there is one doctor for approximately every 2,000 residents; this low density of health workers may correlate with high maternal and infant mortality rates[xli]. The clinic receives 90 to 135 patient visits per day and the clinic director believes there is capacity to meet additional demand if the population grows. It was reported that the RGD clinic personnel are trained between four and five times per year.

The clinic accepts patients with social security cards, state employee health cards, and self-reliance private insurance cards (including the workers and contractors of the Nassau Mine and Suralco). For residents living in Moengo, access to the clinic was not reported to be a problem.

*Suralco Polyclinic*

The Suralco Polyclinic (Polyclinic) is a private clinic in Moengo that serves approximately 500 patients including:

- Active Suralco employees and their families (many from the Moengo area);
- Visiting Suralco employees (approximately 20-25);
- Suralco retirees and their families (approximately 250); and
- Supervised contractors (i.e., contractors that are directly supervised by a Suralco staff; not including outsource contractors).

The Polyclinic provides primary health care and occupational health care including hearing tests, lung function tests, worker health screenings, etc. With one doctor and two nurses on staff, the Polyclinic also has visiting specialists including dental hygienist, psychologist, and lab service. According to the Director of the Suralco Polyclinic, the medical services are underutilized and the polyclinic has the capacity to meet additional demand if required. To date, Surgold have an agreement with Suralco that the Polyclinic can assist in emergency response services. The Polyclinic has one ambulance.

*Lobi Foundation*

The Lobi Foundation was established as a family planning association in 1968 and is a member of the International Planned Parenthood Federation (IPPF). Its primary objective is to improve Sexual and Reproductive Health (SRH) in general with a focus on family planning. Lobi has its headquarters and main clinic in Paramaribo, and has established a clinic in the Moengo in 1995. Another mobile clinic was established in 2009 and operates primarily in the district Commewijne. The range of services includes family planning (provision of reproductive health commodities, education and counseling), pregnancy testing, cervical and prostate cancer screening, HIV/AIDS testing, and infertility counseling.

The clinic services only women and the patients are from all ethnic groups and of all ages. Most come to the clinic for oral contraceptives and condoms. It was reported during interviews that the main challenge facing the Lobi Foundation clinic is that many of the preventative services (e.g., cervical screening, pap smears) are under-utilized. Many are not aware of their services, while some choose to receive the services at a clinic in Paramaribo.

### 14.5.4 *Social Infrastructure, Resources and Services in the Moengo Area*

Social infrastructure and services in Moengo have previously been provided and managed by Suralco as part of their substantial presence in the area associated with the extraction and processing of bauxite. This included free electricity and water, housing, health, education, and even recreation facilities. The gradual downsizing of their activity in the area was reported to affect this service provision and residents report that the overall quality and availability of these services has deteriorated.

*Water and Sanitation*

Piped water is available in Moengo and surrounding areas supplied for a fee by the Surinamese Water Company (*Surinaamsche Waterleiding Maatschappij* or SWM). It was reported during KII with the manager of SWM that at present SWM is unable to meet community demands for water in the area, which equates to approximately 25 cubic meters of water per household per month. The main water users in Moengo are reported to be households and businesses and within Moengo and Wonoredje SWM supplies approximately 1,400 households, 80 businesses and 50 social institutions. This equates to approximately 8.5% of households within Moengo who have access to piped water. In areas, surrounding Moengo people typically have no access to piped water and collect rainwater or water from the Cottica River.

There is reported to be insufficient groundwater to meet this usage and research into alternative sources is being undertaken. This includes a potential purification plant for water from the Cottica River; however, this is only at the concept stage in 2011.

Residents are charged SRD 1,800 (~ US $550) for installation of a residential tap for piped water. 50% of this cost must be paid up front and the remainder can by paid in installments over the next three to six months.

The majority of households and businesses in Moengo use a septic tank for waste water. These tanks are typically collectively financed, managed, and cleaned by groups of households or businesses.

*Electricity*

*Energiebedrijven Suriname* (EBS) manages the supply of electricity to Moengo and surrounding areas. At present only two Megawatts (MW) of energy are available to the town, but there are plans to increase this to 80 MW in collaboration with Moengo Minerals[33]. The timing for this development is not known.

Currently the main source of electricity generation is thermal energy. The capacity of current power generation is 1.9 MW, which is approximately half of what would be needed to meet demand. EBS serves approximately 1,500 households and 12 business units. The rate of house construction in Moengo was not reported to be high, and thus requests for increased supply typically come from existing customers who require additional power for new goods or equipment.

It was reported that the power supply is stable and that power cuts are rare. When they do occur common causes include lightening or damage to power lines from animals.

The cost of electricity per household is an average of between SRD 15 (~ US $4.50) to SRD 20 (~ US $6.10) per month. Businesses pay between SRD 100 (~ US $30.50) and SRD 1,200 (~ US $366). It was reported that approximately 15 to 20% of customers struggle to pay their bills on time.

The cost of connection to the national grid is between SRD 175 (~ US $54) and SRD 275 (~US $84). This price depends on the distance from the pylon to the house and the level of power that the consumer requires.

*Housing*

Anecdotal evidence during semi-structured interviews suggests that availability of housing in Moengo is very limited. As a former 'company town', previously the majority of houses were owned by Suralco and allocated to company employees. When Suralco began leaving the area, most occupied houses were either given or sold to former employees and the majority of the remaining built

[33] Moengo Minerals N.V are a Surinamese Limited Liability Company with kaolin concessions surrounding near to Moengo.

infrastructure and land (including Moengo, Juliana, and Bernhard) was transferred to the government. . Approximately 80% were estimated by interviewees to have been purchased by the ex-employees. Empty housing stock has been used by Suralco as temporary housing for workers who visit the Moengo area.

Decisions on the allocation of property are made in the Domain Office in Paramaribo, based on recommendation from the District Commissioner. It is reportedly very difficult for those who do not have connections to Moengo through either family or birth to receive permission to own or occupy property in the area. It was further reported that since the Interior War the area has been officially classified as a war zone and it is therefore very difficult to receive financing to build new houses and all existing houses are already occupied.

The shortage in adequate housing has led to overcrowding within existing houses, with cases reported of several families and generations of families living under one roof. According to the results of a recent registration campaign carried out by the Moengo District Commissioner, the total number of people seeking housing in Moengo is 893.

Average rental costs in Moengo range from SRD 150-250 (~ US $45.60–76.00) per month. Rent in Stafdorp is reported to be significantly higher and most houses in this area are therefore rented to companies.

*Emergency Services*

Basic emergency services are available in Moengo; however, support would be required from Paramaribo for any large-scale emergency. A new police complex and facilities is presently under construction, financed by the government. The police department in Moengo at present has two pick-up trucks and one 15 passenger bus for transportation of prisoners to Paramaribo.

There is no fire service in Moengo, but the area is serviced by the Albina fire department. This department has one fire truck, which is designed only to extinguish fires.

There is no hospital in Moengo and just one ambulance and paramedic available to transfer patients to Paramaribo in emergency situations.

### *14.5.5 Moengo Area Livelihoods and Socio-Economics*

The majority of Moengo residents were formerly employed either directly or indirectly by Suralco and the area was, therefore, severely affected by the gradual downsizing of Suralco's operations. It was reported during data collection that formal employment opportunities in the area today are limited and that shortage of well-paying jobs is a key driver of out-migration.

According to interviews with local stakeholders, approximately 40% of the local labor force works in the government sector. Of the remaining 60%, the majority are employed in farming (mainly fruits such as melon, podosiri, banana) and several men also work in the nearby mining and timber concessions.

Lack of entrepreneurship and support or training for local business development was cited as a barrier to the development of Moengo and surrounding areas. Vocational training programs offer technical assistance for improved farming techniques or poultry farming, however, there is reportedly little interest in these courses. It was also suggested that people in Moengo are not interested in investing in larger scale farming or vegetable production because it is too labor-intensive.

In the smaller villages surrounding Moengo, data collection indicated that there are almost no formal employment opportunities and residents rely mainly on subsistence agriculture, hunting and fishing, and income generated from petty trading and small-scale mining.

Local stakeholders speculated that employment opportunities in Moengo and surrounding areas would improve over the coming years due to the development of a number of industrial activities in the area. This includes plans by Moengo Minerals to mine kaolin in the former bauxite mines, development of a palm oil plantation by an Indian owned company, and plans by Grassalco to begin granite mining operations.

## 14.6 *TEMPATI AND COMMEWIJNE AREA*

The Tempati and Commewijne area is show in Figure 14-36.

Based on the impact scoping and prediction process, the Tempati and Commewijne area has been included because they are downstream of the TSF.

Based on the impact scoping and prediction process, the baseline for the Tempati and Commewijne area has been structured to consider all topics relevant to potential impacts that may be experienced, perceptions, and relevant considerations for stakeholder engagement and potential Community Investment opportunities. For this area this means that topics are not discussed that are not predicted to be impacted. For example without a permanent population or significant infrastructure, health and education are not discussed.

### *14.6.1 Traditional Saramaka Governance in the Tempati and Commewijne Area*

The communities who identify their ancestral territory within the Tempati and Upper Commewijne area are predominantly Ndjuka and Saramaka Maroon.

Their traditional authority system mirrors that of the Pamaka Maroons including Captains and Basjas. This traditional governance system is maintained and respected within communities from the area despite the fact that most of the villages and the Captains relocated to Paramaribo during and after the Interior War. A village council made up of the traditional authority and selected community representatives still meets regularly in Paramaribo to make decisions pertaining to their ancestral area.

*Land Tenure*

Land tenure in the Tempati and Commewijne area consist of both communally shared territory and formal ownership in the form of timber concessions. The Forestry Act of 1992 stipulates that local government via the District Commissioner should consult the local traditional authority prior to issuing timber concessions, however, throughout Suriname this was reported to be rare. It was reported that within the Tempati and Commewijne area some members of the traditional authority possessed timber concessions.

*Figure 14-36 Tempati and Commewijne Social Study Areas*

The area surrounding the historical Maroon villages along the upper Commewijne was reported to be communally shared territory. During interviews, the village Java was identified as sharing communal land, while the settlements of New Penninika, Gododrai, and Moegotappoe-Kawina were reported to possess logging permits in the Tempati area and at the confluence of the Tempati and Kleine Commewijne.

During interviews, it was stated that anyone wishing to access the Upper Commewijne and Tempati area must receive permission from the Traditional Authority. In the past the area has been used by indigenous, Javanese, and other Maroon communities for informal logging, hunting, fishing, and agricultural activities.

The formal status of the timber concessions in the area is unknown. While a number of timber companies worked in the area in the past, it was not clear whether they received permission from the traditional authority or the formal government to do so.

### *14.6.2 Demography in the Commewijne and Tempati Area*

The total population of the relevant resorts for the Tempati and Commewijne Area (Patamaka, Carolina and Meerzord) is 8,757; however, we can assume that the Commewijne and Tempati Area include only a fraction of this.

According to the 2006 census, the population density of the Meerzorg, Carolina, and Patamaka Resorts is 7.5, 0.2 and 0.4 people per $km^2$, respectively. Based on this low population density and anecdotal evidence gathered through interviews and FGDs the estimated population within the Commewijne and Tempati area is less than 500 people.

The Commewijne and Tempati area are reported to be comparatively uninhabited and anecdotal evidence indicates that the settlements in the Upper Commewijne are virtually deserted. It was reported during fieldwork that the only permanently inhabited areas in the upper extents of the river included Java and Penninika where the population was estimated at five and 12, respectively.

The Tempati Creek, a tributary of the Upper Commewijne, is believed to be used for ASM activities, however, it was reported that there was no inhabitants along the southern tributaries of the Creek.

Temporary or historical population centers do appear in the area where the Tempati joins the Upper Commewijne and permanent settlements are apparent further to the north. Settlements in the Upper Commewijne can typically be divided into two categories:

- Uninhabited or occasionally inhabited villages that were larger historically and the population has emigrated from the area; and
- Seasonally or occasionally used camps that serve as locations for livelihood activities (logging, hunting, fishing, etc.), often in newly build locations.

Returning visitors to the Upper Commewijne area are believed to be Maroons with historical ties to the area and who identified the area to be their ancestral land. The area was historically Maroon land, surrounding Penninika was Ndjuka, and the area around Java was Saramaka. The modern origins of people in the area were mentioned to be a boom in the logging industry during the 1970s, which attracted an influx of Saramaka migratory laborers and their families. However, prior to the Interior War (1986) depopulation was already under way driven by an absence of facilities and infrastructure, this was increased by the Interior War.

Further downstream on the Commewijne, Indigenous Amerindian's are believed to retain some identity and presence in the area and the settlement of Sapaena was identified as predominantly Amerindian. Villages and camps at the confluence between the Tempati and Commewijne area (listed south to north) were reported to be:

- Cassaba Gron;
- MoengoTapoe – Kawina;
- Awara;
- Java;
- Bakarapisi;
- Bergi;
- Maripa Ondro;
- Penninika;
- Sapaena;
- New Gododrai / Mapane;
- New Java;
- Tapoco; and
- Magwa Kondre.

It was reported during key informant interviews that these villages are a mix of Maroon, Amerindian and Javanese villages which are uninhabited or occasionally inhabited as well as private logging, hunting and fishing, and traditional healing camps.

Figure 14-37 shows Cassaba Gron, which was reported to be a seasonal hunting and fishing camp for returning Maroon groups with historical ties to the area.

*Figure 14-37 Cassaba Gron*

### 14.6.3 *Social Infrastructure, Resources and Services in the Commewijne and Tempati areas*

As mentioned previously, villages in the Upper Commewijne and Tempati areas have very few permanent inhabitants. Because of this, social infrastructure and services in this area are almost non-existent.

*Water, Electricity and Communication*

There is no piped water, electricity, or mobile phone reception in the area and very limited radio signal. People use kerosene lamps for lighting and rain or creek water for drinking and cooking. Water from the Upper Commewijne River is only used for bathing and washing clothes as it is reportedly highly polluted due to gold mining activities in some of the creeks.

Some of the captains from the area are attempting to rebuild their villages in an attempt to encourage the communities originally from the area to return and live there. They claim that there is a desire from these communities to return to their traditional villages, but the lack of basic infrastructure makes this unrealistic at present.

*Transport*

The upper Commewijne area can be reached by both land and water transportation. There are two roads leading into the area: one leads off the Afobakkaweg towards Carolina and Pamaka; the other goes from Moengo and the Langa Tabiki road via Patamaka towards Carolina Bridge (currently under construction). Water transport is via boat from Stolkersijver Bridge along the Upper Commewijne River. There are no bridges in the area and people cross the river using boats. Canals have been built in some places to transport wood from logging concessions. There are also three small self-built harbors to load wood.

*Natural Resources*

There is still a high availability of natural resources supplied by the surrounding forest, river and creeks. The area is, therefore, still visited regularly for hunting, fishing, collection of NTFPs, and logging activities. The economic potential supplied by the area's natural resources, particularly the timber concessions, was stressed during stakeholder interviews with the traditional authority from the area. They stated that they want the value of their land and resources recognized and want to be assured that their forests will not be negatively affected by industrial mining activities nearby.

*Community Groups and Associations*

Though few member of the community from the Upper Commewijne live locally, they maintain a strong network in Paramaribo. A small number of groups have been established to represent the community and to work towards reconstructing their traditional villages. These include the Reconstruction Foundation for Upper Commewijne and the Java Foundation.

### *14.6.4 Cultural Heritage in the Tempati and Commewijne Area*

During fieldwork in the Upper Commewijne and Tempati areas culturally significant places were identified by local guides. These included:

- A sacred place at the confluence of the Tempati Creek and the Upper Commewijne River;
- A *faaka taki* or sacrificial altar in Java;
- A mortuary in Java; and
- Communal forests located throughout the area.

### 14.6.5 *Commewijne and Tempati Livelihoods and Socio-Economics*

Although the area surrounding the Upper Commewijne and Tempati are not believed to be inhabited permanently, they do appear to be used for subsistence, income generating and recreational livelihoods.

The area surrounding the creek and the river continue to be used for fishing, hunting, collecting NTFPs, and lumber harvesting. The area was not reported to have been widely used for ASM activities to date although it was beginning in the area since the ASM miners were removed from the Merian IZ. Furthermore, during fieldwork interviewees indicated that the Upper Commewijne was polluted due to ASM miner activity in the tributary creeks including the Tempati and the Sano.

Although the area is not currently used for any significant income generating activities, it was indicated during interviews with the Commewijne traditional authority that the area is viewed as having significant economic value due to its extensive timber concessions and potential gold and bauxite deposits. They also view the area as having significant potential for tourism due to its rich cultural history and natural beauty. There is therefore some concern from those with traditional rights to the area about the potential expansion of mining into what is seen as an area not only of cultural importance but of significant potential economic importance as well.

## 14.7 *TRANSPORTATION CORRIDOR*

The Transportation Corridor is shown in Figure 14-38.

Based on the impact scoping, a profile of the Transportation Corridor has been included within the social baseline due to the potential for traffic accidents / hazards during transport of goods and people. Using a risk based approach, areas that may be more at-risk from Project traffic include the more densely populated area between Paramaribo and the Commewijne River and the villages south of Moengo on the Moengo Road. The baseline context of traffic is discussed in greater detail in Chapter 20, however, to provide some additional characterization the risks include:

- Narrow paved road in the eastern portion of the East-West Highway increasing the possibility for speeding and resultant traffic accidents;
- Dangers associated with the laterite surface of the Langa Tabiki - Moengo Road during the wet season and potential accidents. This may be exacerbated by the use of the road by schoolchildren commuting to the school in Pelgrim Kondre; and

- Dangers associated with the transport of cyanide in relation to the proximity of houses to the road and the reliance on agriculture and surface water throughout the Transportation Corridor.

Based on the impact scoping and prediction process, the baseline for the Transportation Corridor has been structured to consider all issues that may influence safety. For this area, this means that topics are not discussed that are not predicted to be impacted. For example, the Project activities along the Transportation Corridor are limited to use of an existing government-owned road. However, due to the presence of some inhabited areas close to the road the profile considers factors that may influence traffic management and safety and the assessment of these impacts.

It was recognized that the villages directly south of Moengo on the Moengo Road (a laterite two lane track) are potentially more susceptible to impacts due to their proximity to the Project and the presence of a dirt road compared to the paced road of the East-West highway. Because of this a household survey was applied here and can be used as indicative of the typical rural settlements along the Transportation Corridor.

Because of limited impacts predicted along the Transportation Corridor a summary of the social baseline has been presented to help characterize the conditions.

### 14.7.1 *Demography along the Transportation Corridor*

The Transportation Corridor falls within the Districts of Marowijne, Commewijne including the resorts of Moengo and Patamaka (Marowijne), Tamaredjo, Alkmaar, and Nieuw Amsterdam (Commewijne).

The resort directly south of Moengo in which some of the surrounding communities fall is Patamaka, which has a population of 1,183[xlii].

The total population of these four Resorts is 25,296; however, it should be noted that the Transportation Corridor represents only a small percentage of the 2,941 $km^2$ that makes up these Resorts[xliii]. If we consider the potentially impacted corridor to be 50 m either side of the road, which runs for approximately 172 km between Paramaribo and the site, then the Transportation Corridor makes up an area of approximately 8.6 $km^2$, 0.29% of the total area of the Resorts.

The resorts display a distributed mix of language use with indications that the largest ethnic groups include Javanese (21% indicate it is the most spoke language in the household) and Ndjuka Maroons (21.8% indicate it is the most spoke language in the household). This is corroborated by census data regarding religious belief where 30.5% indicated they were Muslim (typical of Javanese) and 38.1% indicated they were Christian (typical of Maroons)[xliv].

*Figure 14-38 Transportation Corridor*

West of Moengo, the road follows a comparatively uninhabited route, however, as it reaches the bridge over the Commewijne River the population density increases and a linear settlement pattern appears as household structures appear often almost unbroken. Figure 14-39 shows the type of linear settlement pattern that is typical in an area between Potribo and Tamaredjo.


Source: Google Earth, 2011

*Figure 14-39 Examples of Linear Settlement between Potribo and Tamaredjo*

Although settlements appear indistinct, villages between Moengo and Paramaribo include:

- Perica;
- Potribo;
- Mon Pere;
- Tamaredjo; and
- Meerzorg.

It should be noted that some single or clusters of structures do exist outside of these villages; however, this list considers the main population centers.

The density of population along the Transportation Corridor is significantly higher closer to Paramaribo and to the East of the Commewijne it is noticeably more populous. However, it should be noted that throughout most of the

Transportation Corridor household structures exist on average between five and 20 m from the road.

In the communities directly south of Moengo where a household survey was applied we can provide more accurate predictions of population. *Table 14-14* shows an estimation of the total population of the relevant villages based on estimates of household numbers and average versus actual surveyed household sizes.

*Table 14-14 Household Survey in the Moengo Area*

| Village | Permanently Occupied Household Structure (Estimated) | Estimated Total Population |
|---|---|---|
| Kasaba Ondro | 7 | 32 |
| Ovia Olo | 35 | 196 |
| Mora Kondre | 22 | 123 |
| Pelgrim Kondre | 6 | 31 |
| Kraboe Olo | 16 | 100 |
| Leewani Ondre | 5 | 37 |
| **Total** | **91** | **519** |

*Source: ERM, 2012*

The household survey results indicate that an average of 52.9% and 47.1% of the population is male and female respectively. This may indicate that outmigration from these settlements is not widespread as this is assumed to result in a higher proportion of males.

All of the households surveyed indicated that they were predominantly members of the Monrovian church. In addition all households except one (which indicated themselves to be Amerindian) indicated they classify themselves as Maroon with approximately 85% indicating they consider themselves to be Saramakan, and approximately 10% indicating they were Ndjuka. Dutch is the most common language used in the households surveyed, spoken as the predominant language by approximately 76% of households surveyed, followed by Saramaka (approximately 21%), and Pamaka (approximately 3%).

The vast majority of respondents indicated that they were born in the community in which they lived with only three respondents indicating that they were born elsewhere in Sipaliwini, in Paramaribo, or in Wanica. This indicates that current levels of in-migration into these communities, typical of small communities along the transportation route, are anticipated to be minimal. The community is ethnically and religiously fairly homogenous and tends to be long-term residents of the area. However, it should be noted that some movement of people does appear to occur from these settlements: approximately 60% of those surveyed indicated that at least one member of the household has been away for more than three months in Paramaribo and approximately 40% indicated the same for elsewhere in Sipaliwini. It is anticipated that migration to Paramaribo is typically in search of educational or employment opportunities, however, it is unclear whether migration within the Interior is in order to pursue employment with Suralco / Surgold, ASM, hunting and gathering of NTFPs, etc.

### *14.7.2 Transportation Corridor Summary Health Profile*

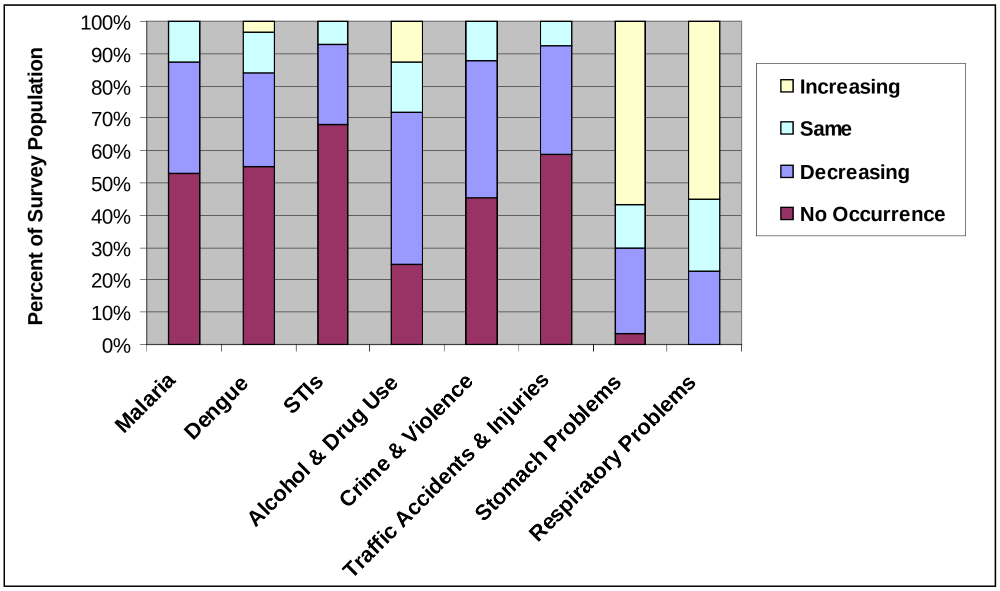
Households surveyed along the Transportation Corridor indicated that the most health concerns were related to fevers. Chronic health concerns were fairly common particularly high and low blood pressure and limited occurrences of diabetes, cancer, and sickle cell. Only one household indicated that someone had been involved in an accident in the past year.

Respondents to the household survey indicated that when someone in the household is sick the most common responses are to self-medicate or to visit the nearest clinic. The nearest medical facility is believed to be in Ovia Olo, however, it is believed to be limited in staffing and capacity.

People living in the rural areas of the Transportation Corridor typically have greater challenges in accessing clinical care due to the distance involved. According to the household survey most of the households (72%) indicate that the availability of health / medical services is 'not very good' or 'very bad' and approximately 40% indicated the quality of the health / medical services are 'not very good' or 'very bad'. Furthermore, FGDs revealed that residents in the surrounding villages are concerned about their health infrastructure, where transport to the clinic in Moengo is by public bus that operates only five days a week. It was reported that the frequency with which the doctors visit the village to hold practice is insufficient.

Based on the household survey results it is anticipated that the majority of residents along rural areas of the Transportation Corridor receive medical care funded by the government. In fact very few respondents indicated that cost was prohibitive to access to health care, but rather that lack of medical professionals, the high cost of travel, and the distance to adequate medical facilities was the key issue.

According to the household survey given in the areas, the majority of households consider their domestic water source and sanitation facilities (sewage, waste water, drains, etc.) as 'not very good' or 'very bad'. More than half of the households perceived stomach and respiratory problems as increasing over the last few years. In addition, there was the perception that other infectious diseases (malaria, dengue fever, and STIs) were not occurring at all or decreasing. Figure 14-40 shows the results of the household survey and the responses to perceived trends in health issues.




*Source: ERM, 2012*

*Figure 14-40 Perceived Trends in Health Issues*

Significantly for these communities, most of the households surveyed perceived traffic accidents and injuries to be non-existent or decreasing. This indicates that traffic accidents are not especially prevalent currently.

### *14.7.3 Transportation Corridor Summary Livelihoods and Socio-Economics*

The household survey applied in villages along the Transportation Corridor south of Moengo is indicative of the typical livelihoods of rural villages throughout the Transportation Corridor.

Respondents indicated that the most common income generating activities were agriculture and salaried work and that the average annual income was approximately SRD 5,432.12 (~US $1,645). Supplemental sources of income mentioned included remittances, pensions and income from small businesses.

According to respondents of the household survey, the most expensive household expenditures were associated with education followed by basic necessities (food, etc.), which make up almost 75% of the annual expenditure.

The average expenditure per annum was reported to be approximately SRD 4,096.27 (~US $1,240) indicating some potential for saving and investment. However, it should be noted that the average level of incomes reported are still considerably below the poverty line as reported by the Statistical Yearbook of Suriname (2006) at approximately SRD 1,049 (~US $323) / month or SRD 12,588 (~US $3,873)per year.

### *14.7.4 Cultural Heritage along the Transportation Corridor*

The Transportation Corridor passes close to a series of cultural and religious buildings between Paramaribo and Moengo.

These include:

- Three mosques within 10-15 m of the road in Tamaredjo and the surrounding;
- A Monrovian church building within 10 m from the road in and around Perica;
- A Dian Christian Community building within 5 m of the road in and around Perica; and
- A mosque, cemetery, Jehovah's Witness and gospel church within 20 m of the road in Potribo and the surrounding area.

## 14.8 *HUMAN RIGHTS AND VULNERABILITY*

The Constitution of Suriname sets out extensive freedoms, human, economic and political rights, and obligations for Surinamese citizens.

The full implementation of these constitutional rights are yet to be achieved and in its human rights report 2010, the US State Department reported the following issues within Suriname: overcrowded detention facilities; an overwhelmed judiciary with a large case backlog; lengthy pre-trial detention; self-censorship by some media; governmental corruption; societal discrimination against women, minorities, and indigenous people; violence against women; trafficking in women, girls, and boys; and child labor in the informal sector[xlv].

Significant human rights abuses were alleged in Suriname during the military rule and Interior War and there are on-going trials of those accused of involvement in those abuses.

The following chapters (*14.8.1 to 14.8.4*) discuss some of the human rights issues that may affect PAPs, and the highlight some potentially vulnerable groups within the SSA.

### 14.8.1 *Maroon Rights in Surinamese Society*

Indigenous and tribal people's rights to self-determination and their rights to ancestral land and resources do not currently exist under Surinamese law. The rulings of a small number of landmark trials taken against the Surinamese State have ordered this to be addressed; however, these rulings are yet to be implemented. Maroons in the Interior of Suriname are economically, socially, and politically disadvantaged. The civil war in the 1980s between the military dictatorship and a group of Maroons destroyed much of the social, educational, and economic infrastructure in Eastern Suriname.

### 14.8.2 *Standard of Living*

Standard of living has been evaluated using vulnerability groupings, household asset indicators, assessment of the incidence of poverty, and levels of income and expenditure (*Chapter 14.4.7*). In addition, standards of living have been assessed through consideration of residents' own perceptions on their quality of life based on focus group discussions and qualitative data from household survey results.

Within the Marowijne Area, 75% of households that provided income data (85 out of 113) are below the poverty line[xlvi]. A precise assessment of poverty based on income levels is difficult due to the limited amount of cash income in the study area and the predominance of unreported social service payments from French Guiana and income from small-scale mining. Figure 14-41 shows the distribution of households according to their relative position to the poverty line.

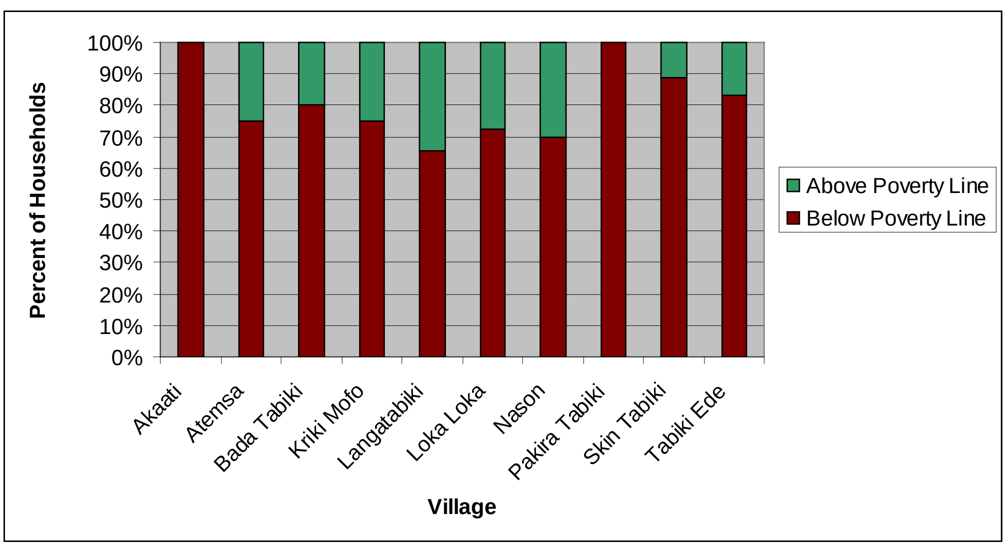



*Figure 14-41 Households Above and Below the Poverty Line*

The majority of households in all villages in the study area are below the poverty line: 100% of households in Akaati and Pakira Tabiki are below the poverty line.

Langa Tabiki, Loka Loka, and Nason, the three largest communities, have the highest percentage of households above the poverty line.

Due to the reliance on subsistence agricultural and non-formal sources of income generation, the calculation of the local unemployment rate in the study area is difficult. According to the household survey, 44% of household heads are unemployed, and 11% of household heads had actively sought work in the last three months. Therefore, the unemployment rate in the villages surveyed is at least 11%, but likely is within the upper range of 11-44%. The unemployment rate in the Sipaliwini District, where these villages are located, is the highest in Suriname, with 20.6% unemployment versus 9.5% on average in Suriname. The estimated unemployment rate in the local study area is significantly higher than both the national and district rates.

Lack of formal employment is described as a critical need in the villages surveyed. Residents with marketable skills are forced to leave the communities and seek work in Paramaribo or French Guiana due to the lack of employment opportunities in the region. Upon finding work in other areas, residents who have left the villages rarely return. This dynamic has increasingly led to the reduction in the population of educated and skilled individuals residing in the villages.

It was apparent during Focus Group Discussions that residents in the Marowijne Area perceive that their overall standard of living has deteriorated in recent years. This was based on reports that it is more difficult to rely on subsistence agriculture and hunting or fishing for food. There is thus an increased dependence on the cash economy, but without a matched increase in availability of income generating activities.

### *14.8.3 Availability of Household Assets*

Standard of living and quality of life can be assessed based on household construction and assets. Using classifications based on the Surinamese National Census, dwellings were classified as one of the following based on the total area of living space: shared dwellings, luxury residences (greater than 120 meters square [$m^2$ ] living space), middle class residences (60-100 $m^2$), low income residences (30-60 $m^2$), or shacks (0-30 $m^2$).

Based on the classification described above, 44.7% of the population in the Marowijne Area lives in low income residences, 25% live in middle class residences, 24.3% live in shacks and the remaining 6.1% are luxury residences, shared housing, or other housing (see Figure 14-42).

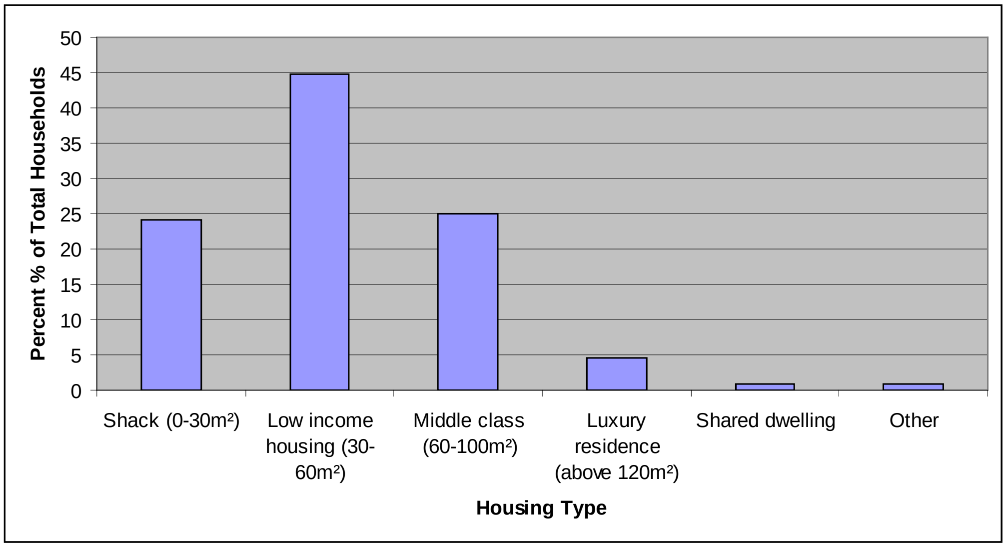



*Figure 14-42 Housing Type throughout Marowijne Area*

Housing materials and household assets are also indicators of the households' standard of living. Roofing materials of the houses varied from thatch to aluminum, while walls and flooring are mostly made from mud, wood, or concrete. Houses are typically built on stilts to reduce the risk of flood damage. Non-elevated houses and shacks are at the most risk from flooding.

### *14.8.4 Child Labor*

ASM globally typically involves considerable numbers of children and frequently child labor[xlvii]. Child labor is typically closely linked to poverty where children are required to work to supplement household income where it is insufficient. This situation frequently creates a continuous cycle of lack of educational achievement, health problems, problems with physical and psychological development, and reliance upon ASM.

Child labor in ASM sites close to the Project area was not witnessed during the fieldwork and teachers in the Pamaka schools indicated that it was not a significant drain on school attendance. However, in light of the low levels of household income in the Project area and the frequency with which ASM globally is linked with child labor, it is highly likely that children are involved with ASM within the Project Area. One ASM miner Landboss indicated that he had employed a child as young as 11 during school holidays although employees are typically aged between 17 and 19.

### *14.8.5 Vulnerable, Sensitive or Marginalized Groups*

*Introduction*

Vulnerability of receptors to social impacts is understood as a reflection of the ability to adapt to socio-economic/cultural or biophysical change resulting in a potential increased susceptibility to negative impacts or a limited ability to take advantage of positive impacts. It is a pre-existing status that is independent of the Project under consideration.

Heightened vulnerability may be reflected by an existing low level of access to key socio-economic/cultural or environmental resources or a low status in certain socio-economic/cultural indicators. Table 14-15 identifies aspects that may influence vulnerability.

*Table 14-15 Characteristics that Underpin Vulnerability*

| Access / Status | Aspects to be considered | Sensitivity Indicators |
|---|---|---|
| **Human Receptors' (individuals, groups, households, communities etc) *access to*:** | | |
| **Livelihoods** | Diversity of livelihoods<br>Legality of livelihood<br>Productivity of livelihood | · Reliance on one principle livelihood<br>· Principle livelihoods are relatively unproductive<br>· Principle livelihoods are unsustainable, fragile or illegal. |
| **Resources** | · Water<br>· Non-Timber Forest Products<br>· Land | · Access limited to few resources<br>· Resource shortages are frequent and serious<br>· Resources available are legally protected and use is illegal |
| **Services and Infrastructure** | · Health<br>· Education<br>· Transport<br>· Recreation<br>· Savings and support networks<br>· Fair Policing and Security | · Minimal access to key services and infrastructure<br>· Provision of key services and infrastructure is poor. |
| **Participation in Political and Civil Institutions and Decision Making** | · Freedom of association<br>· Freedom from corruption | · Minimal ability to participate in orthodox governance and decision making systems<br>· Subject to high levels of corruption<br>· Restrictions on rights of association, ability to participate freely in governance |
| **Community and Social Inclusion and Cohesion** | · Security<br>· Freedom from inter and intra community cohesion | · Subject to marginalization and discrimination.<br>· Subject to violence and conflict. |

| Access / Status | Aspects to be considered | Sensitivity Indicators |
|---|---|---|
| **Human Receptors' (individuals, groups, households, communities etc) *status*:** | | |
| **Health** | · Health status including malnutrition, infectious diseases, disability etc | · Acute illness<br>· Chronic illness<br>· Maternal mortality<br>· Child mortality. |
| **Knowledge, Skills and Education** | · Levels of knowledge skills and education<br>· Ability to participate in orthodox economic and social systems. | · Literacy<br>· School attendance<br>· Education levels achieved |
| **Financial resources** | · Income generation<br>· Savings | · Income levels relative to expenditure<br>· Ability to pay for food, key services, resources and infrastructure |
| **Independent Cultural Identity** | · Desire to maintain strong independent cultural identity.<br>· Desire to avoid all socio-cultural change | |
| **Labor Rights** | · Forced labor<br>· Child labor<br>· Right to association<br>· H&S standards<br>· Minimum wage etc | |

This process of identifying potentially vulnerable groups should pay specific attention the identification of individuals within these groups who may be particularly vulnerable.

### *14.8.6 Vulnerable Groups*

Potentially vulnerable groups within the SSA include people living below the poverty line (BPL), without access to land, the elderly (typically above 60), women-headed households, indigenous peoples, ethnic minorities, and natural resource-dependent communities. When vulnerable individuals are also heads of households, the entire household may also be considered at risk.

The following sections discuss groups who may potentially be vulnerable.

*Female Headed Households*

Female-headed households are considered vulnerable, particularly in the Marowijne Area due to the challenges they face in securing an income for expenditure on food and basic goods. Of the 32% of female-headed households in the Marowijne Area, 82% are living below the poverty line (See Figure 14-43).

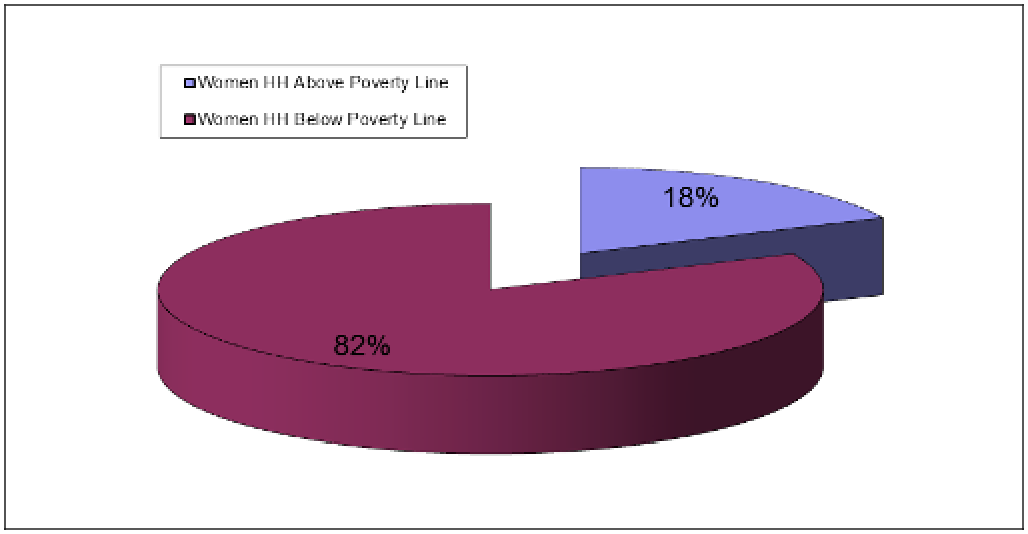



*Figure 14-43 Women Headed Households Below the Poverty Line*

Due to the traditional separation of economic and household activities between males and females in the study area, female-headed households must also rely on other male relatives or neighbor for activities such as boat transport, clearing forest for agricultural plots, and building or improving household structures. Female-headed households can also be considered vulnerable due to the lower levels of female influence in village decision making. Although some villages have female Captains, it was clearly stated during women's FGDs that female Captains are responsible for women's affairs only and it was the male Captain's opinion that counted in matters relating to the whole village. It was further indicated during women's FGDs that women can nevertheless share their views informally through discussion with male relatives. For female-headed households, however, this is obviously not always a possibility.

*Youth*

Youth were consistently identified as a vulnerable group during FGDs due mainly to lack of education, lack of employment opportunities in the area, and lack of finances to expand choices by moving elsewhere. Furthermore, it should be noted that within the Marowijne Area the youth are partially excluded from the traditional decision making processes and as such they can be marginalized within their society.

Young girls were viewed as particularly vulnerable due to their greater reliance on men for income to buy food and other goods. Teenage pregnancy was also raised as an issue during women's FGDs. This is recognized as a problem throughout Suriname but particularly amongst Maroon and indigenous communities. Figures are not available for the Marowijne Area but on a national level it is reported that 16.1% of all pregnancies were a teenage pregnancy in the years 2003-2007 and in Moengo 31% of surveyed teenage girls (aged 15-19) had been pregnant at least once[xlviii]. Unlike older women, teenage mothers do not receive social welfare support.

*People Economically Dependent on ASM*

Men from the Marowijne Area working in the ASM sector can be considered vulnerable because of their dependence on one key livelihood, which is an unreliable and illegal activity when not properly permitted. Due to low levels of educational attainment and limited means to train in alternative livelihoods, men working as ASM miners have few opportunities to seek alternative sources of income. In addition, it is common practice for ASM miners to take out loans to rent or purchase equipment. In other small-scale mining sites globally these loans are often provided by Landbosses who require that the debt be repaid in labor owed. Although exact figures are not available, indentured labor is therefore expected to be widespread in small scale mining camps.
In addition to those working as ASM miners, substantial numbers of people from the Marowijne Area are economically dependent on the small-scale mining industry. These people can therefore also be considered vulnerable due to the absence of alternative local industries generating demand for their supply of goods and services. Once again, due to limited educational or vocational training, there is limited opportunity for alternative employment.

*Children on the Transportation Corridor*

Children along the Transportation Corridor are potentially vulnerable to traffic accidents due to their limited experience of industrial fast moving traffic.

*Elderly or Disabled People*

Elderly or disabled people in the Marowijne Area may be vulnerable to economic change as they have a reduced ability to generate income and produce subsistence items for themselves. These types of vulnerable individuals and households are typically cared for by extended family, neighbors, or church groups. The elderly and some female-headed households also receive minimal social welfare support from the government. However, participants in FGDs reported that since ASM miners were removed from the Project area concession, less support has been available to women and the elderly living in the villages.

*Quantifying Potentially Vulnerable Groups*

The household survey in the Marowijne Area revealed that, of the total households surveyed, approximately 32% are women-headed households, 16% of households have disabled members, and 1 household is headed by youths (Figure 14-44).

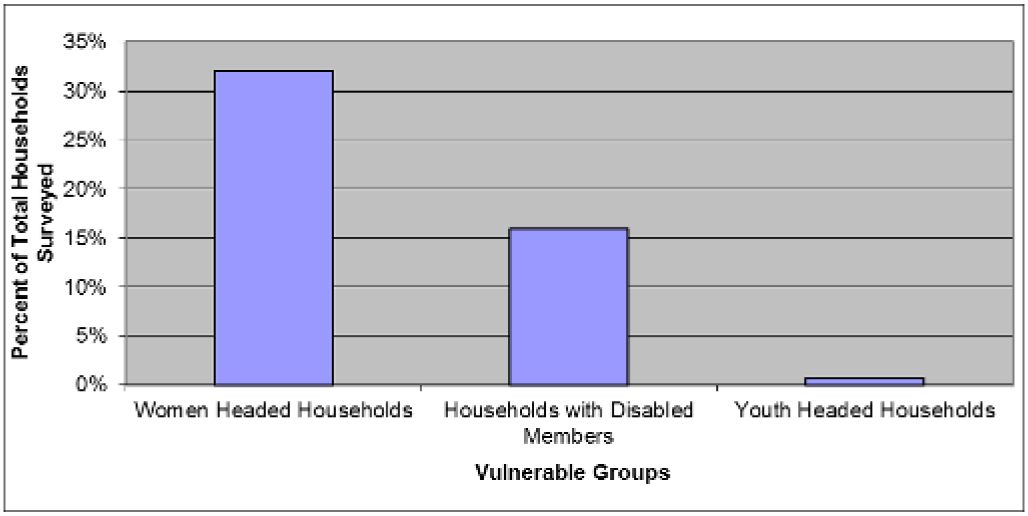



*Figure 14-44 Vulnerable groups*

## 14.9 *STAKEHOLDER PERCEPTIONS AND ATTITUDES*

During the ESIA process a Stakeholder Engagement Plan (SEP) was developed and executed. The SEP is provided in Appendix 14-F. This chapter summarizes the on-going perceptions and attitudes of relevant stakeholders to the Project including:

- Project Affected Peoples' (paps) attitudes and confidence in the gos's ESIA and mine permitting process;
- Stakeholder perceptions of the mining sector nationally and in the Project area (including IAMGOLD, Surgold and Suralco);
- Concerns and expectations regarding the Project's potential impacts; and
- Perceptions and expectations regarding on-going stakeholder engagement.

### *14.9.1 Drivers of Perceptions and Attitudes in the Marowijne Area*

Current community perceptions in the Marowijne Area regarding the Project are influenced by the traditional authority's attitude towards the Project. The Gaanman holds a position of power and respect as the paramount Pamaka chief and his position as the senior traditional authority means that his opinion and actions dictate the Pamaka social norms for interaction with Surgold. Although the inhabitants of the Marowijne Area may hold different opinions, the structure of the Pamaka society means it is difficult for stakeholders to act in opposition to the Gaanman's stated or implied position. The hierarchical nature of Pamaka governance means that suggestions or requests must be brought to village

Captains first, they are responsible for raising it with Head Captains, who will raise it with the Gaanman.

Throughout 2010 and 2011, the Gaanman has made a variety of sometimes conflicting statements regarding his support for the Project. The Gaanman's shifting attitude, interspersed with conflicting statements, appears to influence stakeholders in the Marowijne Area's attitudes towards the Company and the Project.

### *14.9.2 Perceptions of the Project in the Marowijne Area*

Many of the local Pamaka stakeholders have conditional support for the Project; however, this is dependent upon delivery of Project benefits, including the continued ability to pursue ASM and Project support from the Gaanman. Typical demands and expectations of the Company and the GoS include the provision of employment, sourcing of goods and services from the local area, educational initiatives and the continued availability of ASM as a livelihood/income generating activity. These expectations and concerns are detailed in Table 14-16.

Negatives attitudes towards the formal gold mining sector where present, are shaped by perceived failed promises, legacy issues, and confusion surrounding the roles of the Joint Venture (JV) partners, perceived absence of social investment initiatives, and perceived insufficient engagement / dissemination of information. Table 14-16 and Table 14-17 contain a list of concerns and expectations raised by stakeholders that are relevant to the Project. It should be noted that these are the views and opinions of stakeholders gathered during the engagement process and that they do not represent ERM's identified impacts.

*Table 14-16 Stakeholder Concerns*

| Stakeholder Groups | Project Concern |
|---|---|
| Community and civil society stakeholders in Paramaribo, Moengo, the Tempati and Commewijne area and Pamaka villages | Exposure to Environmental Hazardous Materials<br><br>Various stakeholders expressed concerned over health risks from possible environmental contamination during operations as well as post-closure. Specifically, there are concerns with Particulate Matter (PM) or fine dust exposure and contamination of drinking water sources (including turbidity from erosion and road dust). The youth FGD in Moengo revealed concerns over the contamination of the Njan Buroe Creek where they fetch water for drinking and washing. While many stakeholders recognize the Project does not use mercury, they are concerned that the use and transport of other hazardous chemicals, including cyanide and ammonium nitrate (for blasting), could cause environmental damage and pollution. |
| Community and civil society stakeholders in Paramaribo and Moengo | Increased Traffic Accidents in Moengo and on Transportation Corridor<br><br>The Project's use of a Transportation Corridor along the East-West Highway from Paramaribo and the Moengo-Langa Tabiki Road from Moengo to The Project area for transport of heavy materials and dangerous goods is a concern to stakeholders. Their apprehension that after the completion of the East-West Highway Rehabilitation Project, there will be an increased risk of accidents and injuries due to an increase in traffic volume, speeding and night-time driving. There are specific concerns with long work shifts (12 hours per day) if required for truck drivers which may lead to driver fatigue and increased risk of accidents. |

| Stakeholder Groups | Project Concern |
|---|---|
| Community and civil society stakeholders in Paramaribo, Moengo and Pamaka villages | Surgold Workforce Mental Health and Psycho-Social Effects |
| | There are concerns from stakeholders regarding the health of Surinamese workers and their families, particularly if the Project requires long work shifts (12 hours per day). Concerns exist that long work shifts in a closed camp can lead to mental stress and other psychosocial effects among the workers and their families. |
| Community and civil society stakeholders in Paramaribo, Moengo and Pamaka villages | Decrease in Community Safety |
| | There are concerns from stakeholders that influx of Surgold employees into the SSA will result in an increase in theft, violence, and a general sense of lack of safety. |
| Community and civil society stakeholders in Paramaribo and Moengo | Influx of ASM miners into Project Area and Related Health Issues. |
| | There is a concern from stakeholders that small-scale mining camps are known to establish themselves near large-scale mine projects. Should influx occur stakeholders indicated that this may have a series of associated health and environmental impacts including mercury contamination of water ways, spread of infectious diseases, prostitution and associated risk with STIs, violence and conflict, disruption in the |

| Stakeholder Groups | Project Concern |
|---|---|
| | local culture / traditional beliefs of the Marowijne Area and increased substance abuse. |
| Community stakeholders in the Marowijne Area | Increased Poverty |
| | There is a concern from Pamaka stakeholders that the Project will result in increased levels of poverty, as local people will lose access to key gold-bearing areas reducing the productivity of ASM as an income generating activity. This is particularly a concern given the loss of the Project or Gowtu Bergi area as an ASM miner site. |
| Community stakeholders in the Marowijne Area | Restricted Access to the Project Area |
| | There is a concern amongst Pamaka stakeholders that the Project will restrict access to significant areas of forest reducing the ability of local people to hunt, clear new fields for agriculture and gather NTFPs. Access to these areas is perceived as crucial to the freedom of the Pamaka people and the preservation of their culture. An association was frequently made between restriction to their traditional land and activities, and the idea of being enslaved. There were also fears that people would have to leave the area and comparisons were often made to the Brokopondo project, which necessitated the resettlement of several villages. |
| Community stakeholders in the Marowijne Area | Lack of Involvement of Pamaka People in Project |

| Stakeholder Groups | Project Concern |
|---|---|
| | There is a concern in the Marowijne Area that the Project will not involve local people within the decision-making and planning process. Stakeholders mentioned that there is a fear that the GoS will make a decision on how the Project should proceed regardless of what local people think and that the engagement and ESIA process will have no consequence. |
| | There is also a concern that local people are not provided adequate information for them to understand the Project and that their views are not being communicated to senior management and key 'decision makers' within Surgold. |
| | Several stakeholders from the Marowijne Area expressed concerns that Surgold would operate like the formal government, whom they perceive as ignoring the Pamaka people's rights, views and development needs. |
| Community stakeholders in the Marowijne Area | Lack of Social Investment |
| | There is some concern amongst stakeholders that they have not seen any tangible benefits from the Project and that social investment in the Pamaka communities will not occur but that all the money from the mine will go to Paramaribo. Specific concerns include that benefits may not be equally distributed between Upper and Lower Pamaka or between villages, that Surgold will not maintain infrastructure they will not use (e.g., roads) and that the lack of Pamaka organization will mean that they cannot maximize the benefits they could receive. In addition there is a concern that they will not be provided with employment should a mine be developed |

| Stakeholder Groups | Project Concern |
|---|---|
| Community and civil society stakeholders in Paramaribo, Moengo and Pamaka villages | Environmental Damage associated with Mine Closure |
| | There is concern amongst stakeholders that post-closure the area surrounding the mine site will be irreparably damaged and that plants and animals will never return. In addition, there are concerns that the pits may cause geological instability resulting in extreme natural disasters such as earthquakes, mudslides and volcanic eruptions. |
| | Concerns about mine closure are linked to a lack of trust in the will or power of the GoS to enforce legal requirements for proper environmental rehabilitation of the Mine Site. There is a view that there would therefore be little incentive for the company to uphold any promises they make about mine closure. |
| Community and civil society stakeholder in Paramaribo, Moengo and Pamaka villages | Sustainable Development |
| | There is a concern that any benefits that the Project may bring in terms of local employment, local procurement and infrastructure development will not necessarily lead to long-term development of the area but will last only the duration of the Project. In particular, there is a concern that if local people are recruited only for unskilled jobs, there will be no development of employment capacity that would allow those people to find jobs elsewhere after the mine closes. |
| Community stakeholders in the Pamaka and Commewijne area | Extension of ASM miner activities |

| Stakeholder Groups | Project Concern |
|---|---|
| | There is a concern that since the ASM miners were removed from the Industrial Zone they have begun and will increasingly seek alternative areas to mine or alternative access routes to existing Mine Sites, leading to environmental degradation and health and safety concerns in those areas. |

*Table 14-17 Stakeholder Expectations*

| Stakeholder Groups | Project Expectations |
|---|---|
| Community and civil society stakeholders in Paramaribo, Moengo and Pamaka villages | Provision of Employment<br><br>There is expectation amongst stakeholders that the Project will provide long-term employment to a large number of people as well as training of local people to qualify them for work on the Project. |
| Community and civil society stakeholders in Paramaribo and Moengo | Procurement of Goods and Services<br><br>There is expectation amongst stakeholders that the Project will require substantial goods and services and that these may be procured from businesses in Suriname increasing employment and revenue. |
| Community and civil society stakeholders in Paramaribo, Moengo and Pamaka villages | Social Investment Initiatives<br><br>There is an expectation from stakeholders that Surgold will provide a substantial amount of social investment in Suriname including secondary school and vocational training in the Marowijne Area, health infrastructure, fuel and community facilities and support to local stakeholders during periods of environmental disaster (e.g. floods). |

| | |
|---|---|
| Community and civil society stakeholders in Paramaribo and Pamaka villages | Provision of Auriferous Areas for ASM<br><br>There is an expectation from stakeholders that Surgold will provide access to or identify new or shared auriferous areas for ASM miners to mine. This may include construction of new roads and clearing new sites or sharing areas of the Right of Exploitation. There is also some expectation that Surgold will assist in the provision of training to ASM miners in improved mining techniques. |
| Community stakeholders in Marowijne Area | Environmental Protection Cordon<br><br>There is an expectation that Surgold will provide an environmental protection zone (suggested to be 5km) surrounding each village to ensure that resources and ecology is protected for exploitation by local people. |

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