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Environmental Impact Statement

Silangan Gold-Copper Project ECC amendment

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Environmental Impact Statement

Executive Summary

Table of Contents

Executive Summary		**ES-1**
I.	Project Factsheet	ES-1
II.	Background Information	ES-2
III.	Process Documentation	ES-2
IV.	Project Alternatives	ES-3
V.	Summary of Baseline Characterization	ES-3

Executive Summary

I. Project Factsheet

<table>
<tr><td>Name of Project</td><td>Silangan Copper Gold Project</td></tr>
<tr><td>Project Location</td><td>Barangays Timamana and San Isidro, Municipality of Tubod; Barangays Anislagan, Boyongan, San Isidro, Sta. Cruz, and Macalaya, Municipality of Placer; Barangays San Pedro, Lower Patag and Upper Patag, Municipality of Sison; and Barangay Upper Libas, Municipality of Tagana-an, all in the Province of Surigao del Norte.</td></tr>
<tr><td>Nature of Project</td><td>Resource Extractive Industry – Major Mining Project</td></tr>
<tr><td>Scale of Production</td><td>The Project will have a maximum mill throughput of 6.5 million tonnes per annum.</td></tr>
<tr><td>Total Project Area</td><td>532 ha</td></tr>
<tr><td>Project Capital Cost</td><td>PhP 38,000,000,000</td></tr>
<tr><td>Project Proponent</td><td>Silangan Mindanao Mining Co., Inc.</td></tr>
<tr><td>Proponent Representative</td><td>Eulalio B. Austin, Jr.President and Chief Executive Officer</td></tr>
<tr><td>Proponent Address</td><td>Main Office: 2nd Floor Launchpad Building, Sheridan corner Reliance Streets, Brgy. Highway Hills, Mandaluyong City
Mine Office: SMMCI Mine Office, Brgy. Timamana, Tubod, Surigao del Norte</td></tr>
<tr><td>Project Components and area</td><td>
<table>
<tr><th>Component</th><th>Location</th><th>Estimated Area (Ha)</th></tr>
<tr><td colspan="3">MINE AREA</td></tr>
<tr><td>Subsidence area</td><td rowspan="5">Brgy. Timamana, Municipality of Tubod</td><td>~208</td></tr>
<tr><td>Underground Sublevel Caving</td><td>Maximum depth of 400m</td></tr>
<tr><td>Ore Stockpile</td><td>~1</td></tr>
<tr><td>Topsoil Stockpile</td><td>~10</td></tr>
<tr><td>Sedimentation Pond</td><td>~23</td></tr>
<tr><td colspan="3">TAILINGS STORAGE FACILITY</td></tr>
<tr><td>TSF</td><td>Barangays San Pedro, Lower Patag, and Upper Patag, Municipality of Sison; Barangay Upper Libas, Municipality of Libas; Barangays San Isidro, Sta. Cruz, and Anislagan, Municipality of Placer.</td><td>~250 hectares</td></tr>
<tr><td>Tailings Pipeline</td><td>Barangays Timamana and San Isidro, Municipality of Tubod; Barangays Anislagan, Boyongan, Macalaya, Municipality of Placer.</td><td>~5.44 km</td></tr>
<tr><td colspan="3">METALLURGY AND ORE PROCESSING</td></tr>
<tr><td>Mill facility</td><td>Barangay Timamana, Municipality of Tubod; Barangays Boyongan and Macalaya, Municipality of Placer.</td><td>~30</td></tr>
<tr><td>Comminution</td><td colspan="2">Within mill facility</td></tr>
<tr><td colspan="3">SUPPORT FACILITIES</td></tr>
<tr><td colspan="3">• Mine access Roads
• Administration Complex
• Mine Office
• Communication Infrastructure
• Sewage Treatment Plant
• Recreational Facilities
• Water Refilling Station
• Water Treatment Plant for Processing
• Water Treatment Plant for TSF Discharge
• Fuel Storage Facilities</td></tr>
</table>
</td></tr>
</table>

	• Security Headquarters • Core Farm • Assay Laboratory • Accommodations	• Generator sets and Switchyards • Materials Recovery Facility • Ecological Composting Facility • Onsite Sanitary Landfill
	Crushing Facilities and Support Facilities	10 has
	Total Disturbance Area for Underground Mine	532 Has

II. Background Information

The Silangan Copper-Gold Mine Project has previously been awarded ECCs in 2013 and 2016 for the block cave plan and open pit plan respectively. The Declaration of Mine Project Feasibility (DMPF) was also awarded for the project. Since the issuance of project approvals in 2016 a number of regulations where issued that impacted the development of the Project. In particular, DAO 2017-10 entitled "Banning the Open Pit Method of Mining for Copper, Gold, Silver and Complex Ores in the Country" compelled SMMCI to revisit the mine method for the project and consider the viability of sub-level caving in order for the project to proceed. Since change in mine method is considered a major amendment, SMMCI is submitting this EIS to support the application of an amended ECC for sublevel caving.

III. Process Documentation

Jacobs followed the EIA process flow as stipulated in DAO 2003-30, DMC 2014-005, and DAO 2017-05 incorporating the additional steps to enhance public participation for the environmental impact assessment process. The accomplished steps are tabulated below:

Activities	Dates
IEC Campaign and Perception Survey	December 13, 2018 to January 25, 2019
Public Scoping	February 26 to 28, 2019
Technical Scoping	March 11, 2019
Baseline Studies	January 7 to March 22, 2019
Public Hearing	April 29, 2019

Results of baseline studies from surveys conducted from 2013 to 2016 were reviewed. Additional baseline studies were conducted from January 8 to March 5 of 2019. Protocols for sampling for soil, water, and air were taken from relevant DENR guidelines and results of the analyses were also compared to the applicable standards. Transects observations and quadrats were employed for terrestrial biota with the observed species compared against the International Union for Conservation of Nature (IUCN) red list of threatened species to determine if there are vulnerable species within the project site. As for the People module, an updated household and perception survey was conducted among the host and neighboring barangays to determine any changes from the demographic, socio-economic and health data documented in the previous studies. The perception survey was meant to determine the acceptability of the project among the stakeholders.

The draft document was submitted to DENR-EMB last March 21 for procedural screening. The scheduled public hearing is on April 29, 2019 to be conducted in the Gymnasium of the Municipality of Tubod at 9:00 a.m. The EIA team consists of the following specialists and consultants:

Name	Role
Katherine Gavile	Project Manager
Malvin Manueli	Senior Geologist, Pedology and Geohazard Specialist
Rodel Alberto	Land Use Specialist and Forester
Pastor Malabrigo	Senior Forester
Anna Pauline De Guia	Senior Wildlife Specialist
Karel Padayao	Senior Environmental Scientist
Edimar Ederio	Environmental Scientist
John Paul Pareja	Water Quality Specialist
Joyce Almadrones	Water Quality Specialist
Veronica Atienza	Aquatic Ecologist
Joan Julia	Senior Air Quality Specialist
Anthony Magsombol	Air Quality Specialist
Susan Cruz	Sociologist
Fernando Karlo Gavile Jr.	Anthropologist
Engr. Vengel Romero	Proponent

Name	Role
Engr. Amando Reyes IV	Proponent
Engr. Dulce Romero	Proponent

IV. Project Alternatives

Project alternatives were considered in terms of siting, technology selection/operation processes, and design. The results of the alternatives investigation are presented below:

Aspect	Alternatives
Siting	Mining development is constrained by the fixed location of the orebody, site topography, available technology, cost, limited waste storage alternatives, and availability of usable areas. Due to constraints in the location of the mine area, project alternatives and options for the locations of the mine components and waste storage facilities are also limited. In general, the location of the project site was delineated through an integrated assessment of the constraints in the mine area, method and cost as well as potential environmental and social conditions and impacts in the placement of the mine components.
Technology selection/operation processes	Technologies were considered for the viability of block-cave, open pit and sub-level caving. Technologies are available for three options but the final consideration for the method that will be applied concern geotechnical, environmental, and regulatory aspects. Sublevel caving was chosen as it eliminated the issues with safety previously encountered during the block-cave decline development. In terms of environmental impact, the sub-level cave method significantly reduced the surface disturbance area thereby eliminating or reducing the impacts previously associated with the open pit method. Finally, the regulatory restriction on the development of open pit mining compelled SMMCI to adopt the sub-level caving mining method.
Design	The design of the major mine facilities such as the sub-level cave, mill, and TSF were based on available technology, cost, environmental viability and suitability for the site. Preference was given to design that is also implemented by other mines in the Philippines with a similar mine plan and with best performance. The TSF design was based on the requirements of ANCOLD.
No project	The ‘no project’ option must be weighed against the economic benefit that the project would bring to the host barangays and to the national and regional economies. As previously discussed, economic benefits that would be derived from the project are: • Potential to create up to 2,500 jobs during the construction phase; • Royalties and taxes paid locally and shared by provincial, municipal and barangay communities; and • Social development programs that will benefit the host communities If the project does not proceed, the above benefits and the corresponding multiplier effects and general improvement in the conditions of the host communities will not be realized. These being said, this standard of living will remain if the project is not implemented. The project is expected to provide direct and indirect livelihood opportunities for stakeholders within the host barangay.

V. Summary of Baseline Characterization

The total 532 hectares of mine footprint is classified as alienable and disposable land. Based on field observation and mapping data, majority of the actual land use within the project site is utilized for agriculture particularly coconut plantations and minimal rice paddies. The project site also captures only three types of environmentally critical areas (ECA) as defined by DAO 2003-30 namely areas with critical slopes, recharge areas of aquifers, and geohazard-prone areas. ECAs that were previously identified during the open pit mine design are no longer included during the sublevel caving design since the mine footprint was significantly reduced, eliminating the impact.

The project site is located in a geologically active area which is also the reason why the project site and its vicinity have mineral resources. The trenches and faults affecting the Project site are as follows: the Philippine Trench in the Philippine Sea to the east, the Philippine Fault (Surigao Segment) and Cabadbaran Fault along the Malimono Range to the west, the Suriga Valley Fault along the foot of Diwata Range, and the Philipine Fault (Lianga Segment) to the south. PHIVOLCS considers as active the Philippine Trench and the Philippine Fault. The Philippine Trench and the Surigao Segment of the Philippine Fault are the sources of most earthquakes that have happened in the area. The project site is susceptible to geohazards such as ground shaking brought about by seismic activities, slope failure for areas located in critical slopes, and flooding near major river systems and low-lying areas towards the coast and Lake Mainit. Soil investigations conducted within the 6-year period exhibit sufficient organic matter and metals content but slight deficiency in other nutrients. Because of this, there is a limitation as to the kind of crops that can viably grow. The soil characteristics are typical of soil types derived from volcanic rocks.

In terms of terrestrial vegetation and wildlife, there are no protected vegetation communities within the project site based on PD 705, RA 7586 and the CLUPs of the host municipalities. Remaining patches of forests near the project site are forests of limestones located in Barangays Marga and Motorpool in the Municipality of Tubod but these are already heavily disturbed by logging and wildlife poaching. Heavily disturbed forest over limestone were observed in Brgys. Marga and Motor Pool, Municipality of Tubod. The original vegetation community (lowland evergreen forest) within this region has almost been completely wiped out by commercial logging and land conversion to agriculture and agroforestry. The most dominant trees within the project site are coconuts trees and falcata.

The water resources within the project site and vicinity consists of fresh surface water and groundwater or spring sources. The project site straddles three river catchments namely, Hinagasa-an in the north, Magpayang in the south, Bad-as-Amoslog in the east and partly Mayag in the west. Run-off from the Hinagasa-an catchment flows to Sison; run-off from Magpayang flows through Tubod and Placer then down to Mainit, the rest of the run-off from the site will flow to the west. The project site and surrounding areas consist of local and less productive aquifers of relatively low yield that often cannot sustain the needs of the communities being serviced. Based on hydrologic studies, the only domestic well that will be impacted by the project is located in Barangay Timamana. Nevertheless, three Community Water Projects (CWPs) located in Timamana and Anislagan are already constructed and are ready to be energized to provide alternative water sources to the impacted host communities in the event these barangays will have reduction in existing water sources. The characteristics of stream waters are influenced by their location, land use, and geology. Rivers located in the Hinagasa-an catchment generally comply with Class B standards for fresh surface water (DAO 2016-008) except for biological oxygen demand and fecal coliform which exceed the standard. This can be attributed to the impact of domestic and animal wastes and run-off from agricultural lands. On the other hand, rivers within the Magpayang catchment (which includes the mine areas) are generally within the prescribed range of Class B standards except for arsenic and fecal coliform which exceed the standard. Fecal coliform contamination can be attributed to improper disposal of domestic wastes while the arsenic is attributable to the mineralized geology of the area. The Bad-as Amoslog catchment is the most impacted of the river systems registering above-standard levels of heavy metals, oil and grease, bacteriological input and chloride levels. Various tributaries drain into this catchment from land uses that include agriculture, industrial (mining), transport, and construction. Consequently, findings on aquatic ecology is directly related to the stream water quality. Heavily impacted streams are distinguished by the dominance of pollution-resistant phytoplankters while streams of good quality have more diverse assemblage of freshwater biota. Only three genera of fish were documented in the different sampling stations. These include *Anguilla marmorata*, *Rhinogobius* sp. and *Gobius* sp.. Generally, these fishes were caught in Hinigasa-an River and its tributaries.

Jacobs also measured ambient air quality and noise. Average backgound levels of particulate pollutants TSP and PM_{10} range from 6 µg/Ncm to 125 µg/Ncm. These are within the applicable National Ambient Air Quality Guideline Values (NAAQGV). Low background concentrations of SO_2 and NO_2 across the stations were detected during the 1-hr and 24-hr averaging periods which are also within the range of the NAAQGV. Emissions observed come mostly from motor vehicles and the practice of waste open burning. All monitoring stations classified as Class AA exceeded the DENR/NPCC Standards for the 1-hour monitoring and this is due to noise coming from the school and motor vehicles. Nighttime noise levels are attributable to motor vehicles.

The MPSA and total project footprint has no overlap with approved Certificate of Ancestral Domain Titles (CADT), Ancestral Domain Claims (CADC), or Ancestral Land Titles (CALT). The host barangays are rural, mostly leading to, or themselves in, the mountains and in the interior of the host municipalities. While most houses and farm lands tend to be owner occupied, the houses are mostly made of a mix of strong and light materials and the farm lands tend to be small (< 3 hectares). This is a reflection also of the the average household income for all host barangays is of PHP5,803/mo which is significantly below the poverty threshold of PhP 9,063.75 a month. About forthy seven percent (47%) of respondents are strongly in favor of the Project. There is a considerable body of those who mildly support, are neutral or mildly oppose with the vast majority of these respondents expressing neutrality. About eighteen percent (18%) of respondents are strongly not in favor of the project. The main driver for the strong support is the need for employment and livelihood which stakeholders perceive can be realized through the project. The summary of impacts is tabulated below according to the previous and present mine methods for the Project. Residual impacts after the application of mitigation presented in the Environmental Management Plan (EMP) are included below:

Environmental Aspects	Potential Impacts associated with Block Cave Mining	Potential Impacts associated with Open Pit Mining	Potential Impacts associated with Sub-level Caving	Residual Effects after applying Mitigation Measures	Risks and uncertainties relating to the findings and implications for decision-making
Geohazards	• Construction of the TSF may cause a reduction of the frequency of flooding in downstream areas • Breach in TSF may cause flash flooding, high-density flows and spillage of mine tails in downstream areas • Subsidence and slope failure (landslides) may take place during construction and operation • Tension cracks may propagate beyond the estimated limits of the subsidence pit and cause slope failure on adjacent mine facilities or proximal settlements. • Mud rush, or sudden inflow of fine sediments from underground drawpoints, may occur during the mine's construction and operations phase. Mud rush will destroy underground infrastructure.	Except for the impacts identified for the underground mine component, the same set of impacts identified for the underground mine also applies for the Open Pit. In contrast however, the limits of the Open Pit can be accurately planned and defined before Project commissioning thus enabling the proponent to adequately implement engineering control measures specific for the geohazards identified and within the limits of the Open Pit.	The same set of impacts are also identified for the sub-level caving method but due to the reduction of mine footprint, the magnitude and extent of these impacts will be contained within the disturbance areas	Potential for slope failures and TSF issues will be significantly reduced or eliminated with engineering measures. While the extent of the subsidence zone is modeled or computed, provision for buffer and engineering measures that are part of the subsidence zone management will be able to prevent impacts related to slope failure and subsidence	Risks are associated with uncertainties in geotechnical properties of soils and rocks that may be encountered during construction. These can be minimized with the continuation of geotechnical investigations and minimized by phasing the construction schedule
Terrestrial Vegetation and Wildlife	• Construction of the mine components will require stripping of vegetation. • Removal of vegetation may disturb habitat and food source of wildlife and people. • Site clearing for Project development will result in the reduction of wildlife population and may decrease the number of species growing within the footprint.	The impacts identified for terrestrial vegetation for an underground mine project are also applicable for a surface mine project.	The impacts identified for the open pit method also applies for the sub-level caving method but the impact areas are already reduced and with the accomplishment of the tree inventory, the vegetation cover that will be likely removed is also identified. With the reduction in project footprint, more land can be allocated for revegetation and buffer.	With the reduction in footprint and the implementation of mitigation measures, the status of terrestrial flora and fauna within the vicinity of the Project will be improved since there will be active rehabilitation and protection. In fact, even before the project commences, about 287,000 trees have already been planted and survived improving vegetation cover within the vicinity of the project.	None
Hydrology	• The underground mine may potentially impact the spring and groundwater	Impacts to surface water, groundwater and spring sources	Catchments that are previously encroached	With mitigation, the potential water resource	The risks are associated with potential impacts to

Environmental Aspects	Potential Impacts associated with Block Cave Mining	Potential Impacts associated with Open Pit Mining	Potential Impacts associated with Sub-level Caving	Residual Effects after applying Mitigation Measures	Risks and uncertainties relating to the findings and implications for decision-making
	systems within the Project and its vicinity resulting to groundwater drawdown, reduction of flow, or disappearance of groundwater and spring sources within the host barangays. • The development of the TSF and the subsidence pit over time may result in changes to surface hydrology leading to reduction of stream volumetric flows along drainage channels located downstream of these facilities. • Reduction of vegetation cover would result in an increase in surface runoff	may also be potentially impacted over time as the Open Pit is developed similar to what may occur if the mine progresses with the block cave method. In contrast with the underground mining method, surface drainage, diversion and sedimentation controls, and water quality management strategies can be planned before the pit is developed.	by the project during the open pit plan will no longer be impacted due to the reduction of project footprint. Potential impacts to groundwater resource are identified however. To address these impacts, Community Water Projects (CWPs) have already been established.	and supply issues are resolved and potential impacts are minimized.	hydrology that may be observed once the project construction and sublevel caving development. These risks can impact decision making for the development of the CWPs and the mine development to minimize affecting groundwater sources.
Water Quality	• Effluents and process waters enriched in metals and other pollutants may be released from the TSF and mill and be discharged into receiving water bodies • Hydrocarbon leaks and spills from vehicles, fuel tanks and used oil storage may contaminate ground and stream water • Non-mine wastewater from support facilities particularly the administration and accommodations complex and the various warehouses may contaminate surface water bodies.	The potential impacts to water quality for both surface and groundwater resources for the underground method are applicable for the Open Pit as well. The same mineral processing method proposed for the underground mine will also be used for the Open Pit with the modification that the grinding circuits will now be placed on the surface. Contingent to the Open Pit mining method, surface infrastructure footprint is also expected to be larger than the surface footprint of an underground mine.	Surface water bodies that were previously identified to be impacted will no longer be encroached thereby eliminating or reducing the extent and magnitude of potential water contamination.	Minimize or eliminate impacts	Risks are associated with the release of deleterious substances from the process or the TSF which were not previously identified in the mine planning and design. The risks will be eliminated by continued technical studies and pilot testing which will be conducted before the mine operates.
Climate, Air Quality and Noise	• Removal of vegetation would decrease carbon sequestration potential within the Project area • Significant alterations to the topography and hydrology by the Project may affect microclimate conditions • Blasting, vehicular movement and equipment operations will increase ambient noise levels	The impacts identified for the underground mine will also be recognized for the Open Pit operations. However, the magnitude of impact, particularly for decreased carbon sequestration potential and air quality and noise, would be directly related to the Project footprint and the increase of surface infrastructure particularly	With the shift to sublevel caving, most aspects of the operations will shift to the underground reducing the need to clear large areas of vegetation to construct the surface facilities. With the reduction in disturbance areas, more areas within the MPSA	None	None

Environmental Aspects	Potential Impacts associated with Block Cave Mining	Potential Impacts associated with Open Pit Mining	Potential Impacts associated with Sub-level Caving	Residual Effects after applying Mitigation Measures	Risks and uncertainties relating to the findings and implications for decision-making
	• Land clearing, blasting and vehicular movement will increase the amount of fugitive dust and particulates in the air • Metal-rich particulate matter liberated from mineralized materials as a result of mining activities will increase the ambient concentrations of elements suspended in the air. • Vehicle and equipment operation (e.g. diesel generators) will emit additional NO_x, SO_x, heavy metals and other greenhouse gases (GHGs) from the combustion of fuels.	with the addition of the Open Pit and WRD and the corresponding change in footprint for the TSF and the associated mine facilities.	can be allocated for revegetation, wildlife protection, and GHG offsetting. Dust generation will also be limited to the subsidence zone, the haul roads, and the TSF and mill (during construction)		
Socio-Economics, Public Health and Safety	• Inhabitants and properties within the project site may be displaced which may lead to adverse impacts with regards to the cohesion of their community, the quality of life, fears, apprehensions and perceptions of the receiving community and local government units where they will be transferred, and competition for basic utilities, public services, and other limited resources. • Payment of government dues in the local level would bring additional operational funds for local government units (LGUs) • Hiring of a significant amount of locals will bring a steady source of income and contribute to poverty reduction in the impact barangays. • Mining operations will open a market for support services such as security, housekeeping, catering, etc. that can foster local entrepreneurship and contribute to poverty alleviation. • Business opportunities created by the presence of the Project may encourage in-migration to the host barangays / municipalities, causing both positive (hiring) and negative	The potential impacts recognized for this module for the underground mine are also applicable for the Open Pit project. Mining-related guarantee funds and programs, such as the Contingent Liability and Rehabilitation Fund (CLRF) and the Social Development and Management Program (SDMP), are prescribed in the Philippine Mining Act of 1995 (Republic Act 7942) and its implementing rules and regulations DENR Administrative Order (DAO) 96-40. The potential impacts on displacement may also apply for the Open Pit mine method but the magnitude of impact will be highly dependent on the project footprint and the areas the facilities will encroach. It can be surmised that the potential impact of displacement or resettlement is more significant for the Open Pit mine method since surface facilities not present for the underground mine (e.g., WRD)	Stakeholders and infrastructure that were identified to be displaced during the open pit plan will no longer be disturbed as there is no need to construct the WRD. With the reduction in project footprint, previous farmlands that will be encroached by the surface facilities will no longer be disturbed. In order to maximize benefits from employment, the BESO is instituted that allows the barangay to screen and endorse candidates to SMMCI making the opportunity for direct employment equitable among the host barangays. With the previous baseline studies conducted, there was sufficient	Minimize or eliminate impacts in relation to in-migration, waste management, and resource competition. At the same time, benefits from the mine will be enhanced with appropriate measures	Risks are associated with negative perception and conflicts with stakeholders (grievance) which may occur if commitments or measures included in the EIS and SDMP are not fulfilled. Other risks are associated with security. These risks could entail provision for additional resources and manpower to handle community-related issues and security, enhanced coordination with stakeholders and government agencies, and additional measures to manage issues and concerns not previously identified in the EIA.

Environmental Aspects	Potential Impacts associated with Block Cave Mining	Potential Impacts associated with Open Pit Mining	Potential Impacts associated with Sub-level Caving	Residual Effects after applying Mitigation Measures	Risks and uncertainties relating to the findings and implications for decision-making
	(competition for work, resources, service, etc.) socio-economic effects in these areas • In-migration can lead to higher risk of spread of communicable diseases and resource competition • Higher income generation due to direct and indirect contribution from the Project can boost local purchasing power, as well as increase the incidence of theft, drugs, alcohol, gambling and prostitution. • Mine activities will lead to an increase in vehicular traffic leading to the Project site, providing better transportation, as well as increasing accident and health risks to the communities. • Mining operations and in-migration would increase production of human and non-human wastes.	may encroach existing settlements for the Open Pit mine method.	information available to craft a comprehensive SDMP.		

DRAFT

JACOBS

Environmental Impact Statement

Section 1. Project Description

Table of Contents

1.0	Basic Project Information	PD-5
1.1	Project Information	PD-5
1.2	Project Profile	PD-5
1.3	Mineral Resource and Products	PD-5
1.4	Planned Mine and Mill Capacity	PD-5
1.5	History of Mineral Rights	PD-6
1.6	Ownership	PD-8
1.7	Project Development History	PD-8
1.8	Government Approvals	PD-9
2.0	Project Location and Area	PD-12
2.1	Location and Area	PD-12
2.2	Primary and Secondary Impact Areas	PD-13
2.3	Vicinity and Accessibility of Project Area	PD-14
3.0	Project Rationale	PD-20
3.1	Project Contribution to National Development Goals	PD-20
3.2	Project Contribution to Regional and Local Development Goals	PD-21
3.3	Project Alternative	PD-22
4.0	Environmental Impacts	PD-24
5.0	Project Components	PD-29
5.1	Overview of Project Components for Sub-level Cave Mine	PD-29
6.0	Project General Layout	PD-31
7.0	Resource Geology	PD-33
8.0	Description of Project Components	PD-34
8.1	Underground Mine	PD-34
8.2	Mill and Processing Plant	PD-35
8.3	Support Infrastructure Summary	PD-35
9.0	Process Technology	PD-41
9.1	Mining Process	PD-41
9.2	Mineral Processing	PD-42
9.3	General Reagents	PD-51
9.4	Tailings Management	PD-52
9.5	Water Management	PD-53
10.0	Description of the Pollution Control Devices and Non-Mine Waste Management System	PD-56
11.0	Description of the Operations and Maintenance of the Mine Components	PD-61
12.0	Project Size	PD-62
12.1	Mineable Reserve and Mine Life	PD-62
12.2	Total Project Area	PD-62
13.0	Development Plan, Description of Project Phases and Corresponding Time Frame	PD-62
13.1	Project Phases	PD-62
13.2	Project Development Schedule	PD-63
13.3	Manpower	PD-63
13.4	Estimated Development Cost	PD-65

List of Tables

Table 1	Comparison of components under the 2016 ECC and new/additional components under the 2018 application	PD-11
Table 2	Project host administrative region and government units	PD-12
Table 3	Primary and secondary impact areas	PD-13
Table 4	Mining Technology Alternatives	PD-23
Table 5	Project Environmental Impacts	PD-24
Table 6	Components of the Sub Level Cave Mine	PD-29
Table 7	Boyongan JORC Classified Mineral Resource (MPSA – 149)	PD-33
Table 8	Workshop and Warehouses Details	PD-37
Table 9	Administration Complex Details	PD-39
Table 10	General reagents that will be used for mineral processing are presented below	PD-51
Table 11	Pollution Control Devices and Non Mine Waste Management System	PD-56
Table 12	Project Phases Details	PD-62
Table 13	Development Manpower	PD-64
Table 14	Operating Manpower	PD-64

List of Figures

Figure 1	Map of Surigao del Norte Showing MPSA 149 and EP 13	PD-7
Figure 2	Map of the Philippines showing relative locations of Ninoy Aquino International Airport to Surigao del Norte	PD-15
Figure 3	Map of the Northern Mindanao showing relative locations of Bancasi Airport and Surigao City Airport to the Project	PD-16
Figure 4	Map of the Project in Relation to the Biophysical Direct and Indirect Impact Areas	PD-17
Figure 5	Map of the Project in Relation to the Socio-Cultural Direct and Indirect Impact Areas	PD-18
Figure 6	Map of the Project in Relation to Major Access Points in the Region	PD-19
Figure 7	General Layout of the Project Showing Sub Level Caving Mine Facilities	PD-31
Figure 8	Proposed ECC Coverage Area	PD-32
Figure 9	Typical Sub-level Caving Operation	PD-34
Figure 10	Metallurgical Process Flowsheet	PD-43
Figure 11	Typical Section of the Starter Embankment	PD-52
Figure 12	Typical Section Showing Final Crests	PD-52
Figure 13	Water Mangement for TSF	PD-55
Figure 14	Project Timeline	PD-63

1.0 Basic Project Information

1.1 Project Information

Name of the Project:	Silangan Copper-Gold Project
Location:	Barangays Timamana and San Isidro, Municipality of Tubod; Barangays Anislagan, Boyongan, San Isidro, Sta. Cruz and Macalaya, Municipality of Placer; Barangays San Pedro, Lower Patag and Upper Patag, Municipality of Sison; and Barangay Upper Libas, Municipality of Tagana-an, all in the Province of Surigao del Norte
Nature of Project:	Resource Extractive Industry – Major Mining Project
Mineral Production Sharing Agreement (MPSA) Number:	MPSA No. 149-99-XIII
Environmental Compliance Certificate Number:	ECC-CO-1510-26
Maximum Milling Output:	6.5 million metric tons per annum

1.2 Project Profile

Silangan Mindanao Mining Company Inc. (SMMCI) is a joint venture between Philex Gold Philippines, Inc. (PGPI) and Philex Mining Corporation (PMC). All companies are primarily engaged in large-scale exploration, development and processing of mineral resources. The total SMMCI property holdings consist of four non-contiguous tenements in the form of one Mineral Production Sharing Agreement (MPSA), one Exploration Permit (EP) and two Exploration Permit Applications. The Boyongan prospect lies within parcel 2 of MPSA 149-99-XIII located in Brgy. Timamana, Municipality of Tubod.

Name of Proponent:	Silangan Mindanao Mining Company, Inc (SMMCI)
Address of Proponent:	
Main Office:	2nd Floor Launchpad Building, Sheridan corner Reliance, Mandaluyong CIty
Mine Office:	SMMCI Mine Office, Barangay Timamana, Tubod, Surigao del Norte
Company Representative:	Eulalio B. Austin Jr.
Contact Details:	Tel No.: (+63 2) 631-1381 Fax No.: (+63 2) 634-4441

1.3 Mineral Resources and Products

The main mineral resources of the Project are copper and gold. The Project will produce gold and silver dore', copper cathode, and mineral concentrate containing copper and gold. The mineral concentrate will be sold to and shipped for refining and smelting. The end market for the sale of the concentrate is still under study. It is expected that the identification for the market and negotiations for the sale of the concentrates will be finalized before the mine goes into commercial production

1.4 Planned Mine and Mill Capacity

The planned mine capacity is 5 Mtpa. The planned mill capacity is 4 Mtpa capacity.

1.5 History of Mineral Rights

MPSA 149-99-XIII

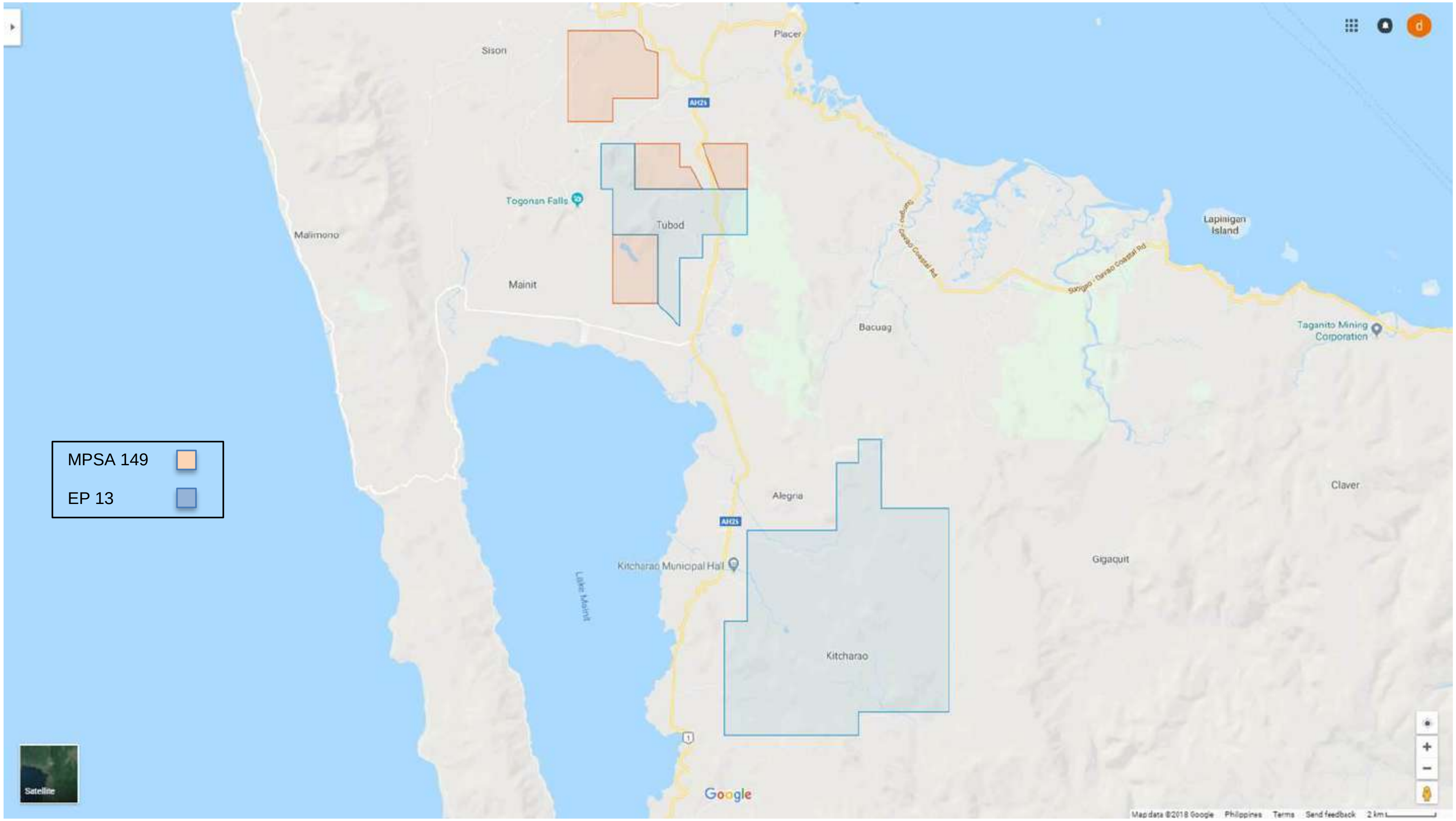
MPSA 149-99-XIII was granted by the National Government thru the Department of Environment and Natural Resources (DENR) in favor of Philex Gold Philippines Inc. (PGPI) on December 29, 1999. The term of the MPSA is twenty-five (25) years and may be renewed for another twenty-fie (25) years thereafter. PGPI and SMMCI executed a Deed of Assignment in favor of SMMCI which was approved by the DENR Secretary on October 24, 2000. The primary purpose of the MPSA is to enable the rational exploration and commercial utilization of copper, gold, silver and other mineral deposits within the amended MPSA area of 2,202 hectares that straddles the Municipalities of Mainit, Placer, Sison, Taganaan and Tubod, Surigao del Norte.

Exploration was completed in 2013 that lead to the discovery of the Boyongan and Bayugo orebodies. SMMCI is bringing forward the development and mining of the Boyongan orebody in the soonest possible time.

EP-13-XII

EP-00013-XIII ("EP") was granted by the DENR MGB on March 11, 2002. The EP was approved for the third time on May 2016 and now covers an area of 5,000 hectares after relinquishments over 2 parcels: (a) Parcel 1 retaining the original area of 1,644 hectares in Tubod, (b) Parcel 2 consisting of 3,356 hectares in the municipalities of Kicharao and Alegria.

Figure 1: Map of Surigao del Norte Showing MPSA 149 and EP 13



1.6 Ownership

SMMCI is a domestic corporation primarily engaged in large-scale exploration, development and processing of mineral resources. SMMCI completed the acquisition of the Silangan Project in April 2010 and has been progressing the development of the project since then.

The Boyongan Deposit and sites for waste and proposed tailings storage facilities are located within the tenement areas covered by MPSA 149-99-XIII. As of the date of reporting, all mineral rights held by SMMCI with respect to the Silangan Project area are valid and subsisting.

Mining activities in the Philippines are mainly governed by Republic Act No. 7942, otherwise known as the Philippine Mining Act of 1995 (the "Mining Act"), which provides the legal framework and some specific customs and tax rules for all mineral exploration and extraction activities. The Mining Act prescribes the conditions and rules governing all phases of mining activity. Pursuant to the Mining Act, the State, being the owner of all mineral resources in private and public lands, may grant to a contractor the exclusive right to conduct mining operations within, but not title over, a demarcated tenement area during a defined period, by entering into a Mineral Production Sharing Agreement ('MPSA') or such other agreement as may be appropriate and necessary.

On December 29, 1999, Philex Gold Philippines, Inc. ("PGPI") was granted an exclusive right to conduct mining operations over the tenement area covered by MPSA 149-99-XIII ('MPSA Contract Area'). Subsequently, PGPI assigned all its rights in or in respect of MPSA 149-99-XIII to SMMCI by virtue of a Deed of Assignment dated May 12, 2000. To date, SMMCI has acquired a total area of 1,956 has within its MPSA Contract Area. However, the current mine development plan requires an additional area of 534 has where the various associated mine facilities will be constructed. SMMCI has confidence that it can secure the remaining land requirement as demonstrated by its previous successful acquisition track record.

Mining activities in the Philippines are subject to payment of certain statutory fees and royalties to the Government of the Philippines. The fees associated with the ownership of mining tenements (e.g., MPSAs, exploration permits) are set forth in the Mining Act. A statutory royalty must be paid by SMMCI to the Government of the Philippines in the form of excise taxes at the fixed rate of 2% computed on the actual market value of the gross output at the time of sale. This was later on increased to 4% with the approval of the TRAIN Law in 2016.

There are no existing recognized Indigenous Peoples/ Indigenous Cultural Communities within the MPSA Contract Area. Therefore, the Free and Prior Informed Consent requirement under Republic Act No. 8371, otherwise known as the Indigenous Peoples Rights Act of 1997 and payment of royalty fee under the Mining Act, do not apply.

1.7 Project Development History

The exploration programs for the Bayugo and Boyongan deposits encompasses two tenements, namely Parcel 1 of MPSA 149-99-XIII and EP-13-XIII located in the Municipalities of Placer and Tubod, Surigao del Norte, which were granted in favor of SMMCI. As such, all other exploration related matters integrate the tenements as one project.

MPSA 149-99-XIII was granted an extension for exploration in late 2008 when Anglo American BVI was about to relinquish its interests on the tenement. As Philex took over in early 2009, the MPSA prospect was still on the third and last renewal of its Exploration Period. Drilling operations resumed in February 2009. Priority drill targets for the first few months were in-fill and definition holes for West Bayugo, which is covered by EP-13-XIII. By the end of 2009, there were 10 holes drilled within the MPSA corresponding to 9,360-m total core length. In-fill drilling at the

Bayugo deposit was completed on June 15, 2010 such that the focus of exploration shifted to step-out drilling in East Bayugo, in-fill drilling in the Exotic Zone prospect between the Boyongan and Bayugo deposits, and geotechnical/hydrogeological drilling for planned mine infrastructure locations. From the first to third quarters of 2010, the total holes drilled at MPSA 149-99-XIII reached 47 holes, equivalent to 30,475 meter core length. For the two year extension of the Exploration Period for MPSA 149,99-XIII, a total of 57 in-fillm definition, step-out, condemnation and geotechnical holes were drilled, equivalent to 39,835-m core length.

The resource definition drilling of the Boyongan deposit was previously completed in 2007 by Anglo American BVI. In June 2010, resource definition drilling at the Bayugo deposit was completed. Subsequently, resources estimation for the Silangan Project Pre-Feasibility Study that will cover an integrated Baguyo and Boyongan deposit was undertaken. In the ensuing 2011-2012 exploration program, diamond drilling for further geotechnical and hydrogeological studies was programmed including the 3'km exploratory decline tunnel which also served as pilot opening to probe/access the Boyongan deposit.

The Boyongan-Bayugo deposit is a blind and deep-seated porphyry copper and gold deposit that is hosted by a composite diorite porphyry stock of late Pliocene age. Determined to be between 0 to 400 meters below sea level, the porphyry underwent pervasive potassic alteration and was affected by weakly developed intermediate argillic event with localized advance overprint.

1.8 Government Approvals

The initial EIS, which supported the granting ECC-CO-1212-0028 on May 24, 2013, was for the initial block-cave mine plan. The development of the block cave mine was at that time deemed to be difficult due to operational force majeure issues causing delays in the project development. Ultimately, management decided to suspend block-cave development and proceed to study the feasibility of an Open Pit / Surface Mine. In relation to this move, baseline studies were updated to capture the impact area of the Open Pit / Surface Mine and its facilities. IECs and stakeholder engagements were also conducted to inform the host communities of the change in mine method and gathered stakeholder issues and concerns regarding the shift to Open Pit / Surface Mining. An EIS supported the acquisition of ECC-CO-1510-0026 on March 15, 2016, which superseded the block-cave ECC. Note that an Environmental Management Plan (EMP), Environmental Protection and Enhancement Program (EPEP), Final Mine Rehabilitation and Decommissioning Plan (FMRDP), and Social Development and Management Program (SDMP) were formulated for each of the mine methods and area
s were issued allowing both project plans to proceed to the Declaration of Mine Project Feasibility (DMPF) and have both versions of the DMPF approved by the Mines and Geosciences Bureau (MGB).

Recent Developments and the Need for Amendment

In 2016 to 2017, a number of administrative orders and memorandum circulars were passed by the DENR as a result of the appointment of new secretaries and the replacement of relevant lead officers within the DENR line agencies.

Sometime in July 2016, President Rodrigo Roa Duterte appointed Ms. Gina Lopez (Ms. Lopez) as Secretary of DENR on an ad interim basis. Ms. Lopez initiated reforms that adversely impacted the local mining sector as soon as she assumed office. After hiring former MGB Director Leo Jasareno as technical adviser, she conducted a series of mine audits resulting in the suspension of several operating metallic mines in Zambales and eastern Mindanao; released show cause orders for the cancellation of issued MPSAs; and imposed a moratorium on environmental applications for new mining projects (DAO No. 2016-01). In April 2017, she issued DAO No. 2017-10 entitled "Banning the Open Pit Method of Mining for Copper, Gold, Silver and Complex Ores in the Country". DAO No. 2017-

10 requires mining contractors, who have not commenced commercial operation but have approved DMPF for open pit mining, to review their planned mining methods within a period of six (6) months. The industry players have challenged the legal basis for the issuance of DAO No. 2017-10, arguing that said regulation is unconstitutional and contrary to the Mining Act, Executive Order ("EO") No. 192, Series of 1987, as amended or the DENR Charter, and EO No. 292 or the Administrative Code. Specifically, DAO No. 2017-10 is being challenged based on the following grounds:

1. It violates equal protection of the laws by creating an invalid classification;
2. It bans the open pit mining method, which is allowed under the Mining Act, and thus effectively subverts the very law it purports to implement;
3. It was issued in the blatant attempt of the former DENR Secretary-Designate to usurp the legislative powers of Congress;
4. It was issued without the required consultation with the parties that would be adversely affected; and,
5. It infringes on the right of foreign investors to "fair and equitable treatment" under the relevant bilateral investment treaties executed by the Philippines.

Aside from the challenge lodged by industry players, SMMCI takes the strong legal position that it is not covered by DAO No. 2017-10 under the 'vested rights' doctrine, because it had secured all the necessary permits and licenses, including the approved DMPF and ECC, to enable SMMCI to operate prior to the issuance of said regulation.

During her stint as Environment Secretary, Ms. Lopez also centralized the approvals of all ECCs in her office with the DENR Secretary as the signatory and removing the authority from the regional DENR-EMB offices and directors (DAO No. 2017-04). This placed the issuance of ECCs for environmentally critical projects at a standstill as manpower at the central office was not sufficient to evaluate all applications. Around the same year, DAO No. 2017-15 was passed with the intention to improve public participation in the EIS process. DAO No. 2017-15 introduced additional steps to the EIA process during the scoping phase where perception surveys will already be conducted post IECs and where the public scoping event will be facilitated by DENR-EMB. The additional steps lengthened the EIS process by incorporating the participation of DENR-EMB and their evaluation of the substance of the initial scoping activities before any formal baseline and stakeholder engagement process within the EIA.

On May 3, 2017, the Commission on Appointments rejected the appointment of Ms. Lopez as DENR Secretary. As her replacement, the President appointed General Roy Cimatu, a retired Philippine Army general who formerly served as the Chief of Staff of the Armed Forces of the Philippines under the regime of President Gloria Macapagal-Arroyo. He assumed office in May 8, 2017 and was officially confirmed by the Commission on Appointments on October 4, 2017. As DENR Secretary, Roy Cimatu believes mining and environmental protection can be balanced and carried out in an environmentally compliant, socially acceptable, technically feasible and financially viable manner.

In July 2017, the DENR Secretary repealed DAO No. 2017-04 which centralized all ECC approvals to the DENR Secretary. On October 24, 2017, the Mineral Industry Coordinating Council (MICC), in cooperation with the technical working group on economic affairs under the Department of Finance (DOF) and technical working group on environment, recommended for the lifting of the open pit ban (DAO No. 2017-10). This comes with the commitment that the MICC will conduct biennial reviews of mining operations in compliance with its mandate and the adoption of Canada's Sustainable Mining practices by members of the Chamber of Mines of the Philippines. While the MICC recommendations were positively received by the Secretary of Finance Carlos Dominguez III and Sec. of Environment Roy Cimatu, President Rodrigo Duterte continues to reject the lifting of the open pit ban. To date, the open pit ban remains and serves as the critical hurdle for the continuation of the Silangan Project.

Wanting to carry the project forward, SMMCI revisited underground mining in 2017. Feasibility studies were completed in partnership with Ausenco, a world-renowned engineering consultancy group out of Brisbane, Australia. Part of the studies is a geotechnical and hydrogeological field investigation that aims to provide more information on the ground and water conditions. As a result, sublevel caving presents itself to be a better method rather than block caving as it supports developing a smaller footprint and mine higher grades with selectivity. Also incorporated are well studied engineering solutions to the issue of water and ground conditions that initially hounded the underground mine plan.

It is recognized that with the addition of underground mining to the project component requires the amendment of the ECC as mandated in the DENR EMB MC No. 2014-05 (Revised Procedural and Screening Guidelines for the Philippine EIS System). The amendment of the ECC requires the following:

1. Conduct of EIA to define impact area for the revised project plan;
2. Conduct of baseline studies to update data collected > 5 years;
3. Update the impacts and mitigations register to reflect acceptable impacts for the reduced footprint and underground mine program;
4. Revise the Environmental Management Plan for the mine project;
5. Conduct stakeholder consultations in relation to revise mine plan;
6. Update closure plan and corresponding consultations to revise mine plan; and,
7. Revisit and revise compliance requirements and conditions in the ECC according to the revised mine plan in cooperation with the responsible regulatory agencies and concerned stakeholders.

Due to the regulatory updates, the process that will be conducted for the amendment would need to be scoped with DENR-EMB. Compliance requirements, while prescribed in the guidelines, are subject to the interpretation and requirements of the incumbent DENR-EMB officials and may slightly vary with the prescribed process in DENR EMB MC No. 2014-05 and DAO No. 2017-15 due to the nature of the project and its history of approvals.

SMMCI holds a Mineral Production and Sharing Agreement (MPSA 149-99-XIII) that allows for the exploration, development and commercial exploitation of mineral deposits within the contract area. In order to be able to construct and operate the mine, a Declaration of Mine Project Feasibility (DMPF) needs to be submitted to and approved by the MGB. The DMPF contains various modular reports including a summary of the EIS and the issued ECC.

The DMPF in respect of the Silangan Project was approved by the DENR-MGB on April 10, 2015, allowing SMMCI to start mining by underground method and transition to the commercial production phase of MPSA 149-99-XIII. An Amended DMPF was approved by the DENR-MGB on May 16, 2016 to cover the changes in the work program from the original underground mine method to surface mining method.

The components of the amendment being applied for are summarized in Table 1.

Table 1: Comparison of components under the 2016 ECC and new/additional components under the 2018 application

Components under ECC-CO-1510-0026 issued on March 15, 2016	New/Additional Components applied for in this ECC Amendment
The project shall be limited to extract a maximum of 39,000 metric tons of ore per day with a maximum milling output of 244,000 metric tons of copper concentrate per year (@20% copper grade), 48,000	Production throughput is reduced to 19,400 metric tons of ore per day resulting to 190,000 metric of copper concentrate (@ 20% copper grade), 44,000 metric tons

metric tons of cathode per year, and 308,000 oz of dore per year.	of copper cathode and 279,000 oz of gold dore per year.
The mine method is Open Pit. Other surface facilities include the Tailings Storage Facility (TSF) and tailings conveyance system (pipeline), Mill, Waste Rock Dumps (WRD), mine dewatering system, silt dams, magazine, water storage dam, mine access road and haul roads, and secondary facilities (mine office, accommodations, motorpool, etc.)	An underground Sub-level cave mine will be added to the project components, which requires specific support facilities and systems such as dewatering and ventilation systems, magazines and mine access and haulage. Surface facilities that will be retained from the previous ECC include the TSF, Mill, Surface diversion drain and dewatering, mine access road and haul roads, and the secondary facilities. Components of the open pit / surface mine will be the same.
The processing plant flow includes flotation, acid leaching, solvent extraction, cyanidation and electrowinning to produce gold and silver dore', copper cathode, and copper-gold concentrate.	Same
Tailings Storage Facility Impoundment (Capacity- 315 million tons) Material Conveyance (Pipeline) Water Storage Dam (Capacity – 1.8 million m3)	Reduced impounding capacity for the TSF; from 315Mt down to 80Mt.
Support facilities as categorically mentioned in the Environmental Impact Statement (EIS)	Same

Since the Silangan Project has not progressed to mine development in view of the prevailing regulatory climate under DENR Department Administrative Order No. 2017-10 (Entitled “Banning the Open Pit Method of Mining for Copper, Gold, Silver and Complex Ores in the Country”) (Order) barring the implementation of the surface mining method, the company was compelled to continuously undertake extended care and maintenance surface activities to ensure that the environmental, social and legal compliance measures are maintained. The Silangan Project has an approved Care and Maintenance Plan for CY2018.

2.0 Project Location and Area

2.1 Location and Area

The Project is located within Region 13 or the CARAGA Administrative Region in the province of Surigao del Norte. The Project facilities and MPSA straddle 11 barangays within the municipalities of Placer, Sison, Tagana-an and Tubod (Table 2 and Figure 4). The Boyongan orebody is found in the municipality of Tubod.

Table 2: Project host administrative region and government units

Region	Province	Municipality	Barangay
CARAGA Administrative Region (Region XIII)	Surigao del Norte	Placer	Anislagan, Boyongan, San Isidro, Sta. Cruz & Macalaya
		Sison	Lower Patag, Upper Patag & San Pedro

		Tagana-an	Upper Libas
		Tubod	San Isidro & Timamana

2.2 Primary and Secondary Impact Areas

The indicative potential primary and secondary impact areas of the Project were delineated based on the definition of direct and indirect areas in the Revised Procedural Manual of DAO 2003-30. Direct impact areas are areas where Project facilities are to be constructed and where Project operations are to be undertaken. Direct impact areas also include areas where emissions and effluent exceed relevant standards, based on the modeling exercises that were previously done for the block-cave baseline studies in 2012 to 2013 and the open pit baseline studies conducted in 2014 to 2015. Indirect impact areas are areas immediately outside the coverage of the Project facilities and project operations/activities. Table 3 presents the potential primary and secondary impact areas of the Project.

Table 3: Primary and secondary impact areas

Area Classification	Area Coverage
Direct Impact Areas	*In terms of biophysical impact:* • The area within the project boundary defined by the project site (MPSA 149-99-XIII) • Proposed locations of the sub level cave mine components such as the underground mine, subsidence area Tailings Storage Facility, Processing Mill, ancillary mine facilities and associated pipelines and road network • Portions of the Timamana River catchment, Hinagasa-an River, and the Bad-as Amoslog catchment which are most proximate to the mine area and proposed location of Tailings Storage Facility (TSF) • Areas where emissions and noise exceed the local standards as defined during the block-cave baseline studies and will be validated as necessary with updated baseline
	In terms of socio-cultural impact: • Barangays and municipalities where the sub-level mine components will be located; and • In terms of benefits, all those who will receive direct benefits from the project such as the host barangays and the host municipalities.
Indirect Impact Areas	*In terms of biophysical impact:* • Catchments surrounding the project site's catchment
	In terms of socio-cultural impact: • Neighbouring municipalities and barangays surrounding the host communities; and • Regional and National government units

2.3 Vicinity and Accessibility of Project Area

The Project is situated at the north-eastern tip of Mindanao Island approximately 750 km southeast of Manila, 32 km south of Surigao City, 123 km north of Butuan City, and 250 km northeast of Cagayan de Oro City (Figure 3). The closest major urban center to the project site is Surigao City, which is accessible by road, air, and sea and has a commercial port, bus terminal (Lipata), and a domestic airport. Alternatively, Butuan City, located 123 km south-south-east of Surigao City, can be used as another point of access. Butuan City, located in the province of Agusan del Norte, has the largest domestic airport within the CARAGA region.

Alternative entry points leading to the site aside from Surigao City are airports and sea ports in Butuan and Cagayan de Oro City. Airlines flying from Manila and Cebu operate daily in Surigao City, Butuan and Cagayan airports. Passenger and cargo ships from Manila also dock in the above mentioned cities. The site can be reached from these alternative entry points via Philippine-Japan 'Friendship' Highway or the National Road to the municipality of Tubod. A network of unsealed private roads connects the national highway to the mine area in Brgy. Timamana. Alternatively, the provincial road in Brgy. San Isidro can also be used to reach the mine area. All unpaved roads at the site are accessible by light vehicles during the dry season and 4x4 service trucks during the rainy season.

Figure 2: Map of the Philippines showing relative locations of Ninoy Aquino International Airport to Surigao del Norte

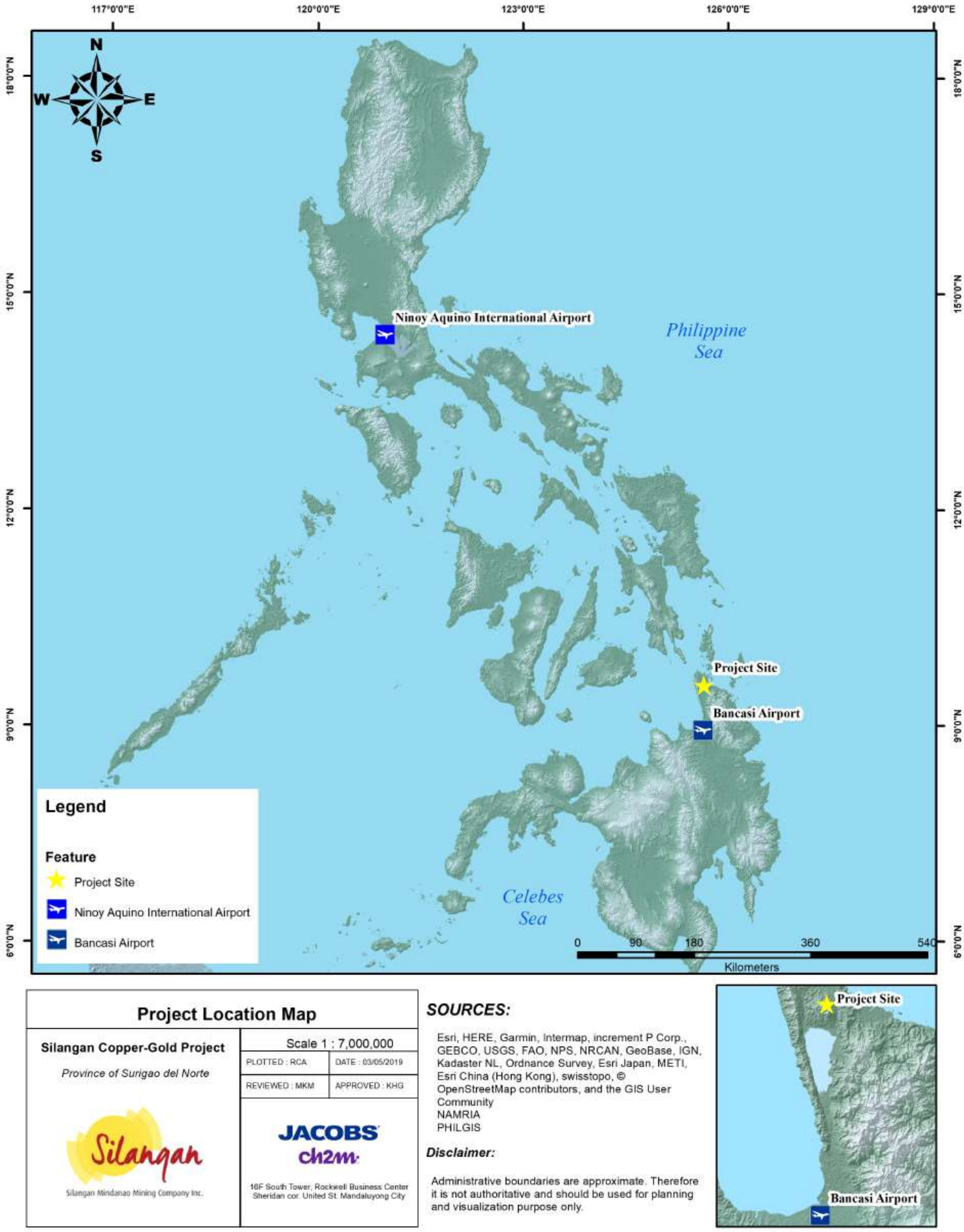


Figure 3: Map of the Northern Mindanao showing relative locations of Bancasi Airport and Surigao City Airport to the Project

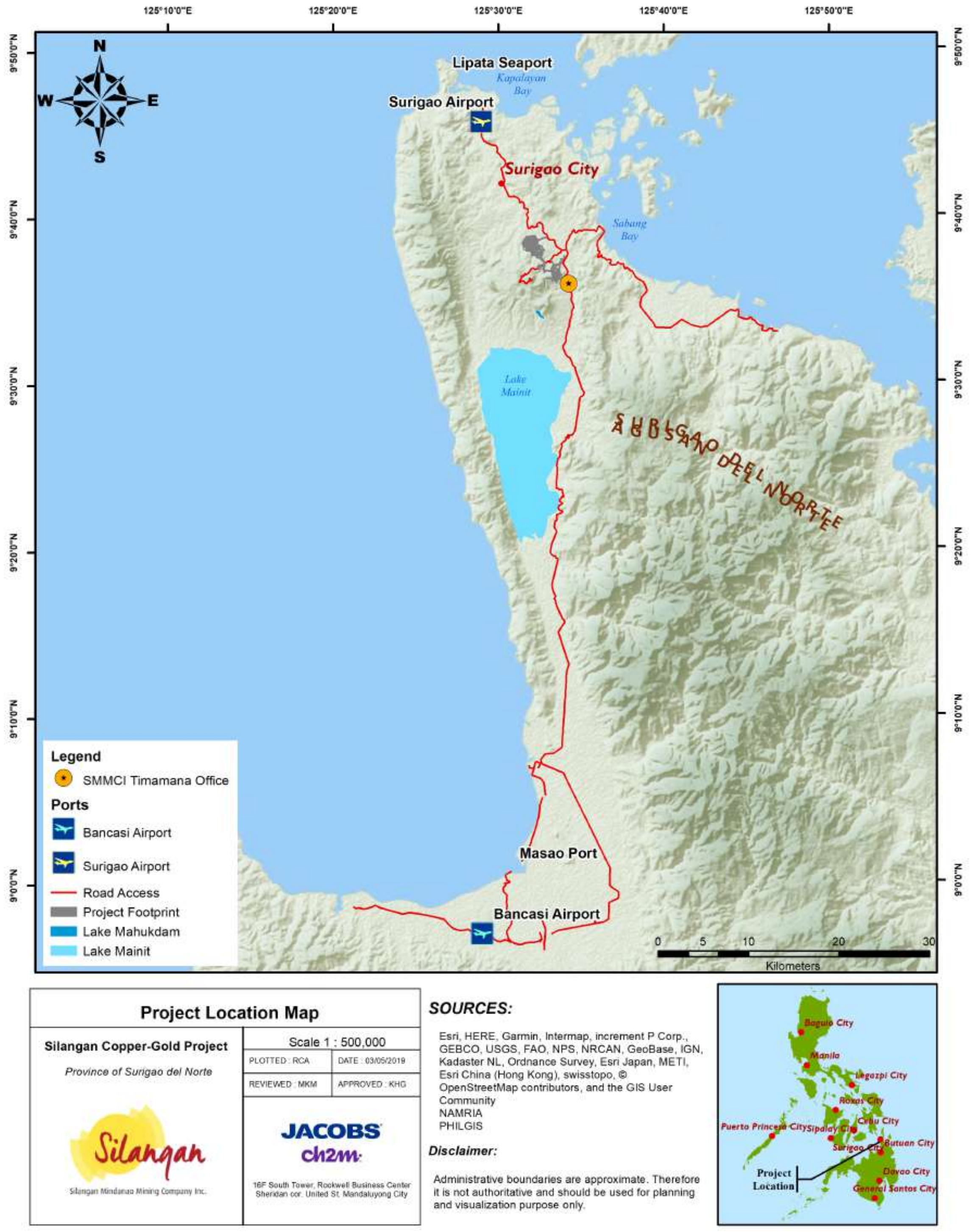


Figure 4: Map of the Project in Relation to the Biophysical Direct and Indirect Impact Areas

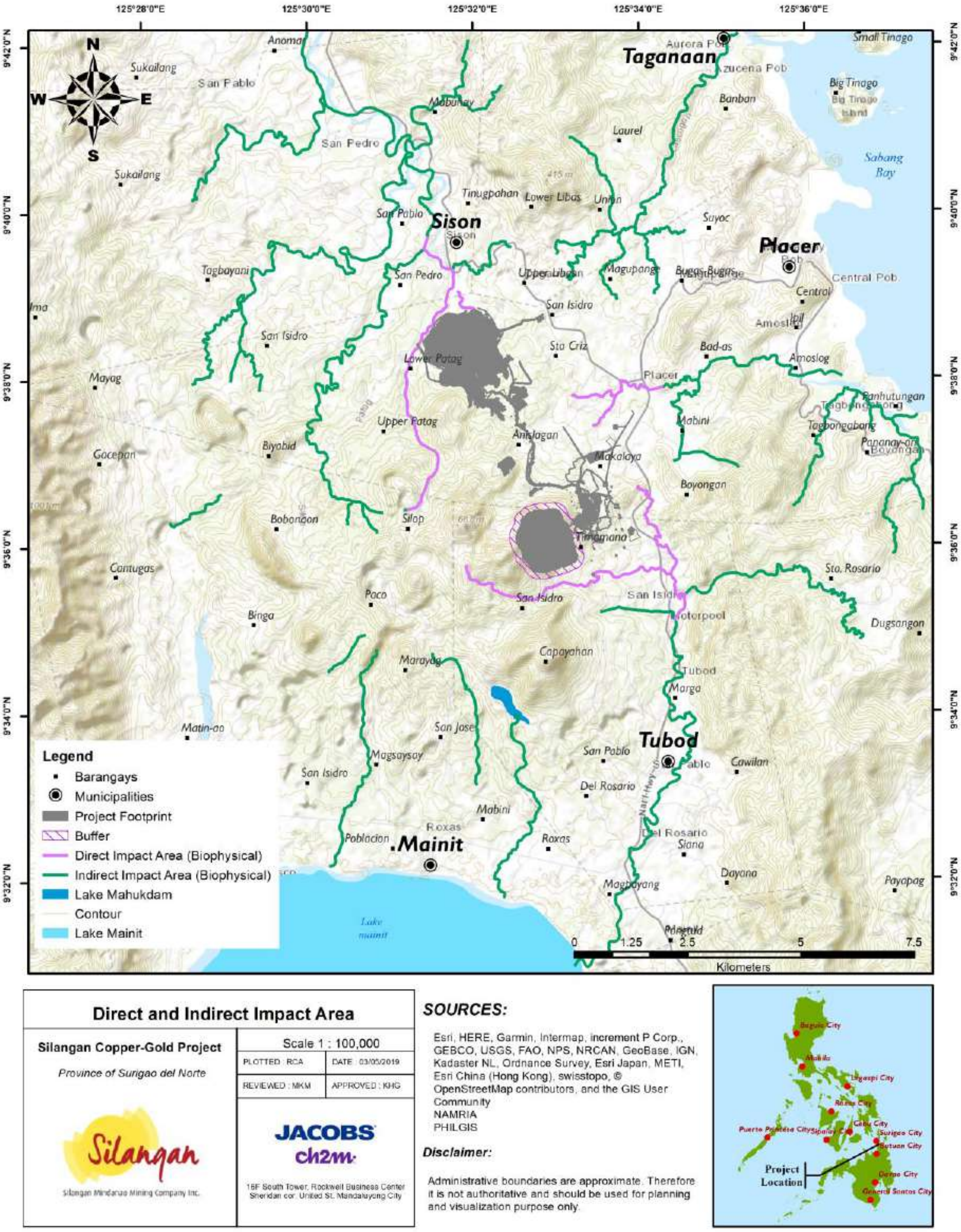


Figure 5: Map of the Project in Relation to the Socio-Cultural Direct and Indirect Impact Areas

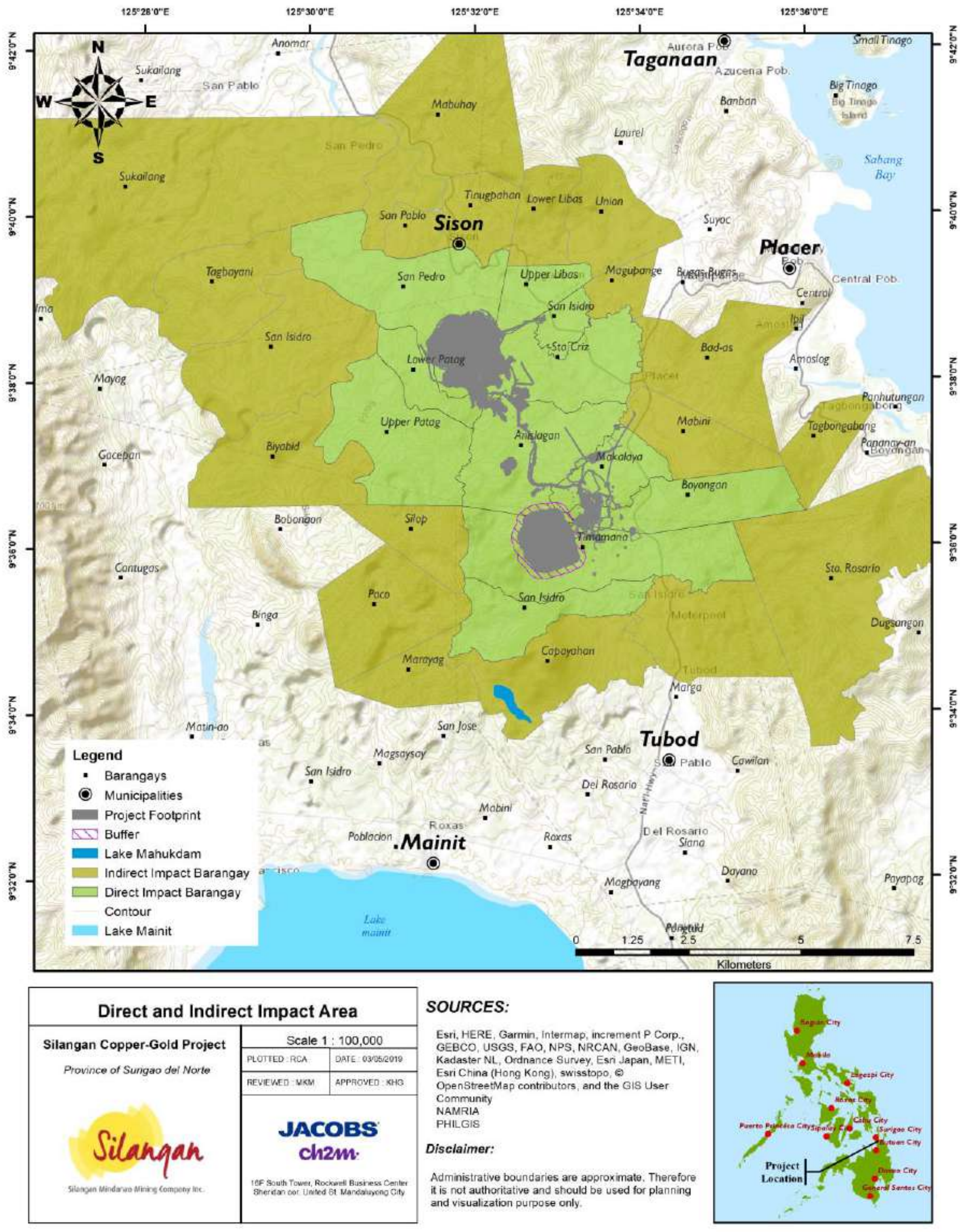
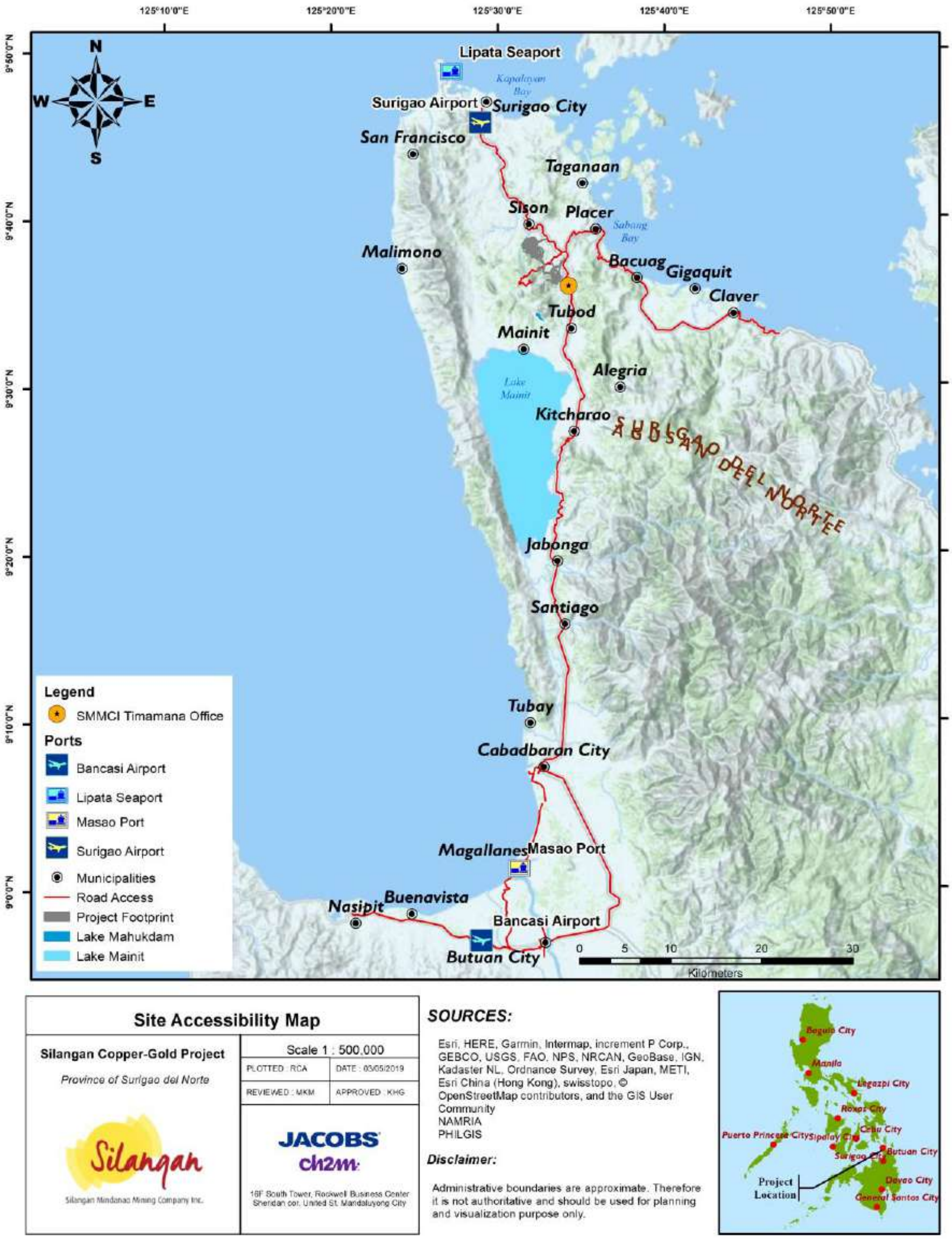


Figure 6: Map of the Project in Relation to Major Access Points in the Region



3.0 Project Rationale

3.1 Project Contribution to National Development Goals

The International Council of Mining and Metals (ICMM) published a series of reports prior to the Rio+20 conference on sustainable development that assessed the contribution of the mining industry to the sustainable development of a country. While there is significant variation in terms of the impact of the mining industry to different countries, the ICMM 2012 reports affirmed that mining industries positively contribute to a country's economy particularly on aspects of foreign direct investment and national revenues and employment generation. Under optimal conditions and with strict compliance to national laws and regulations, a mining project has the potential to be a catalyst for economic and social development as society is wholly dependent on the products of mining. Mineral resources and metals have a gamut of applications from manufacturing, agriculture, fisheries construction, transportation, infrastructure, energy, and medicine. Moreover, the mining industry's need for both skilled and unskilled labour provides opportunities for employment across societal classes and gender that eventually translates to improvement of community services, enhancement of livelihood directly and indirectly related to mining, and enhancement of the well-being of the people. Essentially, a country's sustainable development is tied to its capability to utilize its mineral resources.

The Philippines is ranked 19th globally in terms of production value as percent of Gross Domestic Product from the 16th place in 2012 (World Bank, 2014). The Philippines' mining production value as of 2012 is 2.2% of the gross domestic product (GDP). While the industry's production value and contribution to GDP have generally increased since 2003, the mining contribution remains small due to immense untapped mineral resources. To illustrate the importance of the mining contribution, the country's GDP in 2012 declined by PHP 63 billion (0.7% of GDP) as a consequence of the issuance of Executive Order 79 on July 6, 2012 which imposed a moratorium on the approval of new mineral sharing agreements pending revisions to the revenue sharing scheme.

To date, approximately USD 840 billion or approximately PHP 38 trillion in metallic minerals remain unrecovered from the 9 million hectares of land considered by the Mines and Geosciences Bureau (MGB) to be highly mineralized. According to the State Economic Planning Office (SEPO, 2013), the value of the country's mineral reserves is ten times the current GDP. The total value of the Philippines's unmined gold reserves alone, amounting to approximately USD 17 billion, can significantly reduce (if not eradicate) poverty once utilized efficiently (National Statistical Coordination Board, 2011).

National contributions of mining in terms of royalties and tax revenues can potentially increase with the development of the mining sector and new projects in mining. More importantly, if these revenues can be properly apportioned, the conditions of communities can be improved particularly in rural areas where government services and infrastructure are often lacking. Direct investments by the mine and direct and indirect taxes associated with its capital and operating expenses will potentially add to the national and regional coffers and can be used for national and local government infrastructure development.

Aside from the direct impacts of mining onto national revenue and economic growth, studies show that mining foreign direct investments combined with foreign exchange earnings from mining product exports can improve a country's credit rating which, in turn, allows a country to obtain foreign loans for other development projects.

3.2 Project Contribution to Regional and Local Development Goals

The host municipalities of the Project are 4th and 5th class municipalities that heavily rely on agriculture for income. Previous studies show that most host barangays have decreasing annual growth rate indicating out-migration of people. Likewise, all local government units from regional to municipal level showed a lower average growth rate than the national rate.

Poverty was observed to be widespread within the host barangays during the 2012 and 2014 socio-economic studies. Previous household surveys conducted within the primary impact barangays show that seventy-four percent of households are below the poverty line[1] in contrast to only about 48% for Surigao del Norte. Most households fall below the poverty line suggesting that the most households cannot afford a satisfactory standard of living and cannot buy the right quantity of food to meet their daily nutritional requirement.

Basic services and infrastructure such as electricity, potable water supply, roadways, health centers and sanitation facilities were observed to be lacking. Most government infrastructure and services are located in the municipal centers or poblacions and are not readily accessed by households in far-flung puroks and in the mountains.

The Project can spur local development through the payment of its taxes and permit fees associated with the mine development. SMMCI paid approximately PHP 9 million in taxes for 2014. Revenues from taxes and permit fees can be used to develop government facilities that will provide needed services for the community in terms of transport, health, education, sanitation and other government infrastructure.

Aside from tax revenues, the Community Development Program (CDP) implemented during the exploration phase aided the host communities with the following programs:

1. Construction of Provincial Livelihood and Training Center, Bad-as, Municipality of Placer;
2. Construction of Barangay Hall, Brgy. San Isidro, Municipality of Tubod;
3. Construction of new school building in Capayahan Elementary School, Brgy. Capayahan, Municipality of Tubod;
4. Drainage canal construction in barangays Upper Patag and San Pedro, Municipality of Sison; and
5. Potable Water Systems in Brgy. Lower Patag, Municipality of Sison and Brgy. Boyongan, Municipality of Tubod.

Aside from infrastructure projects, SMMCI, through its CDP provided health services through various medical and dental missions conducted within the exploration phase of the Project. Scholarships and school supplies are also provided to qualified elementary and high school students within the host communities through SMMCI's CDP.

Enterprise Management Training was also one of the projects in the proponent's CDP. The training program empowered women stakeholders from the host barangay Timamana by providing the women skills for making pastries and sweets. Eventually the enterprise management training enabled its trainees to cater social gatherings and sell their products as alternative income sources.

CDP projects amounted to approximately PHP 17.3 million within the years of 2011 to 2014. The expenditure for CDP projects is expected to rise to PHP 20 million within the remaining development period leading up to mine

[1] Based on official poverty statistics (2009) of the National Statistics Coordination Board (NSCB), the poverty line pertains to the amount of income needed for a family to purchase a normative basket of goods and services (e.g. food, shelter, clothing, education, etc) to be socially functional. The poverty line set by the NSCB for 2009 for Surigao del Norte is PHP17, 261 per capita (Php 86,305/ year for a family of five or PHP7,192/month)

operations tentatively in 2017. Projects implemented under the CDP, as provided under Republic Act 7942 (The Philippine Mining Act of 1995), improve the quality of life of communities directly impacted by the project by augmenting services and infrastructure provided by the local government units.

Projects and expenditures under the Social Development and Management Program (SDMP), which is required to be implemented during project operations, are expected to feed at least PHP 80 million into the host communities through programs and projects that will be identified in the formulation of the SDMP. Projects under the SDMP are meant to offset any adverse impact of the mine project with respect to the socio-economic conditions of the host communities and more importantly, prepare the communities for the eventuality of mine closure by developing local infrastructure and promoting alternative and sustainable sources of livelihood to make the communities thrive. Once implemented, projects under the SDMP are anticipated to reduce poverty and ease competition for resources and services within the host communities.

The implementation of the Project is expected to provide direct and indirect employment opportunities to the host communities. Qualified locals may be hired to work directly in the mine or with its contractors. Locals may also find opportunities working for companies or groups that would provide services to the mine such as catering, cleaning services, vegetation clearing in preparation for earthworks and construction activities, or with suppliers that would provide materials and resources needed by the mine. Mine development will potentially generate jobs for unskilled and skilled workers as well as livelihood or business opportunities related to mine activities and transport of needed goods and services.

With opportunities for employment and livelihood, residents will find alternative sources of income aside from agriculture where there is much competition but gains are minimal. In the course of employment, stakeholders may gain skills that will prepare them to work not only within the Project but other mining projects within the region or the country. Results from assessments made by ICMM globally (ICMM, 2014) also show that opportunities provided by a mining project espouse a multiplier effect wherein at least three more people benefit through business or employment for every person directly or indirectly employed by a mine project. Salary and employee benefits rose to PHP 224.7 million in 2013 when initial government permits leading to operations were secured from PHP 65.5 million during the exploration phase. The positive impact of salaries and benefits given to employees was felt in the host communities as the employees spent for food and other items that drove the local economy to cater to these needs and supply products into the markets.

3.3 Project Alternatives

Site Alternatives

Mining is constrained by the fixed location of the orebody, site topography, available technology, cost, limited waste storage alternatives, and availability of usable areas. Due to constraints in the location of the mine area, project alternatives and options for the locations of the mine components and waste storage facilities are also limited. In general, the location of the project site was delineated through an integrated assessment of the constraints in the mine area, method and cost as well as potential environmental and social conditions and impacts in the placement of the mine components.

Technology Alternatives

The mine project aspects where alternatives were assessed include mining method, mineral processing, mine waste management (tailings), location of the mine waste storage facilities (Tailings Storage Facility), and the transport of the products.

Table 4: Mining Technology Alternatives

	Criteria	Options Considered and the Preferred Option	Reason/s for the Selection
Mining method	• Ore body geometry (i.e. depth and dimensions) • Available technology • Safety • Mining Cost	• Underground mining method both block cave and sub level caving • Open pit mining method • Sub level caving or a combination of open pit and sub level caving	• Depends on the prevailing regulatory conditions • Ban on open pit prevents SMMCI to move forward on open pit plan thus the only way to progress is to develop a sub level cave mine
Mineral processing	• Geo-metallurgical properties of the ore • Marketability of final products • Available technology • Capital cost	• The preferred option was the conventional crush-mill-float technology to produce copper as concentrate, followed by acid leaching to recover copper and cyanide leaching to recover gold	• These processes use proven technology that is well understood, used worldwide. • Copper flotation is used by the mother company (Philex) in its Padcal Mine
Transport of ore and waste rock	• Environmental impacts • Capital and operating costs	• In both the sub level cave and open pit mine, the ore and waste will be conveyed by trucks • As the sub level cave mine goes deeper an option to commission a conveyor will be evaluated.	• Trucking is better fitted for the reduced throughput plan for sub level cave and open pit mine. • The basis for commissioning a conveyor will be on the cost and efficiency of trucking as the sub level cave goes deeper.
TSF	• Available technology • Approval process • Environmental impacts • Capital cost • Availability of usable areas • Policy requirements (i.e. DMO 1999-32[2])	• Land-based tailings storage is the preferred method. • Deposition of tailings as paste, thickened tailings or filtered tailings • Deep sea tailings deposition	• The site of the TSF was chosen for its storage capacity, proximity to the processing plant, clearance to major power lines and barren of any mineralization below and at surface. • Thickened and filtered tailings and tailings as paste will be considered once the technology has been proven to work in local setting.

[2] Department of Environment and Natural Resources Memorandum Order 1999-32 – Policy guidelines and Standards for Mine Wastes and Mill Tailings Management

The development of the project will result in extensive physical disturbance of the land, which for the most part is permanent. In recognition of the physical disturbances, rehabilitation and closure strategies will be an integral part of project development.

No Project Alternative

The 'no project' option must be weighed against the economic benefit that the project would bring to the host barangays and to the national and regional economies. As previously discussed, economic benefits that would be derived from the project are:

1. Potential to create approximately 1,900 jobs;
2. Royalties and taxes paid locally and shared by provincial, municipal and barangay communities; and
3. Social development programs that will benefit the host communities.

If the project does not proceed, the above benefits and the corresponding multiplier effects and general improvement in the conditions of the host communities will not be realized. The average household income for all host barangays is PHP 69,637 per annum. Sixty percent of households earn less than PHP 5,000 per month. About 74% of the households for the host barangays are below the poverty line. Households below the poverty line, on the average, earn PHP 3,343/month. In summary, household survey findings suggest that about 7 in every 10 families cannot afford a standard of living that would keep them out of poverty and within the food threshold.

These being said, this standard of living will remain if the project is not implemented as there are no other industry can provide the same magnitude of economic impact for the project area. The project is expected to provide direct and indirect livelihood opportunities for stakeholders within the host barangay.

4.0 Environmental Impacts

The anticipated environmental impacts focusing on the alternatives pertaining to the mining method are presented below. Since the mining area is constrained by the location of the orebody and the means to extract the minerals are limited by available mining technologies common for both underground and surface mining, the key alternative that can be tackled to compare potential environmental impacts pertain to the mining method.

Table 5: Project Environmental Impacts

Environmental Aspects	Potential Impacts Associated with Open Pit Mining	Potential Impacts Associated with Sub-level Cave Mining
Land Use and Classification	• Conversion of existing land classifications (timberland and alienable & disposable land) into mine industrial area. • Possible overlap of Project footprint with Environmentally Critical Areas (ECAs) such as habitats of threatened wildlife, prime agricultural lands, geohazard-prone (flooding) areas, water bodies, recharge areas for aquifers, and areas with critical slopes.	• Impacts of Underground Mine on land use and classification do not differ from the Open Pit project but it is anticipated that the land use conflicts and potential ECA overlaps for the Underground Mine will be significantly smaller than the impact areas identified for the Open Pit. It should also be noted that considerable stakeholder consultations at the municipal and community levels as well as local permitting and approvals have been undertaken for the previous iterations of the mine method such that most areas of the present proposed underground mine footprint have

		already been acquired and/or converted to the present land use.
Topography and Slope	• The Open Pit, TSF and WRD will permanently change the baseline geomorphology within the Project footprint. • With the change in topography, the surface and ground water hydrology within the footprint area and its immediate vicinity will be altered.	• The TSF and the processing plant will change the current, pre-development topography of the Project footprint. • Similarly, the subsidence zone that will develop over time as a result of underground mining will also change baseline topography and alter surface and groundwater hydrology within the footprint area and its immediate vicinity. However, the subsidence footprint is significantly smaller than the Open Pit area. • Additionally, there will be less disturbance area with the removal of the WRD and the reduction in the TSF footprint.
Local Geology	• Excavation of the Open Pit will expose and remove previously buried rocks. • Exposure of sulphide-bearing rocks and gangue minerals to the atmosphere may trigger the generation of acid mine drainage.	• Introduction of heavy loads, stresses and forces by the Project facilities such as the TSF and underground mine will alter prevalent underground structures (e.g. blind faults, groundwater systems, cave systems etc.).
Geohazards	In general, the impacts identified for the surface mine components will be similar for both the open pit and underground mine methods. These cover potential hazards during the construction and operation of the open pit, TSF, and WRD (slope failure, flooding, loss of containment) as well has seismic hazards. • In contrast however, the limits of the Open Pit can be accurately planned and defined before Project commissioning thus enabling the proponent to adequately implement engineering control measures specific for the geohazards identified and within the limits of the Open Pit.	• Subsidence and slope failure (landslides) may take place during construction and operation of the TSF and the development of the subsidence pit as a result of strong earthquakes or extreme precipitation. • Tension cracks may propagate beyond the estimated limits of the subsidence pit and cause slope failure on adjacent mine facilities or proximal settlements.
Soil	• Vegetation clearing and oil stripping will be conducted prior to construction and mine facility development. As a result, the remaining soil cover will be more vulnerable to erosion and change in soil quality. • Potential soil contamination will occur as a result of the movement of mobile equipment and transport of fuel and reagents during the construction and operation phase. • Stockpiled topsoil meant for progressive rehabilitation and backfilling may likely be	• The same impacts recognized for the open pit will also apply for the underground mine as the mine development also requires ground preparation, vegetation clearing, and erosion control. However, in terms of impact area, the surface impact area for the Underground Mine will be significantly smaller than the Open Pit project footprint.

	eroded if no adequate soil conservation measures and erosion control are put in place.	
Vegetation	• Construction of the mine components will require stripping of vegetation. • Removal of vegetation may disturb habitat and food source of wildlife and people. • Site clearing for Project development will result in the reduction of wildlife population and may decrease the number of species growing within the footprint. • Project-related activities in the site may introduce invasive / weed species. • Fugitive dust may settle on leaf surfaces, impairing the photosynthetic ability of plants.	• The impacts identified for the terrestrial vegetation during the Open Pit EIA area also applicable for the Underground Mine albeit with a smaller footprint.
Wildlife	• Construction activities and subsequent installation of Project components and facilities may displace fauna from their natural habitat • Construction activities and subsequent installation of Project components and facilities may restrict mobility and reduce access of fauna to habitats, feeding, hunting or mating grounds. • Habitat fragmentation will reduce the total area of habitat available for wildlife and may lead to crowding and increased competition among individuals and species. • Loss of vegetation cover and increase in level of artificial light can affect biological cycles of animals, cause temporary blindness, or disrupt predator-prey relationships. • Movement of vehicles along access roads would increase the probability of animals being struck or run over. • Vibration and noise induced by mining-related activities (blasting, vehicle movement, mobile and stationary equipment operation) may disturb and affect the habitat and behaviour of wildlife fauna. • Loss or degradation of water bodies within the Project area may affect the survival of wildlife dependent on downstream rivers and streams that will be affected by the mine's activities upstream (including cave ecology).	• The potential impacts to terrestrial fauna for the Open Pit project are also applicable for the Underground Mine though the present project will have a smaller footprint and will have significantly less adverse impacts to threatened species as most surface disturbance are already located in previously cleared/developed areas.
Hydrology	• Adverse impacts to surface water, groundwater, and spring sources may develop over time as the Open Pit progresses and the TSF and WRD are	• Impacts to surface water, groundwater and spring sources will be similar to the Underground Mine project. Water management strategies to manage

	constructed and operated. Impacts may include reduction in flow or disappearance as a consequence of the surface mine development. Consequently, potable and irrigation water sources may also be reduced over time. Potential water competition may arise between the various water users within the vicinity of the Project and the mine • Reduction in vegetation cover may result to increase in surface run-off. • The TSF, WRD and Open Pit will occupy a portion of the watershed translating to change in surface hydrology leading to change in drainage morphology and reduction of volumetric flows.	surface and groundwater resources can be set in place prior to the development of the underground mine and progressively as the mine is developed.
Water Quality	• Earthmoving activities and stockpiling may release significant amounts of soil, sediments and rock into nearby stream and rivers, increasing the turbidity and suspended and dissolved solids in the water • Groundwater inflow and rainwater may percolate into mine workings and interact with highly mineralized materials that may contain soluble minerals and metals • Effluents and process waters enriched in metals and other pollutants may be released from the TSF and mill and be discharged into receiving water bodies • Hydrocarbon leaks and spills from vehicles, fuel tanks and used oil storage may contaminate ground and stream water • Non-mine wastewater from support facilities particularly the administration and accommodations complex and the various warehouses may contaminate surface water bodies.	• Since the surface activities and mineral processing method are similar, the potential impacts to water quality identified during the Open Pit study are similar to the Underground Mine potential impacts to water quality. Contingent to the Underground mining method, surface infrastructure footprint is also expected to be smaller than the surface footprint of an Open pit mine.
Aquatic Biota	• Changes in water flow, volume or size caused by various mining-related activities may alter the hydrological regimes conducive to the survival of aquatic biota, resulting in the loss of habitat particularly for the location of the TSF and the subsidence pit. • Changes in water quality and chemistry induced by mine activities and processes may affect suitability of the water to host aquatic species, resulting in the loss of habitat. • Partial or complete loss and/or degradation of water resources may cause reduction or total loss of species population and/or count	• The identified impacts for aquatic biota in an open pit mine would be similar for the underground mine method though the impacts for the present project are largely dependent on the disturbance area.

	• Loss or degradation of water bodies downstream of the Project may affect the survival of wildlife dependent on downstream rivers and streams that will be affected by the mine's activities upstream (including cave ecology).	
Climate, Air Quality and Noise	• Removal of vegetation would decrease carbon sequestration potential within the Project area • Significant alterations to the topography and hydrology by the Project may affect microclimate conditions such as temperature, precipitation and evapo-transpiration within the impact sites. • Blasting, vehicular movement and equipment operations will increase ambient noise levels especially in areas surrounding the TSF, mill, mine decline, and haul roads. • Land clearing, blasting and vehicular movement will increase the amount of fugitive dust and particulates in the air • Metal-rich particulate matter liberated from mineralized materials as a result of mining activities will increase the ambient concentrations of elements suspended in the air. • Vehicle and equipment operation (e.g. diesel generators) will emit additional NO_x, SO_x, heavy metals and other greenhouse gases (GHGs) from the combustion of fuels. • Chemical fumes will be released in the air from the assay laboratory and mill.	• The impacts identified for the Open Pit will also be the same as the Underground Mine since the surface activities and the mineral processing method will be the same. However, the magnitude and extent of the impact for the present project will significantly be less due to the reduction in the size of disturbance area.
Socio-Economics, Public Health and Safety	• Inhabitants and properties within the project site may be displaced which may lead to adverse impacts with regards to the cohesion of their community, the quality of life, fears, apprehensions and perceptions of the receiving community and local government units where they will be transferred, and competition for basic utilities, public services, and other limited resources. • Payment of government dues in the local level would bring additional operational funds for local government units (LGUs) • Hiring of a significant amount of locals will bring a steady source of income and contribute to poverty reduction in the impact barangays. • Mining operations will open a market for support services such as security, housekeeping, catering, etc. that can foster	• Due to the reduction in project footprint, resettlement/physical displacement, and other impacts associated with the loss of cohesion of the communities' quality of life and culture will be greatly reduced. Much of the surface footprint and subsidence are located in areas long established (since 2012) for mine development and the stakeholders are generally aware of the project's history and coverage. • Since 2012, there has been no significant change in terms of regulations for the coverage of the Social Development and Management Program (SDMP) and the Contingent Liability and Rehabilitation Fund (CLRF) which covers all the mining-related guarantee and rehabilitation funds. However, improvements have been implemented in the formulation, review,

	local entrepreneurship and contribute to poverty alleviation. • Business opportunities created by the presence of the Project may encourage in-migration to the host barangays / municipalities, causing both positive (hiring) and negative (competition for work, resources, service, etc.) socio-economic effects in these areas • In-migration can lead to genetic mixing and higher risk of spread of communicable diseases. • Higher income generation due to direct and indirect contribution from the Project can boost local purchasing power, as well as increase the incidence of theft, drugs, alcohol, gambling and prostitution. • Mine activities will lead to an increase in vehicular traffic leading to the Project site, providing better transportation, as well as increasing accident and health risks to the communities. • Mining operations and in-migration would increase production of human and non-human wastes.	and evaluation of the coverage, programs, and terms of these guarantees as a result of changes in the regulatory administrators and the conduct of successive mine audits to ensure strict compliance.

5.0 Project Components

5.1 Overview of Project Components for Sub-level Cave Mine

Table 6: Components of the Sub Level Cave Mine

Component	Location	Estimated Area (Ha)
MINE AREA		
Subsidence area	Brgy. Timamana, Municipality of Tubod	**~208**
Underground Sublevel Caving		**Maximum depth of 400m**
Ore Stockpile		**~1**
Topsoil Stockpile		**~10**
Sedimentation Pond		**~23**
TAILINGS STORAGE FACILITY		
TSF	Barangays San Pedro, Lower Patag, and Upper Patag, Municipality of Sison; Barangay Upper Libas, Municipality of Libas; Barangays San Isidro, Sta. Cruz, and Anislagan, Municipality of Placer.	**~250 hectares**
Tailings Pipeline	Barangays Timamana and San Isidro, Municipality of Tubod; Barangays Anislagan, Boyongan, Macalaya, Municipality of Placer.	**~5.44 km**
METALLURGY AND ORE PROCESSING		
Mill facility	Barangay Timamana, Municipality of Tubod; Barangays Boyongan and Macalaya, Municipality of Placer.	**~30**

Component	Location	Estimated Area (Ha)
Comminution	Within mill facility	
SUPPORT FACILITIES		
• Mine access Roads • Administration Complex • Mine Office • Communication Infrastructure • Sewage Treatment Plant • Security Headquarters • Core Farm • Assay Laboratory • Accommodations	• Recreational Facilities • Water Refilling Station • Water Treatment Plant for Processing • Water Treatment Plant for TSF Discharge • Fuel Storage Facilities • Generator sets and Switchyards • Materials Recovery Facility • Ecological Composting Facility • Onsite Sanitary Landfill	
Crushing Facilities and Support Facilities		10 has
Total Disturbance Area for Underground Mine		532 Has

6.0 General Layout of Facilities

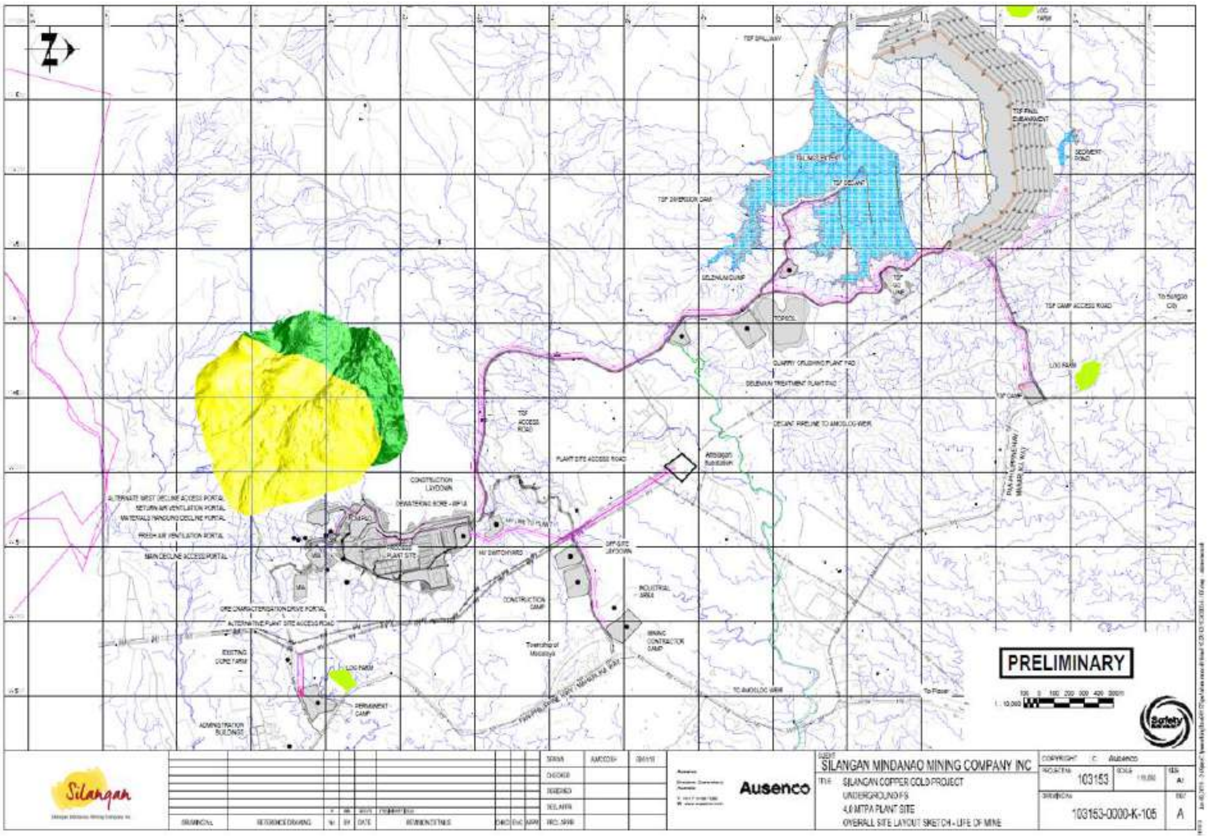
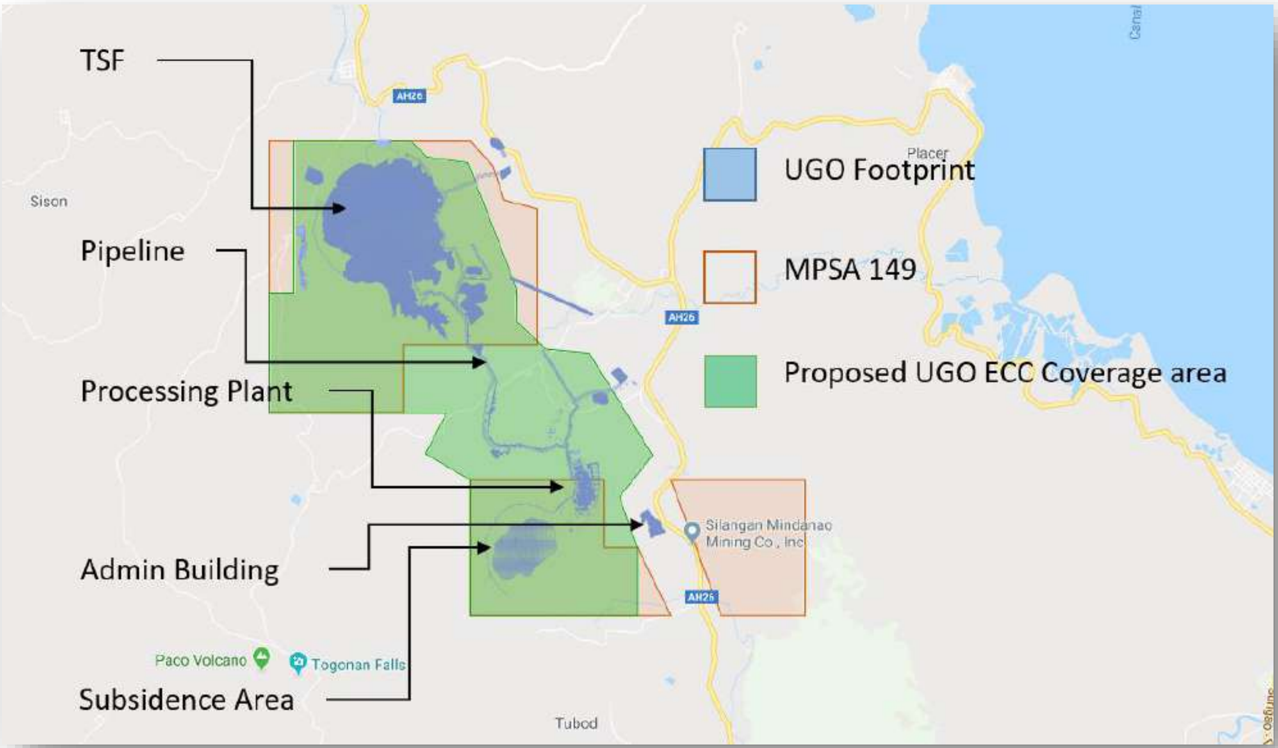


Figure 7: General Layout of the Project Showing Sub Level Caving Mine Facilities

Figure 8: Proposed ECC Coverage Area



7.0 Resource Geology

The Boyongan reportable Mineral Resource at a 0.2% Cu_{eq} cut-off is summarized in Table 7. This was derived from the JORC report.

Table 7: Boyongan JORC Classified Mineral Resource (MPSA – 149)

Cu-eq	Measured					Indicated				
	Tons (Mt)	Cu (%)	Cu (Mlb)	Au (g/t)	Au (Moz)	Tons (Mt)	Cu (%)	Cu (Mlb)	Au (g/t)	Au (Moz)
0.2	427	0.39	3515	0.52	7.17	155	0.30	990	0.35	1.75
0.3	384	0.42	3375	0.57	6.97	129	0.34	906	0.39	1.62
0.4	324	0.476	3117	0.63	6.57	99	0.37	781	0.44	1.42
0.5	262	0.50	2777	0.71	6.00	72	0.42	632	0.51	1.17

Measured + Indicated				
Tons (Mt)	Cu (%)	Cu (Mlb)	Au (g/t)	Au (Moz)
583	0.37	4511	0.48	8.92
512	0.40	4280	0.52	8.60
424	0.44	3895	0.59	7.98
334	0.49	3412	0.67	7.18

Cu-eq	Inferred					Total				
	Tons (Mt)	Cu (%)	Cu (Mlb)	Au (g/t)	Au (Moz)	Tons (Mt)	Cu (%)	Cu (Mlb)	Au (g/t)	Au (Moz)
0.2	115	0.26	639	0.34	1.27	698	0.35	5153	0.46	10.21
0.3	90	0.31	580	0.38	1.11	602	0.38	4867	0.50	9.70
0.4	66	0.36	5067	0.42	0.89	490	0.43	4403	0.56	8.87
0.5	49	0.40	418	0.46	0.73	383	0.47	3829	0.64	7.89

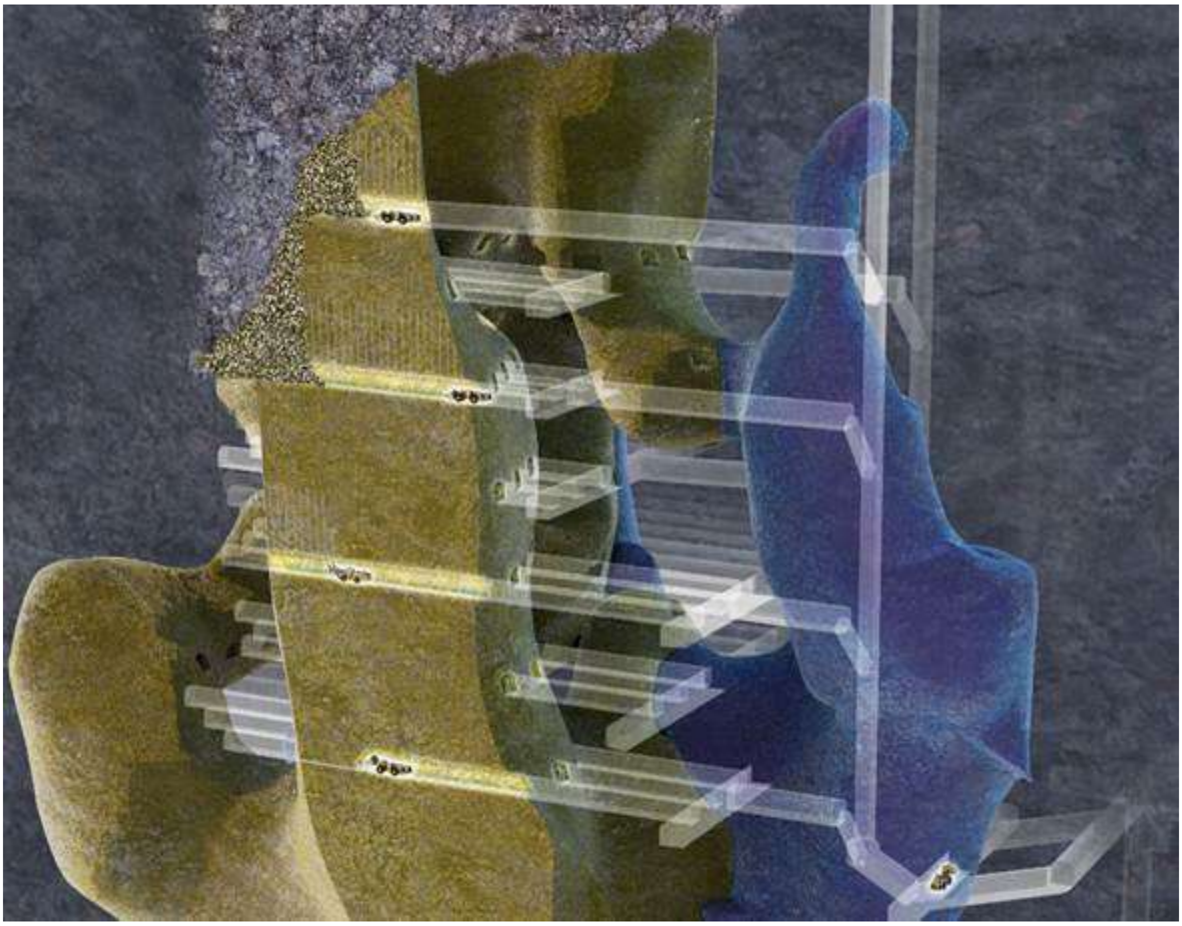
8.0 Description of Project Components

The succeeding sections below discuss in more detail the description of the major mine components particularly the Underground, Mill, and other infrastructure collectively discussed as Support Infrastructure. The TSF is discussed under (Mine Waste Management).

8.1 Underground Mine

Sub-level stoping is a top down mining method following the contours of the orebody. Unlike Block caving, several Sub-levels, which serve as production levels, are developed and are spaced nominally at 25 m to 30 m intervals. On each sub-level, the ore is broken by drilling and blasting a series of up-hole rings and the blasted ore is extracted. The mining method is shown diagrammatically in the following figure.

Figure 9: Typical Sub-level Caving Operations



Sub levels are continuously developed downwards until where it is economic. Ore from each sub levels are trucked to the surface and to the mill.

Water will be managed thru a combination of advance dewatering systems thru dewatering wells, collection and pumping of water from underground to surface and diversion of surface run-offs.

Ample fresh air will be introduced thru the shaft intakes and used air will be expelled via shaft exhausts. An underground temperature control system will be installed as well

8.2 Mill and Processing Plant

The mill will be located in Barangays Macalaya and Boyongan of the Municipality of Placer and partly in Barangay Timamana, Municipality of Tubod. The mill will be designed to treat nominally at an average of 4 Mtpa of copper-gold bearing ore. The mill will produce copper cathode, dore', and copper concentrate, and consists of a number of unit processes, as follows:

1. Crushing and ore stockpiling;
2. Stockpile reclaim, grinding, and classification;
3. Flotation and concrete handling;
4. Atmospheric leaching;
5. Counter Current Decantation (CCD) circuit;
6. Cyanide leaching& carbon adsorption
7. Acid wash, elution, electrowinning and smelting
8. Cyanide destruction
9. Tailings thickening; and
10. Plant services.

The indicative layout of the mill complex is presented in Note that this may still vary as detailed studies progress.

Crushed Run-of-Mine (ROM) will be conveyed as mill feed to a semi-autogenous grinding (SAG) mill.
The grinding plant will be composed of a primary grinding circuit and a secondary grinding circuit. The primary grinding circuit is the SAG mill circuit. The ore is ground and mixed with water to produce slurry and, at the same time, liberate gold, copper, and silver. The SAG mill will be equipped with a grate discharge and screen to size the discharge. Oversize will be fed back to the SAG while undersize will be pumped to the secondary grinding circuit.

The secondary grinding circuit will be composed of a ball mill in closed circuit with cyclones. Ball and SAG mill discharge will be pumped into the cyclones for classification. Underflow will return to the ball mill while overflow will go to the flotation circuit. The flotation circuit will produce the copper concentrate.

Float tails will undergo atmospheric leaching before it is pumped to the CCD circuit. The CCD circuit is a liquid solid separation process using thickeners in which the copper rich solution part of the atmospheric leach discharge slurry is separated from the copper depleted solids component. It consists of a series of six thickener tanks in which the underflow goes in one direction, while the copper-bearing overflow goes in a counter-current direction. The copper rich solution is pumped to the PLS (pregnant leach solution) tank for solvent extraction. The solvent extraction process is in essence a "liquid concentrator" in which the copper grade of the PLS is increased. Copper is electro-won from the final solution in this circuit.

Thickened underflow from the last CCD thickener in series will be pumped to the cyanide pre-leach neutralization tanks. Discharge from the pre-leach neutralisation circuit is pumped to the feed distribution box. The slurry from the feed distribution box will gravitate to the cyanide leach tanks then to adsorption tanks. The carbon desorption circuit will consist of separate acid wash and elution columns. Gold will be eluted from the carbon. Soluble gold and silver recovery will be achieved by electrowinning onto woven, stainless steel wire mesh cathodes. Upon completion of gold electrowinning, gold sludge on the plated cathodes will be washed off the cathodes, filtered and dried. The dried filter cake will be mixed with flux mixture then charged into furnace to produce the gold dore.
Cyanide leach tailings are pumped to the cyanide destruction circuit to reduce the residual cyanide contained within the tailings stream.

8.3 Support Infrastructure Summary

The surface infrastructure for the mine is composed of buildings and facilities not considered critical mining or mineral processing infrastructure. Layout plans for the mine infrastructure and site services are being developed including alignments of access and haul roads, site facilities layout, earthworks, pavement design, drainage systems, electrical and lighting systems and the like. These include alignments of the access and haul roads. General infrastructure requirements including site facilities layout, earthworks, pavement design, storm drainage system and the electrical and lighting systems are also being planned as part of the Project's definitive feasibility study.

8.3.1 Power Substation

The power substation will be located proximal to the mill since the mill requires the most significant load within the Project. Power distribution will require the following utilities:

1. 138/13.2 kV main substation;

2. 13.2 kV primary distribution network; and
3. Emergency generators.

The incoming power supply to the mine will be supplied by the National Grid Corporation of the Philippines (NGCP) Anislagan substation. The main high voltage (HV) substation will be a 138 kV outdoor substation. Sufficient space has been allowed for expansion at the substation at the substation should any future duplication of the NGCP transmission lines provide an opportunity for a second feed. A 13.2 kV Main Switchboard will be located near the transformer. A sub-main 13.2 kV switchboard will be used to minimise cable feeders to the process plant area. Distribution to the sub-surface facilities will be by overhead 13.2 kV lines supplied from the 13.2 kV Main Switchboard. One distribution circuit will reticulate around the mine site.

The surface infrastructure will be provided with emergency standby diesel generators. The generators will be outdoor type, fully packaged.

Power for buildings and other mine facilities will be distributed through low voltage (LV) distribution. A 400 V, three phase wye system, T-T Neutral system will be used.

8.3.2 Explosives Magazine

The explosives magazine will store bulk emulsion type explosives for use in the underground mine. The magazine will have a capacity of 150 metric tons.

8.3.3 Fuel and Lubricants Storage

A fuel storage and distribution facility will be adjacent to mill and will supply all fuel requirements for the operation of the mine. The storage facilities will be adequate for seven days' supply.

Diesel Fuel Storage and Distribution

Diesel fuel will be the main fuel that will be used to run/operate mine's mobile equipment.

Diesel Fuel Storage Tanks

The main diesel fuel storage will use 2 x 67 m^3 Transtanks or similar products. Transtanks are double skinned containers which eliminate the need for bunding. Minimal civil works or site preparation will be needed to accommodate these tanks.

Gaseous Fuel Storage and Distribution

The kitchens and canteens will require the use of a gaseous fuel and will require a suitable storage and distribution solution with a proposed storage capacity of one month. The kitchens are located in the accommodation village, the administration complex, and the construction village.
Each kitchen will be supplied from storage tanks connected to a distribution line. The use of 50 kg LPG bullet tanks is proposed, directly connected to the fuel header through flexible hoses and ready for use by opening the isolation valves. The bullet tanks will be installed directly to the tank stands thereby eliminating double handling.

Blast enclosures will be constructed alongside each kitchen building and will be accessible from the delivery truck unloading area. These enclosures will direct the blast away from occupants and establishments in case of an explosion. Openings for ventilation shall be provided with fine mesh screens to reject entry of ignition sources. The fuel tank enclosures will be provided with suitably sized access doors.

Gaseous fuel from the tanks will be piped to the kitchen area using carbon steel pipes. Flexible hoses will connect the tanks to the header pipes, and isolation valves will be provided for each tank to isolate the tanks if they are not being used, or during replacement of the tanks.

8.3.4 Water Treatment Plant

A water treatment plant (WTP) will be constructed to treat water suitable for processing. A WTP will also be provided to treat water that will be discharged from the TSF.

8.3.5 Sewage Treatment Plant

The sewage treatment plant will be designed to receive the waste from all of the mine facilities sources and to remove materials that damage water quality and compromise public health and safety when discharged into water receiving systems. The sewer treatment plant will be situated adjacent to the construction and accommodation villages.

8.3.6 Raw Water and Fire Water Systems

The raw water pond will be constructed as part of the surface infrastructure package. Water from the raw water pond will be used to supply the plant, the mine and other users around the site.
Raw water will be supplied to the raw water tank in the plant area by the plant raw water pumps, installed in a duty / standby configuration. The raw water tank will provide a small surge capacity between the site raw water pond and the plant delivery systems. The raw water tank will be used to supply gland water to the plant using duty / standby gland water pumps, and raw water to reagent mixing systems, filter cloth washing and process water top up (if required) via the duty / standby raw water pumps.

The mine raw water pumps will supply raw water to the portal using duty / standby pumps.

The site raw water pumps will supply raw water to other users around the site using duty / standby pumps.

The fire water system will be a separate system from the raw water system with a dedicated fire water tank. A vendor package fire water pump system will be provided complete with electric fire water pump, diesel back-up fire water pump and a jockey pump. A number of hydrants and hose reels will be installed around the site to provide protection for the plant and infrastructure.

8.3.7 Process Water System

The plant will have a dedicated process water pond which will provide over six hours of storage capacity. Process water will consist of water from the tailings thickener overflow, concentrate thickener overflow, decant return water, and top up from the raw water system if required. During normal operation, the entire process water demand will be met using recycled water, giving a positive water balance for the site.

Process water will be used around the plant for such duties as dilution and sprays in the grinding, flotation, regrind, thickening and lime slaking areas, and at service points. Duty / standby pumps will be provided for delivery of process water around the plant.

8.3.8 Workshop and Warehouses

Various workshops and warehouses are proposed to support the operations of the mine and are proposed to be located adjacent to the mine and mill areas. These facilities are summarized in Table 18.

Table 8: Workshop and Warehouses Details

Facility	Description
Warehouse Building	Steel-framed metal clad building that will contain the following: • Storage for spare parts and supplies; • Open warehouse area serviced by a gantry crane with 7 t capacity; • Circulation space for fork lift; • Separate oxy/acetylene storage area; • Office; • Receiving and dispatch docks; and • Staff amenities area.
Electrical Workshop Building	Steel-framed metal clad building that will contain the following: • Open plan work area for maintenance of electrical equipment, including shielded welding area and compressed air area, accessed from outside at both ends; • Open work area served by overhead gantry crane, 5 t capacity; • Open work area accessed from each end of the building; • Offices, tool room, store room and counter; • Oven and heater room; • Rewinding room; and • Staff amenities area.
Linatex Workshop Building	Steel-framed metal clad building that will contain the following: • Working and patching area for rubber conveyors accessed from outside at both ends; • Open work area served by overhead gantry crane; • Rubber, tools, and equipment storage room; • Office; and • Staff amenities area.
Machine Shop Building	Steel framed metal clad building that will contain: • Work area including lathe machine area and shielded welding area, accessed from outside at both ends; • Open work area served by overhead gantry crane; • Blacksmith shop (room); • Foundry shop (room); • Grinding shop (room); • Store room and counter; • Office; and • Staff amenities area.
Mine Mechanical Shop	Steel-framed metal clad building that will contain: • Work area for welding and repair; • Open work area served by overhead gantry crane; • Machine shop / lathe room; • Electrical shop (room); • Compressor shop (room); • Battery lamp charge room and stores; • Light vehicle repair shop; • Manager's office; and • Staff amenities area.
Mill Mechanical Shop	Steel-framed metal clad building that will contain the following: • Work area for welding and repair;

	• Open work area served by overhead gantry crane; • Office; and • Staff amenities area.
Mechanical Equipment Maintenance (MEM) Workshop (Also referred to as Motor-Pool Shop)	Steel-framed metal clad building that will contain the following: • Heavy vehicle repair bays; • Heavy tracked vehicle repair bays; • Screened welding bay; • Electrical workshop; • Light vehicle repair bay; • Workshop area served by overhead gantry crane; • Store rooms for spare parts and tools; • Vulcanising shop; • Locker room with amenities; • Mezzanine level office for manager/superintendent and support staff; and • Staff amenities area.
Vehicle Wash Bay	Bunded hardstand area for vehicle/equipment wash down
Vehicle Fueling Bay	Bunded hardstand area for vehicle fuelling
Vehicle Tyre Bay	Hardstand area for tyre fitting
Staff Amenities and Administration Area	Facility may include offices, ancillary storage areas, and staff amenities area.

8.3.9 Administration Complex

The administration complex will be located on a relatively flat terrain with existing topography that varies from 75 m to 80 m. The road to the administrative complex will be a Class 1B road as it is expected that only passenger and small delivery and service vehicles will be allowed to enter the administration complex (refer to discussions below under Roads). The proposed location of the complex will be graded to the design level of the road with a minimum slope of 1% to divert the stormwater flow away from the building pads. The site area will be enclosed by a perimeter fence for security. Each building in the administration precinct will be built in-situ, comprising traditional concrete slab / concrete masonry block / timber framed roofing construction. The design basis is for the administration complex is presented in Table 9.

Table 9: Administration Complex Details

Facility	Description
Administration Building	Facility for administration staff composed of work stations, managerial offices, meeting rooms, pantry/meals room, reception area, and associated male and female staff amenities.
Assay/Metallurgical Laboratory Building	Mineral analysis facility including sample prep area, sample crushing room, sample analysis rooms and the like. Building will also contain offices, meals room, and male and female staff amenities.
Safety/Conference Building	Facility will include offices and training/conference halls, storage, lobby, and male and female staff amenities. The facility will be used for staff training, safety induction, and other similar activities.
Staff House	Staff/guest house will provide rooms with bathroom facilities, common lounge and dining areas, and a commercial kitchen.
Guest House	
Recreational Facility	Tennis and basketball courts.
Security Headquarters Building	This facility will be located proximal to the main mine access road entrance. The facility will contain security offices, storage, and basic staff amenities.

8.3.10 Accommodation Camp

The accommodation camp will consist of a temporary construction village during the construction phase and a permanent employees village during the operation phase.

8.3.11 Construction Village

The construction village will accommodate the construction workforce and will be designed to accommodate approximately 500 personnel per 8-hour shift basis for a construction schedule running 24 hours. A shuttle service will transport shift workers between construction sites and the construction village.

Generally, all housing units will be pre-fabricated container vans to be transported and installed on site and removed at the end of project construction. The construction village will be located near the permanent and executive village, sharing some services and utilities. The infrastructure design will cover site grading of the area, perimeter site fencing and temporary underground utilities, roads and drainage.

The construction village road network will be typically Class 1B and with designated areas to accommodate buses and service vehicles. A temporary security fence will be provided to enclose the construction village.

8.3.12 Permanent Village

The permanent village will be located at a safe distance from the mine and the mill taking into consideration standards for occupational health and safety on air quality, noise, vibrations and other potential health and safety risks. It will be located on graded flat to undulating terrain. Site grading will be designed according to road requirements and to provide positive drainage towards the road channel.

The permanent village will be designed to house approximately 400 mine staff composed of mine workers; project and mine management staff and village administration staff on a permanent or long-term basis. The proposed design will provide for separate areas for regular and executive occupancy. The villages will be enclosed by security fence to avoid unauthorized access.

8.3.13 Services and Utilities

8.3.13.1 Potable Water Services

Potable water will be used in two separate systems in the plant, safety shower / drinking water and plant potable water. The safety shower water tank will provide storage capacity for potable water which will be used in all safety showers and drinking water fountains around the plant. Duty/standby pumps will be provided for delivery of this water.

The plant potable water tank will provide potable water for the MSA, ablutions and buildings in the plant area. The plant potable water pump will deliver potable water to these locations.

8.3.13.2 Low Pressure and High Pressure Air

The mill will be supplied with oil free, clean and dry air from duty / standby rotary screw compressors for plant and instrument air. These will discharge via after coolers and filters into one air receiver and high capacity dryer. As all the air will be clean and dry, there will be no requirement for separate plant and instrument air storage and distribution systems.

Duty/standby low-pressure air blowers will be provided to supply the low pressure air required for the flotation circuit. The blowers will supply low-pressure air to rougher and cleaner flotation via a series of headers.

8.3.14 Roads

Road infrastructure will include the main access road, internal roads to connect various mine facilities, haul roads, and other roads to support the mining operation including their associated storm drainage systems. These facilities are currently being designed and costed.

The mine access road will serve as a link between the existing local road networks and the mine site including all associated facilities. All access roads will be designed according to the DPWH Design Guidelines, Criteria and Standards. The design for the access roads will consider the appropriate alignment, grade, sight distance, drainage requirements, and safety considerations for the geotechnical characteristics of the soil and mine fleet requirements.

The proposed associated stormwater drainage system will be designed to cater for the surface runoff that will be generated from the site. The drainage will be directed to the existing waterways depending on the availability of a suitable outfall. The drainage design will also consider historical rainfall data and climate projections for the region from the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA).

Road Design

Road design has been classified into three categories based on functionality: Class 1, Class 2 and Class 3.

Class 1 road design is for mine fleet operation (light and heavy vehicles) and will be the main access road originating from the existing Pan Philippine Highway (National Highway) to the mine site. It will accommodate traffic related to the mine operation during the construction to operation phase. Class 1A road design is utilised for the link road from the main access road to the mill site and adjacent facilities. Class 1B road design is selected for the mine facilities road network.

Class 2 road design will accommodate heavy vehicles and equipment to serve as haul road for construction of the site facilities.

Class 3 road design is for single carriageway for service and maintenance access.

As asphalt pavement will be provided for the mill road, mine main access road and access to the village area.

Road and Area Lighting

Access roads and open areas will be provided with illumination following the minimum requirements of the latest edition of the Manual of Practice on Efficient Lighting (MPEL) published by Institute of Integrated Electrical Engineers (IIEE) of the Philippines. Access road and area lighting will also be designed in accordance with the requirements of the mill activities, vehicle traffic, safety and security.

9.0 Process Technology

9.1 Mining Process

The key stages for the mining process include the following activities:

1. Site preparation (e.g. clearing of vegetation and harvesting of commercial timber, as feasible);
2. Stripping and stockpiling of topsoil;
3. Developing and construction of a portal and decline access thru drilling, blasting and civil engineering activities;
4. Drilling and blasting thru ore and waste rock using jumbo drills;
5. Developing of ventilation raises thru drill and blast;
6. Underground mine dewatering;
7. Mining of ore and waste rock using Load-Haul-Dump (LHD) and trucks;
8. Hauling of ore from the underground mine to the pit ore stockpiles, or to the crusher feeding the ore conveyor.

The operation will require large-scale mining equipment and will include a fleet of articulated and non-articulated haul trucks, jumbo and longhole drills, rock support machines, LHDs, graders, water trucks, and service vehicles. The operation will be supported by trained personnel and will operate in three shifts per day, 24 hours a day, seven days a week, both during the construction and operation phases.

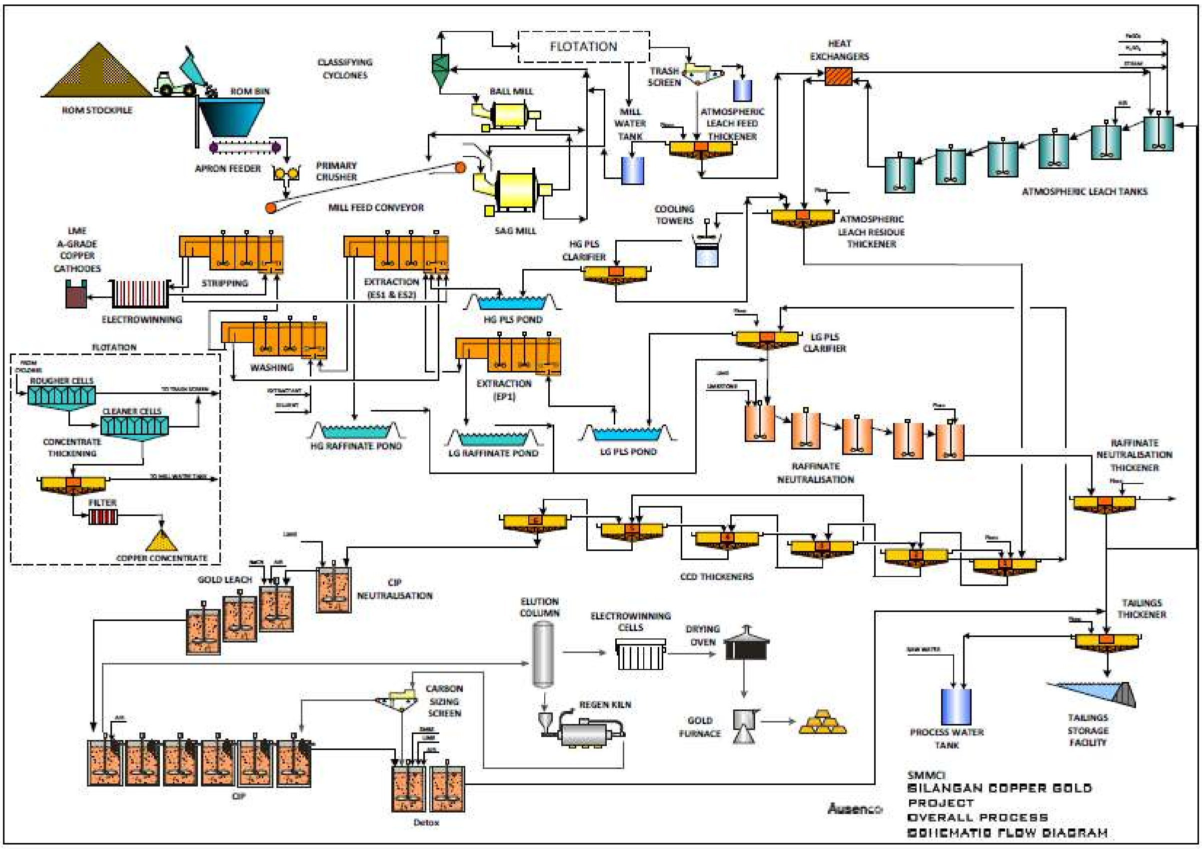
Site preparation will include vegetation clearing and harvesting of commercial timber, as feasible, and soil stripping. Stripped soil will be stockpiled in the topsoil stockpiles for later use in the rehabilitation activities. Initial drilling will be done to assess the rock hardness, fragmentation, and rock type before blasting activities. Blasting will be undertaken using bulk emulsion explosives due to the wet conditions expected at the project site. A comprehensive blasting procedure will be developed as part of the safety management plan to ensure the safety of personnel and equipment. All blasting procedures will be undertaken using a remote means of initiation by trained and certified competent personnel.

9.2 Mineral Processing

The Silangan plant will treat a maximum of 4.5 M dry t/a of ore to produce copper concentrate, copper cathode and gold dore. The overall flowsheet is shown in Figure 10. The flow sheet includes the following steps:

1. Crushing and ore stockpiling;
2. Stockpile reclaim, grinding and classification;
3. Flotation and concentrate handling;
4. Atmospheric leaching;
5. Counter current decantation;
6. Raffinate and raffinate neutralisation;
7. Solvent extraction;
8. Copper electrowinning;
9. Cyanide leaching and carbon adsorption;
10. Acid wash, elution, electrowinning and smelting;
11. Carbon regeneration;
12. Electrowinning and gold room;
13. Cyanide destruction; and
14. Tailings thickening and disposal.

Figure 10: Metallurgical Process Flowsheet



9.2.1 Crushing and Ore Stockpiling

Crushed Run-of-Mine (ROM) will be conveyed as mill feed stockpile to a semi-autogenous grinding (SAG) mill.

9.2.2 Stockpile Reclaim, Grinding and Classification

The grinding circuit will receive ore at a nominal top size of 250 mm.

The facility to direct cyclone underflow to either the SAG mill and/or ball mill feed will be provided in order to give maximum operational flexibility to cope with variations in throughput and ore hardness.

The mill will operate up to 25% ball charge depending on ore hardness and throughput. Ore will be fed to the SAG mill, nominally 931 dry t/h new feed (for 7mtpa), and water added to the feed chute to achieve the desired mill discharge density of 70% solids.

Screening and scats dewatering will be carried out using the SAG mill discharge screen. Slurry will report to the cyclone feed hopper, while dewatered scats will report to first of two scats conveyors.

The scats conveyors will transfer scats to the scats bin. A weightometer will be installed on one of the scats conveyors to ensure that the scats rate can be measured, and the total mill feed calculated. A secondary magnet and metal detector will also be installed to prevent ball fragments from entering the recycle crusher and causing equipment damage. Any metal not recovered by the magnet will be bypassed back to the SAG mill feed conveyor using the scats diverter gate. The scats bin will provide surge capacity for the pebble crusher to ensure that the unit is choke fed at all times. The pebble crusher will be fed typically at 155 dry tph by a variable speed belt feeder. Discharge from the pebble crusher will also report to the SAG mill feed conveyor.

Mill water will be used to dilute the slurry as required to achieve a suitable cyclone feed density of 58% solids. Cyclone feed pumps will be used to transfer slurry to the cyclone clusters.

Cyclone underflow will gravitate to the SAG mill and/or ball mill depending on ore hardness and throughput. Cyclone overflow will report to the trash screen via a linear sampler.
The ball mill will operate with a ball charge of between 36-40% depending on the ore hardness. Circulating load is between 300-400%. Cyclone underflow will be fed to the ball mill feed chute along with mill water to achieve the desired ball mill discharge density of 68% solids. Product from the ball mill will discharge over a trommel. Oversize will report to the scats bunker. Undersize slurry discharged from the ball mill trommel will gravitate to the cyclone feed hopper.

Grinding media for the ball mill will be introduced by use of a ball charging hoist located on the cyclone tower. Ball mill media will be charged using a kibble.

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9.2.3 Flotation and Concentrate Handling

9.2.3.1 Rougher Flotation

The cyclone overflow from the grinding area will pass through a sampler upon entry to the rougher flotation area.

The linear sampler will take a continuous sample to feed the On-Stream Analyser. The remainder of the stream will flow to rougher flotation.

Slurry will go the rougher conditioner tank. The conditioner tank will provide residence time for mixing and contact of reagents with the ore surfaces prior to flotation. PAX will be added into the conditioner tank, while frother will be added to the conditioner tank launder just prior to rougher flotation. Rougher feed is 35% solids.

Rougher flotation consists of six tank cells in series.

Rougher tailings will be sampled by a linear sampler to provide a continuous sample for the On-Stream Analyser. The remaining slurry will be pumped to the atmospheric leach feed thickener feed tank.

9.2.3.2 Cleaner Flotation

Rougher concentrate, will combine with cleaner 2 tails and cleaner scavenger concentrate, will be fed to cleaner 1 flotation cells, PAX will be added.

The cleaner 1 flotation cellswill consist of 4 tank cells in series with 3 units of cleaner scavenger tank cells.

Cleaner 1 concentrate will be pumped to cleaner 2 flotation. Cleaner 1 tailings will gravitate to the cleaner scavenger. The cleaner scavenger tailings will combine the rougher tailings in atmospheric leach feed thickener feed.

Cleaner 2 flotation will be conducted in a series of three cells, PAX and frother will be added at the head of the tank. Cleaner 2 concentrate will gravitate to the cleaner 3 flotation. Cleaner 2 tailings will gravitate to cleaner 1 flotation cells.

Cleaner 3 flotation will be carried out in a bank of two cells. Addition of PAX and frother at the head of the bank will be made.

Cleaner 3 concentrate will report to the final concentrate thickener feed box. Cleaner 3 tailings will gravitate to the cleaner 2.

9.2.3.3 Concentrate Thickening

Final concentrate will be pumped to the final concentrate thickener feed box and will pass through a metallurgical sampler. This sampler will provide a sample for metallurgical accounting purposes. Final concentrate will be combined with filtrate. Dilute flocculant will be mixed with the slurry to achieve the desired settling rate.

Thickener underflow, at approximately 70% solids by weight, will be pumped to the concentrate storage tank by one of two duty / standby concentrate thickener underflow pumps.

Thickener overflow will gravitate to the concentrate thickener overflow tank, which will be equipped with a set of duty / standby pumps. These pumps will transfer the overflow water to the mill water tank for re-use.

One agitated concentrate storage tanks will provide surge capacity between concentrate thickening and filtration.

Concentrate thickener sump pump will service this area for spillage cleanup.

Concentrate will be pumped from the concentrate storage tanks directly to pressure filters.

Each filter will produce filter cake with nominal of up to 13% moisture by weight. The filtrate will be collected in the filtrate tank and recycled to the concentrate thickener feed box by the filtrate pumps.

Dewatered concentrate will be loaded into the concentrate trucks via front-end loader and transported to the port.

9.2.3.4 Atmospheric Leach Feed Thickening

Final tails, consisting of rougher tails and cleaner scavenger tails, will report to the atmospheric leach feed thickener feed tank/

Final tails from the thickener feed tank will go to the atmospheric leach feed thickener.

The atmospheric leach feed thickener will be a high compression thickener. Thickener underflow, 60% solids, will be pumped to the atmospheric leach tank heat exchanger. Thickener overflow will go to thickener overflow tank to be pumped to mill water tank.

9.2.4 Atmospheric Leaching

The thickened underflow after passing through the splash heating and heat will be pumped to the first of six atmospheric leach tanks arranged in series. Slurry at 41% solids is transferred from one tank to the next through an overflow launder with provision made for each tank to be by-passed if required. Each tank is mechanically agitated and fitted with spargers through which low pressure blower air and low pressure steam are supplied. The blower air provides both additional agitation and is a source of oxygen for leaching.

Sulphuric acid for leaching is primarily supplied as 98% sulphuric acid with additional acid added in the form of raffinate solution (for solids density control). Residence time in the atmospheric leach is up to 18hours. Each tank is covered and vented. The exhaust gases are scrubbed in the atmospheric leach wet scrubber before being vented to atmosphere through the atmospheric leach stack.

Leached slurry discharging from the last tank is pumped to the atmospheric leach residue thickener.

9.2.5 Counter Current Decantation

The CCD circuit is essentially a liquid solid separation process using thickeners in which the copper rich solution part of the atmospheric leach discharge slurry is separated from the copper depleted solids component.

Thickener overflows flow in one direction with thickener underflow (55% solids) flowing in the opposite direction. Atmospheric leach residue thickener underflow is fed to the feed tank of CCD No 1 thickener where it is diluted with overflow from CCD No 2 thickener before feeding into the thickener. The overflow from atmospheric leach residue thickener is a copper rich solution which is pumped to the high grade PLS (pregnant leach solution) circuit. Overflow from CCD No.1 thickener is pumped to the low grade PLS circuit.

CCD No 1 thickener underflow is pumped to the feed tank of CCD No 2 where it is diluted with overflow from CCD No 3 thickener before feeding into the thickener. This dilution is in essence a wash, or rinse, stage of the underflow slurry from the previous stage.

CCD No 2 thickener underflow is pumped to the feed box of CCD No 3 where it is diluted with overflow from CCD No 4 thickener before feeding into the thickener.

CCD No 3 thickener underflow is pumped to the feed box of CCD No 4 where it is diluted with overflow from CCD No 5 thickener before feeding into the thickener.

This process continues until the last CCD thickener in is reached. In the feed box of the last thickener the underflow from the previous thickener is diluted with a copper deficient CCD wash stream (neutralised SX raffinate) which as it proceeds through the circuit as a thickener overflow it gradually becomes richer in copper.

Thickened underflow from the last CCD thickener in the train is pumped to the cyanide pre-leach neutralisation stage.

Flocculant is added to each thickener feed tank to assist with the thickening of the solids.

9.2.6 Raffinate and Raffinate Neutralization

Raffinate flow from high grade solvent extraction is directed to the raffinate tank then pumped to the atmospheric leach circuit, while flow from low grade solvent extraction is reporting to the raffinate neutralisation circuit.

The raffinate from low grade solvent extraction is neutralised by limestone in the raffinate stage 1 neutralisation tanks, with discharge reporting to the raffinate stage 1 neutralisation thickener. Stage 1 thickener overflow is further neutralised by lime in the raffinate stage 2 neutralisation tanks, with discharge reporting to the raffinate stage 2 neutralisation thickener. The tanks are mechanically agitated and air is sparged into the tanks to assist in the neutralisation process. Stage 2 neutralisation thickener overflow is pumped to the last thickener in the CCD circuit as CCD wash water. Any excess thickener overflow, along with the thickener underflow, is pumped to the thickened tailings hopper for disposal to the TSF.

9.2.7 Solvent Extraction

In the extraction stage, copper will be extracted from the low acid aqueous PLS into an organic phase before passing into a stripping stage, where copper will be stripped from the organic phase into a high acid copper rich aqueous phase from which copper will be recovered by electrowinning.

PLS will be pumped from the PLS pond through a cooling tower to the pump mixer of the first extraction stage (E1) where it will be mixed with semi-loaded organic coming from the following mixer-settler. Each mixer settler has two mixing stages. Copper from the PLS solution will be extracted into the organic phase by using a copper selective organic reagent mixed with a diluent. PLS cooling is required to ensure that the organic reagent is not degraded by the high temperature of the PLS coming from the atmospheric leaching stage.

The organic/aqueous mixture will flow through the mixers and into the settler where it will be dispersed across the full width of the settler by a primary distributor fence. As the organic and aqueous phases in the mixture have different densities they separate out into their individual components in the settler with the separation aided by the use of “picket fences”. The lighter organic phase floats on top of the denser aqueous phase.

The extraction mixer-settlers are designed to operate with an organic to aqueous phase ratio 1.1 to 1 and the mixer-settlers will be equipped with organic and aqueous recycles to allow this O to A ratio to be changed.

Provision for recycle of organic and aqueous streams will be provided in each settler.

There are two launder compartments at the discharge end of each settler. The copper loaded organic overflows the fixed organic weir into the organic launder whilst the aqueous phase overflows the adjustable aqueous weir will flow under the organic launder into the aqueous launder.

Aqueous from the E1 settler will flow to E2 pump mixer with the copper loaded organic solution flowing by gravity into the loaded organic tank. In E2 the aqueous solution from the E1 stage will be mixed with the strip stage. The mixture will flow through the mixing units into the settler, where the phases will again be separated.

The aqueous phase from the E2 stage contacts with stripped organic coming from the S2 stage. About 90 to 95 % of the PLS copper content will have now been transferred from the aqueous phase into the organic phase. The extraction recovery varies depending on the PLS acidity and copper content. The copper depleted aqueous solution (raffinate) will flow from E2 stage by gravity into the raffinate after settler.

Loaded organic will be pumped to the first stripping stage S1 where it will be contacted with semi-rich electrolyte solution from the second strip mixer-settler (S2). Copper will be stripped from the organic phase back into the aqueous phase by aid of acidity difference between the phases. The rich electrolyte containing close to 50-55 g/L copper will flow from the S1 stage by gravity to the strong electrolyte after-settler. Partially stripped organic solution continues to the S2 stage, where it is mixed with spent electrolyte solution pumped from the spent electrolyte tank located at the tank farm. The spent electrolyte contains 35 to 40 g/L copper and 170-180 g/L sulphuric acid.

The stripped organic returns from the S2 stage to the E2 stage.

In the case of a single strip stage loaded organic is mixed with spent electrolyte with the organic discharge from the strip settler going to the pump mixer of the second extraction stage and the aqueous electrolyte going to the strong electrolyte after settler.

9.2.8 Copper Electrowinning

Copper will be recovered from the strong electrolyte solution by direct current flowing between lead or titanium anodes and stainless steel cathodes with the electric current supplied by a rectiformer (transformer-rectifier). A bus bar system connects the rectifier to the electrowinning cells with inter-cell busbars allowing current to flow between the cells. During the process copper will be deposited on to the stainless steel cathodes and oxygen will be liberated at the anodes.

Electrowinning cells will be made of polymer concrete and equipped with an electrolyte inlet manifold and an overflow box. Each cell contains 69 permanent stainless steel cathodes and 70 cold rolled permanent anodes.

EW feed electrolyte will be pumped from the circulating electrolyte tank into the electrowinning cells which overflow back to the spent electrolyte compartment of the electrolyte circulation tank. Copper content of the electrolyte ranges from 35 to 50 g/L and the acid content from around 150 to 180 g/L. The electrowinning cells operate at a temperature in the range 45°C to 50°C.

The cathodes will be allowed to grow for up to seven days after which they will be removed from the cells. Pulled cathodes will be transported to the receiving conveyor of the stripping machine and stripped automatically after passing through a cathode wash station. Stripped cathodes will be transferred to the discharge conveyor of the stripping machine from where they are taken back to the cells by crane.

At the stripping station the stripped copper cathodes move down and will be turned into the horizontal position.

The stacking unit automatically gathers the cathodes into bundles which will be discharged from the stripping machine to a weighing unit for weighing. The cathode bundles then move onto the strapping station where they will be sampled, labelled and strapped before being removed by forklift and taken to the cathode storage area.

9.2.9 Cyanide Leaching and Carbon Adsorption

9.2.9.1 Cyanide Pre-Leach Neutralization

Thickened underflow from the last CCD thickener in series is pumped to the pre-leach neutralisation tank. Neutralisation in the tank is carried out using milk of lime slurry to raise the pH to 10.5 prior to cyanide leaching. The tanks are mechanically agitated and fitted with air spargers through which air is introduced to assist the neutralisation process.

Slurry discharging from the cyanide pre-leach neutralisation tank is fed over cyanide pre-leach trash screens to remove trash from the slurry. Trash screen underflow is pumped to the cyanide absorption circuit.

9.2.9.2 Cyanide Adsorption Circuit

Discharge from the pre-leach neutralisation circuit with 44% solids target density is pumped to the cyanide leach feed box. The slurry from the feed box will gravitate to the first of the two cyanide leach tank.

If the first leach tank is offline, the slurry will be diverted to the next tank. The ability exists for any this tank to be by-passed if required.

Cyanide, for gold dissolution, will be added to the circuit. The cyanide dosing point will be the cyanide leach feed box.

The operating pH of the cyanidation circuit will be maintained above 10.0 to maintain the protective alkalinity of the circuit and prevent the loss of cyanide to gaseous hydrogen cyanide. Protective alkalinity will be achieved by the addition of lime in the cyanidation circuit. To aid with gold dissolution, oxygen, in the form of aeration air, will be added to the circuit.

Following dissolution in the leach tanks the solubilised gold will be recovered by carbon adsorption. Activated carbon will be retained in each of the adsorption tanks, by an inter-tank screen. The inter-tank screen will be a stainless steel wedge wire cylinder equipped with an internal agitator and external rotating wiper blade mechanism to prevent screen blinding. As the slurry gravitates through the adsorption tanks, the carbon will be advanced counter currently to the slurry flow. This will be managed by balancing the carbon inventory in each adsorption tank, by conducting regular measurements of the carbon concentration. Carbon advancement will be achieved by the adsorption tank carbon transfer pumps, of which there is one transfer pump per adsorption tank. Periodically (four hours per day), loaded carbon from the first adsorption tank (or second if the first is offline) will be pumped by the loaded carbon recovery pump to the loaded carbon screen, where it will be washed with spray water to remove excess slurry. The excess slurry (screen underflow) will return by gravity to the adsorption tank of origin whilst the loaded carbon will gravitate to the acid wash column.

Regenerated carbon (or fresh carbon) will be hydraulically added to the adsorption circuit, from the carbon regeneration circuit. The regenerated carbon (or fresh carbon) will be pumped, to the adsorption circuit, via the carbon sizing screen. The sizing screen will remove excess water and carbon fines. The dewatered carbon will discharge into the last, online, adsorption tank with excess water and carbon fines gravitating to the carbon safety screen.

Slurry discharging the last adsorption tank will gravitate to a carbon safety screen via the carbon safety screen distribution box. The carbon safety screen will capture and recover any carbon exiting the leach circuit. The safety screen oversize will report to a fine carbon bin while the undersize will gravitate to the cyanide adsorption tailings tank from where it is pumped to the cyanide destruction circuit.

The cyanide leach circuit will be serviced by sump pumps which return spillage to the leach circuit.

9.2.10 Acid Wash, Elution, Electrowinning and Smelting

The carbon desorption circuit will consist of separate acid wash and elution columns. Following the acid wash, the carbon will undergo a cold cyanide wash in order to remove any complexed copper which has co-loaded onto the carbon due to the residual unleached copper from the atmospheric leaching stage. Following the cold cyanide wash stage, gold will be eluted from the carbon.

The cold acid wash sequence will be required to remove accumulated, calcified scale, from the carbon surface.

The acid wash column fill sequence will be initiated by pumping carbon from the first CIL tank into the acid wash column via the loaded carbon recovery screen. Carbon will gravitate from the loaded carbon recovery screen directly into the acid wash column. Once the acid wash column is filled to the required level, the carbon fill sequence will be stopped.

The acid wash cycle will utilise a 3% hydrochloric acid solution. This dilute acid will be prepared by the addition of filtered water and 32% hydrochloric acid, into the hydrochloric acid dilution tank. The acid wash sequence will involve the injection of the dilute acid solution into the column by the hydrochloric acid dosing pump, via the feed manifold located beneath the column. The pump will continuously run and allow the acid to circulate through the column, back to the hydrochloric acid dilution tank.

Upon completion of acid circulation, the acid rinse cycle will be initiated by pumping water through the column, to displace the spent acid solution to the tailings thickener. Acid waste and displaced solution from both the acid rinse and wash steps will pass through the acid wash discharge strainer before discharging to the cyanide destruction circuit feed box.

The cold cyanide wash sequence will be required to remove copper which has loaded onto the carbon, prior to the elution circuit, in order to minimise the amount of copper which will be co-plated with gold during electrowinning.

The cold cyanide wash cycle will utilise a NaOH and NaCN solution. The wash sequence will involve the injection of this solution into the column via the feed manifold located beneath the column.

Copper waste and displaced solution from the cold cyanide wash will report to the cold cyanide wash holding tank before being transferred periodically to the cyanide destruction circuit feed box.

The sequence will conclude with carbon being hydraulically transferred to the elution column. Water, for carbon transfer between the acid wash and elution columns, will be supplied from the transfer water tank via the eluate feed pump.

The elution sequence will commence with the injection of water into the column, via the transfer water tank, along with the simultaneous injection of cyanide and caustic solution. A set amount of cyanide and sodium hydroxide will be added to achieve a 2% solids w/w NaOH and 2% solids w/w NaCN solution.

Both reagent additions will be automatically stopped once the prescribed volume has been added. The pre-soak period will then commence. During this period, the caustic solution will be circulated through the column and be preheated. Upon completion of the presoak period, the elution sequence will commence and gold will be stripped from the carbon. Starter eluate, fromthe starter eluate tank will be pumped, by the eluate feed pump, through the recovery heat exchanger, picking up residual heat from the eluate exiting the elution column.

The pre-heated, incoming eluate, will then pass through the primary heat exchanger to elevate the eluate temperature to 120°C prior to entering the base of the column. Elution heater will provide the heat to the primary heat exchanger. A temperature probe will monitor the temperature of eluate exiting the column and will be used to control the heater output. Eluate will flow up and out of the top of the column, passing through the recovery heat exchanger via elution discharge filter. Initially, eluate emerging from the heat exchanger will bedirected to the pregnant eluate tank.

The elution sequence will progress for a period of time. Once the starter eluate storage volume is exhausted, new incoming eluate solution will be sourced from the transfer water tank. This eluate will also pass through the recovery and primary heat exchangers, to be heated to 120°C, prior to entering the base of the column. At this point the elution heater will be switched off, with the last of eluate utilised to cool down the elution column and its contents, to less than 100°C.

Upon completion of the cool down sequence, the carbon will be hydraulically transferred to the carbon regeneration kiln de-watering screen. The acid wash area and elution area will be serviced by the acid wash and elution area sump pumps respectively. Acid wash area spillage will be pumped to the tailings thickener. Elution area spillage will be pumped to the cyanidation circuit feed box.

9.2.11 Carbon Regeneration

After elution, the carbon will be hydraulically transferred from the elution column to the carbon regeneration circuit by pressurizing the column with transfer water. The carbon and transfer water will be directed to the carbon dewatering screen, allowing excess water to be removed prior to the carbon discharging into the kiln feed hopper. Dewatering screen undersize will gravitate to the carbon safety screen at the cyanide leaching circuit. Carbon will be withdrawn from the kiln feed hopper, via the kiln screw feeder, and discharged directly to the carbon regeneration kiln at approximately 800 kg/h. Within the diesel fired, horizontal rotary kiln, the carbon will be heated to 700°C, to remove volatile organic foulants from the carbon surface, thereby restoring the carbon activity.

Re-activated carbon exiting the kiln will discharge directly to the carbon quench tank, where it will be rapidly cooled. From the quench tank carbon will be pumped, by the regenerated carbon transfer pump to the carbon sizing screen located within the cyanidation circuit.

The carbon regeneration area will be serviced by dedicated sump pump. Any spillage generated within this area will be pumped to the carbon safety screen.

9.2.12 Electrowinning and Gold Room

Soluble gold and silver recovery, from the pregnant eluate, will be achieved by electrowinning onto woven, stainless steel wire mesh cathodes. The electrowinning circuit will consist of a number of electrowinning cells containing cathodes and anodes with each cell having a rectifier to supply the necessary current, to electroplate the gold and silver onto the cathode.

Once sufficient pregnant eluate is available, within the pregnant solution tank, the electrowinning sequence will be initiated by starting the pregnant solution pump. During the electrowinning cycle, the electrowinning cell discharge will be continuously returned to the pregnant solution tank.

Once the target barren solution grades have been achieved, the electrowinning cycle is complete, and barren eluate will discharge to the stripping water tank from where strip solution is returned to the elution columns.

Upon completion of electrowinning, gold sludge on the plated cathodes will be washed off the cathodes, with a high pressure cathode washer. The gold bearing sludge will be recovered to a sludge hopper, from where it will be filtered, via a vacuum pan filter.

The gold bearing filter cake will be dried in ovens. The dried filter cake will be mixed with a prescribed flux mixture (silica, nitre and borax), prior to being charged into the diesel fired furnace. The fluxes added react with base metal oxides to form a slag, whilst the gold and silver remains as a molten metal. The molten metal will be poured into moulds, to form doré ingots, which will be cleaned, assayed, stamped and stored in a secure vault ready for dispatch. The slag produced will periodically be returned to the grinding circuit, via the SAG mill.

The gold room and electrowinning area will be serviced by a gold trap and dedicated gold room area sump pump.

Any spillage within this area will be pumped back to the cyanidation circuit.

9.2.13 Cyanide Destruction

Cyanidation tailings are pumped to the first of two cyanide destruction tanks operating in series where cyanide destruction will be achieved utilising the Air/SO2 process. In the Air/SO_2 process, sodium metabisulphite, air, catalyst and milk of lime slurry will be added to complex the residual cyanide or oxidise the residual cyanide to cyanate. The destruction circuit will reduce the residual cyanide contained within the tailings stream. Total residence time for the two tanks is 120 minutes.

Slurry exiting the cyanide destruction circuit will be pumped to the tailings thickener.

The cyanide destruction circuit will be serviced by a dedicated sump pump. Any spillage within this area will be returned to the cyanide destruction feed box.

9.2.14 Tailings Thickening and Disposal

Slurry discharge from the cyanide destruction discharge hopper is pumped to the tailings thickener where flocculant is added to assist in the thickening process. Thickened underflow at 65% solids is pumped to the final tails hopper where it is combined with underflow from the raffinate neutralisation circuit and raffinate bleed from the CCD wash circuit, before being pumped to the TSF. Thickener overflow is directed to the plant process water tank.

9.3 General Reagents

Table 10: General reagents that will be used for mineral processing are presented below

Process	Section	Reagent
Flotation	Rougher flotation, Cleaner flotation	Potassium amyl xanthate (PAX)
	Rougher flotation, Cleaner flotation	Frother (MIBC)
Leaching	Acid Leaching	Sulphuric Acid (H_2SO_4)
	Solvent Extraction	Extractant (Lixiviant)
	Solvent Extraction	Diluent
	Solvent Extraction	Coagulant
	Electrowinning	Cobalt Sulphate ($CoSO_4$)
	Electrowinning	Guar
Cyanide leaching	Cyanidation, Elution	Sodium Cyanide (NaCN)
	Carbon Adsoprtion	Carbin
	Stripping	Sodium Hydroxide (NaOH)

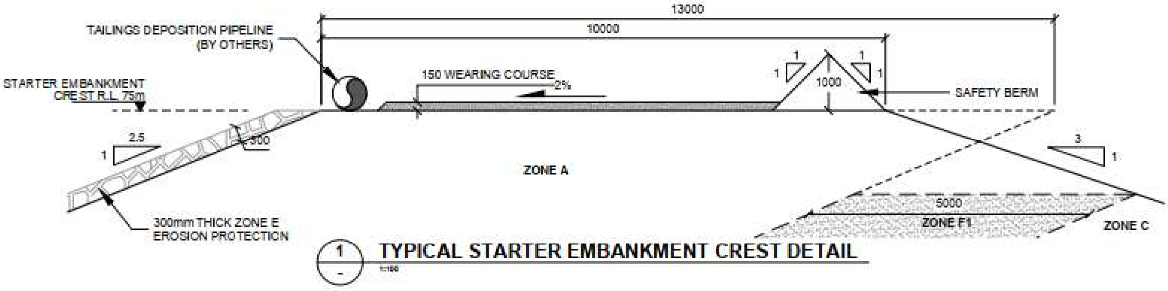
Process	Section	Reagent
	Cyanide Destruction	Sodium Metabisulphate (SMBS)
	Acid Wash	Hydrochloric Acid (HCl)
General	Raffinate Neutralisation	Limestone
	Raffinate Neutralisation, Cyanidation, Cyanide Destruction	Quicklime
	Thickening (Concentrate, Atmospheric Leaching Feed, CCD, PBC, Neutralisation, Tails, Limestone)	Flocculant

9.4 Tailings Management

9.4.1 Tailings Storage Facility

The TSF will be located within seven (7) barangays namely Lower Patag, Upper Patag, and San Pedro in the municipality of Sison; Upper Libas in the municipality of Tagana-an; and San Isidro, Sta. Cruz, and Anislagan in the municipality of Placer. The TSF will be built in four (4) stages with a potential expansion. The total footprint of this mine component is approximately 250 ha (impoundment and embankment) at its maximum embankment height.

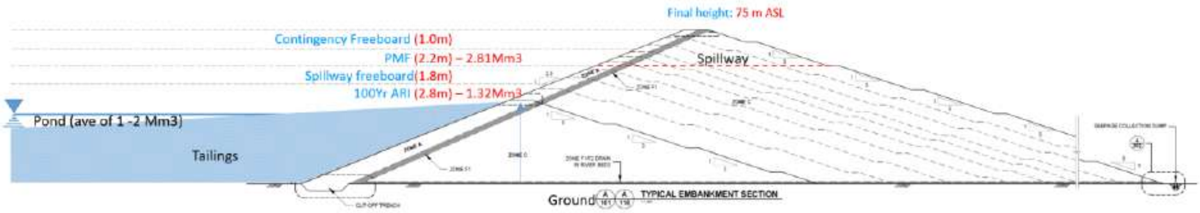
Figure 11: Typical Section of the Starter Embankment



9.4.2 Design Criteria

The TSF design standard follows, at the minimum, DENR Memorandum Order (DMO) 99-32 and the Australian National Committee on Large Dams (ANCOLD). Designs for embankment and internal geometry, mine waste scheduling, test works, and water balance studies are underway in relation to the development of the DFS.

Figure 12: Typical Section Showing Final Crests



9.5 Water Management

The Project, across its various development phases, will require water for construction, mining, ore processing, environmental management, potable and domestic water use, and others. It is therefore critical that water supply is ensured to sustain the Project.

The Project straddles at least three (3) watersheds (Section 2.2.1 “Hydrology and Hydrogeology”) that contain various surface, ground, and spring water resources. Communities within these watersheds depend on these resources for their potable, domestic, and irrigation needs. It is thus important that these essential water supplies be maintained, managed, or replaced to address the needs of the communities depending on these resources.

It is important that the needs of the community and the Project in terms of water resources be addressed and managed. The environmental impact assessment recognizes and partly addresses this concern with the identification of the potential impacts to water resources that may result from the implementation of the Project and the formulation of mitigation and control measures to address these impacts. The water resources issues and concerns, however, must be fundamentally addressed in the Project engineering designs and programs starting with a water management plan that considers protection, conservation, and recycling of water resources for all facilities of the mine.

This section contains discussions on water management strategies that will be implemented for the major mine facilities such as the Underground mine TSF and subsidence area. The water management strategies are formulated for the Project with the following objectives:

1. Comply with regulatory requirements in accordance with the Philippine Clean Water Act of 2004 (RA 9275) and its supporting Implementing Rules and Regulations (DAO 2005-10), current water usage and classification criteria as contained in DAO 2008-16, and the Water Code of the Philippines (PD 1067);

2. Minimize dirty/contaminated water generation;

3. Maximize diversion of clean water from the undergound mine mill, and mine waste storage areas (TSF and WRD);

4. Minimize sedimentation from the project site;

5. Protect, maintain, or replace water resources that may be impacted by the Project;

6. Ensure dependable water supply for the mine operation through conservation and recycling; and

7. Minimize acid mine drainage generation.

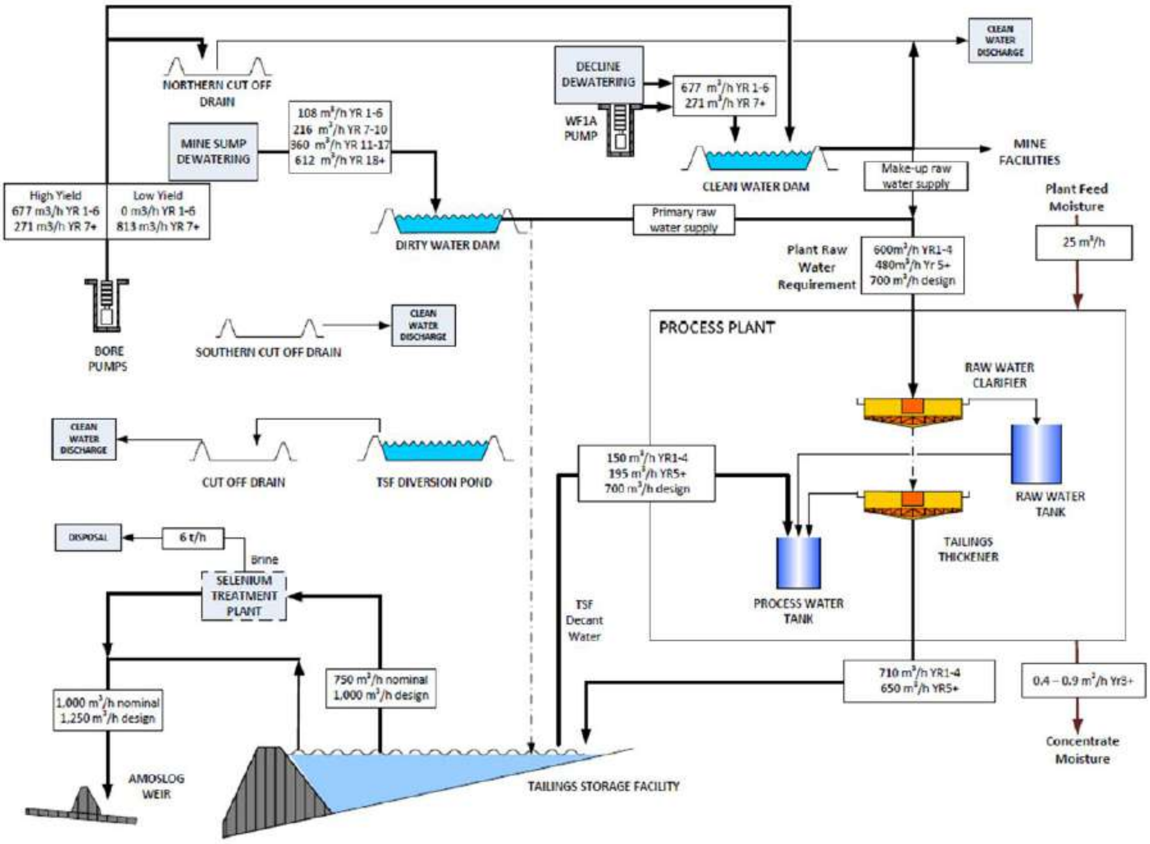
To realize the aforementioned objectives, specific water management measures for each major mine facility was formulated (Site Water Management).

The site water management for the Project operates on the principles of protection, conservation, and recycling. Site water management strategies specific to the main mine facilities such as the Underground Mine, TSF, and mill will be implemented and will coincide with various developmental stages of the mine facilities.

9.5.1 Mine Water Balance

The mine will primarily source water for its processing and mine facilities from the decline dewatering and existing well. During the construction phase when water is not yet required by the processing plant, water from the decline dewatering will be used to provide water supply for construction and mine facilities. Once the processing plant is constructed and commissioned, most of the water from the decline and bore pumps will be used as plant raw water requirement. Overflow (waste water) will go to the TSF. To maintain operation level, the TSF will release water through a treatment plant to remove deleterious substances and treat the water to the receiving water body’s standards (Class B). The treated water will be released through the Amoslog Weir. To replenish the water from for the mill, raw water supply from the dewatering will be supplemented by TSF decant water from the TSF pond.

In order to maintain normal operating levels for the TSF, clean run-off water coming from the Hinagasa-an Catchment will be intercepted by the TSF diversion pond and cut-off drains. Clean run-off will be discharged to the Hinagasa-an River to maintain baseline flow.



9.5.2 Underground Mine

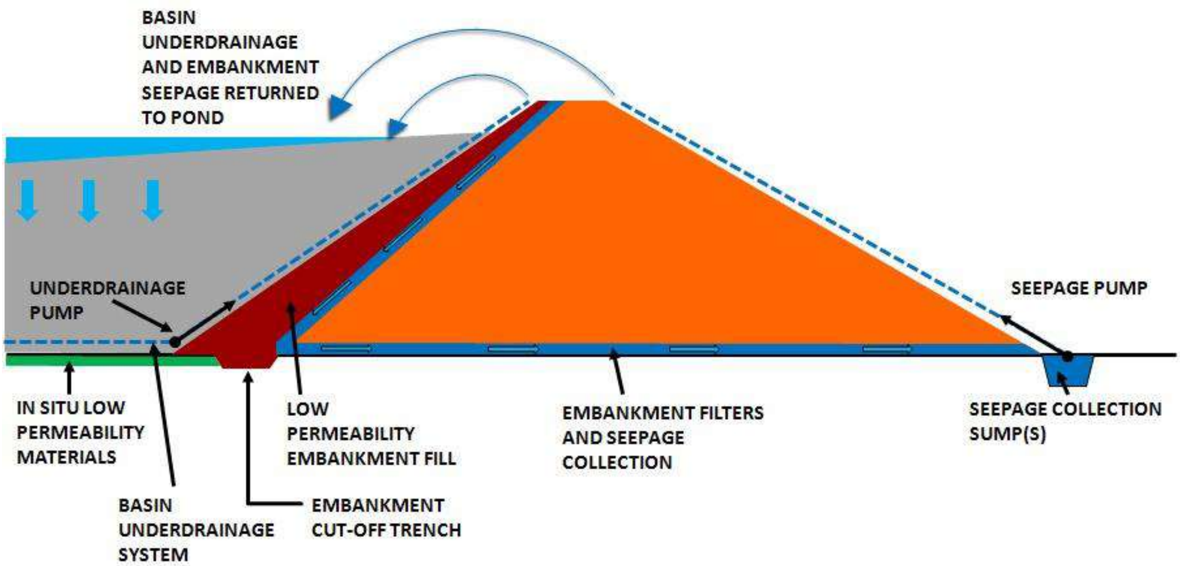
Mine dewatering pumps will be installed to remove water and allow progress of underground decline and sub-level caving. The water obtained from dewatering will service the processing plant primarily and the remainder will be temporarily contained in sedimentation ponds before release to Boyongan and Timamana creeks and treated for use in the process plant.

9.5.3 TSF

Surface water diversions will be constructed in the periphery of the TSF to control amount of run-off reporting to the TSF impoundment and maintain river base flows within the vicinity of the TSF. Controlled discharge during operations will be at Bad-as Amoslog Creek. During adverse weather conditions (>100 year Average Recurrence Interval), excess water will be discharged via a spillway reporting to Piakle Creek which ultimately discharges into Hinagasa-an River (Hinagasa-an Watershed). Embankment toe will be equipped with sedimentation ponds prior to discharge to Hinagasa-an River.

To provide seepage control for the TSF, the impoundment basin will be lined with low permeability fill. A low permeability fill zone will also be constructed on the upstream face of the embankment. A basin lining such as HDPE or similar material will be considered if tailings geochemistry and seepage analysis identify a major environmental risk. Seepage collection sumps will be constructed downstream of the TSF. Underdrainage system will be piped along embankment upstream toe and in valley spines.

Figure 13: Water Mangement for TSF



9.5.4 Mill

The mill will source process water from surface run-off, mine dewatering, and decant water from the TSF. The water will be temporarily impounded in a water storage dam before treatment according to the mill’s process water quality requirements.

10.0 Description of the Pollution Control Devices and Non-Mine Waste Management System

The Project will generate three waste streams: the waste rock generated from the underground mine, the tailings from mineral processing, and the non-mine wastes from various support activities. The tailings generated from ore processing will be stored in the TSF. Process water will be treated prior to release or reuse. Biodegradable waste will be subject to ecological composting. Material recovery facilities will be set up to retrieve recyclable waste that can be reused or sold. Hazardous waste such as batteries, used oil, used chemicals or lead-containing items will be collected and disposed by a third-party contractor.

A Waste Management Plan will be developed to address collection, handling, transport, treatment and disposal of generated wastes. The plan will consider relevant statutory requirements such as the Solid Waste Management Act (R.A. No. 9003), Toxic Substances and Hazardous Wastes Act (R.A. No. 6969), Philippine Clean Air Act of 1999 (R.A. No. 8749) and the Philippine Clean Water Act of 2004 (R.A. No. 9275), among others, to ensure the health and safety of employees and communities and the protection of the environment. Table 11 lists proposed strategies to manage non-mine waste material.

Table 11: Pollution Control Devices and Non Mine Waste Management System

Non-Mine Waste Material	Source and Estimate Amount	Class		Proposed Management Strategies
		Non-Hazardous	Hazardous	
General recyclables (e.g. paper, cardboard, plastic, glass)	Mine office, mine area, accommodation units, administration units, administration buildings, recreational facilities, medical center, religious center, warehouse, maintenance workshop, security/safety quarters, mess hall/kitchen, laundry area. Approximately 1 t per year.	✓		• Collection and segregation of recyclable waste on-site prior to transportation by a waste contractor for off-site recycling where possible • Consider disposal in on-site landfill
General office wastes (e.g. toner cartridges, electronic wastes, batteries)	Mine office, administration buildings, maintenance workshop. Approximately 2 drums per year	✓	✓	• Toner cartridges to be placed in boxes and returned to suppliers when possible • Electronic wastes to be collected by waste contractor
Food wastes	Mine area, offices and accommodation units, 1.5 t	✓		• Composting at the waste management facility will be considered for organic food waste • Other food wastes unsuitable for composting will be disposed of in an on-site landfill

Non-Mine Waste Material	Source and Estimate Amount	Class		Proposed Management Strategies
		Non-Hazardous	Hazardous	
Green wastes	Clearing of vegetation during construction and operation	✓		• Harvest and use of commercial timber, when possible • Re-use on-site for rehabilitation, landscaping, and erosion control, when possible
Timber / wooden pallets	Excess from construction in the mine area, mill and support facilities	✓		• Minimize waste by procuring only the required amount • Excess waste will be shipped and re-used on-site as compost for landscaping and erosion control, when practical • Remaining quantity will be used as construction materials or shed for plant nursery, drill areas, etc.
Scrap metals (e.g. steel, metal off-cuts)	Excess from construction in the mine area, mill and support facilities	✓		• Minimize waste by procuring only the amount required • Collection and segregation on-site prior to off-site recycling by a waste contractor
Concrete	Excess from construction in the mine area, mill and support facilities	✓		• Re-used for minor construction and maintenance works
Hydrocarbon contaminated materials (e.g. soil, oily rags)	Access roads, mine and mill areas, maintenance workshops, motorpool and other support facilities, approximately 2 drums per year		✓	• Contaminated soils will be treated and then re-used as fill • Excess treated soils will be stockpiled for rehabilitation and revegetation • Soils which cannot be used will be disposed in an on-site landfill • Other materials will be treated prior to landfill disposal

Non-Mine Waste Material	Source and Estimate Amount	Class		Proposed Management Strategies
		Non-Hazardous	Hazardous	
Waste oil containers	Maintenance workshops, motorpool and power supply, approximately 2 drums per year	✓		• Primarily to be treated prior to recycle and or re-use • Non-recyclable / re-usable drums to be collected by waste contractor
Air and oil filters	Maintenance workshops, motorpool and power supply	✓		• To be collected by waste contractor
Waste oils and oily water	Maintenance workshops, motorpool and power supply		✓	• To be collected by waste contractor
Miscellaneous chemicals (e.g. lubricants, coolants)	Machinery maintenance workshops, motorpool and power supply		✓	• To be collected by waste contractor
Heavy vehicle tires	From heavy mining and earthmoving equipment collected at workshops, motorpool and other support facilities	✓		• Disposed in on-site landfill or off-site
Vehicle batteries	From heavy mining and earthmoving equipment collected at workshops, motorpool and other support facilities		✓	• Used batteries to be collected by a waste contractor
Medical waste, solvents, refractory	Medical		✓	• Medical waste to be disposed will meet Philippine standards • Waste solvents to be appropriately treated prior to recycle or re-use • Non-recyclable/ re-usable solvents to be treated prior to landfill disposal • Refractory waste to be primarily treated prior to landfill disposal
Domestic sewage treatment plant waste and residues (e.g. sewage)	Administration and accommodation buildings	✓		• Domestic sewage treatment plant waste and residues to be disposed of in a delegated landfill

Non-Mine Waste Material	Source and Estimate Amount	Class		Proposed Management Strategies
		Non-Hazardous	Hazardous	
Process wastes (e.g. pellet bags, pump liners, baghouse filters, steel liners)	Mill, TSF water treatment plant	✓	✓	• Pellet bags to be primarily recycled / re-used • Waste deemed unusable will be disposed in an on-site landfill or off-site • Pump liners to be recycled, when possible • Baghouse filters to be disposed in on-site landfill • Steel liners utilized in mill to be recycled / reused
Chemical wastes	Assay laboratory	✓	✓	• Stored on-site prior to transportation by a waste contractor for off-site treatment and disposal
Soil and Debris	Earthmoving activities during construction	✓		• Stockpile and conserve topsoil for possible landscaping, maintenance of all-weather dirt roads or other purposes
General recyclables (e.g. paper, cardboard, plastic, glass)	Site office, administration, accommodations (if applicable)	✓		• Collection and segregation of recyclable waste on-site prior to transportation by a waste contractor for off-site recycling where possible. Otherwise disposal will be on an on-site landfill
General office wastes (e.g. toner cartridges, electronic wastes, batteries)	Site office	✓	✓	• Toner cartridges placed in boxes and returned to suppliers where possible • Electronic wastes to be recycled by waste contractor
Food wastes	Offices and administration	✓		• Composting will be considered for organic food waste
Green wastes	Clearing of vegetation during construction and operations, if applicable	✓		• Reuse on-site for landscaping where possible

Non-Mine Waste Material	Source and Estimate Amount	Class		Proposed Management Strategies
		Non-Hazardous	Hazardous	
Timber/ wooden pallets	Excess from construction	✓		• Minimize waste by procuring only the amount required
Scrap metals (Steel/ metal off cuts)	Excess from construction	✓		• Minimize waste by procuring only the amount required. • Collection and segregation on-site prior to off-site recycling by a waste contractor
Concrete	Excess materials from construction	✓		• Re-used for minor construction and maintenance works
Hydrocarbon contaminated materials (e.g. soil, oily rags)	Motorpool, parking space		✓	• For offsite disposal by an accredited third party waste hauler
Waste oil containers	Motorpool	✓		• Primarily to be treated prior to recycle and or reuse • Nonrecyclable/reusable drums to be to be collected by waste contractor
Waste oils and oily water	Motorpool		✓	• To be collected by waste contractor
Vehicle batteries	From earthmoving and other company vehicles, motorpool		✓	• Batteries to be collected by a waste contractor
Medical waste, solvents, refractory	Medical clinic. Approximately 1 drum per year.	✓	✓	• Medical waste to be disposed of to meet Philippine standards • Waste solvents to be appropriately treated prior to recycle or reuse • Nonrecyclable/reusable solvents to be treated prior to landfill disposal • Refractory waste to be primarily treated prior to landfill disposal

Non-Mine Waste Material	Source and Estimate Amount	Class		Proposed Management Strategies
		Non-Hazardous	Hazardous	
Domestic sewage treatment plant waste and residues (e.g., sewage)	Administration and Site Office, Accommodation if applicable	✓	✓	• There will be no onsite treatment, Storage will be in the form of septic tanks

11.0 Description of the Operations and Maintenance of the Mine Components

The mine will run 24/7 during its operation phase. Employees and contractors will work in three (3) shifts spanning eight (8) hours each. Development and activities for all mine facilities will occur simultaneously. The mill will run 24/7 as well to produce a maximum throughput of 4.5 Mtpa.

In order to ensure all facilities are operating to their optimum, facilities check-ups and inspections will be conducted on a daily basis to prevent or minimize malfunction and occurrence of incidence. A comprehensive health and safety plan will be implemented which includes operational manuals and guidelines for all mine facilities. Preventive maintenance program will be strictly implemented for the mill complex to prevent occurrence of unwanted outages. In case of repairs, the number of no operation days will depend on the magnitude of repairs required. Repairs will be scheduled and carefully planned to avoid delays in operations.

The TSF will undergo regular monitoring in terms of stability, drainage, and water quality among others. Monitoring piezometers and accelerometers will be installed strategically throughout the facility to monitor for deformation, movement, leaks, seepage and other abnormal occurrences to prevent incidents, breach, or loss of containment. An alarm and emergency response system will be put in place as part of the Emergency Response Plan to serve as the warning devices in the unlikely occurrence of TSF incidents.

12.0 Project Size

12.1 Mineable Reserve and Mine Life

The proposed mine has an estimated mineable reserve of approximately 80 Mt that will be extracted over a mine life of 21 years.

12.2 Total Project Area

The total area applied for the previous ECC was approximately 2,323.92 ha. This was already approved. For this amendment we intend to retain the total area although the active mine area and surface facilities will occupy a smaller footprint of 532 ha.

13.0 Development Plan, Description of Project Phases and Corresponding Time Frames

13.1 Project Phases

The Project will have five (5) major phases, namely: Exploration, Pre-Construction, Construction/Development, Production, and Closure. Estimated mine life is pegged at 23 years, starting from construction. Table 12 briefly discusses the planned activities to be carried out in teach phase.

Table 12: Project Phases Details

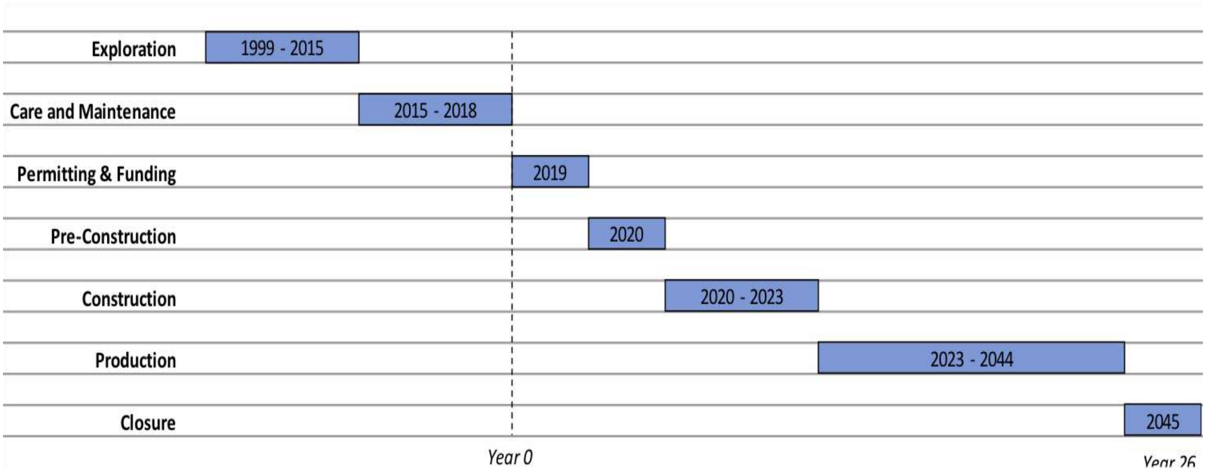
Project Phase	Description
Exploration	Exploration activities are now limited to hydrogeologic and geotechnical investigations to supplement information needed for the underground mine's structural controls and mine development. No exploration activities to define neighbouring resource are being conducted.
Pre-Construction	Pre-construction activities include required consultations and permitting to amend the ECC and secure/renew local permits. The pre-construction phase will also include the conduct of the detailed feasibility study and detailed engineering design for the mine components. Pre-construction activities will also involve land banking as necessary.
Construction and Mine Development	Construction and mine development activities will take approximately 3 years and include ground preparation and earthworks (clearing and overburden removal), civil works, decline and SLC development, construction of starter dam and TSF development, construction of diversion drains, and environmental monitoring
Production	Production will commence after 3 years of construction and will involve progress of the sub-level mine, ore processing, mine and non-mine waste management, progressive rehabilitation, and environmental monitoring.

Project Phase	Description
Mine Closure	As the mine reaches the end of its Production Phase, decommissioning activities will commence to prepare the footprint for Project closure. Rehabilitation, decommissioning and abandonment works on mine-affected areas will be performed in accordance to the Final Mine Rehabilitation and Decommissioning Program (FMRDP). There are also provisions in the FMRDP that detail conditions for premature mine closure, such as obsolescence, bankruptcy or forced closure. Either way, the guiding principles for all closure activities are to revert the conditions of the environment to its pre-development characteristics (at the minimum), prepare the footprint area for post-mining land use, and eliminate long-term environmental impacts that can be caused by abandoned mine facilities.

13.2 Project Development Schedule

An indicative schedule for the development of the Project is shown in Figure 14.

Figure 14: Project Timeline



13.3 Manpower

The manpower requirements for the Project will vary for each development phase. The numbers indicated in the succeeding sections are only indicative and will be updated and finalized as the Project nears implementation. SMMCI is an equal opportunity employer and does not discriminate on the basis of ethnicity, gender, or age. SMMCI commits to a “locals first” hiring policy and the implementation of an employment protocol.

13.3.1 Construction

SMMCI will employ approximately 1,800 personnel during the construction phase (Table 13) These personnel will be engaged in the planning and construction of the mine’s major components and other related infrastructure. The number of the personnel may vary during actual construction commencement and does not include contractors, suppliers or other service providers that may provide supplies or services for the Project as well as other livelihood engagements that cater to workers.

Table 13: Development Manpower

Business Unit	Head Count
Resident Manager Group	
Safety and Health	27
Security	32
Environment	8
Community Relations	6
Human Resources	15
Audit and Finance	6
Information Technology	2
Material Management	39
Tailing Pond	54
Geology and Exploration	18
Office of the RM	8
Maintenance Services Group	26
Mine Division	956
Mill Division	266
Legal Department	37
Contractors and suppliers	300
Total	**1,800**

13.3.2 Operation

Manpower requirement during the operation phase will be approximately 1,630 personnel composed of people engaged in management, technical, administrative, direct mining and processing, and maintenance roles (Table 14). Additional manpower requirements may be outsourced such as housekeeping services.

Local hiring policy will be observed in the recruitment of personnel and staffs for the mine site. Should there be unavailability of special and required skills within nearby municipalities and cities, SMMCI will then extend its employment engagement nationwide

Table 14: Operating Manpower

Business Unit	Head Count
Senior Management Team	5
Corporate Office	33
Support Services	3
Site Services:	
Security	127
Human Resources	17
General Services	45
IT	8

Business Unit	Head Count
Materials Management	25
Finance	10
Mining Division:	
Health and Safety and Training	30
Maintenance	25
Field Servicing	48
Light Vehicles	24
Workshop	115
Refueling	8
Tyre Bay	24
Wash Bay	8
Hydraulic Bay	8
Auto Electrican	24
Underground	19
Technical Services	72
Mining	26
Load and Haulage	172
Pioneering	52
Support	16
Road and Maintenance	11
Drill and Blast	70
Dewatering	27
Government & External Affairs & Environment:	
Environment	33
Landbanking	40
Community Relations	42
Process Division:	
Process	463
Total	**1,630**

Note that this number is indicative only and does not reflect contractors or suppliers that will work directly or indirectly for the Project.

13.4 Estimated Development Cost

The estimated cost of investment to bring the mine to full production, commencing from the date of the Final Investment Decision is PHP 38,000,000,000.

DRAFT

Environmental Impact Statement

Section 2.1 The Land

2.1.1 Land Use

DRAFT

Table of Contents

2.0 Analysis of Key Environmental Impacts 2.1-1

2.1 The Land 2.1-1

2.1.1 Land Use and Classification 2.1-1

2.1.1.1 Methodology 2.1-1

2.1.1.2 Baseline Environment 2.1-2

2.1.1.2.1 Land Classification 2.1-3

2.1.1.2.2 Land Use 2.1-5

2.1.1.2.3 Environmentally Critical Areas 2.1-7

2.1.1.3 Land Tenure 2.1-12

2.1.1.4 Visually significant landforms/landscape/structures 2.1-14

2.1.1.5 Existing solid waste management and related land management scheme in the area 2.1-15

2.1.1.6 Potential Impacts and Options for Prevention or Mitigation or Enhancement 2.1-15

List of Tables

Table 2.1-1 Key Findings and Conclusions - Land Use and Classification Assessment 2.1-2

Table 2.1-2 Land use distribution within the province 2.1-5

Table 2.1-3 Land use distribution within the project site 2.1-5

Table 2.1-4 Types of ECAs within the vicinity of the project site 2.1-8

Table 2.1-5 Potential Impacts and Options for Prevention or Mitigation or Enhancement – Land Use and Classification 2.1-15

List of Figures

Figure 2.1-1 Land classification map

Figure 2.1-2 Regional land use map

Figure 2.1-3 Environmentally Critical Areas in the vicinity of the project

Figure 2.1-4 Land tenure map

List of Plates

Plate 2.1-1 Perspective facing south of the Open Pit – View of the Mt. Maniayao

Plate 2.1-2 Perspective facing west of the Open Pit – View of the Radio Towers

Plate 2.1-3 Perspective facing north of the Open Pit – View of the Location of the TSF and Surigao Strait

2.0 Analysis of Key Environmental Impacts

2.1 The Land

This section describes baseline conditions of the project site in terms of land use and classification, geology, geomorphology and geohazards, pedology, and terrestrial ecology (vegetation and wildlife). The key impacts of the project's activities during pre-construction, construction, operations, and closure/decommissioning stage on these environmental aspects and their corresponding options for prevention, mitigation or enhancement are discussed in this section.

2.1.1 Land Use and Classification

This section describes the existing land classification and land uses within the project site, the potential impacts of the project, and the corresponding mitigating or control measures. Present land tenure and issues within the project site are also discussed. Environmentally Critical Areas within and surrounding the project are identified and located.

Philippine legislations pertaining to land use, land registration and protected areas, among other things, include the Public Land Act, Comprehensive Agrarian Reform Law, Local Government Code, Agricultural and Fisheries Modernization Act, the Indigenous Peoples Rights Act of 1997, the Philippine Mining Act of 1995 and the Mining Act and Executive Order No. 79. Certain specific exclusions also exist as a matter of national interest, such as those under the Philippine Constitution (1987) or as local interest under the Philippine Local Government Code (1991), together with other associated laws. These laws collectively mandate that the nature of a project proposed to be located in a particular area should be consistent with the official land classification of the said area.

According to the Public Land Act, lands of the public domain are classified into three (3) main classifications: (1) Forestland or Timber, (2) Mineral Lands and (3) Alienable and Disposable. Forestland is land subjected to the present land classification and is deemed needed for forest use and is therefore not to be alienated. Mineral lands are lands in which minerals exists in abundance and there is enough justification to extract and utilize. Alienable and Disposable lands are lands that are open to public disposition. They can be further classified according to the intended use or purpose such as agricultural, commercial/industrial, institutional or reservations.

In the year 1939, President Manuel L. Quezon declared the entire Surigao del Norte province as a Mineral Reservation Area under the Presidential Proclamation No. 391. To date, the current redefined mining reserve now covers 20,000 ha of the Mainland province and 5,063 ha in Dinagat Islands (2008, 2003 Legacy Mines Visit of ESSC).

Since the project will impact and change the current land use, it is important to determine and understand the existing land use and determine the legal classifications of the land by the local and national government.

2.1.1.1 Methodology

The evaluation of Land use for the project involved a review of published literature, reports, special studies and surveys, and maps from various sources primarily the Provincial Development and Physical Framework Plan (PDPFP) and the Comprehensive Land Use Plan (CLUP) for the municipalities of Placer, Sison, Tubod and Taganaan where all mine facilities are centrally located. The presented information on land use was mostly based on secondary sources.

Information from walkthrough confirmation surveys specific to the project site was included in the evaluation of observed actual land use for comparison with the legally designated land use.

These information and maps were digitized, encoded and georeferenced using Geographic Information Systems (GIS) with ArcGIS as software. Satellite data from the United States Geological Survey (USGS) was downloaded and incorporated to produce and update the land cover map. Slope maps were generated from the NAMRIA and Mines and Geosciences Bureau (MGB) hazard maps to determine the coverage of existing features within the project site.

Additional information was obtained from the National Mapping Resources Information Agency (NAMRIA) maps for base referencing of key areas within the project site. Presence and proximity to ancestral domains, records of ancestral domains, Environmentally Critical Areas (ECA), and those covered by the National Government's Comprehensive Agrarian Reform Program (CARP) for land redistribution in the area were also examined and included in the assessment. Various thematic maps were developed with the combination of these sources of information for visual appreciation.

2.1.1.2 Baseline Environment

Table 2.1-1 presents the summary of key findings and conclusions for the land use and classification assessment.

Table 0-1 Key Findings and Conclusions - Land Use and Classification Assessment

<table>
<tr><th>Baseline Information *</th><th>Key Findings and Conclusions</th></tr>
<tr><td>Land classification</td><td>The previously approved ECC covers a total area of 2,323.92 ha. The entirety of this area is classified as alienable and disposable land. Out of this 2,323.92 ha, only 532 hectares will be directly disturbed by mining and associated mine facilities (subsidence zone, underground mine, TSF, mill, access and haul roads, and support facilities).</td></tr>
<tr><td>Land use</td><td>Most of the actual land use within the project site is utilized for regular viable agricultural activities. Based on field observation, this land is mostly represented by extensive coconut farming. Minimal rice farming activities also exist in the project site which is typically for subsistence.
<table>
<tr><th>Land Use</th><th>Area (ha)</th><th>Percent</th></tr>
<tr><td>Production within Forestland</td><td>414.85</td><td>17.85</td></tr>
<tr><td>Production within A&D</td><td>1865.30</td><td>80.27</td></tr>
<tr><td>NPAA</td><td>43.77</td><td>1.88</td></tr>
<tr><td>TOTAL</td><td>2,323.92</td><td>100</td></tr>
</table></td></tr>
<tr><td>ECA</td><td>There are ten types of ECAs within the vicinity or proximal to the project site: protected areas, tourist spots, wildlife habitat, prime agricultural areas, archaeological areas, ancestral lands, geohazard areas, areas with critical slope, recharge areas of aquifers, and water bodies for domestic and wildlife/fishery support.</td></tr>
</table>

Baseline Information *	Key Findings and Conclusions
CARP Areas/ Prime Agricultural Areas	• There are no Comprehensive Agrarian Reform Program (CARP) areas in the project site. Although there is the presence of an area within the project that is categorized under the National Protected Areas for Agriculture (NPAA).
Ancestral Land	• There are no Certificate of Ancestral Domain Title (CADT) and Certificate of Land Title (CALT) located within the project site.
Mine Agreements	• Project site is located within a Mine Production Sharing Agreement (MPSA) and an Exploration Permits (EP) where Proponent is the main holder. It also crossed over to an EP and Application for Production Sharing Agreement (APSA) of Manila Mining Corporation.
CBFMA and IFMA	• There are no Community Based Forest Management Agreements (CBFMA) and Integrated Forest Management Agreements (IFMA) in the project site.

2.1.1.2.1 Land Classification

With a total land area of 201,710 ha, almost half (47.57%) of the province of Surigao del Norte is legally classified as Alienable and Disposable (A&D) with the remaining 52.42% classified as Timberland (2012, Provincial Development Physical Framework Plan of Surigao Del Norte). Figure 2.1 1 presents the land classification map of the province of Surigao del Norte including the project.

The project site is located in four host municipalities Placer, Sison, Tubod and Taganaan. With a total of 2,323.92 ha (mine footprint), the project site is covered by one land classification and ownership classes -- Alienable and disposable land.

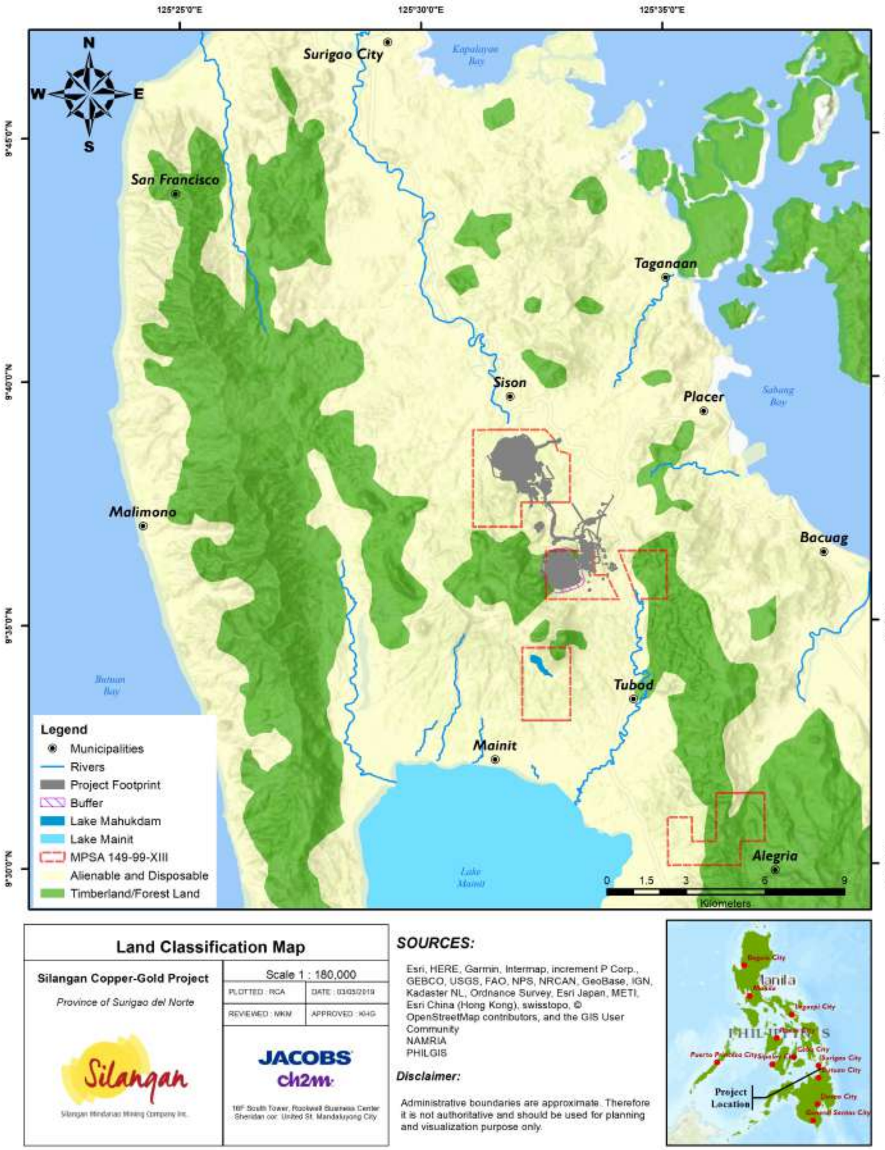


Figure 0-1 Land Classification Map

2.1.1.2.2 Land Use

Almost 97,640ha (48.41%) of the total land area of the province is used for agriculture. These areas are mostly devoted to coconut farming with a total coverage area of 70,556 ha. The other 47,602 ha or 23.6% of the total land area is used as forestland. These areas are classified as open, closed and production forests. Shifting agriculture, social forestry and agri- forestry also exist in the forest lands. The remaining 28.23% of land is allotted for mining, tourism, military reservations and other land use such as brushland, shrub land, grass land and open areas. Settlement areas in the host communities tend to be linear along barangay roads. The land use and distribution within the province is presented in **Table 2.1 2**.

Table 0-2 Land Use Distribution within the Province

Land Use	Area (ha)	Percent (%)
Built-up area	11,123	5.51
Agricultural Area	97,640	48.41
Irrigated areas	*8,601*	*8.81*
Rainfed	*6,500*	*6.66*
Coconut	*70,556*	*72.26*
Other Crops	*11,983*	*12.27*
Fish Pond	1,341	0.66
Forest Land	47,602	23.6
Production Forest- Tenured	*17,427*	*36.61*
Other Forest Areas	*30,175*	*63.39*
Mining/ Industrial	8,235	4.08
Tourism	765	0.38
Military Reservation	41	0.02
Mangroves	14162	7.02
Brush Land	8531	4.23
Grass Land	5,384	2.67
Shrub Land	6,530	3.24
Barren Areas	356	0.18
Total	**201,710**	**100**

The Physical Framework Plan of Surigao del Norte collectively categorizes all areas involving all kinds of agricultural activities, production in forest areas, mining operations, and tourism areas into the term Production Land. This is further subcategorized into (a) Production within Forestland and (b) Production within Alienable and Disposable (A&D).

Majority of the actual land use within the project site is utilized for regular viable agricultural activities. Based on field observation, lands within the project site are utilized for extensive coconut farming. Minimal rice farming activities also occur within the project site, most of which are regarded as subsidence farming. A portion of the Project falls into area that is classified as part of the Network of Protected Areas for Agriculture (NPAA). As per Administrative Order No. 363, these are areas previously identified by the Department of Agriculture (DA) and National Irrigation Authority (NIA) as irrigable lands that support the economic viability of the existing agricultural infrastructure and are therefore protected from and are non-negotiable for conversion without approval from the President and upon favourable recommendation by Cabinet Cluster on Agro-Industrial Development. The land use and distribution of the project site is presented in **Table 2.1 3** and **Figure 2.1 2**.

Table 0-3 Land Use Distribution within the Project Site

Land Use	Area (ha)	Percent (%)
Production within Forestland	414.85	17.85
Production within A&D	1865.3	80.27
NPAA	43.77	1.88
TOTAL	***2,323.92***	***100***

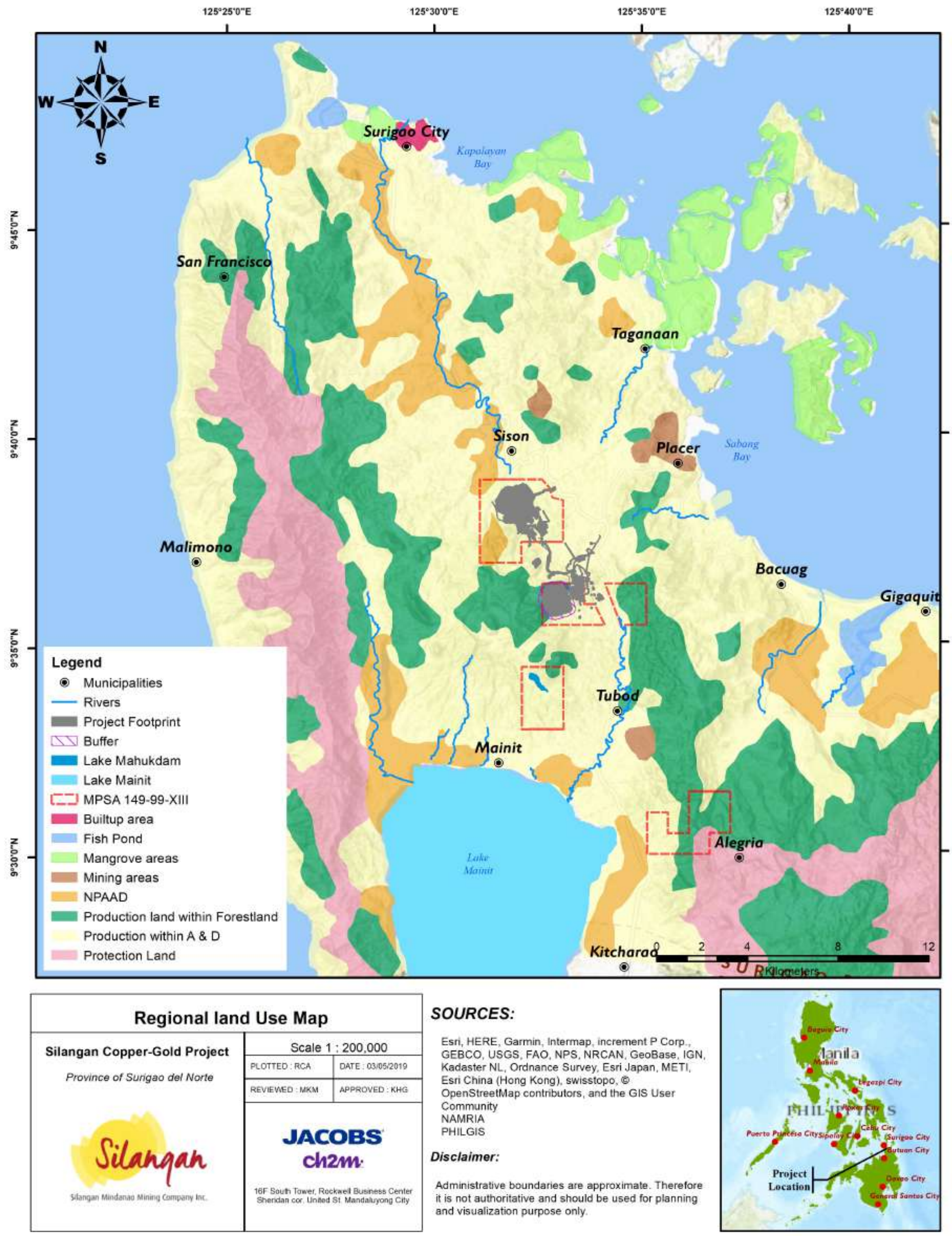


Figure 0-2 Regional Land Use Map

2.1.1.2.3 Environmentally Critical Areas

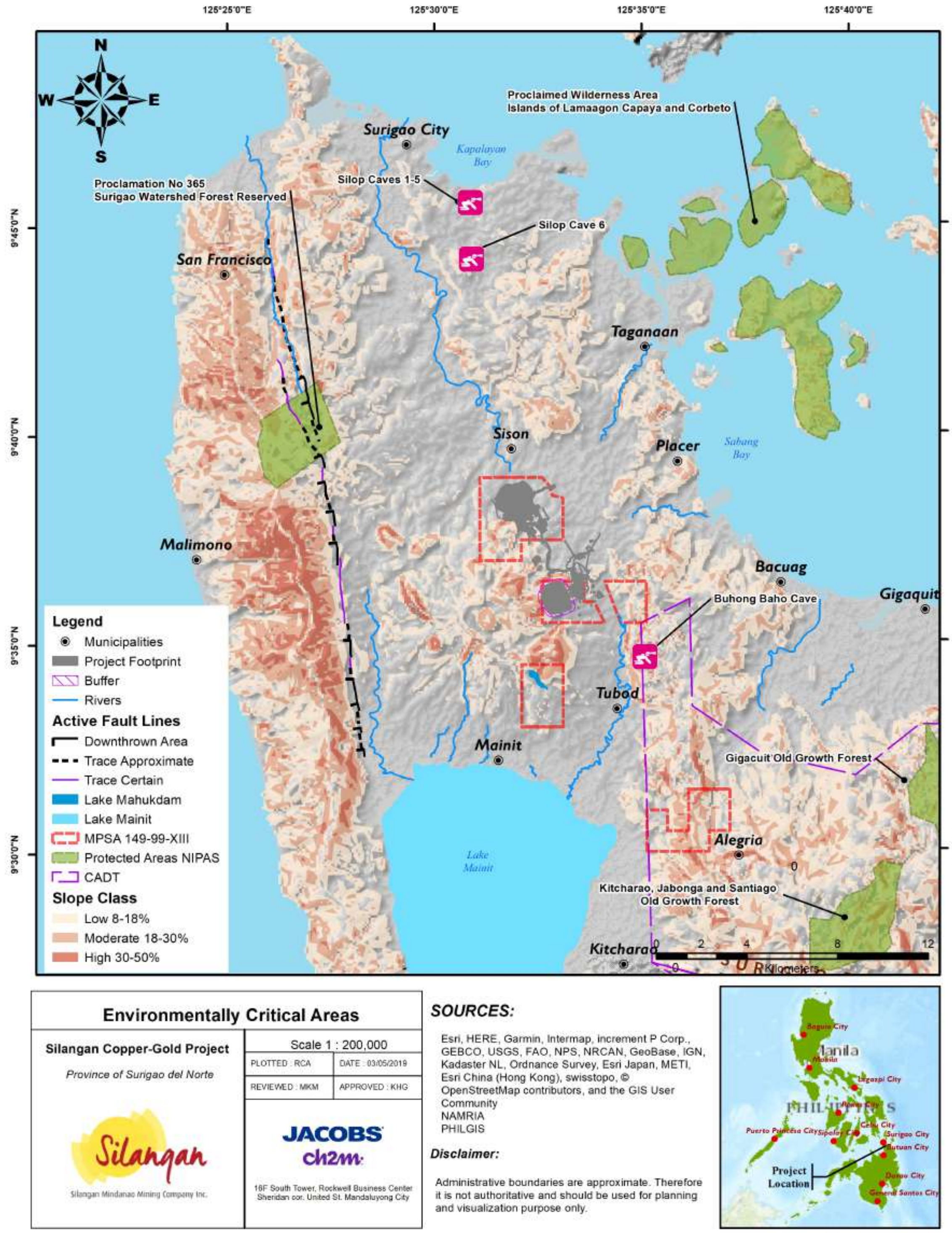
The project site is proximate to areas declared as Environmentally Critical Areas (ECA) based on the Department of Environment and Natural Resources (DENR)-Department Administrative Order (DAO) 2003-30 Revised Procedural Manual of 2007 project site classification. An ECA is an environmentally sensitive area declared through Proclamation 2146 of 1981 where significant environmental impacts are expected if certain types/thresholds of proposed projects are located, developed, or implemented in it. The ECAs and their respective locations with respect to the project site are summarized in **Table**.

Table 0-4 Types of ECAs Within the Vicinity of the Project Site

ECA Category	Technical Description of ECA Category based on DAO 2003-30	Presence within the Project Site	Description
Areas declared by law as national parks, watershed reserves, wildlife preserves, sanctuaries	The laws referred to by this provision are *Presidential Decree No. 705*, as amended, otherwise called as the *Revised Forestry Code*, *Republic Act 7586* or the *National Integrated Protected Areas System (NIPAS) Act*, and other issuances including other proclamations, executive orders, local ordinances, and international commitments and declarations.	Not present within the project site	Surigao Watershed Forest Reserve under Proclamation 635 (approx. 7 km) Gigaquit and Claver Old Growth Forest in the municipalities of Gigaquit nad Claver (approx. 16 km) Old Growth Forest of Kitcharao, Jabonga and Santiago (approx. 17 km) Mt. Maniayao Protected Area as per local ordinance of Tubod. (approximately 31 meters away from project site buffer zone
Coral reefs	Characterized by one or any combination of the following conditions: • With 50% and above live coralline cover; • Spawning nursery grounds for fish; and • Act as natural breakwater of coastlines.	Not present	Not applicable
Mangrove areas	Mangrove areas shall be characterized by one or any combination of the following conditions: • With primary pristine and dense young growth; • Adjoining mouth of major river systems; • Near or adjacent to traditional productive fry or fishing grounds; • Areas that act as natural buffers against shore erosion, strong winds and storm floods; and • Areas on which people are dependent for their livelihood, pursuant to and taking into consideration *Republic Act 7161*, which prohibits the cutting of mangrove species.	Not present	Not applicable

ECA Category	Technical Description of ECA Category based on DAO 2003-30	Presence within the Project Site	Description
Areas which constitute the habitat of any endangered or threatened species of Philippine wildlife (flora and fauna)	This refers to areas considered as wilderness areas and areas identified by the Protected Areas and Wildlife Bureau (PAWB) to be natural habitats of endangered or threatened, rare, and indeterminate species of flora and fauna.	Not Present within the Project Site	Presence of threatened species within the project site. (Refer to Terrestrial Ecology section. Proclaimed Wilderness Areas Islands of Lamagon, Cepaya and Corbeto (approx 7 km)
Areas classified as prime agricultural lands	Prime agricultural lands shall refer to lands that can be used for various or specific agricultural activities and can provide optimum sustainable yield with a minimum of inputs and development costs as determined by the Department of Agriculture	Not Present within the Project Site	Network of Protected Areas on Agriculture and Agri-Industrial Development (NPAAAD in Barangay Lower Patag, Sison that will be covered by TSF.
Areas of unique historic, archaeological, or scientific interest	This refers to areas that are more than 100 years old and declared by the National Historical Institute, National Museum, or National Commission for Culture and the Arts, through national or local laws or ordinances as areas of cultural, historical, and scientific significance to the nation, (e.g., declared national historical landmarks, geological monuments, and paleontological and anthropological reservations)	Not Present within the Project Site	Nearest recorded archeological site is located in the municipality of Placer. Panhuntungan and Amoslog archeological excavations (approx. 3-5 km)
Areas which are traditionally occupied by cultural communities or tribes	This refers to all ancestral lands of the National Cultural Communities in Section 1 of *PD No. 410* and settlements designed, implemented, and maintained by the PANAMIN for national minorities (non-Muslim hill tribes referred to in PD No. 719) as may be amended by *Republic Act 8371* or the *Indigenous Peoples Rights Act of 1997* and its Implementing Rules and Regulations.	Not Present within the Project Site	Nearest approved Certificate of Ancestral Domain (CADT) is located in the municipalities of Alegria, Bacuag, Claver, Guigaquit, and Tubod, Surigao del Norte including the municipality of Kitcharao, Agusan del Norte (approx. 3km)
Areas frequently visited and/or hard-hit by natural calamities (geologic hazards, floods, typhoons, volcanic activity, etc.)	The area shall be so characterized if any of the following conditions exist: • Geologic hazard areas: This refers to all areas identified by the Mines Geosciences Bureau (MGB) as geologic hazard areas. • Flood-prone areas: This refers to low-lying areas usually adjacent to large active water bodies experiencing inundation of at least 2 m, twice a year for the last five years prior to the year	Present within the project site	Nearest active fault which is the Philippine Fault is approximately 8km to the west of the project. Portions of the TSF is highly susceptible to landslides.

ECA Category	Technical Description of ECA Category based on DAO 2003-30	Presence within the Project Site	Description
	of reckoning. For example, a determination made in 2007 will consider the weather records from 2002 to 2006. • Areas frequently visited or hard-hit by typhoons: This refers to all areas where typhoon signal No. 4 was hoisted for at least twice a year during the last five years prior to the year of reckoning. • Areas prone to volcanic activities/earthquakes: This refers to all areas identified as such by the Philippine Institute of Volcanology and Seismology (PHIVOLCS) (e.g., areas within permanent exclusion zones of active volcanoes or areas within the required minimum buffer zone of fault zones as determined by PHIVOLCS).		
Water bodies	Water bodies shall refer to waters that are tapped for domestic purposes or those which support wildlife and fishery activities within declared protected areas, including the buffer zones.	Not Present within the Project Site	Lake Mainit (approx 6km) Songkoy Springs (approx. 2.7km) Mahukdam Lake (approx 1.2km)
Areas set aside as aesthetic potential tourist spots	Aesthetic potential tourist spots declared and reserved by the Department of Tourism or other appropriate authorities for tourism development.	Not Present within the Project Site	Lake Mainit (approx 6km) Songkoy Springs (approx. 2.7km) Mahukdam Lake (approx 1.2km)
Recharge areas of aquifers	Refers to sources of water replenishment where rainwater or seepage actually enters the aquifers. Areas under this classification shall be limited to all local or nonnational watersheds and geothermal reservations.	Present within project site	(Refer to Hydrology section) Based on Regional Groundwater availability of MGB, project is within a local and less active aquifer with low yield. But local accounts and explorations in the area shows otherwise. Silop (approx. 900m) Songkoy Spring (approx. 2.7km)
Areas with critical slopes	This refers to all lands with slopes of 50% or more classified as geohazard by MGB. Such slope conditions favor their natural susceptibility to geohazards such as landslides.	Not Present within the Project Site	(Refer to Geology Section)



Firgure 2.1-3 Environmentally Critical Areas (ECAs) in the vicinity of the Project

2.1.1.3 Land Tenure

The designated buffer zones areas of the Project are defined areas meant to avert the impacts of in terms of air, noise and dust. Since technically these areas will remain untouched and no type of development will occur, these are of no implications in terms of the land tenure.

The Project is located in several mining tenement types according to the Mining Tenements Control Map of the Mines and Geosciences Bureau (MGB) of the DENR published last January 2015.

The major project components such as the Subsidence Area and the Tailings Storage Facility (TSF) are located in a Mine Production Sharing Agreement (MPSA) that has been granted to SMMCI. The rest of the project components which includes the Mill, campsite, and haul roads. **Figure 0-3** shows the Land Tenure Map of the project.

There are no Comprehensive Agrarian Reform Program (CARP) communities within or surrounding the project site. Although there is a portion of the project site, within the MPSA that is covered by the National Protected Areas for Agriculture (NPAA) located in Lower Patag, Municipality of Sison.

There are no Certificate of Ancestral Domain Titles (CADT) or Certificate of Ancestral Land Titles (CALT) within the project site. The closest identified CADT is located approximately 3km away from the project site. With CADT Registration No. R13-CLA-0906-048, it is located in the municipalities of Alegria, Bacuag, Claver, Guigaquit, and Tubod in the province of Surigao del Norte and the municipality of Kitcharao in the province of Agusan del Norte.

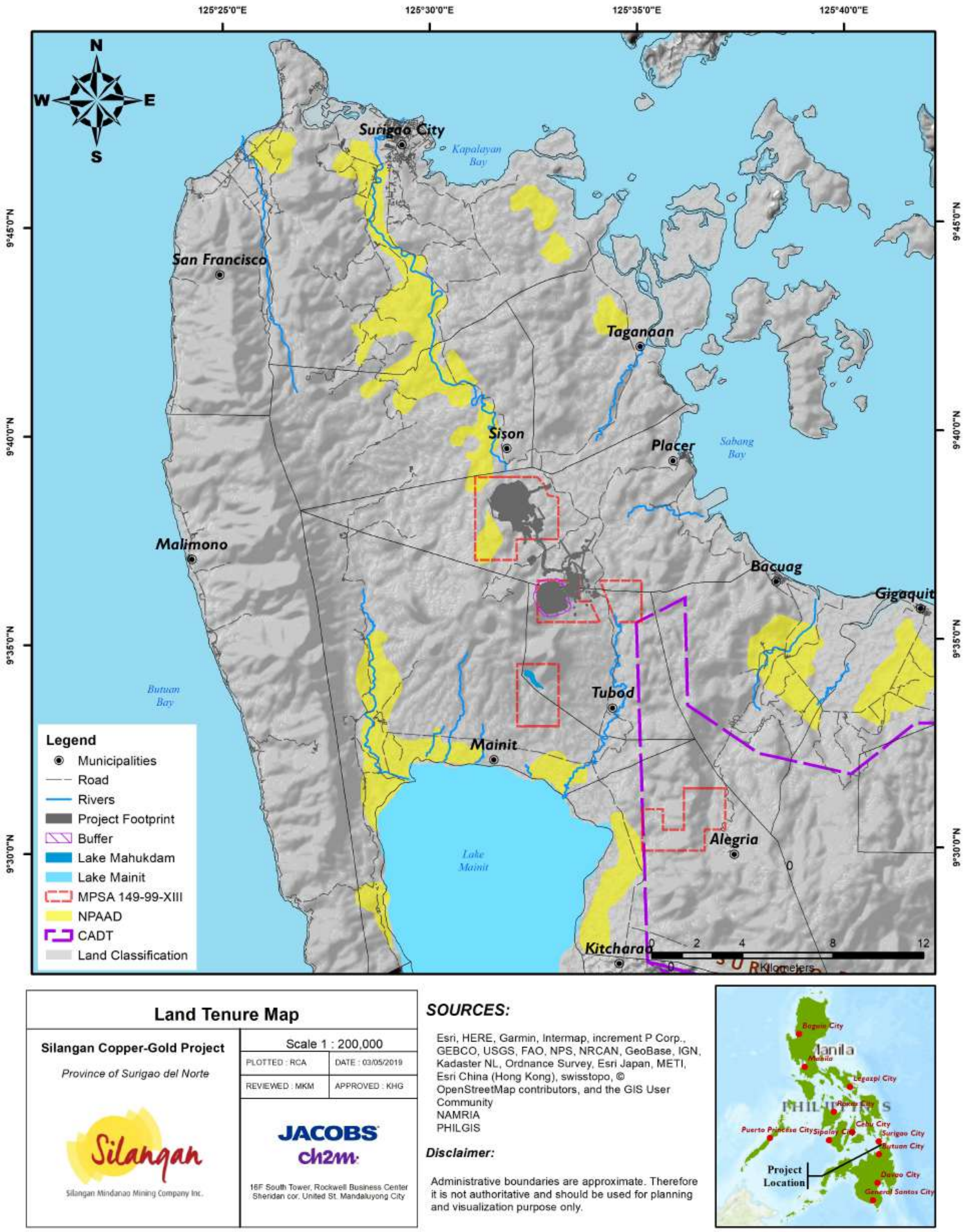


Figure 0-3 Land Tenure Map

2.1.1.4 Visually significant landforms/landscape/structures

A baseline assessment for visual aesthetic evaluation of the Project was undertaken particularly in the location of the most significant surface structure which is the Subsidence Area and the Tailings Storage Facility (TSF).

Looking north from the location of the Subsidence Area, rolling hills on the left side provides a partially obscure view of the location of the TSF which is covered by plantations of coconuts and several agricultural parcels and eventually leading to a vista of Surigao Strait. The south side presents a view of the densely vegetated northern side of Mount Maniayao. Looking to the west gives view to a high mountain top with radio towers erected.

Plate 0-1 presents different perspective of the current state of land where the project components are located.

Plate 0-1 Perspective facing South of the Subsidence Zone – View of the Mt. Maniayao

Plate 0-2 Perspective facing West of the Subsidence Zone – View of the Radio Towers

Plate 0-3 Perspective facing North of the Subsidence Zone – View of the Location of the TSF and Surigao Strait

2.1.1.5 Existing solid waste management and related land management scheme in the area

Based on the results of the household survey, key informant interview and focus group discussions conducted as part of the baseline studies, the host municipalities of Placer, Sison, Tubod and Taganaan are lacking from an established Solid Waste Management Plan. While there are solid waste garbage collectors in the municipalities, they are not sufficient to service the whole community hence most of the populace still prefer to burn their solid waste in their backyards or improperly dispose it in communal open dumpsites.

The location of the proposed project does not have a solid waste management system in place as the major anthropogenic activities in the area consists of agricultural activities consisting of coconut farming, kaingin, grazing and access roads of SMMCI.

2.1.1.6 Potential Impacts and Options for Prevention or Mitigation or Enhancement

The potential impacts of the Project to the baseline land use and classification of the project-impacted areas during each project phase and the corresponding control and mitigating measures are presented in **Table 0-5**.

Table 0-5 Potential Impacts and Options for Prevention or Mitigation or Enhancement – Land Use and Classification

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
Impacts in terms of compatibility with existing land use					
• Short-term (equivalent to Project life) or temporary land use change will occur in areas that will be occupied by the access and haul roads, mill, associated pipelines, topsoil stockpile, administration buildings, accommodation units, recreational facilities, landfill, assay laboratory, core farm, materials recovery facility, clinic, warehouse, maintenance workshop, motorpool, security, mess hall/ kitchen and laundry area. • Permanent land use change will occur in areas defined by the Subsidence Zone, Tailings Storage Facility (TSF).	✓	✓	✓	✓	• Approximately 30 ha of the project site is expected to have a similar post-mining land use capability to pre-mining land use capability after post-closure and decommissioning. Rehabilitation planning will be conducted in accordance with the Final Mine Rehabilitation and Decommissioning Plan (FMRDP) that will be developed for the project in consultation with key stakeholders and in fulfilment of the requirements of the Declaration of Mine Project Feasibility (DMPF) prior to construction. • Rehabilitation and closure planning will be conducted in accordance with the FMRDP in consultation with the key stakeholders to arrive at feasible options for the final land use of the Subsidence Zone and TSF.

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
					• The TSF's final gradient and profile at closure will be planned and engineered to facilitate efficient surface drainage at sufficiently low velocities to reduce potential for long-term erosion. The options for final land use of the TSF will be consulted with the stakeholders and may include future land use such as agroforestry depending on suitable vegetation. Vegetation or crops that may be applied during closure may be included as part of the research proposals for the mine's Environmental Protection and Enhancement Program (EPEP).
Encroachment and disturbance of ECAs and other impacts related to compatibility with the classification of ECAs identified					
• Construction and operation activities on high-angle slopes from the mill to the TSF, vicinity of the TSF, and access roads leading to the vicinity areas may induce landslides and mass wasting in susceptible areas. • Water bodies proximal to the Project site may be affected by project activities. • Domestic water sources such as springs and creeks or water bodies that support wildlife that are proximal to or drains from the project site may be affected by project activities • Vegetation and wildlife species may be removed or driven away due to mine development activities and encroachment of habitat	✓	✓	✓	✓	• Early engineering works (vegetation clearing, construction of access roads) and construction of major mine components will be done progressively to minimize the area of disturbance at any given time as much as practicable. • Observance of safe working slope gradient and placement of landslide control measures will be implemented in susceptible areas where work needs to be undertaken. • Detoxification tests for water that will be discharged from the process facility yielded final total cyanide concentrations less than the prescribed total cyanide levels for Class B freshwater bodies. It is expected that the discharge will be further diluted and cyanide to be degraded in the TSF. Nevertheless, water to be discharged through controlled releases from the TSF will be treated, as necessary, to meet the receiving water body's quality prior to release to prevent adverse impacts to the receiving water bodies.

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
					• Water quality monitoring will be implemented and regularly undertaken in surface water bodies within the impacted catchments (discussed in detail in Section 2.2 The Water). These monitoring activities will be implemented during construction and included in the mine's Environmental Protection and Enhancement Plan (EPEP) for the life of mine. Detailed discussions on water quality controls and management of surface water bodies and riparian habitats are also presented in The Water section. • Containment of chemicals and reagents that will be used for the mill as well as onsite fuel storage will be bunded to be able to accommodate accidental spills or leaks. Multiple redundancy measures will also be put in place for the process plant to TSF pipeline to address potential hazards associated with breach or loss of containment and malfunction in the conveyance of tailings from the process plant to the TSF. • Contamination of water bodies proximal to the Project site will be prevented through proper waste management and housekeeping measures (i.e. collection and containment of waste oil and lubricants from vehicles and equipment, strict implementation of solid and domestic waste management, strict containment and transport of hazardous wastes, and placement of disposal bins for biodegradable, non-biodegradable, and recyclable wastes in strategic locations within the mine development area). • All relevant permits (e.g., Tree Cutting Permit) will be secured from concerned agencies prior to tree cutting activities. As part of the proponent's environmental

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
					protection programs and its compliance to the requirements of the Tree Cutting Permit, a detailed tree inventory will be conducted for areas that will be cleared. • Protection of freshwater and terrestrial habitats and management of habitat loss will be implemented in areas where disturbance may occur. Maintenance of a nursery will aid in the conservation and protection of habitats through re-vegetation and re-greening activities for progressive rehabilitation of disturbed areas or for vegetation offsetting. The nursery may also serve as temporary housing of encountered wildlife whenever applicable. Detailed discussions are included in the Terrestrial Vegetation and Wildlife sections.
Impacts on existing land tenure issues					
• MPSA 149-99-XIII do not have any overlap with other mine tenements, CALT, CADT, and other ancestral claims. Issues and concerns on land tenure issues may stem from potential overlaps with other land titles, exploration permits, or tenements outside MPSA 149-99-XIII.	✓	✓	✓	✓	• SMMCI will continue to coordinate with key government agencies such as DENR and MGB to renew relevant permits. SMMCI has already secured a Certificate of No Overlap (CNO) from the NCIP as proof that no ancestral claims are present in the project site.
Impairment of visual aesthetics					
• The proposed project footprint is characterized by rolling hills with karstic features and a central flat land. The proposed Subsidence Zone location is within an inactive volcanic center. Other prominent topographic highs in the area are Mt. Maniayao (644 masl) and Mt. Silop (664 which is the highest point in the		✓	✓	✓	• Rehabilitation strategies and final land use for mine closure will be discussed and consulted with the project affected stakeholders as part of the FMRDP process. While the land impacted by the Subsidence Zone and TSF will not be reverted to its original landform and use, consultations will be conducted with the stakeholders and further investigations will be conducted to determine the most

Potential Impacts	Phases: Preconstruction	Construction	Operation	Closure	Options for Prevention or Mitigation or Enhancement
project area. With the development of the mine components, the geomorphologic features within the area will be permanently changed or altered. Areas where the Subsidence Zone and TSF will be located may no longer be reverted to their original geomorphology and land use.					feasible options to rehabilitate the area and convert these areas into landforms that will at least match the surrounding environment and will have alternative beneficial use.
Devaluation of land value as a result of loss of topsoil, improper solid waste management, and other related impacts					
• Loss of topsoil may occur due to clearing and consequently heighten erosion as a result of ground preparation, re-grading and clearing during the construction phase and due vehicular and human movement in the vicinity of the Project. • Removal of topsoil will occur as a result of ground preparation activities, construction of access and haul roads, construction and development of major mine components such as the Subsidence Zone, TSF, mill, associated pipelines and support facilities during the various project development phases. • Devaluation of land value may occur as a consequence of improper disposal of solid wastes and soil contamination.	✓	✓	✓	✓	• Soils that will be removed during the clearing and ground preparation activities can be conserved and stockpiled in a dedicated topsoil stockpile area for use in progressive rehabilitation activities or backfilling of service roads. • To prevent erosion, dust generation, and sedimentation from the soil stockpile, the stockpile can be covered with coco matting and graded to a stable relief. Erosion prevention permaculture practices such as planting vetiver grass and related shrubbery can also be applied to prevent mass wasting of the soil stockpile. The planted shrubs or grass will eventually add nutrients and organic matter to the soil increasing soil stability during rehabilitation. • Progressive rehabilitation will be undertaken in applicable areas such as service roads, areas with critical slopes, and temporary camps during the operations phase. • Soil contamination will be prevented through proper waste management and housekeeping measures (i.e. collection and containment of waste oil and lubricants from vehicles and equipment, strict implementation of solid and domestic waste management,

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
					strict containment and transport of hazardous wastes, and placement of disposal bins for biodegradable, non-biodegradable, and recyclable wastes in strategic locations within the mine development area).

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Environmental Impact Statement

Section 2.1 The Land

2.1.2 Geology/Geomorphology

Table of Contents

2.1.2 Geomorphology, Geology and Geohazards 2.1-21
2.1.2.1 Background 2.1-21
2.1.2.2 Methodology 2.1-21
2.1.2.2.1 Study Area 2.1-21
2.1.2.2.2 Secondary Information 2.1-22
2.1.2.2.3 Fieldwork 2.1-22
2.1.2.2.4 Data Processing and Analysis 2.1-22
2.1.2.3 Baseline Environment for Geomorphology, Geology and Geohazards 2.1-23
2.1.2.3.1 Summary 2.1-23
2.1.2.3.2 Geomorphology 2.1-24
2.1.2.3.3 Geodynamic Setting 2.1-26
2.1.2.3.4 Regional Geology 2.1-28
2.1.2.3.5 Local Geology 2.1-28
2.1.2.3.6 Geohazards 2.1-33
2.1.2.3.7 Climate Change Impacts Without the Project 2.1-55
2.1.2.4 Potential Impacts and Options for Prevention or Mitigation or Enhancements for Geomorphology, Geology and Geohazards 2.1-55
2.1.2.4.1 Summary 2.1-55
2.1.2.4.2 Potential Impacts 2.1-55
2.1.2.4.3 Options for Prevention, Mitigation or Enhancement 2.1-62

List of Tables

Table 2.1-6 Geomorphology, Geology and Geohazards
Table 2.1-7 Summary of geohazards in the project site
Table 2.1-8 Possible seismic generators and magnitudes
Table 2.1-9 Ground shaking attenuations on different ground conditions
Table 2.1-10 Modified Mercalli Intensity, De Rossi-Forel and PHIVOLCS Earthquake Intensity Scales
Table 2.1-11 Slope gradient and percent coverage of the project site
Table 2.1-12 Potential Impacts and Options for Prevention or Mitigation or Enhancement – Geomorphology, Geology and Geohazards

List of Figures

Figure 2.1-5 Topographic map of the Silangan Copper-Gold Project
Figure 2.1-6 Principal tectonic and volcanic map of the Philippines
Figure 2.1-7 Geologic map of Silangan Copper-Gold Project
Figure 2.1-8 Stratigraphic column of the Silangan Copper-Gold Project
Figure 2.1-9 Structural map of Surigao del Norte
Figure 2.1-10 Distribution of significant instrumental seismicity in southeastern Philippines
Figure 2.1-11 Earthquake density map of the Philippines
Figure 2.1-12 475-year probabilistic seismic hazard map of the Philippines
Figure 2.1-13 Liquefaction potential map of Surigao del Norte

Figure 2.1-14 Earthquake-induced landslide hazard map of Surigao del Norte
Figure 2.1-15 Tsunami hazard map of the Philippines
Figure 2.1-16 Terrain map of the Silangan Copper-Gold Project
Figure 2.1-17 Slope class map of the Silangan Copper-Gold Mine Project
Figure 2.1-18 Rain-induced landslide and flooding susceptibility map

2.1.2 Geomorphology, Geology and Geohazards

This section discusses the geomorphologic, geologic and geohazard risk assessment for the Underground Mine Project. It attempts to characterize the existing geophysical conditions within the Project's impact area and describe the possible implications of site suitability for project development. The potential impacts of the Project on the existing geomorphic and geological conditions will be similarly discussed, including recommended management for the prevention, mitigation and enhancement measures to address the risk.

2.1.2.1 Background

Most mining projects are generally sited based on the availability of a commercially extractable mineral resource in a given area. The existence of mineral deposits is controlled primarily by geology and geostructural controls, hence mining projects are typically initiated with preliminary geologic surveys. As the resource and its conditions become better understood, planning for extraction provides further emphasis on limiting factors such as topography, geomechanical characteristics and exposure to geologic hazards. The final mine configuration will be based on the most practical combination of applicable and economical extraction methods to the site geophysical conditions.

Planning for the development and commercial operations of a mine requires a full understanding of its effects to the present geophysical environment, particularly the possible inducement of hazards that could affect communities located within the project footprint. Massive earthworks may adversely affect other environmental resources are protected under national and local legislation and regulation. It is necessary to ensure compliance with existing policies meant to sustain the country's natural resources and protect the well-being of people.

Given the importance of the geophysical environment to project feasibility, implementation and environmental compliance, geologic and geohazard risk assessment became embedded in the Philippine's environmental permitting process through Presidential Decree No. 1586 which set up the framework for the Philippine Environmental Impact Statement (PEIS) System. The standard form for Environmental Impact Statement (EIS) submissions under the PEIS acknowledges the influence of geophysical conditions to projects, and conversely, consequential impacts to geomorphology, geology and geohazard exposure by project developments. The ultimate objective of the geophysical assessment is the emplacement of monitors, controls and guarantees across different phases of a project, in accordance with the intention of the PEIS in safeguarding the country's natural resources while promoting sustainability of projects.

2.1.2.2 Methodology

2.1.2.2.1 Study Area

The Silangan Copper-Gold Mine Project straddles across the Municipalities of Tubod, Placer, Sison and Tagana-an, all within the Province of Surigao del Norte. The province lies within the Surigao Peninsula, at the NE tip of Mindanao Island, Philippines. Geomorphologic, geologic and geohazard field observation were conducted around proposed locations of key project components such as the TSF, Process Plant and Subsidence Area. Exposures of outcrops encountered during the conduct of the study were observed and noted.

2.1.2.2.2 Secondary Information

Secondary information for literature review and subsequent data interpretation are gathered from various sources. Discussions on the geology of the mineral resource are based on technical reports and feasibility studies prepared by SMMCI's competent persons and consultants for geology and mining. Additional geologic information were obtained from academic publications on the Boyongan-Bayugo porphyry. Base maps for geomorphic analysis were taken from the National Mapping Resource Information Administration (NAMRIA). Geohazard maps released by READY Project (Hazards Mapping and Assessment for Effective Community-Based Disaster Risk Management), a multi-agency initiative led by the National Disaster Coordinating Council (NDCC) from 2006 to 2011, are primary references for the geohazard assessment of the Project. Maps from the Philippine Institute of Volcanolgy and Seismology (PHIVOLCS) and the Mines and Geosciences Bureau – Region XIII (MGB Region 13) are likewise used as data sources. Historical seismicity data were retrieved from the online catalogue of the National Earthquake Information Center of the United States Geological Survey (USGS-NEIC). Seismic hazard maps were adapted from USGS and other academic sources.

2.1.2.2.3 Fieldwork

Geologic field surveys were conducted in June 15-26, 2012, June 8-9, 2015, and March 4-8, 2019 to validate secondary information, document the existing geomorphology and geology, describe geomorphologic and structural features, and conduct rapid geohazard assessment within the study area. Observations made during the fieldwork were supported with photo documentation and georeferencing.

2.1.2.2.4 Data Processing and Analysis

Map Generation

Maps adopted from various sources, such as PHIVOLCS and MGB geohazard maps, were imported into the ArcMap software of the ArcGIS suite by ESRI, where the standard Jacobs map format was applied.

Historical Earthquake Distribution

A database of historical earthquakes (from 1900 to present equal to or exceeding Magnitude (M) 5.0 within a radius of 200 km around the project area, was downloaded from the USGS earthquake catalogue as a KMZ file, and loaded into the Google Earth Pro (v.7.1.1.1.888) software, and plotted on a base satellite image. To preserve the style elements provided in the USGS KMZ file, a screenshot of the generated map was taken and exported to ArcMap.

Ground Shaking Computation

To assess potential ground shaking intensities from identified earthquake generators (i,e. active faults) within the study area, Peak Ground Acceleration (PGA) values are computed for each identified fault structure. PGA values describe the amount of acceleration that a particle or object on the surface of the earth experiences as it moves irregularly during an earthquake. PGA values are calculated using the formula for ground attenuation devised by Fukushima and Tanaka (1990), as below:

$$\log_{10}A = 0.41M - \log_{10}(R + 0.032\times10^{0.41M}) – 0.0034R + 1.30$$

where: A = mean of the peak acceleration from two horizontal components at each site (in cm/sec^2)

R = shortest distance between the project site and fault rupture or earthquake generator (in km)

M = surface wave magnitude (or mean credible earthquake value as prescribed by PHIVOLCS)

Relative Ground Acceleration is represented by the unitless function ***g***. The average ***g*** is calculated from the resulting mean of peak acceleration represented by A, divided by the acceleration due to gravity constant. The mean of peak acceleration generally decreases for a particular area as its distance increases from the potential epicentre of an earthquake. This decrease also translates to a gradual reduction in ***g*** values as a particular area increases its distance from the same epicentre. Variations in the mean value of ***g*** are calculated based on the type of subsurface material underlying the study area, as different materials have different responses to the transmission of earthquake energy. Four general categories, namely Rock, Hard Soil, Medium Soil and Soft Soil are used to determine different response ranges in the study area.

Slope Gradient Analysis

Slope gradient analysis is performed on the NAMRIA topographic base map with a contour interval of 20 m, using the ArcMap software. A slope gradient rating system is adopted from the old slope classification system of Bureau of Soils and Water Management (BSWM).

2.1.2.3 Baseline Environment for Geomorphology, Geology and Geohazards

2.1.2.3.1 Summary

Table 2.1-7 Key Findings and Conclusions – Geomorphology, Geology and Geohazards

Baseline Information	Key Findings and Conclusions
Geomorphology	• The Project is located in a landscape characterized by rolling hills, steep volcanic domes, and a central flatland. • The Project site is bounded by Malimono Range to the west, Surigao Valley to the north, Diwata Range to the east, and Lake Mainit to the south. • Mts. Silop (664 m) and Maniayao (644 m) are the highest topographic features near the Project.
Geology	• The Project site has exposures of the following geological formations: Maniayao Andesite, Quaternary Andesite Tuff, Timamana Limestone, Motherlode Turbidite, and alluvial deposits.
Geohazards	• The trenches and faults affecting the Project site are as follows: the Philippine Trench in the Philippine Sea to the east, the Philippine Fault (Surigao Segment) and Cabadbaran Fault along the Malimono Range to the west, the Surigao Valley Fault along the foot of Diwata Range, and the Philippine Fault (Surigao-Lianga Segment) to the south. The Philippine Trench and the Philippine Fault Segment are considered as active structures and the primary source of most earthquakes that have occurred in the area. • Based on computations using the Fukushima and Tanaka (1990) formula, a maximum credible earthquake of 8.0 from the Surigao Segment could produce groundshaking ranging from 0.317 (rock) to 0.734 (soft soil) *g*. • The most recent and strong earthquake occurred in 2017 February 10 M6.7 Surigao Earthquake, which caused significant damage to Surigao City and nearby areas. It caused observable ground ruptures in some areas. The second most recent significant earthquake from the Surigao Segment was the 1950 June 18 M6.1 Surigao Earthquake. One of the strongest earthquakes to happen in the region was the 1879 July 01 M6.9 Mindanao Earthquake which left noticeable traces of displacement. • The PHIVOLCS liquefaction potential map shows that the hazard is quite limited along large rivers traversing the project site. • Areas with greater than 45° slope are prone to earthquake-induced landslides. • Areas with greater than 45° slope are prone to rainfall-induced landslides. Around 2.54% of the Project site have slopes having this inclination. • Flooding is prone in areas adjacent to the major rivers to the west and east of the Project site. • Paco volcano is classified by PHIVOLCS as an inactive volcano. Its present activities include fumarole emissions and warm springs. • Differential settlement can occur over areas underlain by different rock types.
Climate Change Impacts Without the Project	• Flooding, storm surges and seiches in lakes, and rain-induced landslides can be triggered by high-intensity rainfall or extreme meteorological events. It can be presumed that the occurrence and magnitude of these hazards will be enhanced with the anticipated climatological changes within the next 10-20 years.

2.1.2.3.2 Geomorphology

The vicinity of the Silangan Copper-Gold Mine Project is characterized by rolling hills with karstic features, steep volcanic domes, and a central flatland. This flatland is bounded to the east and west by two prominent topographic highs forming the Mainit Graben. On its western coast, it is traversed by the north-northwest oriented structurally controlled mountain range known as the Malimono Range. The Diwata Range comprising the Eastern Highlands traverse the entire eastern Mindanao seaboard, from Surigao in the north all the way to Davao Province in the south. The northern segment of the Diwata Range is dominated by karstic features also known as the Timamana Limestone unit.

Internal drainage and steep to sub-vertical slopes descending into the adjacent non-calcareous lithologic units are prominent. The Mainit Graben functions as the catch basin of the bounding highlands' drainage systems which flow into Lake Mainit. Major rivers have a north-south trending direction. The Hinagasa-an River drains mostly the lowland areas, and the Magpayang River that flows southward into Lake Mainit, drains most of the Diwata Range.

The Project Area is situated inside an old volcanic center that rises within the Mainit Graben. Other prominent topographic highs in the area are Mt. Maniayao (644 masl) and Mt. Silop (664 masl), while are south and west of the project site, respectively. Mt. Silop is the highest point in the area.

A topographic map of the project site is shown in **Figure 2.1-**.

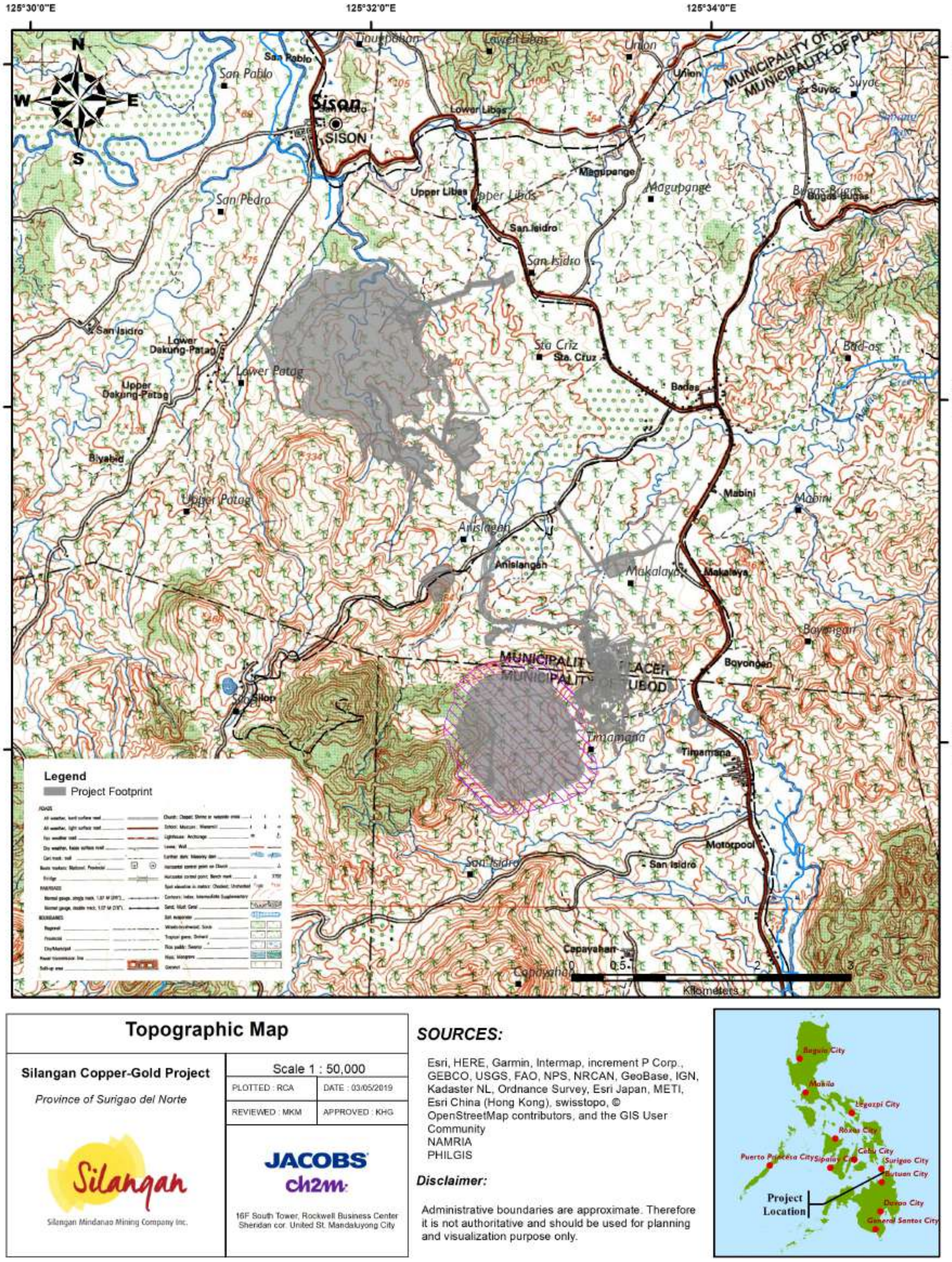


Figure 2.1-5 Topographic map of the Silangan Copper-Gold Project

2.1.2.3.3 Geodynamic Setting

The Project Area is situated in the northeastern tip of Mindanao island in southern Philippines, which form part of the extensive Philippine Mobile Belt (PMB), an actively deforming tectonic zone shaped by a complex system of collision zones, subduction zones, marginal sea basin openings (Gervasio, 1966) and a complex fault system that traverses the entire length of the Philippine archipelago.

Two subduction zones primarily influence the PMB. On the Pacific margin is the west-dipping Philippine Trench, an expression of the subduction-collision of the Philippine Sea Plate under the Philippine Arc (Hamburger, Cardwell, & Isacks, 1983; Cardwell, Isacks, & Karig, 1980; Fitch, 1972). To the west, the Philippine Mobile Belt is bounded by the following tectonic features: the Manila Trench, delineating the subduction of the South China Sea Basin under the Luzon Arc (Karig, 1973); the North Palawan Continental Block which collides with the central portion of the Philippine Mobile Belt to form an arc-continent collision zone (Stephan, Blanchet, Rangin, Pelletier, Letouzey, & Müller, 1986; Marchadier, 1988; Rangin, Porth, & Müller, 1989a; Marchadier & Rangin, 1988; Marchadier & Rangin, 1990); the Negros Trench which delineates the subduction of the Sulu Sea Basin beneath Negros and Panay islands, and; the Cotabato Trench which traces the subduction of the Celebes Sea Basin under Mindanao island (Hayes & Taylor, 1978).

Stretching for about 1,200 km from northwestern Luzon to eastern Mindanao is a complex system of strike-slip faults collectively known as the Philippine Fault (Willis, 1937) or the Philippine Fault Zone (PFZ). This left-lateral strike-slip fault is believed to have been formed to receive oblique movement within the PMB, resulting from subduction-related stresses (Fitch, 1972; Yumul, Dimalanta, & Maglambayan, 2008). It has several segments: the Northern Segment spans from northwest Luzon to Lamon Bay; the Central Segment stretches from Bondoc Peninsula to Leyte, and; the Southern Segment, which cuts along eastern Mindanao southwards to Moluccas. Slip rates vary along different segments. In Luzon, slip rates range from 10 to 40 mm/yr (Galgana, Hamburger, McCaffrey, Bacolcol, & Aurelio, 2007); in the Central Visayas estimates are pegged at ~22 to 36 mm/yr (Galgana, Hamburger, McCaffrey, Bacolcol, & Aurelio, 2007); and in Surigao, slip rate was calculated to be about 24 mm/yr (Aurelio M. , 2000a).

The distribution of active volcanic arcs in the Philippines is typically associated with the subduction zones described in the previous paragraph. For example, the Luzon Arc, comprised of volcanoes in eastern and central Luzon like Pinatubo, Banahaw and Taal, is attributed to the subduction of the Philippine Trench. The volcanic arc in eastern Philippines spanning from Bicol Peninsula to Surigao del Norte, is called the East Philippine Volcanic Arc, which is related to the subduction of the Philippine Trench. But where this arc is clearly defined in Bicol Peninsula by the belt of active and potentially active volcanic centers like Mayon, Bulusan, Isarog, Malinao, Labo and Cabalian, the extent of the active East Philippine Volcanic Arc in northeastern Mindanao is not as evident (Aurelio & Peña, 2010). **Figure 2.1** shows the principal tectonic and volcanic features in the Philippines.

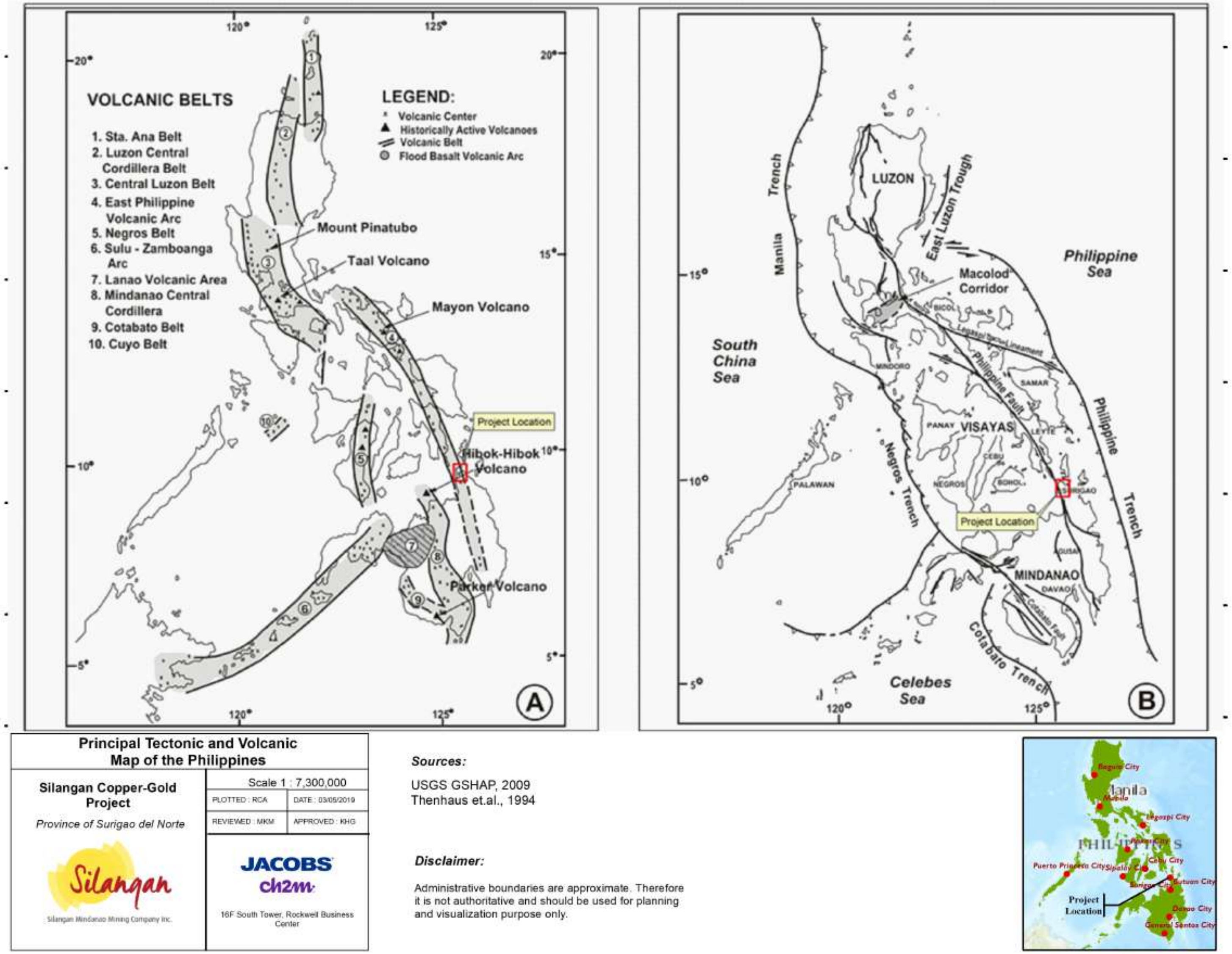


Figure 2.1-6 Principal tectonic and volcanic map of the Philippines

2.1.2.3.4 Regional Geology

The Silangan Copper-Gold Mine Project involves the development of the Bayugo-Boyongan porphyry deposit located in the Surigao Gold District in Surigao del Norte, northwest of the Diwata Range in the northeastern tip of the Pacific Cordillera. High-grade epithermal gold in veins (i.e. Mabuhay deposit, Placer epithermal vein system) and in sediment hosts (i.e. Siana deposit) are known in this district. The project site itself is divided into three physiographic terrains: (1) the Miocene to Pleistocene volcanic arc of eastern Mindanao known as the Pacific Cordillera, (2) the Malimano Range, and (3) the Mainit Graben.

The Pacific Cordillera is a 400-km, NNW-SSE trending orogenic belt that forms the backbone of eastern Mindanao island. Its evolution is thought to be controlled by complex convergent and transcurrent tectonic processes that juxtaposed older metamorphic basement rocks with an ophiolite suite, which was later impinged and overlain by younger, multiple stages of volcanic extrusions, plutonic intrusions, and sedimentary deposition (Mines and Geosciences Bureau - Region XIII, 2012). Volcanic activity along the Pacific Cordillera resulted in the placement of mineral deposits along its length, where the conditions for favorable metallic mineralization were met. Such conditions defined the eastern Mindanao provinces particularly Surigao and Davao as gold-producing districts in the Philippines. The Bayugo-Boyongan deposit is found within this district.

The Malimono Range is another tectonic terrain located ~5–10 km west of the project area. It is a narrow and long mountain range, 3-6 km wide and 45-50 km long. It stretches from Surigao City on its northwstern tip to Tubay-Cabadbaran in Agusan del Norte down south in a NNW-SSE elongation. Its uplift is brought about by movement along the PFZ. This fault is apparent along the eastern flank of the range, with major splays passing through the interior of the mountain range, as deduced. The Malimono Range has exposures of basement rock slices, including ophiolitic materials intruded by younger dikes of intermediate composition. Clastic and volcaniclastic units also comprise the uplifted terrain.

Mainit Graben is an elongated basin bounded to the east by fault systems along the western flank of the Diwata Range, and the PFZ to the west. It stretches 45-50 km from Tubay-Santiago in Agusan del Norte, to Surigao City up north, opening out to the Surigao Strait. It is oriented parallel to the Malimono Range. Mainit Graben's middle portion is 12 km across and is the widest along the structure. Within the graben, there are two distinct landforms: Lake Mainit in southern half of the graben, and Maniayao complex, immediately north of the lake. This is a volcanic complex composed of amain caldera with several parasitic domes in its periphery. It assumes a circular landform that covers an area of 64 km^2.

The mineralization zones within the district are associated with the PFZ and volcanism related to the subduction of the Philippine Trench. The Surigao Gold District, made up of mines and mineral prospects such as Mapawa, Motherlode, Bongbong, Masigad, Duyangan, Danao, Tapian, Nabago, Placer, Lascogon, Boyongan, Taganito and Siana, forms part of the Eastern Mindanao Ridge (EMR), one of the five volcanic belts associated with the Philippine Trench that hosts Paleogene to Quaternary andesitic intrusive (Mitchell & Leach, 1991). The EMR extends from Surigao del Norte to the southern provinces of Agusan, Davao del Norte Norte, Compostella Valley and Davao del Sur.

2.1.2.3.5 Local Geology

The Bayugo-Boyongan porphyry deposit is bounded by the Malimono Range to the west and the Diwata Range to the east. Exposed outcrops of the Malimono range display slices of the basement rocks that include ophiolitic materials (i.e., mafic and ultramafic units) later intruded by dikes. Clastic and volcaniclastic units are also present in the uplifted terrain.

Along faulted areas metamorphosed clastic sedimentary sequences and ophiolite fragments from Surigao District's Cretaceous Basement are evident. The Surigao Ophiolite is widely exposed in the Malimono Range, in the eastern coastline of Surigao del Norte and Surigao Del Sur, and within the islands near Surigao City. Overlying the metamorphic basement is the Late Eocene to Early Miocene Madanlog Formation, an uncomformable thick sequence of sedimentary formations, ~1 km thick basal conglomerate composed of clasts from the ophiolite and metamorphosed sedimentary units with intercalated limestone lenses. Above the basal conglomerate is the widely distributed Bacuag Formation (Late Oligocene to Early Miocene), composed of amygdaloidal basalt flows and pillows inter-layered/inter-fingered with crystalline limestone and clastic sediments. Uncomformably the Motherlode Turbidite, which are finer sediments of the Middle Miocene age overlie the older volcano-sedimentary formations. It is composed of inter-layered siltstone, mudstone and calcisiltite. From Late Miocene to Pliocene, sedimentary breccias have been deposited over these turbidites.

During the Pliocene-Pleistocene epoch, volcanic activity is apparent as shown by the presence of intrusive plutons of the same age. The host rock and the mineralizing and post-mineral intrusions responsible for the formation of the Boyongan-Bayugo deposit are part of this event. The Late Pliocene carbonaceous/coralline Timamana Limestone, Tugunan Formation, Maniayao andesite, and the Paco andesite are the youngest rock units in the area. The three latter units are dated Pleistocene to Holocene. Fluvio-lacustrine inter-layered sandstone-siltstone and debris flows make up the Tugunan Formation. The Maniayao and Paco andesite is made up of thick sequence of lava flows, volcanic breccias, and pyroclastic flows. In some areas, the two formations are observed to inter-tongue. Quaternary alluvium is mapped along active river channels and creeks, and within the vicinity of Lake Mainit.

The stratigraphy of the area is culled from a stratigraphic column for the region (from SMMCI) as modified from previous studies (Santos-Yñigo, 1644). The description and updated ages of the rock units were compiled from the United Nations Development Programme (UNDP) report of 1987 and the Geology and Mineral Resources of the Philippines (Fernandez, 1981). Discussions on the individual formations and units follow:

Madanlog Formation

The Madanlog Formation refers to calcareous conglomerate, sandstone and shale with clasts of gabbro of Eocene (55.8 Ma to 33.9 Ma) age which sits unconformably over the serpentinized peridotite and schist basement complex. The type locality of the formation is found in Mt. Madanlog, with scattered outcrops found across Surigao del Norte.

Bacuag Formation

The Bacuag Formation consists of Late Oligocene (28.4 Ma) to Early Miocene (23 Ma) basalt flows with intercalated basaltic agglomerate, conglomerate and mudstone. The formation is approximately 1,500 m thick, and its type locality formation is found in Surigao del Norte and Masapelid Island. The Bacuag Formation unconformably overlies the Madanlog Formation.

Mabuhay Formation

The Mabuhay Formation is equivalent to the Motherlode Turbidite Formation of UNDP (1987) and the Mabuhay clastics shown in the stratigraphic column. The Early (23 Ma) to Mid-Miocene (13.8 Ma) formation consists of turbidite deposits, sandstone, siltstone, and mudstones with a total approximate thickness of 700 m. The formation's type locality is found along Libas River, south-west of the Motherlode Mine in the municipality of Taganaan. The Mabuhay Formation conformably overlies the Bacuag Formation and is, in turn, conformably overlain by the Timamana Formation.

Mabuhay Clastics

The Mabuhay Clastics are found in Brgy. Mabuhay, Placer and Sison, Surigao del Norte. UNDP (1987) described five lithologic facies: Kambilibid Boulder Beds, West Siana Carbonates, Briggs Pyroclastics, Placer Conglomerates, and small andesite units that were not mapped.

Hinatigan Limestone

This unit was earlier named Hinatigan Marl by UNDP (1987) based on a marl outcrop that was later considered a member of the Timamana Limestone (MGB, 2010). The Hinatigan Limestone is composed of carbonates, marl and siltstones of Pleistocene age (2.6 - 0.01 Ma).

Timamana Limestone

The Timamana Limestone consists of Mid-Miocene reefal limestones with an approximate thickness of 250 m and unconformably overlying the Mabuhay Formation. Outcrops of this formation can be observed in Brgy. Timamana in the Municipality of Tubod, as well as on some of the limestone outcrops comprising the hills east of the national highway .

Tugunan Formation

The Tugunan Formation consists of conglomerates, sandstones, mudstones and turbiditic sequences of Late Miocene (11.6 Ma) to Late Pliocene (3.6 Ma) age found in Sitio Tugunan, the perimeter of Lake Mainit, Asiga River, Cabadbaran River, Calamba Creek, Camp Arega, Anticala and Andana River in the province of Surigao del Norte. This formation unconformably overlies the Timamana limestone.

Hill 169 and 259

These Pliocene (5.3 – 2.6 Ma) andesite units were mapped by UNDP. MGB (2010) consider these hornblende andesite porphyry hills to be equivalent to the Ipil Andesite which unconformably overlies pre-Pliocene deposits in the Malimono mountain range.

Paco Andesite

The Paco Andesite, previously described by UNDP (1987) is an extinct volcanic center with a conical peak located at 524 masl north of Brgy. Paco. This unit consists of hornblende and biotite-bearing andesitic flows, domes, lahars, and tuff deposits.

Maniayao Andesite

This unit is composed of Pleistocene andesite flows and pyroclastic deposits that unconformably overlie older formations. The source of the volcanic deposits, Mt. Maniayao, is an extinct volcano located along the PFZ north of Lake Mainit. Existing K-Ar and Ar-Ar age determinations for volcanic rocks from the Maniayao complex range between 600 and 90 ka (Braxton, et. al., 2007). There was no Carbon-14 dating.

Alipao Andesite

This unit consists of Mid-Miocene (13.0 + Ma based on radiometric dating) hornblende stocks and intrusives of andesitic composition. The lithology is typically porphyritic with phenocrysts of plagioclase and acicular hornblende in an aphanitic groundmass. The Alipao Andesite intrudes the Bacuag Formation. This unit was named and described by UNDP (1987) from outcrops in the vicinity of Alipao and Siana Mines.

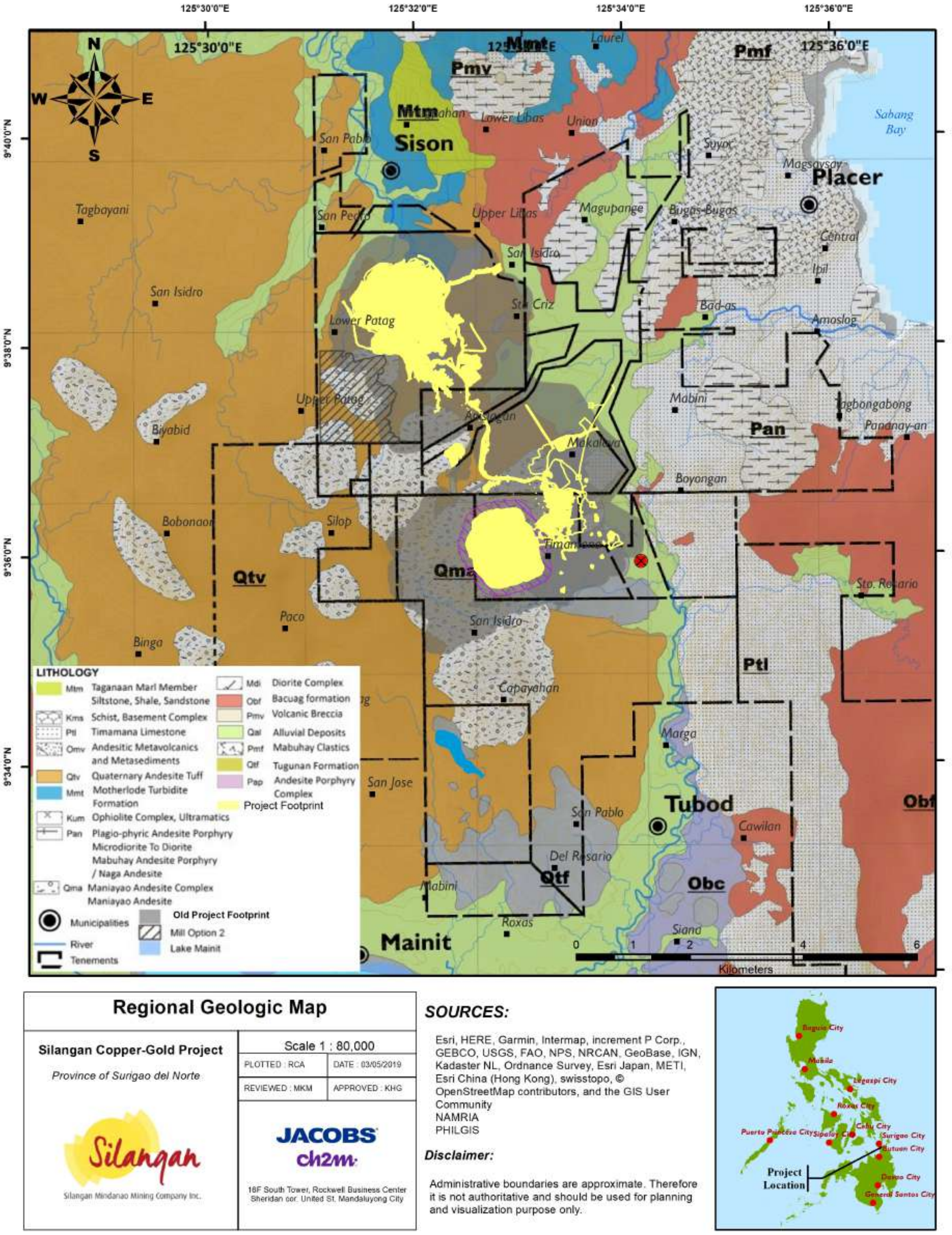


Figure 2.1-7 Geologic map of Silangan Copper-Gold Project

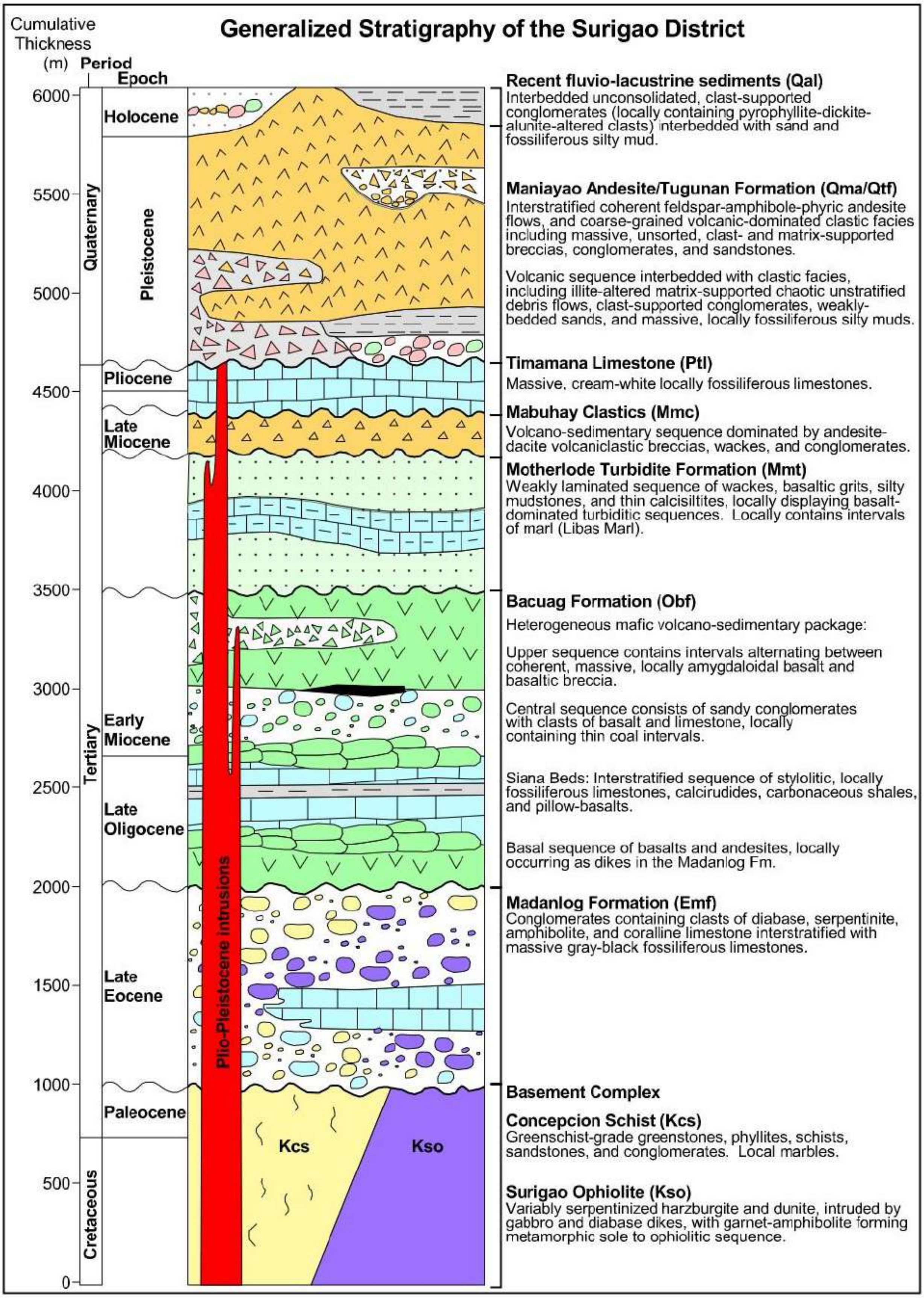


Figure 2.1-8 Stratigraphic column of the Silangan Copper-Gold Project (from (Braxton, 2007))

2.1.2.3.6 Geohazards

The proposed Project is exposed to several geohazard risks due to its topographic and geologic character, and proximity to a prominent seismic generator. A summary of the different geohazards, past occurrence, probability of future occurrence, and potential risks to the Project is presented in **Table** .

Table 2.1-8 Summary of geohazards in the project site

Geohazards		Previous Occurrence Near the Site	Likelihood of Future Occurrence	Potential Areas to be Affected	Potential Risks to Project
Seismic-Related	**Ground Shaking**	• 2017 February 10 (M 6.7, 16km NW of Surigao City) • 1960 June 18 Surigao Earthquake (M 6.1, epicentre 16.5 km)	• Likely	• Areas close to Philippine Fault • Areas with poorly consolidated rocks and loose	• Collapse of buildings • Slope failure in TSF and Subsidence area • Dam breach
	Ground Rupture	• 2017 February 10 (M 6.7, 16 km NW of Surigao City) • 1879 July 01 Mindanao Earthquake (M6.9)	• Possible	• Areas over trace of fault lines, especially Philippine Fault	• Slope failure • Dam breach
	Earthquake-Induced Landslide	• 2017 February 10 (M 6.7, 16 km NW of Surigao City 1879 July 01 Mindanao Earthquake (M6.9)	• Possible	• Steep areas w/ >45° slope angles • Areas underlain with poorly consolidated rocks and loose	• Partial to total destruction of facilities
	Liquefaction	• Unknown	• Possible	• Areas near rivers, underlain w/ poorly consolidated soils and silt	• Damage to TSF
	Seiche	• Unknown	• Likely	• TSF Basin Area	• Damage to TSF
Weather-Related	**Rain-induced Landslide**	• Occasional minor slope failures during heavy rainfall events	• Possible	• Steep areas w/ >45° slope angles • Areas underlain w/ poorly consolidated soils and silt	• Failure of slopes • Dam breach
	Flooding	• Unknown	• Possible	• Areas on Magpayang River floodplain •	• Inundation of facilities • Loss of road access from the south and north
	Storm Surge	• Unkwown	• Unlikely	• None	• None
Volcanic Hazards		• Unknown	• Unlikely	• None	• None

Geohazards	Previous Occurrence Near the Site	Likelihood of Future Occurrence	Potential Areas to be Affected	Potential Risks to Project
Differential Settlement	• Unknown	• Possible	• Areas underlain w/ unconsolidated soils and silt	• Partial to total destruction of facilities
Climate Change Effects	• Not applicable	• Likely	• All areas	• Reduction of stream flows • Increased flooding of low-lying facilities • Increased occurrence of rain-induced landlsides

Seismic Hazards

Movements along faults and trenches within Surigao del Norte can potentially induce seismic hazards that could affect the proposed project site. Common hazards related to seismic events include ground shaking, ground rupture, landslides and rockfalls, subsidence and lateral spreading, liquefaction, and seiche generation. Factors such as the strength of generating event, local topography and subsurface geology can affect the magnitude and extent of impacts brought by these seismic hazards.

Several tectonic structures bound the project site (**Figure**). Around 140 km east of the proposed Subsidence area, the Philippine Trench traces the subduction of the Philippine Sea Plate under the Philippine Arc. The east-facing base of the Malimono Range delineates the path of the NW-trending Surigao Segment of the Philippine Fault (also named Mainit Fault by other authors). The Cabadbaran Fault strikes parallel to the Surigao Segment, albeit along the west-facing base of the Malimono Range. The Mainit Graben, in which Lake Mainit and Maniayao complex are situated, is bounded to the east by Surigao Valley Fault. South of the lake, a splay of Philippine Fault branches to the southeast towards the Philippine Trench which is also known as the Lianga Segment. The active fault map generated by PHIVOLCS over Surigao del Norte (**Figure**) classifies both Surigao and Lianga Segments of the Philippine Fault as active.

The instrumental seismicity map generated within 200 km of the Project Subsidence area site (9°36'00.58" N, 125°32'47.63" E) for ≥M5.0 events (minimum magnitude that can cause damage to engineered structures (Koo, Mote, Manlapig, & Zamora, 2009)) between 01 January 1900 to 31 March 2019 (USGS NEIC, 2019), shows that a majority of the inland seismic events have small magnitudes, shallow depths, and are found along the Surigao Segment (**Figure**). The offshore events, on the other hand, are much more numerous, have greater magnitudes, have a westward-deepening source trend, and are related to subduction along the Philippine Trench. **Figure** shows the Philippine earthquake density map generated by the United States Geological Survey Global Seismic Hazard Assessment Program (USGS GSHAP) which shows the average annual occurrence of ≥M5.0 events over 100 km by 100 km parcels throughout the Philippines, from 1973 (oldest instrumental seismicity records available) to the present (USGS NEIC, 2019). In Surigao del Norte, the map indicates an average of 4 - 5 greater than M5.0 earthquake events has occurred yearly for the past 40 years. This range represents the greatest density of earthquakes anywhere in the Philippines within a year.

Ground Shaking

Ground shaking is the most common hazard associated with seismic activity. Vertical and horizontal ground movements generated by a seismic event are a manifestation of the propagation of surface waves emanating from an earthquake source. The heaving and lurching of the ground causes foundations and structures to shift and settle from a previously stable or static state. Buildings can lean or tip over, and foundations can subside or be thrust upward. The ground can liquefy or rupture, and ground shaking itself can be a trigger for these other hazards.

The most recent recorded seismic event that took place in Surigao occurred on 10 February 2017 with a strength of M6.7 at a depth of 15 km and located 16 km north of Surigao City, Surigao Del Norte. This earthquake caused significant damage to some of the buildings and public infrastructures within Surigao City and nearby areas, which included the closure of the Surigao Airport due to significant damage to its runway. Other records of instrumental measurements of seismic events provide a realistic upper limit to earthquake magnitudes that could take place within the area. Two M7.6 (31 August 2012 and 15 December 1989) were generated by the Philippine Trench 184 km to the northeast and 192 km to southeast during the past 30 years, respectively. Along the Mindanao segments of the Philippine Fault, a M7.2 earthquake was recorded on 13 June 1920, 173 km S-SE of the proposed mine area, near Bunawan in Agusan del Sur. The strongest event attributed to the Surigao Segment is a M6.1 shallow (15 km) earthquake on 18 June 1950, 16.5 km to the northwest of the mine area, along Malimono Range (USGS NEIC, 2019).

Ground shaking hazard assessment is done to identify the potential effects of seismic movement over a particular area by determining the characteristic response of the ground during an event. One method, the Deterministic Seismic Hazard Assessment (DSHA), uses data from known seismic sources to simulate ground motion during discrete, single-valued events. It was first applied for seismic hazard analysis of nuclear power plants and is still commonly used in the evaluation of worst-case scenarios for other large structures like dams. DSHA, however, does not factor in the probability of occurrence of an earthquake of a certain magnitude occurring at a specific area over a given finite period of time, nor the uncertainties in the values needed to compute ground motion characteristics.

A formula developed by Fukushima and Tanaka in 1990 computes for seismic response expressed as peak ground acceleration (PGA) in a specific site using the maximum credible magnitude that can be generated by an earthquake source (i.e. active fault), the seismic generator's distance from the site, and the attenuation of the substrate in that area. The potential earthquake generators around the project site, the estimated perpendicular (or shortest) distance between the seismic generator and the project site, and the maximum credible earthquake (MCE) (Koo, Mote, Manlapig, & Zamora, 2009) are presented in **Table** .

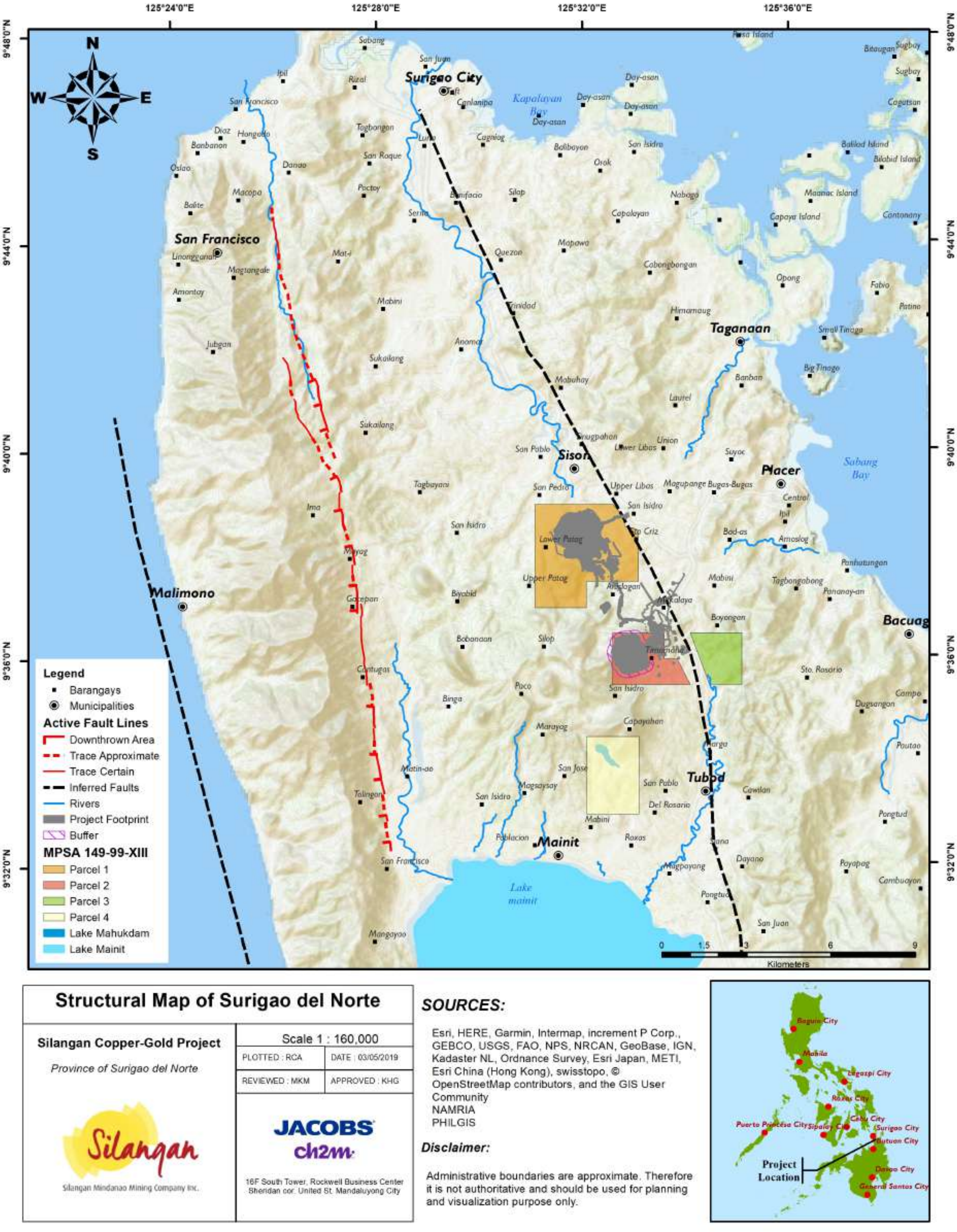
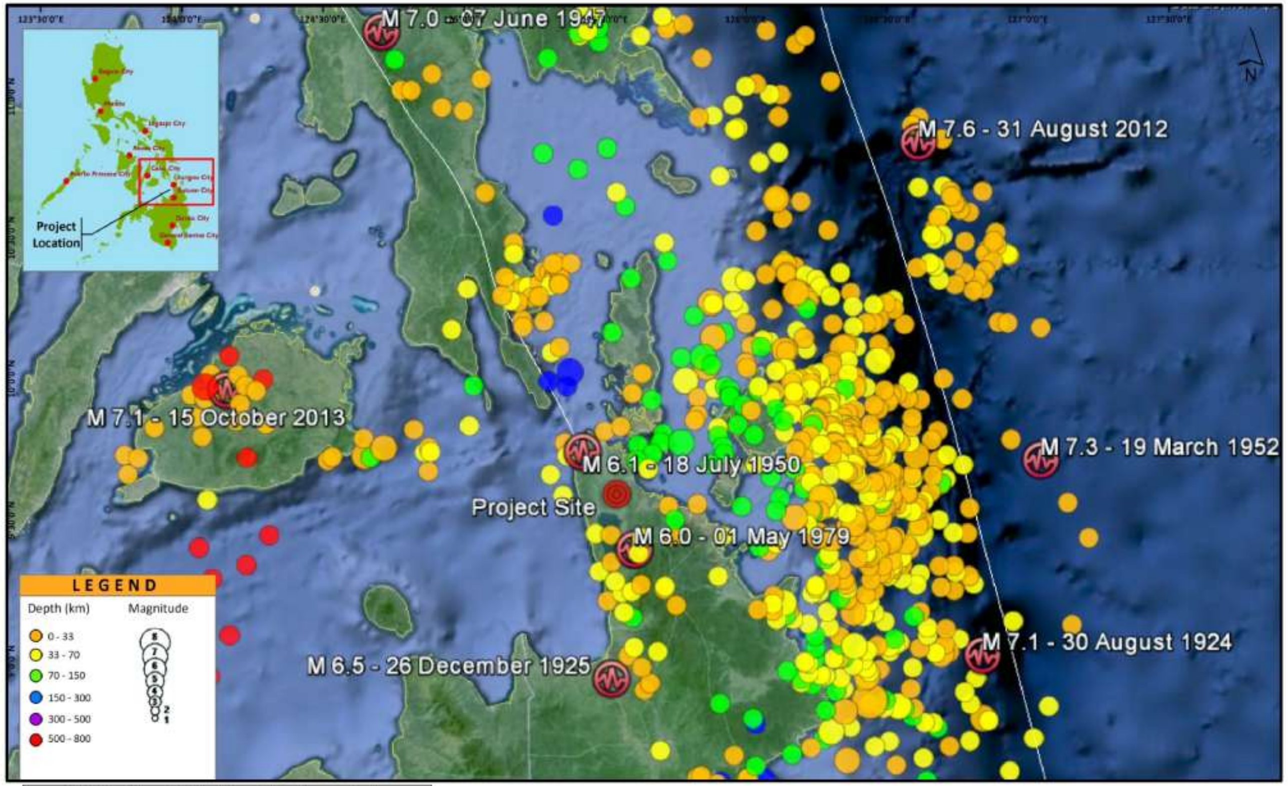


Figure 2.1-9 Structural map of Surigao del Norte



Distribution of Significant Instrumental Seismicity in Southeastern Philippines

Silangan Copper-Gold Project

Province of Surigao del Norte

Silangan

Silangan Mindanao Mining Company Inc.

Scale 1 : 1,300,000	
PLOTTED : RCA	DATE : 03/05/2019
REVIEWED : MKM	APPROVED : KHG

JACOBS ch2m

16F South Tower, Rockwell Business Center

SOURCES:

USGS Earthquake Hazard Program
Google Earth
NAMRIA
PHILGIS

Disclaimer:

Administrative boundaries are approximate. Therefore it is not authoritative and should be used for planning and visualization purpose only.

Figure 2.1-10 Distribution of significant instrumental seismicity in southeastern Philippines

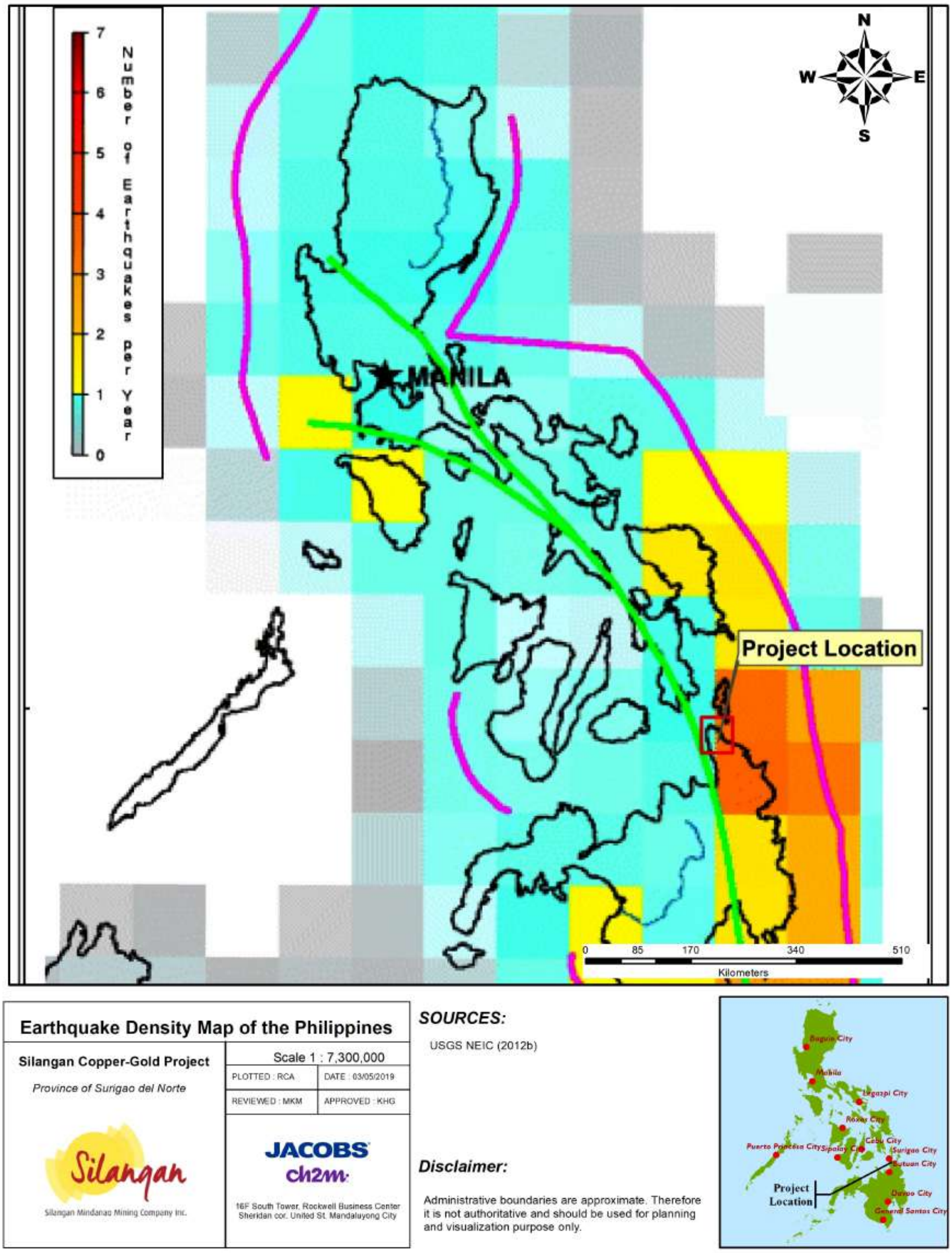


Figure 2.1-11 Earthquake density map of the Philippines (USGS NEIC, 2019)

Table 2.1-9 Possible seismic generators and magnitudes

Seismic Source	Distance (km)	Maximum Credible Earthquake (Magnitude)
Surigao Valley Fault **	2	7.0
Philippine Fault (Surigao Segment) *	8	8.0
Cabadbaran Fault	17	6.0
Philippine Fault (Lianga Segment) *	100	8.0
Philippine Trench *	140	8.0

** considered active by PHIVOLCS*

*** estimated from events centered along inferred trace of fault*

The average PGA value is calculated from the resulting mean of peak acceleration divided by the acceleration due to gravity constant. In general, the average PGA in an area decreases the farther away from the earthquake source, given the same magnitude.

Seismic waves propagate differently across various substrate compositions, resulting in attenuation of ground acceleration. Investigations of acceleration attenuation in strong-motion stations in Japan recognized a divergence of observed measurements from predicted peak horizontal accelerations. By classifying the ground condition and segregating the data, the attenuation or amplification factor was estimated. The four general types of ground conditions used in the Japanese study are Rock, Hard Soil, Medium Soil and Soft Soil (Fukushima & Tanaka, 1990). The three soil types are described as follows (Earthquake Engineering Committee, the Japanese Society of Civil Engineers, 1988):

- Hard Soil: ground before the Tertiary period or thickness of diluvial deposit above bedrock is less than 10 m
- Medium Soil: thickness of diluvial deposit above bedrock is greater than 10 m, or thickness of alluvial deposit above bedrock is less than 10 m, or thickness of alluvial deposit is less than 25 m and thickness of soft deposit is less than 5 m
- Soft Soil: other soft ground such as reclaimed land

Table shows the computed peak ground acceleration values and ground shaking attenuations on different ground conditions, using the formula by Fukushima and Tanaka (1990) and the information provided in **Table** .

Table 2.1-10 Ground shaking attenuations on different ground conditions

Seismic Source	Avg. PGA (*g*)	Rock (0.6*g*)	Hard Soil (1.07*g*)	Med. Soil (0.87*g*)	Soft Soil (1.39*g*)
Surigao Valley Fault	0.577	0.346	0.617	0.502	0.802
Philippine Fault (Surigao Segment)	0.528	0.317	0.565	0.459	0.734
Cabadbaran Fault	0.435	0.261	0.466	0.379	0.605
Philippine Fault (Lianga Segment)	0.110	0.066	0.118	0.096	0.153
Philippine Trench	0.064	0.039	0.069	0.056	0.090

Based on results derived from the computation (**Table**), average peak ground acceleration values computed for a M7.0 MCE generated by the Surigao Valley Fault can potentially generate the strongest shaking in the project area (mine area) ranging from 0.346 (rock) to 0.802 (soft soil) *g*. Historically though, the Surigao Segment of the Philippine Fault is the nearest structure with documented activity, and computation using the Fukushima and Tanaka (1990) formula results in potential 0.317 (rock) to 0.734 (soft soil) *g* shaking from a M8.0 MCE event. The calculated PGA values for the latter earthquake scenario is equivalent to a Modified Mercalli Intensity (MMI) rating of VII – IX (Moderate to Violent) having Destructive to Very Destructive impacts as classified under the PHIIVOLCS Earthquake Intensity Scale (**Table**).

Another method of seismic hazard assessment, called Probabilistic Seismic Hazard Assessment (PSHA), was subsequently developed to accommodate a time component by considering occurrence probabilities of seismic events. The PSHA also allows for uncertainties in size, location and recurrence rates of earthquakes (Anbazhagan, 2007).

PSHA was used in the generation of seismic hazard maps that show the critical level of earthquake ground motion (peak acceleration) in a specific area for a given probability of exceedance (or inversely, the return period). This allows one to set design thresholds for structures within their expected useable life. The peak acceleration is computed essentially the same was as in the DSHA. Some examples of these probabilistic seismic hazard maps are from Thenhaus et al. (1994) and USGS (2009), which show peak ground acceleration levels across the Philippines having 10% probability of exceedance within 50 years (475-year return period). Based on these maps, the proposed project site can anticipate PGAs of about 0.29 to 0.49 *g* (2.8 to 4.8 m/s^2) in 475 years, assuming bedrock foundation for the Thenhaus et al. (1994) computation (0.29 *g*).

If the PGAs obtained thru DSHA are compared with those from PSHA, the higher values computed from the deterministic approach would imply return periods greater than the 475 years interval between seismic events that could generate critical ground movement determined thru PSHA. Spanish colonial era records compiled by Rev. Miguel Saderra Masó, S.J. describe of a M6.9 (Tsutsumi & Perez, 2013) intensity X (De Rossi-Forel scale) event in Surigao Peninsula on 01 July 1879 (Masó, 1910). Referring **Table** , this is equivalent to at least 124% *g* (12.2 m/s^2) (NOAA National Centers for Environmental Information, 2015). An earthquake of this magnitude exceeds the maximum value in the probabilistic PGA scales in **Figure** . The return period for such an event must therefore be longer than 475 years.

Ground Rupture

Ground rupture is the breakage and temporary or permanent opening up of the ground surface as a response to compressive or extensive stress during the occurrence of a seismic event along a fault. It may occur suddenly during an earthquake, or gradually as an effect of fault creep progression. There is displacement of either side of a ground rupture: dip-slip faulting have surface ruptures that feature vertical offset, while strike-slip faulting has a lateral displacement. It is also possible to have a combination of horizontal and vertical slippage. Ground ruptures almost always follow or develop along or adjacent to pre-existing faults. Developments along identified or hidden fault zones are at risk of structural damage if old fault lines or fracture zones are reactivated. The most recent M6.7 earthquake that occurred in 10 February 2017 have generated significant ground ruptures in certain areas including parts of the Surigao City Airport runway.

Table 2.1-11 Modified Mercalli Intensity, De Rossi-Forel and PHIVOLCS Earthquake Intensity Scales

%*g*	MMI	De Rossi-Forel	Perceived Shaking (MMI)	Potential Damage (MMI)	PEIS	Description (PEIS)
< 0.17	I	I	Not Felt	None	I	**Scarcely Perceptible** - Perceptible to people under favorable circumstances. Delicately balanced objects are disturbed slightly. Still water in containers oscillates slowly.
0.17 – 1.4	II – III	I-II	Weak	None	II	**Slightly Felt** - Felt by few individuals at rest indoors. Hanging objects swing slightly. Still water in containers oscillates noticeably.
		III			III	**Weak** - Felt by many people indoors especially in upper floors of buildings. Vibration is felt like one passing of a light truck. Dizziness and nausea are experienced by some people. Hanging objects swing moderately. Still water in containers oscillates moderately.
1.4 – 3.9	IV	IV-V	Light	None	IV	**Moderately Strong** - Felt generally by people indoors and by some people outdoors. Light sleepers are awakened. Vibration is felt like a passing of heavy truck. Hanging objects swing considerably. Dinner, plates, glasses, windows and doors rattle. Floors and walls of wood framed buildings creak. Standing motor cars may rock slightly. Liquids in containers are slightly disturbed. Water in containers oscillates strongly. Rumbling sound may sometimes be heard.
3.9 – 9.2	V	V-VI	Moderate	Very Light	V	**Strong** - Generally felt by most people indoors and outdoors. Many sleeping people are awakened. Some are frightened, some run outdoors. Strong shaking and rocking felt throughout building. Hanging objects swing violently. Dining utensils clatter and clink; some are broken. Small, light and unstable objects may fall or overturn. Liquids spill from filled open containers. Standing vehicles rock noticeably. Shaking of leaves and twigs of trees are noticeable.
9.2 – 18	VI	VI-VII	Strong	Light	VI	**Very Strong** - Many people are frightened; many run outdoors. Some people lose their balance. Motorists feel like driving in flat tires. Heavy objects or furniture move or may be shifted. Small church bells may ring. Wall plaster may crack. Very old or poorly built houses and man-made structures are slightly damaged though well-built structures are not affected. Limited rockfalls and rolling boulders occur in hilly to mountainous areas and escarpments. Trees are noticeably shaken.
18 – 34	VII	VIII-	Very Strong	Moderate	VII	**Destructive** - Most people are frightened and run outdoors. People find it difficult to stand in upper floors. Heavy objects and furniture overturn or topple. Big church bells may ring. Old or poorly built structures suffer considerably damage. Some well-built structures are slightly damaged. Some cracks may appear on dikes, fishponds, road surface, or concrete hollow block walls. Limited liquefaction, lateral spreading and landslides are observed. Trees

%g	MMI	De Rossi-Forel	Perceived Shaking (MMI)	Potential Damage (MMI)	PEIS	Description (PEIS)
						are shaken strongly. (Liquefaction is a process by which loose saturated sand lose strength during an earthquake and behave like liquid).
34 – 65	VIII	VIII+ to IX-	Severe	Moderate to Heavy	VIII	**Very Destructive** - People panicky. People find it difficult to stand even outdoors. Many well-built buildings are considerably damaged. Concrete dikes and foundation of bridges are destroyed by ground settling or toppling. Railway tracks are bent or broken. Tombstones may be displaced, twisted or overturned. Utility posts, towers and monuments may tilt or topple. Water and sewer pipes may be bent, twisted or broken. Liquefaction and lateral spreading cause man-made structures to sink, tilt or topple. Numerous landslides and rockfalls occur in mountainous and hilly areas. Boulders are thrown out from their positions particularly near the epicenter. Fissures and faults rupture may be observed. Trees are violently shaken. Water splash or stop over dikes or banks of rivers.
65 – 124	IX	IX+	Violent	Heavy	VIII	
> 124	X - XI	X	Extreme	Very Heavy	IX	**Devastating** - People are forcibly thrown to ground. Many cry and shake with fear. Most buildings are totally damaged. Bridges and elevated concrete structures are toppled or destroyed. Numerous utility posts, towers and monument are tilted, toppled or broken. Water sewer pipes are bent, twisted or broken. Landslides and liquefaction with lateral spreading and sandboils are widespread. The ground is distorted into undulations. Trees are shaken very violently with some toppled or broken. Boulders are commonly thrown out. River water splashes violently on slops over dikes and banks.
	XII				X	**Completely Devastating** - Practically all man-made structures are destroyed. Massive landslides and liquefaction, large-scale subsidence and uplifting of land forms and many ground fissures are observed. Changes in river courses and destructive seiches in large lakes occur. Many trees are toppled, broken and uprooted.

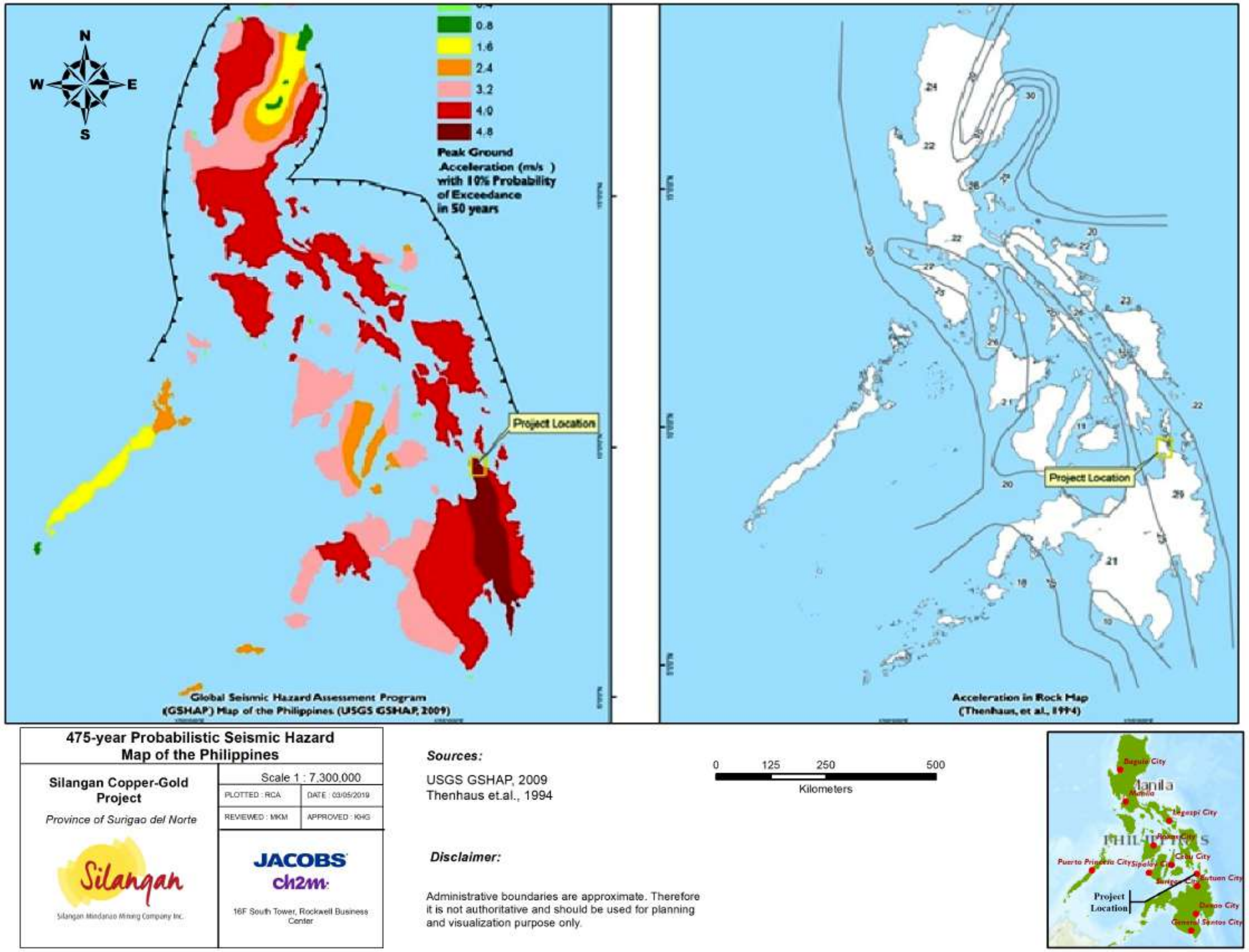


Figure 2.1-12 475-year probabilistic seismic hazard map of the Philippines, from(USGS GSHAP, 2009) and **(Thenhaus, et al., 1994)**

Written accounts of the 1879 Surigao earthquake, attributed to the Surigao Segment of the Philippine Fault, indicate that approximately half a meter drop was observed across the plains located south of Lake Mainit in Augsan del Norte, while aerial photograph interpretation and field mapping revealed offset streams and fault scarps (Perez J. S., Tsutsumi, Ishimira, Cahulogan, & Cabanlit, 2009). Measurement of offset river terraces believed to be related to the 1879 event indicates horizontal displacement of 5.7 ± 1 m, while fault scarp profiling yielded a vertical displacement estimate of 0.5 to 1.0 m (Perez J. S., Tsutsumi, Ishimira, Cahulogan, & Cabanlit, 2009). Further trench investigation suggested that for the past 1,300 years, two to four seismic events produced displacements along the Surigao Segment. The recent M6.7 earthquake left a 1km ground rupture at the town of San Francisco in Barangay Poblacion which was assessed by PHIVOLCS at post-earthquake.

Inferred faults not classified as active by PHIVOLCS may likewise be possible sites of ground rupture if these suddenly or gradually move. The Surigao Valley Fault is the most prominent structure delineated tangential to the boundaries of the project footprint (**Figure**). Several NE-trending lineaments were also traced east of the project area.

Liquefaction

Liquefaction is the process wherein unconsolidated and water-saturated sand or soil is transformed into a suspension during an earthquake or other rapid loading phenomenon. The occurrence of these trigger-events causes pore water pressure in saturated substrates to build up, exceeding the effective stress of grains. This results in the loss of shear stress which causes the ground material to fail and behave like a liquid, which reduces the ability of the soil to support materials and other structures, and causes installations to “sink” or tip over.

The volcanic and carbonate rock units underlying the project area are fairly consolidated, and thus not susceptible to liquefaction. A liquefaction potential map released by PHIVOLCS shows that the northern coastal area of Lake Mainit, and the floodplains along the Hinagasa-and River and Magpayang River south and north of the project area, respectively, are prone to this geohazard. This is mostly due to the loose and saturated sediments deposited in these areas.

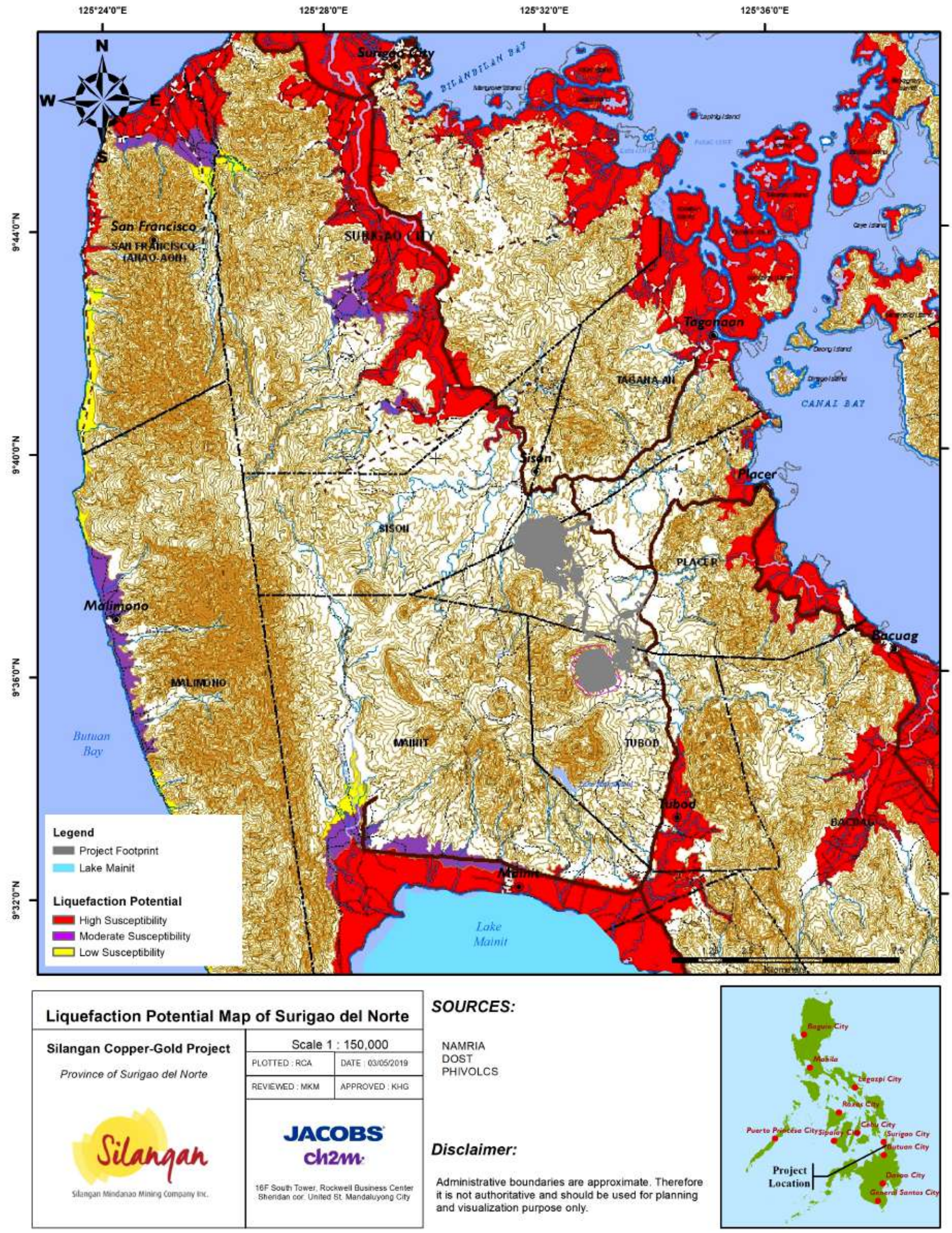


Figure 2.1-13 Liquefaction potential map of Surigao del Norte

Earthquake-Induced Landslide

Failure of slope faces of topographically high land features such as mountains and cliffs can be triggered during earthquakes. Ground shaking destabilizes slopes, causing landslides and rockfalls. Earthquake ruptures along steep mountain faces may also cause mass wasting if the substrate comprising displaced blocks break apart and lose strength. Secondary landslides may develop due to increased water penetration and saturation resulting from the formation of wider cracks and weaker intergranular cohesion bonds after an earthquake. Structures built on the side or at the foot of unstable slopes may face significant damage when foundations fail or are hit directly by landslide debris.

Geohazard reconnaissance of the area did not reveal evidence of large, deep-seated earthquake-induced landslides. Based on slope gradients, however, most of the high relief areas within the project site have been classified as moderately to highly susceptible to earthquake-induced landslides, particularly the areas where the Subsidence Area and Tailings Storage Facility are proposed to be located (**Figure**).

Seiche

Seiches are standing waves oscillating in an enclosed body of water, such as in lakes and are typically caused by strong winds, rapid changes in atmospheric pressure or propagation of earthquakes. In the case of earthquakes, it is different from tsunamis in the way that no displacement of water takes place. Water rebounds from one end of the enclosed water body to another and oscillates back and forth for hours or even days. It is a common phenomenon and often ignored as it does not cause any significant damage for most of the time. In extreme scenarios, however, seiches may be high enough to impact coastal areas of the enclosed water body.

Seiches may develop within the TSF facility when completed and operational. Storm systems and earthquake wave propagation, both common in the region, may drive the water from the man-made lake to overflow and inundate areas downstream of the dam.

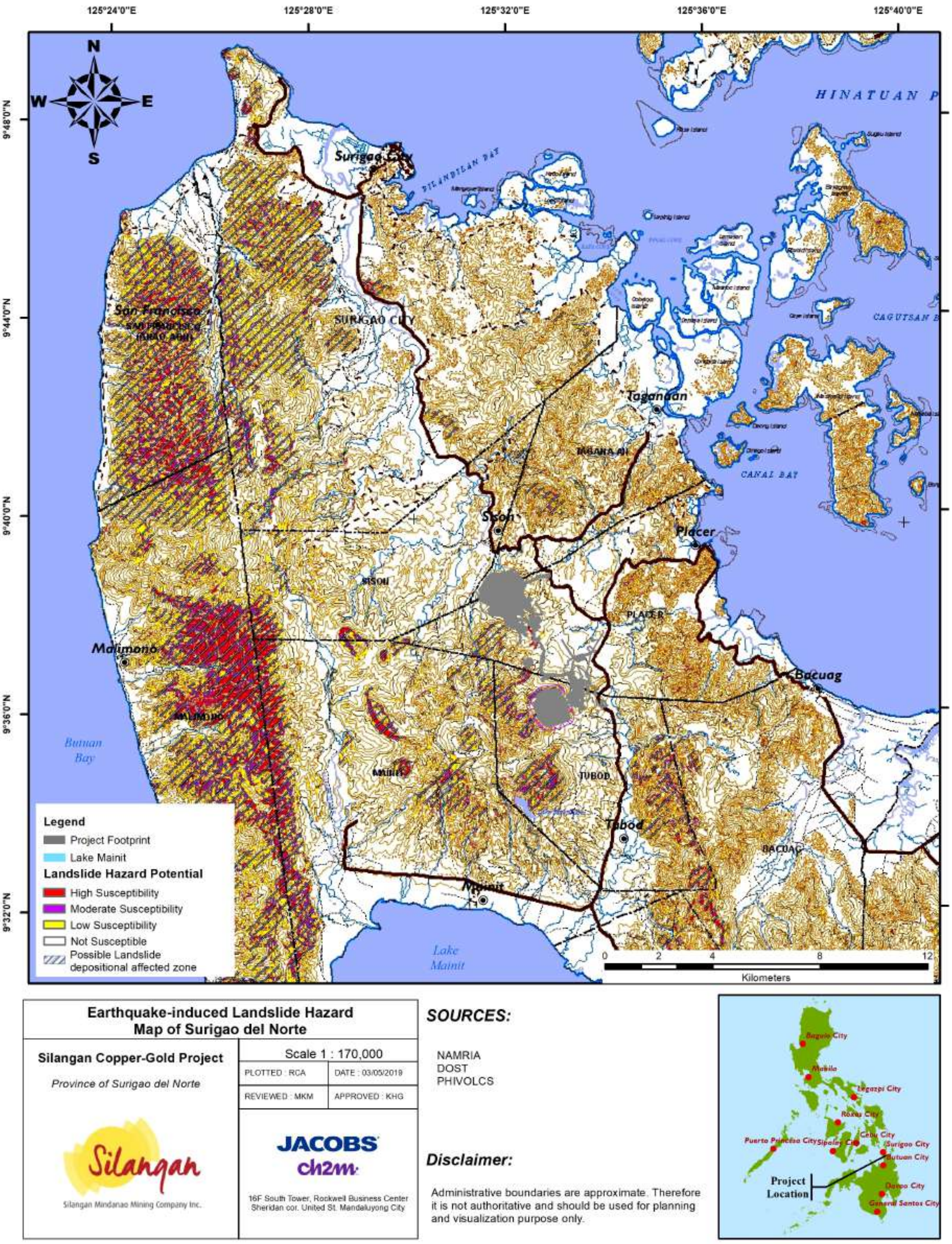


Figure 2.1-14 Earthquake-induced landslide hazard map of Surigao del Norte

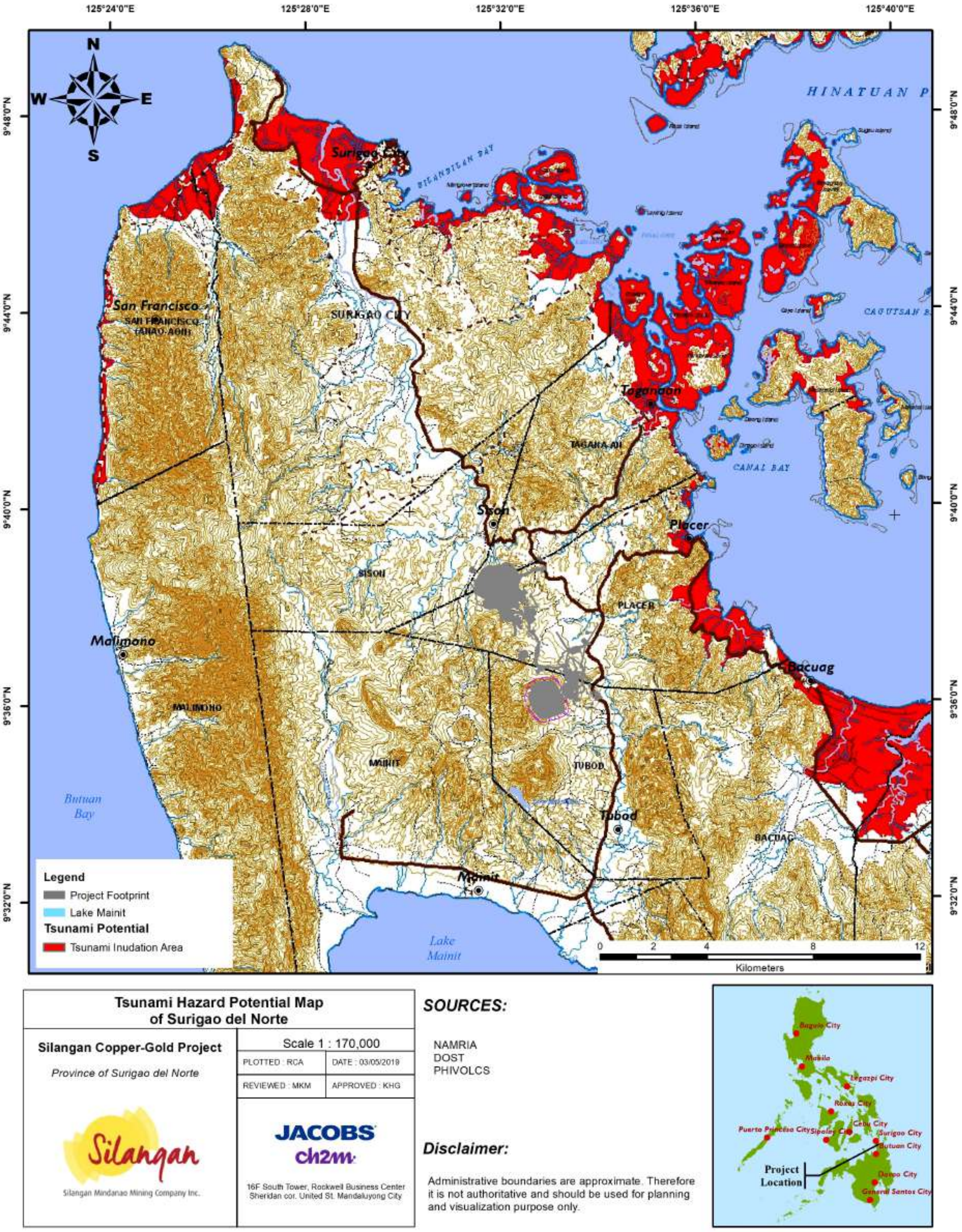


Figure 2.1-15 Tsunami hazard map of the Philippines

Weather-Related Hazards

Rain-Induced Landslide

Rainfall is the most common cause of landslides in the Philippines. Slope failures in hilly or mountainous areas are frequently reported following short rain showers, lengthy monsoon rains, or intense typhoon events. Saturation of slope soil alters the ratio between shear strength (friction and cohesion) and shear stress (weight of overlying material and slope angle) (Dellow, 2013). As the pore spaces between particles are filled with water during rain events, pore water pressure increases, producing hydraulic uplift that counteracts the weight of the material that contributes to slope stability. At the same time, water acts as a lubricant that reduces intergranular friction and cohesion, allowing the particles to slip more freely.

There are 3 rainfall patterns that trigger different types of landslides: (1) short duration, high intensity events such as sudden downpours that typically trigger very fast debris flows and flash flooding; (2) moderate duration and intensity typhoon rains that produce many shallow landslides and a few large landslides that rapidly fail; and (3) long duration monsoon rains with cumulative precipitation in excess of mean rainfall, that is often associated with the reactivation of pre-existing large landslides and a few rapid shallow failures (Dellow, 2013).

There is no comprehensive inventory of landslide occurrences within the project area that can be used for quantitative correlation between rainfall trends and slope failures. However, based on the generally accepted observation that landslides occur more frequently during periods with greater precipitation, it can be assumed that landslides may happen more often during this period. Using rainfall data from the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) synoptic weather station in Surigao City, cumulative monthly precipitation starts to increase during the month of October, reaches maximum values from November to March, and subsides in April. About one tropical cyclone passes through the region in a year. A more detailed discussion of the climatologic and meteorologic rainfall patterns in Surigao del Norte is presented in **Section 2.3.1.3**.

Geologic factors also contribute to the susceptibility of a slope to landslides. Substrates composed of unconsolidated grains or marked with distinct bedding planes, fracture sets, and fault zones can easily be infiltrated with water, which could further reduce shear strength and increase the likelihood of a landslide. Erodibility, and therefore landslide vulnerability can be affected by mineralogy of a lithologic unit. Rocks with considerable clay alteration are soft and more prone to weathering, whereas areas underlain with sturdy bedrock are less likely to fail. Chemical dissolution and mechanical weathering of carbonaceous deposits by water also increases the risk of slope collapse and sinkhole formation. In the Boyongan-Bayugo porphyry where the project is situated, there is considerable soil alteration over the volcanic deposits that generally underlie the area. Also observed within the project site are the presence of carbonate sinkholes and caves formed by underground rivers flowing through the Timamana Limestone. These geologic characteristics heighten the vulnerability of the project area to landslides and ground failure.

Slope gradient also influences failure susceptibility. The angle of repose, which is the steepest angle of descent or dip of the slope relative to the horizontal plane when material on the slope face is on the verge of sliding, varies according to the kind of substrates and if conditions are wet or dry. In lieu of detailed geotechnical assessment of slopes in the area, as a rule of thumb, slopes with smaller gradients are more resistant to landslide movement. The topography within the project area ranges from flat in the lowland valley, to steep towards the volcanic domes hosting the prospect. Slope rating based on digital elevation modelling classifies the slope gradients in the project area between very low (0 to 8% gradient) to very high (greater than 50% gradient) (**Figure**). Comparing the slope class map to MGB's rain-induced landslide and flooding potential map (**Figure**), areas classified as moderate to very high in the former, are declared as highly susceptible to landslides in the latter.

Table shows the slope gradient classifications and equivalent landslide susceptibilities within the project footprint and buffer areas as shown in **Figure** , based on spatial analysis of a digital elevation model (DEM) of the area. Visual comparison with the MGB rain-induced landslide and flooding potential map (**Figure**) shows that more are classified as highly susceptible to landslides in the MGB map compared to the DEM map. The MGB assessment represents a more stringent estimation of hazard exposure that would require a higher factor of safety on structures that will be erected within the area.

Table 2.1-12 Slope gradient and percent coverage of the project site

Slope Gradient	Landslide Susceptibility	Area in *ha*	Per cent %
Level to Nearly Level (0% to 3%)	Very Low	1,413.02	63.23
Nearly Level to Undulating (3% to 8%)			
Undulating to Rolling (8% to 18%)	Low	536.7	24.02
Rolling to Moderately Steep (18% to 30%)	Moderate	228.02	10.21
Moderately Steep to Very Steep (30% to 50%)	High	56.82	2.54
High Angle/ Very Steep (>50%)	Very High	0	0
Total		**2,234.56**	**100.00**

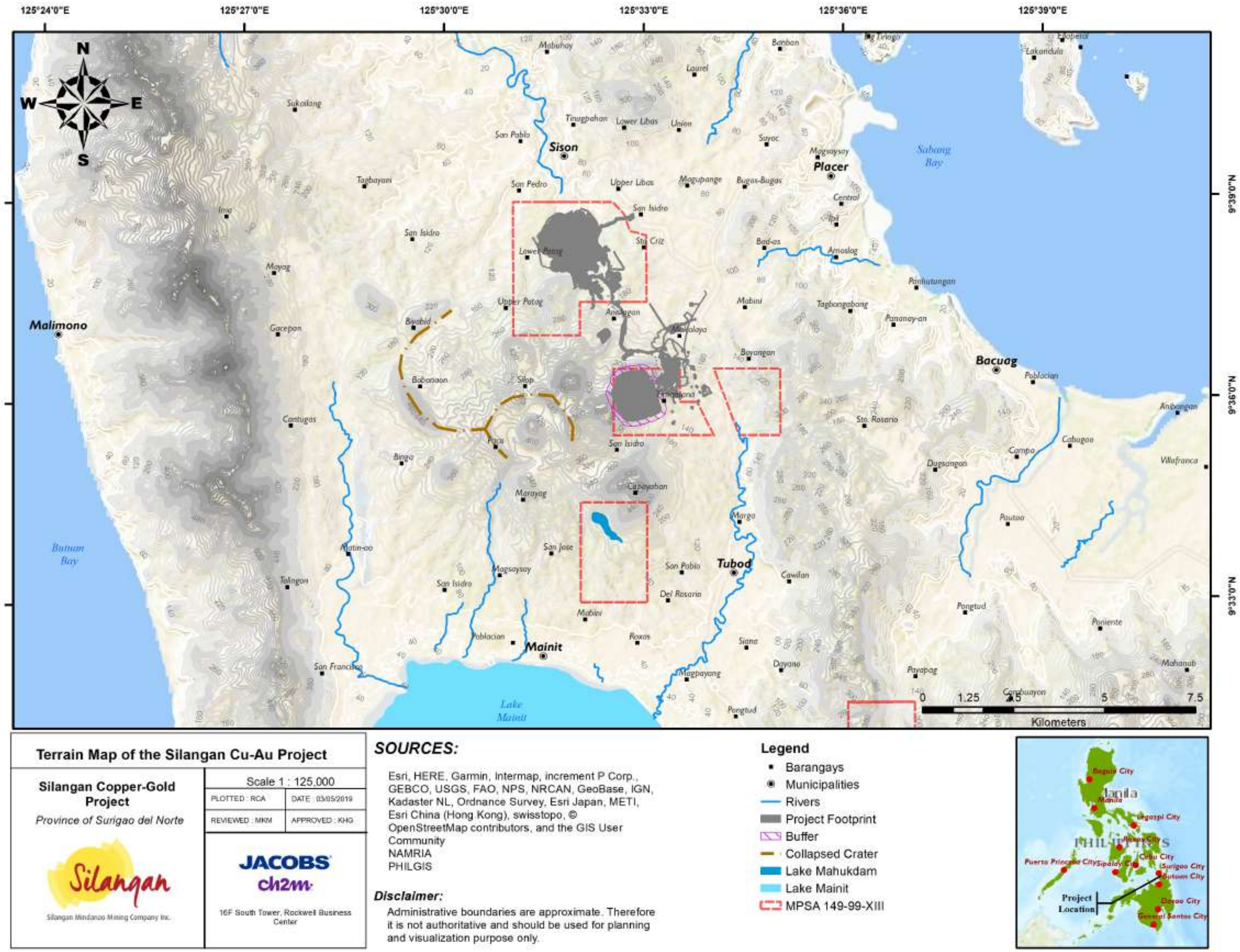


Figure 2.1-16 Terrain map of the Silangan Copper-Gold Project

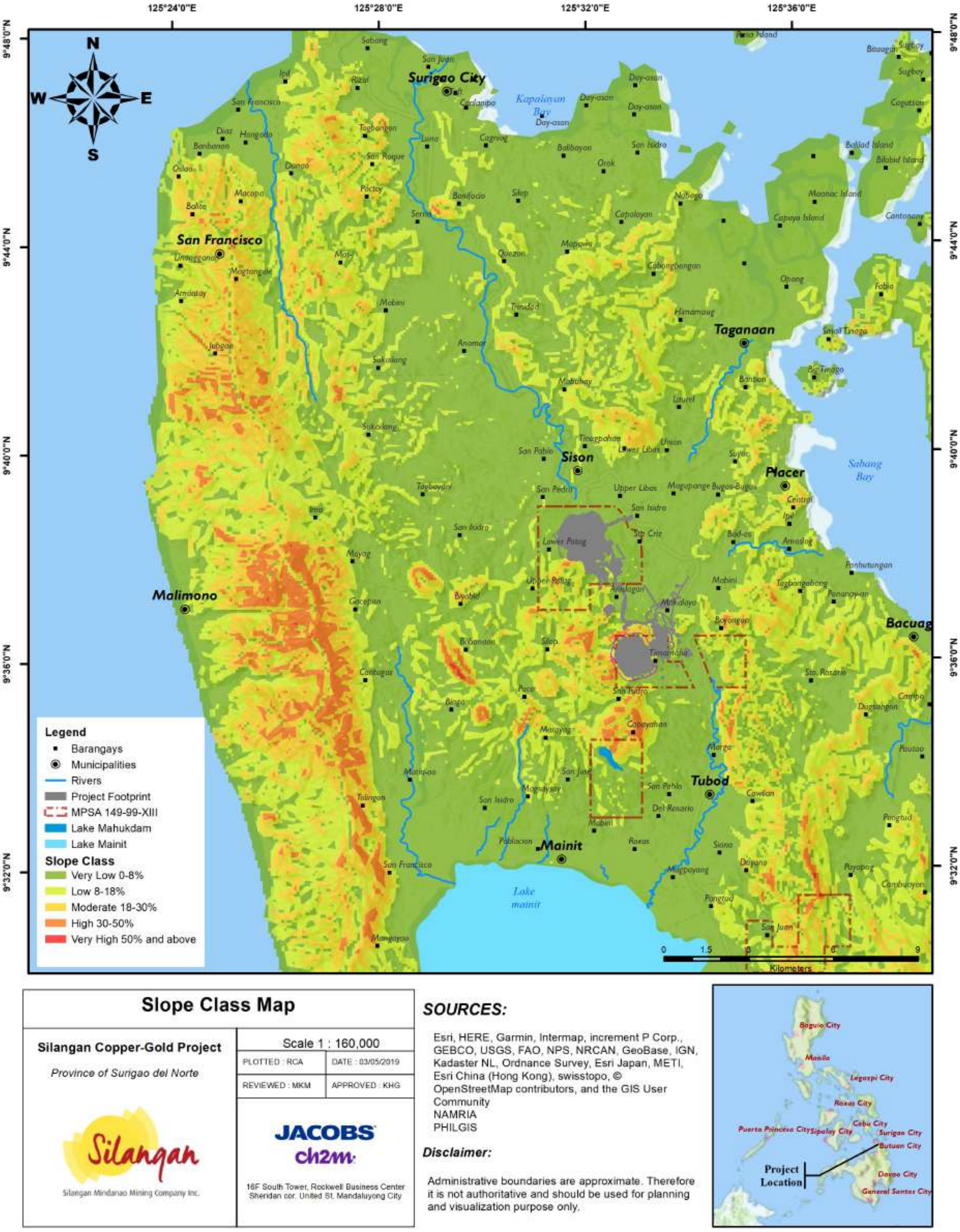


Figure 2.1-17 Slope class map of the Silangan Copper-Gold Mine Project

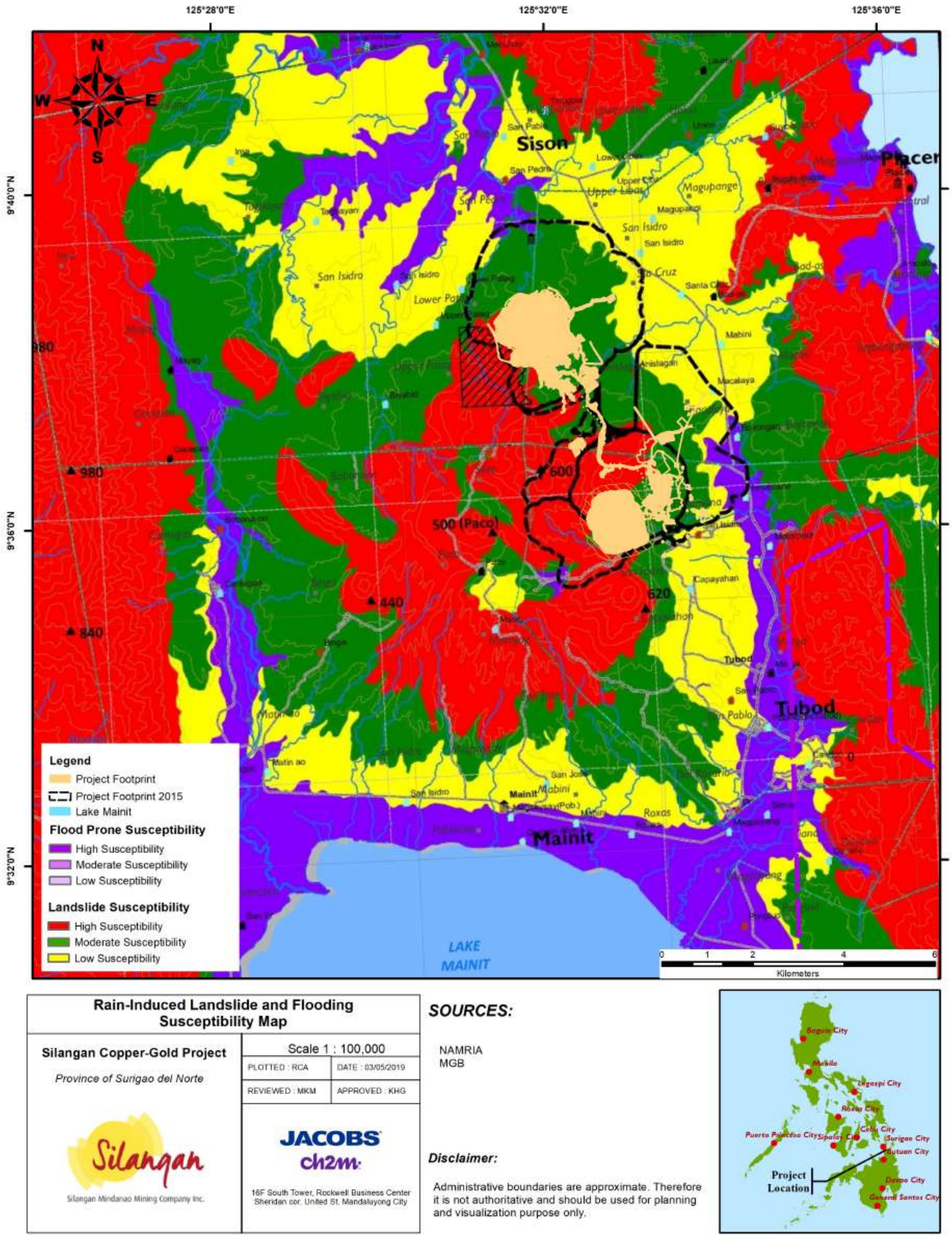


Figure 2.1-18 Rain-induced landslide and flooding susceptibility map of the Silangan Copper-Gold Mine Project

Flooding Hazards

Flooding is one of the costliest annual natural disasters in the Philippines, causing displacement of people and partial to complete damage to structures and properties. Aside from inundation by high water, flooding can also bring about torrential flows that collide with objects in its path, erode riverbeds and riverbanks, and deposit large amounts of debris. It is common in low-lying floodplains or along river channels following intense precipitation brought by typhoon or monsoon rains.

The presence of volcanic domes and eruption deposits around the Maniayao volcanic complex contributes to the loosely conical topography of the area, with a steep center radiating outward to flatter land. Due to this configuration, flood-prone areas are limited to the outermost portions of the volcanic complex, typically along the floodplains of Magpayang River to the east and Mayag River to the west, and on the coast of Lake Mainit to the south. The moderate to steep slopes of the rivers radiating outward Maniayao volcanic complex provides sufficient gradients for water to drain out rapidly to lower elevations, thus preventing the occurrence of extensive flooding along these channels. However, it can be expected for occasional flash floods to take place in these radial gulleys and river channels. Flooding risk is especially higher during months of maximum precipitation, from December to January.

Volcanic Hazards

Volcanic processes prior, during and succeeding eruptions give rise to numerous volcanic hazards that can have different types and magnitudes of impacts on people and property. Commonly known volcanic hazards such as lava flows, pyroclastic flows, lahars, ground rumbling, ashfalls, and volcanic landslides typically affect areas immediately surrounding active volcanoes where these originate. In less frequent instances, the effects of a volcanic eruption may reach great distances, especially if the eruption is powerfully explosive, and physical conditions are optimal for widespread dispersion.

There are no active volcanoes classified by PHIVOLCS around the project area. However, the area within the project site is largely volcanic in origin, derived from ancient eruptions of the inactive Neogene Paco resurgent dome within the Maniayao volcanic complex, located east of the Surigao Segment of the Philippine Fault. Indicating residual volcanic activity in area are the presence of warm springs with neutral alkali chloride waters (Barnet, Delfin, & Española, 1985) and fumarolic emissions (Smithsonian Insitution Global Volcanism Program, 2013). Such activities do not pose imminent threat to surrounding areas. There is, however evidence of volcanic edifice failure in the past. Terrain maps generated from satellite imagery show indications of at least two breached or collapsed calderas. Although dome collapse is unlikely because volcanism is not active within the site, rockfalls and landslides from steep volcanic edifices such as Paco volcano may potentially affect the area if massive slope failure occurs.

Differential Settlement

Substrate materials having different geomechanical properties from one another may have distinct weight-bearing responses when subjected to similar loads. If the ground in a particular area is composed of heterogeneous materials of varying thickness, the surface may settle unevenly, as some constituents may be more compressible to overburden stress than others. Voids, discontinuities and lithologic inclination may also contribute to horizontal variations in substrate strength. In almost all developments, some settlement can be expected after construction. Proper distribution of loads through careful engineering can prevent leaning or tipping over of structures which can lead to total structural destruction.

Differential settlement is especially critical in the design of the Tailings Storage Facility as well as at the Subsidence Area, underlain by various lithologies such as Maniayao andesites, andesite tuff, Tugunan clastics, Motherlode turbidites and alluvial deposits. In both project components, significant building up of load from tailings and waste rock will happen as extraction and processing of ore progresses throughout the mine life. Since the ground is underlain by heterogenous rock types, it is possible for these to behave differently under induced stresses from the operation of these components.

2.1.2.3.7 Climate Change Impacts Without the Project

With the assumption that the Silangan Copper-Gold Mine Project commences within the next few years, it is anticipated that the site will be exposed to the predicted effects of climate change as projected by PAGASA for 2020 and 2050. The PAGASA projections predict less rainfall in the medium-range scenario for 2006-2035 during the dry months, while an increase in rainfall is expected during the wet months. However, for the 2036-2065 medium-range scenario, there will be an overall decrease in cumulative rainfall throughout the year. In terms of extreme weather events, there will be an increase in the number of days having temperatures greater than 35°C, increase in days having less than 2.5 mm/day of precipitation, and increase in days with rainfall greater than 2.5 mm/day, for both period projections compared to the observed baseline. **Section 2.3.1.3** discusses in detail the climate change projections of PAGASA for Surigao del Norte.

The increase in the amount of precipitation and the intensification of extreme climactic conditions based on the PAGASA predictions is expected to have more significant effects on geologic hazards greatly influence by hydrologic processes. Flooding, seiches in lakes, and rain-induced landslides are geohazards triggered by excessive raining or extreme meteorological events. It can be presumed that the occurrence of these hazards would be enhanced with the anticipated climatological changes within the next few decades.

2.1.2.4 Potential Impacts and Options for Prevention or Mitigation or Enhancements for Geomorphology, Geology and Geohazards

2.1.2.4.1 Summary

Table 2.1-13 Potential Impacts and Options for Prevention or Mitigation or Enhancement – Geomorphology, Geology and Geohazards

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
Change in surface landform / geomorphology / topography / terrain / slope					
• The natural terrain of the area will be altered due to clearing, re-grading and construction of mine facilities. • The development of the sublevel block cave beneath the Subsidence Area will leave a shallow depression above the mineralized zone • The TSF will cover existing landforms and will elevate the topography. • The modification of the original topography will cause alterations to the hydrologic conditions in the area.		✓	✓	✓	• Careful planning of mine development will ensure that only necessary disturbance will be made. • The development of mine components like the Sublevel Caving, TSF and Process Facilities will be in stages. • An FMRDP will be prepared to provide an integrated approach in the geomorphic and topographic rehabilitation of disturbed land after mine closure.

Potential Impacts	Phases: Preconstruction	Phases: Construction	Phases: Operation	Phases: Closure	Options for Prevention or Mitigation or Enhancement
Change in subsurface geology / underground conditions					
• Excavation works displaces original surface and introduces new materials having different compositions and mechanical properties. • Buried geological materials are exposed to solar radiation, oxidation, hydrolysis, etc. during excavations, potentially affecting their composition and quality. • Underground stress regimes distributions are altered by the development of the Sublevel Caving and TSF, which could affect the stability and trigger geohazards. • Groundwater drawdown can be induced by the progress development of the Subsidence Area above the Sublevel Caving. • Loss of underground water flows and modifications to hydrologic systems may affect water supply to nearby caves and impact their natural development.		✓	✓		• Mine components will be carefully designed to incorporate stress contributions to the ground. The design will follow local and international engineering and environmental standards. • A systematic land stripping and ore extraction will be implemented to ensure minimum exposure of buried geologic materials to the elements. Pile protection may be used. • Non-reactive materials will be used as linings or building ingredients to prevent soil contamination. • The construction of the Underground Mine and TSF will be performed in stages to allow time for slope stabilization. • Surface diversion drains will redirect runoff water away from the mine components and into rivers. • Reduction of groundwater supply of users will be augmented from other sources. • The TSF will be fitted with monitors and will be regularly inspected for structural integrity. • Seepage into and coming from the TSF and Sublevel Cave will be controlled through drainage canals and seepage sumps to prevent oversaturation, excess erosion and AMD formation and release.
Inducement of subsidence, liquefaction, landslides, mud / debris flow, etc.					
• Dynamite blasting for the operations of the Sublevel Caving and extraction of ore will generate strong vibrations and shockwaves that could trigger the failure of unstable pit walls and ceiling collapses in nearby caves. • Excavations and rock/soil piling increases slope gradients which also heightens susceptibility to landslides. • Portions of the pit slopes are underlain by Maniayao Volcanics which are susceptible to weathering. Some strength parameters of the rocks such as friction angle and cohesion are time-dependent.		✓	✓		• A Blasting and Vibration Management Plan will be implemented to make sure that safety and environmental standards are during blasting activities. • Careful design and development of the mine components will be enforced. The dimensions of berms, piles and lifts will be specified for safety. • Progressive development of the Sublevel Cave and TSF will be observed. • As mining progresses, rock mass is unloaded and exposed to the atmosphere enhancing the physical and chemical weathering of rocks. Over time it is expected that time-dependent strength parameters of rocks such as friction angle, cohesion will

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
• Groundwater drawdown around the Sublevel Cave may induce subsidence at the nearby areas surrounding the Subsidence Area • Overburden from tailings in the TSF will press down on underlying foundation and may induce subsidence and differential settlement.					degrade while deformability and susceptibility to creep will increase. Therefore, assessment of time-dependent strength parameters be included in the development of engineering design and monitoring such as measurement of displacement of pit slope. • Surface and groundwater will be diverted from the mine components to prevent oversaturation, excess erosion and slope failure. • When deemed necessary, the installation of slope stabilization fixtures such as shotcrete, geotextile, weep holes, gabions, etc. will be considered. • The TSF will be regularly monitored for structural integrity.
Increase in flooding potential					
• Massive topographic disturbance caused by the TSF and Subsidence Area may cause the creation of new waterways which could experience flooding. • Discharges from the TSF spillway could trigger flooding in downstream areas. • Structural failure of the TSF may cause spillage of voluminous amounts of water and mine tails downstream of the dam.		✓	✓		• Surface diversion drains will be installed to channel runoff water away from mine components and into natural waterways located downstream. • Dewatering pumps will be installed within the Sublevel Cave and Subsidence area to control groundwater influx. Seepage collection drains will also be installed to collect water running off onto the surface. • The TSF will be designed to stand against a 100-year flood event. It will have an emergency spillway that can release excess water. The TSF design will follow local and international requirements. • Regular monitoring of the TSF will be conducted throughout its lifetime. • An Emergency Response Plan will be developed to handle unlikely occurrence of impoundment failure and downstream flooding.
Inducement of effects of seismic activity					
• Excavations within the Sublevel Cave may uncover structural weaknesses within buried rock units and may promote the formation of extension fractures that could further weaken the rock.		✓	✓		• The mine components will be designed and built according to local seismic conditions and in compliance to local and international safety requirements.

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
• Excess loads from the development of the TSF could cause shifting or movement along buried structural planes (i.e. faults).					• Appropriate runoff and seepage collection systems will be installed in the TSF and Sublevel Cave/Subsidence Area to remove excess water that could intensify earthquake effects. • Structural inspection and monitoring will be conducted during the operational lifetime of the mine components.
Generation of acid rock drainage					
• Rocks excavated from the Sublevel Cave may potentially form acids and metal leach that could be released in surface runoff or groundwater. • Failure of the TSF may release potentially acid-forming material that could generate acid rock drainage when sufficiently oxidized.		✓	✓		• Detailed acid generation and metal leaching potential of rocks will be performed to determine how these rocks can be properly stored. • Prior to construction, the physico-chemical properties of fill material for the TSF will be assessed and characterized in detail to determine material properties, suitability for use, ARD generation potential, and strength parameters. • The TSF will be fitted with seepage drains to capture contact water that could contain AMD or metal leach. The water can be directed to a seepage collection basin or a water treatment facility if tested to have potent acid or metal content. • Special linings may be installed in the TSF to provide added protection from AMD releases. • The TSF will be built according to design standards that incorporate appropriate levels of safety. They will be monitored regularly to ensure that breaching or collapses that can release AMDs will be prevented.
Enhancement of climate change impacts					
• Heavier rainfall could trigger larger landslides and more intense flooding within the Project footprint. • Water releases from the TSF may become more common as an effect of heavier rainfall. • More intense rainfall could make PAFs store more susceptible to acid mine drainage formation.		✓	✓		• All the mine components will be designed and built, taking into consideration the projected intensification of climate conditions in the next few decades. The TSF in particular will incorporate a freeboard and spillway capacity with an acceptable minimum flood design in mind. • An Emergency Response Plan incorporating climate change projections will be drafted and implemented.

2.1.2.4.2 Potential Impacts

Change in surface landform / geomorphology / topography / terrain /slope

The construction and operation of the different components of the mine project will bring noticeable changes to the original or existing topography and surface landforms within the footprint of the Project:

- The creation of new access roads that will serve as construction routes will involve cutting through slopes and flattening of cleared roadways.
- Initial stripping of land will be carried out to prepare development zones prior to main construction works. Excavations will be made to lay down building foundations. Some landforms may be cleared to create open space for construction. Slopes surrounding development sites may be re-engineered to maintain safety of operations in these areas.
- A Subsidence Area will gradually evolve from the Sublevel Caving operations which will leave a depression of about a 208 hectares at the end of mine life.
- Tailings from the ore refinement circuits will be stored in a Tailings Storage Facility (TSF). The development of the TSF will result in the construction of a dam that will be built on top of existing landforms and elevate the original topography where it will be constructed. Continued usage of the TSF will require periodic adjustments to its height to accommodate all the materials it will contain. This will further increase the elevation in the site.
- The modifications to the original topography as a result in the development of the TSF will cause alterations to the hydrologic conditions in higher elevations, subsequently changing the configuration of channels originating from affected slopes. At the same time, the gradual lowering of the Subsidence Area coinciding with the Sublevel Caving Operations may cause a drawdown of groundwater which may partially or completely cut-off water supply to natural springs or aquifers. This may also consequently impact the physical configuration of spring-derived drainage channels.

Change in subsurface geology / underground conditions

Aside from the noticeable changes the Project will bring to existing surface conditions of the geophysical environment of the project site, underground conditions will also be impacted by the construction and operation of the different mine components:

- Construction works for the laying down of foundations for the Process Plant, administrative components, access roads and other ancillary components, and installation of buried pipelines will displace the natural substrate with new material types having different compositions and mechanical properties than the original subsurface lithologies being replaced. Likewise, new material types will be introduced to the ground throughout the operational life of the TSF.
- Excavation works for the development of the Sublevel Cave and the TSF, as well as construction works for foundation-laying of the other mine components, exposes buried geologic materials to the surface. This increases vulnerability to oxidation, solar radiation, hydrolysis, etc. which could alter the chemical and mechanical properties of the substrate.
- The development of the Sublevel Cave and TSF will alter underground stress distributions within the immediate vicinity of these components.
- Groundwater drawdown will be induced by the progressive development of the Subsidence Area coinciding with the operations of the Sublevel Cave, since groundwater may flow into the Sublevel Cave,

and dewatering pumps will take out underground water that could otherwise freely flow into the subsidence area. Areas immediately surrounding the Subsidence Area will experience a noticeable but delayed drawdown as compared to farther areas. The lowering of groundwater levels will effectively decrease pore water pressure of the substrate and may induce subsidence. Surface and underground river channels fed by groundwater within the same hydrologic system may experience a reduction in water flows. The decrease in groundwater flows may impede the natural evolution of cave systems found in the vicinity of the Project.

Inducement of subsidence. liquefaction, landslides, mud / debris flow, etc.

Due to the changes effected on the existing geophysical conditions in the mine site by the project facilities and activities related to their construction and operation, secondary hazards may be induced:

- Dynamite blasting for the development and operations of the Sublevel Caving and the extraction of ore, will generate strong vibrations and shockwaves that could trigger the failure of unstable tunnel walls. This may also cause ceiling collapses in nearby caves and sinkhole formation in settlements established over karstic landscape.
- Excavations and rock/soil piling increases slope gradients which also heightens susceptibility to landslides and other types of slope failures.
- The formation of the Subsidence Area and Sublevel Cave induces decompression, increasing the risk of tunnel wall and slope failure. In addition, water seeping through the walls also increases pore water pressure, further heightening landslide risk. In areas immediately surrounding the Subsidence Area, groundwater drawdown at the Sublevel Cave will induce subsidence of the ground due the reduction of pore water pressure.
- Overburden from tails and waste rock in the TSF will press down on the underlying foundation and induce subsidence and differential settlement of the ground.
- Significant leakage/seepage from the TSF and possibly at the Subsidence Area as it progresses can promote bank and slope erosion which could trigger larger landslides. Downstream, increased sedimentation or siltation of drainage channels or settling ponds will be observed, as a consequence of heavy erosion.

Increase in flooding potential

The modification of hydrologic conditions by mine components and related mine infrastructure may increase flooding potential in some areas inside the project footprint:

- The Subsidence Area may serve as a basin for runoff and groundwater.
- Construction of the TSF and development of the Subsidence Area will alter the topography of catchment areas inside the project footprint, particularly the Timamana and Boyongan Creeks, and the Hinaga-saan River. This may result in the reduction of flows and river sediment yields which could change channel courses. Massive topographic disturbance in upper elevations may even cause the creation of new waterways which have not previously experienced floods or considerable water flows.
- Aside from storing mine tailings, the TSF is also envisioned to hold water in its embankment which will effectively reduce flows downstream of the dam. The TSF dam will be designed with a 100-year average recurrence interval (ARI) even it mind. However, should the rainfall amount exceed the 100-year event, the TSF may release excess water that could trigger floods in the downstream areas.

- Structural failure of the TSF may cause the spillage of voluminous amounts of water and mine tails downstream of the dam.

Inducement of effects of seismic activity

Large mine components such as the TSF, Sublevel Cave and Process Facilities have the capacity to enhance effects of seismic activities especially if these are poorly designed and constructed:

- Excavations within the Sublevel Cave may uncover structural weaknesses within buried rock units. The loss of overburden or lateral support may trigger a shift in internal stress configurations to one that is decompressional or extensional, possibly resulting in the formation of microfractures. During seismic events, shaking may further break apart rocks along these structural planes of weakness, inducing landslides.
- The TSF will involve the storage or piling of 90 MT of tailings. If there are any structural planes such as faults buried beneath these facilities, there is a possibility that the excess loads could cause some shifting or movements along these planes. This could be aggravated during strong seismic events.
- If the TSF is not sufficiently designed and built, there is a possibility of structural collapse during a sufficiently powerful seismic event. This will lead to spillage of mine tails and collected water unto lower-lying areas. Also, if an insufficient freeboard was considered in the design of the TSF, there is a risk of overtopping by intense seiche waves, making TSF walls and coastal areas vulnerable to this hazard.

Generation of acid and metal mine drainage

Because of the highly-mineralized nature of the ore rocks in the Boyongan-Bayugo porphyry, particularly the presence of a wide range of sulfides (pyrite and chalcopyrite) and Cu minerals (chalcocite and covellite) as inferred from conceptual geological models, exposure to sunlight, water or the atmosphere can lead to the formation of acid or metal leach that could mix with groundwater. Although initial geochemical assessment determined that the majority of the mined waste rocks comprised of Maniayao andesites is inert in terms of total sulfide and non-mineralised in terms of copper which presents a negligible risk in terms of acid mine drainage, some of the other mine waste such as debris flow breccia (RGS Environmental Pty Ltd, 2015), Tugunan mudstone, fluvial material and other sedimentary units, were tested to be potentially acid-forming (PAF). In addition, static and kinetic leach data verify the presence of soluble elements that can be leached from the materials into surface or groundwater. These metals include Al, As, Cd, Co, Cu, Fe, Mn, Sb and Zn. Copper will be the key element of concern because it is present at ore grade concentrations, can leach from the materials at a fairly neutral range of pH values (4.6 to 8.8) and may cause environmental harm to freshwater and saltwater flora and fauna even at very low concentrations (RGS Environmental Pty Ltd, 2015).

The TSF is being designed to provide permanent storage for non-mine wastes that could be PAF. Inadequate structural design may lead to the collapse of the TSF, potentially exposing PAF rocks to the elements and favoring the generation of acid and metal leachates.

Enhancement of climate change impacts

Aside from possible enhancements to the present geohazard vulnerability brought about by projected changes in global climates within the next few decades, the installation of the mine’s major components may further intensify these climate change impacts:

- Topographic and geologic disturbance by mine the large components such as the Subsidence Area/Sublevel Cave and TSF would increase the risk of landslides and slope failures especially during stronger weather events (i.e. intense precipitation) if these are not adequately designed, constructed and maintained.
- Barren, disturbed Subsidence Area and TSF slopes face even higher risk of erosion from climate change intensified rainfall. Consequently, this will cause higher sediment yields in rivers located downstream of these components.
- More intense rainfall events as a result of climate change may cause more frequent releases of water from the TSF, making floods more common along drainage channels downstream of the TSF.
- Climate change-related heavy rainfall may cause overtopping or spillage of water from the TSF which could contain acid mine drainage.

2.1.2.4.3 Options for Prevention, Mitigation or Enhancement

Change in surface landform / geomorphology / topography / terrain /slope

The creation of new access roads and development zones will be carefully planned to minimize, as much as practicable, the disturbance of landforms. Avoidance is usually the most basic step to achieve this. Building over existing routes or brownfield areas is always an option that will be considered.

Given the greenfield nature of most mining projects however, it is inevitable to have disturbance in various places within the project site. In these places, progressive development will take place. As much as practicable, slope re-grading and rehabilitation will be performed in conjunction with most clearing and stockpiling activities to ensure stability and visual aesthetics. Mine components such as the Subsidence Area/Sublevel Cave, Process Facilities and TSF shall be constructed in stages, in consideration of safety and appearance, aside from the mining program. Where progressive rehabilitation would be implemented, the methods and designs to be enforced shall be consistent with applicable regulations on mine safety and environmental sustainability.

Some of the planned mine components like the Subsidence Area and TSF are anticipated to alter topography which would consequently affect surrounding hydrologic systems. In river courses projected to have reductions in flows, drainage/seepage canals/galleries will be constructed to collect and direct runoff water from these mine components, to supplement discharge. The Sublevel Cave component beneath the Subsidence Area which is expected to attract seepage of groundwater and cause drawdown of underground water within the project site and surrounding areas, a dewatering system will be installed to pump out groundwater that could otherwise flood Sublevel sections even during operations as a consequence of groundwater inflow. Water from this dewatering system, as well as from the collection of drainage/seepage canals/galleries, will either be used for the mine's operational requirements, pumped into the TSF or discharged to natural streams/rivers after treatment, if necessary. Supplementary water sources will also be provided by SMMCI to stakeholders that rely on surface and spring water for their domestic and potable use.

Towards end of mine life and closure, engineering and environmental measures to rehabilitate the disturbed landscape, especially in the Subsidence Area and TSF, shall be implemented. Rehabilitation of these areas may either be through restoration to conditions that mimic the original, pre-Project aesthetics or use of the land, or re-purposing of the land consistent with post-mine use to be agreed and finalized as the Project progresses. A Final Mine Rehabilitation and Decommissioning Plan (FMRD) will be prepared to provide an integrated approach in the geomorphic and topographic rehabilitation of the disturbed land in preparation for the Closure Phase of the mine.

Change in subsurface geology / underground conditions

The disturbance of original soil and rock materials during the construction and excavation works for the mine exposes these materials to the surface where processes like oxidation, solar radiation, hydrolysis could affect their original characteristics. Progressive and systematic land stripping or excavation would minimize exposure of the soil or rock to the elements. Rock and soil piles using that will be subsequently used for slope rehabilitation or vegetation cultivation will be protected to preserve quality.

In the construction of mine components like the Process Facilities, buried pipelines or lined access roads, materials different from the original substrate will be introduced to the ground. To minimize risk of contamination or chemical alteration of the soil or rock, appropriate materials will be used for these components. These materials will be carefully selected to make sure that these are able to withstand stress conditions on the ground so incidences like leakage or seepage of contaminants will be prevented.

Large Depressed areas such as the Subsidence Area are expected to alter the subsurface conditions in the site, causing adjustments to subsurface stress regimes and groundwater flow. To manage this, programmatic development of the Subsidence Area through systematic ore extraction will be implemented in order to maintain stability and safety within and surrounding the site. Benches with appropriate heights and slope angles will be maintained to prevent failure. When deemed necessary, the installation of slope stabilization fixtures such as shotcrete, geotextile, weep holes, gabions, etc. will be considered. Dewatering pumps and runoff canals and galleries will be installed to control water accumulation within the Sublevel Cave. The loss of usable water brought about by groundwater drawdown as a consequence of the progress development of the Subsidence Area will be augmented by SMMCI from external water sources. However, the effect of the reduction or loss of water supply on cave development may be difficult to mitigate. As groundwater drawdown may affect the stability of ground surrounding the subsidence zone, a buffer zone will be established around its perimeter which will be declared as a no-development zone.

The overburden stress introduced to the ground by the storage of voluminous amounts of mine tail materials in the TSF promotes active deformation of the ground which will require careful design and regular monitoring and engineering mitigation. At the beginning, the TSF will be designed according to locally and internationally accepted specifications, incorporating appropriate factors of safety, to prevent occurrences of breakage or failure. As with the Sublevel Cave/Subsidence Area and TSF, these will also be developed in progression to allow ample time for ground to stabilize. Dam monitors such as accelerometers, piezometers and level gauges, may be installed to regularly check the structural performance of the TSF.

In the TSF, mine tails and waste rock contain excess moisture and possible substances like acid mine drainage and metal leaches that could seep through the underlying natural substrate, causing saturation or chemical contamination. Appropriate linings will be used as a preventive engineering solution to this. Underground seepage collection pipes, basin underdrainage systems and seepage collection sumps will be installed to collect and channel any water or chemical seepage that could escape. Constant monitoring of the seepage will be performed to check if appropriate chemical treatment will be needed prior to disposal. Regular soil and sediment sampling and monitoring will also be performed around the TSF to check for possible contamination and enforcement of necessary mitigation.

Inducement of subsidence. liquefaction, landslides, mud / debris flow , etc.

Strong vibrations and shockwaves from dynamite blasting for the extraction of ore, could trigger other hazards such as landslides, settlement, liquefaction and ceiling collapse. Because the Project will be utilizing a significant amount of explosives throughout its operation, a Blasting and Vibration Management Program (BVMP) will be developed and implemented to make sure that environmental and safety standards are met during blasting activities. The BVMP will contain protocols on the placement, type and amount of explosives needed to appropriately fracture rock as required in ore extraction, while ensuring the surrounding environment is not detrimentally affected by explosives discharge. The BVMP will also contain specifications on explosives storage, buffer zones and environmental standards.

The progress formation of the Subsidence Area increases susceptibility to landslides due to steepening of slopes, loss of lateral support, and the influx of groundwater overtime. To prevent failure of slope walls, benches will be established. The benches will have catch berms to capture seepage and runoff water. When deemed necessary, the installation of slope stabilization fixtures such as shotcrete, geotextile, weep holes, gabions, etc. will be considered. Dewatering pumps will also be installed in the Subsidence Area to draw out groundwater. A buffer zone established in the Subsidence Area periphery will be restricted of development to prevent loss of life or property in the event of a pit wall collapse.

Prior to construction, the TSF will be designed in accordance with locally and internationally accepted standards. It will be constructed in stages to allow for settlement and for the tails to accumulate and become part of the dam's support structure. Throughout its operation, there will be regular monitoring of the TSF's structural integrity, using monitors like accelerometers, piezometers and level gauges. Seepage collection sumps installed at the toe of the dam can prevent erosion that could cause failure of the embankment.

Increase in flooding potential

The topographic modification that will be caused by the construction and progressive development of the Subsidence Area and TSF will alter hydrologic regimes in the areas surrounding these facilities. Flow reductions will be anticipated in rivers flowing near these facilities, although there may also be inducements of flooding in other areas. To prevent this, water channels located upstream of these facilities will be diverted away from the major mine components, and into natural channels located downstream. Water seeping through or running off within the Subsidence Area will be collected by drainage canals and will be directed to either the mine's water circuit or unloaded to nearby rivers.

The Subsidence Area and TSF are particularly vulnerable to flooding since they will act as new catchment basins. Groundwater may contribute to the flooding potential of the Subsidence Area as the Sublevel Caving Progresses, so dewatering pumps will be installed around it to limit water influx into the depression. The TSF, on the other hand, will capture precipitation and runoff, so it will be designed to hold a 100-year flood event. The TSF will also have a spillway that can release excess water. The TSF's design shall comply with local and international requirements.

Since the TSF is essentially a dam, embankment failure can lead to flooding in areas located downstream from it. To lessen the chances of this happening, flood modelling will be performed to better understand flooding potential and allow for appropriate design. The design shall be according to site-specific conditions and must incorporate national and international standards on safety. Regular inspection and monitoring will be conducted to makes sure of its structural soundness throughout its operational life. An Emergency Response Plan will be developed for worst-case dam failure scenarios.

Inducement of effects of seismic activity

The proximity of the active Philippine Fault and Philippine Trench to Surigao del Norte makes the project site susceptible to earthquakes. Due to the scale of some of the mine's components, particularly the Sublevel Cave/Subsidence Area and TSF, these have the capability to further intensify the effects of earthquakes. To reduce potential seismic impacts, the facilities must be first designed and built to conform to international and local standards. Slope enhancement will be performed in highly vulnerable topographies.

Water saturated sediments are especially prone to landslides, liquefaction, and settlement. Therefore measures to drain the deposits of excess water will be performed. This will include seepage/runoff collection, groundwater dewatering and sediment compaction.

Structural monitoring is also essential in minimizing risk from Project-related inducements of seismic effects. Visual inspection is typically the first step in ensuring the structural soundness of the mine components. Regular monitoring also helps gauge the integrity of the structures. The TSF, in particular, will have monitors like accelerometer, piezometer and level gauges.

Generation of acid and metal mine drainage

Due to the natural chemical makeup of the rocks in the project site and high potential for exposure to air and water, acid and mine drainage formation can occur. To mitigate this impact, a detailed study of the acid and metal drainage forming potential of the rocks will first be conducted. Rock types identified to be potentially acid-forming will be permanently stored in the TSF which will be fitted with seepage drains to capture contact water. The water can either be directed to a seepage collection basin or to a water treatment facility that may be constructed if acid mine drainage (AMD) testing determines potency of the generated acids from PAF rocks. As an added protection against AMD, special linings may also be installed to prevent contamination with groundwater. The TSF will be constructed to national and international standards, and will be monitored regularly, to make sure that breaching or collapses that can release AMDs will be prevented.

Enhancement of climate change impacts

The design and construction of the Subsidence Area and TSF will take into careful consideration the climate change projections to prevent further intensification of the effects of climate change. The TSF, especially, will incorporate a minimum flood event design that will capture the more intense precipitation values predicted for the next coming decades. There must be sufficient freeboard and spillway capacity to anticipate heavier rainfall and stronger wind to prevent accidental overtopping and dam breaching.

An Emergency Response Plan integrating the eventuality of more intense weather events will also be drafted and implemented.

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Environmental Impact Statement

Section 2.1 The Land

2.1.3 Pedology

Table of Contents

2.1.3	Pedology	2.1-66
2.1.3.1	Methodology	2.1-66
2.1.3.2	Soils and Sediments Assessment	2.1-66
2.1.3.3	Baseline Environment	2.1-78
	Soil and Sediment Physical Characteristics	2.1-78
	2.1.3.3.1 Soil Fertility and Nutrient Content	2.1-81
	2.1.3.3.2 Geochemistry	2.1-82
	2.1.3.3.3 Soil Types and Land Capability	2.1-82
2.1.3.4	Potential Impacts and Options for Prevention or Mitigation or Enhancement	2.1-85

List of Tables

Table 2.1-14 Soil sample locations and coordinates

Table 2.1-15 Sediment sample locations and coordinates

Table 2.1-16 Parameters used in determining the physical characteristics of soil and sediment samples

Table 2.1-17 Parameters used in determining soil fertility of soil samples

Table 2.1-18 Parameters used in determining the geochemistry of soil and sediment samples

Table 2.1-19 Parameters used in determining the formation of an acid rock drainage of soil and sediment samples

Table 2.1-20 Geo-accumulation enrichment levels and range

Table 2.1-21 Potential impacts and options for prevention or mitigation or enhancement – Pedology

List of Figures

Figure 2.1-19 Sampling location map

Figure 2.1-20 Project area soil map after Mariano and Valmidiano (1972) and Alcasid (1995)

2.1.2 Pedology and Sediments

This section discusses the properties and characteristics of the overlying soils within the project site. The following information presents the baseline soil conditions, soil capability and a land suitability criteria to provide a reference in relation to the proposed underground mine development. In addition, stream and river sediment quality are evaluated for sediment baseline of river systems draining the study area.

The objectives of this study are as follows:

- Identify pedologic characteristics of the study area to evaluate the its capability and suitability in relation to the proposed project;
- Identify the potential impacts of the project to the existing soil conditions and present appropriate mitigation measures to address the potential impacts on the overlying soil; and
- Characterize the sediment quality of water bodies and establish baseline physico-chemical reference conditions.

2.1.2.1 Methodology

The preceding subsections below presents field and desktop procedures undertaken to gather soil and sediment sampling data, including laboratory results of collected samples from the study area, and incorporating relevant standards and guidelines for comparison and interpretation of results. .

2.1.2.2 Soils and Sediments Assessment

Field Survey

A total of 25 soil samples from 14 locations were collected across the study area during the field surveys conducted on 16-26 June 2012 and 8-9 June 2015 and are presented in **Table 2.1-1**. Soil test pits with depths of up to 1.2 m were established in areas where practicable, and other soil observation sites were collected at depths of about ~20 cm. Test pits with varying soil layers were described and physically analysed, and samples from each layer were collected. Morphological characterization of the soil was done based on secondary data from Alcasid (1995). Approximately five kilograms of sample were collected per site/per layer and kept in thick plastic bags tied with a rubber band and labelled accordingly.

About 29 in-situ sediment samples were collected from 22 locations across different rivers and waterways across the project area on 16-26 June 2012, 8-9 June 2015, and 5-7 February 2019 and are presented in **Table 2.1-2**. About two kilograms of sediments were collected and packed similarly with soil samples for laboratory analysis. **Figure 2.1-19** shows the locations of the different sediment and soil sampling sites and soil test pit sites.

Table 2.1-1 Soil Sample Locations and Coordinates

Location	Sample Names	Northing	Easting	Photo
Tagbayani (soil test pit)	TAGBASS01-A1-18062012	9.6539	125. 49236	
	TAGBASS01-B1-18062012			
	TAGBASS01-A2-18062012			
	TAGBASS01-B2-18062012			
San Isidro (Sison)	SANISSS02-A1-18062012	9.64614	125.50688	
	SANISSS02-A2-18062012			
Upper Patag	UPPERSS03-A1-19062012	9.64614	125.51216	
	UPPERSS03-A2-19062012			
Anislagan (soil test pit)	ANISLSS04-A1-20062012	9.6204	125.54968	
	ANISLSS04-A2-20062012			
Anislagan	ANISLSS05-A1-20062012	9.61702	125.53621	

Location	Sample Names	Northing	Easting	Photo
Ginub-An (soil test pit)	GINUBSS06-A1-20062012 GINUBSS06-B1-20062012 GINUBSS06-A2-20062012 GINUBSS06-B2-20062012	9.58275	125.53621	
Capayahan	KAPAYSS07-A1-20062012	9.58163	125.53621	
Sungkoy	SUNGKSS08-A1-21062012	9.55851	125.56077	
Boyongan	BOYONSS09-A1-21062012	9.61053	125.56786	
Bacuag (soil test pit)	BACUASS10-A1-22062012 BACUASS10-B1-22062012	9.52055	125.61746	
San Isidro (Tubod)	SANISSS11-08062015	9.584369	125.53915 3	

Location	Sample Names	Northing	Easting	Photo
San Isidro (Tubod)	SANISSS12-08062015	9.594263	125.55664	
San Isidro (Purok 4)	SANISSED10-A1-20062012 SANISSED10-A2-20062012	9.58967	125.54806	
Timamana	TIMAMSS13-09062015	9.596317	125.52975 9	

Table 2.1-2 Sediment sample locations and coordinates

Location	Sample Names	Northing	Easting	Photo
Tagbayani	TAGBASED01-A1-18062012	9.65365	125.48967	
Upper Patag	UPPERSED02-A1-19062012 UPPERSED02-A2-19062012	9.62394	125.50942	
Upper Patag	UPPERSED03-A1-19062012 UPPERSED03-A2-19062012	9.62628	125.51253	
Lower Patag (drilling site)	LOWERSED04-A1-19062012 LOWERSED04-A2-19062012	9.63976	125.52241	

Location	Sample Names	Northing	Easting	Photo
Upper Patag (Surigao River seds)	UPPERSED05-A1-19062012 UPPERSED05-A2-19062012	9.65575	125.52792	
Sison (Ima)	SISONSED06-A1-19062012	9.68725	125.50511	
Anislagan	ANISLSED06-A1-20062012 ANISLSED06-A2-20062012	9.6194	125.50511	
Bad-as	BADASSED08-A1-20062012			

Location	Sample Names	Northing	Easting	Photo
Ginub-an	GINUBSED09-A1-20062012 GINUBSED09-A2-20062012	9.58139	125.5347	
Capayahan	KAPAYSED11-A1-20062012	9.56183	125.26598	
Tubod (Brgy. Motorpool)	TUBODSED12-A1-20062012	9.58904	125.572	
Tubod	TUBODSED13-A1-20062012	9.55381	125.56808	
Cantugas	CANTUSED14-A1-21062012	9.59555	125.47351	
Matin-ao	MATINSED15-A1-21062012	9.54953	125.4785	

Location	Sample Names	Northing	Easting	Photo
Mapaso (Brgy. Magsaysay)	MAPASSED16-A1-21062012	9.54712	125.5079	
Mabini	MABINSED17-A1-21062012	9.54102	125.53772	
Timamana	TIMAMSED18-A1-21062012	9.59393	125.57036	
	SW-37SED	9.57195	125.57356	
Bacuag	BACUASED19-A1-21062012	9.5329	125.61284	
Upper Amoslog River	Bad-As-Placer	9.63083	125.57296	
Piakle-Hinapuyan Creek Junction	SW34 (Downstream TSF)	9.64987	125.53047	

Location	Sample Names	Northing	Easting	Photo
Mabuhay (Upper Surigao River)	SW13	9.67729	125.52153	
Boyongan Creek	SW-38	9.60897	125.56861	

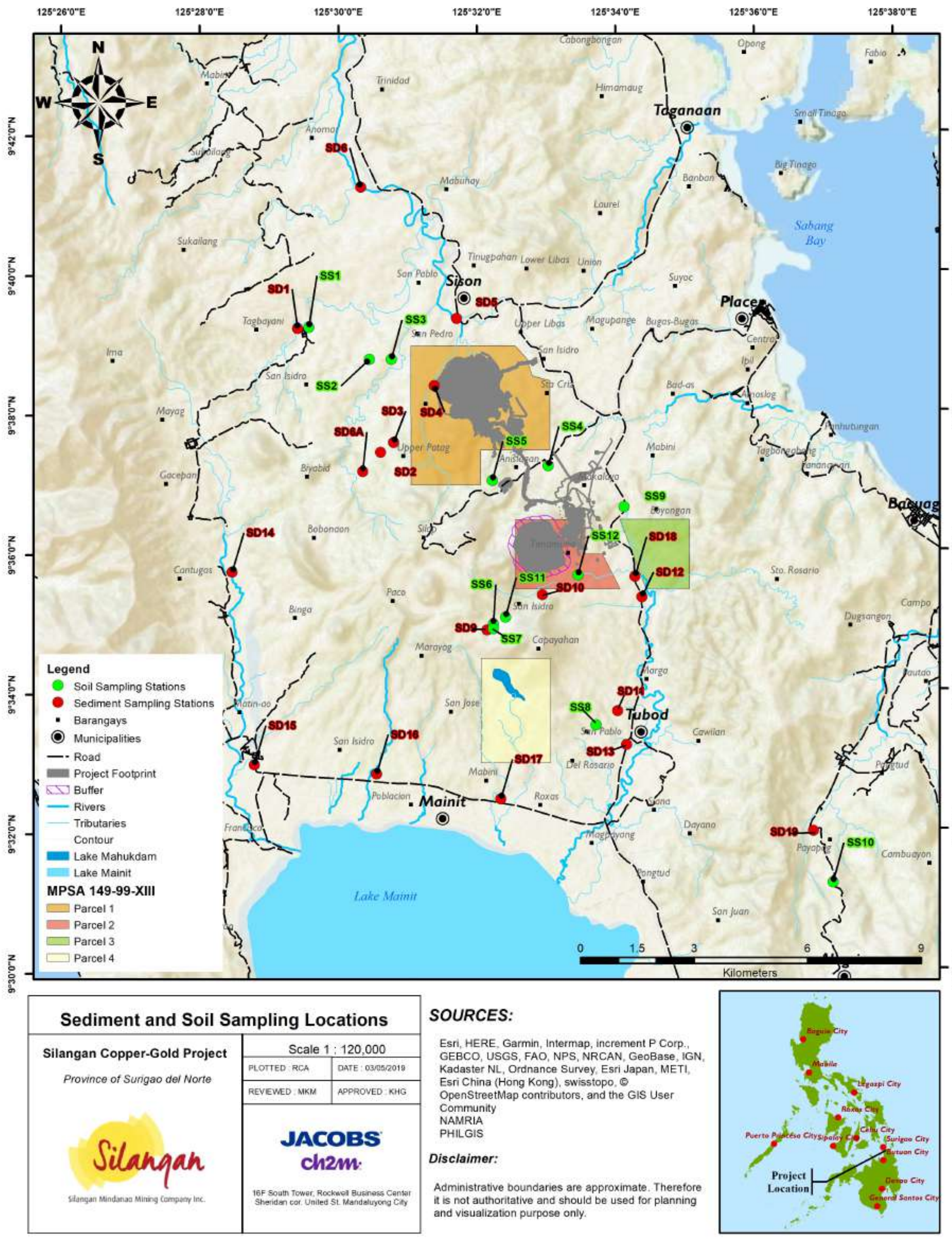

Figure 2.1-1 Sampling Location Map

Laboratory Analysis

Collected samples were analysed by CRL Laboratories (16-26 June 2012, 8-9 June 2015) and Ostrea Mineral Laboratories, Inc. (OMLI) (16-26 June 2012, 8-9 June 2015, and 5-7 February 2019) based on the parameters defined by **Table 2.1-3** to **Table 2.1-6**.

Table 2.1-3 Parameters Used in Determining the Physical Characteristics of Soil and Sediment Samples

Physical Parameter	Method/Purpose
Particle Size Analysis (PSA)	This procedure is used to determine the percent fraction of sand, silt, and clay in both soils and sediments using mechanical sieving and the hydrometer method. Determining the grain size percent also explains the nutrient retention; cation exchange properties; erodibility; permeability; sealing and drainage.
Moisture Content	Gravimetric procedure based on weight loss over a 12-hour drying period at 103ºC to 105ºC.
Bulk Density	The bulk density of the samples was measured at 25ºC using ASTM D854. It is the standard test of the American Society for Testing and Materials for determining the specific gravity of soil solids passing a sieve by means of a water pycnometer. It is used to estimate the density and porosity of the materials.
Soil Texture	Determination of soil texture for the soil samples was done using the USDA Soil Textural Triangle.

Table 2.1-4 Parameters Used in Determining Soil Fertility of Soil Samples

Soil Fertility Parameters	Method/Purpose
Total Nitrogen	Kjeldahl method
Nitrate	Nitrates were obtained using cadmium reduction method. The purpose of determining this parameter is to assess the nitrate supply of the soils.
Total Phosphate	Vanadomolybdophosphoric acid was used to determine the total phosphate amount in the samples.
Total Organic Matter	Obtained by gravimetric analysis. This parameter is a determinant of soil fertility and capability to deliver nutrients to plants
Cation Exchange Capacity	CEC was obtained by the ammonium acetate method. It is used to assess the soil's capability to hold nutrients for a period of time, and the ability of cations to exchange with other cations in the environment.

Table 2.1-5 Parameters Used in Determining the Geochemistry of Soil and Sediment Samples

Geochemical Parameters	Method/Purpose
Metals: Al, As, Cd, Co, Cr, Cu, Fe, Mg, Mn, Mo, Ni, Pb, Se, Zn, Hg	Metals were determined using flame atomic absorption spectroscopy (AAS). Data will be used as baseline environment values and utilized during monitoring periods to check for metal concentration changes in the environment.
Readily Exchangeable Cations: Ca, Mg, K	Flame AAS was also used to determine these parameters.

Table 2.1-6 Parameters Used in Determining the Formation of an Acid Rock Drainage of Soil and Sediment Samples

Acid Rock Forming Parameters	Method/Purpose
Neutralization Potential	The EPA Sobek Method was used to determine the neutralization potential of chosen soil and sediment samples. This parameter indicates whether or not soils or sediments are capable of neutralizing itself, even if total sulphur levels are elevated.
Total Sulphur	The turbidimetric method was used to analyze the total sulphur content of the samples. It is important to determine this parameter because elevated levels of sulphur may produce acidic solutions when mixed with water, which can infiltrate the ground and seep into the groundwater.

Quality Control Procedures

Annex 2.1-1 shows the reference Quality Control (QC) Data Report by CRL to ensure accurate and precise calibration of the instruments used for the experiments, as well as Instrument Calibration Certificates. OMLI on the other hand incorporates its reference QC in its Data Reports as indicated in the same Annex.

Data Analysis

The relative enrichment of heavy metals in soils and sediments were determined using Geo-accumulation indices referenced to the Average Shale Values (ASVs) in the absence of local values. Physico-chemical parameters were assessed in comparison with references from the United States Department of Agriculture (USDA) to determine soil classes. Land Capability was likewise assessed using the standard soil fertility values from the Bureau of Soils and Water Management (BSWM) of the Philippines.

Geo-accumulation Index

The I_{geo} is a quantitative measurement of pollutant enrichment levels in both soils and sediments. Ratings range from practically unpolluted to extremely polluted, based on the study by Müller (1981). The I_{geo} is calculated using the following formula below:

$$\mathbf{I_{geo} = \log_2 (Cn/1.5*Bn)}$$

where,

Cn = measured concentration

Bn = baseline concentration

The ASVs are used as baseline concentrations in the absence of baseline study on concentration of trace metals in sediments. The ASVs are acceptable approximations of baseline metal levels in sediments worldwide. The ASVs are based on the works of Turekian and Wedepohl in 1961, establishing the distribution of major elements from some major units of the earth's crust. Calculated geo-accumulation results are tabulated with a color code corresponding to the geo-accumulation pollution classes of Müller (1981). Note that the term pollution, used in the context of geo-accumulation, pertains to natural or background enrichment levels of the element. It does not refer to the introduction of pollutants or contaminants through anthropogenic means. The colors used for the assessment are presented in **Table 2.1-7**.

Table 2.1-7 Geo-accumulation Enrichment Levels and Range (Muller, 1981)

Pollution Class		I_{geo}
Practically unpolluted		$I_{geo} < 0$
Unpolluted to moderately polluted		$0 < I_{geo} < 1$
Moderately polluted		$1 < I_{geo} < 2$
Moderately polluted to strongly polluted		$2 < I_{geo} < 3$
Strongly polluted		$3 < I_{geo} < 4$
Strongly polluted to extremely polluted		$4 < I_{geo} < 5$
Extremely polluted		$5 < I_{geo}$

Soil Classification

The soil samples were classified using the Soil Map of the Philippines (Mariano, 1964), General Soil Map of the Philippines (Alcasid, 1995) published by the Bureau of Soils and Water Management (BSWM), and the Metadata of Soils in Southeast Asia and the Philippines by the ISRIC World Soil Information. Secondary data were supplemented by soil physico-chemical characteristics obtained from the surveys to validate and correlate previous soil classifications. Previous classifications by soil groups an texture were refined and updated using the USDA Soil Taxonomy Guide (1999) to determine the recent soil sub-order or great group equivalents. Available information was also correlated with the USDA soil orders to determine the major soil types. Natural drainage class for each soil class was correlated with the USDA hydrologic group.

Land Capability Classification

The land capability classifications were made based on the guidelines for arability and land capability categories prescribed by the National Soil Survey Handbook (NCRS-USDA, 2008) and Food and Agriculture Organization (FAO). Land capability was also determined based on the soils' physico-chemical characteristics, slope and landform association, and current land use. Supported vegetation types, hydrologic class, slope, and usage were sourced from the USDA Soil Taxonomy Guide (1999).

2.1.2.3 Baseline Environment

Soil and Sediment Physical Characteristics

The parameters assessed for soil physical characteristics include bulk density (g/mL), moisture content (%), particle size distribution (% clay, sand, and silt), and soil texture. For sediments, particle size distribution and texture parameters were assessed. Bulk density is the representative soil mass divided by its occupied volume and is not an intrinsic property of the materials. It can change depending on how the soil material is handled. Soil bulk density greatly depends on the soils' mineral composition and its degree of compaction. Samples exhibiting greater bulk density may possess greater mineral and organic content. The moisture content indicates the amount of water which the soils can hold. Soils with uniform particle size typically drain easily as opposed to soils with a high variation of particle sizes. In addition, soils with higher moisture content indicate the presence of clay minerals capable of adsorbing water in their matrix. Particle size distribution determines the percent content of different grain sizes found in the soil matrix, typically represented by sand, silt, and clay fractions. Sand has particles defined within the range of 2.0 mm to 0.063 mm while silt has 0.002 mm to 0.063 mm. Clay, being the smallest grain size particle, is less than 0.002 mm ($\leq 2\mu m$). Particle size distribution is also a determinant in identifying the infiltration rate of water into the soils. If the soil matrix contains a higher percent of clay particles, the soils will have a slow infiltration rate as opposed to the matrix which contain higher amount of sand particles.

Particle size distribution is also a basis to identify the soil's capability or sufficiency to support plant life. It is favorable if soils have moderate amount of clay minerals and particles as these can sustain sufficient moisture and carry soil nutrients, which exchange in cation form across the matrix because of the charged nature of the clay mineral. For sediments with higher clay content, this is a good test matrix for water pollution as heavy metals in the water get adsorbed on the clay present in the sediments. This is because of the clay's property to attract cations into its matrix because of its negatively charged surface. Soil texture is based on the USDA Soil Textural Triangle used to group together soils and sediments with varying grain sizes under collective names. This is done to present an easier depiction of the percent composition of soils and sediments. **Annex 2.1-2** shows the USDA Soil Textural Triangle.

The results of the PSA, moisture method, bulk density, and soil texture for soils and sediments are summarized in **Annexes 2.1-3** and **2.1-4**.

Particle Size Distribution and Soil Texture

Based on the particle size distribution of the soils, the soil texture of the samples falls within the ranges of loam, sandy loam, silt loam, and silty clay loam. This indicates that the land use for these areas is agricultural and can support cash crops such as coconut trees, small fruit-bearing shrubs, and grasslands for livestock grazing. For sediments, it falls under the categories of loam, loamy sand, and sand.

Sand

Sands are generally consisting of loose and non-aggregated grains. It feels gritty to the touch and do not adhere to each other hence, it is not sticky. Materials classified as sands must contain 85-100% sand-sized particles, 0-15% silt-sized particles, and 0-10% clay-sized particles. These percentages are based on the boundaries of the sand portion of the USDA textural triangle, as well as the modified Udden-Wentworth grain size scale.

Loamy Sand

Loamy sands on the other hand consist of material containing 70-90% sand, 0-30% silt, and 0-15% clay. It resembles sands as they are also loose and non-aggregated. However, since they contain a slightly higher amount of silt and clay compared to sand, loamy sands are slightly cohesive when moist and can be readily formed compared to sand. Sediments classified as loamy sand is also typically described as clayey sand according to the modified Udden-Wentworth scale.

Sandy Loam

These materials contain less sand, more silt and clay, than loamy sands. They possess characteristics which fall between fine-textured sandy clay loam and coarse-textured loamy sands. Most of the individual sand grains can still be seen and felt but sufficient amounts of silt and/or clay make the soil coherent therefore casts can be formed that may withstand careful handling without breaking.

Loam

Loam is described as a soil material having medium texture. It contains a relatively even mixture of sand, silt, and clay. Loam tends to be soft and friable and it is fairly smooth and slightly sticky and plastic when moist to the touch. This is because of the clay particles present in the loam. With its small size, high surface area, and high physical and chemical activity, it can greatly influence the soil characteristics than does sand or silt.

Silt Loam

Silt loam is composed of small amounts of sand clay and mostly contains silt-sized particles. When silt loam is dry, it is often relatively heavy and clumpy but can be easily broken between the fingers, after which its texture feels soft and flour-like. Moist silt loams feel soft and smooth in between fingers and will not leave residues on the hand.

Silty Clay Loam

Silty clay loam closely resembles clay loam in its cohesive properties but possesses more silt and less sand. Because of this, it has a smooth feel to the touch. Small amounts of sand particles are also present and are generally fine and difficult to detect. It also possesses intermediate characteristics between silty clay and silt loam. When wet, it is sticky and plastic, firm when moist and form casts which are hard when dry.

Sandy Clay Loam

Sandy clay loam is a soil material that contains 20-35% clay, less than 28% silt and 45% or more sand. It has a very gritty feel to the touch. When dry, soil aggregations break away easily without staining on fingers, clods crumble with applied pressure. And when wet, forms a ball with well-defined finger marks, light to heavy soil/water coating on fingers.

Soil texture is important to be determined as it influences many other soil properties that may be of great significance to land use and management. Soils with high sand content tend to be low in organic matter and native fertility. Thus it has low ability to retain moisture and nutrients. As the relative percentage/s of silt and/or clay grain sizes increase, soil properties are increasingly affected as well. Soils and sediments with finer textures are generally more fertile, contain more organic matter, have higher cation exchange capacities, and are more apt to retain moisture and nutrients. It also has a relatively low infiltration rate, which is good for vegetation planted in this type of soil. However, when soils become too fine-textured and are classified as clayey, they become too sticky when wet and too hard when dry to cultivate.

Bulk Density

The bulk density of the soil samples fall within the range of 0.82 g/mL to 1.65 g/mL. Bulk density is dependent on soil texture and the densities of the soil mineral and organic matter particles, as well as their packing arrangement. In agriculture, it can indicate the porosity and structure characteristics of the soil. The soil's structure is significant because it can determine air and water movement through the soil; it can affect cultivation and tillage practices; and it controls surface runoff and erosion. Platy structure normally obstructs free drainage while sphere-like structure (crumbly and granular) facilitates drainage. Crumbly and granular structure gives optimum infiltration, water holding capacity, aeration, and drainage. This structure also serves as a good habitat for microorganisms that provide nutrients to the plant. In addition, bulk density also serves as a measure of degree of soil compaction, which provides a comparative basis to indicate the strength of similar materials. One of the most important factors agriculturally in terms of bulk density is plant growth. If the soil has a high bulk density (compaction) the seed will be restricted in emergence and root growth which will, in turn, affect the total plant growth and yield.

Based on **Annex 2.1-5** bulk densities above the values stated impair the function of root growth. Almost all of the soil samples taken from varying locations within the project site on the other hand exhibit the ideal bulk density for plant growth given their soil texture. This means that root growth function is not impaired in the sampling sites and the soils are generally viable for agricultural use.

Moisture Content

Moisture content present in the soil samples range from 3.75% to 41.31%. Soils with moisture contents that are optimum for plant growth can readily absorb soil water. Soil water dissolves salts present in the soil and creates a solution that is important because it is the medium that supply nutrients to growing plants. Moreover, soil water regulates soil temperature and aids in the chemical and biological activities of the soil. It is a principal constituent for plant growth as it is used in photosynthesis. The optimum water content for plant growth is dependent on the site conditions and plant species.

2.1.2.3.1 Soil Fertility and Nutrient Content

Annex 2.1-6 summarizes the soil fertility and nutrient standards of the BSWM while **Annex 2.1-7** presents the nutrients and metals content of the study samples compared with the BSWM guide levels.

The total organic matter (TOM) concentrations of the soil samples predominantly fall within the favourable category. Copper and zinc concentrations similarly fall within the adequate category. Copper is significant for plants for photosynthesis and conversion of carbohydrates, proteins and other enzymes. Copper, if bio-available, also has a positive impact in terms of strengthening plant cell wall and increases the storage ability for sugars. Zinc, in addition to enhancing plant growth rate, also aids in the metabolism of nitrogen to produce proteins and starch (Ascot, 2003). Most of the phosphorus, iron, manganese and potassium contents of the samples taken from different parts of the study area however generally fall under the ‘deficient’ category. Iron is important because its aids in photosynthesis, respiration, nitrogen fixation and assimilation, and DNA synthesis (Briat, 2005). Manganese, on the other hand, is needed to increase the soil’s oxidation potential and promotes plant growth (Smiley et al., 1986). Potassium is necessary for photosynthesis, carbohydrate transport, water regulation, and protein synthesis. Proper potassium nutrition in plants leads to improved disease resistance, vigorous vegetative growth, and increased in drought tolerance. Consequently, potassium fertilization is frequently associated with improved crop quality as well as better handling and storage properties. Plants deficient in potassium are stunted and develop poor root systems.

The BSWM does not have any criteria for the rest of the metals and macronutrients analysed in this study. Desirable macronutrient levels for soils from the Agricultural Project of South Australia, which has nearly similar conditions for soil mineral levels and moisture to the Philippines, is presented below as reference guidelines (**Annex 2.1-8**).

Based on these guidelines, nitrate and phosphorus levels of the soils within the vicinity of the project are adequate or more than the common crop requirements. Nitrogen in soils is essential because it is a fundamental part of the chlorophyll molecule and is essential in the formation of amino acids and proteins in plants. Plants obtain this from soil as inorganic nitrate and ammonium ions in soil solutions. Soils with high nitrate content in their matrix can administer nitrogen into the plant, and a good supply of this is associated with fast growth and a deep green color in the leaves. Plants deficient in nitrogen typically appear stunted and appear yellowish. Phosphorous may be required in lower amounts compared to other major nutrients, however it is highly needed during the early developmental stages of growth and in energy transfer within the plant throughout the growing season. Studies show that phosphorous stimulates young root development and earlier fruiting in plants. It is also essential in photosynthesis, respiration, cell division, and many other plant growth and development processes.

Cation Exchange Capacity (CEC) refers to the efficiency at which soils can adsorb and exchange cations such as calcium, magnesium, and potassium. Since CEC is an actual measure of the exchange capacity of the nutrients, it can be directly correlated with soil fertility and nutrient retention capacity. Soils with CECs higher than 15 cmol(+)/Kg are considered inherently fertile while soils with CECs less than 5 cmol(+)/Kg are considered infertile. All soil samples analysed have CECs in excess of 15 cmol(+)/Kg making the soils within the vicinity of the project favourable for cultivation.

Exchangeable Sodium Percentage (ESP) refers to the sodium fraction adsorbed on soil particles expressed as a fraction of the cation exchange capacity. Non-sodic soils have ESP values of less than 6 while sodic to very strongly sodic soils have ESP values of 6 to 25. Non-sodic soils are expected to have good soil structure for plant or crop growth. ESP values of soils analysed from the project site are too low to be detectable.

2.1.2.3.2 Geochemistry

All soils naturally contain trace levels of metals hence the presence of metals in soils is not a clear indication of contamination. Varying metal concentrations in uncontaminated soils is primarily related to the geology of the parent material from which the soils were formed. Depending on the local geology, metal concentrations in a soil may exceed the ranges listed in **Annex 2.1-9**. The use of common ranges or average concentration of trace metals in soils as an indicator whether it is contaminated or not is inappropriate since the local concentration of metals in specific soils may fall short or exceed the listed ranges. However, with the use of the geo-accumulation index (I_{geo}) developed by Müller (1981), the quantitative measure of the pollutant enrichment levels in soils and sediments can be rated. Alongside this, the Average Shale Values (ASV) are used as baseline concentrations of trace metals in soils and sediments. These values are based on the studies of Turekian and Wedepohl in 1961 which established the distribution of major elements from different major units of the earth's crust. ASVs are acceptable approximations of baseline metal levels in sediments worldwide.

In **Annexes 2.1-10** and **2.1-11**, quantitative results of the metal concentrations for the different soil and sediment samples taken at the site are tabulated where most of the prominent concentrations are those of magnesium and nickel. Magnesium displays a range of 176 ppm to 10,400 ppm while nickel ranges from 9.7ppm to 454 ppm. Though some metal concentrations were below detection limit such as antimony, cadmium, mercury, and arsenic for the sediment samples, prominent metal concentrations such as magnesium and nickel were detected, ranging from 178 ppm to 20,400 ppm and 8 ppm to 271 ppm, respectively

From the I_{geo} formulated by Müller, all soil and sediment samples in different locations exhibit practically unpolluted metal concentrations except for nickel and magnesium in sampling stations Tagbayani and Piakle-Hinapuyan Creek Junction (moderately polluted for soils and unpolluted to moderately polluted for sediments), San Isidro in Sison (moderately polluted to strongly polluted soils), and Cantugas (moderately polluted sediments). Such values indicate a high enrichment of nickel in the soil which may be attributed to the mineralogic composition of the rocks. The Upper Surigao River also (SW-13) also indicated a moderately polluted condition for copper and could be indicative of weathered runoff from the surrounding mineralized rock units. Geo-accumulation indices of the soil and sediment samples are enumerated in **Annex 2.1-12** and **2.1-13**.

The ore and its host rock contain the minerals, (malachite, azurite, and cuprite). The identified sulphides associated with the ore are chalcopyrite and bornite. Pyrite comprises < 1% of the ore. The amount of arsenopyrite is negligible. Results of the Sobek and pH tests for the sediment and soil studies within the project site also show that gangue materials possibly are non-acid forming.

2.1.2.3.3 Soil Types and Land Capability

Most of the soils sampled in the vicinity of the project are categorized as Inceptisols and Ultisols (Mariano and Valmidiano, 1972; Alcasid, 1995) (**Figure 2.1-20**) A contiguous soil morphological map from the test pit and soils sampling data cannot be generated because the assignment of the sampling stations is based on the location of the facilities alone. In addition the soil profiles appear disaggregated given the terrain conditions. However, the data presented in the EIS are correlated with secondary data from the maps of Alcasid et.al (1995) and current FAO global or regional soil map data (2011).

Modifications for this report are made taking into consideration that the Inceptisols identified in the area are volcanic in origin. Previously (pre-1989) soils of similar characteristics to Inceptisols were categorized under this soil order but under the suborder Andepts or Andisols. In the 1999 USDA classification, Andisols are considered as a soil order on its own and will be thus treated as such for this report. The entire area of the Subsidence Zone and facilities are underlain by this soil type.

Ultisols are clay-rich with low to moderate nutrient richness that is naturally suitable for forestry or cultivation. These soils occur in areas that experience a higher rate of precipitation than evapotranspiration. Extractable bases and aluminium are also typically high as seen in the analytical results for macronutrients and aluminium. Ultisols typically form in areas of moderate to intense weathering and are derived from rocks of mostly Pleistocene age (Maniayao Andesite and associated volcanics). Andisols normally form in areas of moderate to high weathering (mountain slopes and river valleys) to areas of deposition (floodplains and lowlands) where relatively unweathered materials are deposited. It is noted that the entire TSF and nearby areas are overlain by Ultisols, of which the current land in these areas are dedicated to coconut plantations and subsistence rice or grain cropping.

Ultisols have relatively lower soil fertility compared to Andisols. The lower inherent productivity of Ultisols is mainly due to the high aluminium content. Productivity may be improved with the addition of fertilizers and lime. Andisols are considered highly fertile and suitable for cultivation. However, the limited soil profile development particularly in terrain with greater than 18% soil gradient may prove to be a problem with continuous farming thereby requiring additional measures to ensure continued cultivation and long-term stability.

Based on the physical characteristics, nutrient levels, CEC, ESP, and soil types, the land capability for the project area and its vicinity is classified as Class II-III. Class II to III soils are described to have minor to moderate limitations that require moderately intensive management practices to ensure productive cultivation. Class II to III soils also have minor to moderate limitations in terms of crops that can be grown, and land uses that can be adapted adopted. Class II to III areas are typically can be used for grazing/ pasture land, crop cultivation, and forestry.

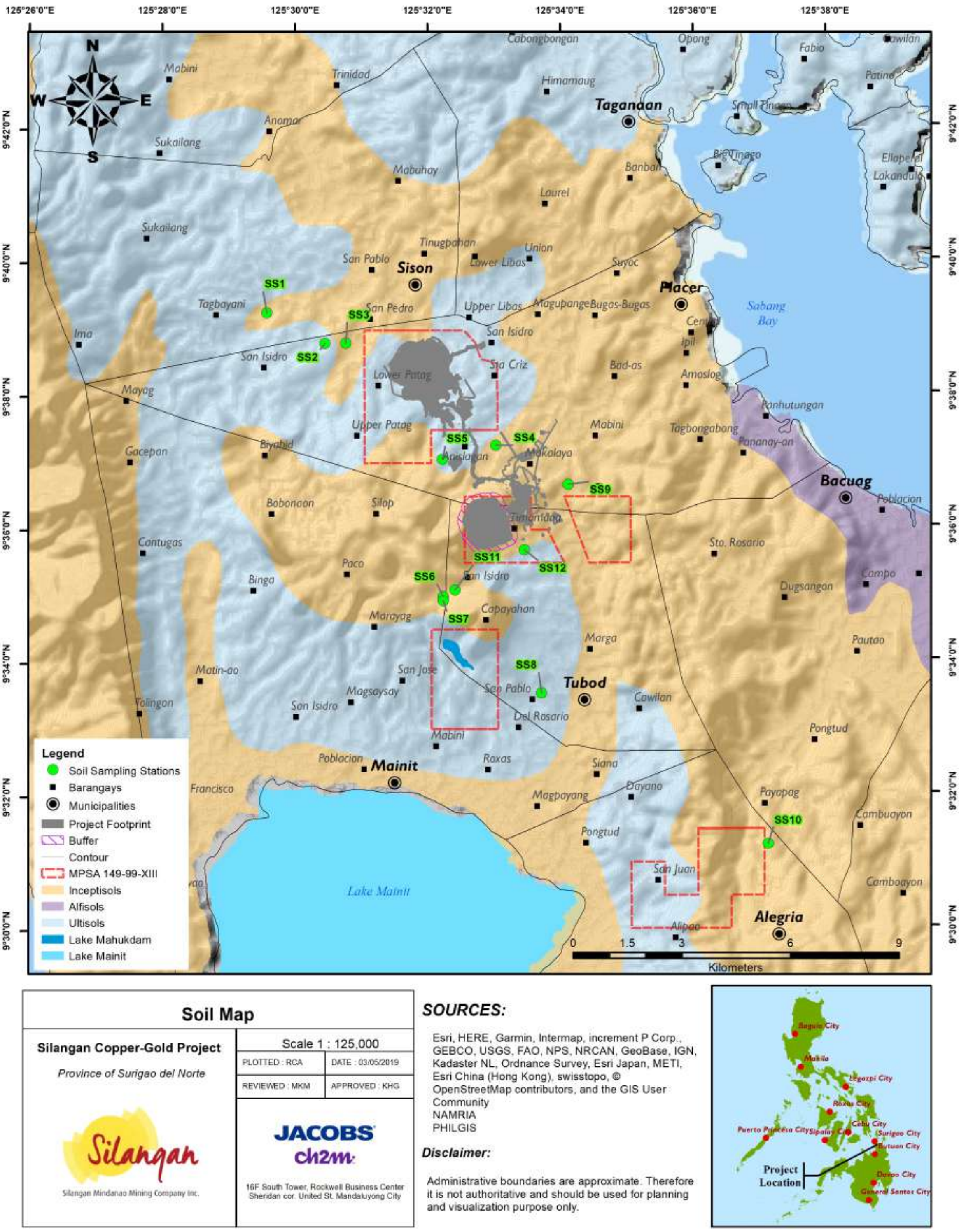

Figure 2.1-2 Project Area Soil Map after Mariano and Valmidiano (1972) and Alcasid (1995)

2.1.2.4 Potential Impacts and Options for Prevention or Mitigation or Enhancement

The potential impacts of the Project to the baseline soil physico-chemical characteristics and land capability of the project-impacted areas during each project phase and the corresponding control and mitigating measures are presented in **Table 2.1-8**. Most of the impacts identified are related to erosion and downstream or down slope sedimentation as a consequence of activities and movement associated with construction and operations, soil disturbance at the surface associated with the development of the Underground Mine, soil loss at the Process Facilities and TSF, soil and sediment contamination from improper waste disposal, accidental spills and change in soil quality.

Table 2.1-8 Potential Impacts and Options for Prevention or Mitigation or Enhancement – Pedology

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
Soil erosion / loss of topsoil / loss of overburden					
• Earthworks, construction activities, and movement of heavy equipment will weaken and induce the natural erosion susceptibility of the soil cover particularly for areas with > 18% slopes or critical slopes.		✓	✓		• At any given time, the mine will stockpile soils not exceeding 20,000 cubic meters in volume or about 0.3 hectares in area. In order to prevent soil erosion, these stockpiles will be conserved for use in backfilling, roadworks, landscaping and revegetation activities.
• Downstream sedimentation and increased soil erosion may occur during mine development activities particularly on ground clearing and preparation, the removal of topsoil in development areas such as the TSF and facilities, and various earthmoving activities.		✓	✓	✓	• Ground preparation and clearing will be conducted progressively to minimize the total area of soil cover and land that will be disturbed at any one time, where practical. • Soil conservation will be undertaken for soil material that will be removed from development areas for re-use during closure. • Placement of Erosion and Sediment Control (ESC) facilities to manage downstream sedimentation
• Removal of soil will occur within the areas covered by project-related infrastructure such as in the Process facilities, appurtenant infrastructures and TSF since these facilities will require various degrees of topsoil disturbance		✓	✓		• Progressive soil rehabilitation will be conducted in disturbed or cleared areas that will not be used for further development over the course of the project to reduce the potential amount of soil cover that may be exposed and eroded. • Soil conservation are recommended to be undertaken for soil material that will be removed from development areas for re-use during closure.

Potential Impacts	Phases: Preconstruction	Phases: Construction	Phases: Operation	Phases: Closure	Options for Prevention or Mitigation or Enhancement
• Erection of ancillary facilities and service roads will also involve varying degrees of earthwork and soil removal.		✓	✓		• Soil material removed during disturbance activities are recommended for post-mine rehabilitation in areas where post-mine land use will be undertaken, such as cultivation or agro-forestry. • It is recommended that a detailed Topsoil Management Plan (TMP) be developed and implemented prior to construction. The TMP will address topsoil stripping methods and depths, stockpiling, the development of topsoil inventories for the Project's rehabilitation activities. • Decommissioning of relevant project-related infrastructure and restoration of disturbed areas will be conducted at closure in accordance with the project's rehabilitation and closure plan and the FMRDP. This will include the rehabilitation and soil respreading and re-grading at closure to match the surrounding landform. • Surface erosion and consequent downstream sedimentation will be managed using erosion and sediment control facility and infrastructure. These controls include the re-grading of the soil stockpile to stable configurations, installation of drainage networks or channels within the vicinity of stockpile and work areas to channel surface run-off away from cleared or work areas, installation of sumps or sedimentation ponds at the bench toes of work areas within the pit and in critical slopes or slopes with >18% gradient, installation of silt traps or sediment control devices such as coconut matting when needed, and application of erosion permaculture measures such as the planting of vetiver grass and related shrubbery in soil stockpile areas.
Change in soil quality / fertility					
• Soil quality will decrease in the progressively rehabilitated areas if not managed appropriately		✓	✓		• TMP will be developed and implemented prior to construction. The TMP will address topsoil stripping methods and depths, stockpiling, the development of topsoil inventories for the project site, re-spreading, soil amelioration, dressing and seedbed preparation.

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
• Soil quality in the recommended soil stockpile may decrease due to unfavourable conditions in storage and stockpiling and erosion and consistency loss during storage.		✓	✓	✓	• Stockpiled soil quality will be improved through conservation management programs and soil quality improvement processes during stockpiling to reduce, if not prevent, soil degradation during the storage period.
• Soil quality may be impacted due to passage of vehicles and heavy equipment passing over soil-covered areas over the course of the project.		✓	✓		• Soils in rehabilitated sites will be subject to re-spreading, amelioration, and seedbed preparation prior to revegetation to improve soil quality • Vegetative cover will be used during rehabilitation to expedite and enhance the recovery of soil quality. Rehabilitated sites will be conditioned prior to seeding with native trees, shrubs, and grass (where applicable) to enhance successful germination and improve plant survival rate. • Vegetative species that will be used are those that are endemic to the area or highly tolerant of recovering or marginal environments.
Enhancement of climate change impacts					
• Intensified rainfall events would increase leaching rates in well-drained soils with high infiltration rates, and would cause temporary flooding or water-saturation, hence reduced organic matter decomposition, to many soils of low-level areas brought by excavation and other earthmoving activities within the project site.		✓	✓	✓	• Employ flood mitigating structural measures that include dams, channel levees and construction of proper drainage and canals in flood prone site. Continuous progressive rehabilitation should be ready at hand where practical to minimize deforestation once operation starts.
• Increased rainfall due to climate change could lead to significant increases in runoff, which would result to higher susceptibility to soil erosion and soil loss, leading to negative impacts on water-holding capacity, pH, organic matter content, total nitrogen, and soluble phosphorus in the soil.		✓	✓	✓	• An Erosion Control Plan, incorporating Best Management Practices should be implemented to manage erosion in all development/construction sites that would include details on soil excavation slope and surface drainage management and stockpiling requirements.

DRAFT

Environmental Impact Statement

Section 2.1 The Land

2.1.4 Terrestrial Ecology

Table of Contents

2.1.4 Terrestrial Ecology 2.1.4.1
2.1.4.1 Process and Methods 2.1.4.1
2.1.4.2 Prior Informed Consent Certificate (PICC) and Gratuitous Permit (GP) 2.1.4.1
2.1.4.3 Methodology 2.1.4.2
2.1.4.4 Baseline Environment for Terrestrial Ecology 2.1.4.8
2.1.4.5 Results and Discussions 1072.1.4.13
2.1.4.6 Potential Impacts and Options for Prevention or Mitigation and Enhancement 2.1.4.42

2.1.4 Terrestrial Ecology

This section presents the terrestrial ecology (i.e. vegetation and wildlife) assessment conducted in the project site. It aims to establish baseline information relating to vegetation (particularly angiosperms, gymnosperms and pteridophytes) and wildlife (particularly amphibians, reptiles, birds and mammals) including the determination of the potential ecological impacts that may arise from the preconstruction, construction, operation and closure phases of the Project. Further, this also aims to provide mitigation and/or enhancement measures to eliminate/minimize detrimental impacts and/or sustain positive ones. The assessment was prepared based on the approved Technical Scoping Checklist / Screening Checklist in line with the EIA process of the Project.

The objectives of the assessment are:

- To perform field surveys of vegetation and wildlife to be used as indicators of the current ecological condition in the project site;
- To describe existing ecological values within the project site that may potentially be affected;
    - Vegetation – vegetation types or communities, species inventory, species richness, species diversity, local distribution, abundance, dominance, evenness, endemicity, conservation status, and economic importance and use.
    - Wildlife – species inventory, species richness, species diversity, distribution range, abundance or general population status, habitat association, dominance, evenness, endemicity, conservation status, and economic importance and use.
- To identify potential impacts of the Project to the ecological values within and the immediate vicinities of the project site; and
- To recommend site specific measures to mitigate potential impacts to ecological values.

2.1.4.1 Process and Methods

Prior to the conduct of field surveys, the terrestrial ecology assessment considered the following:

- Project Description (PD) and other project related information provided by SMMCI;
- Locations of development facilities (e.g. tailings storage facility, subsidence zone, processing mill, haul road and other support facilities);
- Mine development plan;
- NAMRIA 2010 vegetation map of the project site; and
- Vegetation categories as defined in the DENR Memorandum Circular (MC) 2005-05 entitled "*Adopting Forestry Definitions concerning Forest Cover/ land Use*";

The abovementioned information were considered to determine and establish:/

- The location and number of representative transect lines/sampling points/quadrats for the Project based on size, location and development facilities and corresponding development plan;
- The existing vegetation cover within and the immediate vicinities of the project site as classified by NAMRIA (2015) using standardized forestry definitions for forest cover/ land use as stipulated in DENR MC 2005-05;
- Safety and security protocols being implemented by SMMCI; and
- Safety condition/s within the identified transect lines/sampling points/quadrats.

The vegetation and wildlife survey locations were focused mainly within the boundaries of the project site and immediate vicinities (e.g. distinct habitat type and/or ecotourism area proximal to the project site). Field surveys were conducted from July to August 2012 (i.e. July 20, 2012 to August 31, 2012 for vegetation, and July 22, 2012 to August 11, 2012 for wildlife). Moreover, follow-up field surveys were conducted from June 3 to 9, 2015 and February 15 to 18, 2019 to cover additional areas due to change in mining method and inclusion of other facilities. Subsequent data processing and ascertaining of species identification of the collected samples (applicable only to vegetation) followed the field surveys. No wildlife specimens were collected for this assessment. A total of 22 vegetation quadrat and 20 sampling strip locations, and 9 terrestrial wildlife transect sites were surveyed. All field surveys conducted represent mainly the wetter season of the year in Surigao del Norte (Modified Coronas Climate Classification, 2007).

2.1.4.2 Prior Informed Consent Certificate (PICC) and Gratuitous Permit (GP)

As part of best practices of SMMCI, individual Prior Informed Consent Certificates (PICC) from the project affected Municipalities of Sison, Placer, and Tubod were secured prior to the conduct of field data collection. The PICCs were issued by the mayors and the municipal council through a resolution after project presentations (i.e. overall context where this assessment will fall-in within the EIS, why the need to conduct this assessment, specific methods to be employed, location of transects relative to proposed development facilities and vegetation cover, length of field assessment, local guide requirements from the municipality and barangays, and possible specimen collection and their repository). The secured PICCs together with SMMCI's company profile, general project description and terrestrial ecology research proposal were submitted to the Department of Environment and Natural Resources (DENR) - Protected Areas, Wildlife and Coastal Zone Management Services (PAWCZMS) Region 13 to support the requirements of SMMCI's GP application. Finally, a project presentation to DENR - PAWCZMS Region 13 detailing the proposal was conducted on July 3, 2012. The GP (GP # R13-2012-006 SMMCI) for SMMCI's terrestrial ecology assessment was issued on July 16, 2012 (**Annex 2.1-14**).

Any terrestrial ecology assessment to be conducted, as part of a scientific research or any Environmental Impact Assessment (EIA) in support of an ECC application, is required to secure a GP pursuant to the provisions of Republic Act 9147 of 2001 (Wildlife Resources Conservation and Protection Act) and its Implementing Rules and Regulations (IRR) as stipulated in DENR Administrative Order No. 2004-55 prior to any field data collection.

2.1.4.3 Methodology

2.1.4.3.1 Terrestrial Vegetation

Terrestrial vegetation assessment of the project site was conducted by a team of ecologists from Pro-Seeds Development Association and Jacobs Projects Philippines Inc. The said assessment was done to establish baseline vegetation condition (e.g. species composition and structure, vegetation types or communities, etc.) in the project site, to determine potential impacts of the project, enumerate appropriate mitigation measures and propose management strategies. The sections below describe the methodologies employed to assess vegetation condition, and present/ discuss key findings.

<u>Description of Quadrats and Sampling Strips</u>

There were five distinct vegetation communities identified in the project site. Some are remnants of naturally occurring dense vegetation in the past several decades (i.e. residual and/or secondary growth forest, brush and shrublands, and grasslands) while others are highly modified vegetation brought by past and on-going anthropogenic disturbances (i.e. agricultural areas, agroforests and open areas including built-up portions). A distinct and unique vegetation type (i.e. forest over limestone) located outside of the project site was also included in the assessment. It is situated in the chain of lowland hills of Barangays Marga, Mabini and Boyongan in the Municipality of Tubod. It was included to cover potential secondary impacts of the Project to said vegetation type.

The vegetation assessments were completed using quadrat sampling in 2012, strip sampling in 2015, and quadrat and opportunistic sampling in 2019 at pre-selected sites within and the immediate vicinities of the project site. Quadrats and sampling strip locations were distributed in areas projected to be directly (inside the project area) and indirectly (outside the project area) impacted by the Project. Sampling stations located in the project site include F13, F15, F16 all sampling strip locations (VS1 to VS20) while those outside are F1, F2, F3, F4, F5, F6, F9, F10, F11, F12 and F14. The geographical locations and general habitat description of each quadrats are shown in Table 1. In addition Table 2, presents the geographical locations of the sampling strips.

Table 2.1.4 -1 Geographical Locations and General Description of the Flora Sampling Quadrats during the Field Survey in 2012

Quadrats	Latitude	Longitude	Elevation (masl)	Locality	General Habitat Description
F1	9˚34'8.829"	125˚34'40.10"	124.42	Brgy. Marga, Municipality of Tubod, Province of Surigao del Norte	Disturbed limestone forest with some portions planted to coconut (*C. nucifera*). Some tree species composed of *Pometia* sp., *Ficus* sp., *Sterculia* sp. and *Melanolepis* sp. were noted.
F2	9˚32'52.42"	125˚31'41.93"	77	Brgy. San Isidro, Municipality of Mainit, Province of Surigao del Norte	Primarily a coconut (*C. nucifera*) plantation interspersed with *molave (Vitex parviflora), Trema* sp., *Villebrunea* sp. and *Canarium* sp.
F3	9˚34'2.62"	125˚32'39.50"	255.47	Brgy. Capayahan, Municipality of Tubod, Province of Surigao del Norte	A combination of falcata (*P. falcataria*) coconut (*C. nucifera*) and banana (*Musa* sp.) plantation along slope.
F4	9˚34'45.04"	125˚32'47.85"	372.68	Brgy. Marga, Municipality of Tubod, Province of Surigao del Norte	Mainly a coconut (*C. nucifera*) plantation located on a slope. Some areas with isolated stands of molave (*V. parviflora*).

Quadrats	Latitude	Longitude	Elevation (masl)	Locality	General Habitat Description
F5	9˚34'34.38"	125˚34'36.80"	149.42	Brgy. Marga, Municipality of Tubod, Province of Surigao del Norte	A heavily degraded limestone forest with regenerating stands of *Phaeanthus* sp., *Nauclea* sp., *Dysoxylum* sp. and *Ficus* sp.
F6	9˚35'14.98"	125˚34'36.29"	108.01	Brgy. Motorpool, Municipality of Tubod, Province of Surigao del Norte	A limestone forest composed mainly of *Alectryon sp.*, *Ficus sp., Diospyros sp., Euonymus sp.*, *Dysoxylum sp.* and *Firmiana sp.*
F7	9˚35'17.25"	125˚32'28.49"	298.59	Brgy San Isidro, Municipality of Tubod, Province of Surigao del Norte	A down slope area near a small stream. It is overtopped by a large *Pterocarpus sp.* but mainly composed of planted bamboo (*Bambusa sp.*) and *Artocarpus sp.*
F8	9˚35'37.04"	125˚32'29.64"	468.10	Brgy. Timamana, Municipality of Tubod, Province of Surigao del Norte	A sloping residual forest in an abandoned logging road. Rattans are abundant. Recorded trees are composed mostly of *Pterocarpus sp.*, *Turpinia sp.*, *Alstonia sp.*, *Macaranga sp.* and *Adenanthera sp.*
F9	9˚36'20.39"	125˚34'34.28"	159.9	Brgy. Boyongan, Municipality of Placer, Province of Surigao del Norte	This site is mainly coconut (*C. nucifera*) plantation near limestone forest. Trees observed were mostly tibig (*Ficus nota*), *Mallotus sp., Semecarpus sp., Dysoxylum sp.* and *Leea sp.*
F10	9˚35'57.37"	125˚32'55.39"	289.43	Brgy. Timamana, Municipality of Tubod, Province of Surigao del Norte	A secondary forest following the edges of a coconut plantation located along a barangay road. Tree recruits composed mostly of *Pometia sp.* and *Litsea sp.* were noted.
F11	9˚36'30.10"	125˚31'37.38"	422.04	Brgy. Silop, Municipality of Sison, Province of Surigao del Norte	A coconut (*C. nucifera*) falcata (*P. falcataria*) plantation located on a slope. Recorded trees are mostly composed of *Paraserianthes sp.* and *Artocarpus sp*.
F12	9˚36'27.70"	125˚32'12.85"		Brgy. Timamana, Municipality of Tubod, Province of Surigao del Norte	This site is a drill area located on a ridge top which is approximately 90% open. It is planted with mangium (*Acacia mangium*) and falcata. (*P. falcataria*). Residual trees recorded were mostly composed of *Lithocarpus sp*.
F13	9˚37'39.78"	125˚32'10.96"	128.77	Brgy. Anislagan, Municipality of Tubod, Province of Surigao del Norte	A coconut (*C. nucifera*) plantation with regenerating thickets of *Vitex sp., Ficus sp., Petersianthus sp., Astronia sp.* and *Sterculia sp.*
F14	9˚37'22.82"	125˚31'22.65"	234.63	Brgy. Upper Patag, Municipality of Sison, Province of Surigao del Norte	A coconut (*C. nucifera*) plantation interspersed with *Cananga sp.* and *Artocarpus sp.*
F15	9˚38'14.90"	125˚32'7.02"	130.22	Bgy. San Isidro, Municipality of Placer, Province of Surigao del Norte	A coconut (*C. nucifera*) falcata (*P. falcataria*) plantation with *Petersianthus sp.*
F16	9˚38'12.50"	125˚31'33.44"	78	Brgy. Lower Patag, Municipality of Sison, Province of Surigao del Norte	A fairly flat area along a stream. The understorey was noticeably cleared. Trees along the stream are mostly composed of *Pterocarpus sp., Teijsmanniodendron sp.,white*

Quadrats	Latitude	Longitude	Elevation (masl)	Locality	General Habitat Description
					lauan (*Shorea contorta*) *and Elaeocarpus sp.*
F17	9°36'2.20"	125°32'53.29	313	Brgy. Timamana, Municipality of Tubod, Province of Surigao del Norte	Heavily disturbed area located beside a riverbank. Vegetation dominated by banana while majority of the understorey species are *Elatostema* sp. [Urticaceae], *Sphaerotastephanos* sp. [Thelypteridaceae], *Donnax canniformis* [Marantaceae], and *Phrynium* sp [Marantaceae].
F18	9°36'0.00"	125°33'8.31"	249	Brgy. Timamana, Municipality of Tubod, Province of Surigao del Norte	Relatively undisturbed vegetation in a sloping area. Surface of the area is mainly covered by rocks. Wildlings of *Saurauia clementis* [Actinidiaceae] dominates the intermediate and understorey. High canopy species such as *Shorea contorta* [Dipterocapaceae] was also observed.
F19	9°36'14.99 "	125°33'17.52 "	202	Brgy. Boyongan, Municipality of Placer, Province of Surigao del Norte	Generally, a vegetation with a dense canopy cover located in a sloping area covered by litter. Tree species such as *Shorea contorta* [Dipterocapaceae] and *Gironniera celtidifolia* [Cannabaceae] was observed to be the most frequent. *Canarium asperum* [Burseraceae] wildlings dominate the intermediate layer.
F20	9°36'39.77 "	125°33'18.06 ""	201	Brgy. Macalaya, Municipality of Placer, Province of Surigao del Norte	Located within a riverbank with vegetation composed mainly by coconut and *Astronia cumingiana* [Melastomaceae].
F21	9°38'46.71 ""	125°31'48.27 "	67	Brgy. San Pedro, Municipality of Placer, Province of Surigao del Norte	An agroforestry area generally composed of tree crops such as coconut and banana. Common tree species were *Artocarpus blancoi* [Moraceae] and malakape. *Melastoma* sp. [Melastomaaceae] and *Alpinia congesta* [Zingiberaceae] are the usual species that dominates the intermediate layer of the forest.
F22	9°38'20.48 "	125°32'4.48"	108.01	Brgy. San Pedro, Municipality of Placer, Province of Surigao del Norte	A secondary forest with eighty (80) percent closed canopy. Understorey vegetation is dominated by wildlings of *Toona calanta* [Meliaceae] and *Ficus* spp.

Table 2.1.4 - 2 Geographical Coordinates of Strips Traversed for Incidental Survey in 2015

Strip Number	Latitude	Longitude	Elevation (masl)	Locality	Project Component
VS1	125°32'28.23"	9°35'17.45"	329	Brgy. San Isidro, Municipality of Tubod, Province of Surigao del Norte	near Subsidence Zone
	125°32'30.83"	9°35'19.43"			
VS2	125°32'26.36"	9°35'16.56"	297	Brgy. San Isidro, Municipality of Tubod, Province of Surigao del Norte	near Subsidence Zone
	125°32'24.17	9°35'18.97"	343		
VS3	125°32'19.93"	9°35'22.08"		Brgy. San Isidro, Municipality of Tubod, Province of Surigao del Norte	near Subsidence Zone
	125°32'22.81	9°35'23.64"	343		
VS4	125°32'18.98"	9°35'20.41"	342	Brgy. San Isidro, Municipality of Tubod, Province of Surigao del Norte	near Subsidence Zone
	125°32'15.71"	9°35'20.46"	342		
VS5	125°32'18.70	9°35'21.58"	322	Brgy. San Isidro, Municipality of Tubod, Province of Surigao del Norte	near Subsidence Zone
	125°32'16.18"	9°35'23.66"	322		
VS6	125°32'13.22"	9°35'24.49"	361	Brgy. San Isidro, Municipality of Tubod, Province of Surigao del Norte	near Subsidence Zone
	125°32'09.95	9°35'24.34"	379		
VS7	125°32'11.05"	9°35'27.00"	352	Brgy. San Isidro, Municipality of Tubod, Province of Surigao del Norte	near Subsidence Zone
	125°32'13.41"	9°35'29.25"	353		
VS8	125°32'09.47"	9°35'27.35"	369	Brgy. San Isidro, Municipality of Tubod, Province of Surigao del Norte	near Subsidence Zone
	125°32'06.89"	9°35'29.34"	402		
VS9	125°32'12.43"	9°35'31.91"	381	Brgy. San Isidro, Municipality of Tubod, Province of Surigao del Norte	near Subsidence Zone
	125°32'14.72"	9°35'34.23"	358		
VS10	125°32'04.08"	9°35'30.84"	390	Brgy. San Isidro, Municipality of Tubod, Province of Surigao del Norte	near Subsidence Zone
	125°32'01.48"	9°35'32.82"	388		
VS11	125°31'58.29"	9°35'39.98"	367	Brgy. San Isidro, Municipality of Tubod, Province of Surigao del Norte	near Subsidence Zone
	125°31'55.65"	9°35'41.90"	390		
VS12	125°33'17.34	9°35'52.58"	403	Brgy. Timamana, Municipality of Tubod, Province of Surigao del Norte	near Subsidence Zone
	125°33'14.16"	9°35'51.81"	414		
VS13	125°33'11.57"	9°35'51.68"	460	Brgy. Timamana, Municipality of Tubod, Province of Surigao del Norte	near Subsidence Zone
	125°33'08.30"	9°35'51.92"	484		
VS14	125°33'00.97"	9°35'49.91"	193	Brgy. Timamana, Municipality of Tubod, Province of Surigao del Norte	Subsidence Zone
	125°32'58.86"	9°35'52.39"	201		

Strip Number	Latitude	Longitude	Elevation (masl)	Locality	Project Component
VS15	125°32'57.10"	9°35'48.51"	205	Brgy. Timamana, Municipality of Tubod, Province of Surigao del Norte	Subsidence Zone
	125°32'54.25"	9°35'50.12"	206		
VS16	125°32'54.71"	9°35'52.36"	211	Brgy. Timamana, Municipality of Tubod, Province of Surigao del Norte	Subsidence Zone
	125°32'55.59"	9°35'55.49"	234		
VS17	125°32'57.69"	9°35'56.60"	243	Brgy. Timamana, Municipality of Tubod, Province of Surigao del Norte	Subsidence Zone
	125°33'00.69"	9°35'57.91"	262		
VS18	125°32'52.50"	9°35'58.45"	307	Brgy. Timamana, Municipality of Tubod, Province of Surigao del Norte	Subsidence Zone
	125°32'52.51"	9°35'58.61"	333		
VS19	125°32'52.51"	9°36'00.34"	310	Brgy. Timamana, Municipality of Tubod, Province of Surigao del Norte	Subsidence Zone
	125°32'52.53"	9°36'03.59"	327		
VS20	125°32'56.89"	9°36'00.22"	291	Brgy. Timamana, Municipality of Tubod, Province of Surigao del Norte	Subsidence Zone
	125°32'59.76"	9°36'01.78"	193		

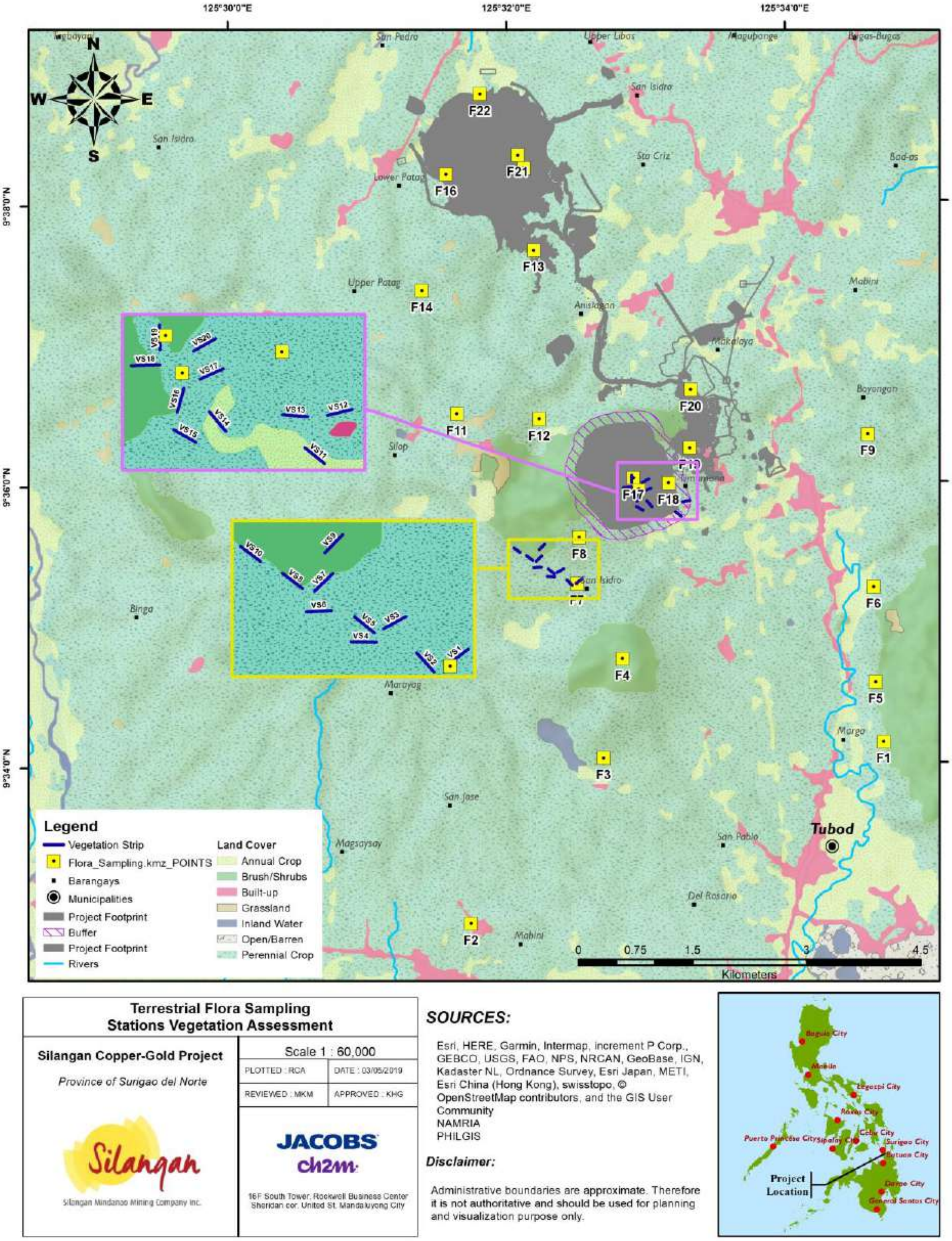

Figure 2.1.4 -1 Locations of Terrestrial Vegetation Sampling Quadrats Established in 2012, 2019 and Sampling Strips in 2015 Within and in the Immediate Vicinity of the Project Site

Vegetation Methods and Sampling Techniques

Sampling Techniques

Quadrat Sampling

The nested quadrat sampling method was the standard technique employed to assess and characterize the structure and composition of the different plant communities during the 2012 and 2019 ecology survey. The locations of the quadrats were selected to represent various vegetation types within the project site to obtain representative results. A 20 m x 20 m quadrat was established at each sampling station where large woody plants with diameter equal or greater than 10 centimeters, measurements of diameter at breast-height (DBH), merchantable height (MH), and total height (TH) were surveyed. Diameter of trees was measured at 1.3 meters above ground or 10 cm above the tallest buttress if taller than 1.3 meters. In case a tree forks below 1.3 m from the ground, all stems with ≥ 5 cm DBH were counted but only the largest diameter stem was measured Individual canopy species were identified to its corresponding taxon (family, genus, species). The total height of each species was measured using Haga Altimeter.

Within the 20 x 20 m quadrats, ten randomly placed 1 m x 1 m subquadrats were established to survey the understorey vegetation. All stems with diameters less than 10 cm DBH including shrubs, vines or lianas, grasses, succulents, wildlings/saplings and various species of herbaceous flora were classified as understorey.

Strip Sampling

In June 2015, strip sampling method was employed to identify and include other species not encountered in the quadrat method. This was performed by establishing 100 m x 5 m sampling strips located perpendicular to existing access roads and foot trails near the subsidence area. All species encountered were identified to its taxon (i.e. species, genus and family. Furthermore, the same method used in the quadrat sampling to determine if a stem is either understorey or canopy species was adopted. Diameters at breast height were measured using diameter tape. Voucher specimens were also collected for species validation.

Sample Preservation and Identification

All voucher specimens collected especially those with buds, flowers in bloom, and fruits were photo-documented and tagged with unique identifier. The Sweinfurth's method of preservation was employed to prevent rapid wilting and crumpled drying of the voucher specimens. This method involved soaking specimen in alcohol and wrapping labelled specimen using old newspapers. The specimens were then packed in polyethylene bags and sealed prior to transport.

Published books and articles, and repositories of online database were accessed to acquire the needed information on species identification. Relevant literature (Co's Digital Flora of the Philippines, Flora Malesiana, Flora of Manila, Enumeration of Philippine Flowering Plants, Lexicon of Philippine Plants, Blumea, Leaflets of Philippine Botany among others) were consulted for the initial identification. Subsequently, photos of the unknown plants were compared using the digital images available online (JSTOR Plant and PhytoImages).

Names of the specimens were verified in the International Plant Names Index (IPNI) and standardized based from the Plant List (http://www.theplantlist.org). Distribution and endemism of plants were determined using online databases such as the Catalogue of Life (http://catalogueoflife.org/), Tropicos (http://www.tropicos.org/), and Global Biodiversity Information Facility (http://GBIF.org).

Data Analysis

Land Cover/Vegetation Mapping

Land cover/vegetation communities map was generated from the latest Landsat Enhanced Thematic Mapper Plus (ETM+) downloaded from the United States Geological Survey (USGS) website. Using the ArcGIS software suite version 10.5.1, spatial analysis using Multivariate Interactive Supervised Classification was performed to classify individual pixels according to reflectance values. The resulting classified raster is then verified onsite by the quadrat method, incidental surveys and walkthrough. The classified image is then converted to a vector layer for easy creation of thematic map features. The generated land cover is further verified using an updated Google Earth Imagery and the 2015 Land Cover Map from NAMRIA. Misclassified polygons are cleansed to produce a clean land cover data layer.

Identification of Protected Vegetation Communities

Protected vegetation communities located within and/or in the vicinity of the project site were determined using PD 705, as amended, (Revise Forestry Code), RA 7586 (National Integrated Protected Areas System) later amended to RA 11038 (E-NIPAS act of 2018) and other issuances, executive orders, local ordinances, and international commitments and declarations. The Comprehensive Land Use Plans (CLUPs) of the Municipalities of Placer, Sison, Tagana-an and Tubod were also utilized to check if there are any areas classified as such based on local ordinances and/or other declarations. Moreover, desktop review of available literatures and their location describing vegetation communities of potential biogeographic zones in the project site were performed. Vegetation survey using quadrat and transect walk samplings were conducted on areas suspected to belong to such communities. This is to affirm if the species in the area are derivatives and/or could be associated to any protected vegetation community. Global Positioning System (GPS) points within the suspected site were taken to provide as reference in extracting their reflectance values on available multispectral satellite images. These points/values will be the basis for analysis that could discriminate the target sites from the others. Detailed discussions on Protected Vegetation Communities and their location are presented in **Section 2.1.1** (Land Use and Classification).

General Statistics and Biodiversity Indices

The vegetation cover were assessed in terms of habitat (i.e. natural, modified and their critical subsets), stratum (i.e. canopy and undergrowth), taxonomy (i.e. species, genus, family), biometrics (i.e. diameter-at-breast-height or DBH, estimated total height, basal area, estimated stand density and volume), and ecology (i.e. biodiversity indices). Densities, frequencies and dominance were calculated utilizing standard formulas to provide indicative representation of each plant species in the sampling quadrats. The quantitative measures such as Shannon's Diversity Index, Pielou's Evenness Index were used to characterize each species in the established sampling locations.

To characterize species dominance, the following indices (**Table 2.1.4 - 3)** were calculated from the quadrat data for each plant species recorded.

Table 2.1.4 - 3 General Statistics and Biodiversity Indices

Biodiversity Indices	Definition
Frequency	the number of occurrences of a given species
Density	the number of individuals of a given species per unit area
Basal Area	0.7854 X DBH^2
Relative Frequency	frequency of a species as percentage of the total frequency for all species
Relative Density	density of a species as percentage of the total density for all species
Relative Dominance	basal area of a species as percentage of the total basal area for all species
Importance Value (IV)	Relative Frequency + Relative Density + Relative Dominance

Other formulas used to characterized the plant species in the sampling quadrats

Diversity Index using Shannon-Weiner Index (H) = $- \Sigma (ni/N) \ln (ni/N)$

Evenness Index using Pielou's formula (J) = $H / \ln S$

Dominance Index (C) = $\Sigma[ni/N]^2$

where: ni = the total number of individuals in each species

N = the total number of all individuals

S = total number of species

Threatened Species

The conservation status of all the identified species was determined using DENR Administrative Order (DAO) 2007- 01 (The National List of Threatened Philippine Plants and their Categories) later updated with DAO 2017-11 along with International Union for the Conservation of Nature (IUCN) 2015 updated to 2018-2. DAO 2007-01 was created pursuant to Republic Act (RA) 9147 otherwise known as the "Wildlife Resources Conservation and Protection Act". The IUCN Red List of Threatened Species provides a global assessment of the conservation status of different plant species. These national and global conservation data sources were significant to enumerate pragmatic mitigating measures to preserve the existence of species specifically that are Threatened.

Lastly, local conditions of Threatened species were noted during the field survey based on observations and interviews with the locals. It should be noted that some Threatened species may exhibit a different population condition (relative to their classification based on DAO 2007-01; 2017-11 and IUCN 2015; IUCN 2018-2) based on local conditions.

Limitations of the Vegetation Survey

Accessibility and absence of distinct features of plant species during the time of the survey were the main limitations encountered. Moreover, ingress to some pre-determined sampling stations was restricted due to security and clearance issues. During the 2019 survey, the plan was to resurvey the old stations back from 2012 and 2015 but due to change in vegetation cover and inaccessible trails new sampling stations were established instead.

Leaf samples were not collected from trees with extreme heights. Distinct features of these trees (i.e. flowers, fruits, inflorescence) were likewise not examined for proper identification of species.

Given these limitations, some voucher plants/trees were designated only to their most probable genera based on observed available morphological characteristics.

Despite the limitations, the majority of the plant species documented and other gathered data are adequate enough to represent the baseline condition of the project site.

2.1.4.3.2 Terrestrial Wildlife

The terrestrial wildlife assessment was conducted by environmental scientists from Pro-Seeds Development Association and Jacobs Projects Philippines Inc. supported by local guides. The assessment was conducted to establish baseline data on wildlife composition, determine potential impacts of the Project and recommend mitigation measures. The succeeding sections below present the methodologies and their discussions.

Description of Transect Lines

The project site has a total area of 542 ha. It rests on a lowland setting with topography ranging from plains to rolling and some steep portions. There were five transects established within the project site while two are in the immediate vicinities representing a distinct habitat type and a local ecotourism area.

The seven transects and the facilities and/or areas they cover are presented below.

- Transect 1 and 9 represents the TSF;
- Transects 2, 3, 6 and 7 represents the subsidence zone;
- Transect 4 represents Lake Mahukdam (considered an ecotourism area in the Municipality of Tubod); and
- Transect 5 represents a forest over limestone patch near the boundary between the municipalities of Tubod and Bacuag.
- Transect 8 traverses a path from subsidence zone going to the mill area

Figure 2.1.4 - 2 shows the location of the transect sites relative to the proposed development facilities. **Table 2.1.4 - 3** presents the transect sites, their geographical locations and general habitat description covered by this survey.

Table 2.1.4 - 4 Geographical Coordinates and General Description of the Fauna Transect Sites

#s	Transect	North	East	Locality	General Habitat Description
1	Transect start	9°38’19.3”	125°32’19.3”	Barangay San Isidro, Municipality of Placer, Province of Surigao del Norte	Coconut (*C. nucifera*) plantation with patches of regenerating forests
	Transect end	9°38’11.3”	125°31’24.1”	Barangay Lower Patag, Municipality of Sison, Province of Surigao del Norte	
2	Transect start	9°35’30.5”	125°33’9.7”	Barangay Timamana, Municipality of Tubod, Province of Surigao del Norte	Secondary forest with coconut and falcata (*P. falcataria*) plantation
	Transect end	9°35’6.7”	125°31’59.8”	Barangay Timamana, Municipality of Tubod, Province of Surigao del Norte	
3	Transect start	9°33’59.2”	125°32’45.5”	Barangay San Isidro, Municipality of Tubod, Province of Surigao del Norte	

#s	Transect	North	East	Locality	General Habitat Description
	Transect end	9°34’35.7”	125°32’13.6”	Barangay San Isidro, Municipality of Tubod, Surigao del Norte	Coconut plantation with patches of secondary forest
4	Transect start	9°34’44.9”	125°34’31.8”	Lake Mahukdam, Barangay Capayahan, Municipality of Tubod, Province of Surigao del Norte	Coconut plantation with patches of secondary forest
	Transect end	9°35’49”	125°34’37.6”	Lake Mahukdam, Barangay Capayahan, Municipality of Tubod, Province of Surigao del Norte	
5	Transect start	9°36’0.2”	125°32’50”	Barangay Motorpool, Municiplaity of Tubod, Province of Surigao del Norte	Forest over limestone with coconut and falcata plantations
	Transect end	9°36’32.2”	125°32’7.4”	Barangay Motorpool, Municiplaity of Tubod, Province of Surigao del Norte	
6	Transect start	9°35'03.9"	125°32'56.3"	Barangay Timamana, Municipality of Tubod, Province of Surigao del Norte	Secondary forest with coconut and falcata (*P. falcataria*) plantation
	Transect end	9°36'00.3"	125°31'46.4"	Barangay Timamana, Municipality of Tubod, Province of Surigao del Norte	
7	Transect start	9°35'50.3"	125°33'18.1"	Barangay San Isidro, Municipality of Tubod, Province of Surigao del Norte	Coconut plantation with patches of secondary forest
	Transect end	9°36'12.9"	125°32'29.2”	Barangay San Isidro, Municipality of Tubod, Province of Surigao del Norte	
8	Transect start	9°35'03.9"	125°32'56.3"	Barangay Timamana, Municipality of Tubod, Province of Surigao del Norte	Secondary forest with coconut and falcata (*P. falcataria*) plantation
	Transect end	9°36'00.3"	125°31'46.4"	Barangay Timamana, Municipality of Tubod, Province of Surigao del Norte	
9	Transect start	9°35'50.3"	125°33'18.1"	Barangay San Isidro, Municipality of Tubod, Province of Surigao del Norte	Coconut plantation with patches of secondary forest
	Transect end	9°36'12.9"	125°32'29.2”	Barangay San Isidro, Municipality of Tubod, Province of Surigao del Norte	

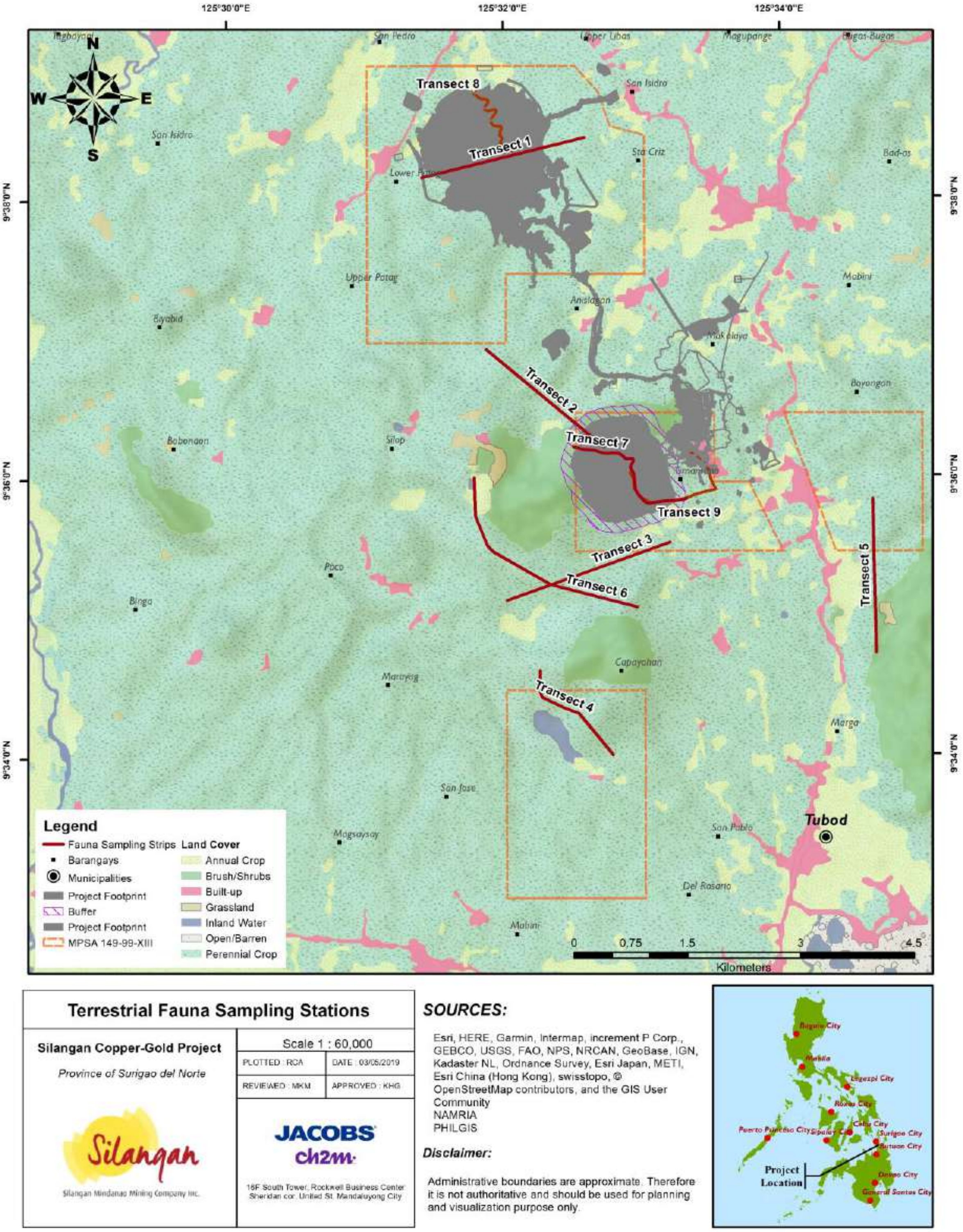

Figure 2.1.4-2 Terrestrial Wildlife Transect Lines

Wildlife Methods and Sampling Techniques

The sampling techniques used for each taxon are presented below. The wildlife surveys included amphibians, reptiles, birds and mammals. It commenced with a general wildlife habitat assessment followed by surveys of the said vertebrate groups. Detailed descriptions of the sampling methods for each group are presented below. When possible, vertebrate wildlife caught and/or observed were identified up to species level using published keys and field guides available including:

- Guide to Philippine Flora and Fauna. Vol 10, Amphibians and Reptiles (Alcala, A.C., 1986);
- Philippine Amphibians: An Illustrated Field guide (Alcala, A.C. and W.C. Brown, 1998);
- A Guide to the Birds of Philippines (Kennedy, R.S., Gonzales, P.C., Dickinson, E.C., Miranda Jr., HC and T.H. Fisher, 2000);
- A Key to the Bats of the Philippine Islands (Ingle and Heaney, 1992); and
- A Sypnopsis of the Mammalian Fauna of the Philippine Islands (Heaney, et al, 1998).

Amphibians and Reptiles

Amphibians and reptiles were collected and recorded mainly through strip transect while opportunistic catching was employed whenever possible (e.g. trap setting, incidental observations during bird transect, site reconnaissance, etc.). Sampling was conducted at least twice a day between 8:00 am to 11:00 am and 2:00 pm to 4:00 pm. These time periods were selected since they were the most convenient and effective schedule that could maximize sampling for these groups given the security risks in the project site. Following the security risks, no night sampling was employed. Suspected microhabitats within the transect (i.e. decaying logs, sections of streams and rivers, leaf axils of aroids, leaf litters, piles of coconut husks, and others) were thoroughly checked and searched with the help of local guides. Two sets of drift fences with collapsible traps were also used for at least three days and two nights per transect site. Collapsible traps were checked early in the morning and late in the afternoon. Upon capture, descriptive and quantitative measurements, as well as photographs, were taken to aid in species identification. All specimens were released at their site of capture. The recent ecological survey employed opportunistic sampling and interviews for amphibians and reptiles. The use of traps was used during the previous surveys. The level of effort is shown in **Table 2.1.4 – 5.**

Table 2.1.4 **– 5.** Level of Effort for Methods Used to Survey Amphibians and Reptiles

Method	Level of Effort (minimum per site, in hours)
Strip transect	250
Drift fence	240
Opportunistic catching	70
Total	**560**

Birds

Surveys were carried out by walking through established 2 km transect routes for each site. An observer walked these routes at a pace of about 250 m/15 minutes thereby completing the whole stretch in about two hours. More observation time (five to ten minutes) was given to mixed feeding flocks to ascertain identities of individuals. Transects were covered at least twice a day between 6:00 am to 9:00 am and 3:00 pm to 5:00 pm since birds are most active during these periods except during heavy rains and/or heavy fog. The species and number of individual birds seen and/or heard were recorded.

Twelve-meter mist nets (standard length used for this survey) were used to capture nocturnal and cryptic bird species. They were left open for 24 hours for at least three days and two nights for the previous sampling activities and two days and two nights for the more recent 2019 ecological survey. Mist nets were checked for possible netted individuals every two hours from 6:00 am to 3:00 pm. The level of effort is shown in **Table 2.1.4 – 6**. All captured individuals were processed by taking standard biometric measurements: total length (TL), tail vent length (TV), weight (WT), wing cord (WC), bill or culmen (B), gape (G), and tarsus (T). Selected individuals were photographed and all were released to their site of capture.

Table 2.1.4 – 6. Level of Effort for Methods Used to Survey Birds

Method	Level of Effort (minimum per site)
Transect walk	70 hours
Mist net	624 hours
Total	**694 hours**

Mammals

Volant Mammals (Bats)

The same mist nets used for birds were used to capture volant mammals (bats). Mist nets were left overnight for at least two nights and checked early in the morning. Net watching was not employed due to security risks within the transect sites. For each transect site, the level of effort is at least 10 net nights. Important information such as weight (WT), sex, and approximate age (i.e. adult, sub-adult, or juvenile as determined by examining digit joint ossification of wings) were recorded. Standard biometric measurements such as total length (TL), tail vent (TV), ear length (EL), forearm length (FA), and hind foot length (HF) were taken. Selected caught individuals were photographed and all were released at their site of capture. The level of effort is shown in **Table 2.1.4 – 7**.

Small Nonvolant Mammals

For small nonvolant mammals (i.e. murid rodents and shrews), two kinds of traps were used (i.e. fabricated live traps, and Victor snap traps). At least 30 fabricated traps and 75 snap traps were set for each transect sites. These were baited with roasted coconut meat coated with peanut butter and were positioned 5 m to 10 m apart along possible runways, near burrow entrances, under root tangles, on top of fallen logs, etc. Level of effort for each transect site was at least 396 trap days **Table 2.1.4 – 7**. Important information such as: weight (WT), sex, approximate age (i.e. sub-adult or adult), and when applicable, reproductive condition, were noted. Standard biometric measurements such as total length (TL), tail vent (TV), ear length (EL), and hind foot (HF) were taken. Selected caught individuals were photographed and all caught individuals were released at their site of capture.

Table 2.1.4 – 7. Level of Effort for Methods Used to Survey Mammals

Method	Level of Effort (minimum per site)
Mist Nets (volant)	82 net nights
Fabricated traps (nonvolant)	396 trap days
Snap traps (nonvolant)	750 trap days
Total	**1,228 net/trap nights**

Medium to Large Mammals

Information on the presence and perceived abundance of large mammals, including civets, wild pigs, and macaques were obtained from knowledgeable guides and hunters encountered during field work. Presence based on indices (e.g. foot prints, wallowing area, scats, bone remains, etc.) were also recorded and considered.

Data Analysis

Range distributions, conservation status, population status and general habitat associations of recorded species were based on the work of the following: Alcala (1986), Alcala and Brown (1998), Kennedy et al. (2000), Ingle and Heaney (1992), Heaney et al (1998) and IUCN (2012). For habitat association, published information was combined with on-site field observations.

Limitations of the Fauna Survey

The survey conducted was considered adequate to assess the general wildlife assemblage likely to be present and allowed assessment of the habitat suitability for wildlife species within the project site. However, the following limitations should be considered:

- The project site has security issues which led to: lack of night collection for amphibians and reptiles, lack of net watch for insectivore bats, and lack of observation time for crepuscular and nocturnal birds;
- Survey period was outside of the migratory season hence, assessment of migratory birds was not covered by the survey;
- Due to inconsistent weather conditions, the assessment presents a view of the species most likely to be active under these conditions during the period of wildlife survey. Continuous field surveys within the project site would likely lead to record of additional species;
- Infrequent rain was experienced during the survey in some of the transect sites which limited bird recognition through audio cues. Also, there is lessened probability of capture through mist nets as birds and bats are less active during rains;
- Cage traps and snap traps were set on the ground which limited capture of arboreal mammal species. Mist nets were also set close to ground which restricted capture of canopy species of birds and high-flying bat species; and
- The fauna survey focused on vertebrate species and no invertebrate survey method was employed.

2.1.4.4 Baseline Environment for Terrestrial Ecology

This section describes the baseline terrestrial ecology condition of the project site. The floristic composition, vegetation communities and conservation status of recorded species were summarized. Species richness, range distribution, general habitat association, and population status including conservation status of wildlife species were also determined and presented. **Table 2.1.4 – 8** and **Table 2.1.4 – 9** provide the key findings and conclusion of the terrestrial ecology assessment.

Table 2.1.4 – 8. Key Findings and Conclusion – Terrestrial Vegetation

<table>
<tr><th>Baseline Information</th><th>Key Findings and Conclusions</th></tr>
<tr><td>Vegetation types or communities</td><td>

The original vegetation community (lowland evergreen rainforest) in the project site have almost been completely wiped out by past and on-going anthropogenic disturbances (e.g. commercial logging up to the early 1950s, land conversion to agricultural areas and agroforest).
Based on floristic composition and analysis of available multispectral satellite image of the project site in 2012 and 2015 and 2015 Land Cover map of CARAGA Region , the major vegetation types are as follows:

<table>
<tr><th>Vegetation Types or Communities</th><th>Total Area within the Project Site (ha)</th></tr>
<tr><td>Agroforest (Perennial Crops)</td><td>312.96</td></tr>
<tr><td>Agricultural Areas (Annual Crops)</td><td>74.60</td></tr>
<tr><td>Brush/Shrublands</td><td>113.80</td></tr>
<tr><td>Open Areas with Built-Up Portions</td><td>7.12</td></tr>
<tr><td>Residual Forest</td><td>23.52</td></tr>
<tr><td>Total</td><td>532.00</td></tr>
</table>

There are no protected vegetation communities within the project site based on PD 705, RA 7586 and the CLUPs of the host municipalities.
Remaining patches of heavily disturbed forest over limestone were observed in Brgys. Marga and Motor Pool, Municipality of Tubod.

</td></tr>
<tr><td>Plant species inventory</td><td>

A total of 386 morpho-species represented by 101 families and 281 genera was documented. Fabaceae was the most species rich family with 32 species followed by Moraceae (22), Rubiaceae (19), Araceae (19), and Graminae (17).
Quadrat 2 has the highest species richness (n=11) and total abundance (n=18) recorded among the 16 quadrats established in 2012. VS1 is the most speciose (n=9) with total abundance (n=11) among the sampling strips recorded in 2015 field survey. For the 2019 survey, F2 has the highest species richness (n=20) and total abundance (n=40).

<table>
<tr><th>Quadrat 2012</th><th>Total Species Richness</th><th>Total Abundance</th></tr>
<tr><td>F1</td><td>8</td><td>10</td></tr>
<tr><td>F2</td><td>11</td><td>18</td></tr>
<tr><td>F3</td><td>2</td><td>17</td></tr>
<tr><td>F4</td><td>5</td><td>12</td></tr>
<tr><td>F5</td><td>4</td><td>4</td></tr>
<tr><td>F6</td><td>8</td><td>9</td></tr>
<tr><td>F7</td><td>5</td><td>7</td></tr>
<tr><td>F8</td><td>10</td><td>14</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>Baseline Information</th><th>Key Findings and Conclusions</th></tr>
<tr><td></td><td>

F9	8	13
F10	5	7
F11	4	7
F12	7	14
F13	9	14
F14	5	12
F15	9	15
F16	10	14
Strip 2015	**Total Species Richness**	**Total Abundance**
VS1	9	11
VS2	7	10
VS3	6	8
VS4	4	4
VS5	5	6
VS6	4	8
VS7	5	7
VS8	5	12
VS9	6	8
VS10	6	11
VS11	6	7
VS12	6	6
VS13	6	8
VS14	5	12
VS15	4	8
VS16	6	11
VS17	7	8
VS18	7	8
VS19	5	12
VS20	5	8
Quadrat 2019	**Total Species Richness**	**Total Abundance**
F17	8	21
F18	17	23
F19	20	40
F20	13	23
F21	13	36
F22	16	34

</td></tr>
<tr><td>Endemicity and conservation status</td><td>

- A total of 59 (15%) species represented by 31 families are endemic or have natural distributions confined only to the Philippines. Of this, 55 are Philippine endemics while four species are confined to Mindanao Island (Mindanao Island Endemic).
- Danser mistletoe (*Decaisnina miniata)* Barlow which is reported only to occur in north eastern Mindanao was recorded within the project site. It utilizes santol (*Sandoricum koetjape*) and lanzones (*Lansium domesticum)* as host trees. Both red and orange color forms of this endemic aerial parasite were encountered.
- A total of 23 Threatened species was recorded in the project site. List of Threatened species were based on the Department Administrative Order (DAO) 2017-11 and 2018 International Union for the Conservation of Nature (IUCN) Red Data List of Plants.

</td></tr>
</table>

Baseline Information	Key Findings and Conclusions
Density, frequency and dominance	• The surveyed sampling quadrats and strips are understocked (<10 individuals with ≥ 10cm DBH) to moderately stocked (10 to 20 inidviduals with ≥10 cm DBH). The average tree density is approximately 278 stems per ha. Coconut (*C. nucifera*) and narra *(Pterocarpus indicus*) were the two most dominant canopy species while *Selaginella sp.* dominated the understorey. Based on the 2019 survey, Coconut (*C. nucifera*) followed by White Lauan (S. *contorta*) are the most dominant canopy species, • Narra (*P. indicus*), molave (*V. parviflora*), White Lauan (*S. contorta*) are among the species classified as critically endangered based on DAO 2017-11 and IUCN 2018 during the 2012 and 2015 survey. These two species registered an importance value of 20.14 and 11.67, respectively. During the recent survey, White Lauan (*S. contorta*) was also added to the list of critically endangered species present in the project site. The importance value calculated for this species is 31.27. • In 2012 and 2015 field surveys, Coconut (*Cocos nucifera*) had the highest importance value of 133.91 followed by narra (*P.Indicus)* with 20.14 and banato (*Mallotus philippinensis*) with 19.94. Coconut still has the highest importance during the 2019 field survey with 35.50 followed by White Lauan (*Shorea contorta*) 31.27, Ilang-ilang (*Cananga odorata*) 22.46 and Antipolo (*Artocarpus blancoi).* A high importance value indicates that a species is well represented in the stand, with high basal area value hence, plays an important ecological role in the locality. • Majority of the species at the canopy and understorey layers included in the top ten based on species richness and dominance are associated with heavily disturbed ecosystems.
Historical occurrences of pest infestation, forest/grass fire and/or similar incidences	• Based on interviews with the locals during the field surveys, grass fire is not observed within the project site and immediate vicinities. This corresponds to the relatively wet condition in the area throughout the year as defined by the Modified Coronas Climate Classification (2007).

Table 2.1.4 – 9. Key Findings and Conclusion - Terrestrial Wildlife

Baseline Information*	Key Findings and Conclusions
Wildlife species inventory	• A total of 148 species of terrestrial wildlife vertebrates were recorded (i.e. 10 amphibians, 25 reptiles, 97 birds, and 16 mammals) representing approximately 27% of the known 550 species for the whole Mindanao faunal region for the 2012 and 2015 survey. • During the 2019 ecological survey, a total of 63 terrestrial wildlife species consisting of two (02) species of frogs, five species of reptiles, 44 species of birds, seven species of bats, five (05) species of small non-volant mammals were recorded • Generally, amphibian, reptile and mammal fauna diversity in the project site is relatively low while avian diversity is high. This is proven to be true for all the ecological sampling activities conducted in the site. • Site 5 has the highest number of species (n=96) and individuals (n=1,325) recorded among the seven sites surveyed.

Transects	Total Species Richness	Total Abundance
Transect 1	87	946
Transect 2	75	815
Transect 3	72	815

<table>
<tr><th>Baseline Information*</th><th>Key Findings and Conclusions</th></tr>
<tr><td></td><td>
<table>
<tr><td>Transect 4</td><td>88</td><td>1005</td></tr>
<tr><td>Transect 5</td><td>96</td><td>1325</td></tr>
<tr><td>Transect 6</td><td>43</td><td>492</td></tr>
<tr><td>Transect 7</td><td>48</td><td>687</td></tr>
<tr><td>Transect 8</td><td>36</td><td>108</td></tr>
<tr><td>Transect 9</td><td>34</td><td>79</td></tr>
</table>
* Note that Transects 6 and 7 covered only birds through transect walk surveys
</td></tr>
<tr><td>Summary of range distribution (includes endemicity)</td><td>

Range distribution was dominated by the native but non-endemics or resident breeders with 78 (53% of the total) species followed by the endemics (i.e. species found nowhere else in the world) with 60 (42% of the total) species. Of these endemics, 33 are Philippine endemics, 19 are greater Mindanao endemics and eight are Mindanao endemics.
Other range distributions noted were: migratory birds with four species; introductions with four species; migratory birds with resident breeding populations with one species; and near-endemics with one species.
The endemicity in the project site is high.

</td></tr>
<tr><td>Conservation status (includes abundance or general population status)</td><td>

The general population status of recorded wildlife was dominated by common species (inclusive of sub-categories: locally common, moderately common and fairly common) with 119 (80%) representatives. Other population status noted were: rare with three species and uncommon with 11 species.
For conservation status, the following were noted: Least Concern with 114 (77%) species, Unassessed with 16 species and Near Threatened with three species.
Least Concern species greatly corresponds with Common population status mentioned above.
While majority of the recorded species are Common and Least Concern, 15 (10% of the total) species are under various threat categories based on the 2015 IUCN Red List of Threatened Species (IUCN, 2015), the Philippine Wildlife Act (PWA) of 2001 [Republic Act (RA) 9147)], and CITES 2015.
However, based on local conditions in the project site, nine species out of the 15 Threatened are common as per observations and interviews with the locals. These species are: Limnonectes magnus, Megophrys stejnegeri, Python reticulatus, Varanus cumingi, Tarsius syrichta, Macaca fascicularis, Naja samarensis, Loriculus philippensis and Bolbopsittacus lunulatus.
General population status was based on Alcala, 1986; Alcala and Brown, 1998; Kennedy et al., 2000; Heaney et al., 1998 and IUCN, 2012. Actual field surveys of population estimates of these particular species are limited and often lacking of detail accuracy.
Least Concern, Unassessed and Near Threatened species were based on The IUCN Red List of Threatened Species. Version 2015.2. <www.iucnredlist.org>. Downloaded on 07 September 2015.
Threatened species were based on The IUCN Red List of Threatened Species. Version 2015.2. <www.iucnredlist.org>. Downloaded on 07 September 2015.

</td></tr>
<tr><td>Historical occurrences of pest infestation, forest/grass fire and/or similar incidences</td><td>

Based on interviews with the locals during the field surveys, grass fire is not observed within the project site and immediate vicinities. This corresponds to the relatively wet condition in the area throughout the year as defined by the Modified Coronas Climate Classification (2007).

</td></tr>
<tr><td>Hindrance to wildlife access across the mine facility sites</td><td>

The field surveys showed that the project site is highly fragmented and degraded due to previous (some 50 years ago) commercial logging, and on-going anthropogenic disturbances (e.g. kaingin farming, agroforest and other forms of agriculture).

</td></tr>
</table>

Baseline Information*	Key Findings and Conclusions
	• Most of the transect sites covered are dominated by agroforest, agricultural areas, brush and shrub lands, grassland and plantation area (coconut and falcata). Remaining patches of residual/secondary forest were confined along gullies/depressions surrounded by grasslands, shurblands, and/or agricultural areasA limestone forest patch near the boundary between the municipalities of Tubod and Bacuag was also noted. • Wildlife access across the project site is already fragmented due to previous and on-going anthropogenic disturbances.

2.1.4.5 Results and Discussions

2.1.4.5.1 Vegetation Types or Communities in the Project Site

The entire project site is dominated by perennial crops commonly used for agroforestry which cover an area of approximately 312.96 ha. This vegetation community type represents more than half (59%) of the project site. It is followed by brush and shrubland with 113.80 ha (21%), agricultural areas with 74.60 ha (14%), residual and/or secondary growth forest with 23.52 ha (4%), and open areas with built-up portions with 7.12 ha (1%). The percent cover of each vegetation type in the project site is presented in **Figure 2.1.4 - 3**. For the purpose of capturing the vegetation communities in the project site in more detail, some general land cover classes from NAMRIA were further divided into more specific land cover classes.

Prior to the entry of the mining companies, majority of the project site has been subjected to commercial logging until the 1950s. This is indicated by the presence of various Timber Licence Agreements (TLAs) especially in the Municipality of Alegria (Local Government Unit of Alegria, 2012). Dipterocarp species, particularly the lauan group, were also selectively harvested until the early 1970s leaving less economically important trees. Based on these accounts, it is highly likely that the previous vegetation community may have been composed of lowland evergreen forest dominated by dipterocarps. A number of large diameter forest trees within the project site, such as *Pometia* sp., *Shorea* sp., *Vitex* sp., and *Pterocarpus* sp. with DBH of 25 to 40 cm, were noted as remnant stands of this previous vegetation type. Forest over limestone was also observed particularly in the Municipality of Tubod. Indicator tree species like *Vitex* sp. was not encountered in any of the other sampled quadrats except within the forest over limestone quadrats. Moreover, intermediate brushes and shrubs belonging to the genera of *Dracaena* sp., *Nauclea* sp., *Phaeantus* sp. and *Dysoxylum* sp. associated with forest over limestone were found to grow abundantly. Kaong or sugar palm (*Arenga pinnata*), an economically important palm was also observed to thrive successfully on these limestone hills but was seldom encountered in other parts of the project site.

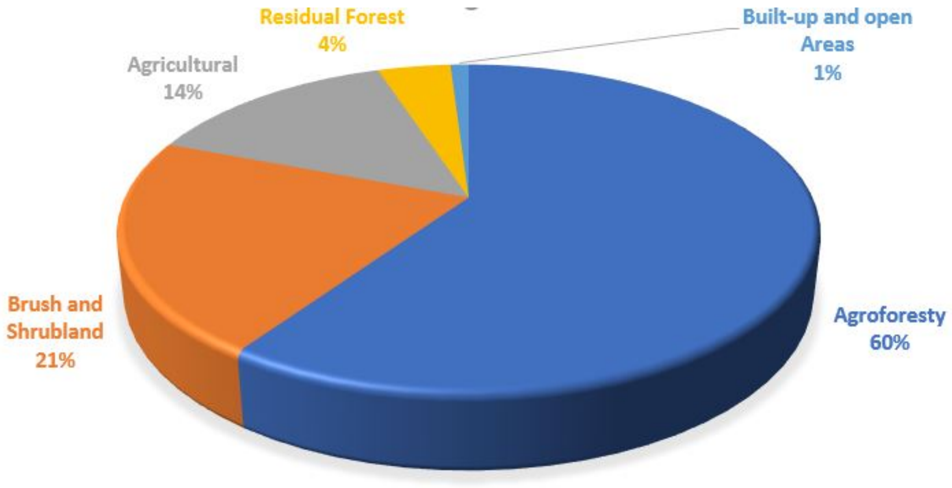

Figure 2.1.4 - 4. Percent Distribution of Vegetation Types in the Project Site

Six vegetation types were identified based on classification and image analysis of a downloaded Landsat ETM+ image **Figure 2.1.4 - 5**. These are agroforest, agricultural areas, residual and/or secondary growth forest, brush/shrublands, grassland and open areas with built-up portions. The extent of each land cover type is presented in **Table 2.1.4 – 10**.

Table 2.1.4 – 10. Identified Vegetation Types and their Extent in the Project Site

Vegetation Types/ Communities	Total Area within the Project Site
Agroforest (Perennial Crops)	312.96
Agricultural Areas (Annual Crops)	74.60
Brush/Shrublands	113.80
Open Areas with Built-Up Portions	7.12
Residual Forest	23.52
Total	**532.00**

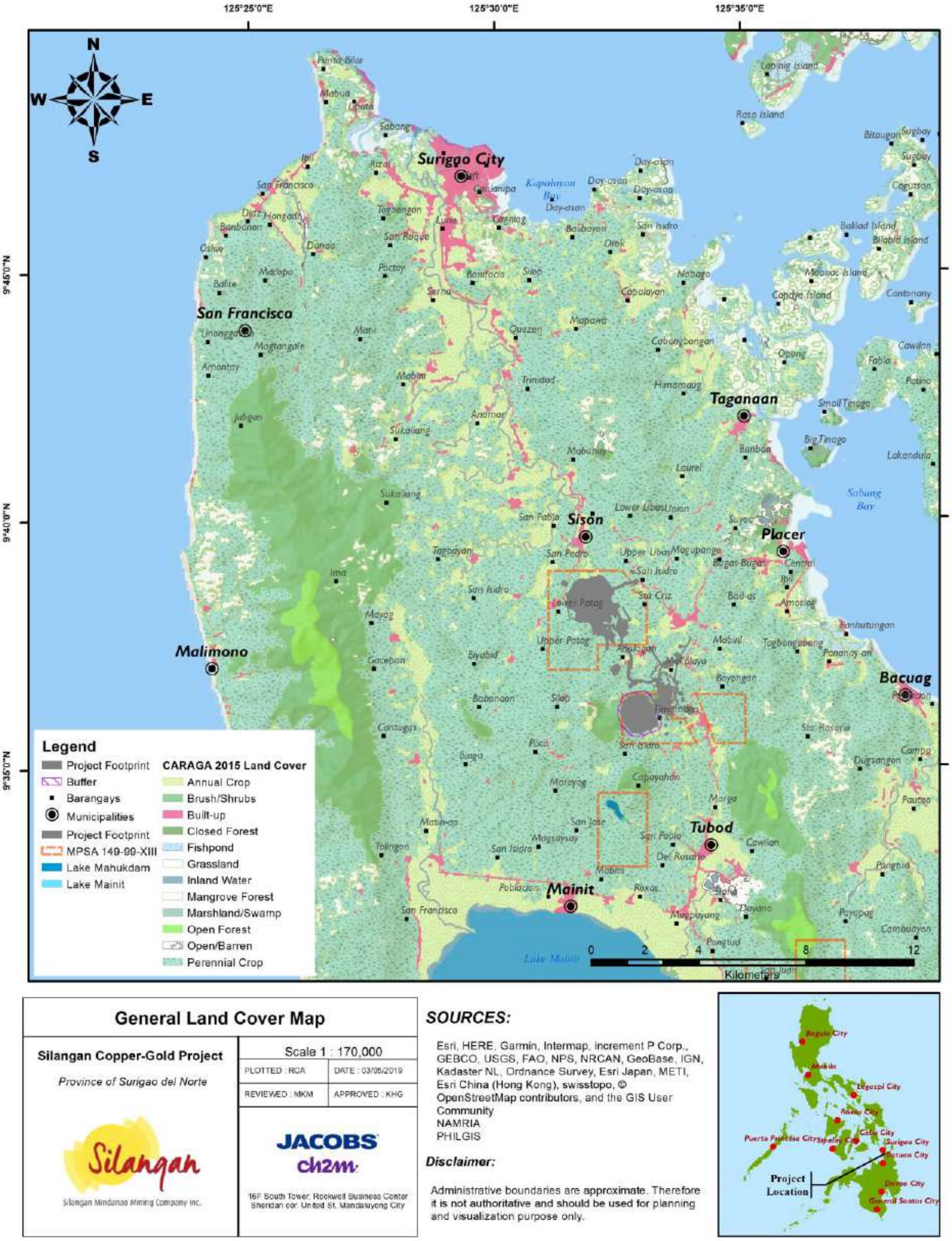

Figure 2.1.4 - 6. Vegetation Types or Communities in the Project Site

2.1.4.5.2 General Description of Vegetation Types or Communities in the Project Site

Agroforest

The agroforest **Plate 2.1.4 - 1** is the major (312.96 ha or 59%) vegetation type in the project site. These areas were once covered by natural lowland evergreen forest but were subjected to commercial logging activities until the 1950s. The cleared areas were subsequently converted to coconut and/or falcata plantations by the settlers. Falcata (*P. falcataria*), as it is well adapted to the humid climate of north eastern Mindanao, became popular in the late 1970s as a complementary component of coconut plantations. It has an average cutting cycle of eight to15 years which suitably supply the demand for pulpwood and timber. Since it is a fast growing tree and a light demanding pioneer, it is well suited to the high light levels under the canopy of coconut plantations.

Operation to manage and control weeds in these plantations do not allow for a diverse understorey to develop. Thus, the understorey was reduced to an almost uniform mix of *Selaginella sp., Homalomena sp., Schismatoglottis sp., Sphaerostephanos sp.* and *Centotheca sp.* Occasionally, in some sites where weeding had been neglected, succession by native pioneer species had established.

Plate 2.1.4 - 2. Typical Agroforest in the Project Site

Agricultural areas

In flat areas within the project site near watercourses and river embankments, the topography had been modified to support the cultivation of paddy rice **Plate 2.1.4 -3**. Here, the native vegetation had entirely been cleared due largely to the intensive land preparation necessary for rice production.

Plate 2.1.4 - -4 An Agricultural Farm (a paddy field) noted within the Project site

Residual Forests

Patches of residual forests (or secondary growth forests) were noted in the project site **Plate 2.1.4-5**. This vegetation community is a remnant of the lowland evergreen forests which once characterize the area prior to the entry of commercial logging activities. Through the natural succession process, colonization of pioneer tree species that belong to Families Fabaceae, Euphorbiaceae and Sapotaceae were favoured. Residual forests are “unstable” ecosystem as they represents a successional stage, if left undisturbed it is highly likely to revert back to its original vegetation community (Odera 2002).

Two quadrats (i.e. 8 and 10) were surveyed to belong to this specific vegetation type. Similar to the characteristics of other residual forests, canopy tree species dominate the upper layer, while vines, epiphytes, lianas, aroids, and various species of herbaceous flora dominated the understorey. Analysis of current satellite image suggests that the remaining patches of this vegetation type are mainly located on mountain peaks and ridges where recurrent disturbances such as timber poaching, coconut plantation establishment, etc. are unlikely due to extreme topography.

Brush and shrub lands

Brush and shrub lands cover majority of the project site Plate 2.1.4**-6.** This vegetation community is characterized by the dominance of woody vegetation that does not attain more than five meters in height at maturity (FAO 2001). The presence of this vegetation indicates a poor ecological state that characterizes major portion of the project site. This is shown by past and on-going anthropogenic disturbances such as fuelwood gathering, cattle grazing and site clearing to give way to agriculture. Native trees recorded to be associated to this vegetation type were those belonging to the genera *Ficus*, *Macaranga*, *Phaeanthus*, *Alstonia,* and *Macaranga*.

Plate 2.1.4-7 Residual Forests along a Ridge Divide in Sitio Pagsak Uno, Barangay Timamana, Tubod

Plate 2.1.4**-8 A Typical brush and Shrub Land within the Project Site**

Open areas

This land cover type was noted mainly in the proposed Tailing Storage Facility and Subsidence Zone locations **Plate 2.1.4-5**. Quadrat F12 which was established in the said locations, characterize it as generally bare/open most likely as a result of previous logging activities and *kaingin* farming. Insignificant patches of shrubs (e.g. *Lithocarpus* sp.) which covers approximately 5% of the open area and some undergrowth (e.g. *Crassocephalum crepidioides, Satureja umbrosa, Dioscorea pentaphylla* and *Digitaria* sp.) were recorded. Hence, this vegetation community type is excluded in the total areas to be cleared in the succeeding discussions. The slope within this vegetation community type ranged from very low (8-18%) to low (0-18%) in Barangay Timamana, Municipality of Tubod.

Plate 2.1.4-5 Open areas in Barangay Timamana in the Municipality of Tubod

Other Vegetation Community in the Immediate Vicinity of the Project Site

Forest Over Limestone

Forests over limestone are in some portions within the project site and other nearby areas where the geology consists largely of limestone such as the low hill chain found in Barangays Mabini, Boyongan and Marga **Plate 2.1.4 – 6.** The vegetation in this forest type is composed mainly of short statured trees which are influenced mainly by the relatively thin soils derived from the often exposed sharp limestone rocks. Being primarily calcium carbonate, the limestone dissolves with the acids of precipitation and weathers over time creating the distinctive crags often seen in limestone formations. The dissolving action of rainwater leads to the formation of solution channels, holes, caves and caverns in the predominantly karst landscape.

All of the three transect sites sampled (Quadrats 1, 5 and 6) in Barangay Marga, Municipality of Tubod show a great degree of anthropogenic disturbance. Portions of this forest type within the said transect sites had been converted to agroforest as shown by the plantations of coconut (*C. nucifera*) and kaong (*A. pinnata*). Native trees recorded for these sites include ibu (*Alectryon glaber),* baras baras (*Euonymus cochinchinensis), Firmiana philippinensis,* kalimatas *(Phaeanthus ebracteolatus),* dita (*Alstonia scholaris),* paisan (*Sterculia stiplulata var. Jagori)* and malugai (*Pometia pinnata).* In the understorey, the main components are *Piper myrmecophilum,* begonia (*Begonia nigritarum),* begonia (*Begonia bolsteri*)*, Nephrolepis spp., Tectaria spp. Etlingera sp., Heterogonium sp.,* and aglaonema (*Aglaonema commutatum).*

Plate 2.1.4 - 6 View of Forest Over Limestone along the National Highway in Tubod

2.1.4.5.3 Protected Vegetation Communities

There are no protected vegetation communities within the project site based on PD 705, RA 7586 and the CLUPs of the host municipalities. Protected vegetation communities nearest to the project site are presented and discussed in detail under **Section 2.1.1** (Land Use and Classification).

2.1.4.5.4 Flora Composition of the Project Site

A total of 386 morphospecies were documented represented by 281 genera in 101 families. The families with the most represented species are Fabaceae (32), Moraceae (22), Rubiaceae (19), Araceae (19), and Graminae (17). **Table 2.1.4 - 11** and **Error! Reference source not found.** show the calculated biodiversity indices for each sampling qaudrat and strip respectively. Evenness and diversity indices scores were computed using Shannon-Weinner formula and Pielou's, respectively.

Table 2.1.4 - 11. Calculated Biodiversity Indices at the Canopy Layer in 2012 and 2015 Field Survey

Quadrats	No. of Individuals	Average Relative Dominance	Average Relative Density	Diversity	Evenness
F1	10	12.5000	0.3125	2.0253	0.9740
F2	20	8.3333	0.4167	2.1760	0.8757
F3	16	50.0000	2.0000	0.6853	0.9887
F4	12	20.0000	0.6000	1.0986	0.6826
F5	4	25.0000	5.0000	1.3863	1.0000
F6	9	12.5000	0.2813	2.0432	0.9826

Quadrats	No. of Individuals	Average Relative Dominance	Average Relative Density	Diversity	Evenness
F7	6	20.0000	0.3000	1.5607	0.9697
F8	14	10.0000	0.3500	2.2056	0.9579
F9	13	11.1111	11.1111	1.9459	0.8856
F10	7	15.4752	0.3500	1.4751	0.9165
F11	7	33.3333	0.5833	0.9557	0.8699
F12	14	14.2857	0.5000	1.4508	0.7456
F13	14	10.0000	0.3500	2.1440	0.9311
F14	11	20.0000	0.5500	1.2945	0.8043
F15	15	12.5000	0.4063	1.5222	0.7320
F16	13	11.1111	0.3611	2.0981	0.9549
F17	21	0.06643	0.2000	0.0664	0.2000
F18	23	0.07316	0.1428	0.7316	0.1428
F19	40	0.30072	0.2589	0.3007	0.2589
F20	43	0.14545	0.1868	0.1454	0.3116
F21	36	0.15369	0.3116	0.1536	0.2244
F22	34	0.18483	0.2244	0.1848	0.2764

Among all the quadrats established F8 has the highest diversity index score of 2.2056 followed by Quadrat F2 with 2.1760 and Qudrat F13 with 2.1440. The diversity index scores from all the sampling quadrats ranged from 2.1760 (low) to 0.0664 (very low) which was mainly influenced by the narrow range of species distribution within the quadrats.

The evenness index scores ranged from 0.6826 (high) to 1.0000 (very high). Among all the sampling quadrats Quadrat F5 had the highest average evenness index score of 1.0000 followed by Quadrat F3 with 0.9887 and Quadrat F6 with 0.9826. The high evenness score indicates that the recorded species are evenly distributed within the defined sampling quadrats.

Table 2.1.4 - 12. Calculated Biodiversity Indices at the Canopy Layer in 2015 Field Survey

Quadrats	No. of Individuals	Average Relative Dominance	Average Relative Density	Diversity	Evenness
VS1	11	11.1111	0.3055	2.1458	0.9766
VS2	10	14.2857	0.3571	1.74806	0.8983
VS3	8	16.6667	0.3333	1.7328	0.9671
VS4	4	25.0000	0.2500	1.3862	1.0000
VS5	6	20.0000	0.3000	1.5607	0.9697
VS6	8	25.0000	0.5000	1.2100	0.8750
VS7	7	20.0000	0.3500	1.4800	0.9171
VS8	12	20.0000	0.6000	1.1000	0.6833
VS9	8	16.6700	0.3300	1.6674	0.9311
VS10	11	16.6700	0.3300	1.6726	0.9342
VS11	7	16.6666	0.2916	1.7478	0.97550
VS12	6	16.6666	1.5000	1.7917	1.0000

Quadrats	No. of Individuals	Average Relative Dominance	Average Relative Density	Diversity	Evenness
VS13	8	20.0000	0.4000	1.3862	0.8613
VS14	12	25.0000	0.7500	0.8369	0.6037
VS15	8	33.3333	0.6666	0.7356	0.6695
VS16	11	18.7923	0.45833	1.5403	0.8596
VS17	8	14.2857	0.29166	1.9061	0.97956
VS18	8	14.1872	0.3000	1.9061	0.97956
VS19	12	20.0000	0.6000	1.31437	0.81666
VS20	8	20.0000	0.4000	1.49417	0.92838

In 2015 field survey, VS1 had the highest diversity index score of 2.1458 followed by VS18 and VS19 with 1.9062 and VS12 with 1.7917. The diversity index scores within the established sampling strips ranged from 2.1458 (low) to 0.3000 (very low). The limited number of species recorded influenced the low diversity characteristic of the surveyed sampling strips.

Of 20 sampling strips surveyed, VS4 and VS12 had the highest evenness index scores with 1.0000 followed by VS 18 and VS 19 with 0.9795 and VS1 with 0.9766. The evenness index scores ranged from 0.6037 (high) to 1.0000 (very high). The highest evenness index value in VS4 and VS12 indicate that the species are evenly distributed within the established sampling strips.

Canopy

Surveyed quadrats ranged from under stocked (<10 stems with ≥ 10 cm DBH) to moderately stocked (10 to 20 stems with ≥ 10 cm DBH). Stems with ≥ 10 cm DBH correspond to the canopy layer of a vegetation type. Areas which are frequently disturbed either by natural occurrences and/or anthropogenic activities tend to have smaller DBH. Quadrats F2, F3 and F15 are the only quadrats with 15 to 18 recorded stems while the rest are with less than 15 stems per quadrat. Furthermore, all the sampling stations established in 2015 field survey have less than 13 stems per strip.

For the quadrat survey, the relative frequency values ranged from 0.92 to 12.0 with *C. nucifera* (coconut) registering the highest relative frequency score which indicates a high likelihood for this species to be encountered in the project site. *Lithocarpus sp.* had the lowest relative frequency which was encountered only in Quadrat F12 as shown in **Annex 2.1-20**.

For the 2015 survey, *C. nucifera* (coconut) remains as the species with the highest relative frequency with 10.5263 and was encountered in 12 sampling strips**.** Several recorded species such as *Desmodium* sp., *Villebrunea rubescens*, *Glochidion* sp. etc. as shown in **Annex 2.1-21** had the lowest computed relative frequency with 0.8771.

Based on **Section 2.1.1** (Land Use and Classification), majority of the project site is classified as alienable and disposable (A&D) land wherein large tracts are utilized as agroforest and cultivated for agricultural crops. This strongly corresponds to the vegetation assessment wherein some of the flora species and vegetation types identified are strongly linked to agroforest and agricultural areas. Coconut and falcata are two most preferred agroforest species hence they are in the top ten dominant species in the canopy layer. Other dominant species based on IV is presented in **Table 2.1-33**. Narra (*P. indicus)* and molave (*V. parviflora)* are both classified as critically endangered species based on DAO 2007-01 were also dominant in the project site based on IV.

Two economically important species of hardwood, narra (*P. indicus*) and molave (*V. parviflora*) also registered high relative dominance values. These species are some of the most commercially sought after timber in the area.

Table 2.1.4 - 13. List of Top Ten Canopy Species Based on the Importance Value (IV) in 2012 and 2015 Field Surveys vs 2019 Field Survey

2012 & 2015 Field Survey					2019 Field Survey				
Species	Relative Frequency	Relative Dominance	Relative Density	Importance Value	*Species*	Relative Frequency	Relative Dominance	Relative Density	Importance Value
Cocos nucifera	10.5263	45.2547	78.125	133.906	*Cocos nucifera*	5.88	21.65	8.26	35.79
Pterocarpus indicus	2.6315	8.1367	9.375	20.1432	*Shorea contorta*	4.41	18.85	8.26	31.52
Mallotus philippinensis Muell. Arg	3.5087	3.9337	12.5	19.9424	*Cananga odorata*	5.88	10.3	6.42	22.6
Paraserianthes falcataria (L.) Nielsen	3.6697	9.6071	4.08342	17.3603	*Artocarpus blancoi (Elmer) Merr.*	5.88	7.36	6.42	19.67
Melanolepis multiglandulosa (Reinw. ex Blume) Reichb. & Zoll	4.3859	3.3366	7.8125	15.5351	*Macaranga hispida (Blume) Müll.Arg.*	4.41	7.76	6.42	18359
Morus alba	3.5087	0.7798	9.375	13.6636	*Macaranga bicolor Mull.Arg.*	2.94	5.89	5.5	14.34
Vitex parviflora	0.8771	4.5449	6.25	11.6721	*Fagraea racemosa Jack*	4.41	3.34	6.42	14.18
Alstonia macrophylla	2.63157	2.8945	4.6875	10.2136	*Planchonia spectabilis Merr.*	2.94	6.36	4.59	13.89
Adenanthera intermedia Merr.	1.75438	1.7441	6.25	9.7484	*Neonauclea calycina (Bartl. ex DC.) Merr.*	4.41	2.05	3.67	10.13
Diospyros poncei Merr. forma poncei	2.6315	1.05391	4.6875	8.3729	*Gironniera celtidifolia Gaudich.*	2.94	3.02	3.57	9.36

<u>Understorey</u>

The understorey layer consists mainly of lower plant form assemblage (i.e. ferns, herbs, lianas) and was generally more diverse than the canopy layer. A total of 158 morphospecies represented by 136 genera in 55 families were recorded. Araceae is the most diverse family with 15 species followed by Fabaceae with 13. Asteraceae and Graminae which are commonly referred as grasses ranked next in terms of diversity with nine and eight species, respectively.

Diversity of the understorey in the project site is comparatively low when compared to the understorey of other ecosystems. Several factors can be accounted for this variation such as water and nutrient availability, soil characteristic, succession history, fragmentation and disturbance.

Assessment at the species level showed that ferns and fern allies dominate the understorey. With 109 individuals, *Selaginella* sp. was the most frequent species, and consequently, holding the highest IV. It is followed by the sword fern (*Nephrolepis falcata*), a fern ally with 119 individuals but was only encountered in six quadrats. The 10 most important species accounted for 30% of the combined importance value of all the species in the understorey. Only a single species of tree in the sapling stage, kataupi (*Ficus villosa*) made it to the list with 0.0487 IV. Most of the species listed are associated with a disturbed ecosystem and this indicates that the project site is continuously exposed to disturbance.

Table 2.1.4 - 14. List of Top Ten Families (Understorey Species) Based on the Number of Species Representatives for 2012 and 2015 Field Surveys

Rank	Families	No. of Species
1	ARACEAE	15
2	FABACEAE	13
3	ASTERACEAE	9
4	GRAMINEAE	8

Rank	Families	No. of Species
5	RUBIACEAE	7
	TECTARIACEAE	7
6	ARECACEAE	6
	LAMIACEAE	6
7	LEEACEAE	6
	ZINGIBERACEAE	5
8	BEGONIACEAE	4
	EUPHORBIACEAE	4
	APOCYNACEAE	4
	MELASTOMATACEAE	4
9	THELYPTERIDACEAE	3
	EUPHORBIACEAE	3
	LOMARIOPSIDACEAE	3
10	COMMELINACEAE	2
	HYPOXIDACEAE	2
	PANDANACEAE	2
	SELAGINELLACEAE	2

Table 2.1.4 - 15 List of Top Ten Understorey Species Based on the Computed Importance Value (IV) for 2012 and 2015 Field Surveys

Scientific Name	No. of Individuals	Frequency	Importance Value
Selaginella sp.	109	12	10.48
Nephrolepis falcata (Cav.) C Chr.	119	6	8.84
Phacelophrynium sp.	93	9	8.49
Scleria scrobiculata Nees & Meyen ex Nees	52	7	5.47
Mikania cordata (Burm.) BL Robinson	34	9	5.20
Schismatoglottis plurivenia Alderw.	52	6	5.10
Ficus villosa Blume	61	4	4.87
Homalomena sp.	53	5	4.79
Donax cannaeformis (G Forst.) K Schum.	50	4	4.26
Nephrolepis sp.	22	7	3.80

<u>Noteworthy Species</u>

New Distribution Record

False kava (*Piper myrmecophilum*), a myrmecophilous scandent shrub previously known only to occur inn Samar and Leyte was found to be an understorey component of the limestone forest in Quadrat **Plate 2.1.4-7.** This survey confirms the range extension of this species to north eastern Mindanao.


Plate 2.1.4-7 *Piper myrmecophilum (false kava)* confirmed to exist in the northeastern part of Mindanao

Single Island Endemics

Danser mistletoe (*Decaisnina miniata)* Barlow, is reported only to occur in north eastern Mindanao **Error! Reference source not found. Plate 2.1.4-8**. It was recorded and noted to utilize santol (*Sandoricum koetjape*) and lanzones (*Lansium domesticum)* as host trees within the project site. Both red and orange color forms of this endemic aerial parasite were encountered.


Plate 2.1.4-8 Left to Right: Red and yellow inflorescence of *D. Miniata* emerged at the nodes

Endemic Species

A total of 59 species comprised of 55 Philippine endemics and four Mindanao Island endemics were documented in the project site. Of this, 27 (68%) are trees, five (12%) are aroids that epiphytic, four (10%) are herbs and one representative each for liana (2.5%), vine (2.5%), fern (2.5%) and rattan (2.5%). Error! Reference source not found. shows the percentage distribution of endemic species based on recorded growth forms. It should be emphasized that categorizing species as endemic is very much dependent on availability of published biodiversity data, recent taxonomic revisions, nomenclatural changes, and new evidences from various disciplines used in systematics among others. Thus, estimates of endemism should be interpreted within the context of the methodologies and limitations imposed by contributing factors. In this study, several specimens were not identified to the species level. This will influence the percent endemism estimates. To date, there is no comprehensive study or research accounting for the total endemic plant species distributed in the Mindanao Island. Hence, there are no reference values which can be used in comparing the endemicity of the project site with that of Mindanao Island.

Table 2.1.4 - 16 List of Recorded Endemics in the Project Site

Families	Scientific Names
ACANTHACEAE	*Dicliptera contorta* (Blanco) Merr.
ACTINIDACEAE	*Saurauia clementis Merr.*
ANACARDIACEAE	Semecarpus macrophyllus Merr.
ANNONACEAE	*Cyathocalyx ap oensis* (Elmer) J Sinclair
ANNONACEAE	*Phaeanthus ebracteolatus* (C Presl) Merr.
ANNONACEAE	*Cyathocalyx apoensis* (Elmer) J Sinclair
APOCYNACEAE	*Dischidia cleistantha* Livshultz
APOCYNACEAE	*Dischidia oiantha* Schltr.
APOCYNACEAE	*Dischidia platyphylla* Schltr.
APOCYNACEAE	*Hoya incrassata* Warb.
APOCYNACEAE	Telosma parviflora Merr.
ARACEAE	*Homalomena philippinensis* Engl.
ARACEAE	*Pothos inaequilaterus* (C Presl) Engl.
ARALIACEAE	*Osmoxylon luzoniense* (Merr.) Philipson
ARECACEAE	*Calamus discolor* C Martius
ARECACEAE	*Caryota cumingii Lodd. ex Mart.*
BEGONIACEAE	*Begonia acuminatissima Merr*
BEGONIACEAE	*Begonia bolsteri* Merr.
BEGONIACEAE	*Begonia nigritarum* Steudel
DILLENIACEAE	*Dillenia philippinensis* Rolfe
DIPTEROCARPACEAE	*Shorea contorta* Vidal
DIPTEROCARPACEAE	*Shorea astylosa Foxw.*
EBENACEAE	*Diospyros poncei* Merr. forma poncei
ELAEOCARPACEAE	*Elaeocarpus macranthus* Merr.
EUPHORBIACEAE	*Macaranga bicolor* Muell.-Arg.
EUPHORBIACEAE	*Mallotus hirsutus Elmer*
FABACEAE	*Adenanthera intermedia* Merr.
FABACEAE	*Callerya scandens* (Elmer ex Dunn) Schot
FABACEAE	*Strongylodon caeruleus Merr.*
CLUSIACEAE	*Garcinia binucao (Blanco)*
FAGACEAE	*Castanopsis philipensis* (Blanco) Vidal
LAMIACEAE	*Clerodendrum mindorense* Merr.
LAURACEAE	*Deehasia purpurea* (Elmer) Kosterm.
LAURACEAE	*Litsea garciae* Vidal
LAURACEAE	*Actinodaphne dolichophylla (Merr.) Merr.*
LORANTHACEAE	*Decaisnina miniata (Danser) Barlow*
DILLENIACEAE	*Dillenia philippinensis Rolfe*
LECYTHIDACEAE	*Barringtonia pterita* Merr.
LECYTHIDACEAE	*Petersianthus quadrialatus* (Merr.) Merr.
MALVACEAE	*Firmiana philippinensis* Kosterm.
MALVACEAE	*Sterculia stipulata* Korth. var. jagori (Warb.) Tantra
MELASTOMATACEAE	*Astronia candolleana* Cogn.
MELASTOMATACEAE	*Astronia cumingiana S. Vidal*
MORACEAE	*Artocarpus blancoi (Elmer) Merr.*
MORACEAE	*Artocarpus ovatus Blanco*
MORACEAE	*Ficus balete* Merr.
MORACEAE	*Ficus gigantifolia* Merr.
MORACEAE	*Ficus linearifolia Elmer*
MORACEAE	*Ficus pseudopalma* Blanco
MORACEAE	*Ficus ulmifolia* Lam.
PIPERACEAE	*Piper mymecophilum C DC*
RUBIACEAE	*Urophyllum memecyloides (C.Presl) Vidal*

RUBIACEAE	*Neonauclea formicaria* (Elmer) Merr.
SALICACEAE	*Homalium bracteatum Benth.*
SALICACEAE	*Ryparosa cauliflora Merr.*
TECTARIACEAE	*Pleocnemia macrodonta* (Fee) Holttum
ZINGIBERACEAE	*Alpinia congesta Elmer*
ZINGIBERACEAE	*Alpinia haenkei* C Presl
ZINGIBERACEAE	Globba campsophylla K.Schum.

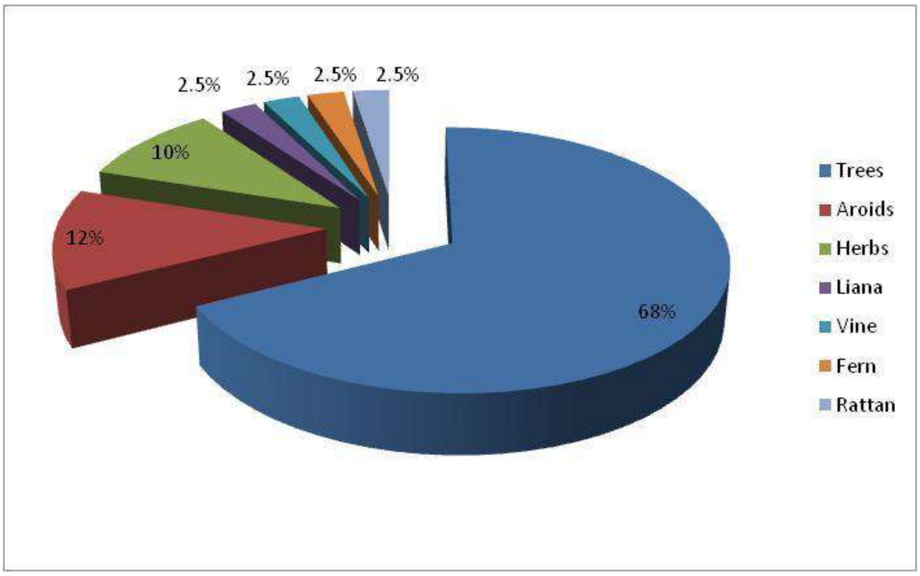

Figure 2.1.4-7 Percent Distribution of Recorded Endemics based on Growth Forms

<u>Threatened Species</u>

A total of 23 species are listed in DAO 2007-1 and the 2015 International Union for the Conservation of Nature (IUCN) Red Data List of Plants and are classified under various threat categories (**Table 2.1.4 -17 and Table 2.1.4 – 18** . The list was updated with DAO 2017- 11 and 2018 International Union for the Conservation of Nature (IUCN). White lauan (*Shorea contorta*) and Narra *(Pterocarpus indicus*) were both present as Critically Endangered species under the IUCN 2018 and DAO 2017-11 conducted in all sampling activities.

Table 2.1.4 - 17 List of Threatened Species Recorded in the Project Site 2012 and 2015

Threatened Species 2012-2015						
Family		**Scientific Name**	**DAO 2007-1**	**DAO 2017-11**	**IUCN 2015**	**IUCN 2018-2**
DILLENIACEAE	Katmon	*Dillenia philippinensis* Rolfe	OWS	Not assessed	VU A1d ver 2.3 (1994)	VU
APOCYNACEAE	Dita	*Alstonia scholaris* (L.) R Br.	Not assessed	Not assessed	LR/lc ver 2.3 (1994)	LC
ASPLENIACEAE	Pugad-Lawin	*Asplenium nidus* L.	VU	Not assessed	Not assessed	Not assessed
EBENACEAE	Ponce kamagong	*Diospyros poncei* Merr.	CR	CR	Not assessed	Not assessed
DIPTEROCARPACEAE	White Lauan	*Shorea contorta* Vidal	VU	VU	CR A1cd ver 2.3 (1994)	CR
FABACEAE	Narra	*Pterocarpus indicus* Willd.	CR	VU	EN	EN
FABACEAE	Tanglin	*Adenanthera intermedia* Merr.	OTS	OTS	VU A1cd ver 2.3 (1994)	VU
FABACEAE	Makapilit	*Pericopsis mooniana* Thwaites	VU	VU	VU A1cd ver 2.3 (1994)	VU
FAGACEAE	Philippine chestnut	*Castanopsis philipensis (Blanco) Vidal*	OWS	Not assessed	Not assessed	Not assessed

VERBENACEAE	Molave	*Vitex parviflora Juss*	EN	EN	VUA1cd ver 2.3	VU
VERBENACEAE	Bagab	*Clerodendrum mindorense* Merr.	VU	VU	Not assessed	Not assessed
MORACEAE	Is-is	*Ficus ulmifolia* Lam.	Not assessed	Not assessed	VU A1cd ver 2.3 (1994)	VU

Table 2.1.4 – 18 List of Threatened Species Recorded in the Project Site 2019

Threatened Species 2019				
Family	**Local Name**	**Scientific Name**	**IUCN 2018-2**	**DAO 2017-11**
Anacardiaceae	Dao	*Dracontomelon dao* (Blanco) Merr. & Rolfe	NA	VU
Anacardiaceae	Amugis	*Koordersiodendron pinnatum* Merr.	NA	OTS
Araceae	Badiang	*Alocasia zebrina* Schott ex Van Houtte	NA	VU
Burseraceae	Pili	*Canarium luzonicum* (Blume) A.Gray	VU	OTS
Dipterocarpaceae	Yakal	*Shorea astylosa* Foxw.	CR	CR
Dipterocarpaceae	White Lauan	*Shorea contorta* S.Vidal	CR	VU
Euphorbiaceae	Tabong	*Macaranga bicolor* Müll.Arg.	VU	
Fabaceae	Tanglin	*Adenanthera intermedia* Merr.	VU	OTS
Fabaceae	Narra	*Pterocarpus indicus* Willd.	EN	VU
Lamiaceae	Uak-uak	*Clerodendrum quadriloculare* (Blanco) Merr.	NA	VU
Meliaceae	Kalantas	*Toona calantas* Merr. & Rolfe	NA	VU
Moraceae	Antipolo	*Artocarpus blancoi* (Elmer) Merr.	VU	
Rosaceae	Balia	*Prunus grisea* (Blume ex Müll.Berol.) Kalkman	LC	VU

2.1.4.5.5 Terrestrial Fauna

General Faunal Profile

A total of 148 terrestrial wildlife species composed of 10 amphibians, 25 reptiles, 97 birds and 16 mammals was recorded within and surrounding areas of the project site. Recorded species represent approximately 27% of the known species for the whole Mindanao faunal region. There were 60 species (42%) that are restricted to the Philippines in distribution (endemics). While most of the species are Common in terms of population status and classified as Least Concern (IUCN, 2015), there were 15 species (10%) that are under various threat categories.

Recorded amphibians and reptiles were mostly common, greater Mindanao endemics or Philippine endemics that are generalist or associated with forest to non-forest habitats. Birds were comprised mainly of common, resident breeders that require some form of forest habitats. Volant (bats) and small nonvolant (murid rodents and shrews) mammals were dominated by common, native but non-endemics found in forest to non-forest areas (also generalist). Medium to large mammals noted were both Threatened species with different habitat associations (one is restricted to forest and the other thrives in both forest to non-forest areas) and distribution range (one is Greater Mindanao endemic while the other is native but non-endemic).

The details of the field surveys are presented below on a per taxon basis (i.e. amphibians and reptiles, birds and mammals). As required in the TSC, each taxon is to be described in terms of species richness, range distribution (includes endemicity), conservation status (includes abundance or general population status), and general habitat association.

The range distributions of documented species including endemics were based on published references: Alcala, 1986; Alcala and Brown, 1998; Kennedy et al., 2000; and Heaney et al., 1998. Near Threatened species were based on IUCN

Red List of Threatened Species (Version 2015.2, <www.iucnredlist.org>, downloaded on 07September 2015). Similarly, threatened species were also based on IUCN Red List of Threatened Species (Version 2015.2, <www.iucnredlist.org>, downloaded on 07 September 2015), and the Philippine Wildlife Act of 2001 as stipulated in DAO 2004-15. Moreover, the list provided in the Convention on International Trade of Endangered Species (CITES) of Wild Flora and Fauna 2015 was also considered. Note that species included under CITES (Appendices I and II) automatically falls within the list of Philippine Wildlife Act of 2001 as stipulated in DAO 2004-15.

A. Amphibians and Reptiles

A total of 35 amphibian and reptile species consisting of 10 frogs/toads, 11 snakes, nine skinks, three agamids, one varanid and one gecko were recorde. This represents approximately 21% of the total (169 species) currently known amphibian and reptile species on the Mindanao Faunal Region (MFR). The MFR is an ecoregion composed of the islands of Bohol, Samar, Leyte, Basilan, Mindanao mainland and adjacent smaller islands which related to each other during the late Pleistocene epoch (Heaney et al., 1998). Species endemism for amphibians and reptiles is high at 60% (i.e. 21 of the total 35 species) including Philippine endemics (eight species) and greater Mindanao endemics (13 species) **Figure** 2.1.4-**8**. Species richness is relatively low within the transect sites covered. This is mainly attributed to the lack of suitable microhabitats brought by the highly fragmented and degraded habitat in the project site. Of the recorded species, the giant marine toad (*Rhinella marina*) is the only introduced species noted in the transect sites.

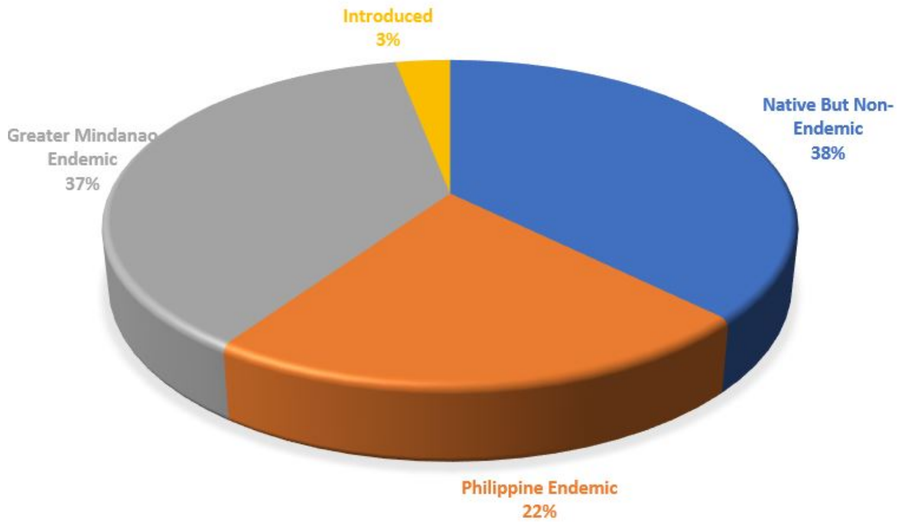

Figure 2.1.4 - 9 Range Distribution of Recorded Species of Amphibian and Reptiles

The absence of intact forest within the project site corresponds to the relatively low diversity of amphibians and reptiles. The presence of a high number of endemics was unexpected since they are supposed to be limited to intact forest wherein certain habitat conditions (e.g. specific food availability, altitude, humidity, temperature etc.) favour their survival. Most of the endemic species within the project site were recorded in coconut plantations interspersed with patches of regenerating forest. This indicates that certain endemic species exhibit a degree of resilience to habitat disturbance. It is also possible that some endemic species are not as sensitive to habitat changes as previously hypothesized. The total species recorded was dominated by common species in two subcategories (i.e. common and locally common) **Figure** 2.1.4 - **7**.

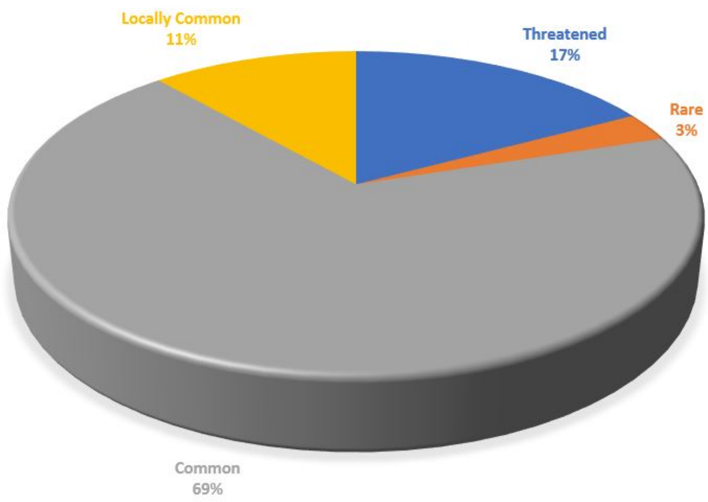

Figure 2.1.4 - **7 General Population Status of Recorded Species of Amphibians**

Majority of the amphibians and reptiles recorded are species associated with forest to non-forest habitats (24 species) followed by species associated with forest habitats (eight species) and non-forest habitats (three species) (**Figure** 2.1.4.**-10**). The high number of forests to non-forest associated species corresponds to the dominant habitat type in the transect sites which is mainly coconut plantations interspersed with patches of regenerating forest. Non-forest vegetations within the project site are composed mainly of shrublands and agricultural areas (i.e. rice paddies). Note that these non-forest vegetations are often in close proximity to patches of regenerating forest. Given the mosaic of vegetation communities in the project site, it is likely that generalist species associated with a wider range of available habitats (e.g. forest to non-forest) are able to adapt and thrive in the area as compared to other species which require forest habitats.

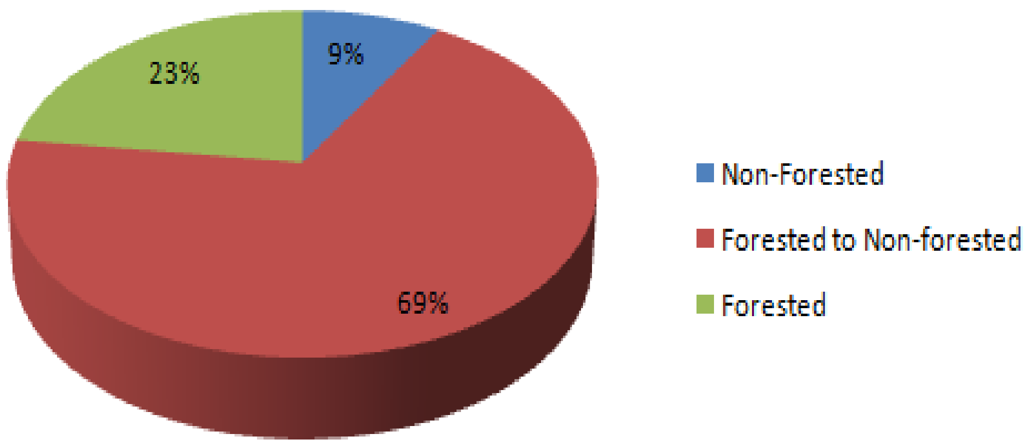

Figure 2.1.4 **-11 Habitat Association of Recorded Species of Amphibians and Reptiles**

While most of the amphibians and reptiles recorded were common species, there were also species of conservation concern, either having a protected status or being globally important. There are seven species (**Annex 2.1-22**) listed as threatened under the 2015 IUCN Red List of Threatened Species (IUCN, 2015) and/or the Philippine Wildlife Act

(PWA) of 2001 (Republic Act (RA) 9147). Three species are currently recognized as “Vulnerable” based on the 2015 IUCN Red List of Threatened Species. Two of these threatened species are endemic species with one Philippine endemic and one Greater Mindanao endemic. One species is listed as “Threatened” and two species are listed “Vulnerable” under RA 9147 and not necessarily in correspondence with the IUCN list. One species, the Samar cobra (*Naja samarensis*) is included under Appendix II of CITES 2015 hence its automatic inclusion as an “Endangered” species under RA 9147. CITES listed species are usually large reptiles hunted either for subsistence purposes or for commercial trade either as food or as pets. However, five of these Threatened species are common in the project site based on observations and interviews with the locals. **Plate 2.1-15** shows the recorded amphibians and reptiles within the transect sites surveyed.

Plate 2.1.4-9 Amphibians and reptiles recorded in the transects. (1) Philippine ratsnake (*Coleognathus erythrurus)* (2) oriental whipsnake (*Ahaetula prasina preocularis)* (3) southern triangle spotted snake (*Cyclocorus nuchalis)* (4) Philippine pit viper (*Parias flavomaculatus)* (5) Samar cobra (*Naja samarensis)* (6) Philippine shrub snake (*Oxyrhabdium modestum)* (7) Schadenberg's burrowing skink (*Brachymeles schadenbergi)* (8) northeastern Mindanao burrowing skink (*Brachymeles gracilis hilong)* (9) banded sphenomorphus (*Sphenomorphus fasciatus)* (10) Jagor's sphenomorphus (*Sphenomorphus jagori)* (11) emerald tree skink (*Lamprolepis smaragdina)* (12) small bent-toed gecko (*Cyrtodactylus annulatus)* (13) reticulated flying lizard (*Draco reticulates)* (14) Philippine giant frog (*Limnonectes magnus)* (15) Mindanao

horned toad (*Megophrys stejnegeri)* (16) white-lipped tree frog (*Polypedates leucomystax)* (17) giant marine toad (*Rhinella marina)* (18) common puddle frog (*Occidozyga laevis)*.

A. Avian Community

In total, there were 97 birds documented from the transect sites (**Annex 2.1-22**) for the complete list). A bird checklist by Avibase (Bird Checklists of the World, 2015) compiled a total of 375 species (composed of 35 endemics, 27 threatened species and one introduction) for Mindanao Island. Documented birds from the transect sites represent approximately 26% of the known birds for Mindanao Island. The relatively high number of species for the transect sites could be attributed to the mosaic of habitat types (i.e. lake environment, rice paddies, agricultural areas like coconut plantation, fragments of secondary growth forest, grassland, brushland, open areas etc.) in the project site. This allows a wide range of bird assemblage to inhabit the area.

Majority (i.e. 77 of the total 97 species) of the birds were documented through direct observations or transect line surveys. Supplemental to transect line surveys were incidental observations (e.g. through calls during early morning, accidental flushing during treks and as individuals being kept as pets by locals) and mist netting activities. The remaining 20 species were identified solely through mist netting. This emphasizes the significance of using mist nets during field surveys to record secretive and nocturnal species otherwise not recorded during regular transect line surveys.

Endemism was high (i.e. 33 of the total 97 species) in the project site. Note that Avibase recorded 35 endemics for the whole Mindanao Island which means that 94% of these endemics are found in the project site. Documented endemics were composed of 22 Philippine endemics, three Greater Mindanao endemics and eight Mindanao endemics recorded. Other identified distribution ranges in the project site are:

- Migrants (four species);
- Migrant with resident breeding populations (one species);
- Near Endemic (one species); and
- Resident (58 species)

Figure 2.1.4-12 shows a chart representing the range distributions of birds recorded in the project site.

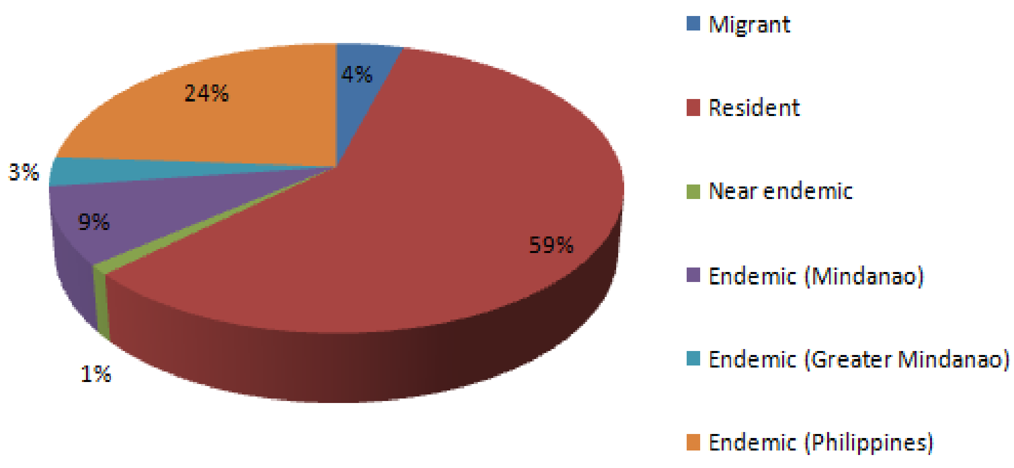

Figure2.1.4-13 Range Distribution of Recorded Bird Species

Six Threatened species composed of the silvery kingfisher (*Alcedo argentata*), Philippine duck (*Anas luzonica*), writhed hornbill (*Aceros leucocephalus*), Mindanao bleeding heart (*Gallicolumba criniger*), colasisi (*Loriculus philippensis*) and guaiabero (*Bolbopsittacus lunulatus*) were recorded in the project site. Two are listed as "Vulnerable" under the 2015 IUCN Red List of Threatened Species (IUCN, 2015). Three are listed as "Vulnerable" and one is considered as "Threatened" under the Philippine Wildlife Act (PWA) of 2001 (Republic Act (RA) 9147). Moreover, two species [i.e. colasisi (*Loriculus philippensis*) and guiabero (*Bolbopsittacus lunulatus*)] are included under Appendix II of CITES 2015. This automatically includes them as "Endangered" under RA 9147. However, the same last two species (i.e. *Loriculus philippensis* and *Bolbopsittacus lunulatus*) although considered Threatened were common in the project site based on observations and interviews with the locals.

Although the transect sites lacked intact forest and instead are dominated by agroforest and brush/shrublands, forest associated species dominated the bird list with 43(47%) species. This is attributed to the high mobility of birds which can come and go within the surrounding areas of the project site. It is likely that the transect sites still provide habitats for a wide range of birds including forest associated species. It is also possible that a number of previously thought strict forest birds (particularly endemics) are able to thrive in habitats that encompass both non-forest and forest areas. Other habitat associations noted in the project site were: forest to non-forest (30%), non-forest (21%) and wetlands (2%). **Figure 2.1.4-14** shows the habitat associations of recorded birds.

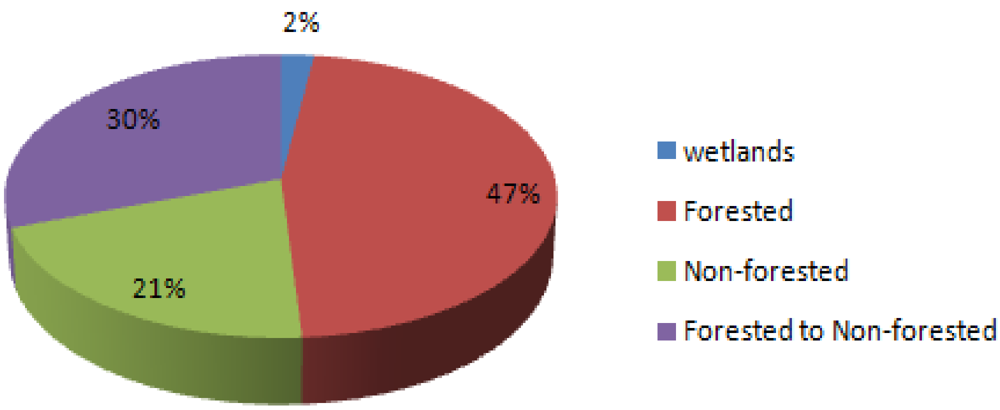

Figure 2.1.4-15 General Habitat Association of Recorded bird Species

Majority (81 of the total 97 species) of the birds are classified as common or under various common categories (i.e. fairly common and locally common). The remaining species were uncommon (nine species), rare (one species) and Threatened (six species). The high number of common species corresponds to the available habitat being characterized mainly by agroforests, brush/shrublands and open areas. These common species are able to occupy these habitats and are able tolerate disturbances within the project site. **Figure** 2.1.4 **-16** shows the population status of recorded bird species.

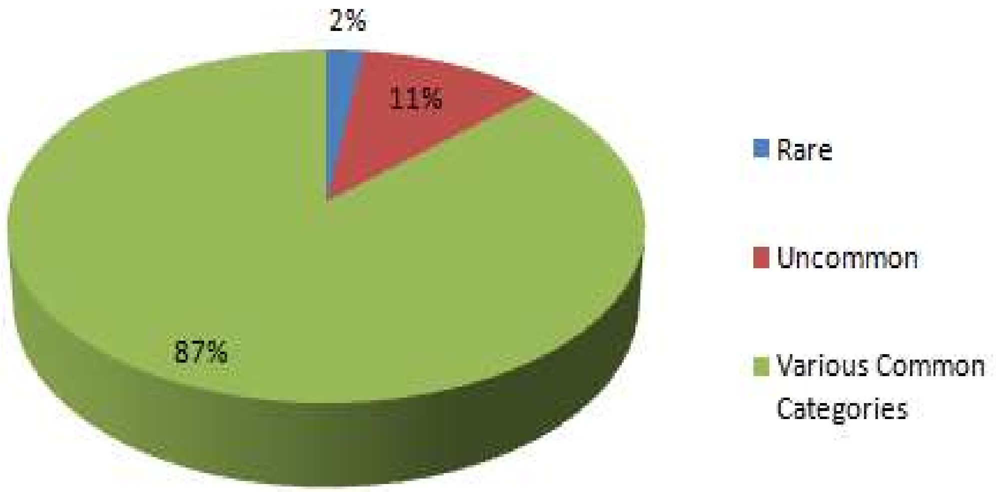

Figure 2.1.4.**-17 General Population Status of Recorded Bird Species**

Plate 2.1.4-10 Birds recorded in the transect sites. (1) olive-bakced sunbird (*Nectarinia jugularis)* (2) grey-hooded sunbird (*Aethopyga primigenius)* (3) little spiderhunter (*Arachnothera longirostra)* (4) yellow-vented bulbul (*Pycnonotus goiavier)* (5) Philippine bulbul (*Hypsipetes philippinus)* (6) yellow-wattled bulbul (*Pynonotus urostictus)* (7) streaked ground babbler (*Ptilocichla mindanensis*) (8) brown tit-babbler (*Macronous striaticeps)* (9) common emerald dove (*Chalcophaps indica)* (10) white-eared brown dove (*Phapitreron leucotis)* (11) silvery kingfisher (*Alcedo argentata)* (12) white-throated kingfisher (*Halcyon smyrnensis)* (13) colasisi (*Loriculus philippensis)* (14) dollarbird (*Eurystomus orientalis)* (15) serpent eagle (*Spilornis holospilus)* (16) blue-throated bee-eater (*Merops viridis)* (17) black-headed tailorbird (*Orthotomus nigriceps)* (18) black-naped monarch (*Hypothymis azurea)*.

B. Mammals

Volant Mammals (Bats)

A total of seven bats comprised of six species from Family Pteropodidae and one species from Family Hipposideridae was documented from the transect sites (**Annex 2.1-22**) for the complete list). All documented Pteropodid bats are frugivorous while the lone representative from Hipposideridae is insectivorous. Due to security risks, net watching was not performed in any of the transect sites which potentially affected their capture. Insectivorous bats are inherently difficult to capture using mist nets since they are able to detect the net and if capture could chew their way out of the net. This could be prevented by net watching and immediate retrieval of captured individuals. Of the recorded species, two are Philippine endemics [i.e. musky fruit bat (*Ptenochirus jagori*) and Philippine dawn bat (*Eonycteris robusta*)] while the other five are native but non-endemic [i.e. common short-nosed bat (*Cynopterus brachyotis*), dagger-toothed flower bat (*Macroglossus minimus*), common rousette (*Rousettus amplexicaudatus*) and common nectar bat (*Eonycteris spelaea*)]. **Figure** 2.1.4 **-18** shows the range distributions of recorded bats from the transect sites.

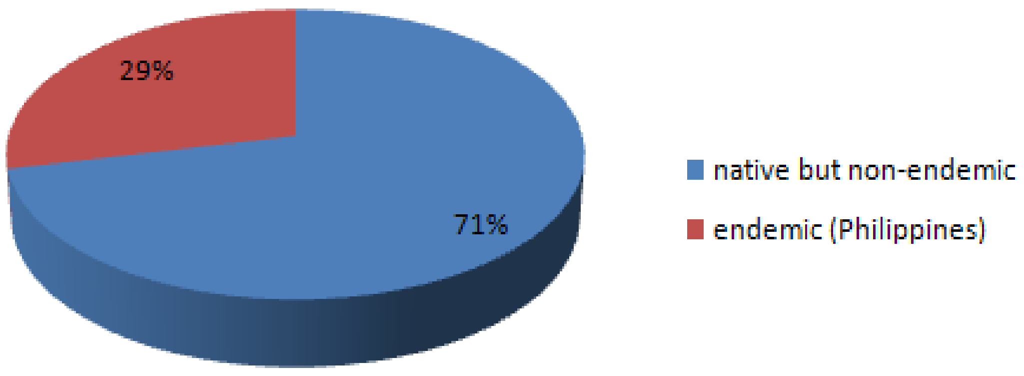

Figure 2.1.4 - 19 Range Distribution of Recorded Species of Volant Mammals

Majority (six of the total seven species) of documented bats were associated with forest to non-forest habitats. Only one species, the Philippine dawn bat (*Eonycteris robusta*) is associated with forest habitats. This species depends primarily on caves as roosting areas though may roost in rock crevices. It is common in undisturbed forest, some in secondary forests and in some disturbed areas which indicate a level of tolerance to habitat disturbance. The other frugivorous species rely on forest to non-forest areas like agricultural lands where food (i.e. nectar and fruits) and roosting areas (i.e. tree holes, dead trees, branches) are available. Insectivore bats also rely on such areas for food foraging, roosting areas and as a habitat. **Figure 2.1.4-20** shows the habitat association of recorded bats.

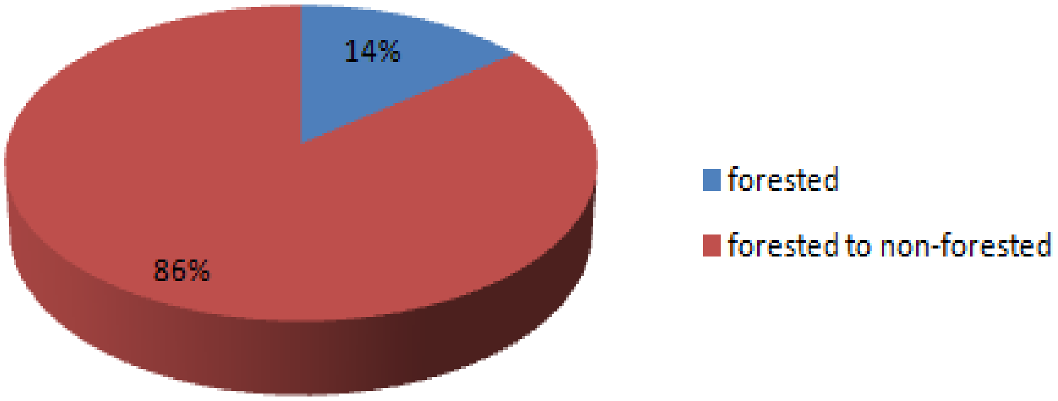

Figure 2.1.4-20 Habitat Association of Recorded Species of Volant Mammals

All but one (i.e. *Eonycteris robusta* considered as rare) of the documented bats are common. These common species are adapted to forest to non-forest habitats. There were no threatened species recorded but one species is listed as near threatened under the 2015 IUCN Red List of Threatened Species (IUCN, 2015) and the Philippine Wildlife Act (PWA) of 2001 (Republic Act (RA) 9147). **Figure** 2.1.4.**-21** shows the population status of recorded bats.

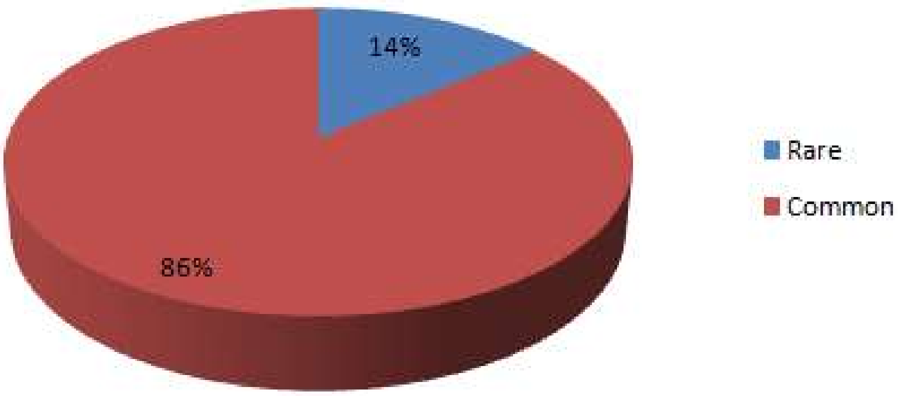

Figure 2.1.4-**22 General Population Status of Recorded Species of Volant Mammals**

Small Nonvolant Mammals

In total, seven small nonvolant mammals represented by five murid species (Rodentia), one shrew (Soricomorpha) and one tree squirrel (Rodentia) were captured and/or observed from the transect sites (**Annex 2.1-22** for the complete list). The survey suggests that there is low diversity of small nonvolant mammals in the transect sites. Moreover, four (i.e. *Rattus tanezumi*, *R. exulans*, *R. argentiventer* and *Suncus murinus*) are commensal species and introduced. These same species are common on agricultural areas and highly degraded forest edge and second growth and could cause considerable damage to crops. Other species noted were endemics composed of Greater Mindanao endemic with two species and Philippine endemic with one species. The abundance and dominance of introduced species reflects the dominant habitat type present in the areas surveyed which is agroforest, brush/ shrublands and agricultural areas.

These species thrive in such areas due to availability of food, proximity to human settlements and less competition to native and endemic species. **Figure 2.1.4-23** shows the distribution range of nonvolant mammals recorded.

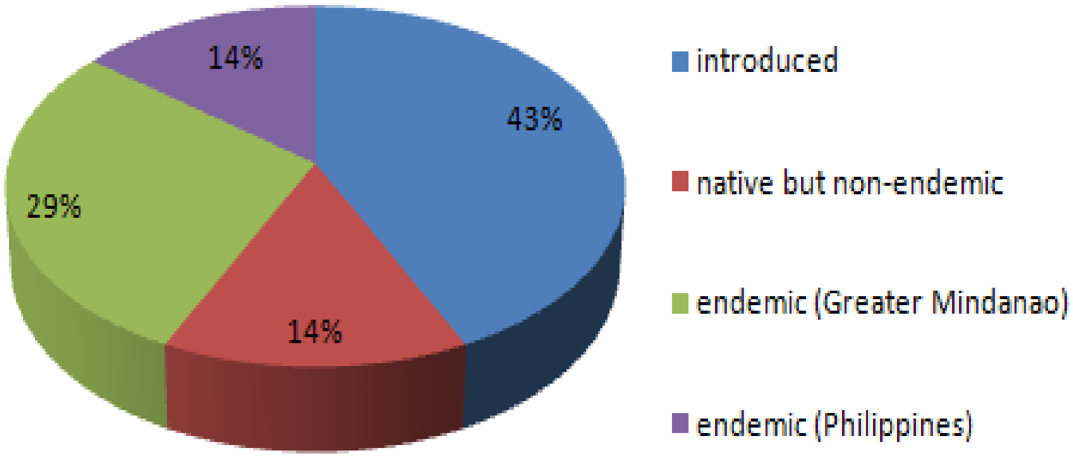

Figure 2.1.4-24 Distribution Range of Recorded Species of Volant Mammals

There are three species that require forest as habitats, three species associated with forest to non-forest areas and one species that thrive in non-forest habitats. Forest associated species were also endemics and their presence in the project site indicate that they exhibit some form of tolerance to habitat disturbance. **Figure 2.1.4-25** shows the habitat association of recorded small nonvolant mammals.

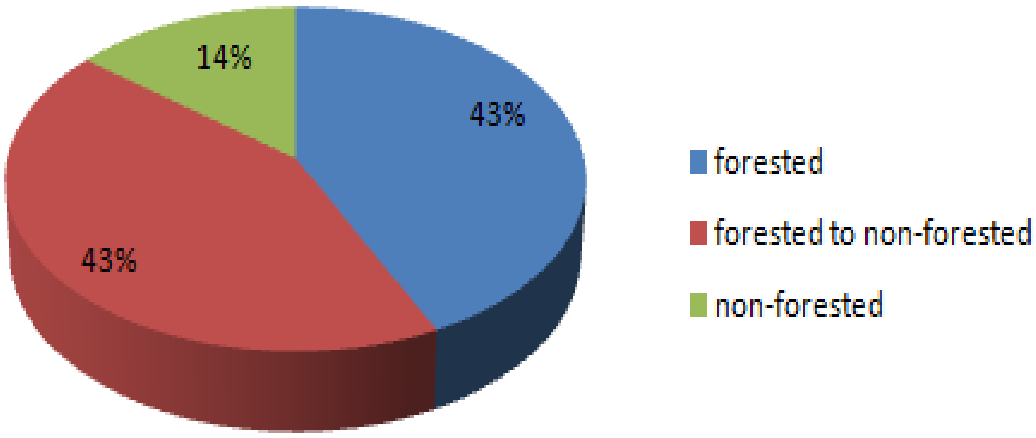

Figure 2.1.4-26 General Habitat Association of Recorded Species of Small Nonvolant Mammals

Recorded species were mostly (five of the total seven species) common. One species is locally common while another is common to uncommon depending on the habitat type. None of the recorded species are listed under the 2015 IUCN Red List of Threatened Species (IUCN, 2015) and Philippine Wildlife Act (PWA) of 2001 (Republic Act (RA) 9147). Figure 2.1.4-27 . shows the population status of small nonvolant mammals.

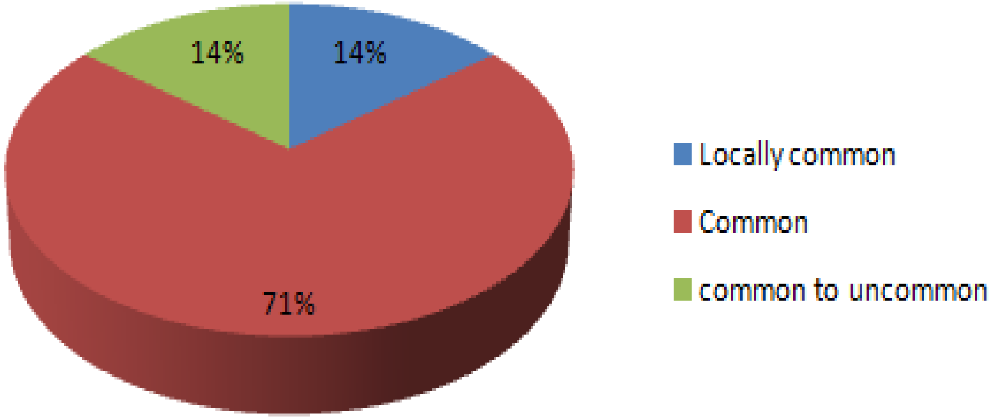

Figure 2.1.4-27 General Population Status of Recorded Species of Small Nonvolant Mammals

Medium to Large Mammals

Two species of medium to large mammals were recorded in the project site. These are long-tailed macaque (*Macaca fascicularis)* and Philippine tarsier (*Tarsius syrichta)*. *M. fascicularis* is a native but non-endemic species associated with forest to non-forest habitats. This species is common to uncommon within the localities where it is present. It is listed as “Threatened” under the Philippine Wildlife Act (PWA) of 2001 (Republic Act (RA) 9147) due to hunting pressure by locals for subsistence purposes and habitat fragmentation/deforestation. *Philippine tarsier* is a Greater Mindanao endemic with an association to forest habitats. It is locally common within its range. It is listed as Near Threatened under the 2015 IUCN Red List of Threatened Species (IUCN, 2015) and “Threatened” under the Philippine Wildlife Act (PWA) of 2001 (Republic Act (RA) 9147) due to habitat fragmentation and destruction and hunting by locals for commercial pet trade. Both of these species are included in the CITES 2015.

Plate 2.1.4-11 **Mammals recorded and photographed in the transect sites. (1) Mindanao bullimus (*Bullimus bagobus)* (2) ricefield rat (*Rattus argiventer)* (3) house shrew (*Suncus murinus)* (4) dagger-toothed long nose fruit bat (*Macroglossus minimus)* (5) lesser dog-faced fuirt bat (*Cynopterus brachyotis)* (6) Philippine dawn bat (*Eonycteris robusta)* (7) common nectar bat (*Eonycteris spelaea*) (8) greater musky fruit bat (*Ptenochirus jagori)* (9) common rousette (*Rousettus amplexicaudatus)* (10) Diadem's roundleaf bat (*Hipposideros diadema)*.**

Noteworthy Species

This succeeding portion presents a list of noteworthy species taken from the overall baseline record to serve as an environmental health indicator for monitoring activities of the Project. They were selected based on several key characteristics, namely:

- Restricted in distribution range to greater Mindanao faunal region, mainland Mindanao or the Philippines;
- Considered as globally threatened based on the 2015 IUCN Red List of Threatened Species (IUCN, 2015) and/or the Philippine Wildlife Act (PWA) of 2001 (Republic Act (RA) 9147); and
- Commonly hunted by the locals for food or as pets.

These species have specific ecological requirements and may react adversely to significant environmental changes. Their range of adaptation (some are sensitive while others are more resilient) suits them as indicators for monitoring purposes to determine the health and condition of local habitat or ecosystem. Any abrupt changes (either increase or decrease) in their numbers can be associated with habitat conditions and/or anthropogenic disturbances.

At least 36 species composed of three amphibians, 14 reptiles, 14 birds, and five mammals were selected as noteworthy species). Of the 36 species, five (14%) are Philippine endemics, 19 (53%) are restricted to the Greater Mindanao Faunal Region, eight (22%) are Mindanao endemic, and four (11%) are native but non-endemics. Hence, approximately 89% of the listed species are composed of endemic species. Moreover, 15 (six birds, two mammals, two reptiles and five reptiles) are considered threatened based on the 2015 IUCN Red List of Threatened Species (IUCN, 2015) and/or Philippine Wildlife Act (PWA) of 2001 (Republic Act (RA) 9147).

2.1.4.5.6 Potential Impacts of Climate Change to Terrestrial Ecology

Without the Project

Based on the 2020 and 2050 PAGASA Climate Change Projection for Surigao del Norte, the number of dry days (days of rainfall less than 2.5 mm/day) is projected to increase from the baseline by 15% in 2020 and 13% in 2050. The number of days with extreme rainfall (daily rainfall greater than 200 mm) is projected to increase from the baseline by 144% in 2020 and continue to increase by 322% in 2050. Moreover, the number of days with extreme temperature (maximum temperature greater than 35°C) in Surigao Del Norte is projected to increase from the baseline by 161% in 2020 and 1,450% in 2050. A detailed discussion on PAGASA climate change projections in the Philippines is presented in **Section 2.3** (Meteorology, Climatology, Greenhouse Gas, Air Quality, and Noise).

It is possible that vegetation types or communities adapted to high rainfall conditions will tend to flourish in the project site. High temperatures increase transpiration in plants affecting photosynthetic rate especially during peak dry seasons where less rain is projected. It is possible that growth in the understorey of existing vegetation and colonization of pioneer trees in the grasslands will increase due to high rainfall.

Climate change has the potential to negatively affect wildlife in the project site mainly through habitat changes. There are no specific studies conducted in the area which documents such negative effects, hence, observations in other areas with similar tropical climate are presented. In general, as climate warms, various vegetation communities and their dependent organisms (e.g. birds, insects) may be expected to shift in their distribution to follow their preferred microclimates. This means that at certain times of the year, it is likely that certain plant groups or layer in the vertical stratification together with their wildlife inhabitants may fluctuate in number. Moreover, their local population in a given geographical location my increase or decrease depending on the prevailing microclimate.

There are studies which have shown that recent climate change has already affected populations of birds. The effects include earlier breeding, changes in timing of migration, changes in breeding performance (egg size and nesting success), changes in population size, changes in population distributions and changes in selection differentials between components of a population (Crick 2004, Robinson et al. 2005). Other effects include disruption of species interaction and communities, synergism with other stresses (e.g. disease, invasive species, habitat degradation), changes in ranges (shifting, contracting, disappearing), and change in population distribution/ land use.

With the Project

With the development of the Project, climate variability and extremes might be potentially enhanced due to clearing of vegetation communities and land-use change. Vegetation clearing and operation of machineries (e.g. trucks/vehicles and other heavy equipment, generators, etc.) would contribute to greenhouse gas emissions and reduce the carbon sequestration of the area. Project activities may give way to introduced weeds and pests that might compete with and infest native vegetation species. This could add stress to the existing vegetation types or communities in the project site. Dust accumulation in plant leaves during project activities coupled with high temperatures would further aggravate physiological stress in terms of photosynthetic rate.

The potential synergism of major project impacts (e.g. vegetation removal and local reduction of carbon sink capability, edge effects, fragmentation, and indirect effects) with climate change could lead to significant changes in population, species range, breeding behaviour and performance, etc. It is critical to aim for a zero biodiversity loss through immediate revegetation of available areas and implementation of offsets. The project should implement offsets to replace affected important wildlife habitats such as residual and/or secondary growth forest, and implementation of a progressive revegetation scheme for available areas within or immediate vicinities the as soon as practicable.

Table 2.1.4-**9 Noteworthy Species (IUCN 2015 and PWA 2001)**

No.	Species	Common Name	Range Distribution	Conservation Status
Amphibians and Reptiles				
1	*Limnonectes magnus*	Philippine giant frog	NBNE	Vulnerable - PWA
2	*Megophrys stejnegeri*	Mindanao horned toad	GME	Vulnerable - IUCN
3	*Hylarana grandocula*	Mindanao stream frog	GME	n/a
4	*Python reticulatus*	reticulated python	NBNE	Threatened - PWA
5	*Naja samarensis*	Samar cobra	GME	Threatened - PWA
6	*Oxyrhabdium modestum*	Philippine shrub snake	GME	n/a
7	*Cyclocorus nuchalis*	southern triangle spotted snake	GME	n/a
8	*Coleognathus erythrurus*	Philippine rat snake	GME	n/a
9	*Ophiophagus hannah*	king cobra	NBNE	Vulnerable - IUCN
10	*Hydrosaurus pustulatus*	sailfin water lizard	PE	Vulnerable - IUCN
11	*Draco cyanopterus*	flying lizard	GME	n/a
12	*Draco reticulatus*	reticulated flying lizard	GME	n/a
13	*Brachymeles Schadenbergi*	Schadenberg’s burrowing skink	GME	n/a
14	*Brachymeles gracilis hilong*	northeastern Mindanao burrowing skink	GME	n/a
15	*Sphenomorphus fasciatus*	banded sphenomorphus	GME	n/a
16	*Sphenomorphus mindanensis*	Mindanao sphenomorphus	GME	n/a
17	*Varanus cumingi*	malay monitor Lizard	GME	Vulnerable - PWA
Birds				
18	*Alcedo argentata*	silvery kingfisher	GME	Vulnerable – IUCN & PWA
19	*Anas luzonica*	Philippine duck	PE	Vulnerable – IUCN & PWA
20	*Aceros leucocephalus*	writhed hornbill	ME	Vulnerable - PWA
21	*Penelopides affinis*	Mindanao tarictic hornbill	ME	n/a
22	*Gallicolumba criniger*	Mindanao bleeding heart	ME	Endangered – PWA

No.	Species	Common Name	Range Distribution	Conservation Status
23	*Loriculus philippensis*	Colasisi	PE	Endangered – PWA
24	*Bolbopsittacus lunulatus*	Guaiabero	PE	Endangered – PWA
25	*Dicaeum proprium*	whiskered flowerpecker	ME	n/a
26	*Centropus melanops*	black-faced coucal	GME	n/a
27	*Aethopyga primigenius*	grey-hooded sunbird	ME	n/a
28	*Orthotomus cinereiceps*	white-eared tailorbird	ME	n/a
29	*Orthotomus nigriceps*	black-headed tailorbird	ME	n/a
30	*Ptilocichla mindanensis*	streaked-ground babbler	ME	n/a
31	*Macronous striaticeps*	brown tit-babbler	GME	n/a
Mammals				
32	*Bullimus bagobus*	Mindanao bullimus	GME	n/a
33	*Tarsius syrichta*	Philippine tarsier	GME	Threatened - PWA
34	*Sundasciurus philippinensis*	Philippine tree squirrel	GME	n/a
35	*Eonycteris robusta*	Philippine dawn bat	PE	n/a
36	*Macaca fascicularis*	long-tailed macaque	NBNE	Threatened - PWA

Legend:

ME Mindanao Endemic PE Philippine Endemic

GME Greater Mindanao Endemic NBNE Native but Non-endemic

2.1.4.6 Potential Impacts and Options for Prevention or Mitigation and Enhancement

A discussion on the key potential impacts of the Project to terrestrial vegetation and wildlife, and their corresponding options for mitigation or prevention or enhancement are presented in the succeeding sections. presents a summary of the key potential impacts to vegetation and wildlife, and their corresponding options for prevention or mitigation or enhancement.

Table 2.1.4.**20** **Potential Impacts and Options for Prevention or Mitigation or Enhancement**

Potential Impacts		Phases				Options for Prevention or Mitigation or Enhancement
		Preconstruction	Construction	Operation	Closure	
Vegetation removal and loss of habitat						
• The total area of the project site to be cleared of vegetation approximately 532 ha. Removal of vegetation within these areas is unavoidable. • It should be noted that the project site has been commercially logged until the 1950s. Subsequently, cleared areas were converted to coconut and falcata plantations, and agricultural areas (rice paddies). • Recorded vegetation types or communities based on this assessment strongly correspond to the past and on-going disturbances in the project site. • More than half (58%) of the project site is dominated by brush/shrublands. • The breakdown of vegetation types or communities to be cleared of vegetation excluding open areas is presented below:					✓	• Clearly delineating and containing the extent of vegetation removal on plans and on the ground prior to removal activities. • A tree cutting permit will be secured form the DENR. Replacement of cut trees will be in accordance to DENR Memorandum Order (DMO) 2012-02. • Wherever feasible, infrastructures should be constructed in existing cleared areas to minimize vegetation clearing. Easement of the major components especially pipelines and access roads should be reduced or limited to maintain considerable amount of vegetation cover. • Development and implementation of a pre-clearing plan prior to construction. The plan should contain detailed clearing and cutting protocols to reduce impacts to the surrounding areas. It would contain handling/ translocation (e.g. balling-out) procedures for vegetation, wildlife and other transportable habitat features such as logs and boulders. Also, it will include handling and management procedures of the cut logs and/or sustainable practices in disposing vegetation waste as per DMO 2013-02. • Provision of offset sites for all areas that will be cleared. Offset site/s will at least be equivalent in area affected by the Project and would jointly be identified by SMMCI and DENR. They will be strategically located to serve as corridors to reconnect fragmented forest habitats surrounding the project site. Offset site can be existing conservation or forest regeneration areas with similar vegetation and wildlife assemblage with that of the affected areas. • Appropriate measures and continuous management of offset sites through access restrictions, weed control and monitoring. • Development of a Biodiversity Management Program (BMP) prior to construction and operation. It will serve as the guideline and framework for the management of potential risks to biodiversity brought about by the

Vegetation Types / Commu-nities	Total Area of Vegeta-tion Commu-nities
Agroforest	225.357
Agricultural areas	53.205
Brush and Shrub lands	40.343
Open	5.210
Total	**324.116**

Potential Impacts	Phases: Preconstruction	Construction	Operation	Closure	Options for Prevention or Mitigation or Enhancement
					activities of the Project during construction, operation and decommissioning phases. Also, it will aim to determine the scale of the ecological impact on species and habitats and quantify the change in biodiversity over time through monitoring activities in the project site.
Vegetation removal as a threat to the local existence of endemic and/or threatened plants and wildlife					
• Vegetation removal could include plant communities and associations, which can be valuable habitat for endemic and/or threatened plant species. At least 100 species of plants and wildlife are endemics while 27 species are under various threat categories.				✓	• Clearing of vegetation will be conducted progressively to allow and optimize seed collection of Threatened and/or endemic species. Also, it will allow migration of highly mobile wildlife species to nearby similar vegetation types or communities. • Provision of offset sites for all areas that will be cleared. Offset site/s will at least be equivalent in area affected by the Project and would jointly be identified by SMMCI and DENR. Offset sites could be rehabilitation areas outside of the project site. • Progressive rehabilitation (within or outside the project site) utilizing propagules of Threatened and/or endemic plants should be undertaken as soon as areas for rehabilitation become available. • Development and implementation of a pre-clearing plan prior to construction. The plan should contain detailed clearing and cutting protocols to reduce impacts to the surrounding areas. It would contain handling/ translocation procedures for wildlife and other transportable habitat features such as logs and boulders. Also, it will include handling and management procedures of the cut logs and/or sustainable practices in disposing vegetation waste as per DMO 2013-02. • Nurseries that will raise seedlings and wildlings of important species for future revegetation requirements shall be established. • Development of a Biodiversity Management Program (BMP) prior to construction and operation. It will serve as the guideline and framework for the management of potential risks to biodiversity brought about by the activities of the Project during construction, operation and decommissioning phases. Also, it will aim to determine the scale of the ecological impact on species and habitats and quantify the change in biodiversity over time through monitoring activities in the project site.
Vegetation removal as a threat to local abundance, frequency and distribution of certain native plants and wildlife					

Potential Impacts	Preconstruction	Construction	Operation	Closure	Options for Prevention or Mitigation or Enhancement
• Removal of vegetation could affect not only endemic and/or threatened species but also other native plants in terms of their local abundance, frequency and distribution. Some plants and wildlife may not be currently categorized as Threatened globally or nationally but may locally be limited in abundance, frequency and distribution in certain areas. Some project activities may potentially contribute to the further decline of these plants in the local setting.				✓	• Identified nurse trees of Threatened and/or endemic plants should be balled-out and relocated outside the project site. • Progressive clearing should be executed to optimize seed collection of Threatened and/or endemic species. It will also allow migration of highly mobile wildlife species to nearby similar vegetation types or communities. • Appropriate silvicultural treatments should be applied to endangered and threatened species to preserve their existence. • As per the proposed pre-clearing plan, procedures on how to handle/ translocate certain wildlife and other transportable habitat features such as logs and boulders will developed and implemented.
Indirect Effects *Aside from direct impacts associated with vegetation removal, the project will also have indirect effects to the project site's ecological values. These associated indirect impacts are presented below:*					
• *Fugitive dust* – generated during various development activities (e.g. excavations, blasting, operation of heavy equipment and vehicles, etc). It may inhibit physiological plant processes (e.g. photosynthesis, transpiration, respiration) and potentially cause physical damage. These will affect wildlife that depend on specific plants for food or the vegetation community that serve as their habitat.	✓			✓	• Major earthworks will be avoided during windy periods. • Sprinkling of access and haul roads including other exposed soils will be implemented during dry weather. • Revegetation of bare areas and/or application of mulch in areas where revegetation is not practicable could be implemented. • Vehicle idling and traffic on exposed soils will be minimized. • All construction vehicles and others will be cleaned ,as necessary, of all loose soil, dust and other debris, prior to leaving the project site. • All trucks, excluding mining haul trucks, loaded with soil or debris will be covered with tarps prior to leaving the site. • A dust control management plan will be implemented using either tarps as cover or erosion control blankets, depending on applicability.. • A speed limit within construction sites to control dust generation will be implemented.
• *Anthropogenic noise* – generated during various development activities may affect the physiology, behaviour, reproduction and the long term survival of wildlife in the project site.					• Whenever practicable there will be revegetation of development area edges to muffle noise during construction and operation phases. • A speed limit within construction sites and internal roads to control noise generation will be implemented. • Scheduling of equipment movements wherever possible to avoid sensitive times (e.g. night time).

Potential Impacts	Phases						Options for Prevention or Mitigation or Enhancement
		Preconstruction	Construction	Operation	Closure		
							• Replacement of standard, tonal reversing beepers on mobile equipment with a lower impact beeper (e.g. "Backalarm" broadband beeper). • Ensuring all vehicles, plant and machinery are maintained in proper working order to avoid unnecessary engine, motor or muffler noise. • Making sure all vehicle and equipment operators are aware of the location of key wildlife habitat and the measures required for limiting noise where possible.
• *Light* – can potentially affect wildlife behaviour, disrupt seasonal day cues, cause temporary blindness, and disrupt predator-prey relationships.		✓				✓	• If feasible, anti-glare lighting will be used to minimize disruption to vision of nocturnal wildlife (e.g. bats, owls, cloud rats). • Use of anti-glare sleeves or shields to control/manage direction of light from vehicle's headlights. • For certain areas, use of light source with directional lighting and screens to concentrate light on operations. • Most wildlife species are expected to habituate to the periodic disturbance and light pollution. Any wildlife individuals that may become attracted to lighting source and may accidentally venture into any development facilities will be carefully removed and brought back into its natural habitat, away from any facilities
• *Vehicle strike* – on various wildlife species could occur along access roads during the construction and operation phases of the project.		✓				✓	• Appropriate driving policies will be implemented and signage will be deployed at key areas for driver's awareness and reduce accidents. Road rules will be clearly conveyed through driver training and strictly enforced as a component of the project safety policies and procedure. • Specific mitigation to be designed and implemented if required for possible areas where frequency of wildlife strikes is high. Wildlife accident trends will be monitored to determine species prone to vehicular strikes, specific areas where accidents commonly take place and at what time. Drivers will have to report incidents concerning wildlife – areas with high incident reports will require specific mitigation (e.g. exclusion fence, culvert crossing, suppression of attractive vegetation that could provide food, shelter or nesting sites, etc.).
• *Increased weed invasion* – opportunistic invasive and exotic weeds might occupy cleared areas and compete with existing vegetation species along the project site especially endemic and/or threatened species.						✓	• Appropriate control measures of weeds will be incorporated in the BMP • Regular brushing, cutting and maintenance of open areas. • All vehicles will be washed down, as necessary, prior to entering the project site to prevent possible introduction of weeds and pests from outside the mine.

Potential Impacts	Phases: Preconstruction	Phases: Construction	Phases: Operation	Phases: Closure	Options for Prevention or Mitigation or Enhancement
Non-continuation of rehabilitation programs					
• Absence of management and non-continuation of rehabilitation programs during decommissioning may lead to failure to regenerate disturbed areas and can further lead to degradation of existing vegetation assemblage.					• SMMCI will implement mitigation/ enhancement measures based on approved EIS. Development of a decommissioning plan together with various stakeholders during the operation of the project • Management of offset sites, and rehabilitated and conservation areas will be turned over to DENR, local government units and people's organizations.

2.1.4.6.1 Potential Impacts to Terrestrial Ecology

Vegetation removal and loss of habitat

Vegetation removal is a major direct impact of the Project **Table 20** presents the areas to be affected per project component. A total of 1,628.51 ha representing various vegetation types or communities will be cleared/ removed of vegetation. The vegetation clearing schedule is presented in**.** However, it should be noted that the project site is heavily disturbed by past and on-going anthropogenic disturbances and that approximately 58% of its total area is covered with brush/shrublands.

Table 2.1.4-**21 Areas to be Affected by the Project Activities per Project Component**

Project Component	Areas to be Affected Excluding Buffer Zones (in ha)
Tailing Storage Facility	250.00
Subsidence	208.00
Ore Stockpile	1.00
Topsoil Stockpile	10.00
Sedimentation Pond	23.00
Mill Facility	30.00
Crushing and Support Facilities	10.00
Total	**~532.00**

**** Note: The area of vegetation communities to be cleared per project component and stages is presented in the succeeding table***

There are two compounding negative effects associated with vegetation removal. These are habitat fragmentation and edge effects. Fragmentation is the process where habitats that were once continuous become divided into separate fragments isolated from each other by non forest land (Lindenmayer and Fischer, 2006). This new dividing habitat type is often artificial and inhospitable to the species remaining within the fragments (Bennett, 1990). Habitat fragmentation also leads to "edge effects", the term given to impacts that occur at the interface between natural habitats, especially forests and disturbed or developed land (Yahner, 1988). When an edge is created between forest and a cleared area, changes to ecological processes within the vegetation can extend between 10 m and 100 m from the edge (Yahner, 1988). These include microclimatic changes in light, temperature, humidity and wind, which can favor a suite of different species and therefore cause significant changes to the ecology of the patch (Lindenmayer and Fischer, 2006).

Vegetation removal will also result to greenhouse gas (GHG) emissions from the decomposition of plant materials and reduced sequestration of greenhouse gases (carbon sinks). Refer to **Section 2.3** (The Air) for the greenhouse gas emissions and carbon sequestration in terms of vegetation clearing.

Vegetation removal to give way for the sub-level caving method will be executed progressively. The degree or magnitude and the time of impact on flora and fauna using the open pit, block-caving and sub-level caving methods are entirely different. In the open pit method, vegetation will be completely removed although clearing will be done in stages hence flora and fauna components will be affected in stages as well. Conversely, the impact of underground mining in the flora and fauna components is gradual whereby the mine area eventually subsides through time leaving some vegetation on top of the soil.

Threat to the local existence of endemic and/or threatened species

The assessment recorded at least 100 endemic species and 27 species that are under various threat categories. These endemic and/or threatened species will be directly affected during vegetation removal. In effect, vegetation removal has the potential to reduce the local abundance of endemic and/or threatened species. In terms of vegetation communities, it will cause the conversion of certain areas that are potential habitat for endemic and/or threatened wildlife species.

Threat to local abundance, frequency and distribution of certain native plants and wildlife

Removal of vegetation has the potential to affect not only endemic and/or threatened species but also other native vegetation and wildlife in terms of their local abundance, frequency and distribution.

Indirect Effects

The Project will also have indirect effects on the ecological values of the project site, including fugitive dust, anthropogenic noise, light, vehicle strike, and increased weed invasion. These indirect effects are discussed below.

Fugitive Dust

When dust settles out of the air, it accumulates on leaf surfaces, thereby negatively affecting various plant processes such as photosynthesis, respiration and transpiration. Dust may also physically affect plants through blockage and damage to stomata, shading, abrasion of leaf surface, which may lead to cumulative effects. Also, dust accumulation on leaf surface increases water loss (transpiration) due to higher absorption of incident radiation (Hirano et al, 1995).These conditions may lead to decreased plant health, decreased productivity, and decreased vigor which means that they become more susceptible to disease and pathogens.

Wildlife species are affected by dust deposition since leaves or fruits covered with dust become less palatable. Moreover it leads to decreased plant health which may result to change in community structure leading to reduced available habitat.

Anthropogenic Noise

Impacts from noise will likely be localized close to the development facilities. It is unlikely to have significant, long- term impact on wildlife populations. Some species are likely to move in response to noise, making the habitat value of the vegetation remaining around the development facilities decrease. It is likely that most animal species will habituate or get used to the periodic noise disturbance, and the construction and operation phases of the Project are likely to only cause temporary disturbance to wildlife.

Light

Effects from night lighting will be particularly localized close to certain development facilities that will have 24/7 operations. These lighting facilities are expected to produce limited glare into the interiors of surrounding natural vegetation due to the naturally thick or dense cover they posses.

Vehicle Strikes

The Project is proposing to construct access roads to connect various facilities. This means new roads for animals to cross and negotiate, as well as an increase in the number of vehicles operating in the project site. These changes are likely to increase the extent of vehicle strikes on native wildlife, with an associated increase in mortality.

Increased Weed Invasion

Clearing of existing vegetation in the project site would mean an opportunity for invasive and introduced weeds to occupy said areas. Access of vehicles and humans within the project site may cause entry of weeds not recorded previously. Introduced weeds may compete with existing vegetation assemblage along the project site.

Non-continuation of Rehabilitation Programs

Some mitigation measures transcend the life of the Project. Hence, non-continuation of rehabilitation programs may negatively affect the project site. To illustrate, access roads could be utilized by locals to access remaining forests located near the TSF and WRD. Absence of the project regulating access to these areas could provide ease of access for timber and wildlife poachers. Moreover, the area would also be accessible to *kaingin* farmers where tracts of remaining vegetated lands may be potentially converted to upland agriculture. These scenarios may limit the natural regeneration of some vegetation communities.

2.1.4.6.2 Options for Prevention, Mitigation or Enhancement

This section presents the recommended options for prevention, mitigation or enhancement of impacts relating to terrestrial vegetation and wildlife.

<u>Vegetation removal leading to habitat loss, fragmentation and edge effects</u>

Areas to be cleared should be clearly and properly delineated as per vegetation clearing schedule and a tree cutting permit should be secured from the Department of Environment and Natural Resources (DENR) prior to vegetation clearing activities. A 100% tree inventory should be conducted to determine the number of trees that will be removed and the corresponding number of replacement seedlings to be outplanted in the identified offset areas as stipulated in DENR Memorandum Order (DMO) 2012-02. The offset sites that will be identified should be at least equivalent in the area affected by the project and would jointly be identified by SMMCI and DENR. They will be strategically located to serve as corridors to reconnect fragmented forest habitats surrounding the project site (e.g. available area between TSF and Subsidence Zone). Offset site/s can be existing conservation or forest regeneration areas with similar vegetation and wildlife assemblage with that of the affected areas. Since 2009, areas outside the predicted disturbance area were planted with a total of 379,345 fruit and forest trees with a survival rate of 92% in support of the Mining Forest Program and the National Greening Program. The summary of the reforestation effort is shown in **Table 2.1.4 - 22**.

Table 2.1.4 - 22 Summary of Reforestation Effort on Immediate Area of the Project

Year Established	Seedling Produced	Seedlings Acquired	Total No. Out-planted	Total No. Re-Planted	Total Area Planted (ha)	No. of Surviving Trees	Survival Rate (%)	Species Planted
July 2009 to June 2010	50,903	-	9,896	1,500	1.59	8,396	85%	Falcata, Mahogany, Mangium, Lazones, Antipolo, Tamarin, Langka, Cacao, Guava, Biasong, Rambutan, Guyabano, Marang, Makopa, Caimito, Mangosteen, Avocado, Bahai, Tambis, Molave, Sagimsim, Kupang, Alinsuwang, Kujait, Golden shower, Talisay, Noni, Caballero, Katurai, Palawan cherry, Bugnay, Durian, Mabolo, Rubber tree, Atsuete
July 2010 to June 2011	36,747	-	12,297	0	4.88	12,297	100%	
July 2011 to June 2012	55,717	-	18,456	5,323	6.36	13,133	71%	
July 2012 to June 2013	65,531	9,748	48,651	3,712	33.42	44,939	92%	
July 2013 to June 2014	89,484	-	8,035	2,125	5.388	5,910	74%	
July 2014 to June 2015	45,730	-	9,185	0	6	9,185	100%	
July 2015 to June 2016	8,122	-	19,084	59	0.85	19,025	100%	
July 2016 to June 2017	111,214	-	102,080	141	60.355	101,939	100%	
2nd Semester 2017 (July to December)	91,236	-	150,661	17,078	36.78	133,583	89%	
July 2017 to June 2018			1,000	0	12.62	1,000	100%	
	554,684	**9,748**	**379,345**	**29,938**	**168.24**	**349,407**	**92%**	

A Biodiversity Management Plan (BMP) should be formulated prior to construction and operation phases. It will serve as the guideline and framework for the management of potential risks to biodiversity brought about by the activities of the Project during construction, operation and decommissioning phases. Also, it will aim to determine the scale of the ecological impact on species and habitats and quantify the change in biodiversity over time through monitoring activities in the project site.

Vegetation removal will be conducted progressively. This is to allow and optimize seed collection of Threatened and/or endemic species. It will also allow the transfer/migration of affected highly mobile wildlife species to nearby similar vegetation types or communities.

Where habitat removal will take place, the limits of clearing will be clearly identified/ delineated on plans and on the ground (using flagging and signage). A pre-clearing plan will be prepared and implemented by SMMCI prior to construction. The plan will contain detailed clearing and cutting protocols to reduce impacts to the surrounding areas and resident wildlife. It is recommended that each development facility (e.g. TSF, Subsidence zone, Processing Mill, access roads and other support facilities) have a pre-clearing plan which will contain an inventory of trees to be removed. The plan will include handling and management procedures of the cut logs and/or sustainable practices in disposing vegetation waste and will be designed in line with DMO 2012-02. Note that prior to any cutting activities, a tree cutting permit will be secured form the DENR.

<u>Threat to the local existence of endemic and/or threatened palnts and wildlife species</u>

The pre-clearing plan will include protocols in handling potential endemic and/or threatened species encountered within all development areas. It would include handling/translocation (e.g. balling-out) procedures not only for vegetation and wildlife but also for other transportable habitat features such as logs and boulders. It is expected that mobile endemic and/or threatened species will move or flee from site due to disturbance. Endemic and/or threatened species that are less mobile (e.g. amphibians, reptiles, nocturnal species, etc.) encountered during vegetation removal will be collected and translocated to other similar nearby habitats.

In the open pit method, progressive vegetation clearing aims to allow and optimize seed and wildling collection from nurse Threatened and/or endemic tree species. Prior to clearing, selected individuals (e.g. those with DBH approximately 20 to 30 cm) of Threatened and/or endemic species should be balled-out and relocated to rehabilitation or offset sites within and/or outside the project site.

Plant nurseries should be established to raise wildlings and saplings of ecologically important species for future revegetation requirements. Further, silvicultural treatments should be applied to preserve the existence of these species. Biodiversity Management Plan (BMP) should be developed prior to construction and operations phases which provide guidelines and framework for the management of potential risks to biodiversity brought about by the activities of the Project during construction, operation and decommissioning phases. Also, it will aim to determine the scale of the ecological impact on species and habitats and quantify the change in biodiversity over time through monitoring activities in the project site.

Provision of offset sites for all areas that will be cleared. Offset site/s will at least be equivalent in area affected by the Project and would jointly be identified by SMMCI and DENR. Offset sites may include regeneration/ revegetation of grassland areas and brush/shrublands. Another option is the rehabilitation/ conservation of residual and/or secondary growth forest. The aim is to achieve a zero-biodiversity loss by replacing affected areas with offset site/s with similar vegetation and wildlife. Offset/s should not be covered by any development activities by the Project and should serve as corridor/s to reconnect fragmented forest habitats. All revegetation activities would conform to DAO-2004-6 “Guidelines in the Integration of Rainforestation Farming Strategy in the Development of Open and Denuded Areas within Protected Areas and other Appropriate Forest Lands”. Furthermore, it would consider the “Manual on the Restoration of Degraded Habitats within Protected Areas” to serve as guide particularly for planting scheme along sloping areas and river banks.

A BMP will be developed and implemented prior to construction. It will aim to determine the scale of the ecological impact on species and habitats and quantify the change in biodiversity over time in the project site. The monitoring sites will be established in areas of vegetation both inside and areas proximal to disturbance areas. Regenerated areas will also be monitored in the long term to allow changes in species composition and structure over time to be quantified. Information collected during monitoring will be used in adaptive management, in order to continually improve the outcomes of regeneration and long term land management, and will form a valuable baseline of data to measure the success of mine rehabilitation.

<u>Threat to local abundance, frequency and distribution of certain native plants and wildlife</u>

Selected nurse trees of endemic plants should be balled-out and relocated to rehabilitation and offset sites within and outside the project site. Appropriate silvicultural treatments should be primarily applied to endemic species to guarantee their continuous survival in the area.

Progressive clearing should be executed to optimize seed collection of Threatened and/or endemic species. It will also allow migration of highly mobile wildlife species to nearby similar vegetation types or communities.

<u>Indirect Effects</u>

Fugitive Dust

The project site has no dry season and is characterized by rain periods all throughout the year. This means that dust problems is insignificant in the project site. However, if needs arise, dust suppression activities along dusty open areas and development sites shall be implemented. Fugitive dust from vehicular traffic and material handling activities will be controlled by management of vehicle speeds and/or application of dust suppression.

- Major earthworks will be avoided during dry and windy periods.
- Sprinkling of access and haul roads including other exposed soils will be implemented during dry days.
- Revegetation of bare areas and/or application of mulch in areas where revegetation is not practicable could be implemented.
- Vehicle idling and traffic on exposed soils will be minimized.
- All construction vehicles and other vehicles will be cleaned, as necessary, of all loose soil, dust and other debris prior to leaving the project site.
- All trucks loaded with soil or debris will be covered with tarps prior to leaving the site.
- Dust generation from exposed fill/stock piles will be covered with tarps or erosion control blankets.
- A speed limit within construction sites to control dust generation will be implemented.

Anthropogenic Noise

The following best practice techniques should be considered by the Project to control noise emission:

- Whenever practicable there will be revegetation of development area edges to muffle noise during construction and operation phases.
- A speed limit of 20 km/h within construction sites and internal roads o control noise generation will be implemented.
- Scheduling equipment movements wherever possible to avoid sensitive times (e.g. night time).
- Replacement of standard, tonal reversing beepers on mobile equipment with a lower impact beeper (e.g. “Backalarm” broadband beeper).
- Ensuring all vehicles, plant and machinery are maintained in proper working order to avoid unnecessary engine, motor or muffler noise.
- Making sure all vehicle and equipment operators are aware of the location of key wildlife habitat and the measures required for limiting noise where possible.

Light

Mitigating measures to minimize light impact on wildlife are provided below.

- If feasible, anti-glare lighting will be used to minimize disruption to vision of nocturnal wildlife (e.g. bats, owls, giant rats).
- Use of anti-glare sleeves or shields to control/manage direction of light from vehicle’s headlights.
- For certain areas, use of light source with directional lighting and screens to concentrate light on operations.
- Most wildlife species are expected to habituate to the periodic disturbance and light pollution. Any wildlife individuals that may become attracted to lighting source and may accidentally venture into any development facilities will be carefully removed and brought back into its natural habitat, away from any facilities.

Vehicle Strikes

With the proper driving speed being followed and with increased driver’s awareness, road accidents are less likely to occur, and animals are expected to be able to avoid vehicles.

Mitigating measures to minimize vehicle strike impact on wildlife are provided below.

- Appropriate driving policies will be implemented, and signage will be deployed at key areas for driver’s awareness and reduce accidents. Road rules will be clearly conveyed through driver training and strictly enforced as a component of the project safety policies and procedure.
- Specific mitigation to be designed and implemented if required for possible areas where frequency of wildlife strikes is high. Wildlife accident trends will be monitored to determine species prone to vehicular strikes, specific areas where accidents commonly take place and at what time. Drivers will have to report incidents concerning wildlife – areas with high incident reports will require specific mitigation (e.g. exclusion fence, culvert crossing, suppression of attractive vegetation that could provide food, shelter or nesting sites, etc.).

Increased Weed Invasion

Appropriate control measures of weeds will be included in the BMP (e.g. recording of weed infestations and monitoring). Regular brushing, cutting and maintenance of open areas (e.g. access roads) will be implemented. All vehicles that might have been from weed-infested areas entering the project site will be washed down to prevent possible introduction of weeds.

Non-continuation of Rehabilitation Programs

SMMCI will need to implement proper rehabilitation and decommissioning of the Project’s components. SMMCI will engage concerned government agencies (DENR), local government units, non-government organizations and people’s organizations in the planning and turnover of management of established rehabilitation and/or conservation areas.

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Environmental Impact Statement

Section 2.2 The Water

Table of Contents

2.2 The Water 2.2-7
2.2.1 Hydrology and Hydrogeology 2.2-7
2.2.1.1 Introduction 2.2-7
2.2.1.2 Regulatory System Applicable to Water Resources Use 2.2-7
National Water Resources Board 2.2-8
National Irrigation Administration 2.2-9
Local Water Utilities Administration 2.2-10
2.2.1.3 Methodology 2.2-11
Survey of Downstream Water Users 2.2-11
2.2.1.4 Surface and Groundwater Availability Analysis 2.2-16
Surface Water Hydrology 2.2-16
Hydrogeology 2.2-24
2.2.1.5 Baseline Environment for Hydrology and Hydrogeology 2.2-25
Hydrologic and Hydrogeologic Setting 2.2-26
2.2.1.6 Dependable Flows and Peak Floods 2.2-32
2.2.1.7 Existing Water Resource Use 2.2-33
Irrigation 2.2-33
Downstream Water Users Survey Results 2.2-34
Domestic Water Use 2.2-38
Water Permits Issued 2.2-40
2.2.2 Project Water Use 2.2-41
Process Water 2.2-43
2.2.3 Site Water Balance 2.2-44
2.2.4 Climate Change Impacts Without the Project 2.2-47
2.2.1.1 Potential Impacts and Options for Prevention or Mitigation or Enhancements for Hydrology and Hydrogeology 2.2-47
2.2.2 Potential Impacts 2.2-47
2.2.2 Water Quality 2.2-51
2.2.2.1 Rationale of the study 2.2-51
2.2.2.2 Regulatory framework of the study 2.2-51
2.2.2.3 Methodology 2.2-52
2.2.5 Assumptions and Limitations 2.2-93
2.2.2.5 Baseline Environment for Water Quality 2.2-94
Stream Water Quality 2.2-96
2.2.2.6 Lake Water Quality 2.2-131
2.2.2.7 Groundwater Quality 2.2-142

2.2.2.8 Sources of Threats to Water Quality 2.2-151
2.2.2.9 Climate Change Impacts Without the Project 2.2-151
2.2.2.10 Potential Impacts and Options for Prevention or Mitigation or Enhancements for Water Quality 2.2-152
2.2.2.11 Options for Prevention, Mitigation or Enhancement 2.2-157
2.2.3 Freshwater Ecology 2.2-161
Background 2.2-161
Assumptions and Limitations 2.2-163
River Systems 2.2-163
Lakes 2.2-169
Baseline Environment for Freshwater Ecology 2.2-172
Baseline Summary for Freshwater Ecology – River Systems 2.2-172
Summary of Endemicity/Conservation Status 2.2-193
Pollution Indicator Species 2.2-194
Sources of Threats to Freshwater Ecology 2.2-195
Climate Change Impacts Without the Project 2.2-196
Baseline Environment for Freshwater Ecology- Lakes 2.2-196
Baseline Environment for Freshwater Ecology- Lakes 2.2-196
Pollution Indicator Species 2.2-198
Sources of Threat to Freshwater Ecology (Lake Mahukdam and Lake Mainit) 2.2-198
Overall Ecology of the Freshwater Ecosystems Studied 2.2-198
Climate Change without the Project 2.2-198
Potential Impacts and Options for Prevention or Mitigation or Enhancements for Freshwater Ecology 2.2-199

Appendix A. Additional Information

2.0 Analysis of Key Environmental Impacts 1
2.1 The Land 1
2.1.1 Land Use and Classification 1
2.1.1.1 Methodology 1
2.1.1.2 Baseline Environment 2
2.1.1.2.1 Land Classification 3
2.1.1.2.2 Land Use 5
2.1.1.2.3 Environmentally Critical Areas 7
2.1.1.3 Land Tenure 12
2.1.1.4 Visually significant landforms/landscape/structures 14
2.1.1.5 Existing solid waste management and related land management scheme in the area 15
2.1.1.6 Potential Impacts and Options for Prevention or Mitigation or Enhancement 15

Important note about your report

Delete after reading: Please include a limitation statement in your report setting out the assumptions and/or limitations that apply to the provision of our services.

By way of example, this could set out:

- *the sole purpose of the report*
- *any information relied upon and presumed accurate in preparing the report (i.e. client and/or third party information)*
- *where data in the report was derived from (i.e. information sourced from the client and/or public domain)*
- *any elements that may require the report to be re-evaluated (e.g. manifestation of latent conditions)*
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- *any project specific limitations (i.e. things that inhibited access to information, time restraints, limited site access etc.)*
- *a statement that the report has been prepared exclusively for Jacobs' client and no liability is accepted for any use or reliance on the report by third parties*

If you require assistance, please contact your regional legal representative.

2.2 The Water

This section provides the baseline assessments for hydrology and hydrogeology, water quality and freshwater ecology.

2.2.1 Hydrology and Hydrogeology

This section presents the results of the studies to assess the potential water impacts from project development and to identify measures for their prevention, mitigation or enhancement. The assessments that were conducted for the project covered both on site and off-site water resources and focused on surface hydrology as well as hydrogeology.

It is recognized that potential adverse impacts on water resources in the surrounding area of the project site is a sensitive issue. On this basis, the most appropriate studies and subsequent mitigation strategies have been considered during the assessment of the project's potential impact on water resources. Specifically, the water resources assessment was undertaken to:

- Obtain baseline hydrometeorological, hydrological, and hydrogeological information;
- Describe the existing water resources at the project site and surrounding areas;
- Understand and assess the existing environmental and community demands on water resources
- Assess how the project will impact upon water resources during construction, operation and closure phases
- Develop mitigation strategies that ensure the necessary community and project water quantity needs are met and
- Formulate a monitoring network whereby any unanticipated impacts resulting from site activities can be rapidly identified and addressed.

2.2.1.1 Introduction

The project site is located in rolling to slightly mountainous topography and extends across several hydrologic catchments and perennial streams along valleys and encompasses the political boundaries of the municipalities of Sison, Placer, Tubod and Mainit.

The project site is situated on the hydrological divide of three river catchments, that of the eastward flowing Bad-as-Amoslog in the east, the Hinagasa-an River flowing northward and the Magpayang flowing southward. The Sub-level Cave Mine is within the catchment of the eastward flowing Timamana Creek, a tributary of the Magpayang River while part of the mine facilities are within the upper catchment of the Bad-as-Amoslog River. The TSF is within the catchment of the northward flowing East Patag Creek, a tributary of the Hinagasa-an River. The assessment of the water resources in these areas are presented in the succeeding sections of this report.

2.2.1.2 Regulatory System Applicable to Water Resources Use

Management of the water resources of the Philippines is undertaken at various levels with responsibility assigned depending upon the type of water and the end use. An understanding of the key Government agencies that regulate the country's water resources is a crucial step in ensuring that, in addition to complying with the proponent's Sustainable Development Policy, all aspects of the project water management strategy and engineering design comply with relevant Philippine legislation and in particular those governing water supply and water discharge.

The four main Government agencies in which management of the water resources is vested are:

- Environmental Management Bureau (EMB);
- National Water Resources Board (NWRB);

- National Irrigation Administration (NIA); and
- Local Water Utilities Administration (LWUA).

EMB and NWRB fall under the jurisdiction of the Department of Environment and Natural Resources (DENR) whereas NIA, which is responsible for the provision of irrigation water for crop production is an agency of the Department of Agriculture. LWUA, being more of an infrastructure focused organization, is attached to the Department of Public Works and Highways (DPWH).

National Water Resources Board

The NWRB is the peak water body in the Philippines and an overview of the functions and responsibilities is outlined on its website (www.nwrb.gov.ph) as:

> *The National Water Resources Board ("NWRB") is the lead government agency in the Philippine water sector, conferred with policy-making, regulatory and quasi-judicial functions. The NWRB is responsible for ensuring the optimum exploitation, utilization, development, conservation and protection of the country's water resource, consistent with the principles of Integrated Water Resource Management.*

The NWRB's functions and responsibilities are three-fold:

- formulation and coordination of policies, programs and standards relating to the Philippine Water Sector;
- management and regulation of all water related activities; and
- regulation and monitoring of water utilities.

The NWRB Board, composed of five cabinet secretaries, a representative from the academe and the executive director, is chaired by the Secretary of DENR. Although independent, insofar as its regulatory and quasi-judicial functions are concerned, the NWRB is under the administrative supervision of the DENR, as an attached agency.

The NWRB executes its water resource regulatory functions through its Water Rights Division, consisting of four sections namely:

- Permits Section;
- Evaluation Section;
- Complaints and Investigation Section; and
- Litigation and Adjudication Section.

As a resource regulator, the NWRB implements the provisions of Presidential Decree No. 1067, otherwise known as the Water Code of the Philippines. Premised on the underlying principle that “all waters belong to the State”, and “the State may allow the use or development of waters by administrative concession”, the NWRB regulates and controls, on behalf of the Government, the utilization, exploitation, development, conservation and protection of all water resources.

More specifically, the NWRB’s functions as a resource regulator include the following:

- issue/suspend/revoke/approve transfer of water permits for the appropriation and use of waters;
- declare waters not previously appropriated exempt from appropriation;

promulgate rules and declare the existence of control areas for the coordinated development, protection, and utilization of ground and surface waters;

- establish minimum stream flows for rivers and streams and minimum water levels for lakes as may be necessary for the protection of the environment, control of pollution, navigation, prevention of salt damage, and general public use;
- issue permits for development of streams, lakes or springs for recreational purposes;
- issue permits for drilling of wells;
- issue rules and regulations for reservoir operations;
- approve transfer of water from one river basin to another;
- coordinate data collection, research and manpower development;
- impose penalties for administrative violations;
- impose and collect reasonable fees or charges for water resource development;
- approve rules and regulations prescribed by other government agencies pertaining to the utilization, exploitation, development, control, conservation or protection of water resources; and
- Adjudicate all disputes relating to appropriation, utilization, exploitation, development, control, conservation and protection of waters.

The NWRB is also mandated, under the Philippine Clean Water Act of 2004 to designate water quality management areas, in coordination with DENR.

In the exercise of its resource regulatory functions, the NWRB is assisted by deputized agents country-wide, which encompass, amongst others:

- District Engineering Offices of the Department of Public Works and Highways;
- Provincial Irrigation Engineering Offices of the National Irrigation Administration;
- Regional Managers of the National Power Corporation; and
- General Managers of Water Districts.

A discussion of the Water Code of the Philippines (Presidential Decree No. 1067) and the associated Implementing Rules and Regulations is presented in Appendix A. It is clear, however, that regulatory approval for the project water supply and issuance of the project site Water Permit rests with the NWRB.

National Irrigation Administration

NIA is primarily a manager and operator of agricultural irrigation schemes. As a rule these are mainly low technology and low operating cost community-scale surface water irrigation schemes, however, in some cases irrigation water is supplied from groundwater sources. It is not believed that any NIA groundwater based irrigation schemes are present in the regional areas surrounding the project although there are a number of NIA managed surface water irrigation schemes present. As managers of the various irrigation schemes in the agricultural districts near to the project site, NIA is a major stakeholder in any impact assessment and an understanding of their role is beneficial. The following extracts from the NIA website (www.nia.gov.ph) provide an insight into the significance of NIA to the project.

Mission

> *To develop and manage water resources for irrigation and provide necessary services on a sustainable basis consistent with the agricultural development program of the government.*

Objectives

- To develop and rehabilitate irrigation systems in support of the national food production program.

- To provide adequate level of irrigation service on a sustainable basis in partnership with the farmers.
- To provide technical assistance to institutions in the development of water resources for irrigation.
- To support economic and social growth in the rural areas through irrigation development and management.
- To improve and sustain the operation of the Agency as a corporation and service-oriented agency.

NIA is essentially a decentralized agency with implementation of the plans, policies and programs designated as the responsibility of the various Regional Irrigation Offices (RIO). Each RIO is headed by a Regional Irrigation Manager. On a Provincial level, Provincial Irrigation Offices (PIO) are responsible for the identification, survey, planning and implementation of communal irrigation projects (CIP), organization and training of Irrigator Associations and provision of services to communal systems. The PIO also assist private individuals or groups of farmers to establish their own irrigation systems.

Local Water Utilities Administration

Until the early 1970s, municipal and community water supply was managed by the local government authorities with no centralized focus. The management was centralized in 1973 when the Philippine Government proclaimed the Provincial Water Utilities Act of 1973 (Presidential Decree No. 198) creating LWUA and allowing for the formation of Water Districts. In 1987, LWUA's area of responsibility was expanded to include provision of Level II (communal faucet system) services to small towns and Rural Waterworks and Sanitation Associations (RWSAs), virtually covering the 1500 or so cities and municipalities of the country. On an operational level, a Water District is a local corporate entity established to operate a water supply system in one or more provincial cities or municipalities. The main role of LWUA is to act as a lending and technical advisory agency to these locally managed Water Districts.

Since its formation, LWUA has been under both the Office of the President and the DPWH. At present it is attached to DPWH as per the requirements of Executive Order No. 387 dated 18 November 2004.

The Placer Water District operates under the supervision of the LWUA.

The Water Code of the Philippines

The management of Philippine water resources; either groundwater or surface water, is governed by the requirements described in the Water Code of the Philippines, issued as Presidential Decree No. 1067 on December 31, 1976. The initial IRR were adopted at the 119th meeting of the National Water Resources Council, now National Water Resources Board (NWRB) on June 11, 1979. An amendment to these IRR was adopted at the 29th meeting of the NWRB on March 21, 2005. A review of the 1979 IRR and 2005 IRR showed that the differences between each are minor.

Article 3 of PD 1067 defines the underlying principles of the Water Code:

Article 3. *The underlying principles of this Code are:*

a. All waters belong to the State.

b. All waters that belong to the State can not be the subject of acquisitive prescription.

c. The State may allow the use or development of waters by administrative concession.

d. The utilization, exploitation, development, conservation and protection of water resources shall be subject to the control and regulation of the government through the National Water Resources Council, hereinafter referred to as the Council.

e. Preference in the use and development of waters shall consider current usages and be responsive to the changing needs of the country.

Water, as applied to PD 1067 is defined in Article 4 and encompasses all waters within the Philippines, viz

> ***Article 4.*** *Waters, as used in this Code, refers to water under the ground, water above the ground, water in the atmosphere and the waters of the sea within the territorial jurisdiction of the Philippines.*

Articles 5 and 6 of PD 1067 provide a further definition of water belonging to the state and leave no doubt to the fact that all waters are subject to State control.

Usage of water is governed by the Rules outlined in the IRR (NWRB, 2005) which state that water may be appropriated for specific purposes. These purposes, listed in decreasing order of priority are:

- *a) domestic;*
- *b) municipal;*
- *c) irrigation;*
- *d) power generation;*
- *e) fisheries;*
- *f) livestock raising;*
- *g) industrial;*
- *h) recreational; and*
- *i) other purposes.*

The industrial usage of water is described (IRR Section 1) as the "utilization of water in factories, industrial plants and mines including the use of water as an ingredient of a finished product." This clearly includes most of the various water related activities associated with the project.

Under the provisions of the Water Code, a Water Permit must be obtained for an industrial supply. This permit is issued by a regional NWRB office.

2.2.1.3 Methodology

Collection of information related to existing water use in the area was made including meteorological data collection to have an appreciation of the water resources, water use and climate in the project area. A survey of water users within the immediate area outside of the project site and surrounding areas was completed for the project.

Data collected from the baseline monitoring network are the key inputs to the surface and groundwater models that have been generated for the project.

Survey of Downstream Water Users

The survey of the number of water supply and irrigation systems, mostly focusing on the seven (7) barangays directly and indirectly affected by the project was undertaken by SMMCI on May 2015. These are:

- Timamana, Tubod, Surigao del Norte
- Boyongan, Placer, Surigao del Norte
- Anislagan, Placer, Surigao del Norte
- San Isidro, Tubod, Surigao del Norte
- Lower Patag, Sison, Surigao del Norte

- Upper Patag, Sison, Suirgao del Norte
- San Isidro, Placer, Surigao del Norte

The objective of the survey was to collect baseline information related to existing water users downstream of the project site that may be potentially impacted by the project. The survey was conducted in coordination with the proponent, various local government units and the NIA. The information gathered during the survey includes:

- Rate of abstraction (from rivers or from groundwater wells or from springs;
- Water usage (irrigation or for domestic use); and
- Number of beneficiaries

The location of water sources were mapped out and discharges from springs were either measured or estimated during the fieldwork. For open springs where the discharge could be directly measured, flow measurement was made by bailing. A container of known capacity (e.g. plastic gallon) was filled from the spring and the fill up rate was recorded to calculate the average discharge. This was done thrice for each spring. Where the water system has no open point/s to measure the discharge, the flow was calculated based on the number of beneficiaries taking into consideration, if any, the number of hours or days that flow is not available.

Domestic water requirement was derived using the following assumptions:

- Six (6) members per households; and
- Per capita consumption at 80 L/person/day.

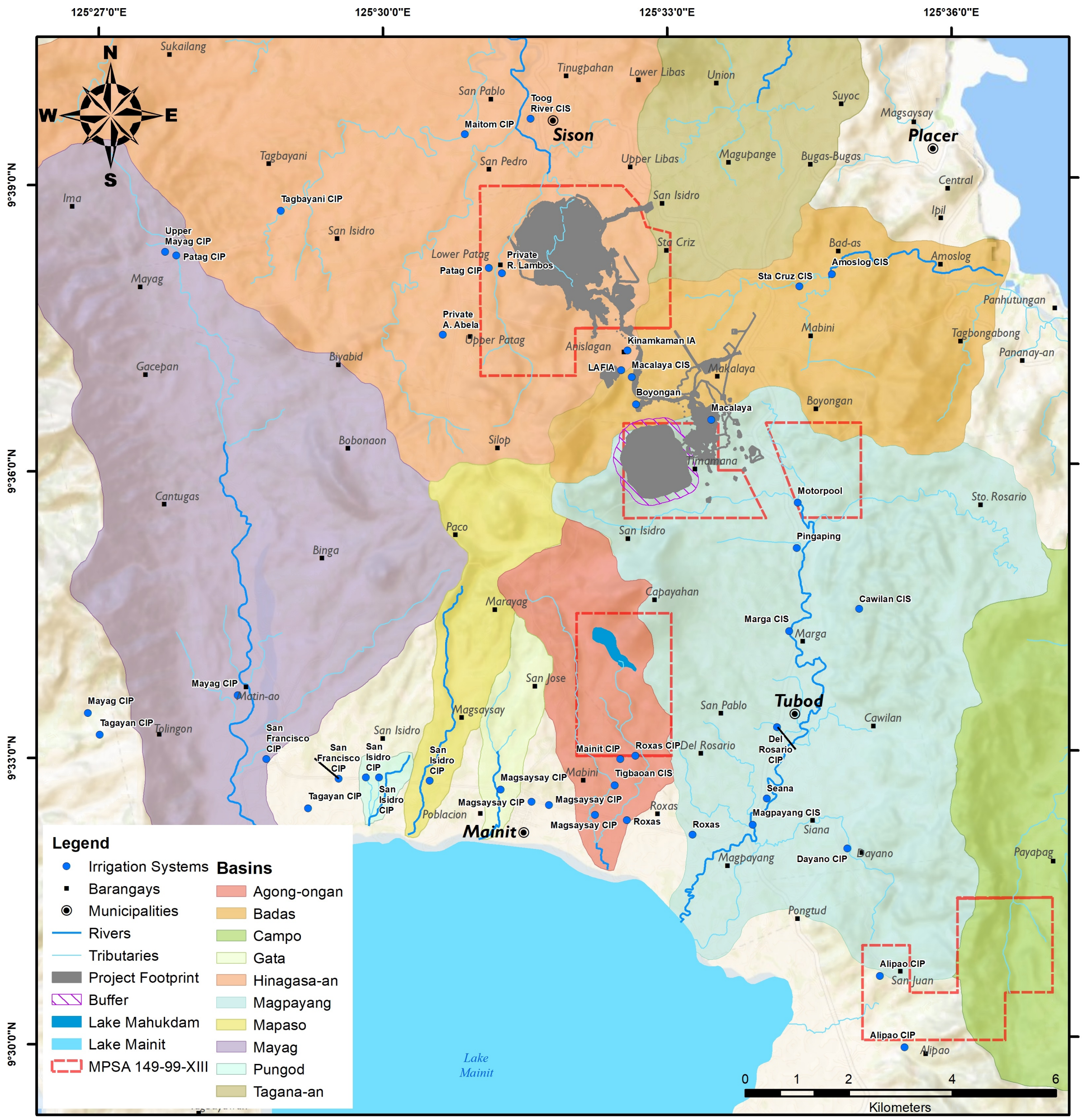
Aside from the seven directly impacted barangays, the following were also visited purposely to map existing water supply systems and users.

- Motorpool, Tubod, Surigao del Norte
- San Pablo, Tubod, Surigao del Norte
- Pingaping, Tubod Surigao del Norte
- Poblacion (San Pedro) Sison, Surigao del Norte
- Maitom, Sison, Surigao del Norte
- Dayano, Mainit, Suirgao del Norte
- Siana, Mainit, Surigao del Norte
- Magpayang, Mainit, Surigao del Norte
- Mabini, Mainit, Surigao del Norte
- San Isidro, Mainit, Surigao del Norte
- Matan-ao, Mainit Surigao del Norte
- Tagbanua, Mainit, Surigao del Norte
- San Francisco, Mainit, Surigao del Norte
- Magsaysay, Mainit, Surigao del Norte
- Roxas, Mainit, Surigao del Norte
- Tigabaoan, Mainit, Surigao del Norte
- Del Rosario, Mainit, Surigao del Norte

Location if existing irrigation systems and domestic water supply sources e.g. springs are shown in

Figure 2.2.1-1 and

Figure 2.2.1-2 respectively.



Existing Irrigation Systems

Silangan Copper-Gold Project

Province of Surigao del Norte

Scale 1 : 100,000	
PLOTTED : RCA	DATE : 03/05/2019
REVIEWED : MKM	APPROVED : KHG

Silangan

Silangan Mindanao Mining Company Inc.

JACOBS ch2m

16F South Tower, Rockwell Business Center Sheridan cor. United St. Mandaluyong City

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Disclaimer:

Administrative boundaries are approximate. Therefore it is not authoritative and should be used for planning and visualization purpose only.

Figure 2.2.1-1Existing Irrigation Systems

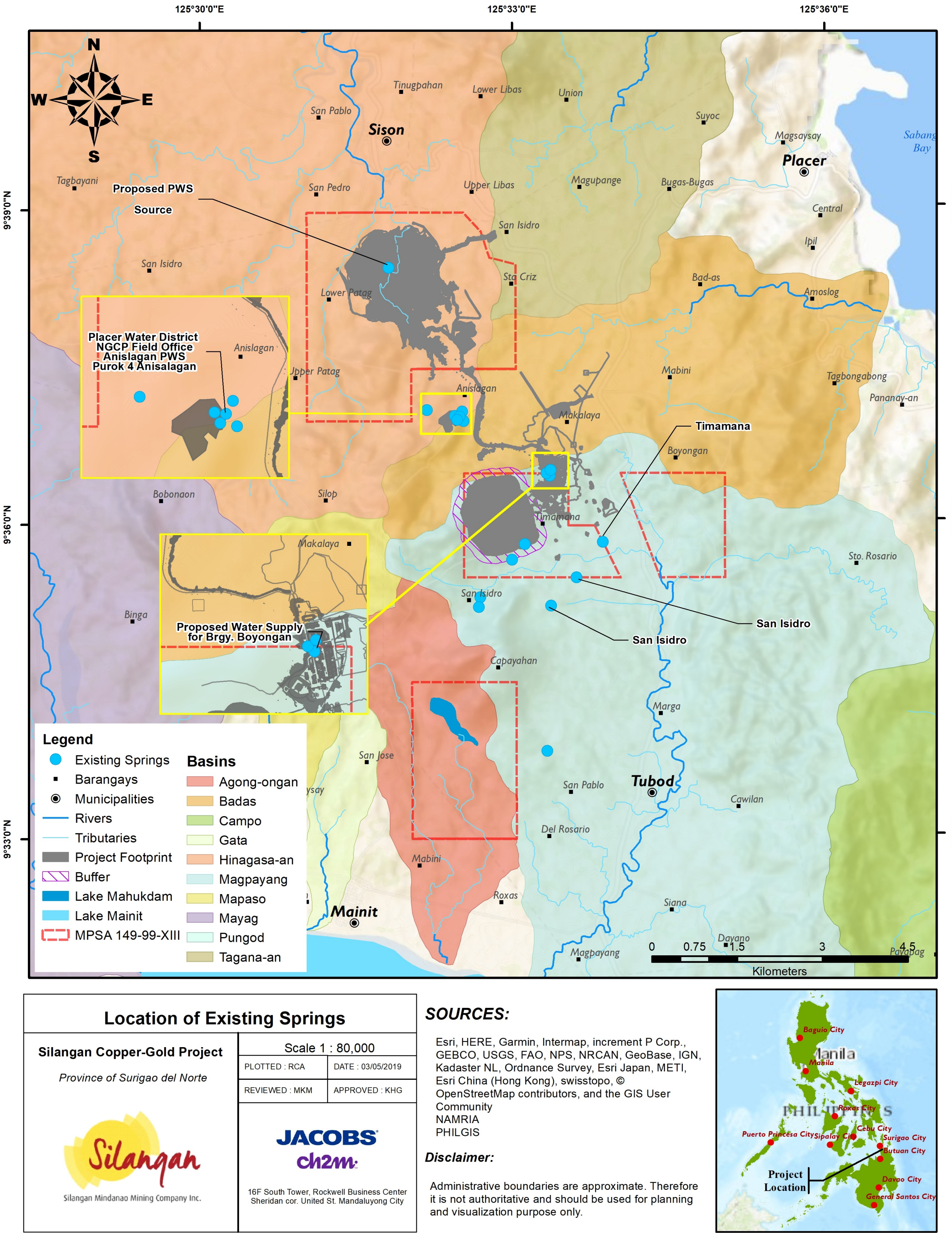


Figure 2.2.1-2 Location of Existing Springs

2.2.1.4 Surface and Groundwater Availability Analysis

A surface water availability analysis was conducted by the proponent of the project to determine dependable flows of ungauged waterways as well as potential maximum flows of waterways that are directly and indirectly impacted by the project. Groundwater modelling was also conducted by the proponent to determine the extent of hydrological impact particularly to springs. Springs are the main source of domestic water supply in the three municipalities.

Surface Water Hydrology

Data Collection

The surface water availability analysis was conducted using the project site hydrometeorological base data as one of the key inputs to the exercise. The primary inputs in the analysis are rainfall and stream flow.

Several stream monitoring stations were also established by SMMCI as part of the hydrometeorological network. Rating curves of each stream were developed to determine the rate of discharge. By simply reading the elevation of the water surface from installed staff gauge, discharge is readily determined from the generated rating curve equation.

The main source of river flow information came from the BRS. This government line agency is operating under the umbrella of the DPWH. The agency is mandated to collect stream flow data of major rivers in the country. The river gauging stations located in Mayag, Surigao, Bacuag and Sonkoy Rivers were obtained from BRS and were used as reference in the study (

Figure 2.2.1-3).

The collated stream flow data were used to generate the flow duration curves of each rivers. From the flow duration curve, a flow series is established showing the dependable flows at various percent of time. The NIA uses the 80% dependability limit stream flows for irrigation and the NWRB also uses it for purposes of granting water permits/rights to irrigators.

Surface Water Hydrologic Analysis

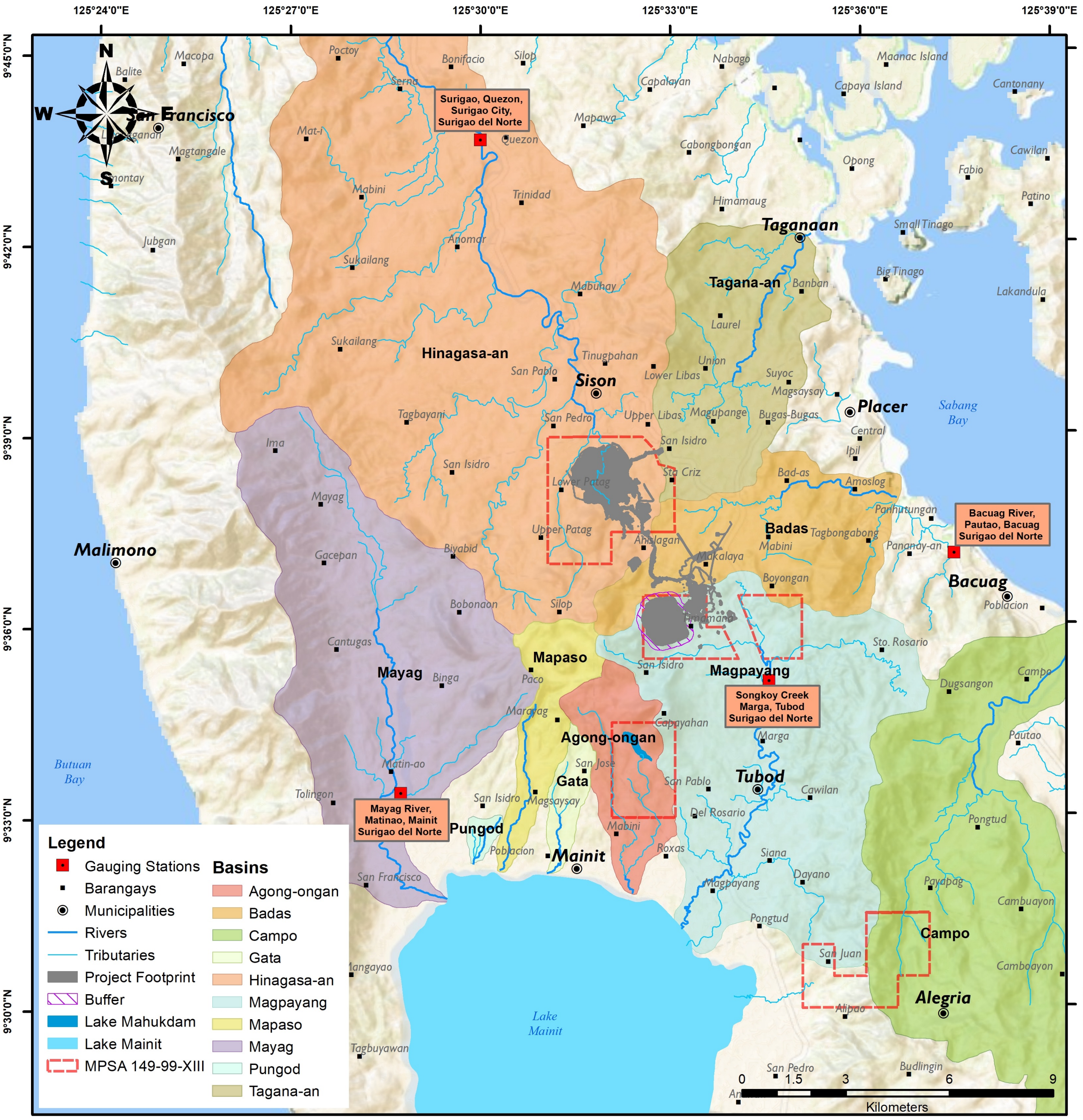
The construction of large infrastructures requires identification of structure related risk, and subsequent development of strategies to reduce that risk, and the creation of policies to put these strategies into effect. These are made to assess hazards that will potentially occur. Vulnerabilities are also analysed to have an understanding of the consequences should an event of certain magnitude and frequency occur. From the results of modelling, mitigating measures are developed and their effectiveness evaluated to eliminate or reduce the identified risks.

The surface water hydrologic analysis conducted focused primarily on the following waterways:

- East Patag Creek in Brgy. Lower Patag, Sison where the TSF is located
- The Bad-as-Amoslog River in Brgy. Macalaya, Placer where the Process Plant, the camp and other mine facilities are located; and
- The Timamana Creek in Brgy. Timamana, Tubod where the Sub-level Cave Mine and Ore Stock Pile are located.
- The Agong-ongan Creek in Brgy. Mabini, Municipality of Mainit.

Flooding potentials were determined through the estimation of flood peaks.

A site water balance analysis taking into consideration the dependable flow of the waterways was likewise constructed to determine potential water resource use computation impacts.



Stream Flow gauging Stations

Silangan Copper-Gold Project

Province of Surigao del Norte

Silangan Mindanao Mining Company Inc.

Scale 1 : 150,000	
PLOTTED : RCA	DATE : 03/05/2019
REVIEWED : MKM	APPROVED : KHG

16F South Tower, Rockwell Business Center
Sheridan cor. United St. Mandaluyong City

SOURCES:

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Figure 2.2.1-3 Stream Flow Gauging Stations of DPWH-NRS

Estimation of Probable Maximum Flood

The design flood flow is called Probable Maximum Flood or PMF. It is the flood that is expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in a particular catchment. It is estimated through synthetic means which calculates the volumetric rate of flow of a certain magnitude in a waterway that will occur in a certain period of time. The calculation of PMP focused on the East Patag Creek, the Bad-as – Amoslog River and Timamana Creek.

Probable Maximum Flood

The occurrence of extraordinary storms and floods usually assumes a process where relationships between frequency and the design event e.g. design flood, structure design life, and the probability of failure within the design life is theoretically defined. The rarer the design event, the higher the cost of mitigating structure. In the process, a balance between mitigating structure cost, structure design or service life, and the consequences of failure must be derived. For example, the probability of failure of a hydraulic structure such as a bridge with a 20-year design life is to be 5% within that 20-year design life, the design must have an average recurrence interval (ARI) of approximately 400 years or more. If a structure has a design life with a 1% chance of failure during design life, then a 0.1% probability design event is appropriate. A probability of 0.10% is equivalent to an ARI of 1,000 years.

For this study, a 1% (1:100) of probability of occurrence in any year was used as a design event for potential flooding downstream of Timamana and Bad-as-Amoslog Creek.

The magnitude of flood from catchments depend on intensity, duration, and distribution in time and space of the rainfall over the catchment and on the physiographic parameters that would affect the runoff viz. Drainage basin area, shape, slope, land use pattern, surface infiltration characteristics of the soil, vegetation cover and initial wetness of the soil. The magnitude of flow is the net result of all these factors acting individually and collectively hence the need to carry probability and frequency analysis to calculate probable flood flow for a given period. With the availability of Rainfall Intensity Duration Frequency RIDF) Data from PAGASA, the frequency analysis is simplified and the methodology described in the DPWH Design Guidelines, Criteria and Standards, Vol. 2 is adopted. Design flows for the various waterways are calculated based on 1:100 years.

Catchment areas were delineated from the 1:50,000 scale maps obtained from the NAMRIA. The catchment areas were determined by overlaying the map in CAD and delineating the catchment electronically. Lengths of waterways were likewise determined electronically in the CAD file including the elevation of the furthest point of interest.

For the delineated catchments, the Rational Method and the Unit Hydrograph is used in estimating the design flow

Rational Method

The Rational Formula provides satisfactory discharge results on catchments with areas 20 km^2 or less. Where the catchment area is more than 20 km^2, an aerial reduction factor is applied. This method is best suited when point rainfall intensities for storms 15, 30, 45 and 60 minutes duration (and also 3, 6, 12 hours, etc.) for different return periods viz. 1, 20 year, 100 years, etc is readily available for the study area. Point rainfall intensities for the required storm duration and return period is read from the RIDF tables prepared by PAGASA. For this study the RIDF data of Surigao City Climatological Station was used. The RIDF data is attached as **Annex 2.2-1**. These intensities of rainfall are made of in the Rational Formula:

$$\mathbf{Q = 0.278\ CIA}$$

Where:

Q = peak discharge in cubic meter per second (m^3/s)

C = Runoff coefficient based on the physiographic characteristics condition of the catchment

I = Rainfall intensity in mm/hour

A = catchment area in square kilometres (km^2)

(a) Time of Concentration

The time of concentration by the runoff from the furthest point of the periphery of the catchment (critical point) to reach the site of the structure being analysed is called the time of concentration "t_c". The intensity of rainfall increases with reduction in duration of the storm. The storm duration should not be shorter than the concentration time for the catchment, otherwise, flow from distant parts of the catchment will not be able to reach the structure site to make its contribution. The peak discharge at the point of interest was therefore obtained from the rainfall intensity corresponding to the duration of time of concentration for delineated catchment.

The time of concentration depended on the distance from the critical point to the site and the average flow velocity. Examining the catchment areas, both assumes an elongated form. This means that for the drop of rainfall from the furthest point to contribute to the flow, it travels a longer time, hence the time of concentration is higher unlike in compact catchment. The higher the tc is, the lower the rate of runoff. Time of concentration tc is obtained by a formula developed by Kirpich as will be shown below:

$$\mathbf{T_c = L^{1.15} / 51H^{0.385}}$$

Where:

T_c = time of concentration in hours

L – distance from the critical point to the site in question in meters

H = fall in level from the critical point to the site in meters

Knowing L and H from the topographic survey or from the NAMRIA Map, t_c can be readily calculated.

For calculated t_c values less than five (5) minutes, the t_c value used in estimating runoff is, for convenience, equal to five (5) minutes.

(b) Runoff Coefficient "C"

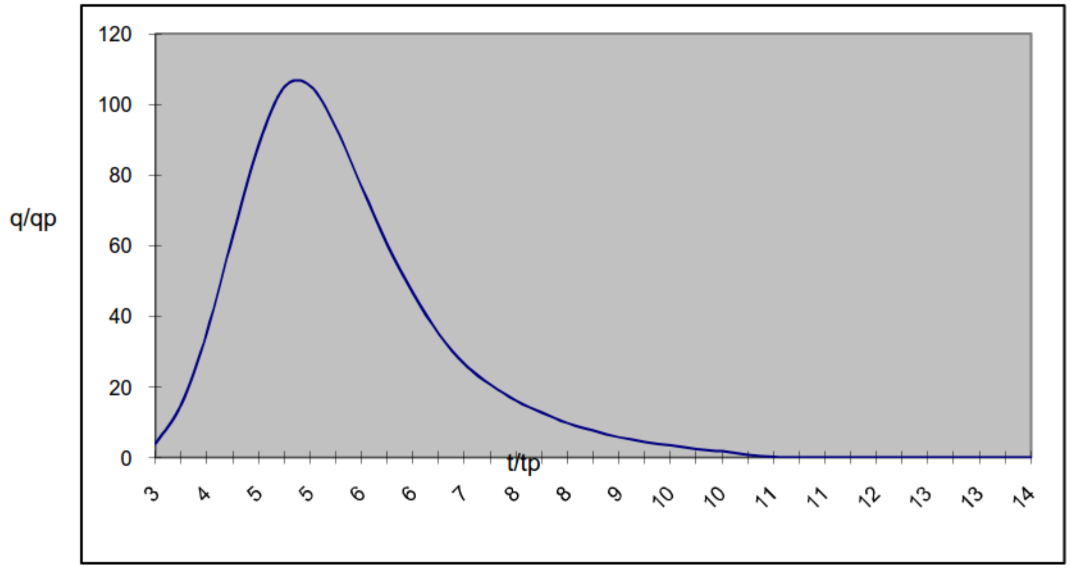
Runoff Coefficient is a constant "C" which characterizes the cover, slope and discharge capacity of the drainage basin.

Considering the existing land use within the catchment, a runoff coefficient of 0.45 was used. Design discharges were calculated for 1:50, 1:100 and 1:200 year storm return period

<u>Unit Hydrograph</u>

The hydrograph of a catchment is defined as the direct runoff hydrograph resulting from a unit volume of excess rainfall of constant intensity and uniformly distributed over the catchment. The duration of the unit volume of excess or effective rainfall, sometimes referred to as the effective duration, defines and labels the particular unit hydrograph. The unit volume is considered as 1 centimetre (or 1 inch) deep of effective rainfall distributed uniformly over the catchment or basin.

To validate the PMF derived from the Rational Formula, the Unit Hydrograph method was also employed. The Dimensionless Unit Hydrograph shown in the figure below masks the effect of basin size and essentially eliminates the effect of shape except as they are reflected in the estimate of basin lag tp and runoff volume.



The general expression for basin lag takes the following equation:

$$\mathbf{Tp = Ct\ (LL_C/S^{1/2})^{0.38}}$$

Where:

Tp = lag time in hours

Ct = coefficient varying from 0.35 for valley areas, 0.75 for hilly areas, and 1.2 for mountainous areas

L – main stream distance from the outlet divide, in km

Lc = stream distance from outlet to the point perpendicular to the basin centroid, km

S = average channel slope

The Model Hyetograph for the catchment area is created by the method of Soil Conservation Service (US-SCS)

In arriving at the model hyetograph, rainfall intensity duration is calculated using the equation

$$\mathbf{I = A\ (t_p + C)^b}$$

Coefficient A, c and b were derived from regression analysis.

The cumulative runoff is determined from the equation

$$\mathbf{Q = P - Ia)^2 / P\text{-}\ Ia + S)}$$

Where:

Q = cumulative runoff (mm)

P = cumulative rainfall (mm)

F = cumulative infiltration (mm)

Ia = Initial abstraction (wetness) = 0.2S

CN = Curve number (Antecedent Moisture Condition III)

Discharge values are in cubic meter per second (m^3/s). **Table 2.2.1-1** shows a summary of the modelled flood flow of rivers present within the project site at pre-mining condition. The Rational Formula Calculations and Unit Hydrograph Models are appended in this document.

Table 2.2.1-1 Modelled Flood Flows of Rivers

Name of River		Location	Catchment Area (km^2)	Estimated Flood Flow (cms)				
				Rational Formula	Unit Hydrograph	Rational Formula	Unit Hydrograph	Rational Formula
				50 years		100 years		200 yea
Hinagasa-an (Toog CIS)		Poblacion (San Pedro), Sison	32.119	581	592	663	678	757
Bad-as Creek (Bad-as-Amoslog confluence)		Amoslog, Placer	9.577	213	192	242	220	276
Magpayang River (Magpayang CIS)		Magpayang, Mainit	53.275	782	864	897	990	1,031
East Patag Creek (confluence Toog Creek)		Lower Patag, Sison	6.593	166	143	188	164	213
Timamana Creek (Magpayang Confluence)		Timamana, Tubod	5.325	144	115	162	132	183

Dependable flow of Waterways

Dependable Flow of Waterways

The successful operation of the project as well as other water downstream is primarily dependent on water availability. The objective of determining the dependable flow of waterways therefore is to have an understanding of potential water resources competition impacts, if any, so that appropriate mitigation measures can be developed.

The yield of surface as well as groundwater resources is by and large dependent on Rainfall. Surigao is considered tropical rainforest type, Koppen Class Af (Type II Climate of the Modified Coronas Classification) with an average rainfall of 308 mm (**Figure 2.2.1-4**). It is distinctly wettest between the months of November until March. During the dry season which is between April to September, afternoon showers and thunderstorms locally called Sobasco are common. This large amount of precipitation feeds the various streams of Surigao del Norte which includes Hinagasa-an, Bad-as-Amoslog and Magpayang Rivers.

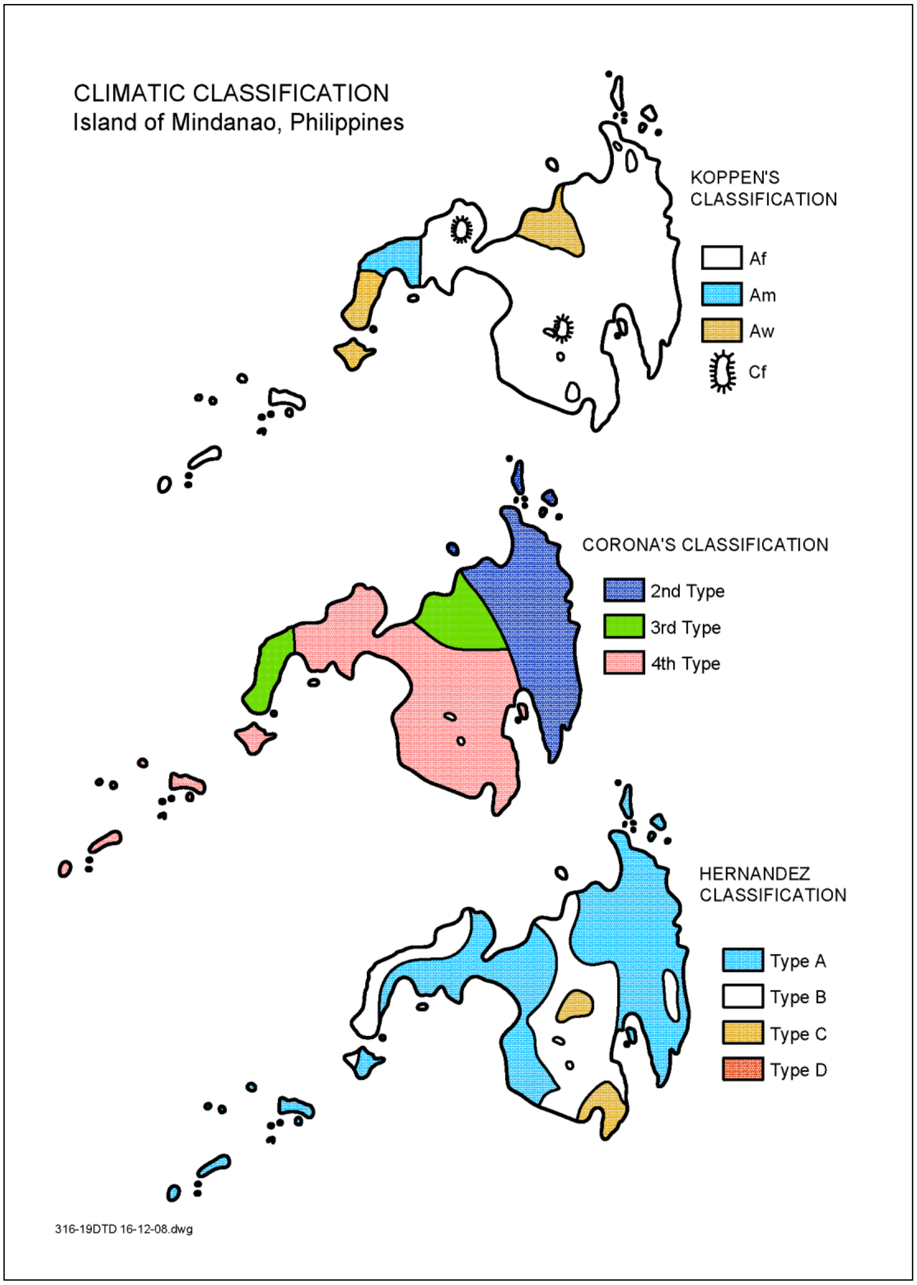


Figure 2.2.1-4 Climate Classification of Mindanao Island

The surface water models were developed using historical information of gauged streams with the objective of producing a model that adequately represents the observed flows with the study rivers, e.g. the probable flows of waterways draining the project site,

The probability of stream flows is termed as flow duration curve (FDC). The flow at various percent of time representing the FDC is called Dependable Flows. In order to assess the potential impacts on stream flows and to provide targets against which mitigation measures need to be established, FDCs defining the annual mean daily flow and the annual minimum mean flow daily flow for the existing surface water regime were developed at a number of rivers and creeks influencing the project site.

To develop the FDC of the various ungauged creeks, the Regional Analysis suing the Multi-river Correlation Method was employed. In this method, the flow series of the various gauged rivers were made as input in a regression analysis to arrive at a common equation representing the discharge. This equation was used to generate the flow series for the ungauged streams with the catchment area as the constant of proportionality.

The inputs used in the surface flow model are the catchment area, basic attributes of catchments (**Table 2.2.1-2**) and flow of various gauged rivers at certain percent of time from the flow series.

Table 2.2.1-2 Basic Catchment Attributes of Gauged of Rivers

Catchment Name	Outlet Location		Catchment Area (km^2)	Mean Annual Runoff (m^3/s)
	Easting (m)	Northing (m)		
Surigao River	125° 29' 17"	9° 44' 26"	101	10.48
Sonkoy River	125° 34' 18"	9° 32' 25"	2	0.27
Mayag River	125° 29' 35"	9° 32' 45"	41	3.52
Bacuag River	125° 37' 00"	9° 37' 00"	64	2.75

Climate Change Impacts on Dependable Flow of Waterways

Last February 2011, the MDG Achievement Fund, funded by the Spanish Government and implemented through the UNDP, the ADPTayo, and an IEC campaign program of the DENR in cooperation with PAGASA published a report entitled Climate Change In the Philippines. The report discusses, among others, current climate change trends in the country, climate scenarios and climate projections focusing on climatic variations for temperature and rainfall. In general, models were developed to estimate climate projections in the country.

In particular, climate projections in Year 2020 and 2059 in Region 13 which include the Province of Surigao del Norte were made. Seasonal (during northeast monsoon, summer season, southwest monsoon and transition from southeast to northeast monsoon), rainfall changes were predicted. The study estimated that from year 2006 to year 3035, a potential decrease in rainfall of about 3.3% during the southwest monsoon season and a fairly larger amount of 11.7% during the “summer” season. However a slight increase in rainfall is predicted during the transition season from southwest to northeast monsoon seasons. From 2036 to 2050, the study predicted more than 30% decrease in rainfall during the “summer” season but slight rainfall is predicted during the southwest monsoon, which means more pronounced rainfall.. This predicted trend has been considered in the water management program of the mine as operation progresses to mitigate potential water competition impacts, if any.

Analysis of Site Water Balance

In order to meet more water demand, required riparian flow releases and downstream water users requirements were taken into consideration. An analysis of site water balance for the mine operation was undertaken considering the following:

- Water pumped out from the underground mine facilty
- Water stored at the regulating/sediment pond
- Water recirculated in the process plant
- Water stored at the TSF; and
- Flows from identified water sources

The analysis was conducted considering the various project site components that will use water or are related to water management such as the dewatering facility (from underground), the TSF, the concentrator and the employee village.

Hydrogeology

The hydrogeology of The Project area comprises of four (4) hydrogeological units. These are:

- *Quaternary Alluvial* deposits consisting of loose to moderately compacted clay, sand, silt and gravel fill the river channels and floodplains (this unit has very limited distribution and was not incorporated into the numerical groundwater flow model).
- The *Quaternary Maniayao Andesite*, consisting of a thick sequence of andesitic lava flows, volcanic breccias and pyroclastic rocks. The andesites lie directly over the Boyongan mineral deposit to a thickness of up to 400 m. Andesite thickness is highly variable within the groundwater flow model domain, ranging from more than 900 m to the west from the deposit to almost 5 m to the east. Saturated thickness varied from about 650 m to 5 m in the west-east direction.
- *Quaternary Tugunan Clastics* sediment formation, including volcaniclastics, debris flow materials, and lakebed sediments (mud, silts, sands, fluviatile conglomerates, and some fossils and decayed organic matter). Thickness of this mudstone unit varies from 150 m to zero; the mudstone layer pinches out in a few locations in the Boyongan area and to the southeast from Bayugo East.
- *Pleocene Intrusive Complex*, which hosts the Boyongan deposit. This complex was subdivided into three units based on defined geotechnical domains (i.e., bedrock of Argillic domain, bedrock of Intermediate domain, and bedrock of Moderate domain).

SMMCI has estimated the dewatering requirements for the Sub-level CaveMine construction activity. Groundwater modelling was conducted to determine potential hydrogeological impacts of the project particularly on surface waters and springs. This was conducted to satisfy the following objectives:

- Identification of alternative sources of water for the host communities should the projected mining operation affect present water sources
- Assessment of the sustainability of present water sources particularly springs
- Assessment of the vulnerability of the groundwater to pollution and contamination from mining and milling operation
- Develop measures to mitigate the effects of mining and milling operation e.g. groundwater drawdown impacts on sprigs and stream discharge.

The hydrogeological model was based on previous studies and on results of a hydrogeological campaign.

The following studies were used in the current hydrogeological conceptual model:

- 2008 Baseline Study by ERM; water levels in 12 bore holes, inventory of 29 springs located at elevations from 160 mAMSL to 330 mAMSL, with measured flows between one and 100 L/s; water quality sampling in springs (56 samples); and preliminary site water balance with an annual rainfall of 4,866 mm/yr (65% surface runoff, 19% potential evapotranspiration, and 16% groundwater recharge).
- 210 Hydrogeological Study by Geotechnical; 47 packer tests in two bore holes and water levels in ten piezometers. The geological units tested were sand, silty sand, andesite, andesite brecchia, and mudstone, and the measured hydraulic conductivity values ranged from 0.004 m/d to 46 m/d.

- 2010 Hydrogeological Investigation by Aqua-Dyne; geo-resistivity survey and preliminary permeability estimation of hydrogeological units.
- 2010 Hydrogeological Investigation. 15 packer-isolated tests in four PQ and HQ core holes (ten of the test yielded valid results), two short term airlift-recovery tests, five falling head tests, and three rising-head test. The units tested were alluvium, andesite, andesite breccia and intrusive and the measured hydraulic conductivity values ranged from 0.0004 m/d to 2.6 m/d.

2.2.1.5 Baseline Environment for Hydrology and Hydrogeology

This subsection presents the key findings and conclusions of the studies for hydrology and hydrogeology of the project site.

Summary – Hydrology and Hydrogeology

Table 2.2.1-3 Key Findings and Conclusions – Hydrology and Hydrogeology

Baseline Information	Key Findings and Conclusions
Hydrologic and Hydrogeologic Setting	• The project site is located in a moderate to slightly mountainous topography becoming gentler towards Sison Municipality. The notable peaks in the mining area are the Mt. Maniayao (Elev. 642 masl) and Mt. Torre (Elev. 678) • The lower reaches of these river systems are agricultural lands mostly planted with paddy rice • The project site straddles three (3) major river catchments namely, Hinagasa-an in the north, Magpayang in the south and the Bad-as-Amoslog in the east. Two (2) minor catchments are also partly straddled by the project site. These are the Mapaso, and Agong-ongan catchments, all located south of the project site. • The hydrogeology of The Project area comprises of four (4) hydrogeological units. These are: - *Quaternary Alluvial deposits* - *The Quaternary Maniayao Andesite* - *Quaternary Tugunan Clastics sediment formation* - *Pleocene Intrusive Complex*
Surface Waterway Morphology	• Runoffs from catchments of the Hinagasa-an River flows downstream to the plains of the Municipality of Sison. • Runoff from catchments of the Magpayang River discharges to the Lake Mainit. The farmlands surrounding the lake most often are flooded during extreme rainfall events. • There is no recorded recent flooding incidence in the Municipalities of Tubod, Sison and Placer. However, water levels along waterways during extreme rain events increases and inundate areas adjacent the waterways. • The proposed TSF straddles the catchment of the Upper Patag Creek, an upstream tributary of the Hinagasa-an River. • The Process Plant, camp and other mine facilities straddle the upper catchment of the Bad-as-Amoslog River. • The upstream catchment of the Magpayang River is partly straddled by the Sub-level Cave Mine and part of the Process Plant and camp facilities.
Groundwater Environment	• The project site and surrounding areas consist of local and less productive aquifers of relatively low yield. • Majority of groundwater within the project site is held within the fractures and joints of the rock. • Wells are uncommon in the project area.

Baseline Information	Key Findings and Conclusions
Dependable Flows and Peak Floods	• The dependable flow at the Hinagasa-an River reckoned from a river point in the Municipality of Sison at existing condition is about 1,668 l/s in 50% of years. • For Bad-as-Amoslog and Magpayang Rivers, the modelled average flow is about 730 and 2,357 L/s, respectively. The probability that these flows or more than these flows will happen is 50%. • There is no recorded recent flooding in the Municipalities of Tubod, Sison and Placer. However, flooding is experienced on areas adjacent the waterways. These areas are mostly farmlands.
Existing Water Resource Use	• There are forty-five (45) group water users recorded within an outside the project site. Thirty eight (38) of these are irrigation systems, Five (5) domestic water supply system from springs • Two (2) undeveloped spring sources were also mapped. However, these will be straddled by the Sub-level Cave Mine. • The Anislagan Spring provides the water requirement of the Municipality Placer; the Caga-asan Spring provides water to Brgys. Bad-as, Boyongan and Mabini; The Linao Spring provides water to Brgy. Macalaya
Climate Change Impacts Without the Project	• From year 2006 to year 3035, a potential decrease in rainfall of about 3.3% during the southwest monsoon season and a fairly larger amount of 11.7% during the “summer” season is predicted. • Slight increase in rainfall is predicted during the transition season from southwest to northeast monsoon seasons. • From 2036 to 2050, more than 30% decrease in rainfall during the “summer” season but slight rainfall is predicted during the southwest monsoon, which means more pronounced rainfall.

Hydrologic and Hydrogeologic Setting

Water Resources

Catchment Area and Drainage

The project site straddles the uppermost catchments of the northward flowing Hinagasa-an River, the eastward flowing Bad-as-Amoslog and the southward flowing Magpayang Rivers. The topography can be described as rolling to slightly mountainous, dissected with gullies and creeks. Within the project site, ground levels range from approximately 300 to 500 masl.

The slopes are lined with gulleys and a major source of silt and debris downstream. The waterways in the upper catchments are narrow and river beds have steep grades with fast cascading flows. The lower reaches located further downstream of the project site have gentle slopes and have wider river regime.

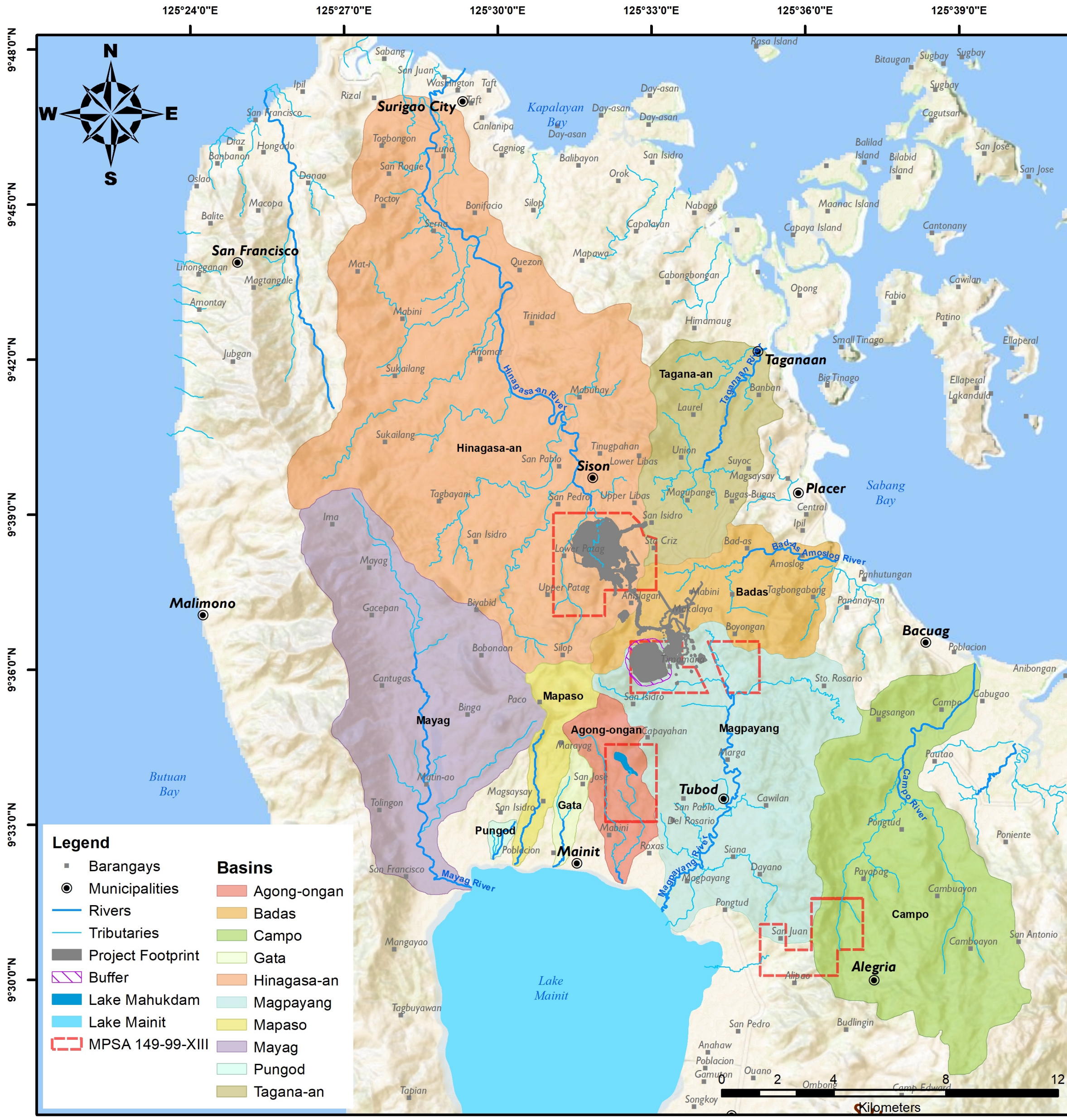
The Sub-level Cave Mine and or stockpile facility directly straddle the upper catchment of the Timamana Creek, a tributary of the Magpayang River. The Magpayang River discharges to Lake Mainit. The Process Plant and camp facilities straddles the upper catchment of the eastward flowing Bad-as-Amoslog River. The TSF on the other hand straddles the catchment of East Patag Creek, a tributary of the Hinagasa-an River. This river flows northward to Surigao City and discharges to the Kapalayan Bay.

Table 2.2.1-4 presents the catchment areas of rivers within the influence of the project site. The largest is the Magpayang catchment and the smallest is the Bad-as-Amoslog catchment.

Figure 2.2.1-5 shows the project catchment area map.

Table 2.2.1-4 Catchment Areas of Major Rivers

Catchment	Estimated Catchment Area (km^2)
Hinagasa-an (Toog CIS as reference point)	32.119
Bad-as/Amoslog (Bad-as confluence as reference point)	9.577
Magpayang Catchment (Magpayang CIS as reference point)	53.275



Project Catchment Map

Silangan Copper-Gold Project

Province of Surigao del Norte

Silangan Mindanao Mining Company Inc.

Scale 1 : 185,000	
PLOTTED : RCA	DATE : 03/05/2019
REVIEWED : MKM	APPROVED : KHG

JACOBS ch2m

16F South Tower, Rockwell Business Center Sheridan cor. United St. Mandaluyong City

SOURCES:

Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community
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Figure 2.2.1-5 Project Catchment Map

Surface Waterway Morphology

Surface waterways follow the topography of the land exhibiting predominantly radial flow from areas of topographic highs and following lithologic boundaries between rock types. Rivers are generally sinuous to braided characteristic of rivers.

Vegetation along the river banks consist mostly of shrubs and unidentified species of bamboos. Most of the channel banks are prone to erosion more particularly along the bends. As erosion proceeds, the gradient of the waterway bed becomes progressively gentler. This is observed in the lower reaches of the Magpayang and Hinagasa-an Rivers.

Groundwater Environment

Groundwater availability in the country has been studied on a national scale by the Mines and Geosciences Bureau (MGB). The study has classified areas in the regions based on aquifer type and potential yields. The result of the study is a map showing the regional groundwater availability that is generally based on the hydrogeologic characteristics of the area. The various classes of groundwater are summarized in **Table 2.2.1-5**, while the regional groundwater availability map for Mindanao is shown in **Figure 2.2.1-6**.

Table 2.2.1-5 Philippine Groundwater Classes

Class	Description
Rocks in which flow is dominantly inter-granular	
Class I (A)	Extensive and Highly Productive Aquifers – with an average potential recharge of 0.5 m to 1 m, greater near influent rivers, with known production well yields mostly between 50 to 100 L/s but as high as 150 L/s at some sites. High to very high permeability.
Class I (B)	Fairly Extensive and Productive Aquifers – with average annual potential recharge of 0.3 m to 0.8 m; greater near influent rivers; with known production well yields mostly about 20 L/s but as high as 60 L/s at some sites. Moderate to high permeability.
Class I (C)	Local and Less Productive Aquifers – well yields mostly about 2 L/s but as high as 20 L/s in some sites.
Rocks in which flow is dominantly through fracture and/or solution openings	
Class II (A)	Fairly Extensive and Productive Aquifers with High Potential Recharge – includes limestones with production well flows up to 30 L/s in highly karstic areas and volcanics with production well flows up to 15 L/s and spring flows up to 60 L/s.
Class II (B)	Fairly to Less Extensive and Productive Aquifers with Low to Moderate Potential Recharge – includes massive to bedded limestone with few interconnected solution cavities, little groundwater development with domestic well yields 3 L/s or less. Strong spring yields reported in local but highly fractured rocks.
Local groundwater regions underlain by impermeable rocks generally without significant groundwater except ion residuum, sufficiently leached and/or fractured zone	
Class III (A)	Rocks with Limited Potential, Low to Moderate Permeability – includes Quaternary lava flows, fair to hard consolidated sandstone, shales conglomerates, metasediments, mudstones etc.
Class III (B)	Rocks without any known significant groundwater obtainable through drilled wells – geological units as above but significantly less fractured, largely untested.

Figure 2.2.1-6 shows that most of the area surrounding the project site is under Class I (C) consisting of local and less productive aquifers of relatively low yield. From a general groundwater perspective these rocks are not typically known as

aquifers. Indicative yields from this class are mostly about 2 L/s but as high as 20 L/s in some sites. On the flatter agricultural areas, the aquifers are generally under Class III (A).

The majority of groundwater within the project site is held within the fractures and joints of the rock (i.e., within secondary porosity features) and for the most part is independent of geology. A more detailed description of the geology in the project site is discussed in **Section 1.1.**

Due to high rainfall, springs are common within the project site and serve to ensure that streams generally continue to flow year-round. A survey undertaken in July 2012 and May 2015 identified five (5) springs in the immediate area of the project site e.g. Anislagan, Municipality of Sison, upstream of TSF. Measured flow rates were up to 4.8 L/s , suggesting a local recharge source. Majority of the springs however had a flow rate of less than 0.3 L/s.

Water from the springs is potable.

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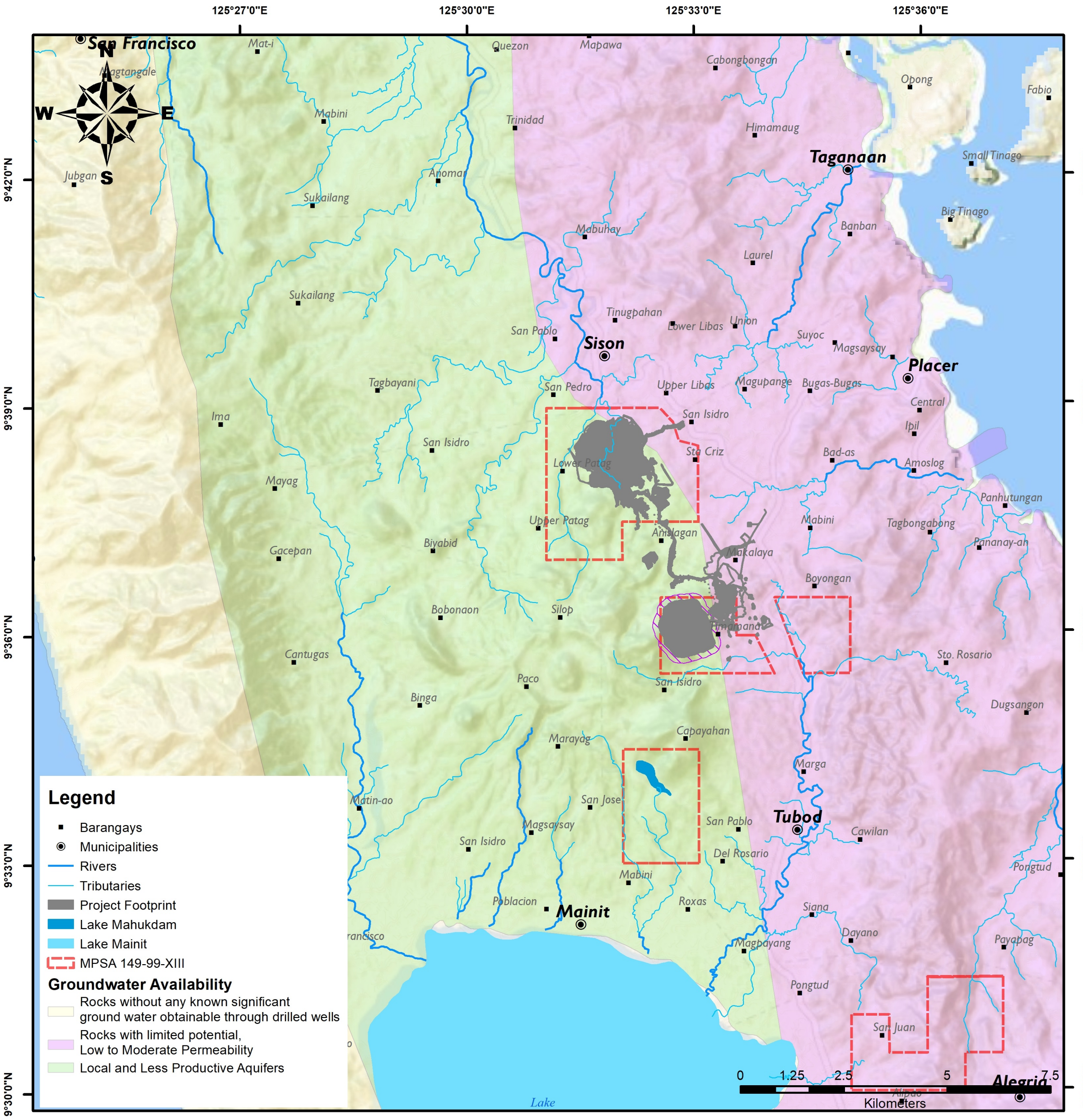

Groundwater Availability	
Silangan Copper-Gold Project *Province of Surigao del Norte*	Scale 1 : 125,000
	PLOTTED : RCA / DATE : 03/05/2019
	REVIEWED : MKM / APPROVED : KHG
Silangan Silangan Mindanao Mining Company Inc.	JACOBS ch2m 16F South Tower, Rockwell Business Center Sheridan cor. United St. Mandaluyong City

SOURCES:

Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community
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Administrative boundaries are approximate. Therefore it is not authoritative and should be used for planning and visualization purpose only.

Figure 2.2.1-6 Regional Groundwater Availability (Surigao)

2.2.1.6 Dependable Flows and Peak Floods

Table 2.2.1-6 shows the generated dependable flows of Hinagasa-an, Bad-as-Amoslog and and Magpayang Rivers based from historical flow records. The dependable flow at the Hinagasa-an River reckoned from a river point in the Municipality of Sison at existing condition is about 1,668 l/s in 50% of years. This means that the probability that this volume of flow may be equalled or exceeded in any given year is 50%. At the Bad-as-Amoslog and Magpayang Rivers, the modelled average flow is about 730 and 2,357 L/s, respectively. The probability that these flows or more than these flows will happen is 50%.

The table also shows the modelled pre-mining flows of the ungauged waterways namely East Patag and Timamana Creeks.

Table 2.2.1-6 Modelled Pre-mining Flows of Gauged and Ungauged Rivers

Name of River	Location	Catchment Area (km^2)	Dependable Flow (in cms) at				
			1%	10%	50%	80%	90%
Hinagasa-an (Toog CIS)	Poblacion (San Pedro), Sison	32.12	13.09	4.86	1.67	1.05	0.84
Bad-as Creek (Bad-as-Amoslog confluence)	Amoslog, Placer	9.58	3.42	1.53	0.73	0.51	0.42
Magpayang River (Magpayang CIS)	Magpayang, Mainit	53.28	22.93	7.89	2.36	1.43	1.12
East Patag Creek (confluence Toog Creek)	Lower Patag, Sison	6.59	2.26	1.07	0.57	0.41	0.34
Timamana Creek (Magpayang Confluence)	Timamana, Tubod	4.67	1.54	0.77	0.45	0.33	0.28

The development of the mine will potentially impact downstream flood flows in the Hinagasa-an, Bad-as-Amoslog and the River catchments. **Table 2.2.1-7** to **Table 2.2.1-9** present the estimated flood flows downstream of the project site during the pre-mining, mining and post mining phases, with different probabilities. The changes in flood peaks for the mining and post mining phases, compared to the existing (pre-mine) conditions, are discussed for each impacted catchment in the following sections.

Table 2.2.1-7 Design Flood Peaks at Existing Condition (m^3/s)

Catchment	Area (ha)	Recurrence Interval (years)		
		50	100	200
Hinagasa-an (at Toog CIS)	3211.9	592	678	777
Bad-as-Amoslog (at Bad-as confluence)	957.7	213	242	276
Magpayang (at Magpayang CIS)	5,327.5	864	990	1138
East Patag (at Toog confluence)	659.3	166	188	213
Timamana (at Motorpool CIS)	532.5	144	162	183

Table 2.2.1-8 Design Flood Peaks During Mine Operation (m^3/s)

Catchment	Area (ha)	Recurrence Interval (years)		
		50	100	200
Hinagasa-an (at Toog CIS)	3211.9	634	724	827
Bad-as-Amoslog (at Bad-as confluence)	957.7	214	243	277
Magpayang (at Magpayang CIS)	5,327.5	866	992	1140
East Patag (at Toog confluence)	659.3	220	249	282
Timamana (at Motorpool CIS)	532.5	161	181	205

Table 2.2.1-9 Design Flood Peaks at Post Mining Condition (m^3/s)

Catchment	Area (ha)	Recurrence Interval (years)		
		50	100	200
Hinagasa-an (at Toog CIS)	3211.9	634	724	827
Bad-as-Amoslog (at Bad-as confluence)	957.7	214	243	277
Magpayang (at Magpayang CIS)	5,327.5	866	992	1140
East Patag (at Toog confluence)	659.3	220	249	282
Timamana (at Motorpool CIS)	532.5	161	181	205

From the above tables, slight increase in flow along the rivers will be experienced mainly due to change in topography, vegetation cover and land use. The average increase in flow is about 10%. Highest increase in flow in terms of percentage is experienced at East Patag catchment because most of the creek's catchment is straddled by the TSF. However, this increase in flow will be offsetted as diversion channels will be constructed along the pheripery of the TSF. Direct rainfall will be captured and stored in the TSF.

2.2.1.7 Existing Water Resource Use

Irrigation

Irrigation water is abstracted from surface water systems either through the use of diversion weirs or via an intake structure. The irrigation systems, in general, comprise a series of canals and ditches traversing the higher reaches of farmlands or upstream slopes. Water is drawn from these canals through improvised off-takes or directly carved out notches from the side of the earth canals.

The diversion weirs are typically made of concrete, rubble masonry or comprise a simple brush embankment. Weirs of large irrigation systems, particularly those implemented by the NIA, are mostly made of rubble masonry. Canals are generally concrete lined, made of concrete hollow blocks or plain earth-lined.

The irrigation systems are maintained by community-based irrigator associations with minor supervision from NIA Provincial Irrigation Management Offices (PIMO). Fees are collected by NIA based on the number of hectares irrigated.

Flood irrigation is generally carried out for irrigating rice crops (palay), however, for crops like papaya and banana irrigation water is applied until soil saturation.

Irrigation water requirement is the quantity of water diverted from the abstraction point. It encompasses water losses due to evaporation, percolation, and crop water requirements. It is expressed in liters per second per hectare (L/s/ha) and NIA terms it as “water duty”. Water duty depends on the cropping pattern and the climate. Multiplying the water duty by the area that is suitable for irrigation gives the total water requirement for an area. In general, the average water duty for rice production is about 1.5 L/s/ha. On Mindanao Island, where the rainfall pattern is evenly distributed, the average water duty is about 1.3 L/s/ha.

Water demand varies through the cropping cycle. During land soaking and planting, water duty may increase up to 2.5 L/s/ha, while during crop maintenance it will fall to about 1.0 L/s/ha. During the dry months where flows in streams are insufficient to provide the required volume of irrigation water, the service area is reduced by as much as 50%.

Downstream Water Users Survey Results

The downstream water users’ survey covered a total of 45 water sources within the catchments immediately surrounding the project site. Out of the 45 water sources, thirty-eight (38) are classified as irrigation systems, five (5) as main source of domestic water supply system and two (2) potential source of domestic water supply.

A summary of the water users based on their location and purpose or type of supply is provided in **Table 2.2.1-10**. Details of the irrigation and domestic water supply use are discussed in the next two sections.

Table 2.2.1-10 Existing group Water Users

Municipality	Irrigation	Spring	Well	Potential
Tubod	5	3	-	-
Placer	5	2	-	2
Mainit	15	-	-	-
Alegria	3	-	-	-
Sison	10	-	-	-
Total	**38**	**5**	**0**	**2**

The project footprint straddles the upper catchment areas of the Hinagasa-an, Bad-as-Amoslog and the Magpayang Rivers. The lower reaches of these catchments are agricultural areas planted with paddy rice. The demand for irrigation water is concentrated at the downstream areas of Hinagasa-an and Magpayang Rivers where large NIA irrigation systems are located.

The Sub-level Cave Mine is located at the upper catchment areas of the Magpayang River while the other mine facilities e.g. concentrator and process plant are within the Bad-as-Amoslog Catchment.

There are 19 irrigation systems that draw water within these three catchments. These irrigation systems have a total service area of about 1,077 has and will required an average of about 1,400 l/s of irrigation water using an average water duty of 1.30 l/s/ha. The irrigation systems are shown in **Table 2.2.1-11** below.

Table 2.2.1-11 List of Irrigation Systems and Estimated Service Area and Water Requirement

Catchment	Name of Irrigation System/User	Water Source	Barangay/ Municipality	Crops	Vol. (L/s)	Vol. (M^3/hr)	Estimated Service Area (ha)
Hinagasa-an	Tagbayani CIP[1]	Maragong-ong Creek	San Pedro, Alegria	palay	50	180	38
	Maitom CIP[6]	Mapaso Creek	Maiton, Sison	palay	65	234	50
	Patag CIP[6]	Patag River	Patag, Sison	palay	26	94	20
	Maitom Extension[6]	Hinagnoyan River	Maitom, Sison	palay	26	94	20
	Toog River CIS	Toog Creek	San Pedro, Sison	palay	390	1404	300*
	Privately owned by Antonio Abela	Hugabong River	Upper Patag, Sison	palay	3	11	2
	Privately owned by Ricardo Lombos	Upper Patag Creek	Upper Patag, Sison	palay	4	14	3
Bad-as-Amoslog	Macalaya CIS[6]	Cagaasan Creek	Macalaya, Placer	palay	26	94	20
	Amoslog CIS[6]	Amoslog Creek	Amoslog, Placer	palay	78	281	60
	Boyongan CIS	Makalaya Creek	Boyongan, Tubod	palay	7	25	5
Magpayang	Tubod CIS[2]	Tubod River	Tubod, Tubod	palay	85	306	65
	Marga CIS[6]	Marga River	Marga, Tubod	palay	85	306	65
	Cawilan CIS[6]	Cawilan River	Cawilan, Tubod	palay	52	187	40
	Magpayang CIS[6]	Magpayang River	Magpayang, Mainit	palay	337	1213	259
	Motorpool FIA	Tubod River	Motorpool, Tubod	palay	65	234	50
	Pingaping FIA	Otsan River	Motorpool, Tubod	palay	20	72	15
	Del Rosario	Tubod River	Del Rosario, Mainit	palay	26	94	20
	Siana CIP[6]	Un-named waterway	Siana, Mainit	palay	39	140	30
	Dayano CIP[6]	Dayano River	Dayano, Mainit	palay	20	72	15

The total irrigation water requirement for the irrigation systems at Hinagasaan, Bad-as-Amoslog and Magpayang are 564 L/s, 111 L/s, and 729 L/s, respectively. The 80% dependable flows which is the norm for NIA are 1,050 L/s, 510 L/s and 1,430 L/s for Hinagasaan, Bad-as-Amoslog and Magpayang Rivers, respectively.

[1] National Irrigation Administration, Surigao del Norte District II
[2] Source: National Irrigation Administration, Surigao del Norte District II

There are other irrigation systems located within the MPSA where the catchments are not impacted by the project. These are listed in **Table 2.2.1-12** below.

Table 2.2.1-12 Irrigation Systems Within the MPSA but not Impacted by Project

Catchment	Name of Irrigation System/User	Water Source	Crops	Estimated Service Area (ha)	Vol. (M^3/hr)	Vol. (L/s)
Bad-as	Sta. Cruz CIS[6]	Bogho Creek	palay	26	122	34
Placer	Pananay-an CIS[6]	Un-named Waterway	palay	15	72	20
Mayag	Mayag CIS[6]	Mayag River	palay	534	2502	695
	Ima CIP[6]	Ima Creek	palay	30	140	39
	Bitan-ag CIP[6]	Un-named Waterway	palay	50	234	65
	Tagayan CIP[6]	Tagayan River	palay	136	637	177
	Cantugas CIP[6]	Paspason Creek	palay	90	421	117
	Patag Extension[6]	Mayag River	palay	35	166	46
	Upper Mayag CIS[6]	Buruburhon Creek	palay	50	234	65
	San Francisco	Un-named Waterway	palay	50	234	65
Pungod	San Isidro	Un-named Waterway	palay	20	94	26
Mapaso	Magsaysay	Magsaysay Creek	palay	50	234	65
Agong-ongan	Roxas[7]	Un-named Waterway	palay	30	140	39
	Mainit CIS[3]	Mainit River	palay	110	515	143
	Tigbaoan CIS[7]	Tigbaoan River	palay	230	1,076	299
	Roxas CIP	Agong-ongan Creek	palay	100	468	130
Campo	Alipao CIP[7]	Baluran Creek, Alimpatayan Creek, Togbongon Creek	palay	270	1,264	351
	Gamuton CIP[7]	Magtiaco River	palay	100	468	130
	San Pedro CIP[7]	Lomondo Creek	palay	140	655	182

The above irrigation systems have a total aggregate service area of 2,066 ha with a total water demand of 2,700 L/s.

At Hinagasaan catchment, the nearest mine facility to an irrigation system is the TSF. Toog River Irrigation System in the Municipality of Sison is approximately 10 km downstream of the facility. While the Regional NIA Extension office in Butuan City has identified Toog CIS as one of their projects, it was not included in the list of irrigation system provided by the office. Farmers beneficiaries of the irrigation system informed that Toog CIS has a designed service area of about 300 has. This will then require an average of 390 L/s of water from Toog River to irrigate the rice lands. **Plate 2.2.1-2** to **Plate 2.1-1** shows the diversion work structures of the various river irrigation systems.

[3] National Irrigation Administration, Surigao del Norte District II

Plate 2.2.1-2 Toog River IS, Sison (July 2012)

Plate 2.2.1-3 Magpayang CIS, Mainit (July 2012)

At Magpayang Catchment, the nearest NIA-implemented irrigation system is the Motorpool CIS in the Municipality of Tubod. The irrigation system draws water from the Timamana Creek and is about 2 kilometers downstream of the WSD. Further downstream along the Magpayang River are Marga and Magpayang CIS. Marga CIS is about 5 kilometers downstream of the WSD while Magpayang CIS is about 10 kilometers downstream. The three irrigation systems have an aggregate total service area of 309 ha requiring about 402 l/s of irrigation water.

Plate 2.2.1-4 Intake of Motopool CIS, Tubod (July 2012)

Plate 2.2.1-5 Intake of Timamana CIS, Tubod (July 2012)

Plate 2.2.1-6   Tigbawan CIS, Mainit (July 2012)

Plate 2.2.1-7   Matin-ao CIS, Mainit (July 2012)

Domestic Water Use

Domestic water requirements identified during the survey include drinking water, water for hygiene/sanitation services and general domestic use (e.g. food preparation, cooking, washing, etc.). Domestic water requirement is derived mostly from communal water supply systems where the main water source is spring. The Municipality of Placer gets its domestic water supply requirement from a spring located in Barangay Boyongan (**Plate 2.2.1-8**). Domestic water supply requirement of the Municipality of Sison comes from a spring located in Barangay Anislagan (**Plate 2.2.1-9**) while the Municipality of Tubod from springs located in Barangays San Isidro and Timamana (**Plate 2.2.1-10** and **Plate 2.2.1-11**).

Plate 2.2.1-8   Boyongan Intake Box (July 2012)

Plate 2.2.1-9   Anislagan Intake Box (July 2012)

Plate 2.2.1-10 San Isidro Intake Box (July 2012)

Plate 2.2.1-11 Timamana Intake Box (July 2012)

There were about forty five (45) water users recorded within and outside the project site during the survey. Thirty eight (38) were irrigation systems, seven (7) sites were classified as springs where two of these are still undeveloped and were identified as potential source. No wells were seen during the field survey. The spring developments consist of multiple communal faucets strategically located near residential clusters, with some of the houses with individual connections.

In more remote areas, spring flow is extracted by inserting a short PVC pipe into the spring outcrop. As part of the water survey, spring flows were measured. However, difficulties were encountered in measuring the flow from springs particularly in closed water systems where there is no section or point along the main pipeline to measure the actual discharge. At some other spring sites, flows are not totally captured in the intake box and flows were observed alongside or under the intake box structure. Two methods were used in determining the spring discharges. For spring systems where no points are open to measure the discharge, the flow was calculated based on the number of household beneficiaries. Where spring flow can be directly measured, plastic containers of known capacity were used in the measurement considering the time to fill the container. Plate 3.2-7 to Plate 3.2-9 show the existing intake boxes found within and outside the project site.

Springs

For settlements located in the highlands, the main sources of domestic water supplies are from springs (Plate 3.2-9). A short PVC pipe or bamboo is directly inserted into the spring outcrop. Water is collected through plastic containers. Springs are also the main source of water supply for the lowland barangays. A spring box is constructed enclosing the spring outcrop to prevent contamination. Water is transported and distributed through a pipe network into the various communal faucets. One communal faucet typically serves 5 to 10 households. In some barangays, supply pipes are installed in individual households. An overflow pipe is provided at the spring box or at the reservoir to discharge excess flow.

In Barangay Anislagan, excess flow from various discharge pipes is conveyed into a pond. An area is provided for clothes washing and excess flow is used for irrigation (as shown in **Plate 2.2.1-12** and **Plate 2.2.1-13**). **Table 2.2.1-13** shows estimated water requirements to some of the barangays of Municipality of Tubod and Placer.

Plate 2.2.1-12 Discharge Pipes from Intake Box

Plate 2.2.1-13 Pond Below Anislagan Intake Box

Table 2.2.1-13 Estimated Domestic Water Requirements[4]

Municipality	Water User (Barangay)	Water Source	Projected Water Demand (M^3/hr)	Projected Water Demand (L/s)	Projected Population (2030)[5]
Tubod	San Isidro	spring	6.4	1.8	1911
	Capayahan	spring	4.7	1.3	1408
	Timamana	spring	10.4	2.9	3114
Placer	Anislagan	spring	8.2	2.3	2471
	Macalaya	spring	3.9	1.1	1164
	Boyongan	spring	2.5	0.7	762
	Sta Cruz	spring	12.8	3.6	3828
Sison	Upper Patag	spring	2.8	0.8	853
	Lower Patag	spring	4.1	1.1	1236
	San Pedro	spring	14.1	3.9	4232
	San isidro	spring	2.4	0.7	718
		Total	**72.3**	**20.2**	**21,697**

Water Permits Issued

Surface Water Extraction Permits

Surface water is the main and common source of irrigation water. The main agricultural crop planted is rice (palay), requiring a significant volume of water. The plain areas west and east of the project site are mostly planted with rice.

[4] Population data from SMMCI records
[5] Based on 1.6% population increase per year

NIA irrigation systems are normally granted with water permits at the beginning of the construction of the project. After completion of the project, it becomes a system where it is managed by an irrigator's association organized by NIA. Irrigation fees are collected by NIA after every cropping season.

NIA Provincial Irrigation Office for Surigao del Norte informed that all irrigation systems constructed under the agency have water extraction permits. No copies of the permits however were shown during the visit as these are reportedly kept at the Central Office. Considering that these are already existing irrigation system, their water requirements will be included in the overall site water balance regardless whether these have or no water extraction permits.

Groundwater Extraction Permits Issued

There were no wells visited during the field survey. Individual household shallow wells, if any, are not required to secure water permits.

The Local Water Utilities Administration is responsible for securing water permits for water supply system implemented by the agency. It is noted however that the existing water system of Placer, Tubod, and Sison was reportedly implemented directly by each municipality. Water permits were reportedly obtained before project implementation.

2.2.2 Project Water Use

Adverse impacts on water resources in the surrounding area is a sensitive issue, hence the mitigation of potential water resource impacts is an integral component of the project design in all its stages. On this basis, a Site Water Management Plan for the project was developed based on the following:

- Impacts on surface and groundwater systems is prevented or minimized;
- Water supply for mining operations is assured;
- Minimize the generation of contaminated water;
- Prevent clean water contact with contaminated water and mine waste;
- Maximize the use of recycled water;
- Ensure that the containment of contaminated water is at high level of certainty;
- Recognise existing water users' rights and water use priorities in accordance with the requirements of PD 1067 – The Water Code of the Philippines; and
- Other statutory compliance.

Water supply will be required by the project for a variety of purposes. These include ore processing, maintaining the water cover at the TSF, water for dust suppression, and potable use for offices and camp facilities, among others. Water quality requirements are dependent upon the end use of the water. For instance, the quality of potable water will conform to the standards set by the Department of Health (DOH); excess water for release to water bodies will conform to the adopted site discharge water quality standards.

Five general water types have been identified, which includes water that is available onsite and is required for various purposes. These are:

- Fresh water
- Potable water
- Reclaim water
- Process water

A description of each type and an overview of its usage and place in the overall site water management strategy are provided below.

Fresh Water

Fresh water is the untreated water from groundwater pumped from the Sub-level Cave Mine. In this report, this will also be referred to as “uncontaminated” water. Fresh water is required for:

- Riparian or environmental flows;
- Compensatory flows for irrigation water requirement
- Dust suppression/road watering;
- Vehicle wash-down; and
- Fire control water.

The main source of fresh water for the process plant and mine potable water requirement is the pumped water from the Sub-level Cave Mine. The Project will not extract water from streams within the project area.

A summary of average operational fresh water demands and defined usage is provided below in **Table 2.2.1-14**.

Table 2.2.1-14 Fresh Water Supply Requirements

Usage	Average Demand (m^3/hr)	Average Demand (L/s)
Road Watering/Dust suppression, truck wash and construction water	22	6
Make up water for the process plant (during operation)	911	253
Total	**933**	**259**

Potable Water

Potable water is required as a domestic water supply for the construction camp facilities and offices during construction as well as during operation. This includes water for drinking, bathing, and washing. The mine facilities that require potable water supply include the:

- Construction camp/s
- Mine Operations Facility; and
- Administration Offices and staff accommodation areas.

Flow requirements for drinking water are based primarily on the projected per capita consumption at each site. For the purposes of establishing the total potable water supply requirement, a consumption of 80 L/person/day is assumed. Potable water requirement of the mine will be sourced from boreholes within the Sub-level Cave Mine. If necessary, this will be treated to potable water standards before distribution to the various camp facilities.

Site operations during construction and operation will be undertaken 24 hours a day. It is estimated that up to about 1,500 workers will be required during construction and about 1,650 during operations. The potable water supply requirements will be for the maximum total number of workers required for mining operation and allows sufficient water supply for off-duty mine workers.

Table 2.2.1-15 shows the summary of the average potable water supply demands. During operation, the total potable water demand will be approximately 1.7 L/s and this is included in the process plant water requirement.

Table 2.2.1-15 Potable Water Supply Requirements

Usage	Average Demand (m^3/hr)	Average Demand (L/s)
Mine operations facilities and offices (During Construction)	5	1.4
Mine operations facilities and offices (During Operation)	6	1.7

All potable water will be treated to meet or exceed the Philippine National Standards for Drinking Water (PNSDW 2017), Water Quality Guidelines of 2016 for Class AA Water Bodies (DAO 2016-08 WQG Class AA) and of DOH (AO 2007-12).

Reclaim Water

Water recovered from the TSF is called Reclaim Water. This will be pumped to the process plant and used as process water. During operations, about 1,412 m^3/hr may be reclaimed from the TSF for process plant water requirement.

Process Water

The process plant is designed to process up to 244,000 tonnes per annum of concentrate. The volume of water required is governed by this output. Process water will be derived from drained water from the Sub-level Cave Mine and reclaim water from the TSF.

Water pumped from the underground mine facility during dewatering operation will report to a regulating cum storage pond that will also function as a sedimentation pond. About 3,121 m^3/hr will be required during the start up. This volume of water will be available from the regulating pond at this stage.

During operations, about 77% (2,374 m^3/hr) of the startup water will be circulated and reused within the process plant. Make up water for water losses will mainly be sourced from stored water at the TSF or from the Sub-level Cave Mine.

The mine water requirements are consisting of the following:

Table 2.2.1-16 Mine Water Requirements during Operations

Usage	Average Demand (m^3/hr)	Average Demand (L/s)
Make up water (due to losses)	406	112
Process plant (circulating water within the process plant)	(2,374)	(659)
Process water bound to the tailings	505	140
Total	**911**	**252**

The process plant will require about 2,374 m^3/hr of process water during operation and this will be circulating within the plant. About 911 m^3/hr will be required by the plant to compensate for water losses and the water reporting into the tailings pond as part of the slurry. These losses will be compensated from pumped flows from the underground mine facility and water extracted from ore.

2.2.3 Site Water Balance

The site water balance for the project was developed to study the available water resources against the overall mine and existing water user's requirement. The key assessment criterion for the robustness of the water balance is anchored on the following:

- Sufficient water for mine demand
- Efficient water management and reuse of water; and
- Storage at the sedimentation cum storage ponds and the TSFs.

Water Balance during Construction

Dewatering operation at the Sub-level Cave Mine starts with the development of this facility. Extracted water consists of direct rainfall and water from dewatering bores drilled within the underground mine facility. During the initial stages of excavation, drained water will be stored at the regulating cum storage/sedimentation pond. The stored water will be used during the startup operation complemented by pumped water from the underground mine. The dewatering works will continue as development progresses and will be the main source of make-up water required during mine operation. Compensatory flows for Hinagasa-an and Magpayang Rivers through the TSF and Regulating Pond, respectively, will also be provided to satisfy irrigation water requirement downstream. Quality of water discharged to existing water bodies shall conform to applicable and accepted water quality standards in the country.

Water from the Sub-level Cave Mine will also be used as construction water and as feed water for the water treatment plant for potable water supply.

The site water balance during the construction is shown below.

Table 2.2.1-17 Site Water Balance During Construction

Facility	Description	Inflow (m^3/ hr)	Outflow (m^3/ hr)	Available for DS Water Users (m^3/ hr)
Sub-level Cave Mine / regulating Pond and Process Plant	*Dewatering Operation:* Groundwater from shallow groundwater system Groundwater inflow from deep intrusive groundwater system	3,184		
	Road Watering/Dust suppression/ Truck/vehicle wash and Construction Water		22	
	Total	**3,184**	**22**	**3,162**

Water Balance at Start Up

As earlier mentioned, about 3,121 m^3/hr will be required by the process plant during the startup stage of mine operation. At this stage, it is envisaged that there is sufficient water stored in the regulating pond for the process plant to start operation and to provide compensatory flows at Magpayang River. Compensatory flows for the Hinagasaan River during the construction stage will mainly be sourced from intercepted surface water around the TSF and pumped water during dewatering operation.

During operation, compensatory flows for the Hinagasa-an and Magpayang Rivers may also be sourced from pumped water from the underground mine facility through the TSF and Regulating Pond, respectively.

The site water balance during the startup stage is shown below.

Table 2.2.1-18 Site Water Balance at Start up

Facility	Description	Inflow (m^3/ hr)	Outflow (m^3/ hr)	Available for DS Water Users (m^3/ hr)
Sub-level Cave Mine and Regulating pond	Stored water at the Regulating Pond and pumped water from the Sub-level Cave Mine	3,121		
	Infiltration from direct rainfall (regulating pond)	42		
	Moisture from Ore	164		
Process Plant	Process Plant water requirement		3,121	
	Road watering and truck wash		22	
	Total	**3,327**	**3,143**	**184**

Water Balance during Operation

The dewatering works will continue as further development of the Sub-level Cave Mine progresses and will be the main water source of make-up water required for the mine operation. The other source of make-up water is the reclaimed water from the TSF.

The site water balance during mine operation is shown **Table 2.2.1-19** below.

Table 2.2.1-19 Site Water Balance During Operation

Facility	Description	Inflow (m^3/ hr)	Outflow (m^3/ hr)	Available for DS Water Users (m^3/ hr)
Sub-level Cave Mine	***Dewatering Operation:*** Groundwater from shallow groundwater system Groundwater inflow from deep intrusive groundwater system	2,980		
	Infiltration from direct rainfall	204		
Regulating Pond	Infiltration from direct rainfall	42		
	Road watering and truck wash		22	
	Discharge to Magpayang River			1,131
Process Plant and TSF	Water retained for recirculation during Operations	(2,374)	(2,374)	
	Moisture from ore	164		
	Various losses		406	
	Infiltration from direct rainfall	1,055		
	Evaporation loss at TSF		342	
	Discharge to Sabong Bay		1,412	

Facility	Description	Inflow (m^3/ hr)	Outflow (m^3/ hr)	Available for DS Water Users (m^3/ hr)
	Discharge to Hinagasaan River			1132
	Total	**4,445**	**2,182**	**2,263**

The figure below presents the general site water balance during start up and operation stages.

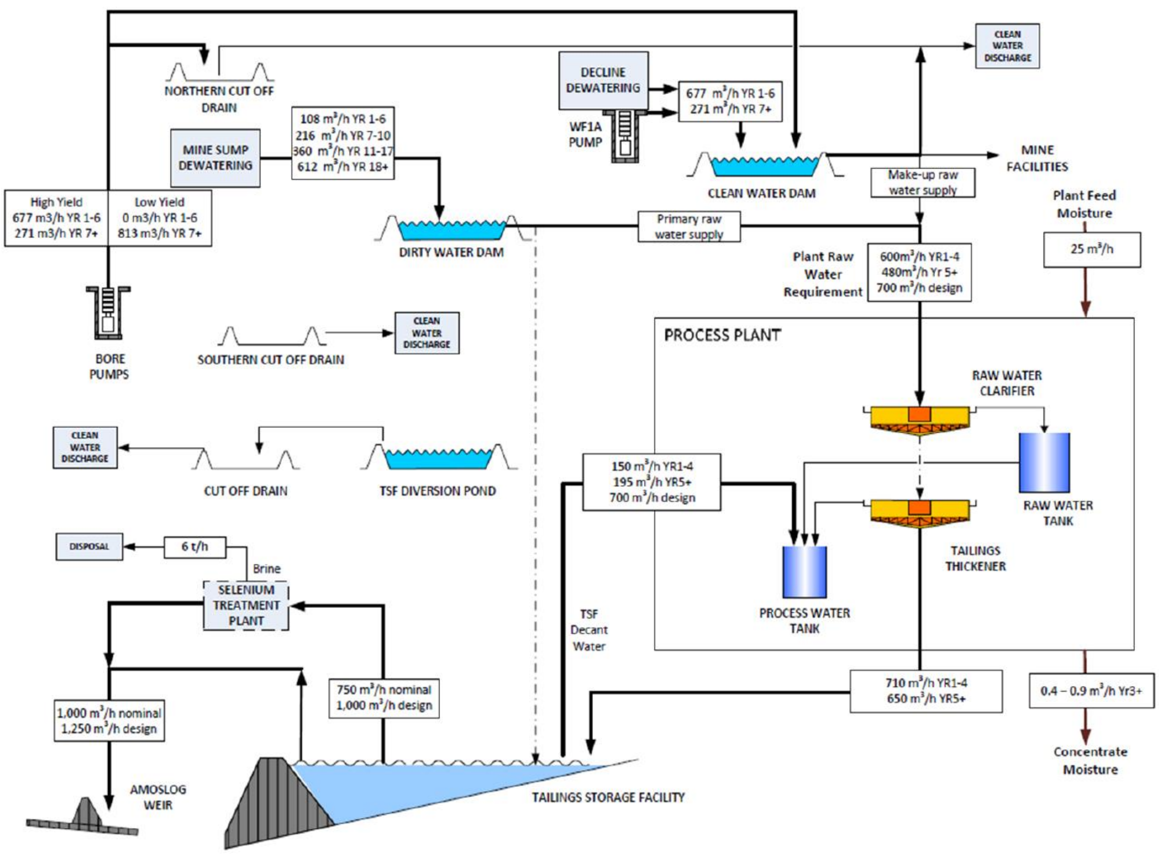


Figure 2.2.1-7 General Site Water Balance Diagram

The mine will primarily source water for its processing and mine facilities from the decline dewatering and existing well. During the construction phase when water is not yet required by the processing plant, water from the decline dewatering will be used to provide water supply for construction and mine facilities. Once the processing plant is constructed and commissioned, most of the water from the decline and bore pumps will be used as plant raw water requirement. Overflow (waste water) will go to the TSF. To maintain operation level, the TSF will release water through a treatment plant to remove deleterious substances and treat the water to the receiving water body's standards (Class B). The treated water will be released through the Amoslog Weir. To replenish the water from for the mill, raw water supply from the dewatering will be supplemented by TSF decant water from the TSF pond.

In order to maintain normal operating levels for the TSF, clean run-off water coming from the Hinagasa-an Catchment will be intercepted by the TSF diversion pond and cut-off drains. Clean run-off will be discharged to the Hinagasa-an River to maintain baseline flow.

2.2.4 Climate Change Impacts Without the Project

Climate change is a long-term change in the statistical distribution of weather patterns over periods of time that may range from decades to millions of years. These changes may be in terms of average weather conditions or a change in the distribution of weather events with respect to an average, for example, greater or fewer extreme weather events. Climate change may be limited to a specific region or may occur across the whole Earth.

When using climate change impact modelling, large numbers of parameters need to be considered. Prepared climate change models can demonstrate anything as long as there are enough information and data available. Published climate change models describe real, physical processes in the earth's atmosphere. Differential equations describe how wind, temperature and air pressure develop in connection with each other. The impact of water – in the form of moisture or clouds, made up of rainfall as well as the role of greenhouse gases like CO_2 is taken into account. In the country, CO_2 emission, among others, was primarily used as bases in predicting climate change impacts in terms of temperature and extreme rainfall variations. On the other hand, it is a fact that it is not known for sure until the end of 2050 whether climate change predictions made are correct.

There will be increased CO_2 emissions from the construction equipment during construction. To predict project climate change e.g. increase or decrease in rainfall, occurrences of extreme rainfall events, change in rainfall pattern, increase in temperature, etc. attributed to the activities undertaken in this Project would admittedly be very difficult, and hence will not be attempted in this study. Instead, the document "Climate Change in the Philippines" prepared by PAGASA was made as reference on how the project will respond to extreme events without catastrophic implications.

2.2.1.1 Potential Impacts and Options for Prevention or Mitigation or Enhancements for Hydrology and Hydrogeology

The potential impacts of the project on surface water and groundwater resources, particularly on flows and downstream water uses, are presented in this section.

2.2.2 Potential Impacts

Surface Water Impacts

The combined footprint of all the facilities and the mines area when fully operatioal represents about 19.74% of the total area of the river catchments mentioned above. **Table 2.2.1-20** shows the area that will be occupied by each of mine facilities in the catchments.

Table 2.2.1-20 Estimated Area Occupied by the TSF, Sub-level Cave Mine, Mine Facilities

Mine Infrastructure/ Catchment	Hinagasa-an	Bad-as-Amoslog	Magpayang	Agong-ongan/ Mapaso	Tagana-an	Mapaso
	Area (ha)					
TSF	924.78	20.15	0	0	29.46	0
Sub-level Cave Mine	0	51	0	0	0	0
Haul Roads	34.07	36.16	0	0	0	0
Mill and Camp facilities	0	276.61	221.42	0	0	0

Potential impacts on downstream river flow in these catchments include reduction of flows as well as flooding. These flow impacts are the primary concern raised during the stakeholder consultations conducted for the project. Potential occurrences of these impacts are discussed below.

Impacts on Volume of Flows

Magpayang River

The Sub-level Cave Mine is within the catchment of the Magpayang and Badas-Amoslog catchment. It will occupy about 51 ha of the catchments. Part of the Timamana Creek will be diverted around the underground mine area to prevent interception during excavation. Flow reduction in the Magpayang Catchment will be compensated by the treated runoff and re-routing of the headwaters of Timamana Creek.

There are three irrigation systems impacted in case of flow reduction. These are Motorpool, Marga and the Magpayang CIS. These irrigation systems have a total aggregate service area of 374 ha with a total irrigation water demand of 487 L/s.

The 80% dependable flow in the Magpayang River reckoned from Magpayang CIS is currently about 1,427 L/s.

There are other irrigation systems within the Magpayang Catchment. These are the Pingaping CIS, Cawilan CIS, Del Rosario CIS, Dayano CIP, and Seana CIP. These irrigation systems divert water from tributaries of the Magpayang River. shows the results of the modeling, indicating the pre-mining stream flows across a range of probabilities at Magpayang River near Magpayang CIS.

Table 2.2.1-21 Modelled Magpayang Flows at the Magpayang CIS

Flow/Season	Condition	Dependable Flow (m^3/sec)				
		1%	10%	50%	80%	90%
	Pre-mining	22.93	7.89	2.36	1.43	1.12

Note: Percentages show the probability that flow will be exceeded in any given year

Flooding

The development of the mine will potentially impact downstream flood flows in the Hinagasa-an, Bad-as-Amoslog and the Magpayang River catchments. **Table 2.2.1-7** to **Table 2.2.1-9** earlier presented the estimated flood flows downstream of the project site during the pre-mining, mining and post mining phases, with different probabilities.

Slight increase in flow along the rivers will be experienced mainly due to change in topography, vegetation cover and land use. The average increase in flow is about 10%. Highest increase in flow in terms of percentage is experienced at East Patag catchment because most of the creek's catchment is straddled by the TSF.

Impacts on Groundwater

Groundwater studies and modelling have been completed. The results of these studies were used to determine the potential impacts and the magnitude of these impacts on the groundwater system and supply of the project site.

A summary of the potential impacts to surface water and groundwater flow and supply, along with the proposed measures for their prevention, mitigation or enhancement, are presented in **Table 2.2.1-22**.

Table 2.2.1-22 Potential Impacts and Options for Prevention or Mitigation or Enhancement – Hydrology and Hydrogeology

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
Change in drainage morphology					
• With construction of the TSF, the existing shape of the river channel for the section straddled by this mine facility will change. Part of headwaters of the Hinagasa-an River will be submerged. This reduces vegetation cover. The surface area of the water body will increase. This increases evaporation losses.		✓	✓	✓	• SMMCI has been conducting reforestation activity since the start of exploration not only to compensate any loss of vegetation cover attributed to mine development but to also increase the present forest cover in the area. • The loss of water due to increased evaporation and potential reduction of base flow due to decreased catchment area is offset by the re-routing of the Piakle Creek.
Change in Stream Water Depth					
• Pumped groundwater from the Sub-level Cave Mine will contribute to local flooding.		✓	✓	✓	• All pumped water from the underground mine will be discharge to the dewatering ponds and to the sedimentation ponds prior to pumping into the process plant for reuse. Portion of the pumped out groundwater will be treated for use in the base camp.
• Water from the TSF will be released through the spillway only during emergency cases such as the occurrence of extreme multiple rainfall events.		✓	✓	✓	• The catchment area of the Hinagasa-an River will remain the same. The change in vegetation cover from sparsely vegetated to TSF area will only contribute about 1% increase in volumetric rate of flow which can be considered as insignificant. • The TSF is provided with sufficient freeboard to contain any excess flows from the catchments.
Inducement of flooding					
• Release of stored water from the TSF will induce flooding downstream of the Hinagasa-an River, but may only occur during emergency cases.		✓	✓	✓	• The TSF is provided with sufficient freeboard to contain any excess flows from the catchments. This facility will also be provided with spillway from which water will only be released during extreme multiple rainfall events.
Reduction in stream volumetric flow					
• Intercepted groundwater will be drawn from the Sub-level Cave Mine. With the drawdown of water table created by dewatering, the surrounding catchment areas would experience a reduction in the volumes of groundwater-derived		✓	✓	✓	• The potential reduction in flow is offset by the treated water from the sedimentation pond. • Headwaters of Timamana Creek will be re-routed around the underground mine facility. Average flows in Magpayang River will be maintained at pre mining condition.

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
flow. This is predicted in Magpayang River where its headwaters are the Timamana Creek.					
• Potential reduction of the surface flow at Hinagasa-an River due to encroachment of the catchment areas by the TSF. Part of the surface flows will be intercepted by the TSF.		✓	✓	✓	• The potential reduction of flow due to decreased catchment area is offset by the increase in runoff from the placed tailings.
Water resources user / competition in water uses					
• The project water demand will stress existing water sources and reduce available water for existing domestic and irrigation water users.		✓	✓	✓	• The process water requirement of the mine will be recycled water from the Sub-level Cave Mine and the decant water TSF. Mine water demand will come from the treated water from pit dewatering.
• Possible reduction of the mean flow in Magpayang River due to reduction of catchment area encroached by the Sub-level Cave Mine will potentially impact on the availability of irrigation water downstream.		✓	✓	✓	• During the initial stages of development, water will be drawn from the underground mine during the dewatering process. Timamana River will be rerouted around the underground mine facility.
Reduction/Depletion of Groundwater Flow					
• Lowering of groundwater levels (drawdown) in areas adjacent to the Sub-level Cave Mine due to inflow to the underground mine during operations and to the final void post closure. The will deplete existing water sources.		✓	✓	✓	• For springs and other domestic water sources impacted by the mine, alternative water sources will be provided by SMMCI. At present, alternative water sources have been identified to replace existing water sources that will be impacted by the mine. Over the life of the project SMMCI will continue to explore alternative and sustainable (gravity-fed) water sources.
Enhancement of climate change impacts					
• About 2000 has of mostly coconut planted land with be cleared for the mine facilities. CO2 emissions generated by equipments during construction and operation as well as clearing of vegetation will potentially have micro-climate change impact in the region which may lead to increased or decreased seasonal rain fall change.					• CO2 emissions generated during construction and operation of the project constitute a very minute portion of the total emissions generated in the entire Caraga Region 13. Similarly, impact of vegetation clearing will be nil considering that tree planting activity is already being implemented even at the start of exploration stage. Climate change impacts that may be associated to the construction of the project can be considered as insignificant.

2.2.2 Water Quality

This section presents the results of the baseline water quality sampling activities held in June and July 2012, in May 2015 and last February 2019. Primary data were compared with the water quality monitoring data for the Boyongan prospect provided by SMMCI, water quality assessment of Lake Mainit obtained from the Mindanao State University, Lake Mainit Development Alliance (LMDA), and other educational institutions. The water quality assessment aims to:

- Characterize the streams within the Primary impact (Hinagasaan, Magpayang and Bad-as/Amoslog) and Secondary impact (Tagana-an, Pungod, Gata, Mapaso, Agong-ongan and Campo) catchments; Lakes of Mainit, Mahukdam and Guinob-an; and groundwater sources within the host barangays; and

- Recommend mitigation and enhancement measures to address any identified impacts on water quality.

2.2.2.1 Rationale of the study

A baseline water quality assessment is required to gauge the current status of the streams, lake and ground water bodies within, near and adjacent to the project site. Comprehensive water quality data are used to identify the potential impacts of the construction and operation of the mining facilities which include the TSF, Sub-level Cave Mine, process plant and other auxiliary facilities such as the workers' camp and access roads. Recommended mitigation and enhancement measures to address any foreseen impacts to the waterways and groundwater sources are formulated at the end of the assessment to ensure the integrity of the water sources in the area.

2.2.2.2 Regulatory framework of the study

The Philippine Clean Water Act of 2004 (CWA 2004) under Republic Act No. 9275 is the overarching legislation for the protection and preservation of water bodies in the country. Pursuant to Section No. 32 of this national legislation, the Department of Environment and Natural Resources (DENR) promulgated the Implementing Rules and Regulations (IRR) of the CWA 2004 under Administrative Order No. 10, series of 2005 (DAO 2005-10) to facilitate the water quality management and abatement of water pollution in the Philippine's water resources.

The DENR Administrative Order No. 34, series of 1990 (DAO 1990-34), entitled the Revised Water Usage and Classification/Water Quality Criteria Amending Section Nos. 68 and 69, Chapter III of the 1978 NPCC Rules and Regulations (DAO 1990-34) provides the classification and water quality guidelines of the fresh and marine waters based on their best usage.

The Water Quality Guidelines and General Effluent Standards of 2016 (DAO 2016-08) took effect last 14 June 2016, and was created to provide guidelines for the classification of water bodies in the country, determine time trends and evaluate stages of deterioration/enhancement in water quality, evaluate the need for taking actions in preventing, controlling, or abating water pollution, designate water quality management areas (WQMA), and set the General Effluent Standards. DAO 2016-08 repeals DENR Administrative Order 1990-34 (DAO 1990-34), Revised Water Usage and Classification/Water Quality Criteria Amending Section Nos. 68 and 69, Chapter III of the 1978 NPCC Rules and Regulations, and modifies DENR Administrative Order No. 35 (DAO 1990-35), Revised Effluent Regulation of 1990, Revising and Amending the Effluent Regulations of 1982. The DAO 2016-08 was used to assess the existing water quality condition of the stream and lake waters adjacent, near and within the vicinity of the project site.

Guidelines for groundwater quality are provided in Section 6.2 of DAO 2016-08. DAO 2016-08 states that "groundwater shall be maintained at a quality consistent with its intended beneficial use." Groundwater sources used by communities for drinking were also compared to the Philippine National Standards for Drinking Water released last 23 June 2017 (PNSDW 2017; DOH AO No. 2017-0010) as a reference. The PNSDW 2017 of the country's Department of Health aims to protect public health, safety, and welfare by ensuring quality standards of drinking water. Standards that were set in the PNSDW 2017 were based on the criteria or guidelines recommended by international institutions including the World Health Organization and the United States Environmental Protection Agency, while also considering the country's national priorities and economic conditions.

2.2.2.3 Methodology

Surface water and groundwater quality sampling activities were conducted from the last week of June to first week of July 2012. Additional primary data on surface waters and major groundwater sources within the vicinity and adjacent the TSF and Sub-level Cave Mine were collected on 26 to 27 May 2015 and 6--9 February 2019.

Sampling Stations

Grab samples were obtained from a total of 69 sampling sites including 34 stream, 10 lake and 20 ground water stations for the 2012 and 2015 sampling activities. This February 2019 sampling, there were a total of 12 stream and 2 ground water stations sampled. These 14 stations were already established in the 2012 and 2015 sampling. From the Hinagasa-an Catchment the 5 stream water stations which were sampled in 2019 were SW13-HA-BMR, SW14-HA-DTOC, SW16-HA-UTOC, SW17-HA-BBR and SW34-HA-PHC. For Magpayang Catchment, the 4 stream water stations were SW19-MP-DLTC, SW38-MP-BC, SW35-MP-BTC and SW37-MP-TC. For the Bad-As/Amoslog Catchment, the 2 stream water quality stations were SW29-BA-DBAC and SW31-BA-UBAC. From Lake Mahukdam, station L1 was sampled in the recently concluded baseline activities together with 2 groundwater monitoring stations GW15-WR-AP located at Brgy. Anislagan in Placer and GW3-SS-SPT located at Sitio Lambuyo, Brgy. San Pablo in Tubod.

Stream

Thirty-two stream water stations were established within and outside the project site in 2012. The surface water stations were situated based on the water bodies' proximity to the mining facility in order to assess their condition prior to the commencement of the Project. Portions of the streams that straddle downstream of the TSF and Soil Stock File Facility were also included to further describe the existing condition of the water courses that might be affected in case of facility failure and extreme weather events. Two additional surface water stations were placed along the upstream portion of Boyongan Creek and its tributary in May 2014 to capture the water quality of the streams that straddle adjacent to the undergound mine facility.

Names of the rivers were based on NAMRIA. The streams not named in the NAMRIA map were arbitrarily labelled according to the sitio or barangay where the samples were taken from.

The stream water ID codes were designated based on the type of water body and the sample number, the name of stream catchment, and the section of the stream from where the sample was obtained. For example, SW36-HA-UPC stands for Surface Water sample 36 – Hinagasa-an – Upstream of Piakle Creek.

The stream water stations were divided into ten catchment areas: (1) Hinagasa-an, (2) Tagana-an, (3) Bad-as/Amoslog, (4) Campo, (5) Magpayang, (6) Agong-ongan, (7) Gata, (8) Mapaso, (9) Pungod, and (10) Mayag. Six of the catchments

(Magpayang, Agong-ongan, Gata, Mapaso, Pungod, and Mayag) located south of Surigao del Norte drain to Lake Mainit, one (Tagana-an) drains to Canal Bay, two (Bad-as/Amoslog and Campo) at the western section discharge to Sabong Bay, and one (Hinagasa-an) at the upper half of the region joins Surigao River. The catchments were named after the major river basins that receive the discharges from headwaters and tributaries. Tagana-an catchment was arbitrarily named after the municipality covering the sampling station because the name of the main river is unknown.

The catchments that are perceived to be potentially directly impacted by the proposed project include the Hinagasaan, Magpayang, and Bad-as/Amoslog. The proposed TSF lies adjacent to the headwaters (Piakle Creek) of the Hinagasaan catchment, with the flow eventually exiting the Surigao River. The Sub-level Cave Mine is concentrated in the Magpayang catchment, straddling the upstream portions of Boyongan and Timamana Creeks. The TSF will discharge to the marsh portion of the Bad-as/Amoslog River.

Although no significant impacts are foreseen in other catchments, runoff from the proposed mining facilities may possibly reach or indirectly affect the water quality of streams within the adjacent catchments of Mayag, Pungod, Mapaso, Gata, Campo and Tagana-an, and downstream catchment of Agong-ongan. Hence, the water quality of the secondary impact catchments is also covered in this baseline assessment.

The direct and secondary impact catchments are described below.

Primary impact Catchments

Hinagasa-an Catchment

The Hinagasa-an catchment consists of the Hinagasa-an River (SW11-HA-HAR) and its tributaries: Piakle Creek (SW36-HA-UPC and SW18-HA-DPC) and its confluence with Hinapuyan Creek (SW34-HA-PHC), Toog Creek (SW16-HA-UTOC and SW14-HA-DTOC), and unnamed rivers traversing Brgy. Sison (SW17-HA-BBR), Brgy. Tagbayani (SW15-HA-TAR), Brgy. Mabuhay (SW13-HA-BMR), Brgy. Anomar (SW12-HA-SAR). The receptor, Hinagasa-an River, joins Surigao River farther downstream. The team collected additional baseline water quality data for SW13-HA-BMR, SW14-HA-DTOC, SW16-HA-UTOC, SW17-HA-BBR and SW34-HA-PHC in the 2019 sampling activities.

Magpayang Catchment

Eight stations were sampled within Magpayang Catchment in 2012. These are the downstream of Timamana Creek (SW19-MP-DTC), Boyongan Creek (SW38-MP-BC), Tubod Creek (SW20-MP-TUC), middle course of Magpayang River (SW22-MP-MPR), Confluence of Boyongan and Timamana Creeks (SW35-MP-BTC), Boyongan Creek (SW37-MP-MR), upstream of Timamana Creek (SW39-MP-UTC) and upper course of Magpayang River (SW23-MP-MPR).

In 2015, additional samples were obtained from the headwaters of Boyongan Creek (SW40-MP-UBo) and unknown upstream tributary of Timamana Creek (SW41-CA-UCT).

For Magpayang Catchment, the 4 stream water stations which were sampled last February 2019 SW19-MP-DLTC, SW38-MP-BC, SW35-MP-BTC and SW37-MP-TC

Bad-as / Amoslog Catchment

There are two sampling sites (SW31-BA-UBAC and SW29-BA-DBAC) in the Bad-as/Amoslog catchment. The water body is named as Bad-as Creek by NAMRIA, while its downstream section is arbitrarily named after Brgy. Amoslog. The upstream station (SW31-BA-UBAC) is a freshwater stream located near the road and a residential area. The downstream site (SW29-BA-DBAC) along Bad-as Creek is considered brackish water due to possible occurrence of backflow during high tide. The Bad-as/Amoslog Creek drains to the Sabong Bay. These 2 sampling sites were included in the recently conducted February 2019 sampling activities.

Secondary impact Catchments

Tagana-an

One station (SW33-TG-BNR) was sampled in the Tagana-an catchment, which is located outside the mining tenement. The unnamed river drains to Canal Bay.

Mayag

Five stations were sampled within Mayag Catchment. These are the upstream (SW1-MG-UMGR) and downstream (SW2-MG-DMGR) sections of Mayag River, upstream (SW3-MG-UPYR) and downstream (SW4-MG-DPYR) of Payanasa River, and confluence of Mayag River with its tributaries (SW5-MG-MGC).

Pungod

Pungod Catchment is a small catchment consisting of three streams merging into one before draining towards Lake Mainit. SW6-PU-PUR is located along Pungod River after the convergence of the three streams.

Gata

Gata Catchment is composed of Gata River which drains to Lake Mainit. One station (SW8-GT-GTR) was established in this river.

Mapaso

Mapaso River (SW7-MA-MAR) is located in a catchment with an inactive volcano, Mt. Paco. In the upstream section, the Mapaso Spring (GW2-HS-MM), a hot spring, joins the Mapaso River, then eventually drains towards Lake Mainit. Before the confluence of Mapaso Spring and Mapaso River, an existing hot spring resort was built and is open for public bathing. The igneous source rocks in Mapaso Spring affect the water quality of the downstream portion of Mapaso River.

Agong-ongan

One station for stream waters was sampled within Agong-ongan Catchment. This station is located at the mouth of Agong-ongan River (SW10-AO-AR), where the only outlet of Lake Mahukdam runs, before draining towards Lake Mainit.

Campo

Sampling stations in Campo Catchment include Station SW24-CA-PR in the Payapag River which is an upstream tributary of Campo River, where SW25-CA-CR is located.

Table 2.2.2-1 provides detailed description of the stream water sampling sites. The locations are shown in **Figure 2.2.2-1**. The type of waterway was determined based on the river morphology as described in **Annex 2.2-2**.

Table 2.2.2-1 Stream Water Quality Stations

Station ID	Photo	Name and Location of Water Body	Catchment and Waterway Type	Description of Sampling Station	Coordinates and Elevation
Primary impact Catchments					
Hinagasa-an Catchment					
SW36-HA-UPC		**Waterway name:** Upstream of Piakle Creek (UPC) **Sampling location:** Brgy. Silop, Municipality of Mainit	***Catchment:*** Hinagasa-an (HA) ***Waterway Type:*** Bedrock controlled boulder	The bed of the creek consists of boulder-sized sediments, creating turbulent flow. The channel is relatively straight, with a width of 3 m. The creek converges with an open spring (GW21-IBS-SM) which is a source of water supply in Brgy. Silop. The station is surrounded with shrubs and other riparian vegetation. This is the upstream-most station of the Hinagasa-an catchment, along the confluence of Piakle Creek and an open spring.	**Latitude:** 9° 36' 28.12" N **Longitude:** 125° 31' 23.19" E **Elevation:** 361 m
SW18-HA-DPC		**Waterway name:** Downstream of Piakle Creek (DPC) **Sampling location:** Purok 3, Brgy. Lower Patag, Municipality of Sison	**Catchment:** Hinagasa-an (HA) **Waterway Type:** Bedrock controlled boulder	This station is located downstream of the Piakle Creek, bounded by a dense riparian vegetation. The channel is continuously layered with boulders, leading to fast turbulent flows. Few houses are scattered downstream of the station. The creek has clear water which is used by the residents for recreational and domestic purposes.	**Latitude:** 9° 37' 54.80" N **Longitude:** 125° 31' 13.79" E **Elevation:** 129 m
SW34-HA-PHC		**Waterway name:** Confluence of Piakle and Hinapuyan Creeks (PHC) **Sampling location:** Brgy. San Pedro, Municipality of Sison	**Catchment:** Hinagasa-an (HA) **Waterway Type:** Alluvial boulder and gravel	The station is approximately 500 m away from the proposed TSF and 20mins trek from nearest drop off area. The confluence of the two creeks has a rocky substrate, with a moderately turbulent flow. The channel inset of the Piakle Creek has eroded, with the gravel and boulder-sized sediments reaching the confluence. Steep river banks are covered with grass, and the valley floor is dominated by trees, particularly coconut trees.	**Latitude:** 9° 39' 00.29" N **Longitude:** 125° 31' 49.09" E **Elevation:** 62 m

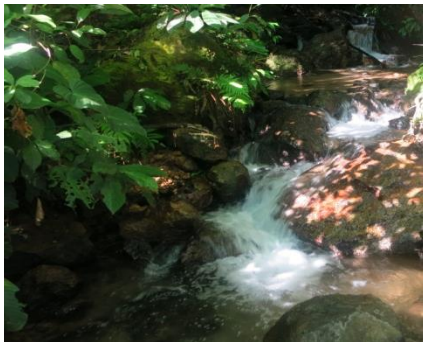
Station ID	Photo	Name and Location of Water Body	Catchment and Waterway Type	Description of Sampling Station	Coordinates and Elevation
SW16-HA-UTOC		**Waterway name:** Upstream of Toog Creek, confluence with its tributaries (UTOC) **Sampling location:** Brgy. San Pedro, Municipality of Sison	**Catchment:** Hinagasa-an (HA) **Waterway Type:** Alluvial boulder	The station is approximately 40m away from National Highway. The station is a confluence of SW34-HA-PHC and an unnamed tributary. The bed mainly consists of boulder size rocks. The isle of boulders in the midstream section produces uneven flow. The creek channel is parallel to the main hi-way and is near a residential community. Different types of vegetation thrive on the river banks.	**Latitude:** 9° 39' 15.96" N **Longitude:** 125° 31' 43.86" E **Elevation:** 48 m
SW17-HA-BBR		**Waterway name:** Unnamed River 1 - Stream in Sitio Busong-busong (BBR) **Sampling location:** Brgy. Sison, Municipality of Sison	**Catchment:** Hinagasa-an (HA) **Waterway Type:** Bedrock controlled boulder	The station has limited vehicle access and approximately 10mins trek from the nearest drop-off. This unnamed river is one of the tributaries of Toog Creek. The station has clear water with turbulent flow. The river channel meanders approximately 7 km, with the headwaters in Upper Patag. The channel is controlled by different sizes of boulders. The area is predominantly surrounded by coconut trees. Domesticated animals graze on the grassy river banks.	**Latitude:** 9° 39' 23.84" N **Longitude:** 125° 31' 21.59" E **Elevation:** 32 m
SW15-HA-TAR		**Waterway name:** Unnamed River 2 - River in Tagbayani and San Isidro (TAR) **Sampling location:** Purok 2, Brgy. Tagbayani, Municipality of Sison	**Catchment:** Hinagasa-an (HA) **Waterway Type:** Alluvial gravel	The station is situated along an unnamed river which converges with Toog Creek and drains into the Hinagasa-an River. Residential communities are located approximately 100 m from the sampling site. The river channel is bounded by an elevated valley floor and a low-lying grass, gravel, and sand-filled flood-plains. Carabaos and pigs bathe and a pool of small fishes thrive in the clear water. Water flows in a laminar direction.	**Latitude:** 9° 39' 16.20" N **Longitude:** 125° 29' 29.44" E **Elevation:** 53 m

Station ID	Photo	Name and Location of Water Body	Catchment and Waterway Type	Description of Sampling Station	Coordinates and Elevation
SW14-HA-DTOC		**Waterway name:** Downstream of Toog Creek (DTOC) **Sampling location:** Purok 1, Brgy. San Pablo, Municipality of Sison	**Catchment:** Hinagasa-an (HA) **Waterway Type:** Alluvial gravel	The station is accessible through dirt road and approximately 200m away from the National Highway. The station is near a residential area. The channel has a rocky substrate and laminar flow. The water is clear, with mosses on the gravel-filled isle. The channel is located between steep valleys dominantly covered with grass and surrounded by coconut trees.	**Latitude:** 9° 40' 15.19" N **Longitude:** 125° 31' 36.17" E **Elevation:** 34 m
SW13-HA-BMR		**Waterway name:** Unnamed River 3 - River in Brgy. Mabuhay (BMR) **Sampling location:** Brgy. Mabuhay, Municipality of Sison	**Catchment:** Hinagasa-an (HA) **Waterway Type:** Alluvial gravel	The station is accessible through dirt road and approximately 300m away from the National Highway. The bed and floodplains consist of fine sand and gravel-sized sediments. The station has a streamwidth of 18 m and has laminar flow. The valley floor is an agricultural area, surrounded by trees. Carabaos graze on the river banks. The station is located near a residential area. Water is used for domestic, bathing and recreational purposes.	**Latitude:** 9° 40' 39.54" N **Longitude:** 125° 31' 20.62" E **Elevation:** 37 m
SW12-HA-SAR		**Waterway name:** Unnamed River 4 - River in Sukailang / Anomar (SAR) **Sampling location:** Purok 6, Brgy. Anomar, Surigao City	**Catchment:** Hinagasa-an (HA) **Waterway Type:** Bedrock controlled boulder	The channel directly drains into the Hinagasa-an River. Cogon and trees dominate the river banks. Few houses are scattered in the area. There is a makeshift bridge upstream and rice fields downstream of the station. Small-scale mining activities upstream of the river have been reported. The water is slightly turbid and forms riffles due to the boulders in channel.	**Latitude:** 9° 40' 26.85" N **Longitude:** 125° 28' 54.81" E **Elevation:** 53 m

Station ID	Photo	Name and Location of Water Body	Catchment and Waterway Type	Description of Sampling Station	Coordinates and Elevation
SW11-HA-HAR		**Waterway name:** Hinagasa-an River (HAR) **Sampling location:** Brgy. Quezon, Surigao City	**Catchment:** Hinagasa-an (HA) **Waterway Type:** Alluvial gravel	The station is located along the drainage area, Hinagasa-an River. Both the bed and floodplains are predominantly composed of alluvial fine sand and gravel. Collective mass of moss and algae form on the side streams. The water is clear and has laminar flow. There is a residential area nearby and rice fields at the upstream portion of the river. One side of the river banks has a steep elevation.	**Latitude:** 9° 42' 19.14" N **Longitude:** 125° 30' 12.15" E **Elevation**: 28 m
Magpayang Catchment					
SW38-MP-BC		**Waterway name:** Boyongan Creek (BC) **Sampling location:** Brgy. Boyongan, Municipality of Placer	**Catchment:** Magpayang (MP) **Waterway Type:** Bedrock controlled gravel	The station is accessible through footpath and approximately 90m from the National Highway. The sampling station is surrounded by riparian vegetation and a small community is located upstream. Ricefield and banana trees are observed to be adjacent to the creek. The water is fast-flowing and the channel bed consists of gravel.	**Latitude:** 9° 36' 32.09" N **Longitude:** 125° 34' 07.22" E **Elevation:** 103 m
SW39-MP-ULTC		**Waterway name:** Timamana Creek – Upstream of Left Course (ULTC) **Sampling location:** Brgy. San Isidro, Municipality of Tubod	**Catchment:** Magpayang (MP) **Waterway Type:** Bedrock controlled boulder	The sampling station is located at the upper catchment of Timamana Creek and is surrounded by dense riparian vegetation. Plants observed include coconut trees and various species of fern and palm. The channel consists of small rapids owing to the interspersed boulders.	**Latitude:** 9° 35' 22.00" N **Longitude:** 125° 32' 52.67" E **Elevation:** 198 m

Station ID	Photo	Name and Location of Water Body	Catchment and Waterway Type	Description of Sampling Station	Coordinates and Elevation
SW19-MP-DLTC		**Waterway name:** Timamana Creek - Downstream of Left Course (DLTC) **Sampling location:** Brgy. Timamana, Municipality of Tubod	**Catchment:** Magpayang (MP) **Waterway Type:** Bedrock controlled boulder	The station is located at the lower section of Timamana Creek before it drains into the upper catchment of Magpayang River. During the sampling, bridge rehabilitation was being undertaken downstream of the station. Domestic activities such as laundry washing were observed upstream of the station. Water flow is medium turbulent.	**Latitude:** 9° 35' 38.86" N **Longitude:** 125° 34' 11.48" E **Elevation:** 90 m
SW35-MP-BTC		**Waterway name:** Confluence of Boyongan Creek and Timamana Creek (BTC) **Sampling location:** Brgy. Motorpool, Municipality of Tubod	**Catchment:** Magpayang (MP) **Waterway Type:** Bedrock controlled boulder	The station is accessible through dirt road. The sampling station is at the upper catchment of Magpayang River. Stream bed is composed of mossy rocks. Coconuts and ricefield are observed in the area.	**Latitude:** 9° 35' 26.44" N **Longitude:** 125° 34' 28.98" E **Elevation:** 70 m
SW37-MP-TC		**Waterway name:** Timamana Creek (TC) **Sampling location:** Brgy. Marga, Municipality of Tubod	**Catchment:** Magpayang (MP) **Waterway Type:** Bedrock controlled boulder	The station is accessible through footpath and approximately 130m from the National Highway. The sampling station is along Timamana Creek according to the NAMRIA map. Coconut trees and rice field are located nearby. The substrate is rocky. Flow is slow and laminar at the wider portions of the river and turbulent where boulders are clustered.	**Latitude:** 9° 34' 18.42" N **Longitude:** 125° 34' 24.74" E **Elevation:** 65 m

Station ID	Photo	Name and Location of Water Body	Catchment and Waterway Type	Description of Sampling Station	Coordinates and Elevation
SW20-MP-TUC		**Waterway name:** Tubod Creek (TUC) **Sampling location:** Brgy. San Pablo, Municipality of Poblacion	**Catchment:** Magpayang (MP) **Waterway Type:** Alluvial gravel	The sampling station is a tributary of Magpayang River and located parallel to Tubod Creek. Garbage and oil and grease were observed in the area. There are residential areas on both sides of the stream. Water is slightly turbid and flows slowly along the gravelly stream bed.	**Latitude:** 9° 33' 14.95" N **Longitude:** 125° 34' 05.02" E **Elevation:** 59 m
SW23-MP-UMPR		**Waterway name:** Magpayang River – Upper Course (UMPR) **Sampling location:** Brgy. Siana, Municipality of Mainit	**Catchment:** Magpayang (MP) **Waterway Type:** Alluvial gravel	The sampling station is located at the upstream section of Magpayang River. A makeshift bridge and a drainage outlet from the Greenstone Resources Corp. compound is located downstream of the station. The water is clear and has slow laminar flow.	**Latitude:** 9° 32' 13.45" N **Longitude:** 125° 34' 32.18" E **Elevation:** 48 m
SW22-MP-MMPR		**Waterway name:** Magpayang River – Middle Course (MMPR) **Sampling location:** Brgy. Magpayang, Municipality of Tubod	**Catchment:** Magpayang (MP) **Waterway Type:** Alluvial gravel	The station is located downstream of several unnamed creeks converging to Magpayang River. Pungtod Bridge is located 150 meters downstream of the station. The water is turbid and flow is laminar. The substrate is sandy. Few residents were observed washing laundry at the time of sampling.	**Latitude:** 9° 31' 52.96" N **Longitude:** 125° 33' 55.15" E **Elevation:** 58 m

Station ID	Photo	Name and Location of Water Body	Catchment and Waterway Type	Description of Sampling Station	Coordinates and Elevation
SW41-MP-UCT		**Waterway name:** Unknown Creek Tributary of Timamana Creek (UCT) **Sampling location:** Sitio Paragayo, Brgy. Timamana, Municipality of Tubod	**Catchment:** Magpayang (MP) **Waterway Type:** Confined system	This unknown tributary of Timamana Creek is characterized by clear water with turbulent flow. It has a narrow channel with boulder-sized substrate. Station SW41-MP-UCT is located within the Sub-level Cave Mine area. The sampling area is rich with riparian vegetation.	**Latitude:** 9° 35' 38.3" N **Longitude:** 125° 32' 58.8" E
SW40-MP-UBo		**Waterway name:** Upstream of Boyongan Creek (UBo) **Sampling location:** Sitio Cagaasan, Brgy. Boyongan, Municipality of Placer	**Catchment:** Magpayang (MP) **Waterway Type:** Confined system	Station SW40-MP-UBo has clear water draining into the Boyongan Creek. The narrow channel crosses the access road in the proposed Sub-level Cave Mine area. The ankle-deep water has moderate laminar flow. This stream resulted from the overflow of spring water contacting with the surface.	**Latitude:** 9° 35' 56.0" N **Longitude:** 125° 33' 24.8" E **Elevation:** 165 m
Bad-as/Amoslog Catchment					
SW31-BA-UBAC		**Waterway name:** Upstream of Bad-as Creek (UBAC) **Sampling location:** Brgy. Bad-as, Municipality of Placer	**Catchment:** Bad-as/Amoslog (BA) **Waterway Type:** Bedrock controlled gravel and boulder	The station is accessible through dirt road and 40 meters away from the National Highway. Some houses are on the riverbank. During the time of sampling, river widening excavation was being undertaken downstream of the station. The bed of the river segment sampled is uneven due to patchy piles of gravel, garbage and vegetation.	**Latitude:** 9° 37' 51.28" N **Longitude:** 125° 34' 3.07" E **Elevation:** 88 m

Station ID	Photo	Name and Location of Water Body	Catchment and Waterway Type	Description of Sampling Station	Coordinates and Elevation
SW29-BA-DBAC		**Waterway name:** Downstream of Bad-as Creek (DBAC) - Arbitrarily named as Amoslog River (AR) **Sampling location:** Brgy. Amoslog, Municipality of Placer	**Catchment:** Bad-as/Amoslog (BA) **Waterway Type:** Alluvial gravel	The water body is named as Bad-as Creek by NAMRIA, but the community residing near the sampling station arbitrarily called this section of the river as Amoslog River. The area is accessible through foot path and 10m away from the National Highway. The meandering side of the river near the provincial road has an embankment. Houses and piggery are observed to be situated along this embankment. Agricultural lands, mostly ricefields, comprise the upper portion of Amoslog River. High tide in Sabong Bay causes backflow of water into the river. The portion of the river sampled is presumed to be brackish.	**Latitude:** 9° 38' 1.12" N **Longitude:** 125° 35' 55.51" E **Elevation:** 20 m
Secondary impact Catchments					
Taganaan Catchment					
SW33-TG-BNR		**Waterway name:** Unnamed River 5 - River in Brgy. Banban (BNR) **Sampling location:** Sitio Dijo, Brgy. Banban, Municipality of Taganaan	**Catchment:** Taganaan (TG) **Waterway Type:** Alluvial gravel	There is an on-going construction of a box culvert/spillway downstream of the station. Flow is laminar upstream and becomes slightly turbulent downstream due to disturbance caused by the spillway construction. The river is surrounded mostly by coconut trees and scattered houses. The river bed is sandy and large limestone rocks are exposed on the river banks. Water level increases during high tide in Canal Bay due to backflow of brackish water.	**Latitude:** 9° 41' 26.09" N **Longitude:** 125° 34' 47.69" E **Elevation:** 22 m
Mayag Catchment					

Station ID	Photo	Name and Location of Water Body	Catchment and Waterway Type	Description of Sampling Station	Coordinates and Elevation
SW1-MY-UMYR		**Waterway name:** Upstream of Mayag River (UMYR) **Sampling location:** Sitio 6, Brgy. Cantugas, Municipality of Mainit	**Catchment:** Mayag (MY) **Waterway type:** Bedrock controlled boulder	Rice fields and coconut trees surround the upstream of Mayag River. Residential communities are located approximately 500 m away from the sampling station. Gravel, rocks, sand, and wild weeds form the river banks. The riverbed is rocky, with clear water and laminar flow.	**Latitude:** 9° 35' 36.83" N **Longitude:** 125° 28' 31.08" E **Elevation:** 92 m
SW2-MY-DMYR		**Waterway name:** Downstream of Mayag River (DMYR) **Sampling location:** Brgy. Matinao, Municipality of Mainit	**Catchment:** Mayag (MY) **Waterway Type:** Alluvial gravel	The station is located approximately 200 m away from the bridge of Brgy. Matinao. Rich riparian vegetation is intact on one side of the river while the opposite side is composed of gravel and sand. Rice fields and coconut plantations located nearby. Mosses cover the river banks. The downstream section is characterized by slightly turbid water with slow laminar flow.	**Latitude:** 9° 33' 24.33" N **Longitude:** 125° 28' 39.82" E **Elevation:** 60 m
SW3-MY-UPYR		**Waterway name:** Upstream of Payanasa River (UPYR) **Sampling location:** Brgy. Matinao, Municipality of Mainit	**Catchment:** Mayag (MY) **Waterway Type:** Alluvialgravel	The upstream of Payanasa River has depths ranging from the heel to below the knee. The river meanders approximately 4 km. The area is surrounded by coconut plantations and old rice fields. Carabaos graze on the river banks. The bed consists of a mixture of gravel, boulders, and sand. This sampling site has clear water with slow turbulent flow.	**Latitude:** 9° 33' 18.98" N **Longitude:** 125° 28' 55.32" E **Elevation:** 59 m

Station ID	Photo	Name and Location of Water Body	Catchment and Waterway Type	Description of Sampling Station	Coordinates and Elevation
SW4-MY-DPYR		**Waterway name:** Downstream of Payanasa River (DPYR) **Sampling location:** Brgy. Matinao, Municipality of Mainit	**Catchment:** Mayag (MY) **Waterway Type:** Alluvial gravel	The bed of the downstream section of Payanasa River is predominantly comprised of alluvial fine silt, sand, and mud, indicating high sediment load. The river has minimal, laminar flow and a slightly turbid appearance. The sampling site is located downstream of the Brgy. Matinao bridge and is approximately 200 m from a dam. The water is used for irrigation purposes as the river channel straddles a rice field. This site receives the effluent from pigpens and poultry located approximately 300 m upstream of the station, as well as from carabaos bathing in the area.	**Latitude:** 9° 32' 57.03" N **Longitude:** 125° 28' 39.68" E **Elevation:** 57 m
SW5-MY-MYC		**Waterway name:** Confluence of Mayag River and tributaries (MYC) **Sampling location:** Brgy. Matin-ao, Municipality of Mainit	**Catchment:** Mayag (MY) **Waterway Type:** Alluvial gravel	This sampling site receives water from Payanasa River and other tributaries prior to its discharge into Lake Mainit. The river has a stream-width of 15 m, clear water and laminar flow. The river channel outlines the foot of a mountain range while cutting through a farmland. The adjacent area are floodplains which makes the area suitable for farming.	**Latitude:** 9° 32' 30.22" N **Longitude:** 125° 28' 17.79" E **Elevation:** 53 m
Pungod Catchment					

Station ID	Photo	Name and Location of Water Body	Catchment and Waterway Type	Description of Sampling Station	Coordinates and Elevation
SW6-PU-PUR		**Waterway name:** Pungod River (PUR) **Sampling location:** Brgy. San Isidro, Municipality of Mainit	**Catchment:** Pungod (PU) **Waterway Type:** Valley fill systems	Pungod River has two tributaries. The channel traverses a rice field and has undefined river banks.. The bed is composed of fine silt and gravel. Water level is above the ankle, is clear, and has laminar flow.	**Latitude:** 9° 32' 23.51" N **Longitude:** 125° 29' 40.31" E **Elevation:** 49 m
Gata Catchment					
SW8-GT-GTR		**Waterway name:** Gata River (GTR) **Sampling location:** Brgy. Magsaysay Municipality of Mainit	**Catchment:** Gata (GT) **Waterway Type:** Bedrock controlled boulder	Gata river is an arbitrary name. The river has clear shallow water and laminar flow. The river discharges to Lake Mainit. The sampling station is situated downstream of the Gata River. The bed consists mostly of boulders, and has an inset channel on one side. Few houses and various types of vegetation surround the sampling station which is near the bridge of Brgy. Magsaysay.	**Latitude:** 9° 32' 39.51" N **Longitude:** 125° 31' 11.59" E **Elevation:** 60 m
Mapaso Catchment					

Station ID	Photo	Name and Location of Water Body	Catchment and Waterway Type	Description of Sampling Station	Coordinates and Elevation
SW7-MA-MAR	 	**Waterway name:** Mapaso River (MAR) **Sampling location:** Brgy. San Isidro Municipality of Mainit	**Catchment:** Mapaso (MA) **Waterway Type:** Alluvial boulder and gravel	Mapaso River is an arbitrary name. The Mapaso River discharges at Lake Mainit. Upstream of the sampling station, alluvial silt and gravel form the bank at one side of the river, while riparian vegetation and coconut trees dominate the opposite bank. Along the downstream section, there is a flood control dike protecting the left side of the river channel. Gravel and boulders, occupy the downstream portion of the station. The river has clear water with laminar flow.	**Latitude:** 9° 32' 48.85" N **Longitude:** 125° 30' 28.47" E **Elevation:** 65 m
SW10-AO-AOR		**Waterway name:** Mouth of Agong-ongan River (AOR) **Sampling location:** Brgy. Roxas, Municipality of Mainit	**Catchment:** Agong-ongan (AO) **Waterway Type:** Valley fill systems	The river name is arbitrarily based on the water body's local name. The station is at the mouth of Agong-ongan River just before it converges with Lake Mainit. The slightly turbid water has fast laminar flow. The narrow channel is controlled by alluvial fine silt and sand. Tall cogon grasses cover the river banks.	**Latitude:** 9° 31' 43.37" N **Longitude:** 125° 32' 24.27" E **Elevation:** 24
Campo Catchment					

Station ID	Photo	Name and Location of Water Body	Catchment and Waterway Type	Description of Sampling Station	Coordinates and Elevation
SW24-CA-PR		**Waterway name:** Payapag River (PR) **Sampling location:** Sitio Baliw, Brgy. Payapag, Municipality of Bacuag	**Catchment:** Campo (CA) **Waterway Type:** Bedrock controlled boulder	The water body is arbitrarily named after the local name used by the community residing near the sampling station. The sampling site is in the upper section of Payapag River. Stream bed is composed entirely of boulders. At the time of sampling, narrow riffle series were observed due to the low water level and the boulders in the channel bed. Quarrying was observed upstream of the station at the time of sampling.	**Latitude:** 9° 31' 58.20" N **Longitude:** 125° 36' 46.11" E **Elevation:** 65 m
SW25-CA-CAR		**Waterway name:** Campo River (CR) **Sampling location:** Sitio Greenhills, Brgy. Campo, Municipality of Bacuag	**Catchment:** Campo (CA) **Waterway Type:** Alluvial gravel	Campo River is an arbitrary name based on the proximity of the sampling station to Brgy. Campo. The sampling station is at the lower section of Campo River. Downstream of the station is Campo Bridge and the barangay hub. Carabaos were observed upstream and downstream of the station. The midsection of the river is shallow due to piles of debris and rocks. Algal colonies were abundant. The upper catchment is mostly agricultural.	**Latitude:** 9° 34' 43.75" N **Longitude:** 125° 38' 21.65" E **Elevation:** 20 m

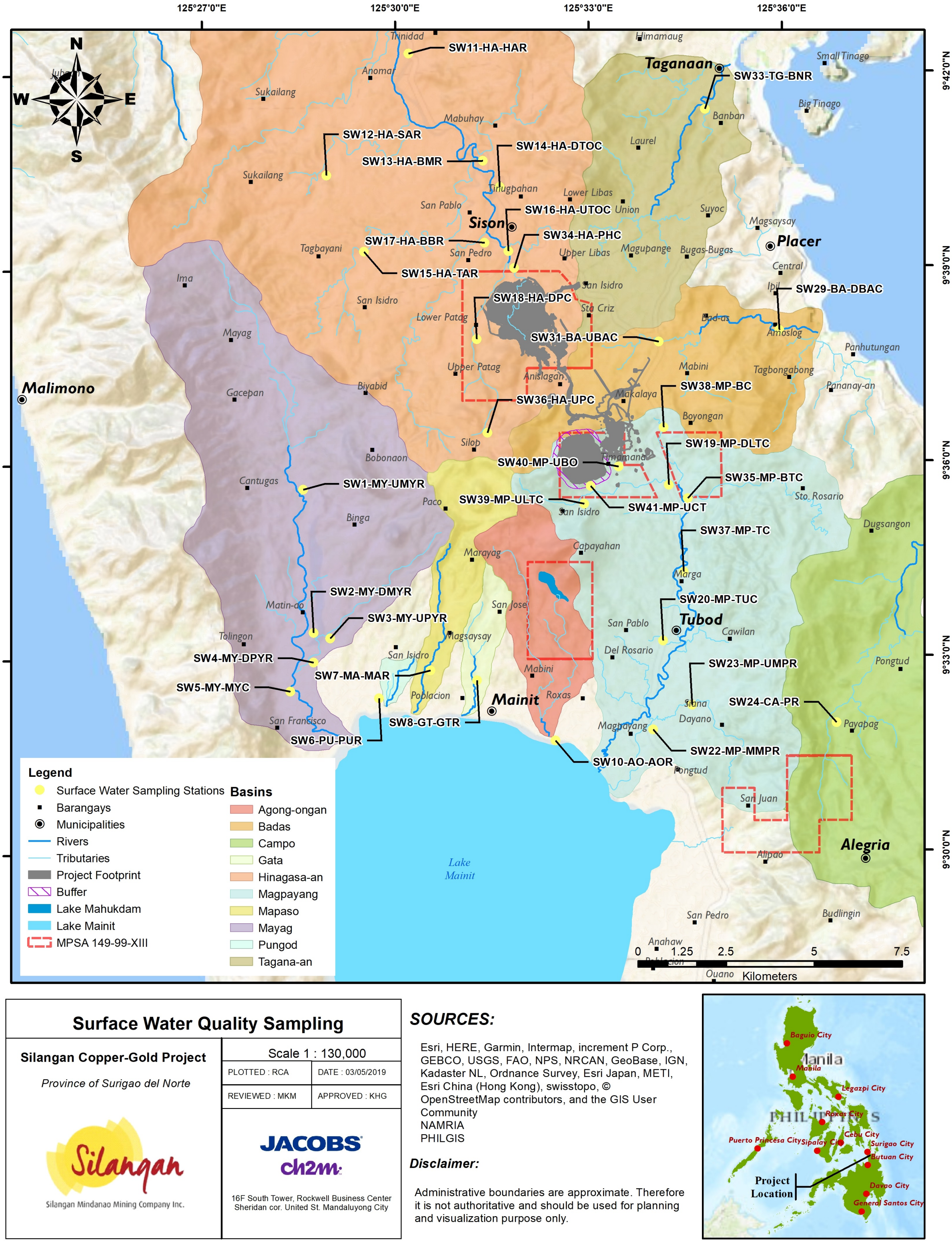


Figure 2.2.2-1 Surface Water Quality Sampling Stations

Lake

Lake Mainit and Mahukdam are known lakes within the region. These two lakes are considered significant water resources in the province of Surigao del Norte. Lake Mainit is the drainage of the Magpayang, Agong-ongan, Gata, Mapaso, Pungod, and Mayag catchments, while Lake Mahukdam is connected to the Agong-ongan River which will eventually drain to Lake Mainit.

Lake Mainit

Lake Mainit is the fourth largest lake in the Philippines. This freshwater lake is approximately 17,340 ha and more than 45 km in length. The widest surface of the lake measures 12 km. Its maximum depth reaches 223 m which is below sea level. Surrounding the lake are the municipalities of Alegria, Mainit, Sison, and Tubod in Surigao del Norte, and towns of Jabonga, Santiago, Tubay, and Kitcharao in Agusan del Norte. Around 20 small rivers and creeks in Surigao del Norte drain to the lake. The water from the lake exits through the Kalinawan River in Agusan del Norte which joins Aciga and Tubay Rivers, and eventually drains to Butuan Bay. Lake Mainit is 7 km to 8 km south of the Boyongan prospect. The northern edge of the lake is 9 km, in terms of aerial distance, from the mine site (ERM, 2008). This lake is considered to be oligotrophic, referring to a nutrient-poor and oxygen-rich environment, based on the limnological study conducted by the Mindanao State University (MSU) in year 2004.

Plate Error! No text of specified style in document.**.2.2-1 Mountain ridges surrounding Lake Mainit**

Six stations were established in Lake Mainit in 2012, consisting of five stations near six river mouths or major inlets (San Juan, Magpayang, Tigbawan, Agong-ongan, Mapaso, and Mayag Rivers), and one station at the center of the lake (**Table 2.2.2-2**).

Table 2.2.2-2 Water Quality Sampling Stations in Lake Mainit

Station ID	Location of Sampling Station	Description of Sampling Station	Coordinates	Elevation
LM1	Brgy. San Juan, Municipality of Alegria	• Near the mouth of San Juan River • Sampling site surrounded by fishpens	9° 30' 10.00" N 125° 33' 36.00" E	15 m
LM2	Brgy. Magpayang, Municipality of Mainit	• Near the mouth of Magpayang River; • Sampling site surrounded by fishpens	9° 30' 46.00" N 125° 32' 52.00" E	9 m
LM3	Brgy. Mabini/Roxas, Municipality of Mainit	• In-between the mouths of Tigbawan River in Brgy. Mabini and Agong-ongan River in Brgy. Roxas	9° 31' 23.00" N 125° 32' 06.00" E	16 m
LM4	Brgy. San Isidro, Municipality of Mainit	• Near the mouth of Mapaso River and Brgy. Poblacion	9° 31' 47.00" N 125° 30' 40.00" E	14 m
LM5	Brgy. Matinao, Municipality of Mainit	• Near the mouth of Mayag River; • Areas near the shore are used for agriculture (rice fields)	9° 31' 31.00" N 125° 29' 39.00" E	17 m
LM6	Municipality of Mainit	• Located at the middle of the lake • Serves as the control station;	9° 30' 20.00" N 125° 30' 48.00" E	23 m

Station ID	Location of Sampling Station	Description of Sampling Station	Coordinates	Elevation
		• Approximately 3 km away from the shore		

Lake Mahukdam

Lake Mahukdam is a lake formed out of a depression from remnant geologic structures, and over time, was filled with water (**Plate 2.2.2-2**). The lake covers an area of 18 ha. It is located at the base of Mt. Maniayao. This lake has a muddy substrate. Lake water is used for primary contact recreation and irrigation, and is a source of food of the locals. Lake Mahukdam is within the vicinity of the mineral prospect.

The three sampling stations designated in Lake Mahukdam in 2012 covered the right, left, and middle sections of the lake (**Table 2.2.2-3**).

From Lake Mahukdam, station L1 was sampled in the recently concluded February 2019 baseline studies.

Table 2.2.2-3 Water Quality Sampling Stations in Lake Mahukdam

Station ID	Location of Sampling Station	Description of Sampling Station	Coordinates	Elevation
L1	Brgy. San Pablo, Municipality of Tubod	• Located at the southern end of the lake • Coconut plantations and rice fields line the shore	9° 34' 02.20" N 125° 32' 22.28" E	202 m
L2	Brgy. San Pablo, Municipality of Tubod	• Located at the northern end of the lake • Drains to Agong-ongan River	9° 34' 17.13" N 125° 32' 13.78" E	200 m
L3	Brgy. San Pablo, Municipality of Tubod	• Located at the center of the lake	9° 34' 06.02" N 125° 32' 22.93" E	201 m

Lake Guinob-an

Lake Guinob-an is a swamp or marsh land found in the highlands of San Isidro, within the vicinity of the mina facilities. (**Plate 2.2.2-2**). The lake has a greenish reflection indicating the presence of algal bloom. Coconut plantation surrounds the valley. Residents use the lake for sustenance fishing.

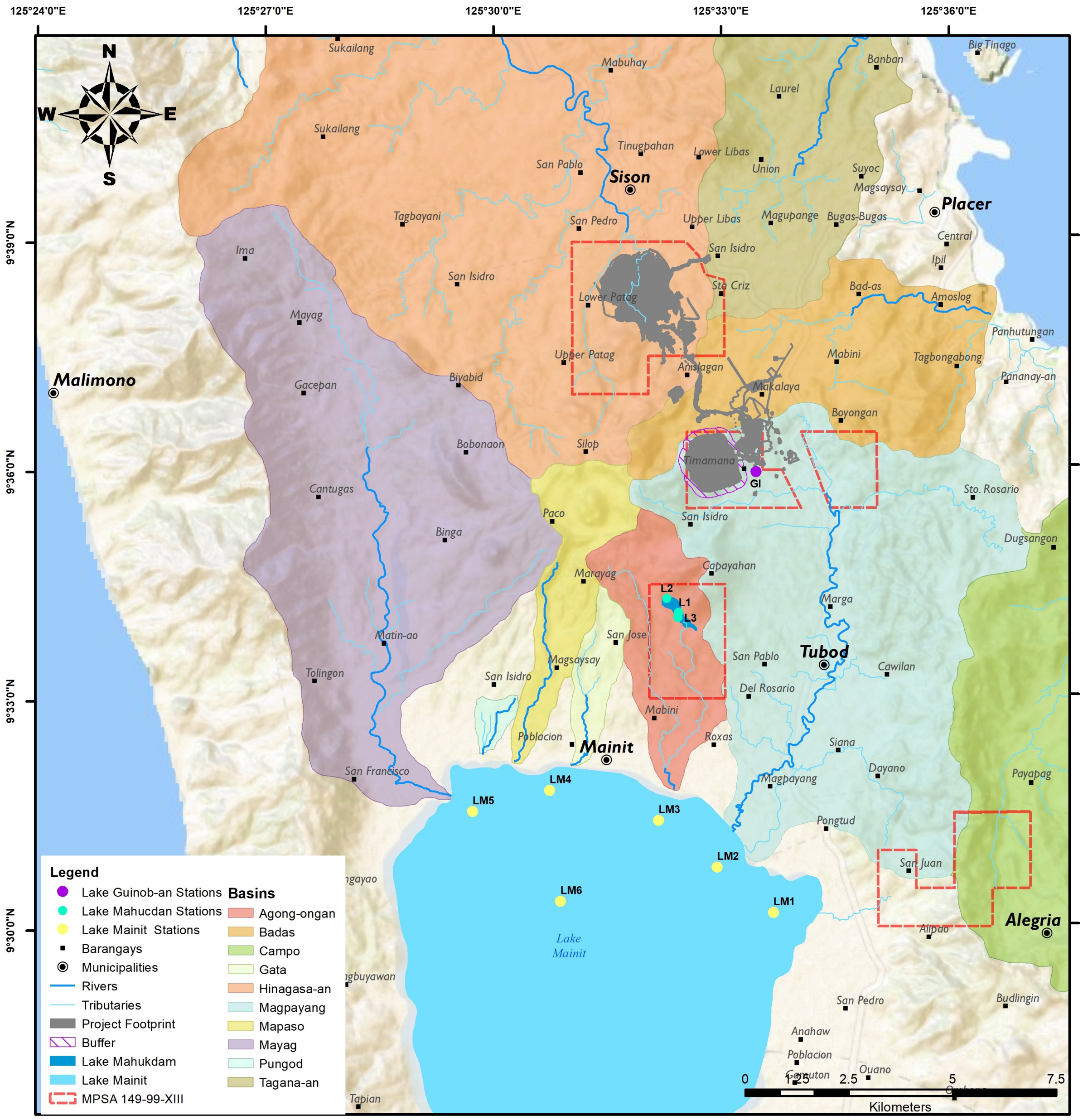
Only one station was established in Lake Guinob-an in May 2015, which is approximately 50 m from the bank (**Table 2.2.2-4**).

Table 2.2.2-4 Water Quality Sampling Station in Lake Guinob-an

Station ID	Location of Sampling Station	Description of Sampling Station	Coordinates	Elevation
GI	Sitio Guinob-an, Brgy. San Isidro, Municipality of Tubod	• Located at 50 m from the bank • Sampling station characterized by muddy substrate, with greenish water reflection	9° 35' 56.0" N 125° 33' 24.8" E	160 m

Plate 2.2.2-2 South-west portion of Lake Mahukdam

Plate 2..2.2-3 Guinob-an Swamp



Lake Water Quality Sampling

Silangan Copper-Gold Project

Province of Surigao del Norte

Silangan

Silangan Mindanao Mining Company Inc.

Scale 1 : 125,000	
PLOTTED : RCA	DATE : 03/05/2019
REVIEWED : MKM	APPROVED : KHG

JACOBS ch2m

16F South Tower, Rockwell Business Center Sheridan cor. United St. Mandaluyong City

SOURCES:

Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community
NAMRIA
PHILGIS

Disclaimer:

Administrative boundaries are approximate. Therefore it is not authoritative and should be used for planning and visualization purpose only.

Figure 2.2.2-2 Lake Water Quality Sampling Stations

Groundwater

The main water supply sources of the municipalities of Sison, Tagana-an, Placer, Tubod, and Mainit were selected as the groundwater stations, covering a total of 20 stations. Spring is the main source of potable water of the host municipalities, tapped through pipe networks connected to household faucets and communal stand pipes. Sixteen sampling sites were established at the most populated areas surrounding the project area from the last week of June to first week of July 2012. Additional four groundwater sources within the perimeter of the TSF in the municipalities of Tubod and Placer were sampled from 26 to 27 May 2015.

The groundwater sampling station ID codes were designated based on the following sequence: source of the sample and the designated sample number, the groundwater source, and the location of the station. For example, GW13-PWS-UPS refers to Ground Water sample 13 – Potable Water System – Brgy. Upper Patag, Sison municipality.

Groundwater sources in each municipality are described below.

Municipality of Sison

The Municipality of Sison utilizes the water coming from natural springs for drinking and domestic water use. Groundwater samples were collected from the intake box (GW13-PWS-UPS), and from two faucets (GW10-PWS-MS and GW12-FS-LPS) which are both connected to springs. Water from GW10-PWS-MS is sourced from the Mabuhay water system through a PVC pipe that traverses a hill in Purok 4. GW12-FS-LPS located in Brgy. Lower Patag is directly connected to a spring in Sitio Piakli, Brgy. Upper Patag. The three stations are part of different distribution systems.

Municipality of Tagana-an

One groundwater sampling station was established in the Municipality of Tagana-an. This town taps the natural spring found in Brgy. Paniking as the municipality's source of drinking and domestic water supply. Due to difficulty of access to the spring source, samples were obtained from a backyard faucet (GW14-FS-UT) connected to the spring.

Municipality of Placer

Of the four groundwater stations sampled in 2012 in Placer, only one station (GW15-WR-AP) is an intake box located in Brgy. Anislagan. GW15-WR-AP was also sampled this February 2019. The rest (GW11-FWR-IP, GW17-FWS-BP and GW20-FWR-CP) are household faucets connected to a water reservoir. In 2015, additional groundwater samples were obtained from the water supply source of Boyongan managed by LUWA (GW22-BWS-BP). Springs are the main source of water supply for drinking and domestic purposes within the municipality.

together with 2 groundwater monitoring stations GW15-WR-AP located at Brgy. Anislagan in Placer and GW3-SS-SPT located at Sitio Lambuyo, Brgy. San Pablo in Tubod.

Municipality of Tubod

The potable water system in Tubod is supplied mainly by Songkoy Spring located in Brgy. Marga. This spring is the domestic water supply source of majority of the households. Water for drinking and domestic use is also tapped from Badjang Spring of Brgy. Capayahan and Motorpool, Itom Spring of Brgy. San Isidro, Paragayo Spring of Brgy. Timamana and Tinag-an Spring of Brgy. Cawilan (Tubod Municipal Profile, MPDO 2010). The excess water from the Timamana spring is supplied to some areas for irrigation of ricefields, and to a lesser extent, for livestocks (Philex, 2010).

A total of eight groundwater sampling stations were established in the Municipality of Tubod in 2012 and 2015, including four spring water collected from an intake box (GW3-SS-SPT, GW18-IBS-TT, GW23-SB-TT and GW25-SB-IT), three faucets (GW19-FIB-TT, GW5-FS-CT and GW16-FS-GIT) each connected to a springbox, and a potential water source (GW24-PWS-TT) in Brgy. Timamana. Station GW19-FIB-TT is a household faucet connected to GW18-IBS-TT, while faucet at GW5-FS-CT is connected to GW3-SS-SPT. GW16-FS-GIT is a faucet located approximately 15 m away from its intake box. Groundwater station GW3-SS-SPT located at Sitio Lambuyo, Brgy. San Pablo, Tubod was included in the baseline sampling activities last February 2019.

Municipality of Mainit

Similar to other municipalities in Surigao del Norte, Mainit's potable water system is supplied mainly by springs. Three groundwater stations were sampled within this municipality. GW1-SPS-CM is a stand pipe connected to a spring in Sitio Bojo. The water is used by the Mamanwa (indigenous people) for domestic and drinking water use. GW21-IBS-SM is a spring collected from an intake box located in Brgy. Silop. This spring source supplies water to approximately 70 households. Results of the sampling activities conducted at GW1-SPS-CM and GW21-IBS-SM were assessed according to the prescribed PNSDW 2017 and DAO 2016-08 criteria. GW2-HS-MM is the Mapaso hot spring. Sample was collected from a bamboo pipe connected to the spring. The spring is not used for drinking but for recreational purposes, thus the laboratory test results were compared to the freshwater Class B guidelines in the DAO 2016-08.

The groundwater sampling stations are described in **Table 2.2.2-5**, while locations are presented in **Figure 2.2.2-3**.

Table 2.2.2-5 Groundwater Sampling Stations

Station ID	Photo	Groundwater Source and Sampling Location	Description of Station	Coordinates	Elevation
Municipality of Sison					
GW13-PWS-UPS		**Groundwater type:** Spring - Sison Potable Water System (PWS) **Sampling location:** Purok 3, Brgy. Upper Patag, Municipality of Sison (UPS)	Main source of water supply in the Municipality of Sison. The spring is surrounded by boulders and vegetation. A metal pipe is connected to the covered intake box which supplies water to the town proper. The water sourced from the Sison Potable Water System is used for drinking and domestic purposes. Located south-west of the proposed TSF in East Patag.	**Latitude:** 9° 37' 19.00" N **Longitude:** 125° 30' 23.50" E	182 m
GW12-FS-LPS		**Groundwater type:** Spring - Faucet connected to a spring (FS) **Sampling location:** Purok 1, Brgy. Lower Patag, Municipality of Sison (LPS)	The hose connects the faucet to the spring in Sitio Piakle, Brgy. Upper Patag. The sampling site is located along an access road of the various barangays in the Municipality of Sison. Residents utilize the water for drinking and other domestic needs.	**Latitude:** 9° 38' 27.48" N **Longitude:** 125° 31' 16.29" E	103 m
GW10-PWS-MS		**Groundwater type:** Spring - Faucet connected to Mabuhay Potable Water System (PWS) **Sampling location:** Purok 4, Brgy. Mabuhay, Municipality of Sison (MS)	The PVC pipe connects the faucet to the Mabuhay Potable Water System which is an open spring. The pipe traverses the hill in Brgy. Mabuhay. The faucet is located at the backyard of a household in Purok 4. Boulders surround the faucet, where the water is obtained for washing, bathing, and other domestic use.	**Latitude:** 9° 40' 50.99" N **Longitude:** 125° 31' 36.52" E	31 m

Station ID	Photo	Groundwater Source and Sampling Location	Description of Station	Coordinates	Elevation
Municipality of Tagana-an					
GW14-FS-UT		**Groundwater type:** Spring - Faucet connected to a spring (FS) **Sampling location:** Brgy. Union, Municipality of Taganaan (UT)	The faucet is located in front of a household, along the main road in Brgy. Union. Water is sourced from a spring in Paniking. A rubberized hose connects the faucet and the spring. Water is for domestic consumption.	**Latitude:** 9° 39' 34.55" N **Longitude:** 125° 33' 26.43" E	81 m
Municipality of Placer					
GW15-WR-AP		**Groundwater type:** Spring - Water reservoir (WR) **Sampling location:** Brgy. Anislagan, Municipality of Placer (AP)	The sampling site is within the property of the Placer Water District and accessible through paved road. Samples were collected from a PVC pipe which is directly connected to an intake box of a spring. Litters are observed in the area. Thick vegetation covers the pipe where water flows freely. A fence was built around the intake box. This is a source of potable water.	**Latitude:** 9° 37' 01.23" N **Longitude:** 125° 32' 28.14" E	221 m
GW20-FWR-CP		**Groundwater type:** Spring - Faucet connected to a water reservoir (FWR) **Sampling location:** Brgy. Sta. Cruz, Municipality of Placer (CP)	Samples were taken from the faucet inside the barangay office of Sta. Cruz. The drinking water is distributed to the households through pipes connected to a water reservoir.	**Latitude:** 9° 38' 01.83" N **Longitude:** 125° 33' 34.21" E	115 m

Station ID	Photo	Groundwater Source and Sampling Location	Description of Station	Coordinates	Elevation
GW11-FWR-IP		**Groundwater type:** Spring - Faucet connected to a water reservoir (FWR) **Sampling location:** Brgy. San Isidro, Municipality of Placer (IP)	The water was collected from a household faucet in Brgy. Isidro. A distribution system supplies water to the households in the Municipality of Placer. The faucet is connected to a water reservoir	**Latitude:** 9° 38' 33.94" N **Longitude:** 125° 33' 11.88" E	101 m
GW17-FWS-BP		**Groundwater type:** Spring - Faucet connected to a water reservoir (FWS) **Sampling location:** Brgy. Boyongan, Municipality of Placer (BP)	The sampling station is a faucet at a household backyard in Brgy. Boyongan. The faucet is connected to a water reservoir, which is a spring, through a rubberized hose. The owner uses the water for drinking and other domestic purposes..	**Latitude:** 9° 36' 33.53" N **Longitude:** 125° 34' 3.99" E	93 m
GW22-BWS-BP		**Groundwater type:** Boyongan Water Supply (BWS) - Intake box **Sampling location:** Sitio Cagaasan, Brgy. Boyongan, Municipality of Placer (BP)	Station GW22 is an intake box containing spring water. It is the source of water supply of Brgy. Boyongan, which is being managed by LUWA. Residents claimed that there has been a remarkable change in taste due to mining activities. A stream has been formed from the spring's overflow or contact with the surface. Samples taken in 2015 were directly collected from the intake bod.	**Latitude:** 9° 35' 32.4" N **Longitude:** 125° 32' 56.3" E	207 m
Municipality of Tubod					

Station ID	Photo	Groundwater Source and Sampling Location	Description of Station	Coordinates	Elevation
GW18-IBS-TT		**Groundwater type:** Spring - Water from an intake box of Paragayo spring (IBS) **Sampling location:** Brgy. Timamana, Municipality of Tubod (TT)	Spring water flows freely from a PVC pipe connected to a concrete intake box, impounding the Paragayo spring. The pipe has an approximate length of 10 m. The intake box is roofed with a tarpaulin to prevent litter and debris from falling into the spring source. The intake box is located on top of a hill and is surrounded by coconut trees and other types of vegetation. Water is supplied to the communities of Tubod.	**Latitude:** 9° 35' 47.09" N **Longitude:** 125° 33' 49.59" E	138 m
GW19-FIB-TT		**Groundwater type:** Spring - Faucet connected to an intake box (FIB) **Sampling location:** Brgy. Timamana, Municipality of Tubod (TT)	This station is a faucet in one of the households in Brgy. Timamana. The faucet is connected to the intake box, GW18-IBS-TT. Water is used for drinking and domestic purposes.	**Latitude:** 9° 35' 51.76" N **Longitude:** 125° 34' 08.02" E	106 m

Station ID	Photo	Groundwater Source and Sampling Location	Description of Station	Coordinates	Elevation
GW3-SS-SPT	 	**Groundwater type:** Spring (SS) - Intake box of Songkoy spring **Sampling location:** Sitio Lambuyo, Brgy. San Pablo, Municipality of Tubod (SPT)	The area is accessible through paved road. Samples were collected from an intake box of Songkoy spring in Sitio Lambuyo. Organic debris from surrounding trees falls into the open intake box. Several pipes are connected to this spring which is a source of drinking and domestic water of Barangays Poblacion, San Pablo, Magpayang, Siana, Del Rosario, and Marga in the Municipality of Tubod. The excess water serves as a pool used for recreation and laundry. Small fishes and mass of aquatic plants thrive in the clear water of the pool.	**Latitude:** 9° 33' 51.56" N **Longitude:** 125° 33' 16.65" E	151 m
GW5-FS-CT		**Groundwater type:** Spring - Faucet connected to the Songkoy spring (FS) **Sampling location:** Brgy. Casilag, Municipality of Tubod (CT)	The water is distributed to the households through a series of pipes connected to Songkoy spring (GW3-SS-SPT). This sampling station is a faucet where water is drawn for drinking and domestic purposes.	**Latitude:** 9° 33' 36.17" N **Longitude:** 125° 34' 10.59" E	71 m

Station ID	Photo	Groundwater Source and Sampling Location	Description of Station	Coordinates	Elevation
GW16-FS-GIT		**Groundwater type:** Spring - Faucet connected to Itom spring (FS) **Sampling location:** Purok 5, Sitio Guinob-an Brgy. San Isidro, Municipality of Tubod (GIT)	The faucet is located near a community in Sitio Guinob-an. The faucet is directly connected to a spring approximately 15 m away from the station. The spring is confined within an intake box. A cemented basin is constructed to catch the excess water flowing from the faucet.	**Latitude:** 9° 35' 0.88" N **Longitude:** 125° 32' 7.51" E	324 m
GW23-SB-TT		**Groundwater type:** Springbox (SB) **Sampling location:** Brgy. Timamana, Municipality of Tubod (TT)	Samples were taken from the surface overflow of the spring. Pipes are connected to the surface runoff of the spring as this is the main source of potable water of Brgy. Timamana. The springbox intake near the source has been abandoned. This station was established in May 2015.	**Latitude:** 9° 35' 46.1" N **Longitude:** 125° 33' 02.9" E	223 m
GW24-PWS-TT		**Groundwater type:** Potential Water Source (PWS) **Sampling location:** Brgy. Timamana, Municipality of Tubod (TT)	Station GW24-PWS-TT may be tapped as a potential groundwater source for Tubod. It is a spring which has a strong flow. The surrounding area is saturated with water due to the high groundwater flow. The water is currently used for irrigation. Samples were collected from the surface flow. This station was established in May 2015.	**Latitude:** 9° 35' 37.0" N **Longitude:** 125° 32' 57.5" E	219 m

Station ID	Photo	Groundwater Source and Sampling Location	Description of Station	Coordinates	Elevation
GW25-SB-IT		**Groundwater type:** Springbox (SB) **Sampling location:** Purok 5, Sitio Guinob-an, Brgy. San Isidro, Municipality of Tubod (IT)	Station GW25-SB-IT is a springbox that serves Brgy. San Isidro. It is one of the three spring sources in the area. Samples were directly obtained from the water freely flowing from the pipe connected to the springbox. This station was established in May 2015.	**Latitude:** 9° 35' 16.8" N **Longitude:** 125° 32' 38.4" E	267 m
Municipality of Mainit					
GW21-IBS-SM		**Groundwater type:** Spring - Water from an intake box (IBS) **Sampling location:** Brgy. Silop, Municipality of Mainit (SM)	Spring water was collected from an intake box. Pipes are installed for water distribution to households in the Municipality of Mainit. About 70 households are served by this water source. The downstream of the spring converges with a stream sampling station, Piakle Creek (SW36-HA-UPC). This station is the farthest among the established sampling sites, and has the highest elevation. Formed between the Maniayao andesite caps and Togonan clastics.	**Latitude:** 9° 36' 27.43" N **Longitude:** 125° 31' 23.37" E	363 m
GW2-HS-MM		**Groundwater type:** Hot spring (HS) **Sampling location:** Brgy. Mapaso, Municipality of Mainit (MM)	A wooden pipe is directly connected to a hot spring which is used for primary contact recreation. The water flow produces the orange color in the rocks that indicates the presence of iron. A recreational pool was built downstream of the spring, the Mapaso hot spring.	**Latitude:** 9° 34' 30.20" N **Longitude:** 125° 30' 41.19" E	185 m

Station ID	Photo	Groundwater Source and Sampling Location	Description of Station	Coordinates	Elevation
GW1-SPS-CM		**Groundwater type:** Spring - Stand pipe connected to a spring (SPS) **Sampling location:** Purok 1, Brgy. Cantugas, Municipality of Mainit (CM)	The stand pipe is located within a residential area. The pipe is connected to a spring in Sitio Bojo. The water is utilized by the indigenous people community for domestic and drinking water use.	**Latitude:** 9° 34' 40.76" N **Longitude:** 125° 28' 25.16" E	78 m

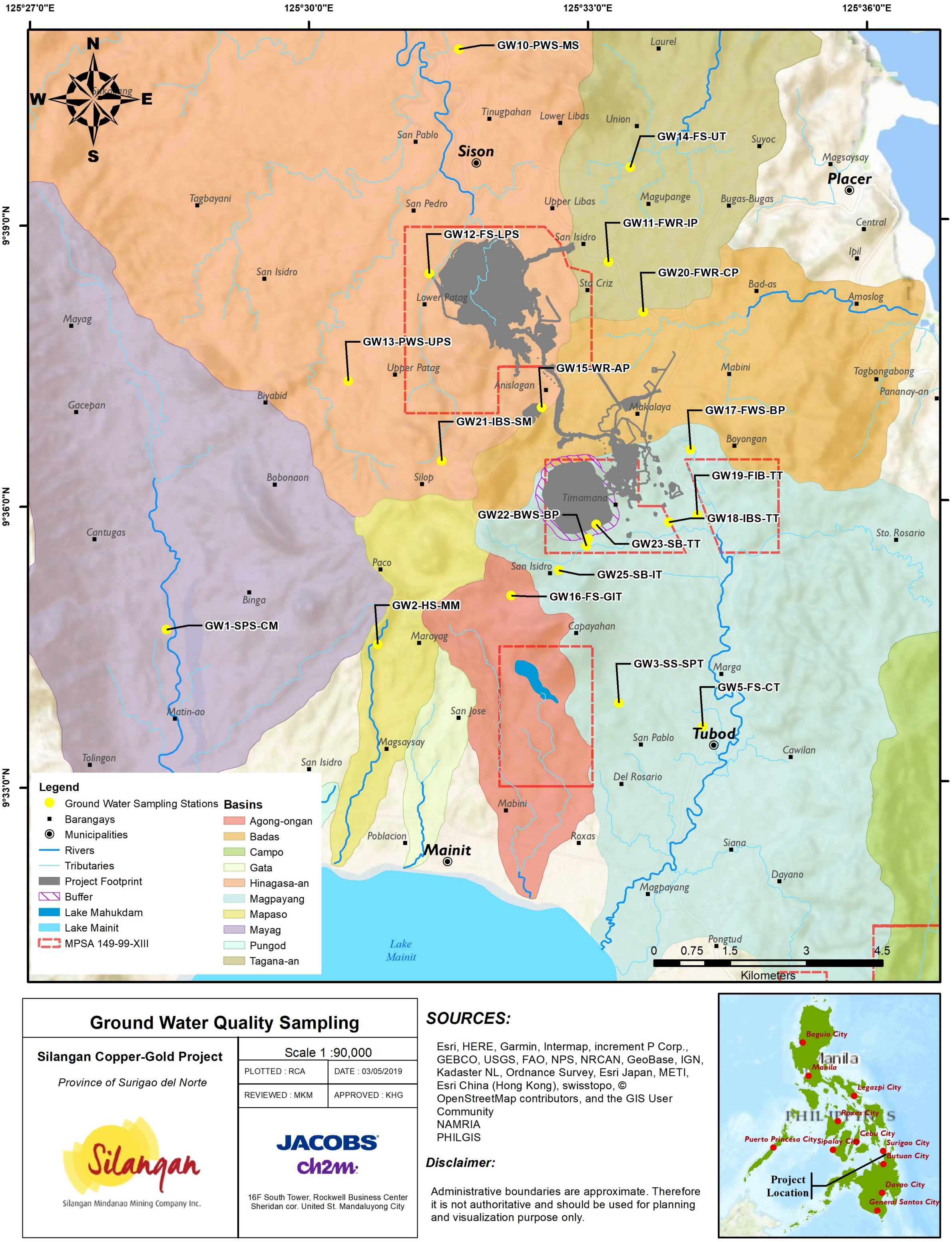


Figure 2.2.2-3 Ground Water Quality Sampling Stations

2.2.2.4 Sampling and Analytical Procedures

In-Situ Measurements

Hand-held meters were used to determine the availability of dissolved oxygen in surface water, ambient temperature, conductivity, and pH of ground, stream, and lake waters (**Plate 2.2.2-5**). For the 2012 and 2015 sampling activities, temperature and DO were measured *in*-situ using the YSI EcoSense® DO200 meter. The pH levels were determined using the HORIBA® glass electrode-pH meter D-52 model, while conductivity readings were obtained using the YSI EcoSense® EC300 conductivity meter. For the February 2019 baseline studies, *in-situ* measurements for pH, DO, conductivity, temperature and turbidity were obtained using the YSI Multi-Meter U-500. All equipment were calibrated prior to the sampling date to ensure the validity and reliability of data. The calibration and verification certificates are attached as **Annex 2.2-3**.

Plate 2.2.2-5 Hand-held Meters used during the fieldwork activities

Stream flow of each stream was determined based on the measured stream-width, average depths and velocities. Stream flow or discharge refers to the volume of water that passes through a cross-section of a stream over a set period of time (University of Wisconsin, 2002). This parameter defines the course of the stream. For the purpose of this study, the volume of water is only limited to the calculated instantaneous stream flow.

The factors gathered during the field study were the stream velocity, water depth, stream-width, and dominant materials comprising the bottom of a stream water station, which were used to compute the stream flow. A straight cross section near the sampling point with apparent movement and less flow obstructions was chosen for the cross-sectional area measurement. The channel width of the streams and creeks was taken using a measuring tape. The measuring tape was secured on opposite banks to create a transect line across the stream. The chosen stream segment was divided equally, covering at least 3 points. At each equal interval, water depth was measured using a metric-scaled pole and the average velocity of the flow was read by a current flow meter. The Valeport Ltd® “Braystroke” current flow meter was used by the first team, while the Global Water® Flow model FP111 current flow meter was used by the second team (**Plate 2.2.2-6** and **Plate 2.2.2-7**). The propeller of the current flow meter was oriented against the direction of the flow and adjusted along the pole at approximately one third of the depth measurement from the surface water. In cases when measuring the water depth and current flow pose life risks, estimated stream width and depth measurements were considered or an alternate sampling point was chosen to measure the stream flow.

Plate 2.2.2-6 In-situ measurement of stream-width, depth, and velocity using the Global Water® Flow model FP111 current flow meter at Stations (a.) SW3-MG-UPR and (b.) SW17-HA-UP

Plate 2.2.2-7 Stream velocity measurement at SW10-AO-AR using the Valeport Ltd® "Braystroke" meter

The average depth of the sampling site was multiplied with the stream width to get the average cross-sectional area. To determine the average surface velocity, the total of average velocities along the transect line is divided by the number of intervals. Surface water moves faster than the subsurface water due to resistance or rough bottom. A correction factor (coefficient) was multiplied with the average surface velocity to account for the effect of friction. The correction factor depends on the bottom composition of the stream. Multiplying the surface velocity with a correction factor provides a better approximate of the stream's overall velocity (EMB, 2008).

Stream flow is equivalent to the average cross-sectional area multiplied by the corrected average surface velocity. The following equation describes the stream flow:

Stream Flow (m^3/s) = AV

where: A = average cross sectional area (m^2)
V = corrected average surface velocity (m/s)

Detailed equations and procedures in calculating the stream flows are attached as **Annex 2.2-4**.

Sampling and Handling Procedures

The sampling and handling techniques for all water bodies are based on the Australian/New Zealand Standard® Water Quality Sampling Guidance: AS/NZS 5667 series of 1998 (ISO 5667-1). Other specific parts of this international guideline served as supplementary references for ground (AS/NZS 5667.11), stream (AS/NZS 5667.6), lake (AS/NZS 5667.4), water sampling. The procedure is also in accordance with the Water Quality Monitoring Manual for Ambient Water Quality Monitoring issued by the Environmental Management Bureau of DENR (2008).

Groundwater

Groundwater samples were obtained from the main sources of water supply like open spring and intake box (**Plate 2.2.2-8**). For sites that have accessibility and security issues, the team utilized available hose and faucets in the residential areas which are connected to natural springs. Sampling containers were directly filled with water from the hose and faucets connected to the main source. For springs which do not have hose and faucet attachments, grab sampling was conducted.

Plate 2.2.2-8 Sample collection at (a.) an intake box and (b.) a household faucet

Stream

The midstream portion of the site having the deepest water level and fastest current was chosen as the sampling point, whenever practicable. Grab samples[6] were collected by submerging the laboratory prepared containers, facing downward, at a depth of approximately 20 cm or whenever the water level of the stream permits (**Plate 2.2.2-9**). After filling with water, containers were slowly lifted against the stream flow. Sterilized bottles for coliform were only filled to the line to allow headspace for proper mixing of samples. Filling and handling techniques for other parameters followed the AS/NZS 5667.1:1998. Samples for oil and grease were obtained from the surface of the water using wide-mouthed glass bottles and were immediately covered with aluminum foil to prevent any oil and grease from adhering to the container cap. Samples that will be analyzed for dissolved cyanide and dissolved metals (Hg, Sb, As, Cd, Cu, Cr, Pb, Al, B, Mg, Ni, Zn, Ba, Fe, Mn, and Se) were filtered on site using a Nalgene® filtration apparatus and Mityvac® handpump. Samples were passed through a GF/C® glass fiber filter, with pore size of 0.45 µm. In the February 2019 sampling activities, none of the samples were filtred on site.

Plate Error! No text of specified style in document.**.2.2-9 Stream water sampling**

Lake

Differences in water quality of a lake occur within a column due to stratification and influences of abiotic factors such as temperature and sedimentation. It also has a high turnover which mixes the upper layer of the lake water with the lower layers. To have representative samples, a vertical sampler was used to collect water within a column which captures the heterogeneity of Lakes Mainit and Mahukdam. The Niskin® 2-L vertical water sampler (General Oceanics) was lowered approximately 1 m from the surface to collect composite samples (**Plate 2.2.2-10**). A faucet is connected to the cylindrical tube for collection. Samples were only collected 20 cm from the surface of Lake Guinob-an due to its shallowness.

[6] Grab samples refer to discrete sample taken randomly, with regard to time and location, from a body of water (AS/NZS 5667.1:1998).

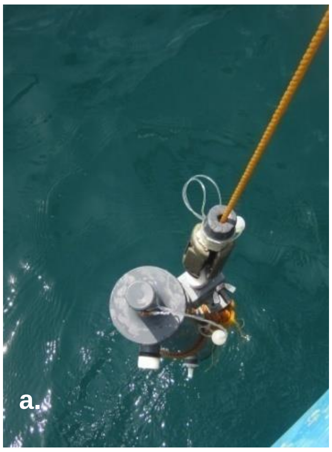


Plate 2.2.2-10 (a.) Deployment and (b. and c.) sample collection, using the Niskin® 2-L vertical water sampler

Water Quality Parameters

The physico-chemical properties, organic and inorganic composition, level of bacteriological contamination, and presence of trace metals were determined by analyzing the parameters summarized in **Table 2.2.2-6**. Same set of analytes were examined for all stream, ground and lake water samples.

Table 2.2.2-6 Parameters Analyzed for Ground, Stream and Lake Water Quality

Physico-Chemical Properties	• pH • Temperature • Dissolved oxygen (DO) • Electrical conductivity • Color (apparent) • Turbidity	• Biochemical oxygen demand (BOD) • Oil and grease • Total alkalinity as $CaCO_3$ • Acidity as $CaCO_3$ • Total hardness as $CaCO_3$	• Total suspended solids (TSS) • Total dissolved solids (TDS)
Inorganic Non-metallic Parameters	• Sulfate • Chloride • Fluoride	• Total cyanide • Dissolved cyanide	• Nitrate • Phosphate • Ammonia
Bacteriological Parameters	• Total coliform • Fecal coliform		
Metals and Major Cations (total and filtered)	• Aluminum (Al) • Antimony (Sb) • Arsenic (As) • Barium (Ba) • Boron (B) • Cadmium (Cd) • Chromium (Cr)	• Copper (Cu) • Dissolved Copper • Iron (Fe) • Lead (Pb) • Manganese (Mn) • Magnesium (Mg) • Mercury (Hg)	• Nickel (Ni) • Selenium (Se) • Zinc (Zn) • Hexavalent chromium (Cr^{+6}) • Total calcium (Ca)

Each parameter has a specific type of container and volume requirement. Sampling containers were prepared according to the specifications approved by AS/NZS 5667.1:1998 and US EPA 2007. Samples were cool-stored at approximately 6°C, as necessary. Appropriate preservation reagents were added to prolong the holding time of the samples, as indicated in the US EPA 2007. Samples were shipped to the partner laboratories accredited by DENR and certified by the Department of Trade and Industry (DTI) (**Annex 2.2-5** and **Annex 2.2-6**). The CRL Environmental Corporation (CRL) in Clarkfield, Pampanga was commissioned in 2012, while Ostrea Mineral

Laboratories, Inc. (OMLI) conducted the analysis in 2015 and 2019. Due to the distance of the project site from the laboratory, samples for BOD, total and fecal coliforms were not analyzed within the 6-hour maximum holding period, but were sent to HiAdvance Pilippines, Inc. However, cool storage of the samples was still observed prior to the conduct of laboratory analysis, thus minimizing the extent of deviation.

Same laboratory techniques and methods were applied by CRL, OMLI and HiAdvance which are based on the US EPA (2007) and Standard Methods for the Examination of Water and Wastewater by the American Public Health Association (2005). These are the same procedures described in the DAO 2016-08 and PNSDW 2017.

The container requirements, applicable preservation measures, and laboratory analytical methods are detailed in **Annex 2.2-7**. Quality assurance and quality control measures were ensured at the time of sampling. To assess this in 2012, sets of blind samples were used with the methodology based on AS/NZS 5667.1:1998 (**Annex 2.2-8** and **Annex 2.2-9**).

2.2.4.7.1 Criteria for Comparison and Assessment

The water quality of the ground and surface waters were assessed based on local guidelines (DAO 2016-08 and PNSDW 2017) and available secondary data.

Stream

The DAO 2016-08 describes the classification and the beneficial use of fresh water and coastal/marine water bodies (**Table 2.2.2-7**) in the Philippines. This guideline prescribes the water quality criteria for a water body's best designated use. The quality of effluent being discharged into a water body is regulated to ensure that the water quality of the receiving waters will continue to support the designated use of the water source.

The DENR amended the classification of coastal and marine waters in year 1997 through the Administrative Order No. 23, entitled Updating Departments Administrative Order No. 34, Series of 1990 Otherwise Known as the Revised Water Usage Classification/Water Quality Criteria Amending Section Nos. 68 and 69, Chapter III of the 1978 NPCC Rules and Regulations (DAO 1997-23).

Table 2.2.2-7 DAO 2016-08 Water Usage and Classification Guidelines for Fresh Surface Waters

Classification	Beneficial Use*
Class AA	**Public Water Supply Class I** Intended primarily for waters having watersheds, which are uninhabited and/or otherwise declared as protected areas, and which require only approved disinfection to meet the PNSDW
Class A	**Public Water Supply Class II** Intended s sources of water supply requiring conventional treatment (coagulation, sedimentation, filtration, and disinfection) in order to meet the latest PNSDW
Class B	**Recreational Water Class I** Intended for primary contact recreation (bathing, swimming, etc.)
Class C	**Fishery Water** For the propagation and growth of fish and other aquatic resources **Recreational Water Class II** (e.g., boating, etc.). **For agriculture, irrigation, and livestock watering**
Class D	**Navigable waters**

* For unclassified water bodies, classification shall be based on the beneficial use as determined by the Environmental Management Bureau

The water bodies that will receive discharges from the project are currently unclassified by the DENR. The catchments where the project site is located have not been assigned a water body classification. For the purpose of referencing the stream water quality results with the DAO 2016-08 criteria, the results were compared against the criteria for the observed best beneficial use of the creeks and streams.

Surface waters in the Hinagasa-an catchment are generally used for domestic and recreational activities. The domestic purpose of the streams within this catchment is the best actual usage of water which requires higher water quality criteria. Further, the Hinagasa-an River merges with Surigao River which was identified as Class A by DENR in year 1978, according to the memorandum circular no. 07, series of 1993 (DMC 1993-07) (**Annex 2.2-10**). Therefore, Class A (Public Water Supply Class II) freshwater guidelines were used to assess the water quality of the streams and creeks within this catchment.

The sampling station (SW33-TG-BNR) in the Tagana-an catchment and one site (SW29-BA-DBAC) in the Bad-as/Amoslog catchment have brackish waters due to their proximity to Canal and Sabong Bays, respectively. But the DAO 2916-08 for freshwater Class B was referenced for water quality assessment since the areas are used for primary contact recreation.

Lake

Lake Mainit has a high ecological value due to the existence of rare species of fish. The need to sustain such abundant natural resources in the lake compelled the provincial governments of Surigao del Norte and Agusan del Norte to form an alliance group called the Lake Mainit Development Alliance (LMDA). LMDA was organized in 1999 to sustain, preserve, and manage the lake (LMDA EMP).

According to the DENR-CARAGA regional office, Lake Mainit watershed is proposed as a protected area under the National Integrated Protected Area Systems (NIPAS) (ERM, 2008 and LMDA EMP). The proposed protected area is estimated to be more than 19,000 ha, covering the municipalities of Jabonga and Kitcharao in Agusan del Norte and municipalities of Mainit and Alegria in Surigao del Norte. The interim members of the Protected Areas Management Board (PAMB) for Lake Mainit were formed in year 2002 (ERM, 2008). Up to this date, no decision has been made on the application as there is no official memorandum circular from DENR declaring Lake Mainit as a protected watershed area. In the event of reclassification as a protected area, a more stringent monitoring of the water quality of Lake Mainit will be implemented by the local government units (LGU) of Surigao del Norte and Agusan del Norte, as stipulated in the DAO 2005-10.

Lake Mainit is a large freshwater lake. The portion of Lake Mainit under the jurisdiction of Agusan del Norte is classified as Class A (Public Water Supply Class II) through the DENR Memorandum Circular No. 13, series of 2004 (DMC 2004-13), which may be referred to in **Annex 2.2-11**. The section of Lake Mainit bounded by the province of Surigao del Norte has not yet been classified by DENR. The inlets consisting of rivers and creeks are found in Surigao del Norte, while the only outlet of the lake (Kalinawan River) is within Agusan del Norte. For the purposes of this study, Class A was used in the water quality assessment of Lake Mainit in Surigao del Norte to retain the integrity of the water body (**Table 3.2-33**). Other uses of the lake include bathing, boating, fishing, breeding ground of some species of birds, and tourism (ERM, 2008).

DENR has not yet classified Lake Mahukdam hence, the observed best actual usage of the lake served as a reference in assessing its water quality. Results were compared with the freshwater Class B guidelines (Recreational Water Class I) since lake water is best used for recreational purposes.

Lake Guinob-an is a marshy valley or swamp which has no official classification from DENR. Since the lake is used for fishing, the freshwater guidelines for Class C waters have been assigned for comparison purposes of this study.

Table 2.2.2-8 summarizes the classifications used to assess the water quality of the streams and creeks in each catchment, sampling stations in Lakes Mainit, Mahukdam and Guinob-an based on the observed best use.

Table 2.2.2-8 Classification of Stream and Lake Waters (based on observed use)

Water Body	Station ID	Observed Best Use	Assumed Classification
Stream			
Hinagasa-an	• SW36-HA-UPC • SW18-HA-DPC • SW34-HA-PHC • SW16-HA-UTOC • SW17-HA-BBR • SW15-HA-TAR • SW14-HA-DTOC • SW13-HA-BMR • SW12-HA-SAR • SW11-HA-HAR	• Domestic e. cooking, dishwashing) • Laundry	Class A (Public Water Supply Class II)
Tagana-an	• SW33-TG-BNR (brackish water)	• Primary contact recreation e. bathing, swimming)	Class B (Recreational Water Class I)
Bad-as/ Amoslog	• SW31-BA-UBAC	• Primary contact recreation (i.e. bathing, swimming) • Laundry	Class B (Recreational Water Class I)
	• SW29-BA-DBAC (brackish water)	• Primary contact recreation (i.e. bathing, swimming)	Class B (Recreational Water Class I)
Campo	• SW24-CA-PR • SW25-CA-CAR	• Primary contact recreation (i.e. bathing, swimming) • Laundry	Class B (Recreational Water Class I)
Magpayang	• SW38-MP-BC • SW39-MP-ULTC • SW19-MP-DLTC • SW35-MP-BTC • SW37-MP-TC • SW20-MP-TUC • SW23-MP-UMPR • SW22-MP-MMPR	• Primary contact recreation (i.e. bathing, swimming) • Laundry	Class B (Recreational Water Class I)
Agong-ongan	• SW10-AO-AOR	• Primary contact recreation (i.e. bathing, swimming)	Class B (Recreational Water Class I)
Gata	• SW8-GT-GTR	• Primary contact recreation (i.e. bathing, swimming) • Laundry	Class B (Recreational Water Class I)
Mapaso	• SW7-MA-MAR	• Primary contact recreation (i.e. bathing, swimming)	Class B (Recreational Water Class I)
Pungod	• SW6-PU-PUR	• Primary contact recreation (i.e. bathing, swimming)	Class B (Recreational Water Class I)

Water Body	Station ID		Observed Best Use	Assumed Classification
Mayag	• SW1-MY-UMYR • SW2-MY-DMYR • SW3-MY-UPYR	• SW4-MY-DPYR • SW5-MY-MYC	• Primary contact recreation (i.e. bathing, swimming) • Laundry	Class B (Recreational Water Class I)
Lake				
Lake Mainit Portion in Surigao del Norte	• LM1 • LM2 • LM3	• LM4 • LM5 • LM6	• Section bounded by the province of Agusan del Norte is classified as Class A by DENR	Class A (Public Water Supply Class II)
Lake Mahukdam	• L1 • L2 • L3		• Primary contact recreation (i.e. bathing, swimming)	Class B (Recreational Water Class I)
Lake Guinob-an	• GI		• Fishery Water for the propagation and growth of fish and other aquatic resources	Class C (Fishery Water)

Groundwater

Groundwater sources within and near the project site are mainly for drinking and domestic consumption, hence, the laboratory test results were compared with the DAO 2016-08 guideline and PNSDW 2017 values pertaining to microbiological quality, inorganic chemical constituents with health significance, and physical and chemical quality for acceptability aspects.

The Mapaso hot spring (GW2-HS-MM) is neither potable nor utilized for domestic purposes. This spring is used for primary contact recreational activities (bathing and swimming), making it a known local tourist destination. The best actual usage of the spring was considered in the assessment of its water quality. Therefore, the DAO 2016-08 freshwater guidelines for Class B (Recreational Water Class I) waters were used as a reference in the water quality assessment of this spring.

2.2.5 Assumptions and Limitations

Natural variability is a fundamental characteristic of a water body. Water quality may differ according to seasons; hence water quality sampling should consider different seasons in the area or locality (EMB, 2008). However, the project site has only one pronounced season – wet season. Maximum rain period occurs from December to February. Water sampling for this study is representative of the wet season.

Silangan maintains a regular water quality monitoring within and outside the vicinity of their mine which may be used to reflect monsoonal variations if any. The monitoring results of the internal sampling activities conducted by SMMCI in 2015 have been summarized and included as an attachment to characterize the streams within the project site to reflect any wet season variation.

The results of the laboratory analysis of total and dissolved metals were generally reported as below the method detection limit except for iron, calcium, magnesium (both total and filterable) in the stream and ground waters, and arsenic (both total and filterable) in twelve groundwater stations. The dissolved and total metals data should be used with caution because even with modern techniques and equipment, there are limits to which a water testing laboratory may determine the amount of a given contaminant in water.

2.2.2.5 Baseline Environment for Water Quality

2.2.2.5.1 Summary

Table 2.2.2-9 Key Findings and Conclusions – Water Quality

Baseline Information	Key Findings and Conclusions
Stream Water Quality	• The Hinagasa-an River and its tributaries generally conform to the DAO 2016-08 Class A guidelines based on the 2012 water quality data, except for color at Stations SW12-HA-SAR and SW36-HA-UPC. There is enough supply of oxygen in the surface waters, but with moderate to high bacterial contamination coming from agricultural runoff and domestic wastes from surrounding residential areas. The farthest upstream station along Piakle Creek (SW36-HA-UPC), which is upstream of the proposed TSF, differs from the other streams within the catchment, in terms of aesthetic quality and physico-chemical quality (i.e. pH, temperature, conductivity, apparent color, turbidity, TDS, TSS, alkalinity, calcium, magnesium, acidity, and total hardness). The unique characteristic of SW36-HA-UPC could be due to the geology of the area as this station is located north-west of the Boyongan mine prospect and along the confluence of the Piakle Creek and a spring formed from the Maniayao andesite caps. In the 2019 water sampling activities, the river and its tributaries generally conform to the water quality guideline for all parameters except for BOD in the following stations (SW14-HA-DTOC, SW16-HA-UTOC and SW34-HA-PHC), Fecal Coliform (SW130HA-BMR, SW14-HA-DTOC, SW16-HA-UTOC, SW17-HA-BBR, SW34-HA-PHC). There were also recorded exceedances for Iron on (SW13-HA-BMR and SW17-HA-BBR) and Arsenic (SW17-HA-BBR). • The quality of the stream water resources sampled in Magpayang Catchment is typical of an undisturbed water body. The aesthetic quality of the streams within the Magpayang catchment are relatively good as the physico-chemical parameters in 2012 and 2015 conform to the DAO 2016-08 Class A guidelines, except for pH (6.4) at Station SW41-CA-UCT in the unknown tributary of Timamana Creek within the vicinity of the proposed Sub-level Cave Mine. Dissolved ions and presence of arsenic contributed to the below neutral pH of water at SW41-CA-UCT. The headwaters of Magpayang catchment near underground mine have clear water as low TSS, color and turbidity values were recorded in the Timamana and Boyongan Creeks. The clarity deceases as water drains to the main channel of Timamana Creek and converges with the Tubod Creek and Magpayang River. The presence of total and fecal coliform in the water samples indicate bacterial contamination coming from animal and domestic waste discharges as most of the streams are used for primary contact recreation. In the February 2019 sampling, there were recorded non-conformances and exceedances for the parameters and stations as follows: pH (SW38-MP-BC), BOD (SW19-MP-DLTC, SW38-MP-BC, SW35-MP-BTC and SW37-MP-TC),) TSS (SW19-MP-DLTC) which is downstream of the Timamana creek caused by the dust and soil particles introduced from the creek's tributaries. Total Cyanide levels for SW19-MP-DLTC, SW38-MP-BC and SW35-MP-BTC exceeded the guideline value as well. The downstream of Timamana Creek receives a lot of water quality contamination coming from its tributaries where farmlands, small scale mining activities and domestic areas discharge. • The upstream and downstream sections of Bad-as Creek conform to the DAO 2016-08 criteria for Class B water based on the results of the 2012 sampling, with moderate to high bacterial contamination. Debris from

Baseline Information	Key Findings and Conclusions
	stacks of rice hulls along the river banks, agricultural runoff, carabaos bathing, improper disposal of wastes and domestic discharges from residential areas nearby contribute to the elevated total coliform downstream of Bad-as Creek (SW29-BA-DBAC). Station SW29-BA-DBAC has elevated concentrations of dissolved chemical substances as reflected in the high conductivity, TDS, and chloride levels, indicating the brackish condition of sampling area due to saltwater infiltration from the Sabong Bay. The Bad-as Creek has poor water quality relative to the results of the streams in other catchments. This is supported by the poor aesthetic quality, low oxygen availability, and elevated coliform counts in the two sampling stations along the creek. In the February 2019 sampling, results show that SW31-BA-UBAC had non-conformances/exceedances for phyico-chemical parameters and metal concentrations. DO level for the station was recorded to be below the minimum value of 5 mg/L, which shows that a there are pollutants in the station introduced consuming/altering the DO. Oil and Grease, TSS, Color, Total Cyanide, As, Dissolved Cu, Fe, Mn and Ni were also recorded to exceed their respective DAO 2016-08 guideline values. The downstream station (SW29-BA-DBAC) also had exceedances for Total Cyanide and Iron. • Streams in the secondary impact catchments (Tagana-an, Mayag, Pungod, Gata, Mapaso, Agong-ongan, and Campo) generally conformed to the DAO 2016-08 guidelines for Class B waters. Station SW33-TG-BNR in the Tagana-an Catchment is characterized by high dissolved substances due to saltwater intrusion from the Canal Bay. Streams in the Mayag and Gata catchment have good aesthetic water quality. The river in the Pungod catchment is the typical water body found in a rural agricultural area. Agricultural activities affect the water quality of Pungod River. Since the area is used mainly for agriculture, elevated levels of total and fecal coliform is expected. Agricultural runoff containing animal excreta and fertilizers could be the potential sources of coliform and phosphate, respectively. The igneous source rocks in Mapaso Spring potentially affect the water quality of the downstream portion of Mapaso River. The valley-filled river in the Agong-ongan catchment is typical of an undisturbed river. Stations in the Campo catchment have minimal bacterial contamination.
Lake Water Quality	• The good aesthetic and environmental conditions of Lake Mainit support primary productivity and aquatic life. Results of this study affirm the oligotrophic condition of Lake Mainit due to minimal concentrations of nutrients, high oxygen availability, and clarity of water that supports optimum survival of aquatic life. • Parameters defining the aesthetic quality of Lake Mahukdam conform to the specific limits in the DAO 2016-08 for Class B waters, with low to high coliform counts possibly coming from agricultural runoff, as well as from human excreta brought by the improper domestic discharge. Results of the February 2019 sampling reveal that there are exceedances in BOD and Total Cyanide for station L1, which is at the southern end of the lake which is contaminated by the nearby tributaries. • Lake Guinob-an has poor aesthetic quality as manifested in the elevated levels of BOD, TSS, conductivity, color, and turbidity due to its swamp or marshland characteristic.
Groundwater Quality	• Spring is the major source of drinking water in the host municipalities, In general, groundwater sources from the Municipalities of Sison, Tagana-an, Placer, Tubod, Mainit complied with the PNSDW 2017 standards and

Baseline Information	Key Findings and Conclusions
	DAO 2016-08 for Class A waters, except mostly for total and fecal coliform. Possible sources bacterial contamination in groundwater include agricultural runoff, shallowness of the source thereby allowing domestic wastes to penetrate the aquifer and exposure of the spring box to environmental litter, debris and feces. Results of the February 2019 sampling show that fecal coliform concetrations for GW15-WR-AP and GW3-SS-SPT exceed the guideline values. There were also recorded exceedances in As and BOD concentrations for GW15-WR-AP. GW3-SS-SPT also had exceedances in BOD and phosphate levels. Exceedances show that water discharges from the nearby domestic areas and farmland contribute to the contamination of the springs.
Sources of Threats to Water Quality	• Sources of threats to stream water quality include the untreated domestic discharges, agricultural runoff and alleged quarrying and small-scale mining activities. Agricultural runoff and domestic discharges affect the water quality of the lakes. As for groundwater, the exposure of spring to environmental contaminants affects the water quality of the water supply tapped by the communities.
Climate Change Impacts Without the Project	• The increased rainfall in the coming years can hasten erosion and cause sedimentation of rivers, thus affecting the flow and quality of the waterways. This is also true for lakes and bays. For groundwater sources, higher recharge rate of the aquifer may be experienced due to increased rainfall events, hence influencing groundwater quality.

Stream Water Quality

Primary impact and Secondary Impact Catchments have good aesthetic quality and generally conform to the DAO 2016-08 freshwater guidelines, but with bacterial contamination. Laboratory certificates in 2012, 2015 and 2019 are attached as **Annex 2.2-12** and **Annex 2.2-13**.

Primary Impact Catchments

Hinagasa-an Catchment

Results of the baseline sampling conducted in 2012 in this catchment are presented in **Table 2.2.2-10**.

Table 2.2.2-10 Stream Water Quality Baseline Results (Hinagasa-an Catchment) in 2012 and 2019

Parameter	Unit	February 2019					2012										DAO 2016-08 Class A
		SW13-HA-BMR	SW14-HA-DTOC	SW16-HA-UTOC	SW17-HA-BBR	SW34-HA-PHC	SW11-HA-HAR	SW12-HA-SAR	SW13-HA-BMR	SW14-HA-DTOC	SW15-HA-TAR	SW16-HA-UTOC	SW17-HA-BBR	SW18-HA-DPC	SW34-HA-PHC	SW36-HA-UPC	
		Unnamed river in Brgy. Mabuhay	Downstream of ToogCreek	Upstream of Toog Creek, confluence with its tributaries	Unnamed river in Sitio Busong-busong	Confluence of Piakle and Hinapuyan Creeks	Hinagasa-an River	Unnamed river in Brgy. Anomar,	Unnamed river in Brgy. Mabuhay	Downstream of ToogCreek	Unnamed river in Brgys. Tagbayani	Upstream of Toog Creek, confluence	Unnamed River in Sitio Busong-	Downstream of Piakle Creek	Confluence of Piakle and Hinapuyan	Upstream of Piakle Creek	
Physico-chemical Properties																	
pH		7.88	7.86	7.99	7.61	7.92	8.4	7.0	7.8	8.0	7.9	7.9	7.6	7.9	7.7	6.6	6.5-8.5
Temperature	ºC	28.0	26.7	27.9	28	28.4	30.2	27.1	29.9	30.7	34.4	29.6	32.9	27.3	29.1	24.3	26-30 (a,b)
Dissolved oxygen (DO)	mg/L	7.50	7.13	7.11	7.73	7.10	6.6	8.0	6.2	8.3	8.9	6.2	7.6	7.2	7.0	6.8	minimum of 5.0
Biochemical oxygen demand (BOD)	mg/L	2.79	3.69	9.17	1.59	5.57	2	1	2	1	< 1	2	1	1	1	2	3
Oil and grease (as hydrocarbons)	mg/L	<1.0	<1.0	<1.0	<1.0	<1.0	< 0.40	0.43	< 0.40	0.43	< 0.40	0.41	0.45	< 0.40	< 0.40	0.47	1

Parameter	Unit	February 2019					2012										DAO 2016-08 Class A
		SW13-HA-BMR	SW14-HA-DTOC	SW16-HA-UTOC	SW17-HA-BBR	SW34-HA-PHC	SW11-HA-HAR	SW12-HA-SAR	SW13-HA-BMR	SW14-HA-DTOC	SW15-HA-TAR	SW16-HA-UTOC	SW17-HA-BBR	SW18-HA-DPC	SW34-HA-PHC	SW36-HA-UPC	
		Unnamed river in Brgy. Mabuhay	Downstream of ToogCreek	Upstream of Toog Creek, confluence with its tributaries	Unnamed river in Sitio Busong-busong	Confluence of Piakle and Hinapuyan Creeks	Hinagasa-an River	Unnamed river in Brgy. Anomar,	Unnamed river in Brgy. Mabuhay	Downstream of ToogCreek	Unnamed river in Brgys. Tagbayani	Upstream of Toog Creek, confluence	Unnamed River in Sitio Busong-	Downstream of Piakle Creek	Confluence of Piakle and Hinapuyan	Upstream of Piakle Creek	
Total suspended solids (TSS)	mg/L	29	26	20	39	22	4	18	6	7	8	10	9	6	9	24	50
Electric conductivity	µS /cm	198.1	197.5	180.2	204.3	173	294.1	362.5	241.8	248.3	282.0	253.3	259.6	191.4	222.0	104.1	-
Color, Apparent	PCU	5	5	15	25	15	20	80	20	20	20	20	20	10	20	130	50 (c)
Turbidity	NTU	15.1	12.7	5.15	23.8	7.36	1.8	11	0.8	0.65	2.6	0.75	0.65	0.25	0.85	23	-
Alkalinity, Total	mg/L	78.2	89.7	82.0	75.8	66.6	141	147	118	132	168	139	119	121	135	48	-
Acidity	mg/L	2.1	2.1	2.1	2.6	2.1	6.2	6.2	4.1	4.1	8.3	6.2	6.2	6.2	4.1	24	-
Total Hardness (as $CaCO_3$)	mg/L	41.14	53.90	41.50	38.96	66.65	109	143	96	82	107	107	82	76	98	34	-
Total dissolved solids (TDS)	mg/L	121.6	123.5	111.8	126.1	106.6	192	223	146	158	145	171	186	151	162	70	-
Stream Flow	m^3/s	19.77	1.75	5.39	8.13	3.67	0.92	0.38	1.42	2.41	0.23	0.60	0.87	0.65	0.59	0.23	-
Inorganic Non-metallic Parameters																	

Parameter	Unit	February 2019					2012										DAO 2016-08 Class A
		SW13-HA-BMR	SW14-HA-DTOC	SW16-HA-UTOC	SW17-HA-BBR	SW34-HA-PHC	SW11-HA-HAR	SW12-HA-SAR	SW13-HA-BMR	SW14-HA-DTOC	SW15-HA-TAR	SW16-HA-UTOC	SW17-HA-BBR	SW18-HA-DPC	SW34-HA-PHC	SW36-HA-UPC	
		Unnamed river in Brgy. Mabuhay	Downstream of ToogCreek	Upstream of Toog Creek, confluence with its tributaries	Unnamed river in Sitio Busong-busong	Confluence of Piakle and Hinapuyan Creeks	Hinagasa-an River	Unnamed river in Brgy. Anomar,	Unnamed river in Brgy. Mabuhay	Downstream of ToogCreek	Unnamed river in Brgys. Tagbayani	Upstream of Toog Creek, confluence	Unnamed River in Sitio Busong-	Downstream of Piakle Creek	Confluence of Piakle and Hinapuyan	Upstream of Piakle Creek	
Sulfate	mg/L	6	9	5	10	6	15	9.4	11	11	11	10	9.6	8.1	12	9.9	250
Chloride	mg/L	6.5	6.3	5.3	8.9	5.1	12	25	5.8	6.1	2.9	3.6	8.3	2.4	4.4	1.5	250
Total cyanide (CN)	mg/L	0.07	0.05	0.07	0.07	0.06	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.07 (f)
Dissolved CN	mg/L	0.06	0.05	0.05	0.06	0.06	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	- (f)
Nitrate	mg/L	0.11	0.09	0.07	0.09	0.08	< 0.01	< 0.01	0.02	0.08	0.22	0.09	0.12	0.22	< 0.01	0.10	7 (d)
Phosphate	mg/L	0.10	0.09	0.06	0.09	0.06	0.10	0.08	0.11	0.13	0.08	0.11	0.14	0.14	0.11	0.17	0.5
Ammonia as NH3-N	mg/L	0.03	0.04	<0.03	<0.03	<0.03											0.05
Bacteriological Parameters																	
Total coliform	MPN/100mL	22,000	14,000	160,000	14,000	160,000	1,600	5,400	160,000	3,300	92,000	3,500	4,900	1,600	3,500	92,000	-
Fecal coliform	MPN/100mL	7,900	9,400	28,000	7,000	35,000	32	3,500	92,000	3,300	22,000	2,400	3,300	540	1,300	35,000	<1.1 (b)

Parameter	Unit	February 2019					2012										DAO 2016-08 Class A
		SW13-HA-BMR	SW14-HA-DTOC	SW16-HA-UTOC	SW17-HA-BBR	SW34-HA-PHC	SW11-HA-HAR	SW12-HA-SAR	SW13-HA-BMR	SW14-HA-DTOC	SW15-HA-TAR	SW16-HA-UTOC	SW17-HA-BBR	SW18-HA-DPC	SW34-HA-PHC	SW36-HA-UPC	
		Unnamed river in Brgy. Mabuhay	Downstream of ToogCreek	Upstream of Toog Creek, confluence with its tributaries	Unnamed river in Sitio Busong-busong	Confluence of Piakle and Hinapuyan Creeks	Hinagasa-an River	Unnamed river in Brgy. Anomar,	Unnamed river in Brgy. Mabuhay	Downstream of ToogCreek	Unnamed river in Brgys. Tagbayani	Upstream of Toog Creek, confluence	Unnamed River in Sitio Busong-	Downstream of Piakle Creek	Confluence of Piakle and Hinapuyan	Upstream of Piakle Creek	
Metals and Major Cations																	
Total Metals																	
Aluminum (Al)	mg/L						< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	-
Antimony (Sb)	mg/L						< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-
Arsenic (As)	mg/L	<0.001	<0.001	<0.001	0.080	<0.001	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01
Barium (Ba)	mg/L	<0.20	<0.20	<0.20	<0.20	<0.20	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	0.7
Boron (B)	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004	< 0.30	4.4	0.56	6.7	< 0.30	1.4	< 0.30	< 0.30	< 0.30	< 0.30	0.5
Cadmium (Cd)	mg/L	<0.003	<0.003	<0.003	<0.003	<0.003	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.003
Chromium (Cr)	mg/L						< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	-
Copper (Cu)	mg/L						< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	-
Fluoride (F)	mg/L	0.08	0.07	0.07	0.07	0.07											1

Parameter	Unit	February 2019					2012										DAO 2016-08 Class A
		SW13-HA-BMR	SW14-HA-DTOC	SW16-HA-UTOC	SW17-HA-BBR	SW34-HA-PHC	SW11-HA-HAR	SW12-HA-SAR	SW13-HA-BMR	SW14-HA-DTOC	SW15-HA-TAR	SW16-HA-UTOC	SW17-HA-BBR	SW18-HA-DPC	SW34-HA-PHC	SW36-HA-UPC	
		Unnamed river in Brgy. Mabuhay	Downstream of ToogCreek	Upstream of Toog Creek, confluence with its tributaries	Unnamed river in Sitio Busong-busong	Confluence of Piakle and Hinapuyan Creeks	Hinagasa-an River	Unnamed river in Brgy. Anomar,	Unnamed river in Brgy. Mabuhay	Downstream of ToogCreek	Unnamed river in Brgys. Tagbayani	Upstream of Toog Creek, confluence	Unnamed River in Sitio Busong-	Downstream of Piakle Creek	Confluence of Piakle and Hinapuyan	Upstream of Piakle Creek	
Iron (Fe)	mg/L	1.34	0.69	0.19	1.80	0.28	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	1 (b)
Lead (Pb)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.01
Manganese (Mn)	mg/L	0.043	0.035	0.024	0.071	<0.003	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.2
Magnesium (Mg)	mg/L						14	28	11	7.3	19	12	9.2	7.7	9.7	2.9	-
Mercury (Hg)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.001
Nickel (Ni)	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	0.02
Selenium (Se)	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.01
Zinc (Zn)	mg/L	<0.003	<0.003	<0.003	<0.003	<0.003	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2

Parameter	Unit	February 2019					2012										DAO 2016-08 Class A
		SW13-HA-BMR	SW14-HA-DTOC	SW16-HA-UTOC	SW17-HA-BBR	SW34-HA-PHC	SW11-HA-HAR	SW12-HA-SAR	SW13-HA-BMR	SW14-HA-DTOC	SW15-HA-TAR	SW16-HA-UTOC	SW17-HA-BBR	SW18-HA-DPC	SW34-HA-PHC	SW36-HA-UPC	
		Unnamed river in Brgy. Mabuhay	Downstream of ToogCreek	Upstream of Toog Creek, confluence with its tributaries	Unnamed river in Sitio Busong-busong	Confluence of Piakle and Hinapuyan Creeks	Hinagasa-an River	Unnamed river in Brgy. Anomar,	Unnamed river in Brgy. Mabuhay	Downstream of ToogCreek	Unnamed river in Brgys. Tagbayani	Upstream of Toog Creek, confluence	Unnamed River in Sitio Busong-	Downstream of Piakle Creek	Confluence of Piakle and Hinapuyan	Upstream of Piakle Creek	
Hexavalent chromium (Cr^{+6})	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	0.01
Calcium (Ca)	mg/L						21	10	20	21	11	23	18	18	23	8.8	-
Filtered Metals																	
Al	mg/L						< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	-
Sb	mg/L						< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-
As	mg/L						< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	-
Ba	mg/L						< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	-
B	mg/L						< 0.30	3.5	< 0.30	2.7	< 0.30	1.2	< 0.30	< 0.30	< 0.30	< 0.30	-
Cd	mg/L						< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	-

Parameter	Unit	February 2019					2012										DAO 2016-08 Class A
		SW13-HA-BMR	SW14-HA-DTOC	SW16-HA-UTOC	SW17-HA-BBR	SW34-HA-PHC	SW11-HA-HAR	SW12-HA-SAR	SW13-HA-BMR	SW14-HA-DTOC	SW15-HA-TAR	SW16-HA-UTOC	SW17-HA-BBR	SW18-HA-DPC	SW34-HA-PHC	SW36-HA-UPC	
		Unnamed river in Brgy. Mabuhay	Downstream of ToogCreek	Upstream of Toog Creek, confluence with its tributaries	Unnamed river in Sitio Busong-busong	Confluence of Piakle and Hinapuyan Creeks	Hinagasa-an River	Unnamed river in Brgy. Anomar,	Unnamed river in Brgy. Mabuhay	Downstream of ToogCreek	Unnamed river in Brgys. Tagbayani	Upstream of Toog Creek, confluence	Unnamed River in Sitio Busong-	Downstream of Piakle Creek	Confluence of Piakle and Hinapuyan	Upstream of Piakle Creek	
Cr	mg/L						< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	-
Cu	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.02 (e)
Fe	mg/L						< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	-
Pb	mg/L						< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	-
Mn	mg/L						< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	-
Mg	mg/L						10	25	11	6.8	19	11	6.7	7.2	9.7	2.4	-
Hg	mg/L						< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	
Ni	mg/L						< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	-
Se	mg/L						< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-

Parameter	Unit	February 2019					2012										DAO 2016-08 Class A
		SW13-HA-BMR	SW14-HA-DTOC	SW16-HA-UTOC	SW17-HA-BBR	SW34-HA-PHC	SW11-HA-HAR	SW12-HA-SAR	SW13-HA-BMR	SW14-HA-DTOC	SW15-HA-TAR	SW16-HA-UTOC	SW17-HA-BBR	SW18-HA-DPC	SW34-HA-PHC	SW36-HA-UPC	
		Unnamed river in Brgy. Mabuhay	Downstream of ToogCreek	Upstream of Toog Creek, confluence with its tributaries	Unnamed river in Sitio Busong-busong	Confluence of Piakle and Hinapuyan Creeks	Hinagasa-an River	Unnamed river in Brgy. Anomar,	Unnamed river in Brgy. Mabuhay	Downstream of ToogCreek	Unnamed river in Brgys. Tagbayani	Upstream of Toog Creek, confluence	Unnamed River in Sitio Busong-	Downstream of Piakle Creek	Confluence of Piakle and Hinapuyan	Upstream of Piakle Creek	
Zn	mg/L						< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	-

Note: - No recommended value/ Not included in the parameters analyzed

a The natural background temperature as determined by EMB shall prevail if the temperature is lower or higher than the WQG; provided that the maximum increase is only up to 10 percent and that it will not cause any risk to human health and the environment

b Do not apply if natural background is higher in concentration. The latter will prevail and will be used as baseline.

c Changed unit to TCU from PCU (DAO 1990-34)

d Changed expression to Nitrate as NO_3-N from Nitrate as N (DAO 1990-34)

e Changed expression to Dissolved Copper from Total Copper (DAO 1990-34)

f Changed expression to Free Cyanide from Total Cyanide (DAO 1990-34) and to Dissolved Free Cyanide from Dissolved Cyanide (DAO 1990-34)

The Hinagasa-an River and its tributaries generally conform to the DAO 2016-08 Class A guidelines based on the 2012 water quality data, except for color at Stations SW12-HA-SAR and SW36-HA-UPC (**Table 2.2.2-10**). The farthest upstream station along Piakle Creek (SW36-HA-UPC) differs from the other streams within the catchment, in terms of aesthetic quality and physico-chemical quality (i.e. pH, temperature, conductivity, apparent color, turbidity, TDS, TSS, alkalinity, calcium, magnesium, acidity, and total hardness). Station SW36-HA-UPC is located along the confluence of Piakle Creek and a spring formed between the Maniayao andesite caps. Hence, this station's unique water quality could be due to the geology of the area.

Stations along the Piakle Creek in the 2012 sampling activities which are within (SW18-HA-DPC) and downstream (SW34-HA-PHC and SW16-HA-UTOC) of the proposed Sub-level Cave Mine as well as its tributary creek (SW17-HA-BBR), have above neutral (7.6) to almost basic pH (7.9). Alkaline samples were obtained from the farthest downstream station along the Hinagasa-an River (SW11-HA-HAR) and the downstream section of Toog Creek (SW14-HA-DTOC), with pH levels at 8.4 and 8.0, respectively. The only below neutral pH measurement (6.6) was noted at the headwater of Piakle Creek, upstream of the proposed location of the TSF. The type of rocks consisting the groundwater recharge pathway and channel of the stream, along with the extent of contact of water with the rocks, may have influenced the pH of water at SW36-HA-UPC. SW36-HA-UPC also had the lowest alkalinity and highest acidity which translate to the water's weak capacity to neutralize acid and its constituents' strong attraction to hydroxyl ions, due to low concentrations of carbonates in the creek. The spring (GW2-HS-MM) also registered a pH of 6.5 during the 2012 groundwater sampling. All pH values of the samples from the Hinagasa-an catchment in 2012 are within the DAO 2016-08 Class A recommended range. In the 2019 water sampling activities, the Hinagasa-an Catchment sampling stations generally conform to the DAO 2016-08 water quality guideline values for all parameters except for BOD concentrations in SW14-HA-DTOC (3.69), SW16-HA-UTOC (9.17) and SW34-HA-PHC (5.57).

Extreme values of temperature, conductivity, apparent color, turbidity, TDS, TSS, alkalinity, calcium, magnesium, acidity, and total hardness were noted at SW36-HA-UPC which is situated upstream of the proposed TSF. The high elevation of SW36-HA-UPC influences the cold surface temperature of the creek. The low carbonate systems and the presence of few calcium and magnesium cations affect the softness (0 to 75 mg/L $CaCO_3$) of water at SW36-HA-UPC (34 mg/L $CaCO_3$). This station has the highest turbidity (23 NTU), TSS (24 mg/L) and apparent color (130 PCU) results, and the least concentration of ions as reflected in the conductivity level (104.1 µS/cm). However, all 2012 values describing the aesthetic quality of water are within the DAO 2016-08 Class A guidelines. The morphology of the rocks underlying the headwaters of Piakle Creek affects the physical and chemical properties of water at SW36-HA-UPC which is located north-west of the Boyongan mine prospect.

The sampling stations within the Hinagasa-an Catchment have sufficient supply of oxygen, but have moderate to high bacterial contamination. DO levels in all sampling stations are above the minimum requirement set for Class A waters (5.0 mg/L), with values ranging from 6.22 mg/L to 8.85 mg/L. High DO levels could have been influenced by the continuous aeration of water through turbulent flow along boulder-sized sediments in the upstream stations and laminar flow along beds consisting of alluvial gravel deposits in the downstream stations. Calculated instantaneous stream flows varied from 0.23 m^3/s to 2.41 m^3/s (**Table 2.2.2-10**). The availability of oxygen in the surface waters may also be due to the minimal presence of organic matter, as reflected in the BOD measurements of below detection (<1 mg/L) to 2 mg/L. High total coliform counts were recorded in almost all surface water stations. Hinagasa-an River (SW11-HA-HAR) has the least fecal coliform count (32 MPN/100mL) which is lower than the maximum permissible limit for Class A waters (200 MPN/100mL). Runoff from agricultural lands surrounding the sampling sites, carabaos human excreta, and domestic wastes from residential areas contribute to the pathogens in the streams and creeks within the catchment area. The highest TDS level (223 mg/L) was registered at SW12-HA-SAR, possibly due to agricultural runoff and allegedly-reported small-scale mining activities upstream of the station. Cyanide and toxic metals (both total and dissolved) were below their respective detection limits.

The February 2019 sampling results reveal that the following stations had exceeding fecal coliform concentrations: SW13-HA-BMR (7,900 MPN/100mL), SW14-HA-DTOC (9,400 MPN/100mL), SW16-HA-UTOC (28,000 MPN/100mL), SW17-HA-BBR (7,000 MPN/100mL) and SW34-HA-PHC (35,000 MPN/100mL). Possible coliform sources are runoff from farmlands and domestic discharges from the area. Iron concentrations for SW13-HA-BMR and SW17-HA-BBR exceeded the guideline value having concentrations of 1.34 mg/L and 1.80 mg/L respectively. Arsenic concentration for SW17-HA-BBR (0.080 mg/L also exceeded the guideline value.

Magpayang Catchment

The quality of the stream water resources sampled in Magpayang Catchment is typical of an undisturbed water body. Results of the combined water quality data obtained in 2012, 2015 and 2019 are presented in **Table 2.2.2-11**.

The aesthetic quality of the streams within the Magpayang catchment are relatively good as the physico-chemical parameters conform to the DAO 2016-08 Class A guidelines, except for the pH at Station SW41-CA-UCT. In general, unknown tributary of Timamana Creek (SW41-CA-UCT) located within the vicinity of the proposed underground mine (pH of 6.4) has saturated ions potentially having acidic quality as reflected in the high conductivity level (443.2 µS/cm) and minimal arsenic concentration (0.010 mg/L). The Timamana, Boyongan, Tubod and Magpayang Rivers have slightly basic pH ranging from 7.3 to 8.2 based on the 2012 and 2015 data. The catchment is favorable to aquatic organisms as DO concentrations are above the minimum requirement set by the DAO 2016-08 for Class A water, with the Tubod Creek (SW20-MP-TUC) having the lowest reading. The stream flows ranged from 0.09 m^3/s to 2.08 m^3/s contributing to the sufficient supply of oxygen in water. BOD and TSS concentrations were below detection to minimum, with values below the maximum guideline for Class A. Oil and grease was not detected (<0.40 mg/L and <1.0 mg/L) in any of the stations as levels registered below 1 mg/L. The headwaters of Magpayang catchment near the Sub-level Cave Mine have clear water as low TSS, color and turbidity values were recorded in the Timamana (SW41-CA-UCT, SW39-MP-ULTC and SW19-MP-DLTC) and Boyongan (SW40-MP-UBo and SW38-MP-BC) Creeks and their confluence (SW35-MP-BTC). The clarity deceases as water drains to the main channel of Timamana Creek (SW37-MP-TC) and converges with the Tubod Creek (SW20-MP-TUC) and Magpayang River (SW23-MP-UMPR and SW22-MP-MMPR), but the aesthetic parameters of TSS and apparent color are within the DAO 2016-08 Class A limit. The highest TDS level was noted in the downstream left course of the Timamana Creek (SW19-MP-DLTC) when bridge rehabilitation was ongoing at the time of sampling in 2012. The recorded TDS level in 2012 at SW19-MP-DLTC exceeded the Class A criterion. Inorganic non-metallic parameters were minimal and negligible in concentrations, with chloride, total and dissolved cyanide, and nitrate passing the Class A guideline values.

The presence of total and fecal coliform in the water samples indicate bacterial contamination coming from animal and human wastes as most of the streams are used for primary contact recreation. Total coliform counts in 2012 and 2015 ranged from 1,700 MPN/100mL to 920,000 MPN/100mL, while fecal coliform varied from 1,100 MPN/100mL to 920,000 MPN/100ml, with the least counts both measured from Station SW41-CA-UCT, within the restricted area of the proposed underground mine facility. These results cannot directly be compared with DAO 2016-08 Class B criteria for total and fecal coliforms since the limits refer to the geometric mean of results for consecutive sampling period. Nevertheless, if Class B is used as a reference, all the samples from the stations within the Magpayang Catchment, which are downstream of the Sub-level Cave Mine, exceeded the recommended maximum counts for total and fecal coliform. The stations with the highest counts of total and fecal coliform (SW38-MP-BC, SW20-MP-TUC and SW22-MP-MPR) are those located near a community and where carabaos were observed.

Calcium and magnesium were detected in all samples, which could have been potentially generated by the weathering of rocks. Other total and dissolved metals were below their respective detection limits. At a lower MDL, arsenic was found to be less than 0.01 mg/L at Stations SW41-CA-UCT and SW40-MP-UBO situated along the upstream portions of Timamana and Boyongan Creeks within the underground mine area.

In the February 2019 sampling, there were recorded non-conformances and exceedances for the parameters and stations as follows: pH of SW38-MP-BC (8.72), BOD concentration of SW19-MP-DLTC (8.16 mg/L), SW38-MP-BC (7.97 mg/L), SW35-MP-BTC (9.06 mg/L) and SW37-MP-TC (5.49 mg/L). The TSS level at SW19-MP-DLTC (81 mg/L) exceeded the guideline value. Total Cyanide levels for SW19-MP-DLTC (0.13 mg/L), SW38-MP-BC (0.12 mg/L) and SW35-MP-BTC (0.11 mg/L) exceeded the guideline value. Possible sources cyanide may come from the existing small-scale mining activities which contaminate the Mabuhay River, Toog Creek, Busong-busong River, Piakle and Hinapuyan Creek. Small-scale underclared mining activities within the project site's vicinity is considered as a viable source of cyanide in the surface water bodies. The chemical is used for the efficient extraction of gold metals from its ore.

Table 2.2.2-11 Stream Water Quality Baseline Results (Magpayang Catchment) in 2012, 2015 and 2018

Parameter	Unit	February 2019				May 2015		June to July 2012								DAO 2016-08 Class A
		SW19-MP-DLTC	SW38-MP-BC	SW35-MP-BTC	SW37-MP-TC	SW41-MP-UCT	SW40-MP-UBo	SW39-MP-ULTC	SW19-MP-DLTC	SW38-MP-BC	SW35-MP-BTC	SW37-MP-TC	SW20-MP-TUC	SW23-MP-UMPR	SW22-MP-MMPR	
		Timamana Creek - Downstream of Left Course (DLTC)	Boyongan Creek	Confluence of Boyongan Creek and Timamana	Timamana Creek	Unknown Creek Tributary of Timamana Creek	Upstream of Boyongan Creek	Timamana Creek - Upstream of Left Course	Timamana Creek - Downstream of Left Course (DLTC)	Boyongan Creek	Confluence of Boyongan Creek and Timamana	Timamana Creek	Tubod Creek	Magpayang River – Upper Course (UMPR)	Magpayang River – Middle Course (MMPR)	
Physico-chemical Properties																
pH	(b)	7.85	8.72	7.82	7.65	6.4	7.6	8.1	8.0	7.6	8.2	7.3	7.3	7.7	7.4	6.5-8.5
Temperature	°C	26.2	26.3	26.9	26.9	26.6	25.4	25.0	27.7	27.0	27.2	27.2	26.6	28.8	28.4	26-30 (a)
Dissolved oxygen (DO)	mg/L	7.07	6.60	6.57	6.87	7.11	7.46	8.4	7.9	8.0	9.7	6.2	5.0	6.7	7.2	minimum of 5.0
Biochemical oxygen demand (BOD)	mg/L	8.16	7.97	9.06	5.49	<1	3	1	3	2	1	2	2	3	1	3
Oil and grease (as hydrocarbons)	mg/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.44	0.44	< 0.40	0.42	< 0.40	0.4	0.43	< 0.40	1
Total suspended	mg/L	81	8	17	9	1	1	3	< 2.5	9	< 2.5	13	11	9	13	50

Parameter	Unit	February 2019				May 2015		June to July 2012								DAO 2016-08 Class A
		SW19-MP-DLTC	SW38-MP-BC	SW35-MP-BTC	SW37-MP-TC	SW41-MP-UCT	SW40-MP-UBo	SW39-MP-ULTC	SW19-MP-DLTC	SW38-MP-BC	SW35-MP-BTC	SW37-MP-TC	SW20-MP-TUC	SW23-MP-UMPR	SW22-MP-MMPR	
		Timamana Creek - Downstream of Left Course (DLTC)	Boyongan Creek	Confluence of Boyongan Creek and Timamana	Timamana Creek	Unknown Creek Tributary of Timamana Creek	Upstream of Boyongan Creek	Timamana Creek - Upstream of Left Course	Timamana Creek - Downstream of Left Course (DLTC)	Boyongan Creek	Confluence of Boyongan Creek and Timamana	Timamana Creek	Tubod Creek	Magpayang River – Upper Course (UMPR)	Magpayang River – Middle Course (MMPR)	
solids (TSS)																
Electric conductivity	µS/cm	149.1	351.6	287.5	158.4	443.2	297.8	133.37	222.47	398.20	331.97	145.57	164.37	355.63	480.97	-
Color, Apparent	PCU	50	10	15	10	5	5	< 4	5	10	15	40	25	20	40	50 (b, c)
Turbidity	NTU	8.23	7.82	14.7	5.21	0.5	1.2	0.3	0.5	0.8	3.1	3.1	8.5	6.4	15	-
Alkalinity, Total	mg/L	58.9	164.1	126.4	103.3	100.9	46.1	84	88	225	171	72	81	210	173	-
Acidity	mg/L	2.1	0	0	1.4	100.6	5.3	8.2	3.2	14	3.2	8.2	8.4	6.3	8.4	-
Total Hardness (as $CaCO_3$)	mg/L	55.20	168.20	131.66	99.07	174.76	109.61	50	69	203	148	54	59	142	150	-
Total dissolved solids (TDS)	mg/L	95.65	224.5	180.5	97.5	329	222	85	1,522	281	236	96	102	234	296	-
Stream Flow	m^3/s	0.63	0.38	3.60	1.63	0.14	0.20	0.73	0.28	0.61	0.41	0.35	0.09	-	2.08	-
Inorganic Non-metallic Parameters																

Parameter	Unit	February 2019				May 2015		June to July 2012								DAO 2016-08 Class A
		SW19-MP-DLTC	SW38-MP-BC	SW35-MP-BTC	SW37-MP-TC	SW41-MP-UCT	SW40-MP-UBo	SW39-MP-ULTC	SW19-MP-DLTC	SW38-MP-BC	SW35-MP-BTC	SW37-MP-TC	SW20-MP-TUC	SW23-MP-UMPR	SW22-MP-MMPR	
		Timamana Creek - Downstream of Left Course (DLTC)	Boyongan Creek	Confluence of Boyongan Creek and Timamana	Timamana Creek	Unknown Creek Tributary of Timamana Creek	Upstream of Boyongan Creek	Timamana Creek - Upstream of Left Course	Timamana Creek - Downstream of Left Course (DLTC)	Boyongan Creek	Confluence of Boyongan Creek and Timamana	Timamana Creek	Tubod Creek	Magpayang River – Upper Course (UMPR)	Magpayang River – Middle Course (MMPR)	
Sulfate	mg/L	15	11	20	17	47	54	6	30	14	29	10	13	5	46	250
Chloride	mg/L	5.1	7.2	8.7	6.7	4.8	9.0	2	3	6	6	2	3	3	31	250
Total cyanide (CN)	mg/L	0.13	0.12	0.11	0.11	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.07 (b, f)
Dissolved CN	mg/L	0.09	0.09	0.08	0.08	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	- (f)
Nitrate	mg/L	0.19	0.06	0.05	0.08	<0.01	<0.01	<0.01	<0.01	0.04	0.11	0.04	0.14	0.08	0.11	7 (d)
Phosphate	mg/L	0.11	0.09	0.09	0.09	0.12	0.07	0.18	0.11	0.17	0.09	0.18	0.21	<0.007	005	0.5
Ammonia as NH_3-N	mg/L	<0.03	0.04	0.03	0.14											0.05
Bacteriological Parameters																
Total coliform	MPN/100 mL	160,000	14,000	13,000	7,000	1,700	3,500	3,500	3,500	920,000	35,000	35,000	160,000	3,500	28,000	-
Fecal coliform	MPN/100 mL	22,000	21,000	35,000	17,000	1,100	1,700	2,400	2,400	920,000	4,900	1,100	3,400	2,400	14,000	<1.1 (b)
Metals and Major Cations																
Total Metals																
Aluminum (Al)	mg/L					<0.10	<0.10	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	-

Parameter	Unit	February 2019				May 2015		June to July 2012								DAO 2016-08 Class A
		SW19-MP-DLTC	SW38-MP-BC	SW35-MP-BTC	SW37-MP-TC	SW41-MP-UCT	SW40-MP-UBo	SW39-MP-ULTC	SW19-MP-DLTC	SW38-MP-BC	SW35-MP-BTC	SW37-MP-TC	SW20-MP-TUC	SW23-MP-UMPR	SW22-MP-MMPR	
		Timamana Creek - Downstream of Left Course (DLTC)	Boyongan Creek	Confluence of Boyongan Creek and Timamana	Timamana Creek	Unknown Creek Tributary of Timamana Creek	Upstream of Boyongan Creek	Timamana Creek - Upstream of Left Course	Timamana Creek - Downstream of Left Course (DLTC)	Boyongan Creek	Confluence of Boyongan Creek and Timamana	Timamana Creek	Tubod Creek	Magpayang River – Upper Course (UMPR)	Magpayang River – Middle Course (MMPR)	
Antimony (Sb)	mg/L					<0.002	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
Arsenic (As)	mg/L	0.002	<0.001	<0.001	<0.001	0.010	0.007	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Barium (Ba)	mg/L	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	0.7
Boron (B)	mg/L	<0.004	<0.004	<0.004	<0.004	<0.1	<0.1	0	<0.30	4	<0.30	<0.30	<0.30	<0.30	<0.30	0.5
Cadmium (Cd)	mg/L	<0.003	<0.003	<0.003	<0.003	<0.002	<0.002	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.003
Chromium (Cr)	mg/L					<0.003	<0.003	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	-
Copper (Cu)	mg/L					<0.002	<0.002	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	-
Fluoride (F)	mg/L	0.14	0.12	0.09	0.10											1
Iron (Fe)	mg/L	3.33	0.56	0.90	0.80	<0.02	<0.02	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	1 (b)
Lead (Pb)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.005	<0.005	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.01
Manganese (Mn)	mg/L	0.138	0.052	0.080	0.077	<0.002	<0.002	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.2
Magnesium (Mg)	mg/L					9.26	2.33	5	3	12	9	4	7	1	7	-

Parameter	Unit	February 2019				May 2015		June to July 2012								DAO 2016-08 Class A
		SW19-MP-DLTC	SW38-MP-BC	SW35-MP-BTC	SW37-MP-TC	SW41-MP-UCT	SW40-MP-UBo	SW39-MP-ULTC	SW19-MP-DLTC	SW38-MP-BC	SW35-MP-BTC	SW37-MP-TC	SW20-MP-TUC	SW23-MP-UMPR	SW22-MP-MMPR	
		Timamana Creek - Downstream of Left Course (DLTC)	Boyongan Creek	Confluence of Boyongan Creek and Timamana	Timamana Creek	Unknown Creek Tributary of Timamana Creek	Upstream of Boyongan Creek	Timamana Creek - Upstream of Left Course	Timamana Creek - Downstream of Left Course (DLTC)	Boyongan Creek	Confluence of Boyongan Creek and Timamana	Timamana Creek	Tubod Creek	Magpayang River – Upper Course (UMPR)	Magpayang River – Middle Course (MMPR)	
Mercury (Hg)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.001
Nickel (Ni)	mg/L	<0.02	<0.02	<0.02	<0.02	<0.005	<0.005	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	0.02
Selenium (Se)	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	< 0.001	< 0.001	< 0.001	< 0.001	<0.001	<0.001	< 0.001	< 0.001	0.01
Zinc (Zn)	mg/L	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2
Hexavalent chromium (Cr^{+6})	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.004	<0.004	<0.004	< 0.004	<0.004	< 0.004	<0.004	<0.004	0.01
Calcium (Ca)	mg/L					54.71	40.05	12	23	61	45	15	13	55	49	-
Filtered Metals																
Al	mg/L					<0.10	<0.10	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	-
Sb	mg/L					<0.002	<0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-
As	mg/L					0.009	0.006	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	-
Ba	mg/L					<0.20	<0.20	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	-
B	mg/L					<0.1	<0.1	< 0.30	< 0.30	2	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	-
Cd	mg/L					<0.002	<0.002	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	-
Cr	mg/L					<0.003	<0.003	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	-

Parameter	Unit	February 2019				May 2015		June to July 2012								DAO 2016-08 Class A
		SW19-MP-DLTC	SW38-MP-BC	SW35-MP-BTC	SW37-MP-TC	SW41-MP-UCT	SW40-MP-UBo	SW39-MP-ULTC	SW19-MP-DLTC	SW38-MP-BC	SW35-MP-BTC	SW37-MP-TC	SW20-MP-TUC	SW23-MP-UMPR	SW22-MP-MMPR	
		Timamana Creek - Downstream of Left Course (DLTC)	Boyongan Creek	Confluence of Boyongan Creek and Timamana	Timamana Creek	Unknown Creek Tributary of Timamana Creek	Upstream of Boyongan Creek	Timamana Creek - Upstream of Left Course	Timamana Creek - Downstream of Left Course (DLTC)	Boyongan Creek	Confluence of Boyongan Creek and Timamana	Timamana Creek	Tubod Creek	Magpayang River – Upper Course (UMPR)	Magpayang River – Middle Course (MMPR)	
Cu	mg/L	<0.005	<0.005	<0.005	<0.005	<0.002	<0.002	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.02 (e)
Fe	mg/L					<0.02	<0.02	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	-
Pb	mg/L					<0.005	<0.005	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	-
Mn	mg/L					<0.002	<0.002	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	-
Mg	mg/L					7.30	2.24	3	2	11	3	3	5	1	6	-
Hg	mg/L					<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Ni	mg/L					<0.005	<0.005	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	-
Se	mg/L					<0.0002	<0.0002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
Zn	mg/L					<0.003	<0.003	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	-

Note:
- \- No recommended value/ Not included in the parameters analyzed
- a The natural background temperature as determined by EMB shall prevail if the temperature is lower or higher than the WQG; provided that the maximum increase is only up to 10 percent and that it will not cause any risk to human health and the environment
- b Do not apply if natural background is higher in concentration. The latter will prevail and will be used as baseline.
- c Changed unit to TCU from PCU (DAO 1990-34)
- d Changed expression to Nitrate as NO_3-N from Nitrate as N (DAO 1990-34)
- e Changed expression to Dissolved Copper from Total Copper (DAO 1990-34)

f Changed expression to Free Cyanide from Total Cyanide (DAO 1990-34) and to Dissolved Free Cyanide from Dissolved Cyanide (DAO 1990-34)

Bad-as / Amoslog Catchment

The upstream and downstream sections of Bad-as Creek conform to the DAO 2016-08 criteria for Class B water based on the results of the 2012 sampling, with moderate to high bacterial contamination. The two stations along Bad-as Creek have lower DO levels compared to the streams in other catchments. The low oxygen availability is attributed to the influence of high temperature at the time of sampling and minimal current flow. Because of the wider cross-sectional area of the downstream portion of Bad-as Creek, SW29-BA- DBAC has a higher stream flow compared to the upstream section (SW31-BA-UBAC) (**Table 2.2.2-12**). Debris from stacks of rice hulls along the river banks, agricultural runoff, carabaos bathing, improper disposal of wastes and domestic discharges from residential areas nearby contribute to the elevated total coliform downstream of Bad-as Creek (SW29-BA-DBAC). Station SW29-BA-DBAC is the receptor of effluent and domestic discharges in the Bad-as/Amoslog catchment. Metals were below their respective detection limits, except for calcium and magnesium. Station SW29-BA-DBAC has elevated concentrations of dissolved chemical substances as reflected in the high conductivity, TDS, and chloride levels, indicating the brackish condition of sampling area due to saltwater infiltration from the Sabong Bay.

The Bad-as Creek has poor water quality relative to the results of the streams in other catchments. This is supported by the poor aesthetic quality, low oxygen availability, and elevated coliform counts in the two sampling stations along the creek.

In the February 2019 sampling, results show that SW31-BA-UBAC had non-conformances/exceedances for phyico-chemical parameters and metal concentrations. DO level for the station was recorded to be below the minimum value of 5 mg/L, which shows that there are pollutants in the station introduced consuming/altering the DO. Oil and Grease (3.4 mg/L), TSS (414 mg/L), Color (50 TCU), Total Cyanide (0.13 mg/L), As (0.013 mg/L), Cu (0.049 mg/L), Fe (17.27 mg/L), Mn (0.305 mg/L) and Ni (0.07 mg/L) were recorded to exceed their respective DAO 2016-08 guideline values. The downstream station (SW29-BA-DBAC) also had exceedances for Total Cyanide and Fe concentrations at 0.13 mg/L and 1.44 mg/L respectively.

Table 2.2.2-12 Stream Water Quality Baseline Results (Bad-as/Amoslog Catchment) in 2012 and 2019

Parameter	Unit	February 2019		2012		DAO 2016-08 Class B
		SW31-BA-UBAC	SW29-BA-DBAC	SW31-BA-UBAC	SW29-BA-DBAC	
		Upstream of Bad-as Creek	Downstream of Bad-as Creek (arbitrarily called Amoslog River)	Upstream of Bad-as Creek	Downstream of Bad-as Creek (arbitrarily called Amoslog River)	
		Freshwater	*Brackish water*	*Freshwater*	*Brackish water*	
Physico-chemical Properties						
pH		7.85	7.56	7.8	7.6	6.5-8.5
Temperature	°C	27.6	26.4	31.1	30.9	26-30 (b)
Dissolved oxygen (DO)	mg/L	4.46	5.23	6.8	6.7	minimum of 5.0 (b)
Biochemical oxygen demand (BOD)	mg/L	9.17	6.73	< 1	< 1	5 (b)
Oil and grease (as hydrocarbons)	mg/L	3.4	<1.0	0.44	< 0.40	1.00 (b)
Total suspended solids (TSS)	mg/L	414	23	24	26	65 (b)
Electric conductivity	µS/cm	151.9	204	191.60	3,480	-
Color, Apparent	PCU	250	20	20	20	50 (b,c)
Turbidity	NTU	315	26	3.7	6	-
Alkalinity, Total	mg/L	56.0	98.4	101	133	-
Acidity	mg/L	2.1	1.4	6.1	8.1	-
Total Hardness (as $CaCO_3$)	mg/L	63.27	91.50	62	306	-
Total dissolved solids (TDS)	mg/L	99	129.3	143	1,550	-
Stream Flow	m^3/s	1.51	4.13	0.54	1.08	-
Inorganic Non-metallic Parameters						
Sulfate	mg/L	11	6	11	97	250
Chloride	mg/L	5.8	10.1	3.2	575	250

Parameter	Unit	February 2019		2012		DAO 2016-08 Class B
		SW31-BA-UBAC	SW29-BA-DBAC	SW31-BA-UBAC	SW29-BA-DBAC	
		Upstream of Bad-as Creek	Downstream of Bad-as Creek (arbitrarily called Amoslog River)	Upstream of Bad-as Creek	Downstream of Bad-as Creek (arbitrarily called Amoslog River)	
		Freshwater	*Brackish water*	*Freshwater*	*Brackish water*	
Total cyanide (CN)	mg/L	0.13	0.13	< 0.02	< 0.02	0.07 (b,f)
Dissolved CN	mg/L	0.10	0.09	< 0.02	< 0.02	- (f)
Nitrate	mg/L	0.63	0.03	0.18	0.21	7 (d)
Phosphate	mg/L	<0.01	0.09	0.11	0.11	0.5
Ammonia as NH_3-N	mg/L	<0.03	0.04			0.05
Total coliform	MPN/100mL	220,000	17,000	920	28,000	-
Fecal coliform	MPN/100mL	7,900	2,300	920	9,400	100 (b)
Metals and Major Cations						
Total Metals						
Aluminum (Al)	mg/L			< 0.40	< 0.40	-
Antimony (Sb)	mg/L			< 0.001	< 0.001	-
Arsenic (As)	mg/L	0.013	<0.001	< 0.01	< 0.01	0.01 (b)
Barium (Ba)	mg/L	<0.20	<0.20	< 0.15	< 0.15	0.7
Boron (B)	mg/L	<0.004	<0.004	< 0.30	< 0.30	0.5
Cadmium (Cd)	mg/L	<0.003	<0.003	< 0.01	< 0.01	0.003
Chromium (Cr)	mg/L			< 0.03	< 0.03	-
Copper (Cu)	mg/L			< 0.02	< 0.02	
Fluoride (F)	mg/L	0.10	0.11			1
Iron (Fe)	mg/L	17.27	1.44	< 0.03	< 0.03	1 (b)
Lead (Pb)	mg/L	<0.01	<0.01	< 0.04	< 0.04	0.01
Manganese (Mn)	mg/L	0.305	0.059	< 0.02	< 0.02	0.2 (b)
Magnesium (Mg)	mg/L			5.8	55	-

Parameter	Unit	February 2019		2012		DAO 2016-08 Class B
		SW31-BA-UBAC	SW29-BA-DBAC	SW31-BA-UBAC	SW29-BA-DBAC	
		Upstream of Bad-as Creek	Downstream of Bad-as Creek (arbitrarily called Amoslog River)	Upstream of Bad-as Creek	Downstream of Bad-as Creek (arbitrarily called Amoslog River)	
		Freshwater	*Brackish water*	*Freshwater*	*Brackish water*	
Mercury (Hg)	mg/L	<0.0001	<0.0001	< 0.0001	< 0.0001	0.001
Nickel (Ni)	mg/L	0.07	<0.02	< 0.03	< 0.03	0.04 (b)
Selenium (Se)	mg/L	0.0004	<0.0002	< 0.001	< 0.001	0.01
Zinc (Zn)	mg/L	0.026	<0.003	< 0.02	< 0.02	2
Hexavalent chromium (Cr^{+6})	mg/L	<0.01	<0.01	< 0.004	< 0.004	0.01
Calcium (Ca)	mg/L			15	33	-
Filtered Metals						
Al	mg/L			< 0.40	< 0.40	
Sb	mg/L			< 0.001	< 0.001	
As	mg/L			< 0.01	< 0.01	
Ba	mg/L			< 0.15	< 0.15	
B	mg/L			< 0.30	< 0.30	
Cd	mg/L			< 0.01	< 0.01	
Cr	mg/L			< 0.03	< 0.03	
Cu	mg/L	0.049	<0.005	< 0.02	< 0.02	0.02 (b,e)
Fe	mg/L			< 0.03	< 0.03	
Pb	mg/L			< 0.04	< 0.04	
Mn	mg/L			< 0.02	< 0.02	
Mg	mg/L			5.8	49	
Hg	mg/L			< 0.0001	< 0.0001	
Ni	mg/L			< 0.03	< 0.03	
Se	mg/L			< 0.001	< 0.001	

Parameter	Unit	February 2019		2012		DAO 2016-08 Class B
		SW31-BA-UBAC	SW29-BA-DBAC	SW31-BA-UBAC	SW29-BA-DBAC	
		Upstream of Bad-as Creek	Downstream of Bad-as Creek (arbitrarily called Amoslog River)	Upstream of Bad-as Creek	Downstream of Bad-as Creek (arbitrarily called Amoslog River)	
		Freshwater	*Brackish water*	*Freshwater*	*Brackish water*	
Zn	mg/L			< 0.02	< 0.02	

Note: - No recommended value/ Not included in the parameters analyzed

a The natural background temperature as determined by EMB shall prevail if the temperature is lower or higher than the WQG; provided that the maximum increase is only up to 10 percent and that it will not cause any risk to human health and the environment

b Do not apply if natural background is higher in concentration. The latter will prevail and will be used as baseline.

c Changed unit to TCU from PCU (DAO 1990-34)

d Changed expression to Nitrate as NO_3-N from Nitrate as N (DAO 1990-34)

e Changed expression to Dissolved Copper from Total Copper (DAO 1990-34)

f Changed expression to Free Cyanide from Total Cyanide (DAO 1990-34) and to Dissolved Free Cyanide from Dissolved Cyanide (DAO 1990-34)

Secondary Impact Catchments

Tagana-an Catchment

The 2012 data on physico-chemical properties, inorganic parameters and metals are within the DAO 2016-08 Class B guidelines. Station SW33-TG- BNR has a pH level of 7.9, with high levels of conductivity (2,280 µS/cm), TDS (1,020 mg/L), and chloride (527 mg/L) due to saltwater intrusion. The river channel exits to the Sabong Bay, making it susceptible to water backflow. The river has clear water, as indicated by the low apparent color, turbidity, and TSS values. This unnamed river has a moderate stream flow (0.49 m^3/s) compared to the streams in other catchments (**Table 2.2.2-13**), influencing the circulation of oxygen in water and contributing to the high DO concentration at the station (8.5 mg/L). Nitrate and phosphate were detected at minimum levels. The water is hard (150 mg/L to 300 mg/L CaCO3), indicative of the presence of cations and carbonates. The instantaneous results on total and fecal coliform could not be directly compared with the DAO 2016-08 coastal guidelines for Class B water. If referenced, SW33-TG- BNR slightly exceeds the criterion for fecal coliform. The low coliform counts of the river compared to the streams in other catchment areas could be due to its distance to the residential area. Only few scattered houses could be located within the vicinity of the sampling station. Other parameters pertaining to the aesthetic quality of water meet the Class B guideline values. Total and filterable metals, except for calcium and magnesium, were not detected at the station. Thus, the toxic metals (As, Cd, Cr^{+6}, Pb, Hg) and harmful substance (CN) meet the limits for Class B.

All water quality parameters measured at SW33-TG-BNR passed the specified limit for Class B in the DAO 2016-08 guidelines. The station is characterized by the presence of high dissolved chemical constituents coming from the Canal Bay during the process of saltwater intrusion, with low bacterial contamination.

Table 2.2.2-13   Stream Water Quality Baseline Results (Tagana-an Catchment) in 2012

Parameter/ Station ID	Unit	SW33-TG-BNR Downstream of an unnamed river (brackish water) Brgy. Banban	DAO 2016-08 Class B
Physico-chemical Properties			
pH		7.9	6.5-8.5
Temperature	°C	29.1	26-30 (a)
Dissolved oxygen (DO)	mg/L	8.5	minimum of 5.0
Biochemical oxygen demand (BOD)	mg/L	1	5
Oil and grease (as hydrocarbons)	mg/L	0.48	1.00
Total suspended solids (TSS)	mg/L	13	65
Electric conductivity	µS/cm	2,280.00	-
Color, Apparent	PCU	20	50 (c)
Turbidity	NTU	0.99	-
Alkalinity, Total	mg/L	139	-
Acidity	mg/L	< 0.30	-
Total Hardness (as $CaCO_3$)	mg/L	289	-
Total dissolved solids (TDS)	mg/L	1,020	-
Stream Flow	m^3/s	0.49	-
Inorganic Non-metallic Parameters			

Parameter/ Station ID	Unit	SW33-TG-BNR Downstream of an unnamed river (brackish water) Brgy. Banban	DAO 2016-08 Class B
Sulfate	mg/L	91	250
Chloride	mg/L	527	250
Total cyanide (CN)	mg/L	< 0.02	0.07 (f)
Dissolved CN	mg/L	< 0.02	- (f)
Nitrate	mg/L	0.04	7 (d)
Phosphate	mg/L	0.01	0.5
Bacteriological Parameters			
Total coliform	MPN/100mL	920	-
Fecal coliform	MPN/100mL	240	100 (b)
Metals and Major Cations			
Total			
Aluminum (Al)	mg/L	< 0.40	-
Antimony (Sb)	mg/L	< 0.001	-
Arsenic (As)	mg/L	< 0.01	0.01
Barium (Ba)	mg/L	< 0.15	0.7
Boron (B)	mg/L	< 0.30	0.5
Cadmium (Cd)	mg/L	< 0.01	0.003
Chromium (Cr)	mg/L	< 0.03	-
Copper (Cu)	mg/L	< 0.02	-
Iron (Fe)	mg/L	< 0.03	1
Lead (Pb)	mg/L	< 0.04	0.01
Manganese (Mn)	mg/L	< 0.02	0.2
Magnesium (Mg)	mg/L	38	-
Mercury (Hg)	mg/L	< 0.0001	0.001
Nickel (Ni)	mg/L	< 0.03	0.04
Selenium (Se)	mg/L	< 0.001	0.01
Zinc (Zn)	mg/L	< 0.02	2
Hexavalent chromium (Cr^{+6})	mg/L	< 0.004	0.01
Calcium (Ca)	mg/L	54	-
Filtered			
Al	mg/L	< 0.40	
Sb	mg/L	< 0.001	
As	mg/L	< 0.01	
Ba	mg/L	< 0.15	
B	mg/L	< 0.30	
Cd	mg/L	< 0.01	
Cr	mg/L	< 0.03	
Cu	mg/L	< 0.02	0.02 (e)
Fe	mg/L	< 0.03	
Pb	mg/L	< 0.04	
Mn	mg/L	< 0.02	

Parameter/ Station ID	Unit	SW33-TG-BNR Downstream of an unnamed river (brackish water) Brgy. Banban	DAO 2016-08 Class B
Mg	mg/L	36	
Hg	mg/L	< 0.0001	
Ni	mg/L	< 0.03	
Se	mg/L	< 0.001	
Zn	mg/L	< 0.02	

Note:
- \- No recommended value/ Not included in the parameters analyzed
- a The natural background temperature as determined by EMB shall prevail if the temperature is lower or higher than the WQG; provided that the maximum increase is only up to 10 percent and that it will not cause any risk to human health and the environment
- b Do not apply if natural background is higher in concentration. The latter will prevail and will be used as baseline.
- c Changed unit to TCU from PCU (DAO 1990-34)
- d Changed expression to Nitrate as NO_3-N from Nitrate as N (DAO 1990-34)
- e Changed expression to Dissolved Copper from Total Copper (DAO 1990-34)
- f Changed expression to Free Cyanide from Total Cyanide (DAO 1990-34) and to Dissolved Free Cyanide from Dissolved Cyanide (DAO 1990-34)

Results of the water quality sampling events in 2012 in the secondary impact catchments of Mayag, Pungod, Gata, Mapaso, Angong-ongan, and Campo are presented in **Table 2.2.2-14**.

Table 2.2.2-14 Stream Water Quality Baseline Results (Mayag, Pungod, Gata, Mapaso, Agong-ongan, and Campo Catchments) in 2012

Parameter/ Station ID	Unit	Mayag					Pungod	Gata	Mapaso	Agong-ongan	Campo		DAO 2016-08 Class B
		SW1-MY-UMYR	SW2-MY-DMYR	SW3-MY-UPYR	SW4-MY-DPYR	SW5-MY-MYC	SW6-PU-PUR	SW8-GT-GTR	SW7-MA-MAR	SW10-AO-AOR	SW24-CA-PR	SW25-CA-CAR	
		Upstream of Mayag River	Downstream of Mayag River	Upstream of Payanasa River	Downstream of Payanasa River	Confluence of Mayag River and tributaries	Pungod River	Gata River	Mapaso River	Mouth of Agong-ongan River	Holilon River	Campo River	
Physico-chemical Properties													
pH		7.4	8.6	7.9	7.8	8.1	7.8	8.0	8.5	7.5	8.3	7.9	6.5-8.5
Temperature	°C	27.8	31.8	30.7	32.5	28.5	31.9	28.1	29.8	31.5	31.3	29.1	26-30 (a,b)
Dissolved oxygen (DO)	mg/L	5.0	7.2	7.8	7.1	8.1	7.3	7.5	7.8	6.4	8.6	6.9	minimum of 5.0
Biochemical oxygen demand (BOD)	mg/L	3	1	2	1	1	2	2	1	2	< 1	< 1	5
Oil and grease (as hydrocarbons)	mg/L	0.43	0.41	0.54	< 0.40	< 0.40	0.42	0.41	0.44	0.41	0.50	0.43	1.00
Total suspended solids (TSS)	mg/L	4	4	11	8	4	6	5	5	455	4	17	65 (b)
Electric conductivity	µS/cm	207.40	221.03	178.30	185.00	228.93	223.17	210.50	63.47	220.10	240.10	295.40	-
Color, Apparent	PCU	10	10	20	25	10	40	10	10	1,300	< 4	10	50 (b,c)
Turbidity	NTU	0.3	0.5	0.8	4.1	0.45	2.9	0.35	0.4	75	0.25	0.85	-
Alkalinity, Total	mg/L	124	101	91	101	117	107	125	214	101	132	170	-
Acidity	mg/L	2.1	< 1.0	2.1	4.2	5.3	6.3	8.4	< 1.0	10	< 0.30	8.1	-

Parameter/ Station ID	Unit	Mayag					Pungod	Gata	Mapaso	Agong-ongan	Campo		DAO 2016-08 Class B
		SW1-MY-UMYR	SW2-MY-DMYR	SW3-MY-UPYR	SW4-MY-DPYR	SW5-MY-MYC	SW6-PU-PUR	SW8-GT-GTR	SW7-MA-MAR	SW10-AO-AOR	SW24-CA-PR	SW25-CA-CAR	
		Upstream of Mayag River	Downstream of Mayag River	Upstream of Payanasa River	Downstream of Payanasa River	Confluence of Mayag River and tributaries	Pungod River	Gata River	Mapaso River	Mouth of Agong-ongan River	Hollon River	Campo River	
Total Hardness (as $CaCO_3$)	mg/L	106	86	62	60	104	70	70	201	97	105	139	-
Total dissolved solids (TDS)	mg/L	124	127	118	104	123	144	134	411	131	138	178	-
Stream Flow	m^3/s	0.66	1.13	0.09	0.08	0.70	0.17	0.27	0.39	0.22	0.03	1.70	-
Inorganic Non-metallic Parameters													
Sulfate	mg/L	12	11	< 5.0	< 5.0	10	13	12	50	17	< 5.0	7	250
Chloride	mg/L	4	5	3	3	5	5	3	40	2	2	2	250
Total cyanide (CN)	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.07 (b,f)
Dissolved CN	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	- (f)
Nitrate	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.05	< 0.01	0.01	0.08	0.07	7 (d)
Phosphate	mg/L	3	0.13	0.30	< 0.007	1.4	3.5	< 0.007	0.26	0.08	< 0.007	0.04	0.5
Bacteriological Parameters													
Total coliform	MPN/ 100mL	240	240	1,600	14,000	4,600	54,000	9,200	7,900	5,400	220	920	-
Fecal coliform	MPN/ 100mL	130	240	1,600	7,900	2,100	54,000	470	3,300	2,400	46	130	100 (b)
Metals and Major Cations													
Total													
Aluminum (Al)	mg/L	<0.40	<0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	-
Antimony (Sb)	mg/L	<0.001	<0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-

Parameter/ Station ID	Unit	Mayag					Pungod	Gata	Mapaso	Agong-ongan	Campo		DAO 2016-08 Class B
		SW1-MY-UMYR	SW2-MY-DMYR	SW3-MY-UPYR	SW4-MY-DPYR	SW5-MY-MYC	SW6-PU-PUR	SW8-GT-GTR	SW7-MA-MAR	SW10-AO-AOR	SW24-CA-PR	SW25-CA-CAR	
		Upstream of Mayag River	Downstream of Mayag River	Upstream of Payanasa River	Downstream of Payanasa River	Confluence of Mayag River and tributaries	Pungod River	Gata River	Mapaso River	Mouth of Agong-ongan River	Holilon River	Campo River	
Arsenic (As)	mg/L	<0.01	<0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01 (b)
Barium (Ba)	mg/L	<0.15	<0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	0.7
Boron (B)	mg/L	0	< 0.30	5	< 0.30	< 0.30	4	3	6	< 0.30	< 0.30	< 0.30	0.5
Cadmium (Cd)	mg/L	<0.01	<0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.003
Chromium (Cr)	mg/L	<0.03	<0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	-
Copper (Cu)	mg/L	<0.02	<0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	
Iron (Fe)	mg/L	0	<0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	1
Lead (Pb)	mg/L	<0.04	<0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.01
Manganese (Mn)	mg/L	<0.02	<0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.2
Magnesium (Mg)	mg/L	15	11	7	7	15	7	7	21	15	3	5	-
Mercury (Hg)	mg/L	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.001
Nickel (Ni)	mg/L	<0.03	<0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	0.04
Selenium (Se)	mg/L	<0.001	<0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.01
Zinc (Zn)	mg/L	<0.02	<0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2
Hexavalent chromium (Cr^{+6})	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	0.01
Calcium (Ca)	mg/L	18	16	14	12	17	16	16	46	13	37	48	-
Filtered													
Al	mg/L	<0.40	<0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	-

Parameter/ Station ID	Unit	Mayag					Pungod	Gata	Mapaso	Agong-ongan	Campo		DAO 2016-08 Class B
		SW1-MY-UMYR	SW2-MY-DMYR	SW3-MY-UPYR	SW4-MY-DPYR	SW5-MY-MYC	SW6-PU-PUR	SW8-GT-GTR	SW7-MA-MAR	SW10-AO-AOR	SW24-CA-PR	SW25-CA-CAR	
		Upstream of Mayag River	Downstream of Mayag River	Upstream of Payanasa River	Downstream of Payanasa River	Confluence of Mayag River and tributaries	Pungod River	Gata River	Mapaso River	Mouth of Agong-ongan River	Hollon River	Campo River	
Sb	mg/L	<0.001	<0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-
As	mg/L	<0.01	<0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	-
Ba	mg/L	<0.30	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	-
B	mg/L	< 0.30	< 0.30	1	< 0.30	< 0.30	1	2	5	< 0.30	< 0.30	< 0.30	-
Cd	mg/L	<0.01	<0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	-
Cr	mg/L	<0.03	<0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	-
Cu	mg/L	<0.02	<0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.02 (b,e)
Fe	mg/L	<0.03	<0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	-
Pb	mg/L	<0.04	<0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	-
Mn	mg/L	<0.02	<0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	-
Mg	mg/L	13	11	7	6	14	5	7	20	15	2	3	-
Hg	mg/L	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	<0.0001	-
Ni	mg/L	<0.03	<0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	-
Se	mg/L	<0.001	<0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-
Zn	mg/L	<0.02	<0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	-

Note: - No recommended value/ Not included in the parameters analyzed

a The natural background temperature as determined by EMB shall prevail if the temperature is lower or higher than the WQG; provided that the maximum increase is only up to 10 percent and that it will not cause any risk to human health and the environment

b Do not apply if natural background is higher in concentration. The latter will prevail and will be used as baseline.

c Changed unit to TCU from PCU (DAO 1990-34)

d	Changed expression to Nitrate as NO_3-N from Nitrate as N (DAO 1990-34)
e	Changed expression to Dissolved Copper from Total Copper (DAO 1990-34)
f	Changed expression to Free Cyanide from Total Cyanide (DAO 1990-34) and to Dissolved Free Cyanide from Dissolved Cyanide (DAO 1990-34)

Mayag Catchment

The streams sampled within this catchment in 2012 have almost similar water quality characteristics. The waters of the streams within the catchment are basic based on the 2012 water quality data (**Table 2.2.2-14**). The downstream of Mayag River (SW2-MG-DMGR) has the most basic water with pH of 8.6. This slightly exceeded the pH range (6.5-8.5) set for Class B waters.

Dissolved oxygen levels of the stream waters within the catchment ranged from 5.0 mg/L to 10.2 mg/L. The stream flows of the stations within this catchment varied from 0.08 m^3/s to 1.13 m^3/s.

Total and fecal coliform were found in all samples. Total coliform counts ranged from 240 MPN/100mL to 14,000 MPN/100mL, while fecal colifom counts varied from 130 MPN/100mL to 7,900 MPN/100mL. Stations along Mayag River (SW1-MG-UMGR and SW2-MG-DMGR) had lower total and fecal coliform counts compared to stations along Payanasa River (SW3-MG-UPYR and SW4-MG-DPYR). The area of Mayag Catchment is used mainly for agricultural purposes such as piggeries, poultry and rice farming which are expected to generate coliform bacteria.

SW1-MG-UMGR and SW5-MG-MGC have phosphate levels that slightly exceeded the DAO 2016-08 maximum limit prescribed for Class B waters (0.2 mg/L). Phosphate levels of SW1-MG-UMGR and SW5-MG-MGC are 3.1 mg/L and 1.5 mg/.L, respectively. This could be attributed to agricultural fertilizers and manure since Mayag River and its tributaries stretch along farmland/cultivated land.

Pungod Catchment

The river has water quality commonly found in a rural agricultural area (**Table 2.2.2-14**). All parameters in 2012 meet the Class B criteria, except for coliform and phosphate. Since the area is used mainly for agriculture, elevated levels of total and fecal coliform is expected. Agricultural runoff containing animal excreta and fertilizers could be the potential sources of coliform and phosphate, respectively.

Gata Catchment

The laboratory test results in 2012 indicate that the water quality of this stream is comparable to an unpolluted waterbody. The water is basic with pH 8 (**Table 2.2.2-14**). The dissolved oxygen level (7.5 mg/L) exceeds the minimum requirement (5.0 mg/L) for Class B waters. The river has a stream flow of 0.27 m^3/s.

The measured water quality parameters in 2012 are within the recommended limit for Class B, except for total and fecal coliform. Total and fecal coliform counts were 9,200 MPN/100mL and 470 MPN/100mL, respectively. Potential sources of bacterial contamination are the agricultural runoff, and human and animal excreta. All metals were below their detection limits except for the low concentration of boron. Concentration of boron in stream waters depends on its concentration in the sediments. Stream waters can also receive boron inputs from municipal sewage treatment plants (Green Facts, 2012).[7]

Mapaso Catchment

The igneous source rocks in Mapaso Spring potentially affect the water quality of the downstream portion of Mapaso River. Mapaso River (SW7-MA-MAR) has alkaline waters with a pH of 8.5 based on the 2012 data (**Table 2.2.2-14**). The water quality test results showed that the water is unpolluted and conforms to DAO 2016-08 Class

[7] Green Facts, www.greenfacts.org, accessed on 05 August 2012

B criteria, except for bacteriological parameters. The total and fecal coliform counts measured from Mapaso River were 7,900 MPN/100mL and 3,300MPN/100mL, respectively. The recorded stream flow in this river was 0.39 m^3/s.

All metals were below their respective detection limits, except for boron. Total and dissolved boron were 5.5 mg/L and 5.1 mg/L, respectively. Relatively high boron content found in the samples of Mapaso River could be attributed to the existence of a hot spring upstream of the sampling station. Several studies noted the correlation of high boron content of water to the presence of thermal springs.[8]

Agong-ongan Catchment

The quality of this stream water resource is typical of an undisturbed river. The water quality test results obtained in 2012 indicate that Agog-ongan River (SW10-AO-AR) conform to the water quality criteria set for Class B waters specified in DAO-2016-08, except for fecal coliform (**Table 2.2.2-14**). The total coliform count was 5,400MPN/100mL while the fecal coliform concentration was 2,400 MPN/100mL. The downstream section of Agong-ongan River stretches along farmland/cultivated area which could have been a potential source of colifom bacteria as rainwater washed down soil and plant debris.

The apparent color of this river was relatively high at 1,300 PCU compared to those of other rivers, but no abnormal discoloration from unnatural causes was observed at the time of sampling in 2012. The color of natural waters generally results from leaching of organic debris (Hem, 1985).[9]

The high turbidity level at SW10-AO-AR (75 NTU) at the time of sampling in 2012 could possibly be due to impurities that include clay, silt, finely divided inorganic and organic matter, soluble organic compounds, plankton and other microscopic organisms[10]. The turbid water in the Agong-ongan River is supported by the high TSS concentration (455 mg/L), owing to its valley filled systems morphology (**Table 2.2.2-14**).

Calcium and magnesium were detected in the Agong-ongaan River samples, but at low concentrations. The presence of these alkaline constituents in the stream water is common due to natural weathering of rocks.

The 2012 water quality results in Agong-ongan River conform to all the limits prescribed in the DAO 2016-08 for Class B waters.

Campo Catchment

Based on the 2012 sampling results, Stations SW24-CA-PR and SW25-CA-CAR both conform to the guidelines prescribed for Class B in the DAO 2016-08, with minimal bacterial contamination. The pH levels of both stations are within the normal range of Class B freshwaters (6.5 to 8.5) (**Table 2.2.2-14**). Stations CW24-CAPR (105 mg/L $CaCO_3$) and SW25-CA-CR (139 mg/L $CaCO_3$) have moderately hard[11] water based on the US EPA Quality Criteria for Water. Total alkalinity, total calcium, total and dissolved magnesium were also higher at SW25-CA-CR. TDS values recorded were at 138 mg/L and 178 mg/L, with the higher value registered in the Campo River.

TSS and turbidity both indicate the amount of solids suspended in the water, be it soil particles, organic materials or other particulate matter. TSS values recorded were 4.0 mg/L and 17 mg/L at SW24-CA-PR and SW25-CA-CR, respectively. Turbidity was measured at 0.25 mg/L at SW24-CA-PR and 0.85 mg/L at SW25-CA-CR. Hence, both TSS and turbidity affected the water color of SW25-CA-CR.

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[8] Schofield (1960) attributed the high boron concentration in water in the Waikato district of New Zealand to thermal effects. Koga (1975) observed high boron concentrations in the hot springs of Beppu, Japan - Study and Interpretation of Chemical Characteristics of Natural Water. Third Edition. John D. Hem.1985
[9] Study and Interpretation of Chemical Characteristics of Natural Water. Third Edition. John D. Hem.1985
[10] EPA Guidance Manual Turbidity Provisions, April 1999
[11] Classification of Water by Hardness Content: 75 mg/L to 150 mg/L CaCO3 concentration is moderately hard

Higher DO level was measured at SW24-CA-PR since the stream is riffled-serried while SW25-CA-CR has laminar flow. BOD levels at both stations were less than the detection limit of 1.0 mg/L, indicating the negligible presence of organic matter in water.

Phosphates and sulphates were detected at Station SW25-CA-CR but the values recorded are within typical ranges in freshwater bodies. Runoff from agricultural lands upstream of the sampling station may have contributed to sulphates and phosphates in the Campo River.

Total and fecal coliform were detected at both stations, with SW25-CA-CR having higher counts. All coliform values, however, are still within the Class B criteria.

Results for hexavalent chromium, dissolved and total cyanide, dissolved and total boron and dissolved and total metals were all below detection limit at both stations.

2.2.2.6 Lake Water Quality

Lake Mainit

The physico-chemical properties, bacteriological quality, and chemical constituents of the lake meet the DAO 2016-08 Class A guidelines (**Table 2.2.2-15**).

Table 2.2.2-15 Lake Water Quality Baseline Results, Lake Mainit (2012)

Parameter	Unit	Lake Mainit						DAO 2016-08 Guideline Class A
		LM1	LM2	LM3	LM4	LM5	LM6	
		Near mouth of San Juan River	Near mouth of Magpayang River	In-between mouth of Tigbawan and Agong-ongan	Near mouth of Mapso River	Near mouth of Mayag River	Middle of the lake	
Physico-chemical Properties								
pH		8.5	8.5	8.5	8.5	8.5	8.4	6.5-8.5
Temperature	°C	29.8	29.9	29.6	29.5	29.5	29.3	26-30 (a)
Dissolved oxygen (DO)	mg/L	6.7	6.9	6.9	7.0	6.6	6.7	minimum of 5.0
Biochemical oxygen demand (BOD)	mg/L	1	1	1	1	< 1	1	3
Oil and grease (as hydrocarbons)	mg/L	0.42	< 0.40	0.43	0.42	0.45	< 0.40	1
Total suspended solids (TSS)	mg/L	3	< 2.5	4	3	< 2.5	5	50
Electric conductivity	µS/cm	166.5	167.8	167.5	166.4	166.6	164.2	-
Color, Apparent	PCU	5	5	5	5	5	5	50 (c)
Turbidity	NTU	0.8	1.0	0.8	0.8	0.9	0.5	-
Alkalinity, Total	mg/L	77	78	79	82	79	82	-
Acidity	mg/L	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	-

Parameter	Unit	Lake Mainit						DAO 2016-08 Guideline Class A
		LM1	LM2	LM3	LM4	LM5	LM6	
		Near mouth of San Juan River	Near mouth of Magpayang River	In-between mouth of Tigbawan and Agong-ongan	Near mouth of Mapso River	Near mouth of Mayag River	Middle of the lake	
Total Hardness (as $CaCO_3$)	mg/L	63	67	57	71	65	65	-
Total dissolved solids (TDS)	mg/L	102	100	102	95	96	94	-
Inorganic Non-metallic Parameters								
Sulfate	mg/L	6.1	6.8	6.1	6.2	6.1	6.5	250
Chloride	mg/L	5.40	5.90	5.40	5.40	5.40	5.10	250
Total cyanide (CN)	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.07 (f)
Dissolved CN	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	- (f)
Nitrate	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.04	7 (d)
Phosphate	mg/L	< 0.007	< 0.007	< 0.007	< 0.007	0.01	< 0.007	0.5
Bacteriological Parameters								
Total coliform	MPN/100mL	26	280	17	9.2	9.3	240	
Fecal coliform	MPN/100mL	<1.8	<1.8	<1.8	<1.8	4	4.5	<1.1
Metals and Major Cations								
Total Metals								
Aluminum (Al)	mg/L	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	-
Antimony (Sb)	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-
Arsenic (As)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01
Barium (Ba)	mg/L	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	0.7
Boron (B)	mg/L	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	0.5
Cadmium (Cd)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.003
Chromium (Cr)	mg/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	-
Copper (Cu)	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	-
Iron (Fe)	mg/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	1
Lead (Pb)	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.01
Manganese (Mn)	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.2
Magnesium (Mg)	mg/L	5.3	5.3	4.3	5.8	5.8	5.3	-
Mercury (Hg)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.001
Nickel (Ni)	mg/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	0.02
Selenium (Se)	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.01
Zinc (Zn)	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2
Hexavalent chromium (Cr^{+6})	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	0.01
Calcium (Ca)	mg/L	17	18	16	19	17	17	-

Parameter	Unit	Lake Mainit						DAO 2016-08 Guideline Class A
		LM1	LM2	LM3	LM4	LM5	LM6	
		Near mouth of San Juan River	Near mouth of Magpayang River	In-between mouth of Tigbawan and Agong-ongan	Near mouth of Mapso River	Near mouth of Mayag River	Middle of the lake	
Filtered Metals								
Al	mg/L	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	-
Sb	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-
As	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	-
Ba	mg/L	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	-
B	mg/L	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	-
Cd	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	-
Cr	mg/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	-
Cu	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.02 (e)
Fe	mg/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	-
Pb	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	-
Mn	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	-
Mg	mg/L	4.8	5.1	3.4	5.8	5.3	1.4	-
Hg	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	-
Ni	mg/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	-
Se	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-
Zn	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	-

Note: - No recommended value/ Not included in the parameters analyzed

a The natural background temperature as determined by EMB shall prevail if the temperature is lower or higher than the WQG; provided that the maximum increase is only up to 10 percent and that it will not cause any risk to human health and the environment

b Do not apply if natural background is higher in concentration. The latter will prevail and will be used as baseline.

c Changed unit to TCU from PCU (DAO 1990-34)

d Changed expression to Nitrate as NO_3-N from Nitrate as N (DAO 1990-34)

e Changed expression to Dissolved Copper from Total Copper (DAO 1990-34)

f Changed expression to Free Cyanide from Total Cyanide (DAO 1990-34) and to Dissolved Free Cyanide from Dissolved Cyanide (DAO 1990-34)

Table 2.2.2-16 presents the physico-chemical parameters measured in the baseline study by MSU and the corresponding range of values in the sampling sites established by SMMCI. Site to site comparisons between the three-baseline information could not be made since the locations of the sampling stations of MSU are not available.

Table 2.2.2-16 Physico-chemical parameters measured in Lake Mainit by the MSU and SMMCI baseline studies

Parameters	Range of values in several surface water stations in Lake Mainit (MSU, 2004)	Range of values in the six sampling sites along the upper portion of Lake Mainit (SMMCI, 2012)
Temperature (°C)	29.2°C to 30.6°C *(surface waters)*	29.3°C to 29.9°C
pH	7.9 *(average level, from surface to 5 m)*	8.4 to 8.5
DO (mg/L)	7.31 mg/L to 7.67 mg/L *(surface to 10 m)* 6.0 mg/L to 8.05 mg/L (surface areas)	6.61 mg/L to 7.04 mg/L
Turbidity (NTU)	0.35 NTU to 1.45 NTU (surface waters)	0.50 NTU to 0.95 NTU
Nitrate (mg/L)	0.51 mg/L (average level at the surface)	< 0.01 mg/L to 0.04 mg/L
Phosphate (mg/L)	Below detection limit (average at the surface)	< 0.007 mg/L to 0.01 mg/L

The surface temperatures of the sampling stations, varying from 29.3°C to 29.9°C, are within the range of values (29.2°C to 30.6°C) recorded by the MSU (2004) in their baseline study. The high temperature readings, despite the cloudy weather condition during the time of sampling in 2012, could be associated with the presence of hot springs near the sampling stations. According to the conducted study on January 2004 by MSU, the thermocline layer, where rapid mixing of the upper and lower layers of the lake occurs, is found at a depth of approximately 10 m to 35 m.

Lake Mainit has alkaline water, with pH levels at the established surface water stations reaching the maximum limit of 8.5 for Class A. The values are higher compared to the MSU's (2004) recorded average pH level of 7.9 at the surface down to 5 m depth. It was noted in the MSU's study that the pH level decreases with depth due to the diffusion of carbon dioxide (CO_2), which is a weak acid, and processes of respiration and decomposition of organic matter that settles in the bottom.

The availability of dissolved oxygen is sufficient to sustain aquatic life as the measured levels (6.61 mg/L to 7.04 mg/L) at the sampling stations were above the minimum requirement of 5 mg/L. Higher DO levels (7.31 mg/L to 7.67 mg/L) were recorded by MSU at the upper layer extending to a depth of 10 m, while most surface water areas of the lake had DO levels of 6.0 mg/L to 8.05 mg/L on the January 2004 sampling period.

The apparent color and TSS of the samples both pass the DAO 2016-08 Class A values that are way below the specified limits. All water samples were clear as also reflected in the low turbidity levels recorded at all stations, with values ranging from 0.5 NTU to 0.95 NTU. These turbidity readings are within the range measured by MSU (2004) during a clear day (0.35 NTU to 1.45 NTU). The maximum transparency among the stations established near the river mouths is 86% which translates to water visibility that reaches more than three-fourths of its depth. The clarity of the water allows sufficient sunlight distribution among the lake water strata. This is the same finding in the baseline profiling study for the Boyongan-Copper Project which cited that the sunlight penetrates to an approximate depth of 13 m from the surface.

The mean value of nitrate obtained by MSU at the surface water in year 2004 is 0.51 mg/L, which was attributed to rain-induced surface runoff from agricultural lands surrounding the lake. The mean phosphate concentrations were mostly below the analytical detection limit at the surface water (MSU, 2004). In the baseline study of SMMCI in 2012, nutrient levels including nitrate and phosphate were below detection in almost all lake water stations. This indicates optimum dispersion of inorganic substances as water drains from the inlets (Mayag, Pungod, Mapaso, Gata, Agong-ongan, Tigbawan, Magpayang and San Juan Rivers) to the lake. Nitrate was detected (0.04 mg/L) in the center of the lake (LM6) only, while phosphate was at minimal (0.01 mg/L) near the mouth of Mayag River (LM5). These levels are expected for an oligotrophic lake, maximum of 0.3 mg/L for nitrate and 5 g/L for phosphate (Wetzel, 1983 and Likens, 1985 *as cited* in MSU, 2004). The measured values in this study are within the maximum permissible limits for nitrate (10 mg/L) and phosphate (0.1 mg/L) set by the DAO 2016-08 for lakes.

Untreated domestic sewage and runoff from agricultural fields along the shores pose bacteriological threats to Lake Mainit. However, total and fecal coliform counts at all sampling stations are still within the Class A limit of 1,000 MPN/100mL and 100 MPN/100mL[12], respectively. Total coliform counts ranged from 9.2 MPN/100mL to 280 MPN/100mL, while a range of less than 1.8 MPN/100mL to 4.5 MPN/100mL were reflected for fecal coliform. The coliform counts at all six sampling stations are lower compared to the wide range of values (less than 2 MPN/100mL to 1,600 MPN/100mL) recorded by MSU in the areas of Lake Mainit on 2004. Only minimal treatment, which includes disinfection, is needed for the lake water to pass the requirements for drinking water supply.

MSU considered only three heavy metals that may be potential indicators of pollution coming from mining operations and have significant impact to aquatic survival and human health (**Table 2.2.2-17**). These metals are lead, cadmium, and mercury. In the study conducted by MSU, a concentration of 0.04 mg/L was noted near the municipality of Mainit, which possibly resulted from the navigational activities of local fishermen and passenger boats. The threshold concentration that may cause adverse effects to aquatic organisms is 0.2 mg/L (Wong *et al.*, 1978 as cited in MSU, 2004). Cadmium was detected at minimum levels, ranging from 0.001 mg/L to 0.004 mg/L, in different areas near the shores of Mainit, Magpayang, and Alegria (MSU, 2004). According to the study by MSU, the presence of cadmium in Lake Mainit had come from the river tributaries which receive runoff from surrounding agricultural farmlands that apply pesticides and fertilizers. Mercury was below detection in the three areas of Lake Mainit.

Unlike the results of MSU's water quality study, the sampling conducted by SMMCI in 2012 showed that toxic metals, including lead, cadmium, and mercury were below detection limit This baseline information does not discount the possible presence of metals in water as the method detection limit having 99% confidence interval was used by the laboratory. Therefore, total and dissolved metals may be present at concentrations below the reported method detection limit. The recorded values of metals in the sampling stations within Lake Mainit still meet the DAO 2016-08 Class A requirements.

Table 2.2.2-17 Heavy metal concentrations in the upper portion of Lake Mainit (Surigao del Norte)

Total metals	MSU Baseline Study (2004)			SMMCI Baseline Study (2012)
	Mainit (9.4959 N; 125 E)	Magpayang (9.4691 N; 125 E)	Alegria (9.4406 N; 125 E)	
Cd (mg/L)	0.002	0.004	0.001	< 0.01
Pb (mg/L)	0.04	-	-	< 0.04
Hg (mg/L)	-	-	-	< 0.0001

Note: - below detection concentration
Source: MSU, 2004

[12] Total and fecal coliform limits are based on the geometric mean of coliform count (MPN) during a three-month period (DAO 2016-08 guidelines for Class A waters).

Calcium and magnesium were the only metals detected in the lake samples, but at low concentrations. The low salinity, which can be seen from minimal levels of TDS and dissolved ions such as calcium and magnesium, and low hardness levels (57 mg/L to 71 mg/L) indicate the softness of water in Lake Mainit. Further, the results are also indicative of the minimal runoff and siltation generated from agricultural activities.

The good aesthetic and environmental conditions of Lake Mainit support primary productivity and aquatic life. Thus, the locals depend on the abundance of fish species for food consumption. Results of this study affirm the oligotrophic condition of Lake Mainit due to minimal concentrations of nutrients, high oxygen availability, and clarity of water that supports optimum survival of aquatic life.

Lake Mahukdam

The 2012 results of the water sampling conducted in Lake Mahukdam are summarized in **Table 2.2.2-18**, with the corresponding secondary data provided by SMMCI, and the DAO 2016-08 freshwater guidelines for Class B.

Table 2.2.2-18 Lake Water Quality Baseline Results, Lake Mahukdam (2012 and 2019)

Parameter	Unit	JPPI (February 2019)	SMMCI (June to July 2012)			SMMCI (August 2010 to April 2011)	DAO 2016-08 Class B
		L1	L1	L2	L3	3 Stations	
		Southern end of the lake	Southern end of the lake	Northern end of the lake	Center of the lake	Northern, Southern, and Center of Lake	
Physico-chemical Properties							
pH		8.08	8.3	7.9	8.4	6.6 - 8.13	6.5-8.5
Temperature	°C	29.2	30.3	30.3	30.0	24.3 - 27.5	26-30 (a)
DO	mg/L	6.04	8.4	6.5	9.1	3.3 – 10.8	5 (b)
BOD	mg/L	5.79	3	2	1	1 – 3.8	5
Oil and grease	mg/L	<1.0	< 0.40	< 0.40	< 0.40	*	1
TSS	mg/L	9	15	10	14	4-80	65
Electric conductivity	µS/cm	48.7	72.8	72.6	71.7	40 - 80	-
Color, apparent	PCU	10	30	40	30	*	50 (c)
Turbidity	NTU	2.75	6.6	6.5	5.4	10 - 650	-
Total alkalinity	mg/L	11.6	36	42	39	*	-
Acidity	mg/L	2.1	3.1	5.1	6.1	*	-
Total hardness (as $CaCO_3$)	mg/L	23.40	18	22	22	*	-
TDS	mg/L	29.90	52	48	52	30 - 50	-
Inorganic Non-metallic Parameters							
Sulfate	mg/L	2	< 5.0	< 5.0	< 5.0	*	250
Chloride	mg/L	4.3	1.50	0.98	0.98	*	250
Total cyanide	mg/L	0.07	< 0.02	< 0.02	< 0.02	*	0.07 (f)

Parameter	Unit	JPPI (February 2019)	SMMCI (June to July 2012)			SMMCI (August 2010 to April 2011)	DAO 2016-08 Class B
		L1	L1	L2	L3	3 Stations	
		Southern end of the lake	Southern end of the lake	Northern end of the lake	Center of the lake	Northern, Southern, and Center of Lake	
Dissolved cyanide	mg/L	0.07	< 0.02	< 0.02	< 0.02	*	- (f)
Nitrate	mg/L	<0.01	0.11	0.11	0.01	*	7 (d)
Phosphate	mg/L	0.01	0.03	< 0.007	< 0.007	*	0.5
Ammonia as NH3-N	mg/L	<0.03					0.05
Bacteriological Parameters							
Total coliform	MPN/100mL	12	240	4.5	9,200	*	-
Fecal coliform	MPN/100mL	6.9	33	<1.8	20	*	100
Metals and Major Cations							
Total Metals							
Aluminum (Al	mg/L		< 0.40	< 0.40	< 0.40	*	-
Antimony (Sb)	mg/L		< 0.001	< 0.001	< 0.001	*	-
Arsenic (As)	mg/L	<0.001	< 0.01	< 0.01	< 0.01	*	0.01
Barium (Ba)	mg/L	<0.20	< 0.15	< 0.15	< 0.15	*	0.7
Boron (B)	mg/L	<0.004	< 0.30	< 0.30	< 0.30	*	0.5
Cadmium (Cd)	mg/L	<0.003	< 0.01	< 0.01	< 0.01	*	0.003
Chromium (Cr)	mg/L		< 0.03	< 0.03	< 0.03	*	-
Copper (Cu)	mg/L	<0.005	< 0.02	< 0.02	< 0.02	*	-
Fluoride (F)	mg/L	0.05					1
Iron (Fe)	mg/L	<0.02	< 0.03	< 0.03	< 0.03	*	1
Lead (Pb)	mg/L	<0.01	< 0.04	< 0.04	< 0.04	*	0.01
Manganese (Mn)	mg/L	<0.003	< 0.02	< 0.02	< 0.02	*	0.2
Magnesium (Mg)	mg/L		1.4	2.4	3.4	*	-
Mercury (Hg)	mg/L	<0.0001	< 0.0001	<0.0001	<0.0001	*	0.001
Nickel (Ni)	mg/L	<0.02	< 0.03	< 0.03	< 0.03	*	0.04
Selenium (Se)	mg/L	<0.0002	< 0.001	< 0.001	< 0.001	*	0.01
Zinc (Zn)	mg/L	<0.003	< 0.02	< 0.02	< 0.02	*	2
Hexavalent chromium (Cr^{+6})	mg/L	<0.01	< 0.004	< 0.004	< 0.004	*	0.01
Calcium (Ca)	mg/L		4.7	4.8	3.2	*	-
Filtered Metals							
Al	mg/L		< 0.40	< 0.40	< 0.40	*	-
Sb	mg/L		< 0.001	< 0.001	< 0.001	*	-
As	mg/L		< 0.01	< 0.01	< 0.01	*	-

Parameter	Unit	JPPI (February 2019)	SMMCI (June to July 2012)			SMMCI (August 2010 to April 2011)	DAO 2016-08 Class B
		L1	L1	L2	L3	3 Stations	
		Southern end of the lake	Southern end of the lake	Northern end of the lake	Center of the lake	Northern, Southern, and Center of Lake	
Ba	mg/L		< 0.15	< 0.15	< 0.15	*	-
B	mg/L		< 0.30	< 0.30	< 0.30	*	-
Cd	mg/L		< 0.01	< 0.01	< 0.01	*	-
Cr	mg/L		< 0.03	< 0.03	< 0.03	*	-
Cu	mg/L	<0.005	< 0.02	< 0.02	< 0.02	*	0.02 (e)
Fe	mg/L		< 0.03	< 0.03	< 0.03	*	-
Pb	mg/L		< 0.04	< 0.04	< 0.04	*	-
Mn	mg/L		< 0.02	< 0.02	< 0.02	*	-
Mg	mg/L		1.2	2.4	3.4	*	-
Hg	mg/L		< 0.0001	< 0.0001	<0.0001	*	-
Ni	mg/L		< 0.03	< 0.03	< 0.03	*	-
Se	mg/L		< 0.001	< 0.001	< 0.001	*	-
Zn	mg/L		< 0.02	< 0.02	< 0.02	*	-

Note: - No recommended value/ Not included in the parameters analyzed

a The natural background temperature as determined by EMB shall prevail if the temperature is lower or higher than the WQG; provided that the maximum increase is only up to 10 percent and that it will not cause any risk to human health and the environment

b Do not apply if natural background is higher in concentration. The latter will prevail and will be used as baseline.

c Changed unit to TCU from PCU (DAO 1990-34)

d Changed expression to Nitrate as NO_3-N from Nitrate as N (DAO 1990-34)

e Changed expression to Dissolved Copper from Total Copper (DAO 1990-34)

f Changed expression to Free Cyanide from Total Cyanide (DAO 1990-34) and to Dissolved Free Cyanide from Dissolved Cyanide (DAO 1990-34)

Parameters defining the aesthetic quality of Lake Mahukdam conform to the specific limits in the DAO 2016-08 for Class B waters. Almost all three stations have alkaline waters (7.9 to 8.4). The pH values of L1 and L3 are above the range of levels obtained from the three sections of the lake, but are still within the DAO 2016-08 Class B guidelines. Surface water temperatures measured from three points in the lake ranged from 30.0°C to 30.3°C which are higher compared to the values obtained in separate study by SMMCI (24.3°C to 27.5°C). Concentrations of DO in Lake Mahukdam ranged from 6.5 mg/L to 9.1 mg/L, with the values meeting the minimum requirement of 5 mg/L. These values are also within the range of DO values recorded by SMMCI in the August 2010 to April 2011 sampling. BOD levels in 2012 are within the range of data recorded from August 2010 to April 2011. The range of apparent color levels (30 PCU to 40 PCU) is high as manifested in the greenish color appearance of the lake. This is indicative of algal bloom in the lake. Turbidity and TSS measurements were relatively low. But results of the monitoring activities conducted by SMMCI in the lake show higher turbidity readings ranging from 10 NTU to 650 NTU, while TSS varying from 4 mg/L to 80 mg/L. The sunlight extends to an average depth of1 m below the surface, as reflected in the transparency levels recorded in the aquatic ecology study conducted by SMMCI .

Station L2 located at the northern end of the lake has the least coliform counts among the three stations. The highest total coliform count (9,200 MPN/100mL), which exceeded the total coliform limit for Class B waters, was recorded at Station L3 (center of the lake).

Lake Mahukdam has soft water, as indicated by the minimum concentrations of hardness and soluble ions of the samples. TDS values are comparable with the results of SMMCI. Total and filterable metals, as well as pollutants that pose health risks, were less than their respective detection limits and conformed to the DAO 2016-08 Class B criteria. Only Mg and Ca were detected in the surface waters of Lake Mahukdam, but at minimum concentrations.

Results of the baseline study conducted by SMMCI in 2012 indicate that Lake Mahukdam pass the Class B freshwater guidelines, with low to high coliform counts due to agricultural runoff, as well as human excreta from improper domestic discharge. These are supported by the data trend of the sampling activities held by SMMCI from August 2010 to April 2011.

Results of the February 2019 sampling reveal that there are exceedances in BOD (5.79 mg/L) and Total Cyanide (0.07 mg/L) for station L1, which is at the southern end of the lake and receives contamination from the nearby tributaries. Cyanide contamination may come from the tributaries of Lake Mahukdam which receive discharges from small-scale mining activities.

Lake Guinob-an

Lake Guinob-an has poor aesthetic quality as manifested in the elevated levels of BOD, TSS, conductivity, color, and turbidity in 2015 (Table 2.2.2-19). The swamp or marshland condition of Lake Guinob-an explains the poor baseline status of its water quality. The lake water is slightly acidic (6.4), with the pH level not meeting the minimum pH range limit (6.5). There is sufficient supply of DO in the surface lake water, but the presence of high BOD level which exceeds the Class C limit indicate the presence of organic matter that may lead to oxygen depletion. The lake is characterized by turbid water resulting from agricultural and surface runoff, with suspended solids and saturated ions causing water discoloration. Nutrients are present at minimum concentrations as shown in the low concentrations of nitrate and phosphate which both conform to the DAO 2016-08 Class C limits for lakes and reservoirs. Domestic and agricultural discharges are not prominent in the area as indicated by the low total and fecal coliform counts. Cyanide and toxic metals (i.e. As, Cd, Pb, Hg) were not detected at Station GI. Aluminum, iron, mercury, and calcium were measured at negligible to minimum levels. Except for pH, BOD, and color, other water quality parameters are within the limits for Class C freshwater as specified in the DAO 2016-08.

Table 2.2.2-19 Lake Water Quality Baseline Results, Lake Guinob-an (2015)

Parameter	Unit	Lake Guinob-an GI (SW42)	DAO 2016-08 Guideline Class C
Physico-chemical Properties			
pH		6.4	6.5-9.0
Temperature	°C	37.3	25-31 (a,b)
Dissolved oxygen (DO)	mg/L	6.22	minimum of 5.0
Biochemical oxygen demand (BOD)	mg/L	14	7 (b)

Parameter	Unit	Lake Guinob-an GI (SW42)	DAO 2016-08 Guideline Class C
Oil and grease (as hydrocarbons)	mg/L	1.1	2.00
Total suspended solids (TSS)	mg/L	172	80
Electric conductivity	µS/cm	30,700	-
Color, Apparent	PCU	250	75 (b,c)
Turbidity	NTU	192	-
Alkalinity, Total	mg/L	4.3	-
Acidity	mg/L	12.6	-
Total Hardness (as $CaCO_3$)	mg/L	0.47	-
Total dissolved solids (TDS)	mg/L	76	-
Inorganic Non-metallic Parameters			
Sulfate	mg/L	1	275
Chloride	mg/L	2.8	350
Total cyanide (CN)	mg/L	<0.05	0.10 (f)
Dissolved CN	mg/L	<0.05	-(f)
Nitrate	mg/L	0.59	7 (d)
Phosphate	mg/L	0.06	0.5
Bacteriological Parameters			
Total coliform	MPN/100mL	170	-
Fecal coliform	MPN/100mL	110	200
Metals and Major Cations			
Total Metals			
Aluminum (Al)	mg/L	3.79	-
Antimony (Sb)	mg/L	<0.002	-
Arsenic (As)	mg/L	<0.001	0.02
Barium (Ba)	mg/L	<0.20	3
Boron (B)	mg/L	<0.1	0.75
Cadmium (Cd)	mg/L	<0.002	0.005
Chromium (Cr)	mg/L	<0.003	-
Copper (Cu)	mg/L	<0.002	-
Iron (Fe)	mg/L	0.48	1.5
Lead (Pb)	mg/L	<0.005	0.05
Manganese (Mn)	mg/L	<0.002	0.2
Magnesium (Mg)	mg/L	<0.02	-
Mercury (Hg)	mg/L	0.0005	0.002
Nickel (Ni)	mg/L	<0.005	0.2
Selenium (Se)	mg/L	<0.0002	0.02
Zinc (Zn)	mg/L	<0.003	2
Hexavalent chromium (Cr^{+6})	mg/L	<0.01	0.01
Calcium (Ca)	mg/L	0.19	-
Filtered Metals			
Al	mg/L	0.36	-
Sb	mg/L	<0.002	-
As	mg/L	<0.001	-
Ba	mg/L	<0.20	-

Parameter	Unit	Lake Guinob-an GI (SW42)	DAO 2016-08 Guideline Class C
B	mg/L	<0.1	-
Cd	mg/L	<0.002	-
Cr	mg/L	<0.003	-
Cu	mg/L	<0.002	0.02 (e)
Fe	mg/L	<0.02	-
Pb	mg/L	<0.005	-
Mn	mg/L	<0.002	-
Mg	mg/L	<0.02	-
Hg	mg/L	0.0005	-
Ni	mg/L	<0.005	-
Se	mg/L	<0.0002	-
Zn	mg/L	<0.003	-

Note: - No recommended value/ Not included in the parameters analyzed

a The natural background temperature as determined by EMB shall prevail if the temperature is lower or higher than the WQG; provided that the maximum increase is only up to 10 percent and that it will not cause any risk to human health and the environment

b Do not apply if natural background is higher in concentration. The latter will prevail and will be used as baseline.

c Changed unit to TCU from PCU (DAO 1990-34)

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e Changed expression to Dissolved Copper from Total Copper (DAO 1990-34)

f Changed expression to Free Cyanide from Total Cyanide (DAO 1990-34) and to Dissolved Free Cyanide from Dissolved Cyanide (DAO 1990-34)

2.2.2.7 Groundwater Quality

Table 2.2.2-20 presents the 2012 and 2015 results of the groundwater baseline study, alongside with the PNSDW 2017 limits. The laboratory results are attached as **Annex 2.2-13**.

Table 2.2.2-20 Ground Water Quality Baseline Results for Municipalities of Sison, Tagana-an, Placer, and Tubod (2012, 2015 and 2019)

Parameter	Unit	Placer	Tubod	Sison			Tagana-an	Placer					Tubod								PNS DW 2017
		GW15-WR-AP	GW3-SS-SPT	GW13-PWS-UPS	GW12-FS-LPS	GW10-PWS-MS	GW14-FS-UT	GW15-WR-AP	GW20-FWR-CP	GW11-FWR-IP	GW17-FWS-BP	GW22-BWS-BP	GW18-IBS-TT	GW19-FIB-TT	GW3-SS-SPT	GW5-FS-CT	GW16-FS-GIT	GW23-SB-TT	GW24-PWS-TT	GW25-SB-IT	
		February 2019		2012			2012	2012				2015	2012					2015			
		Water reservoir, Brgy. Anislagan	Intake box of Songkoy spring, Brgy. San	Sison Potable Water System, Brgy. Upper Patag	Faucet connected to a spring, Brgy. Lower Patag	Faucet connected to Mabuhay Potable Water System, Brgy. Mabuhay	Faucet connected to a spring, Brgy Union,	Water reservoir, Brgy. Anislagan	Faucet connected to a water reservoir, Brgy. Sta. Cruz	Faucet connected to a water reservoir, Brgy. San Isidro	Faucet connected to a water reservoir, Brgy. Boyongan	Boyongan Water Supply, Sitio	Intake box of Paragayo spring, Brgy. Timamana	Faucet connected to an intake box, Brgy. Timamana	Intake box of Songkoy spring, Brgy. San Pablo	Faucet connected to the Songkoy spring, Brgy. Casilag	Faucet connected to Itom spring, Sitio Guinob-an, Brgy. San Isidro	Springbox, Brgy. Timamana	Potential Water Source, Brgy.	Springbox, Purok 5, Sitio Guinob-an, Brgy.	
Microbiological Quality																					
Total coliform	MPN/100mL	>23	9.2	5.1	6.9	>23	3.6	<1.1	3.6	<1.1	<1.1	>8.0	>23	16	>23	>23	>23	>8.0	>8.0	>8.0	< 1.1 (b)
Fecal coliform	MPN/100mL	16	9.2	<1.1	<1.1	>23	<1.1	<1.1	<1.1	<1.1	<1.1	>8.0	1.1	3.6	>23	9.2	>23	>8.0	<1.1	<1.1	< 1.1 (b)
Inorganic Chemical Constituents																					
Total Sb	mg/L			< 0.001	< 0.001	< 0.001	< 0.07	< 0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	<0.002	<0.002	<0.002	0.02
Total As	mg/L	0.012	0.005	0.009	0.003	< 0.001	0.002	0.006	0.002	0.005	0.003	0.006	0.004	0.003	0.003	0.003	< 0.001	0.007	0.014	0.012	0.01 (b)
Total Ba	mg/L	<0.20	<0.20	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	<0.20	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	<0.20	<0.20	<0.20	0.7
Total B	mg/L	<0.004	<0.004	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	<0.1	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	<0.1	<0.1	<0.1	0.5
Total Cd	mg/L	<0.003	<0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	<0.002	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	<0.002	<0.002	<0.002	0.003
Total Cr	mg/L			< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	<0.003	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	<0.003	<0.003	<0.003	0.05
Total Cyanide	mg/L	0.15	0.06	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	<0.05	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	<0.05	<0.05	<0.05	0.07 (b,f)
Total F	mg/L	0.13	0.10																		1
Total Pb	mg/L	<0.01	<0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	<0.005	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	<0.005	<0.005	<0.005	0.01
Total Hg	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0007	0.0009	0.001
Total Ni	mg/L	<0.02	<0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	<0.005	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	<0.005	<0.005	<0.005	0.02
Nitrate	mg/L	0.03	<0.01	< 0.008	< 0.008	0.03	0.13	< 0.008	< 0.008	< 0.008	< 0.008	<0.01	1.2	1.1	0.63	< 0.008	0.32	<0.01	0.07	0.17	50
Total Se	mg/L	<0.0002	<0.0002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	<0.0002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	<0.0002	<0.0002	<0.0002	0.01
Physical and Chemical Quality for Acceptability Aspects																					

Parameter	Unit	Placer	Tubod	Sison			Tagana-an	Placer					Tubod								PNS DW 2017
		GW15-WR-AP	GW3-SS-SPT	GW13-PWS-UPS	GW12-FS-LPS	GW10-PWS-MS	GW14-FS-UT	GW15-WR-AP	GW20-FWR-CP	GW11-FWR-IP	GW17-FWS-BP	GW22-BWS-BP	GW18-IBS-TT	GW19-FIB-TT	GW3-SS-SPT	GW5-FS-CT	GW16-FS-GIT	GW23-SB-TT	GW24-PWS-TT	GW25-SB-IT	
		February 2019		2012			2012	2012				2015	2012					2015			
		Water reservoir, Brgy. Anislagan	Intake box of Songkoy spring, Brgy. San	Sison Potable Water System, Brgy. Upper Patag	Faucet connected to a spring, Brgy. Lower Patag	Faucet connected to Mabuhay Potable Water System, Brgy. Mabuhay	Faucet connected to a spring, Brgy Union,	Water reservoir, Brgy. Anislagan	Faucet connected to a water reservoir, Brgy. Sta. Cruz	Faucet connected to a water reservoir, Brgy. San Isidro	Faucet connected to a water reservoir, Brgy. Boyongan	Boyongan Water Supply, Sitio	Intake box of Paragayo spring, Brgy. Timamana	Faucet connected to an intake box, Brgy. Timamana	Intake box of Songkoy spring, Brgy. San Pablo	Faucet connected to the Songkoy spring, Brgy. Casilag	Faucet connected to Itom spring, Sitio Guinob-an, Brgy. San Isidro	Springbox, Brgy. Timamana	Potential Water Source, Brgy.	Springbox, Purok 5, Sitio Guinob-an, Brgy.	
Color, apparent	PCU	5	5	5	5	< 4	< 4	5	< 4	5	< 4	5	5	< 4	< 4	5	5	5	5	5	10 (c)
Turbidity	NTU	0.47	0.16	0.20	0.20	0.30	0.30	0.15	0.20	0.20	0.20	0.4	0.20	0.15	0.25	0.30	0.20	0.3	0.4	0.7	5
Total Al	mg/L			< 0.07	< 0.07	< 0.07	< 0.07	< 0.07	< 0.07	< 0.07	< 0.07	<0.10	< 0.07	< 0.07	< 0.07	< 0.07	< 0.07	<0.10	1.22	0.29	0.2 (b)
Chloride	mg/L	3.9	4.6	4.4	2.9	1.5	3.9	2.9	2.4	2.4	3.4	18.0	5.3	5.3	2.4	2.4	1.2	2.8	6.9	1.4	250.0
Total Cu	mg/L			< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	<0.002	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	<0.002	<0.002	<0.002	1.0
Total hardness (as $CaCO_3$)	mg/L	65.69	43.59	83	88	82	181	79	39	67	91	103.05	103	90	57	61	40	120.37	196.17	37.34	300
Total Fe	mg/L	<0.02	<0.02	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	<0.02	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	<0.02	<0.02	<0.2	1.0
Total Mn	mg/L	<0.003	<0.003	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	<0.002	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	<0.002	<0.002	<0.002	0.2
pH		7.08	6.98	7.2	7.1	8.3	7.6	7.1	6.4	7.1	7.5	6.9	6.8	6.8	7.0	7.2	7.0	7.2	6.2	6.3	6.5-8.5 (b)
Sulfate	mg/L	11	6	10	< 5.0	< 5.0	23	6.2	< 5.0	6.2	18	19	73	37	9.2	8.2	< 5.0	26	89	8	250
TDS	mg/L	120.1	91	187	175	134	244	150	103	151	160	176	184	148	102	116	72	106	353	165	500
Total Zn	mg/L	<0.003	<0.003	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.014	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	<0.003	<0.003	<0.003	2.0
Other Parameters																					
Physico-Chemical Properties																					
Temperature	°C	25.3	26.6	25.4	26.3	28.6	29.1	25.4	28.7	27.9	27.6	25.4	25.9	28.2	25.1	27.1	25.9	24.6	26.4	25.6	26-30
DO min	mg/L	5.04	5.04	6.45	5.08	*	5.73	5.26	5.47	5.11	6.21	5.90	5.42	6.04	5.82	6.42	5.67	6.70	4.96	4.59	
Conductivity	µS/cm	184.1	140.9	137.4	220.4	205.4	423.6	187.9	144.0	192.8	201.4	266.8	251.9	217.6	145.2	152.2	117.3	127.2	489.47	158.0	
BOD	mg/L	1.03	2.32	< 1	< 1	2	< 1	< 1	< 1	< 1	< 1	<1	< 1	2	1	< 1	1	<1	<1	<1	
Oil & grease	mg/L	<1.0	<1.0	< 0.40	< 0.40	0.43	< 0.40	0.43	< 0.40	0.42	< 0.40	<1.0	< 0.40	0.43	< 0.40	< 0.40	< 0.40	<1.0	<1.0	<1.0	1
Total alkalinity	mg/L	79.6	56.0	140	142	101	197	104	71	91	89	77.0	57	59	54	67	64	42.6	116.6	68.4	
Acidity	mg/L	2.8	8.2	43	19	< 0.30	14	19	53	20	9.1	26.9	19	21	12	12	18	15.5	159.2	49.4	
TSS	mg/L	<1	<1	3.0	< 2.5	< 2.5	19	< 2.5	< 2.5	< 2.5	< 2.5	<1	< 2.5	< 2.5	8.0	< 2.5	< 2.5	2	<1	2	
Inorganic Non-metallic Parameters																					

Parameter	Unit	Placer	Tubod	Sison			Tagana-an	Placer					Tubod								PNS DW 2017
		GW15-WR-AP	GW3-SS-SPT	GW13-PWS-UPS	GW12-FS-LPS	GW10-PWS-MS	GW14-FS-UT	GW15-WR-AP	GW20-FWR-CP	GW11-FWR-IP	GW17-FWS-BP	GW22-BWS-BP	GW18-IBS-TT	GW19-FIB-TT	GW3-SS-SPT	GW5-FS-CT	GW16-FS-GIT	GW23-SB-TT	GW24-PWS-TT	GW25-SB-IT	
		February 2019		2012			2012	2012				2015	2012					2015			
		Water reservoir, Brgy. Anislagan	Intake box of Songkoy spring, Brgy. San	Sison Potable Water System, Brgy. Upper Patag	Faucet connected to a spring, Brgy. Lower Patag	Faucet connected to Mabuhay Potable Water System, Brgy. Mabuhay	Faucet connected to a spring, Brgy Union,	Water reservoir, Brgy. Anislagan	Faucet connected to a water reservoir, Brgy. Sta. Cruz	Faucet connected to a water reservoir, Brgy. San Isidro	Faucet connected to a water reservoir, Brgy. Boyongan	Boyongan Water Supply, Sitio	Intake box of Paragayo spring, Brgy. Timamana	Faucet connected to an intake box, Brgy. Timamana	Intake box of Songkoy spring, Brgy. San Pablo	Faucet connected to the Songkoy spring, Brgy. Casilag	Faucet connected to Itom spring, Sitio Guinob-an, Brgy. San Isidro	Springbox, Brgy. Timamana	Potential Water Source, Brgy.	Springbox, Purok 5, Sitio Guinob-an, Brgy.	
Dissolved cyanide	mg/L	0.10	0.06	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	<0.05	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	<0.05	<0.05	<0.05	(f)
Phosphate	mg/L	0.11	0.14	0.17	0.16	0.18	< 0.007	0.15	0.12	0.13	0.17	0.07	0.15	0.17	0.08	0.14	0.05	0.11	0.12	0.14	0.5
Ammonia as NH_3-N	mg/L	<0.03	<0.03																		0.05
Metals and Major Cations																					
Cr^{+6}	mg/L	<0.01	<0.01	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	<0.01	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	<0.01	<0.01	<0.01	0.01
Total Mg	mg/L			3.9	8.2	5.4	13	8.6	3.4	6.2	3.9	6.63	2.0	4.8	2.9	4.8	2.4	10.02	9.33	3.04	
Total Ca	mg/L			27	21	24	51	17	10	17	30	35.20	38	28	18	17	12	31.68	63.17	9.94	
Dissolved Al	mg/L			< 0.07	< 0.07	< 0.07	< 0.07	< 0.07	< 0.07	< 0.07	< 0.07	<0.10	< 0.07	< 0.07	< 0.07	< 0.07	< 0.07	<0.10	<0.10	0.10	
Dissolved Sb	mg/L			< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	<0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	<0.002	<0.002	<0.002	
Dissolved As	mg/L			0.008	0.002	< 0.001	0.002	0.005	0.001	0.005	0.003	0.006	0.004	0.003	0.003	0.003	< 0.001	0.006	0.012	0.011	
Dissolved Ba	mg/L			< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	<0.20	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	<0.20	<0.20	<0.20	
Dissolved B	mg/L			< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	<0.1	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	<0.1	<0.1	<0.1	
Dissolved Cd	mg/L			< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	<0.002	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	<0.002	<0.002	<0.002	
Dissolved Cr	mg/L			< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	<0.003	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	<0.003	<0.003	<0.003	
Dissolved Cu	mg/L	<0.005	<0.005	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	<0.002	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	<0.002	<0.002	<0.002	0.02
Dissolved Fe	mg/L			< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	<0.02	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	<0.02	<0.02	<0.02	
Dissolved Pb	mg/L			< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	<0.005	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	<0.005	<0.005	<0.005	
Dissolved Mn	mg/L			< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	<0.002	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	<0.002	<0.002	<0.002	
Dissolved Mg	mg/L			2.9	7.2	4.4	8.3	8.2	1.9	5.8	3.4	3.68	1.5	3.9	2.9	4.4	1.5	1.05	8.37	2.64	
Dissolved Hg	mg/L			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0007	0.0009	
Dissolved Ni	mg/L			< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	<0.005	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	<0.005	<0.005	<0.005	
Dissolved Se	mg/L			< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	<0.0002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	<0.0002	<0.0002	<0.0002	
Dissolved Zn	mg/L			< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	<0.003	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	<0.003	<0.003	<0.003	

Note: - No recommended value/ Not included in the parameters analyzed b Do not apply if natural background is higher in concentration. The latter will prevail and will be used as baseline.

c Changed unit to TCU from PCU (DAO 1990-34)

d Changed expression to Nitrate as NO_3-N from Nitrate as N (DAO 1990-34)

e Changed expression to Dissolved Copper from Total Copper (DAO 1990-34)

f Changed expression to Free Cyanide from Total Cyanide (DAO 1990-34) and to Dissolved Free Cyanide from Dissolved Cyanide (DAO 1990-34)

Municipality of Sison

Groundwater stations conformed to the PNSDW 2017 limits for physical and chemical parameters, with minimal to moderate bacterial contamination (**Table 2.2.2-20**). The water sample from GW10-PWS-MS is alkaline (8.3), while near-neutral waters were obtained from GW12-FS-LPS (7.1) and GW13-PWS-UPS (7.2). All stations have clear water that passed the criteria for apparent color, turbidity, and TSS levels. Concentrations of dissolved inorganic ions were below the threshold for drinking water, as also manifested by the TDS and conductivity values. Organic matter was not detected in the samples from GW12-FS-LPS and GW13-PWS-UPS, but was present at low concentration (2 mg/L) at GW10-PWS-MS. The springs have low nutrient content (nitrate and phosphate) and moderate hardness (75 mg/L to 150 mg/L $CaCO_3$) based on the US EPA (2007) guideline. The moderate hardness of water is associated with low concentrations of calcium, magnesium and other soluble ions. Arsenic was detected in the samples collected from GW12-FS-LPS) and GW13-PWS-UPS, but with values not exceeding the prescribed criterion for drinking water. Other metals were below their respective detection limits, thus meeting the PNSDW 2017 criteria. Fecal coliform was not detected (<1.1 MPN/100mL) at GW12-FS-LPS and GW13-PWS-UPS, but total coliform of 6.9 MPN/100mL and 5.1 MPN/100mL, respectively, were recorded at both stations. The highest total and fecal coliform counts were recorded in the water sample from GW10-PWS-MS. Pathogens may be due to exposure of springs to animal excreta from agricultural runoff and from lack of maintained sewage facilities in the municipality.

The good aesthetic quality and acceptable concentrations of chemical constituents indicate minimal occurrence of runoff in these natural spring sources. However, a treatment process that would completely eliminate pathogens prior to water distribution to the municipal households is necessary.

Municipality of Tagana-an

Water quality parameters are within their corresponding limits in the PNSDW 2017, except for total coliform (**Table 2.2.2-20**). Total coliform at GW14-FS-UT exceeded the PNSDW 2017 maximum allowable limit of less than 1.1 MPN/100mL, while fecal coliform was not detected (<1.1 MPN/100mL) in the samples. The aesthetic parameters are well within the acceptable range for drinking water. Apparent color is below detection (<4 PCU). Concentration of soluble ions coming from weathered rocks and other natural sources is far below the WHO (2006) threshold level for TDS (1,000 mg/L). High concentration of soluble ions can make the water unpalatable. TDS and chloride levels pass the limits specified in the PNSDW 2017. Station GW14-FS-UT has hard water (150 mg/L to 300 mg/L $CaCO_3$) due to the presence of divalent cations (calcium and magnesium). Toxic and deleterious substances, including metals and cyanide (both total and dissolved), were not detected in the groundwater source. Other chemical constituents of the spring water are within the standard range specified in the PNSDW 2017.

Municipality of Placer

The pH levels of the groundwater sampled within the municipality ranged from 6.4 to 7.5 (**Table 2.2.2-20**). Although the standard range for drinking water is 6.5-8.5, the acceptable range may be broader in the absence of a distribution system (PNSDW 2017). The slight deviation from the pH range standard, particularly of the sample obtained from GW20-FWR-CP (6.4) is not of high concern. The pH has no adverse impact on consumers, hence no health-based guideline value was prescribed for this parameter in the WHO drinking guidelines (2006). However, pH is an operational water quality parameter which is an important gauge to ensure the effectiveness of the water clarification and disinfection processes of a water treatment facility (WHO, 2006).

Metal concentrations were below detection limit, except for total and filterable arsenic. Arsenic levels measured from the groundwater samples within Placer ranged from 0.001 mg/L to 0.006 mg/L which are below the maximum concentration of 0.01 mg/L specified in the PNSDW 2017. Arsenic can be considered naturally-occurring in the groundwater although at very low concentration.

Total and fecal coliform counts were below the detection limit (<1.1 MPN/100mL), except at GW20-FWR-CP and GW22-BWS-BP. The total coliform count at GW20-FWR-CP and both total and fecal coliform counts at GW22-BWS-BP exceeded the standard value[13] of less than 1.1 MPN/100mL specified in the PNSDW 2017. One possible source of total coliform in groundwater is agricultural runoff, considering that a large portion of the municipality (75%) is devoted to agriculture. The exposure of the spring box to environmental litter, debris and feces could have contaminated the water at GW22-BWS-BP.

Water samples from the water reservoir in the Placer Water District vicinity in Brgy. Anislagan were collected by SMMCI for water quality testing from August 2010 to June 2011. A total of fourteen sampling activities were conducted for this period. The water samples were analysed for pH, conductivity, turbidity, temperature, DO, BOD and TDS. The results of the physical and chemical analyses of the water samples are presented in **Annex 2.2-16**. **Table 2.2.2-21** presents the results of the one-time sampling conducted by SMMCI in 2012 (GW15-WR-AP) and the range of values recorded by SMMCI from 2010 to 2011 for comparison.

Results of the February 2019 sampling show that fecal coliform concetrations for GW15-WR-AP had exceedances in As (0.012 mg/L) and BOD (1.03 mg/L) concentrations.

Table 2.2.2-21 Results of SMMCI Baseline Studies for the Placer Water District Water Reservoir

Parameters	GW15-WR-AP (Intake box) JPPI (Feb 2019)	GW15-WR-AP (Intake box) (2012)[a]	Water Reservoir (vicinity of Placer Water District) SMMCI (2010 to 2011)[b]
pH	7.08	7.1	6.12 - 7.8
Conductivity (µS/cm)	184.1	187.9	166 – 240
Turbidity (NTU)	0.47	0.15	1 – 11
Temperature (°C)	25.3	25.4	20.4 - 27.9
DO (mg/L)	5.04	5.26	7.1 – 9.0
BOD (mg/L)		<1	0.2 – 1
TDS (mg/L)	120.1	150	110 – 150

Notes: a – One time sampling only between June and July 2012
b – Range of values for the 14 sampling activities held from August 2010 to June 2011

The levels of pH, conductivity, temperature, and TDS noted at GW15-WR-AP are within the baseline data collected by SMMCI. The water from the reservoir was generally neutral throughout the monitoring of SMMCI with recorded values ranging from 6.12 to 7.8. Three out of the fourteen readings were slightly below the pH range (6.5 – 8.5) prescribed in the PNSDW 2017. Temperature readings in the baseline data of SMMCI ranged from 20.4°C to 27.9°C, with the lowest temperature recorded on February 2011. The electrical conductivity of water samples from the reservoir were recorded to be within the values of 166 µS/cm to 0.24 µS/cm, while total dissolved solids concentrations varied from 110 mg/L to 150 mg/L which were well within the 500 mg/L PNSDW 2017 standard value for TDS.

13 Should be validated and approved by Department of Health (PNSDW 2017)

Turbidity and DO readings at GW15-WR-AP are lower compared to the range of values noted during the August 2010 to June 2011 sampling activities of SMMCI. Three turbidity readings recorded by SMMCI were above the PNSDW 2017 maximum level (5 NTU) for turbidity. The baseline study of SMMCI showed BOD concentrations ranging from 0.2 mg/L to 1 mg/L in the water reservoir.

The water quality of all groundwater samples collected from Placer meets the PNSDW 2017 limits for physical and chemical quality in terms of apparent color, turbidity, TDS, hardness, chloride, and sulfate.

Municipality of Tubod

Concentrations of water quality parameters are within their corresponding limits in the PNSDW 2017, except for total and fecal coliform, aluminum, pH and arsenic (**Table 2.2.2-20**). Springs in Tubod passed the standard values for inorganic chemical constituents with health significance (Sb, As, Ba, B, Cd, Cr, CN, Pb, Hg, Ni, NO_3 and Se), except for GW24-PWS-TT and GW25-SB-IT. Parameters pertaining to physical and chemical quality for acceptability of drinking water are below their corresponding maximum standard values. The pH levels of spring water collected from GW24-PWS-TT (6.2) and GW25-SB-IT (6.3) did not meet the minimum requirement of 6.5 in drinking water. Others are within the acceptable pH range, with values ranging from 6.8 to 7.2. The mineralized rocks within the area of Stations GW24-PWS-TT and GW25-SB-IT generate metals (i.e. As, Al) and dissolved substances that potentially contribute to the acidity of the springs within the vicinity of the underground mine facility. All sampled groundwater sources in Tubod are contaminated with total coliform which comes from the sampling stations' exposure to environmental contaminants such as plant litter and debris as most are springboxes. Only the fecal coliform counts at GW24-PWS-TT and GW25-SB-IT meet the PNSDW 2017 limit. Both Stations GW24-PWS-TT and GW25-SB-IT are located within the restricted area of the mine site, therefore preventing the residents from contaminating these springs.

The spring water samples from GW3-SS-SPT, GW5-FS-CT, GW16-FS-GIT and GW25-SB-IT are considered soft, with hardness levels ranging from 37.34 mg/L $CaCO_3$ to 57 mg/L $CaCO_3$. The water sample collected from GW18-IBS-TT, GW19-FIB-TT and GW23-SB-TT are moderately hard at 90 mg/L and 120.37 mg/L $CaCO_3$. Station GW24-PWS-TT has hard water, with level at 196.17 mg/L $CaCO_3$. Water hardness is attributable to the dissolution of limestone during percolation of rainwater.

GW3-SS-SPT also had exceedances in BOD (2.32 mg/L) and phosphate (0.14 mg/L) levels in the February 2019 sampling. Exceedances show that water discharges from the nearby domestic areas and farmland contribute to the contamination of the springs.

Municipality of Mainit

Spring water samples collected from GW1-SPS-CM and GW21-IBS-SM both passed the standard values set in the PNSDW 2017 for physico-chemical parameters except pH. GW21-IBS-SM had slightly acidic water with a pH of 6.4. The samples from both stations also passed the PNSDW 2017 limits for inorganic chemicals with health significance. However, both samples were positive for bacterial contamination, with total coliform count exceeding the acceptable limit of <1.1 MPN/100ml. The sample collected from GW21-IBS-SM exceeded the acceptable limit. Springs are susceptible to contamination from agricultural run-offs, decaying plants, and soils, which account for the presence of bacteria.

GW2-HS-MM (Mapaso hot spring) has a temperature of 39.5 °C at the time of sampling. The high temperature of the spring water is attributable to heat retention by the igneous rocks underneath to which the water comes in contact with hot spring. The water is slightly acidic at pH 6.5 but still within the DAO 2016-08 standard range (6.5 to 8.8) for Class B waters. The spring water had an elevated TDS level (2,100 mg/L) which is common in groundwater due to its contact with various rocks and sediment and to the water's capability to remobilize sediments and weather minerals. The apparent color was high at 75 NTU which can be attributed to presence of iron, sulfur and suspended matter. Expectedly, the water from this station is very hard (greater than 300 mg/L $CaCO_3$). High level of water hardness is attributable to elevated levels of magnesium, calcium, chlorides and iron. GW2-HS-MM has a high arsenic concentration at 0.18 mg/L. Presence of arsenic could be due to weathering of intermediate igneous rocks and alteration of igneous minor rocks from the hot spring source. The detected levels of arsenic and boron are higher compared to the maximum permissible limits set by PNSDW 2017 for drinking water. The hot spring is used mainly for recreational purposes, hence exposure through skin contact may not pose health implications. However, there is a possibility for ingestion.

Table 2.2.2-22 Ground Water Quality Baseline Results for the Municipality of Mainit (2012)

Parameter	Unit	GW21-IBS-SM	GW1-SPS-CM	PNSDW 2017	GW2-HS-MM	DAO 2016-08 Class B
		Water from an intake box, Brgy. Silop	Stand pipe connected to a spring, Brgy. Cantugas		Hot spring, Brgy. Mapaso	
Microbiological Quality						
Total coliform	MPN/100mL	>23	12	< 1.1 (b)	>23	
Fecal coliform	MPN/100mL	>23	<1.1	< 1.1 (b)	1.1	100
Inorganic Chemical Constituents						
Total Sb	mg/L	< 0.001	< 0.001	0.02	< 0.001	-
Total As	mg/L	< 0.001	< 0.001	0.01	0.18	0.01
Total Ba	mg/L	< 0.15	< 0.15	0.7	< 0.15	0.7
Total B	mg/L	< 0.20	< 0.20	0.5	3.9	0.5
Total Cd	mg/L	< 0.003	< 0.003	0.003	< 0.003	0.003
Total Cr	mg/L	< 0.03	< 0.03	0.05	< 0.03	-
Total cyanide	mg/L	< 0.02	< 0.02	0.07 (f)	< 0.02	0.07 (f)
Total Pb	mg/L	< 0.01	< 0.01	0.01	< 0.01	0.01
Total Hg	mg/L	<0.0001	<0.0001	0.001	<0.0001	0.001
Total Ni	mg/L	< 0.01	< 0.01	0.02	< 0.01	0.04
Nitrate	mg/L	0.58	0.63	50	< 0.008	7 (d)
Total Se	mg/L	< 0.001	< 0.001	0.01	< 0.001	0.01
Physical and Chemical Quality for Acceptability Aspects						
Color, apparent	PCU	< 4	5	10	75	50 (c)
Turbidity	NTU	0.20	0.20	5	23	-
Total Al	mg/L	< 0.07	< 0.07	0.2	< 0.07	-
Chloride	mg/L	1.5	2.7	250.0	298	250
Total Cu	mg/L	< 0.02	< 0.02	1.0	< 0.02	-
Total Hardness (as $CaCO_3$)	mg/L	46	118	300	1,240	-
Total Fe	mg/L	< 0.03	< 0.03	1.0	0.15	1
Total Mn	mg/L	< 0.02	< 0.02	0.4	< 0.02	0.2

Parameter	Unit	GW21-IBS-SM Water from an intake box, Brgy. Silop	GW1-SPS-CM Stand pipe connected to a spring, Brgy. Cantugas	PNSDW 2017	GW2-HS-MM Hot spring, Brgy. Mapaso	DAO 2016-08 Class B
pH		6.4	7.8	6.5 - 8.5 (b)	6.5	6.5 – 8.5
Sulfate	mg/L	< 5.0	9.8	250	269	250
TDS	mg/L	90	164	500	2,100	-
Total Zn	mg/L	< 0.02	< 0.02	5.0	< 0.02	2
Other Parameters						
Physico-Chemical Properties						
Temperature	°C	24.4	27.8	26-30 (a)	39.5	26-30 (a)
DO	mg/L	5.68	5.66	-	2.58	5.0 min
Conductivity	µS/cm	122.8	269.1	-	3,795.3	-
BOD	mg/L	4	1	-	1	5
Oil & Grease	mg/L	< 0.40	0.52	1	0.53	1
Total alkalinity	mg/L	73	143	-	1020	-
Acidity	mg/L	42	5.3	-	111	-
TSS	mg/L	< 2.5	< 2.5	-	13	-
Inorganic Non-metallic Parameters						
Dissolved cyanide	mg/L	< 0.02	< 0.02	- (f)	< 0.02	-
Phosphate	mg/L	0.13	< 0.007	0.5	< 0.007	0.2
Metals and Major Cations						
Cr^{+6}	mg/L	< 0.004	< 0.004	0.01	< 0.004	0.01
Total Mg	mg/L	4.8	12	-	151	-
Total Ca	mg/L	10	28	-	247	-
Dissolved Al	mg/L	< 0.07	< 0.07	-	< 0.07	-
Dissolved Sb	mg/L	< 0.001	< 0.001	-	< 0.001	-
Dissolved As	mg/L	< 0.001	< 0.001	-	0.04	-
Dissolved Ba	mg/L	< 0.15	< 0.15	-	< 0.15	-
Dissolved B	mg/L	< 0.20	< 0.20	-	3.9	-
Dissolved Cd	mg/L	< 0.003	< 0.003	-	< 0.003	-
Dissolved Cr	mg/L	< 0.03	< 0.03	-	< 0.03	-
Dissolved Cu	mg/L	< 0.02	< 0.02	0.02	< 0.02	0.02 (e)
Dissolved Fe	mg/L	< 0.03	< 0.03	-	< 0.03	-
Dissolved Pb	mg/L	< 0.01	< 0.01	-	< 0.01	-
Dissolved Mn	mg/L	< 0.02	< 0.02	-	< 0.02	-
Dissolved Mg	mg/L	4.8	11	-	143	-
Dissolved Hg	mg/L	<0.0001	<0.0001	-	<0.0001	-
Dissolved Ni	mg/L	< 0.01	< 0.01	-	< 0.01	-
Dissolved Se	mg/L	< 0.001	< 0.001	-	< 0.001	-

Parameter	Unit	GW21-IBS-SM	GW1-SPS-CM	PNSDW 2017	GW2-HS-MM	DAO 2016-08 Class B
		Water from an intake box, Brgy. Silop	Stand pipe connected to a spring, Brgy. Cantugas		Hot spring, Brgy. Mapaso	
Dissolved Zn	mg/L	< 0.02	< 0.02	-	< 0.02	-

Notes:
- \- No recommended limit
- < Less than the MDL
- a Refer to the geometric mean of the most probable number (MPN) of coliform during a 3-month period and that the limit shall not be exceeded in 20% of the samples taken during the same period
- b Do not apply if natural background is higher in concentration. The latter will prevail and will be used as baseline
- c No abnormal discoloration from unnatural causes
- d Not more than 3°C maximum rise
- e Not more than 30% increase

Values highlighted with red means exceeded the PNSDW 2017 limit

2.2.2.8 Sources of Threats to Water Quality

Sources of threats to surface water quality in all catchments include the untreated domestic discharges and agricultural runoff. According to the residents, there are quarrying and small-scale mining activities in the Hinagasa-an catchment. Erosion in the highlands could also affect the aesthetic quality of water within the Magpayang catchment. Road repairs and other improvement projects also contribute to water contaminants downstream of the Tagana-an catchment. Improper disposal of wastes clog and alter the water quality of the Bad-as/Amoslog Creek, specifically in the downstream section. Agricultural runoff and domestic discharges also affect the water quality of the lakes. The most common sources of contaminant include domestic waste water discharges, primary economic activities such as agriculture, aquaculture, and industrial activities like mining and quarrying. As for groundwater, the exposure of spring to environmental contaminants affects the water quality of the water supply tapped by the communities. All these threats contribute to the degradation of water quality.

2.2.2.9 Climate Change Impacts Without the Project

The increased rainfall in the coming years can hasten erosion and cause sedimentation of rivers. Suspended solids introduced in the water bodies during extreme rainfall events could affect the aesthetic quality of water and eventually change the chemical content of the streams. Metals may be adsorbed to the surface of suspended solids and be washed down into the streams, thus affecting the pH levels. Turbid water may reduce light penetration, thus impacting other water quality parameters such as dissolved oxygen and flow of water. Same scenario could also occur in the lakes and bays. For groundwater source, faster recharge rate or recuperation of the aquifer may be experienced due to increased rainfall events, thus affecting groundwater quality. Thus, the targeted construction period of the mine facilities should fall under the dry season to eliminate or at least lesten the chances of having too much rainfall, allowing runoff carrying sediments to contaminate the nearby water bodies.

2.2.2.10 Potential Impacts and Options for Prevention or Mitigation or Enhancements for Water Quality

2.2.2.10.1 Summary

Table 2.2.2-23 summarizes the potential impacts of the Project to the surrounding water bodies within and outside the Project Site, with the corresponding prevention or mitigation or enhancement measures.

Table 2.2.2-23 Potential Impacts and Options for Prevention or Mitigation or Enhancement – Water Quality

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
Degradation of surface water quality					
• The preparation, earthmoving activities, stockpiling, and maintenance of the mine area and facilities may release soil, sediments, rocks, minerals and windblown debris which may affect the water quality of the streams and creeks within the Hinagasaan, Magpayang and Bad-as/Amoslog straddled by the mine footprint. The construction activities may also affect the stream water depth, volume and flow.		✓	✓		• Sediment and erosion control measures which include: - River bank and slope stabilization strategies in affected waterways - Establishment of silt traps, settling ponds and other sediment control measures across waterways or gullies - Rehabilitation of exposed area (i.e. planting of erosion-control crops) • Stockpiles will be placed away from the water courses and protected against natural elements to prevent the transport of soil and sediment. • Drainage canals that will direct runoff to silt traps and settling ponds will be built around the stockpile to prevent sedimentation of nearby water bodies. • Water-sprinkling of dirt roads during construction will be implemented to reduce debris during the construction phase. • Drainage channels and sand bags will be established along the embankment of the underground mine facility to trap sediments that may be released into the Boyongan and Timamana Creeks. • Upstream diversions channels will be established to prevent excessive runoff and prevent significant amount of water away from the tailings area. • Regular monitoring of the affected and adjacent creeks and streams prior, during, and even after the construction phase to monitor the water quality and ensure the continuous conformance of the water bodies to their respective water quality criteria. Water quality monitoring will be conducted on a monthly basis during the construction phase and quarterly during the operation phase of the project.

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
• Runoff and contact water from the Sub-level Cave Mine ore stockpile may affect the water quality of Timamana and Boyongan Creeks. Further, surface runoff may come into contact with the exposed areas of the TSF and drain into the adjacent streams.		✓	✓		• Mine drainage gullies and catch berms will be installed within the underground mine area to segregate contact and non-contact waters. • Erosion control measures in the form of cocomatting will be conducted for the soil stockpiles. • Runoff diversion channels and weirs will be established around the perimeter of the TSF to prevent the clean surface runoff from coming into contact with contaminated water. • Erosion control and slope protection measures will include the installation of bench drains to minimize the erosion of the outer layer of the TSF. • Regular monitoring of the affected and adjacent creeks and streams to monitor the water quality and ensure the continuous conformance of the water bodies to their respective water quality criteria. Water quality monitoring will be conducted on a monthly basis during the construction phase and quarterly during the operation phase of the project.
• Chemicals in the TSF may become unstable overtime. Therefore, any potential seepage from the TSF may affect the water quality of streams nearby.			✓	✓	• Batters will be flattened, with progressive rehabilitation conducted to ensure stability. Underdrainage will also be part of the design. • TSF seepage and management monitoring shall be established which include: - Pumped understorage system; - Filter/drainage zones of the low permeability core; and - Seepage collection towers • Seepage Collection Ponds and Drainage Systems will be installed, including the development of drains and sumps to prevent water ponding. • Regular surface water quality monitoring shall be conducted at established sampling stations even during the post closure phase. Water quality monitoring will be conducted quarterly during the operation phase of the project.

Potential Impacts	Phases: Preconstruction	Construction	Operation	Closure	Options for Prevention or Mitigation or Enhancement
• Dewatering of the Sub-level Cave Mine it and diversion of the Boyongan and Timamana Creeks may change their water depth, volume, and flow, and may even induce flooding downstream of the underground mine facility, therefore affecting water quality.		✓			• Sediment and silt traps and control will be installed to prevent erosion and sedimentation. Plants will also be used to reduce and regulate the change in water depth, volume, and flow. • Dewatering will be temporary. Extracted water during dewatering will be used in the processing plant or stored into the TSF once operational. • Regular monitoring of the affected and adjacent creeks and streams prior, during, and even after the construction phase to monitor the water quality and ensure the continuous conformance of the water bodies to their respective water quality criteria. Water quality monitoring will be conducted monthly during the construction phase.
• The spillway of the TSF could induce flooding in the headwaters of the Magpayang catchment, thus altering water quality.			✓	✓	• The spillway will be designed to withstand extreme rainfall and flood events. Engineering design of the spillway will adhere to acceptable standards. • Regular monitoring of the affected and adjacent creeks and streams prior, during, and even after the construction phase to monitor the water quality and ensure the continuous conformance of the water bodies to their respective water quality criteria. Water quality monitoring will be conducted quarterly during the operation phase of the project.
• Dam breach and overtopping may cause contamination of streams within the headwaters of Hinagasaan Catchment.			✓	✓	• The TSF will be designed to meet internationally accepted standards on safe design and operating standards, while considering seismicity, potential geohazards, and rainfall and flood events. • Monitoring the integrity of these structures will be implemented regularly even after mine closure and rehabilitation. • An emergency response plan will be in place to manage any possible failure in the future. • Regular monitoring of the water quality of the surrounding water bodies will be established to ensure the integrity of the surrounding water bodies. Water quality monitoring will

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
					be conducted quarterly during the operation phase of the project.
• Hydrocarbon leaks, spills from vehicles, fuel tanks, used oil storage and oil-contaminated materials from the access roads, mine and mill areas, maintenance workshops, motorpool and other support facilities may contaminate surface runoff, leading to surface water contamination. Such event may also occur during the storage, handling and transport of chemicals and reagents used in the mill process, assay laboratory, and TSF.		✓	✓	✓	• Motorpool area, maintenance workshop, and fuel storage area will be provided with proper drainage, Bunds and sorbents will be placed in the fuel and oil storage areas. • Washbay has oil separator. • Proper handling of hydrocarbons and other hazardous materials and implementation of good housekeeping practices will be enforced to workers. • Waste oils, oily water and other hazardous wastes will be collected and disposed offsite by an accredited third party waste hauler. • Monitoring systems will be in place to immediately address any leakage.
• Non-mine wastewater including domestic sewage discharges and residues from the administration and accommodation may contaminate the nearby streams if not properly handled.		✓	✓		• Sewage and other domestic discharges will not be treated onsite; Storage will be in the form of septic tanks and hauled by an accredited third party hauler. • A Waste Management Plan for non-mine wastes will be implemented to address collection, handling, transport, treatment and disposal of generated wastes.
Degradation of lake water quality					
• Potential seepage from the TSF and runoff from the Sub-Level Cave Mine may change the water quality of the Guinob-an Lake and streams within the Magpayang catchment, which eventually drain to the Mainit Lake.		✓	✓	✓	• Seepage Collection Ponds and Drainage Systems will be installed, including the development of drains and sumps to prevent water ponding. • The Sub-level Cave Mine will be designed to meet internationally accepted standards on safe design and operating standards, while considering seismicity, potential geohazards etc. • Water quality monitoring of the Guinob-an and Mainit Lake will be conducted quarterly during the construction and operation phases of the project. • An emergency response plan will be in place to manage any possible failure in the future.
Degradation of groundwater quality					
• Groundwater inflow and rainwater may percolate into the mine area		✓	✓	✓	• Site water management strategies will be implemented which will involve the:

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
and interact with highly mineralized materials, thus contributing to soluble minerals in the groundwater and affecting the content and quality of the aquifers.					▪ Establishment of vertical clay core protected by a downstream crushed rock filter zone within the TSF embankment to contain the contaminated tailings water. ▪ Stable lining of the TSF basin, with thick non-acid forming layer. ▪ Installation of drains and sumps downstream of the embankment to control any potential seepage and sediment runoff from the TSF during operations.
• Potential seepage from the TSF may possibly affect the aquifers.			✓	✓	• The TSF will have a non-acid forming lining and stable engineering structure to prevent any leakage. • Ground water quality monitoring of the wells installed across the site shall be conducted on a quarterly basis during operation.
• Dam breach and overtopping may cause contamination of the springs and other groundwater sources within the Municipality of Tubod, Sison and Placer.			✓	✓	• The TSF will be designed to meet internationally accepted standards on safe design and operating standards, while considering seismicity, potential geohazards, and rainfall and flood events. • Monitoring the integrity of these structures will be implemented regularly even after mine closure and rehabilitation. • An emergency response plan will be in place to manage any possible failure in the future. • Site water management strategies will be established to ensure the integrity of the surrounding water bodies.
Enhancement of climate change impacts					
• In the event of intense rainfall, construction and operation activities may aggravate the siltation/sedimentation in the three catchments (Hinagasaan, Bad-as/Amoslog and Magpayang).		✓	✓	✓	• Sediment and erosion control measures will be implemented even prior to the construction activities. • Earthworks will be undertaken preferably during dry weather. • Sub-level Cave Mine and water management will be implemented including the installation of drainage channels, sand bags, sediment traps and settling ponds. • Seepage Collection Ponds and Drainage Systems will be installed, including the

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
					development of drains and sumps to prevent water ponding. • All infrastructures will be designed to meet internationally accepted standards on safe design and operating standards, while considering seismicity, potential geohazards, and rainfall and flood events. • Regular monitoring of the affected and adjacent creeks and streams prior, during, and even after the construction phase to monitor the water quality.

2.2.2.10.2 Potential Impacts

Degradation of surface water quality

Siltation and erosion of the Hinagasa-an, Bad-as/Amoslog and Magpayang Catchments

Earthmoving activities during the construction of the Sub-level Cave Mnine, process plant, TSF and auxiliary facilities such as the access roads and camps may release soil, sediments, rocks, minerals and windblown debris which may affect the water quality of the streams and creeks within the Magpayang and Bad-as/Amoslog Catchments, and headwaters of Hinagasaan Catchment. The soil stockpile shall be in dedicated soil storage stockpiles, thus potentially affecting Timamana and Boyongan Creeks in the Magpayang Catchment. Stockpile runoff and debris, if not properly stored, would introduce suspended solids in the waterways and degrade the aesthetic quality of water. Turbid water reduces light penetration required for aquatic biota production. Organic matter and metal adsorption to the surface of eroded soils might change the chemical quality of water, increasing the BOD, TDS, conductivity and metal concentrations, and eventually leading to oxygen deletion in the surface waters.

Stream contamination by contact water from Sub-level Cave Mine, TSF

A stockpile of ore will be positioned near the underground mine facility, which will be fed to the plant. Its capacity may increase as the need arises. Runoff and contact water from the Sub-level Cave Mine if not properly managed, may affect the water quality of adjacent streams, particularly the Timamana and Boyongan Creeks and their tributaries.

In addition, surface runoff may also come into contact with the exposed areas of the TSF and drain into the adjacent streams.

Potential seepage from the TSF

Chemicals contained in the TSF may become unstable overtime. Potential seepage from the dams may affect the water quality of streams within the Hinagasa-an and Magpayang Catchments.

Dewatering of the Sub-level Cave Mine and diversion of Boyongan and Timamana Creeks

Water in the underground mine facility will be pumped out. Upstream portions of the Boyongan and Timamana Creeks and their tributaries will be diverted during the construction phase. Both activities may affect stream flow, and therefore potentially changing the water quality of the affected waterways.

Discharge from the spillway of the TSF

Release from the spillway of the TSF will only occur during emergency cases such as a multiple high intensity rainfall event. The pond capacity of the TSF may mitigate potential flooding to an extent prior to spillway discharge. High rainfall events and decant pump failure would increase flood risk downstream.

Effluent from the TSF and discharge from the process plant

The tailings from ore processing will be contained in the TSF. Effluent from the process plant contains total cyanide, but has been found to be less than standard limit for all classification of water bodies. Chemicals from the TSF and discharged contaminated water from the process plant may potentially alter the aesthetic and chemical characteristics of the receiving waterways.

Dam breach and overtopping

Potential dam breach and overtopping of the TSF may occur in the unlikely event of operation failure and extreme weather conditions. Such scenario may possibly cause contamination of the Piakle Creek and its tributaries in the Hinagasaan Catchment, downstream of the TSF. The downstream receiving water bodies of these headwaters might also be affected, altering the aesthetic quality and changing the chemical content of water.

Hydrocarbon and chemical spills and leaks

Hazardous wastes that will be generated include used batteries, used oils, chemicals and lead-containing items. Oil leaks from vehicles and heavy equipment during the construction phase, hydrocarbon spills from fuel tanks and stored oil from the maintenance workshops and motorpool, as well as oil-contaminated materials that are not properly disposed may contaminate surface runoff, leading to contamination of waterways. Chemical spills and leaks may also occur during the storage, handling and transport of reagents used in the mill process, assay laboratory, and TSF. Other hazardous wastes that are not properly stored may clog the nearby waterways and potentially alter their water quality.

Non-mine wastewater and solid wastes

Non-mine wastewater including domestic sewage discharges and residues from the administration and accommodation may contaminate the nearby streams if not properly handled. In addition, improper disposal of solid wastes in the nearby streams could degrade the aesthetic and physic-chemical quality of water. Discharge of untreated wastes may lead to bacterial contamination, therefore increasing the total and fecal coliform counts in water.

Degradation of lake water quality

Change in lake water quality of Guinob-an and Mainit Lake

Potential seepage and runoff from the Sub-level Cave Mine may change the water quality of the Guinob-an Lake and streams within the Magpayang catchment, which eventually drain to the Mainit Lake. Guinob-an Lake is located within the vicinity of the underground mine facility, and thus may be affected by the construction and operation activities.

Degradation of groundwater quality

Change in quality of groundwater sources

Change in quality of groundwater sources in the Municipalities of Tubod, Sison and Placer may potentially be triggered by the following factors:

- Groundwater inflow and percolation of rainwater in the mineralized areas;
- Potential seepage from the TSF; and
- Possible dam breach, affecting the groundwater sources of the Municipalities of Tubod, Sison, and Placer.

2.2.2.11 Options for Prevention, Mitigation or Enhancement

Degradation of surface water quality

Siltation and erosion of the Hinagasa-an, Magpayang and Bad-as/Amoslog Catchments

Sediment and erosion control measures, progressive rehabilitation, drainage systems and encapsulation of potentially chemical waste rocks will be applied during the construction phase and extending to the operation phase to prevent the contamination of adjacent and downstream water bodies within the Hinagasa-an, Magpayang and Bad-as/Amoslog. Sediment and erosion control measures include the stabilization of banks and slopes of primary impact waterways, installation of silt traps, settling ponds and gullies, and revegetation rehabilitation of exposed areas. Use of vegetation to reduce and regulate the change in depth, volume and flow will also be considered. Earthworks, if necessary, will be undertaken preferably during dry weather. Stockpile will be distant from water courses, with protection against natural weather and environmental elements to prevent the soil dispersion and sedimentation of streams. During construction, water trucks shall sprinkle the access roads to reduce windblown debris from getting into the waterways. Drainage channels will be established along the embankment of the stockpile and underground mine facility to trap sediments that may be released into the Boyongan and Timamana Creeks, while diversions channels will be constructed upstream to prevent excessive runoff and prevent significant amount of water away from the tailings area. Waste rocks will be contained to prevent their contact with the downstream and adjacent water bodies of Hinagasa-an and Magpayang Catchments. Primary impact creeks and streams will be monitored regularly for BOD, TSS, TDS, pH and DO during the construction phase and covering additional relevant parameters such as metals during the operation stage. Water quality monitoring will be conducted on a monthly basis during the construction phase and quarterly during the operation phase of the project.

Stream contamination by contact water from pit ore stockpile and TSF

There will be a progressive rehabilitation which includes the installation of gullies to prevent water ponding. Mine drainage gullies and catch berms will be installed within the area to segregate contact and non-contact waters. Only the clean water will be captured by the drainage channels along the embankment of the progressive phases of the underground mine. The ore stockpile will be captured and managed to prevent dispersion of mineralized soils to adjacent streams.

To segregate the clean surface runoff and contact water from the TSF, runoff diversion channels and weirs will be established around the perimeter of the dams. The contact diversion channel shall be lined to prevent the infiltration of contact water into the clean portion of the catchment. Clean water diversions will be provided to catch clean surface runoff. Upstream diversion channels will be utilized to divert water away from the tailings area and back into local watercourses.

Monthly and Quarterly monitoring of the primary impact and adjacent water bodies will be maintained during the construction and operation phase, respectively, to ensure conformance to the water quality guidelines.

Potential seepage from the TSF

The integrity of the TSF is ensured to adhere to acceptable standards and withstand extreme weather events to prevent any seepage. TSF seepage and management shall include the installation of pumped underdrainage system, filter/drainage zones of the low permeability core, and seepage collection towers. The effectiveness of these measures shall be observed by monitoring the surface water quality of the established stations on a quarterly basis during the operation phase of the project.

Dewatering of the Sub-level Cave Mine and diversion of Boyongan and Timamana Creeks

Sediment traps and control including the use of vegetation will be installed to prevent the siltation and regulate the change in water depth, volume and flow of Boyongan and Timamana Creeks during the process of diversion. Release of water during the dewatering of the Sub-level Cave Mine willl be regulated to control the outflow into the Boyongan and Timamana Creeks, and to sustain the carrying capacity of these downstream water bodies. Both creeks, including their tributaries, will be monitored monthly during the construction phase to ensure conformance to the DAO 2016-08 water quality guidelines.

Effluent from the TSF and discharge from the process plant

The mill includes a neutralization and cyanide destruction process before the tailings are discharged to the TSF. These processes will ensure the cyanide content and other chemicals are significantly reduced, if not removed, before impoundment in the TSF. The cyanide concentration of the discharge from the mill plant is lower than the set standard limit for effluent for all water body classifications. Cyanide will be further disintegrated by sunlight in the TSF. Effluent from the mining facilities will be monitored, as well as the receiving water bodies to maintain the integrity of the surface waters within the Hinagasa-an and Bad-as/Amoslog Catchments.

Dam breach and overtopping

The TSF will be designed to meet internationally accepted standards on safe design and operating standards. Safety precautions to withstand seismicity, potential geohazards, and maximum rainfall and flood events in the area will also be integrated in the dam design. The integrity of the structures will be checked regularly even up to mine closure and rehabilitation. In the unlikely event of dam breach and overtopping, an emergency response plan will be in place to manage any spills and leaks, and to contain the contaminated wastewater. Quarterly water quality monitoring of the surrounding water bodies will be implemented during the operation phase.

Hydrocarbon and chemical spills and leaks

There will be a provision for proper drainage in the motorpool area, maintenance workshop, and fuel storage area. Bunds and sorbents will be placed in the fuel and oil storage areas. Good housekeeping practices will be enforced at all times and workers will be trained to properly handle hydrocarbons and other hazardous materials. Waste oils, oily water and other hazardous wastes will be collected and disposed offsite by an accredited third party waste hauler. Monitoring systems will be in place to immediately address any leakage.

Non-mine wastewater and solid wastes

Sewage and other domestic discharges will not be treated onsite; Storage will be in the form of septic tanks and hauled by an accredited third party hauler.

Solid non-mine wastes that may potentially clog the waterways will be sorted, disposed and managed through the following methods: ecological composting of biodegradable wastes, Material Recovery Facility (MRF) for recyclable wastes, temporary holding facility for off-site waste disposal, and on-site sanitary landfill. A Waste Management Plan will be developed to address collection, handling, transport, treatment and disposal of generated wastes, considering relevant statutory requirements.

Degradation of lake water quality

Change in lake water quality of Guinob-an and Mainit Lake

The Sub-level Cave Mine will be designed to meet internationally accepted standards on safe design and operating standards, while considering the potential geohazards and occurrence of extremities in the area. Potential impact to the lakes will be addressed by establishing Sediment Collection Ponds and Drainage Systems within the perimeter of the underground mine which include drains and sumps to prevent water ponding. The Guinob-an and Mainit Lakes will be monitored quarterly to assess their quality during the construction and operation phases. An emergency response plan will be rolled out to immediately address and manage any possible dam breach and operation failure.

Degradation of groundwater quality

Change in quality of groundwater sources

- Groundwater inflow and percolation of rainwater in the mineralized areas;
- Potential seepage from the TSF; and
- Possible dam breach, affecting the groundwater sources of the Municipalities of Tubod, Sison, and Placer.

To prevent the infiltration of contact water, the site water management strategies will include the:

- Establishment of vertical clay core protected by a downstream crushed rock filter zone within the TSF embankment to contain the contaminated tailings water;
- Stable TSF basin, with thick non-acid forming layer; and
- Installation of drains and sumps downstream of the embankment to control any potential seepage and sediment runoff from the TSF during operations.

Dam structures will adhere to internationally-accepted standards on safe design, engineering and operating standards to prevent any potential seepage or leakage. The design of the TSF will also consider the seismicity, potential geohazards, maximum rainfall and flood events in the area. The integrity of these structures will be monitored regularly even after mine closure and rehabilitation.

In the unlikely event of dam breach and overtopping, an emergency response plan will be in place to manage and contain the seepage and address the leaks.

Ground water quality monitoring of the wells installed across the site shall be conducted on a quarterly basis during operation.

2.2.3 Freshwater Ecology

This section presents the assessment of the baseline freshwater ecology conducted for the proposed project as part of the EIS. Data generated through field survey and secondary data collection were used to characterize the baseline freshwater ecology and to assess potential impacts to freshwater biota associated with the proposed project development and identify corresponding measures to enhance, mitigate or prevent these impacts. Primary data collection was conducted for periphyton, plankton, macrobenthos, and fish.

The freshwater ecology baseline assessment was conducted to:

- Determine freshwater biota (periphyton, plankton, macrobenthos, and fish) composition, abundance, distribution, and diversity in the waterways to be potentially impacted by the proposed project;
- Determine presence of pollution indicator organisms in the waterways sampled;
- Determine endemicity or conservation of freshwater biota documented in the sampling stations; and
- Assess potential impacts of the proposed project to freshwater biota and identify corresponding measures to enhance, mitigate or prevent these impacts.

Background

Water bodies play an important role in human society. Humans are highly dependent on the utility of water, most especially fresh water bodies such as rivers, streams, lakes and ponds (Nwonumara, 2018). Due to this, these systems receive a continuously increasing amount of pressure and pollution in the form of nutrient-rich run-off, sewages, siltation, industrial effluents, contaminat drainages, and toxic or potentially toxic metals and compounds (Anna-lissa and Galina, 1999). It is important to understand the inter-relationships present in these ecosystems as they can provide valuable information to determine the status of a study area's overall environmental health (Singh et al., 2013). Other external studies which applied the utilization of bioindicator species to determine water quality and aquatic biota health are referred to and cited in this document. Moreover, in this section, both physical and biological connectivity were considered in the baseline characterization, impact assessment, and identification of mitigation measures.

The Study Area

A total of 11 catchments (i.e. Hinagasa-an, Bad-as/Amoslog, Campo, San Juan, Magpayang, Agong-ongan, Gata, Mapaso, Pungod, Mayag and Timamana) surrounding the proposed project were studied from the previous baseline study conducted by AECOM. River systems that were considered as primary impact areas are the Hinigasa-an, Magpayang, and Bad-as – Amoslog Rivers. Specifically, the Boyongan and Timamana Creeks, tributaries of Magpayang River, three stations that are located south of the open pit, mine facilities, and WRD; and tributaries of Hinagasa-an River. two stations that are located north of the TSF, were retained for this baseline activity. Tributaries of Bad-as – Amoslog River located east of the open pit and mine facilities, were not included in this study. Moreover, the catchments of Campo, San Juan, Agong-ongan, Gata Mapaso, Mayag and Pungod were classified as secondary impact areas and were also not sampled in this study. Best observed use for the rivers included in the study is primary contact recreation (i.e. swimming) and laundry except for Hinagasa-an River which has a domestic use (i.e cooking and dishwashing). Aside from the abovementioned catchments, the lakes of Mainit and Mahukdam were also included in the studies as secondary impact areas. Lake Mainit based on its classification is used as public supply water class II while Lake Mahukdam is used for primary contact recreation such as swimming. However, based on observations both lakes are primarily use for fisheries. Lake Mainit is the drainage basin of Magpayang River and Lake Mahukdam drains to Agong-ongan River which ultimately empties to Lake Mainit. Connectivity of aquatic ecosystems surrounding the proposed project site was taken into account as understanding the role of spatial and temporal variability of ecological processes is fundamental in predicting the consequence of potential land use change due to the proposed project. Detailed descriptions of aforementioned waterways were discussed in **Sections 2.1 Hydrology and Water Resources and Section 2.2 The Water Quality.**

Regulatory framework of the study

Aside from the Philippine Environmental Impact Statement (EIS) System embodied in PD 1586 which provides the legal and procedural framework for conducting Environmental Impact Assessment (EIA) for projects likely to have significant impact on the environment and its Implementing Rules and Regulations (DAO 2003-30), other national legislations and regulations of known relevance to the proposed project were compiled as shown in **Table 2.2.3-1**

Table 2.2.3-1 National and Local Legislations on Aquatic Ecology

National Legislations and Regulations	Overview and Purpose
Republic Act 8550	This act also known as Philippine Fisheries Act of 1998 provides for the development, management and conservation of the fisheries and aquatic resources, integrating all laws pertinent thereto, and for other purposes.
DAO 1998-03	This Department of Agriculture Administrative Order provides the guidelines for the implementation of the Philippine Fisheries Act of 1998.
Republic Act 7160	This act is also known as the Local Government Code of 1991. This act under Section 149 provides exclusive right to Local Government Units to utilize, monitor, and conserve their municipal waters and to grant fishery privileges and impose rentals, fees or charges thereto.
Republic Act 9147	This act, also known as the Wildlife Conservation and Protection Act of 2001 seeks to conserve and protect wildlife species and their habitats to promote ecological balance and enhance biological diversity; regulate the collection and trade of wildlife; pursue, with due regard to the national interest, the country's commitment to international conventions and treaties; and initiate or support scientific studies on the conservation of biological diversity.
FAO 2010-233	This Fisheries Administrative Order was promulgated to provide Aquatic Wildlife Conservation, controlled utilization of aquatic wildlife, set fees, fines, and penalty thereto pursuant to RA 9147.
FAO 208, s. 2001	This order seeks to conserve rare, threatened and endangered fishery species.
FAO 216, s. 2001	This seeks for the removal of all obstruction to navigation in streams, rivers, lakes and bays.

Methodology

The following subsection describes the sampling stations, strategies, and data analyses. Freshwater ecology studies are further subdivided into phytoplankton, zooplankton and macrobenthos, and periphytes. Different sampling methods were employed for each target fauna and separately discussed. The sampling strategies used for field surveys were adapted from scientifically accepted methods and data analyses were based on published scientific articles and technical papers.

The methods utilized the presence of bioindicators to evaluate existing ecological conditions of the sites sampled or surveyed. Naturally occurring bioindicators in freshwater ecosystems, such as invertebrates, plankton and periphyton are the common biological group of organisms whose function, population, or status can reveal substantial details pertaining to the degree of ecosystem or environmental integrity present. Periphyton are assemblages of benthic algae attached to substrates in streams and rivers. Plankton is a diverse group of organisms that thrives in the water column which cannot swim against the current. These organisms provide a crucial source of food to many large aquatic organisms (e.g. fish, crustaceans, and molluscs). Plankton is subdivided into two main groups, namely, phytoplankton and zooplankton. Phytoplankton are photosynthetic organisms, primary producers in the aquatic ecosystems, as such they highly depend on sunlight to survive and propagate. Zooplankton are microscopic (though some (i.e. jellyfish) are larger and visible with the naked eye) animals that drift or float in bodies of water. Macroinvertebrates are small stream-inhabiting organisms that are large enough to be seen with the naked eye and spend all or part of their life cycle in or on the stream bottom (Pamar et al., 2016).

The results presented in this document are the products of the assessment of data collected from the first application until the primary sampling event for 2019.

Assumptions and Limitations

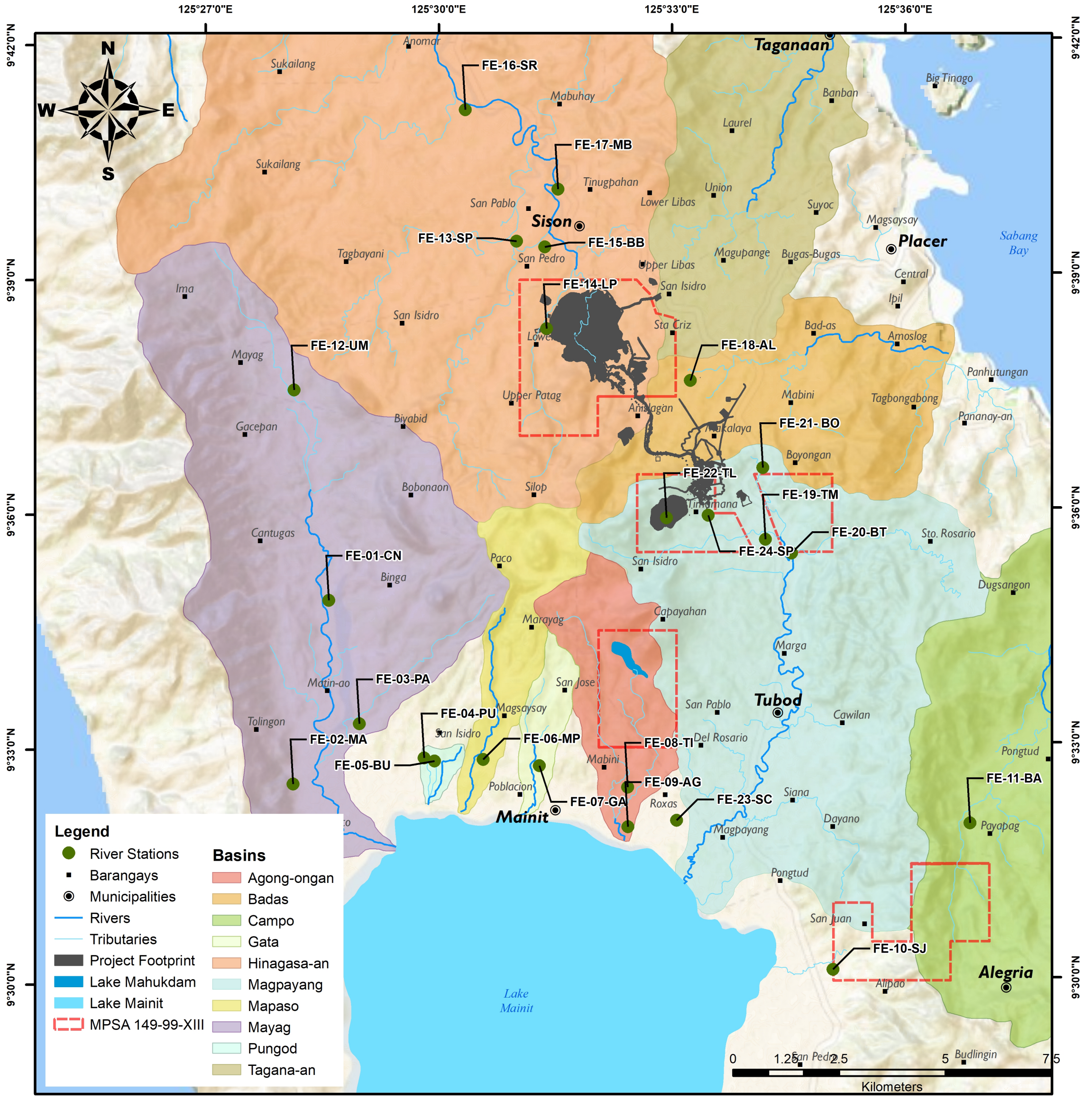
Sampling was conducted on February 2019. The project site falls under the Type II Modified Coronas Classification which has no dry season with a very pronounced maximum rain period from December to February. Seasonal variation was not accounted for as monsoons in the project site are not pronounced wherein the entire year has precipitation as aforementioned. Furthermore, no major project activities are conducted in the project site to significantly alter the freshwater environment since the July 2012 and April 2015 sampling periods.

Although previous studies have been conducted in 2012 and 2015, data comparisons and statistical analyses may deem insignificant as methodologies, analyses, and other factors vary.

River Systems

Sampling Sites

Five of the former twenty four biological stations established in the rivers and their tributaries traversing the proposed project site were retained in order to assess freshwater biota occurring within the study area that have the most potential to be impacted by the project (**Figure 2.2.3-1**). The biological sampling sites were identified based on their proximity to the project components. The retained stations were coincident with the water quality stations in order to correlate biological and physico-chemical characteristics of the sampling sites. Brief site descriptions and geographic coordinates are given in **Table 2.2.3-2.** For site observations, sampling sites were characterized based on general observations such as physical characteristics (substrate type, flow, etc) of the river systems; observed use (laundry, swimming, etc); general type of riparian vegetation (i.e trees, shrubs, vines, and grasses); and general type of macrophytes or aquatic plants. Macrophytes were characterized based on observed coloration and no detailed taxonomic identification was done.



Freshwater Ecology River Sampling Stations	
Silangan Copper-Gold Project	Scale 1 : 120,000
Province of Surigao del Norte	PLOTTED : RCA / DATE : 03/05/2019
	REVIEWED : MKM / APPROVED : KHG
Silangan Mindanao Mining Company Inc.	JACOBS ch2m 16F South Tower, Rockwell Business Center Sheridan cor. United St. Mandaluyong City

SOURCES:

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community
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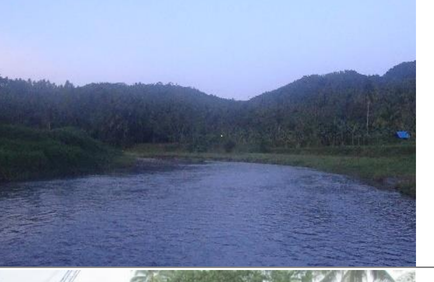
Figure 2.2.3-1 Freshwater Ecology Sampling Stations - River Systems

Table 2.2.3-2 Site description of the 5 sampling stations in freshwater streams within and surrounding the Silangan Copper-Gold Project Site. * Primary Impact Area

Station ID	Station Name	Catchment	Site	Longitude	Latitude	Site Observations
FE-15-BB	Busong-busong**	Hinagasa-an		9.65625	125.52230	The station has limited vehicle access and approximately 10mins trek from the nearest drop-off. This unnamed river is one of the tributaries of Toog Creek. The station has clear water with turbulent flow. The river channel meanders approximately 7 km, with the headwaters in Upper Patag. The channel is controlled by different sizes of boulders. The area is predominantly surrounded by coconut trees. Domesticated animals graze on the
FE-17-MB	Mabuhay**	Hinagasa-an		9.66851	125.52524	The station is accessible through dirt road and approximately 200m away from the National Highway. The station is near a residential area. The channel has a rocky substrate and laminar flow. The water is clear, with mosses on the gravel-filled isle. The channel is located between steep valleys dominantly covered with grass and surrounded by coconut trees.
FE-19-TM	Timamana**	Magpayang		9.59369	125.56916	The station is located at the lower section of Timamana Creek before it drains into the upper catchment of Magpayang River. During the sampling, bridge rehabilitation was being undertaken downstream of the station. Domestic activities such as laundry washing were observed upstream of the station. Water flow is medium turbulent.

Station ID	Station Name	Catchment	Site	Longitude	Latitude	Site Observations
FE-20-BT	Boyongan and Timamana Creeks	Timamana		9.5907	125.5747	The station is accessible through dirt road. The sampling station is at the upper catchment of Magpayang River. Stream bed is composed of mossy rocks. Coconuts and ricefield are observed in the area.
FE-21- BO	Boyongan Creek	Timamana		9.6089	125.5687	The station is accessible through footpath and approximately 90m from the National Highway. The sampling station is surrounded by riparian vegetation and a small community is located upstream. Ricefield and banana trees are observed to be adjacent to the creek. The water is fast-flowing and the channel bed consists of gravel.

Sampling Methodology

Plankton

Plankton samples were collected by dragging a 25µm mesh cone net for phytoplankton and a 60µm cone net for zooplankton for a distance of about 5 meters in the mid to top layer of the water surface. Plankton sampling was conducted in duplicates for every station. Samples were then preserved in 35% ethanol solution and brought to the laboratory for identification. In-situ photographs of plankton sampling are provided in **Plate 2.2.3-1.** Abundance, and taxa richness of plankton samples were computed per station.

(a) Plankton nets are dragged against stream flow to collect samples.

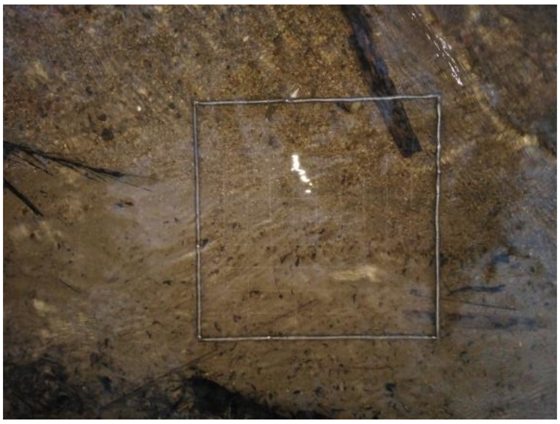
(b) Plankton nets are rinsed to concentrate samples towards the cod end in preparation for transfer into sampling bottles.

(c) Plankton sample being transferred into sampling bottle, preserved and sealed to be taken to the lab for analysis.

Plate 2.2.3-1 Plankton Sampling in River Systems

Periphyton

Periphyton was assessed in the areas where algal attachments on the substrates were clearly observed. In the previous study, periphyton were sampled via scraping in lieu of plankton sampling for stations FE-20 and FE-21. In this study, only percent coverage will be recorded using a 10x10 quadrat grid via random throws around the station body where the most periphyton was observed, such as in stations FE-15, FE-17 and FE-19. Sample quadrats observed from FE-21 and FE-17 are provided in **Plate 2.2.3-2**.



An example of a random throw from station FE-21.

An example of a random throw from station FE-17.

Plate 2.2.3-2 Quadtrat sampling

Macrobenthos

A triangular kick net with a 500µm mesh size was used to obtain duplicate samples of macrobenthos in riffles or shallow portions of the river. While the sampler is held downstream, the net was oriented with the opening facing upstream. The substratum or the bottom substrate was then disturbed by kicking or dislodging the river bed material while moving backward in an upstream direction, allowing any disturbed materials to flow into the net. All collected organisms are placed in stackable sieves of 500µm, 220µm and 120µm wherein macroinvertebrate organisms were either hand-picked with fine-tipped forceps or rinsed into sample bottles and preserved in 35% ethanol in separate, labeled containers. Samples were brought back to the lab for identification. In-situ photographs are provided in **Plate 2.2.3.-3.**

(a) D-frame kicknet facing upstream while disturbing substrate.

(b) Rinsing kicknet to concentrate samples towards the cod end.

(c) Concentrated sample contained in cod end.

(d) Collected sample is filtered through stackable sieves of 500µm, 220 µm and 120 µm.

(e) Specimens are transferred into sampling bottles.

(f) Preservatives are added and bottles are labelled accordingly.

Plate 2.2.3-3 Macrobenthos Sampling

Fish

Information on fishes occurring in the different streams were gathered based on field observation and informal interviews with some of the locals encountered during the site visit and collection of primary data for plankton and macrobenthos. Photos were taken of the fishes caught by the locals whenever they were observed.

Four species of commonly caught freshwater fishes from the surrounding fresh water systems were bought from the local market at Mainit. Phots from the local market are illustrated in **Plate 2.2.3-4.** The species collected include the Tilapia (*Oreochromis nilotica*), Eleotrid Goby (Hypseleotris agilis), Bareye/White Goby (*Glossogobius giuris*) and Snakehead Murrel (*Channa striata*)**.** Samples were measured, photographed and desktop studies were conducted to determine the endemicity, ecological and economical importance of each species.

	
(a) A collection of the most common fish being sold at the local market near Lake Mainit.	*(b) Hayuan/Dalag (Channa striata) displayed at the market.*

Plate 2.2.3-4 Commercial fish observed from the local market

Lakes

Sampling Sites

A total of three and seven sampling stations were established in Lake Mahukdam and Lake Mainit, respectively (Figure 2.2 12Figure 2.2 12). Sampling stations in Lake Mahukdam were established based on the baseline studies of the Boyongan Copper Gold Project (2008) while sampling stations in Lake Mainit were arbitrarily assigned in areas close to river tributaries to account for the river inputs in the lake. The sampling stations were common for both plankton and soft-bottom benthos surveys.

Sampling Methodology

Plankton

Plankton samples were collected using a 25µm mesh net for phytoplankton and a 64µm for zooplankton with 0.25m mouth diameter and 1m length (**Plate 2.2.3-5**). Vertical hauls of the plankton nets were done to determine phytoplankton and zooplankton abundance and density for each station. The net was lowered at a depth based on the transparency measured by Secchi disk. Then the net is raised at a rate of approximately 1m/s towards the surface. Duplicate samples were collected for each station. Water samples from the net were immediately preserved in Lugol's solution for laboratory identification.

Chlorophyll-a and Nutrients Determination

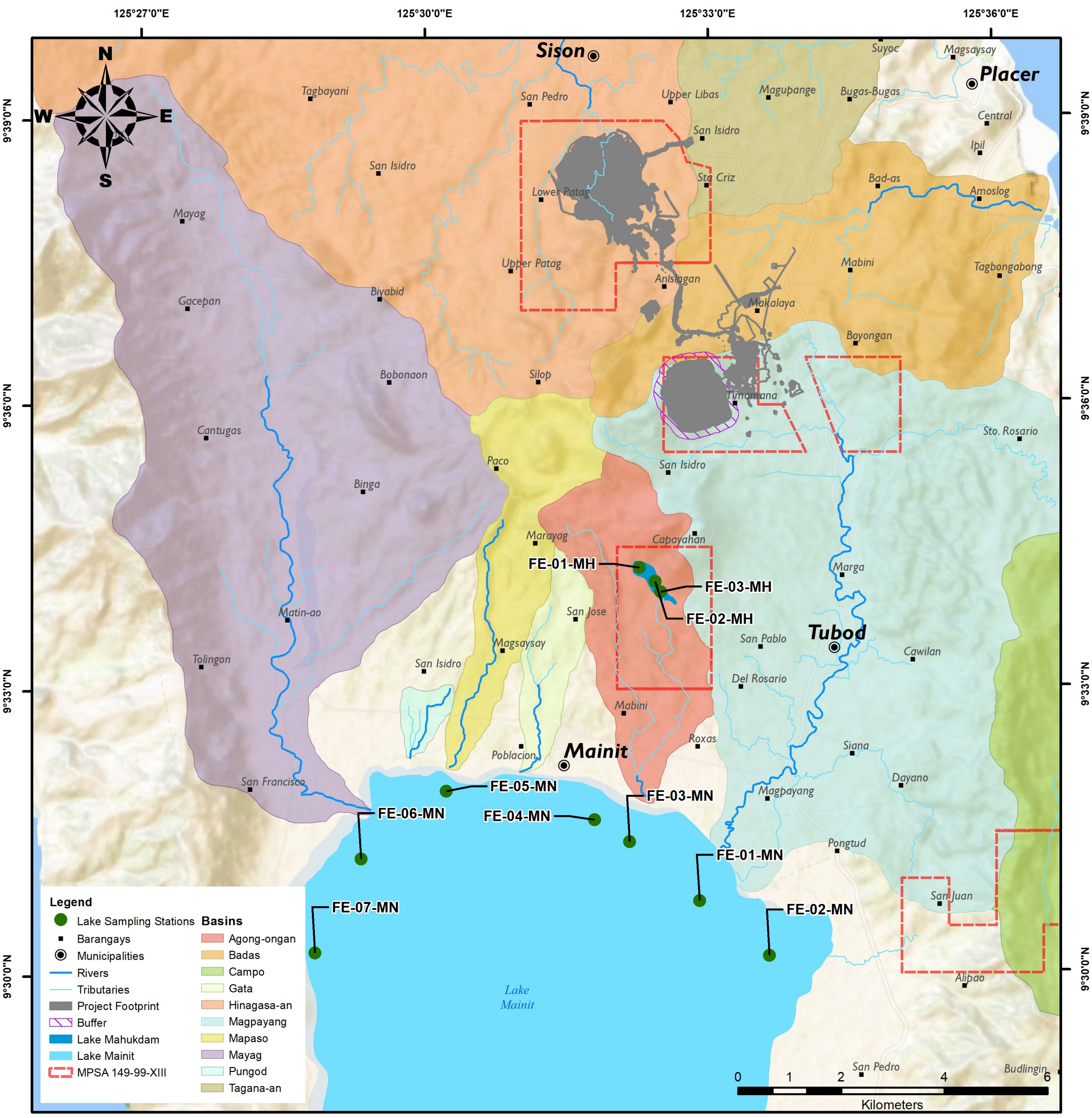
Surface water for nutrients (nitrate, nitrite, ammonia and phosphate) and chlorophyll-a determination were collected in each station. Nutrients and chl-a samples were filtered through a Whatman GF/C glass fiber filter. Magnesium carbonate was added during filtration of chlorophyll-a samples to prevent filter acidification. Water samples for nutrients and filtrate for chl-a were cool-stored and sent to the laboratory for analyses.

Plate 2.2.3-5 Plankton sampling in lake water stations

Soft-bottom Benthos

Sediment samples were collected from three sampling stations in Lake Mahukdam and seven in Lake Mainit, using an Ekman grab sampler with an area of 0.0225m2 (**Plate 2.2.3-6**). Collected samples were placed in separate, labeled containers and fixed in 70% ethanol with RoseBengal vital stain. Samples were brought to the National Museum of the Philippines for laboratory processing and soft-bottom benthos identification.

Plate 2.2.3-6 Grab sampling for soft-bottom benthos



Freshwater Ecology Lake Sampling Stations	
Silangan Copper-Gold Project *Province of Surigao del Norte* Silangan Mindanao Mining Company Inc.	Scale 1 : 120,000 PLOTTED : RCA / DATE : 03/05/2019 REVIEWED : MKM / APPROVED : KHG JACOBS ch2m 16F South Tower, Rockwell Business Center Sheridan cor. United St. Mandaluyong City

SOURCES:

Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community
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Administrative boundaries are approximate. Therefore it is not authoritative and should be used for planning and visualization purpose only.

Figure 2.2.3-2 Freshwater Ecology - Lake Sampling Stations

Fish Bioassay

Three species of commonly caught freshwater fishes from Lake Mainit (Tumanda et al. 2005, De Guzman et al. 2008) were bought from the local market at Mainit. The species collected include the tilapia (Oreochromis nilotica), goby (Glossogobius giuris) and dalag (Ophicephalus striatus) (**Plate 2.2.3-7**). The samples were placed in plastic bags, freeze-stored and brought to the Philippine Institute for Pure and Applied Chemistry (PIPAC) of the Ateneo de Manila University in Quezon City where they were analysed for cadmium, copper, lead, zinc, mercury and arsenic.

Since there are no local standards, the resulting concentrations were then compared with available international standards namely, the Australia New Zealand Food Authority (ANZFA) Standards, Codex Alimentarius of the United Nations Food and Agriculture Organization (UNFAO), United States Food and Drug Administration (USFDA), European Commission (EU) Contaminants Framework Regulation, and the United Kingdom (UK). Values are available only for cadmium, lead, mercury and arsenic. The levels for the other metals were compared with reported levels from other bodies of water.

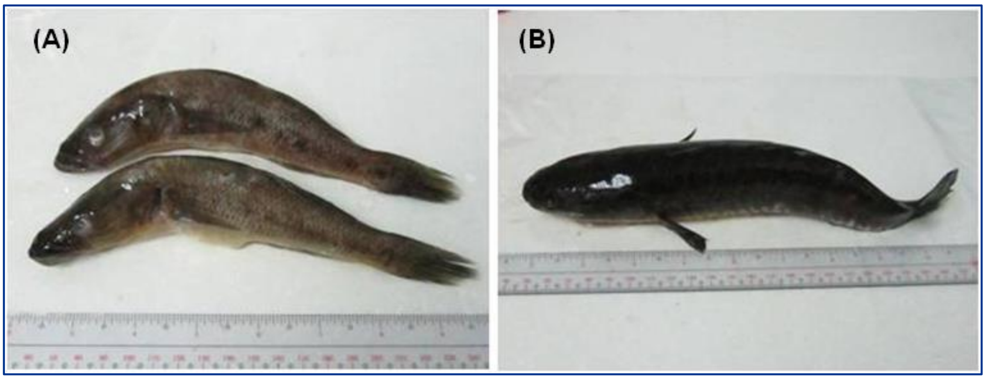


Plate 2.2.3-7 Fish samples (A) goby (Glossogobius giuris) (B) dalag (Ophicephalus striatus)

Baseline Environment for Freshwater Ecology

This subsection presents the key findings and conclusions of the freshwater ecology studies garnered from the results of the data collected from the first application until the primary sampling conducted for 2019. This subsection is further divided into subsections for the river systems and the lakes baseline results.

Baseline Summary for Freshwater Ecology – River Systems

Key findings and conclusions of the rivers systems studied were presented in this subsection.

Table 2.2.3-1 Key Findings and Conclusions – Freshwater Ecology (River Systems)

Baseline Information	Key Findings and Conclusions
Plankton	• Six major Phytoplankton taxonomic groups (i.e. *Bacillariophyta, Chlorophyta, Cyanophyta, Dynophyta, Euglenophyta and Rhodophyta*) comprising of 38 generas were identified. *Bacillariophyta* was found to compirise 76.6% of the total phytoplankton abundance across all sampled stations during this study, while *Chlorophyta* comprised 19.4%, *Cyanophyta* at 2.4%, Dinophyta at 0.4%, *Euglenophyta* at 1%, and Rhodophyta at 0.3%. Highest phytoplankton concentration was observed in FE-17 at 2.88E+05 cells/L and the least in FE-21 with a concentration of 8.20E+03 cells/L. The station richest in taxa was FE-20 with a total assemblage of 26 generas

Baseline Information	Key Findings and Conclusions
	identified and the least in FE-21 with only 17 generas. Diversity indixes were found to range from 1.01 to 1.23. • Total abundance means, and taxa richness were plotted with water quality results for inorganic non-metallic parameters (Phosphates, Nitrates and Ammonia), as well as some physico-chemicaal properties (temperature, electric conductivity, turbidity, TSS and stream flow) to demonstrate possible relationships between variables and changes in weather conditions. • Highest correlation coefficient (r) were found between abundance, taxa richness and ammonia which may suggest that these may be limiting factors for planktonic proliferation in this area. Although a visual plot of abundance and surface water velocity showed that it is inversely proportional with each other. This may infer that high run-off due to high rainfall can inhibit plankton growth, while an increase in plankton abundance may be expected during less rainfall and drier months. • The recurrent dominance of *Fragilaria sp.* and other pollution indicator species present in the sampled stations may infer that these systems are already under pressure. • Although there were enough data to perform statistical analyses, it is not sufficient to illustrate trends. Moreover, this study's findings cannot be successfully compared to previous sampling data as units and methodologies differ. Zooplankton • Zooplankton counts were combined with macrobenthos samples as both had very similar species composition due to the substrate being constantly and easily disturbed as the sampled streams, creeks and rivers are very shallow. Please see Macrobenthos section.
Periphyton	• Periphyton coverage was found to have the highest percent coverage in station FE-19 with a total sampling mean of 34.17%. Periphyton are known to thrive better in slow flowing streams, ponds and rivers. In this station, mean stream flow was recorded at 0.63 m^3/s. A green algae, Spirogyra sp., and a blue-green algae, Oscilatoria sp., were found to dominate algal growths in the sampling stations.
Macrobenthos	• Zooplankton and macrobenthos data were combined as many of the identified individuals overlapped as sampling stations are relatively shallow with the substrate easily disturbed even during cone sampling for planktons. • A total of 2,399 individuals were identified under 4 classes, 2 subclasses, 1 family and 12 orders in this study with the most abundant individuals being under the PET (Orders *Plecoptera, Ephemeroptera* and *Trichoptera*) taxa. *Plecopterans* made 64.4%, and *Ephemeropterans* made 21.6% of the community. • Highest heterogeneity was observed in FE-20 (Boyongan and Timamana Creeks). Similarly with the observed phytoplankton assemblage, high diversity in this this station may be attributed to minimal anthropogenic disturbances.
Fish	• Five species of fish were recorded to be the most common in the fresh water systems surrounding the study area, namely, the Marbled Eel (Anguilla

Baseline Information	Key Findings and Conclusions
	marmorata), Tilapia (Oreochromis niloticus), Eleotid Goby (Hypseleotris agilis), Bareye/White Goby (Glossogobius giuris), and Snakehead Murrel (Channa striata). Fishing activities of the locals utilized home-made spears, hook and line or "bingwit" and electro-fishing.
Summary of Endemicity/ Conservation Status	• No rare or threatened plankton or macrobenthos were observed in the surveyed freshwater streams. • Four of the five fish species evaluated in this study are also found to be widespread all over the Pacific island regions and are commercially cultured or fished. Despite their economic role and extensive exploitation, these fish species are listed as Species of Least Concern under the IUCN Red List. An exception is with H. aguilis which has not been widely evaluated. .
Pollution Indicator Species	• A number of pollution indicators in the phytoplankton assemblage have been identified during this study which included *Coscinodiscus, Fragilaria, Navicula, Nitzschia, Pleurosigma, Surirella, Synedra, Spirogyra and Euglena*. Indicators such as these may either be sensitive to changes or extremely tolerant. • A 97.67% and 50% decrease in the PET:C ratio found in stations FE-17 (Mabuhay) and FE-19 (Timamana), respectively, may indicate an enormous decline in water conditions. These reported decreases are to be expected as these stations are highly disturbed due to quarrying activities present in FE-17 and anthropogenic wastes received by FE-19. • Degrees of pollution were determined based on the WQI score garnered from the results and it was reported that all retained stations have some degree of pollution present except for FE-20 (Boyongan and Timamana Creeks) which remained to have an excellent water quality rating.
Sources of Threats to Freshwater Ecology	• Pollution and wastes from domestic, industrial and agricultural plots may increase pressure on these systems as both organic and in-organic pollutants may lead to eutrophication and algal blooms causing a *Bottom-Up trophic cascade.* • Non-indigenous Invasive Species (NIS) introduced in a natural system may alter the feeding behaviors of certain individuals which may cause eliminations of certain species in the local hierarchy of an ecosystem causing a *Top-Down trophic cascade.*
Climate Change Impacts Without the Project	• The projected increasing extreme precipitation in the whole of Surigao del Norte Province will cause potential flooding of the river systems even without the project. Severe flooding can affect in-stream and riparian habitats and associated aquatic assemblages through significant reductions in the density and biomass of these communities and shifts in community composition. During drier dry periods these river systems are prone to drought that can cause stream contraction that can bring about concentration of solutes, materials, and organisms; separation of populations; reduction of habitat availability; and alteration of ecosystem processes. • Climate change and drastic anthropogenic driven deviations may influence the intensity of each others impacts.

Baseline Information	Key Findings and Conclusions
An overview of the overall site conditions and dominant species across all sampling events conducted at the retained sampling stations.	

Parameters	February 2019	April 2015	July 2012
Ambient Temperature (°C)	26.7	28.2	28.5
Temperature (°C)	26.2 - 28	*nc	27 – 32.9
Turbidity (NTU)	7.82 – 23.8	*nc	0.5 – 3.1
TSS (mg/L)	8 - 81	*nc	<2.5- 9
Nitrates (mg/L)	0.05 - 0.19	*nc	<0.01 - 0.12
Phosphates (mg/L)	0.09 - 0.11	*nc	0.09 - 0.17
Ammonia (mg/L)	<0.03 - 0.04	*nc	*nc
Surface Water Velocity (m^3/s)	0.63 – 8.13	*nc	0.28 - 2.41
Average Monthly Rainfall (mm)	446.4	219.1	171.1
Dominant Plankton	*Fragilaria sp.*	*Synedra sp.*	*Fragilaria sp.*
Dominant Invertebrate	*Plecoptera Ephemeroptera*	*nc	*Trichoptera*
Periphyton Coverage (%)	0-34.17%	*nc	*nc
Average WQI Rating	Very Good	*nc	Excellent
Degree of Pollution	Possible slight organic pollution	*nc	Organic pollution unlikey
**nc – not calculated*			

Plankton

Phytoplankton identified belong to six major taxonomic groups (i.e. Bacillariophyta, Chlorophyta, Cyanophyta, Dynophyta, Euglenophyta and Rhodophyta) as listed in **Table 2.2.3-4.** Assemblages are comprised of 38 generas wherein Bacillariophyta was found to compirise 76.6% of the total phytoplankton abundance across all sampled stations during the study, while Chlorophyta comprised 19.4%, Cyanophyta at 2.4%, Dinophyta at 0.4%, Euglenophyta at 1%, and Rhodophyta at 0.3%. Total mean abundances and distribution of the 6 major groups across all sampled stations in 2019, 2015 and 2012 are shown in **Figure 2.2.3-3**. Highest phytoplankton concentration was observed in FE-17 at 2.88E+05 cells/L and the least in FE-21 with a concentration of 8.20E+03 cells/L. The station richest in taxa was FE-20 with a total assemblage of 26 generas identified and the least in FE-21 with only 17 generas. A total of 6 generas were identified in 2015, and 6 as well in 2012. The summary of taxonomic richness across the five retained sampling stations for all sampling years are exhibited in Table 2.2.3**-5.** As for diversity, diversity indixes were found to range from 1.87 (FE-21) to 3.82 (FE15) during this sampling year.

Table 2.2.3-2 List of identified generas and mean abundance (cells/L)

Major Group	Genera	FE-15	FE-17	FE-19	FE-20	FE-21	MEAN
Bacillariophyta	*Amphipleura*	0.00E+00	0.00E+00	3.10E+02	0.00E+00	0.00E+00	6.20E+01
	Asteromphalus	8.33E+01	2.09E+02	0.00E+00	0.00E+00	6.20E+01	7.08E+01
	Coccoensis	1.02E+03	2.06E+03	1.67E+02	4.16E+03	5.07E+02	1.58E+03
	Coscinodiscus	2.45E+02	6.33E+03	2.59E+03	1.85E+03	2.07E+03	2.62E+03
	Cyclotella	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.50E+02	5.00E+01
	Cymbella	2.28E+02	1.15E+03	0.00E+00	6.61E+02	0.00E+00	4.08E+02
	Diadesmis	4.53E+04	6.10E+05	4.50E+04	2.95E+05	1.36E+03	1.99E+05
	Fragilaria	1.34E+05	2.85E+06	1.31E+06	9.50E+05	7.47E+04	1.06E+06
	Gyrosigma	1.63E+02	0.00E+00	0.00E+00	1.85E+02	0.00E+00	6.95E+01
	Leptocylindrus	1.18E+04	8.11E+04	4.07E+04	2.81E+04	6.62E+03	3.37E+04
	Navicula	4.93E+02	0.00E+00	1.18E+03	1.52E+03	1.10E+03	8.58E+02
	Nitzschia	5.27E+02	6.92E+02	1.76E+03	1.28E+03	2.86E+02	9.10E+02
	Pleurosigma	1.30E+02	2.09E+02	0.00E+00	6.21E+02	0.00E+00	1.92E+02
	Skeletonema	1.44E+03	2.38E+04	3.97E+03	8.85E+03	0.00E+00	7.61E+03
	Surirella	1.55E+04	1.26E+04	1.43E+03	1.43E+04	2.68E+03	9.30E+03
	Synedra	0.00E+00	0.00E+00	1.02E+05	0.00E+00	0.00E+00	2.05E+04
	Tabellaria	2.02E+03	4.16E+03	2.83E+02	7.92E+02	2.60E+04	6.66E+03
Chlorophyta	*Chaetophora*	5.87E+02	3.56E+04	1.10E+04	1.26E+05	8.91E+02	3.48E+04
	Chlamydomonas	0.00E+00	0.00E+00	2.50E+02	0.00E+00	0.00E+00	5.00E+01
	Closteria	7.63E+03	8.88E+03	7.20E+03	3.34E+03	4.98E+02	5.51E+03
	Coelastrum	0.00E+00	0.00E+00	0.00E+00	3.32E+02	0.00E+00	6.65E+01
	Dictyosphaerium	0.00E+00	0.00E+00	1.81E+04	0.00E+00	0.00E+00	3.63E+03
	Golenkinia	0.00E+00	0.00E+00	0.00E+00	6.65E+01	0.00E+00	1.33E+01

	Micratinium	4.89E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.77E+00
	Monoraphidium	0.00E+00	0.00E+00	2.19E+02	3.03E+02	0.00E+00	1.04E+02
	Oocystis	0.00E+00	0.00E+00	3.87E+02	0.00E+00	0.00E+00	7.75E+01
	Spirogyra	7.72E+04	7.86E+05	0.00E+00	4.84E+03	3.60E+03	1.74E+05
	Stigeoclonium	0.00E+00	0.00E+00	2.32E+02	9.37E+03	0.00E+00	1.92E+03
Cyanophyta	*Aphanizomenon*	0.00E+00	0.00E+00	0.00E+00	2.41E+04	0.00E+00	4.81E+03
	Oscillatoria (strip)	0.00E+00	0.00E+00	3.01E+02	0.00E+00	0.00E+00	6.01E+01
Dinophyta	*Ceratium*	0.00E+00	0.00E+00	7.75E+01	0.00E+00	0.00E+00	1.55E+01
	Noctilluca	5.88E+02	1.02E+02	0.00E+00	0.00E+00	0.00E+00	1.38E+02
	Peridinium	0.00E+00	0.00E+00	8.33E+02	1.51E+03	4.00E+03	1.27E+03
	Prorocentrum	9.77E+01	0.00E+00	0.00E+00	1.48E+03	5.58E+02	4.28E+02
	Protoperidinium	3.26E+02	1.99E+03	6.40E+01	1.28E+03	0.00E+00	7.32E+02
	Pyrocystis noctilluca	0.00E+00	5.09E+01	0.00E+00	0.00E+00	0.00E+00	1.02E+01
Euglenophyta	*Euglena*	1.73E+03	5.90E+02	1.42E+03	1.31E+03	1.87E+02	1.05E+03
Rhodophyta	*Rhodophyta*	0.00E+00	0.00E+00	0.00E+00	1.33E+03	0.00E+00	2.66E+02

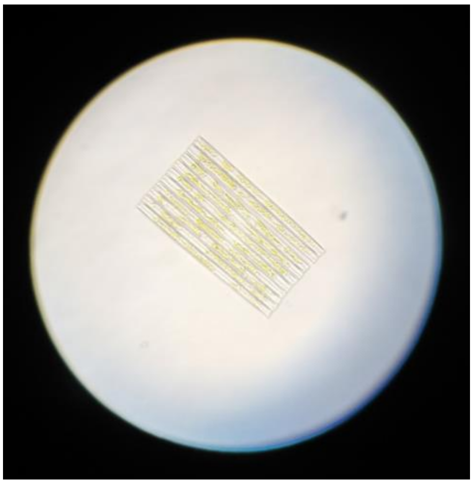
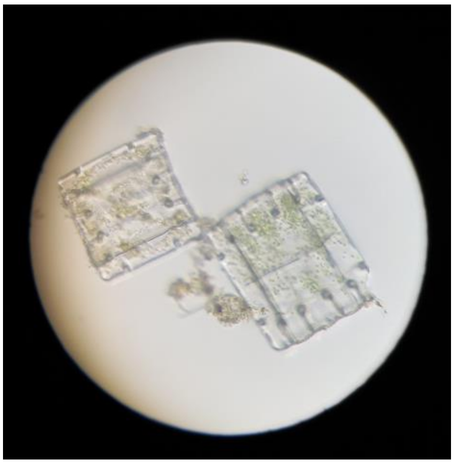
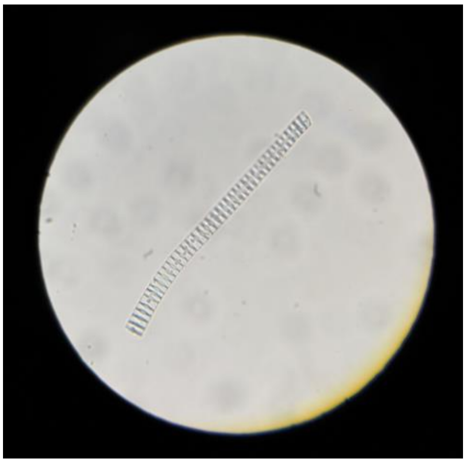
Highest major group densities were consistently observed for *Bacillariophytas* making up 76.6% of the total counts during this study and 73.1% in 2012. A dominant species, *Fragilaria sp.,* ranged from 7.47E+04 cells/L in FE-21 to 2.85E+06 cells/L in FE-17 this year which may indicate eutrophic to polluted water systems (Singh et al., 2013). *Fragilaria sp.*'s dominance has also been observed in the previous studies conducted at the site. High plankton diversity in water systems may indicate healthy and unpolluted conditions while dominance of only a few species may suggest otherwise (Rai et al, 2008). The dominance of *Fragilaria sp.* as well as the presence of several pollution indicator species such as *Coscinodiscus sp., Navicula sp., Nitzschia sp., Pleurosigma sp., Surirella sp., Spirogyra sp., Aphanizomenon sp., Oscillatoria sp., Ceratium sp., Prorocentrum sp., Protoperidinium sp.,* and *Euglena sp.* may signify that the surrounding water systems are already under pressure (Nwonumara, 2018).

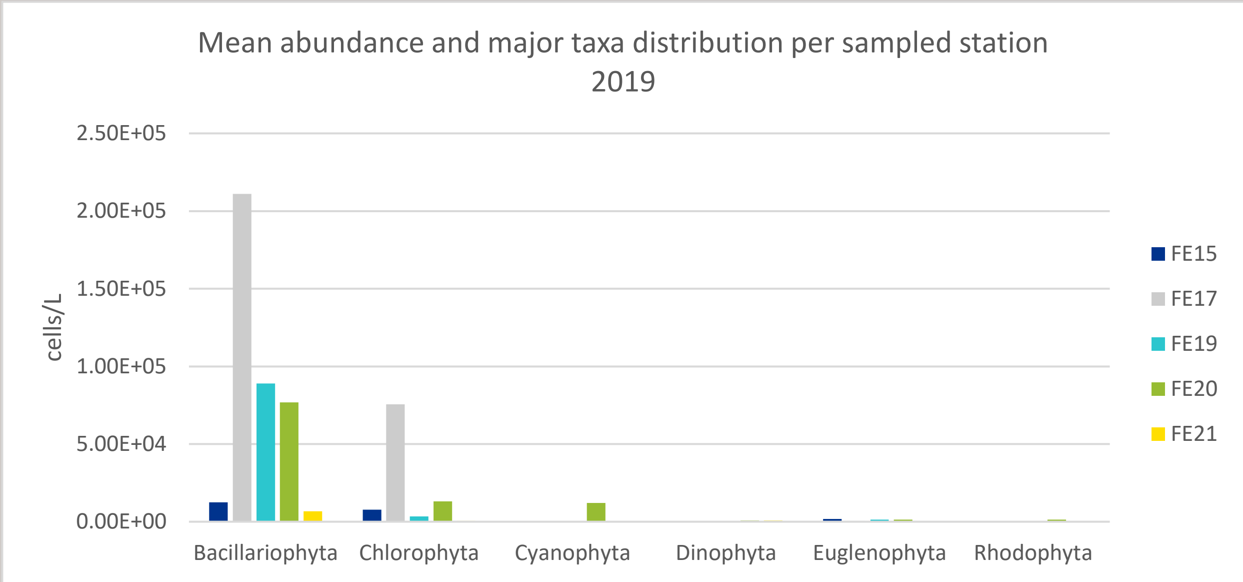
Table 2.2.3-3 Taxonomic Richness per station per sampling year

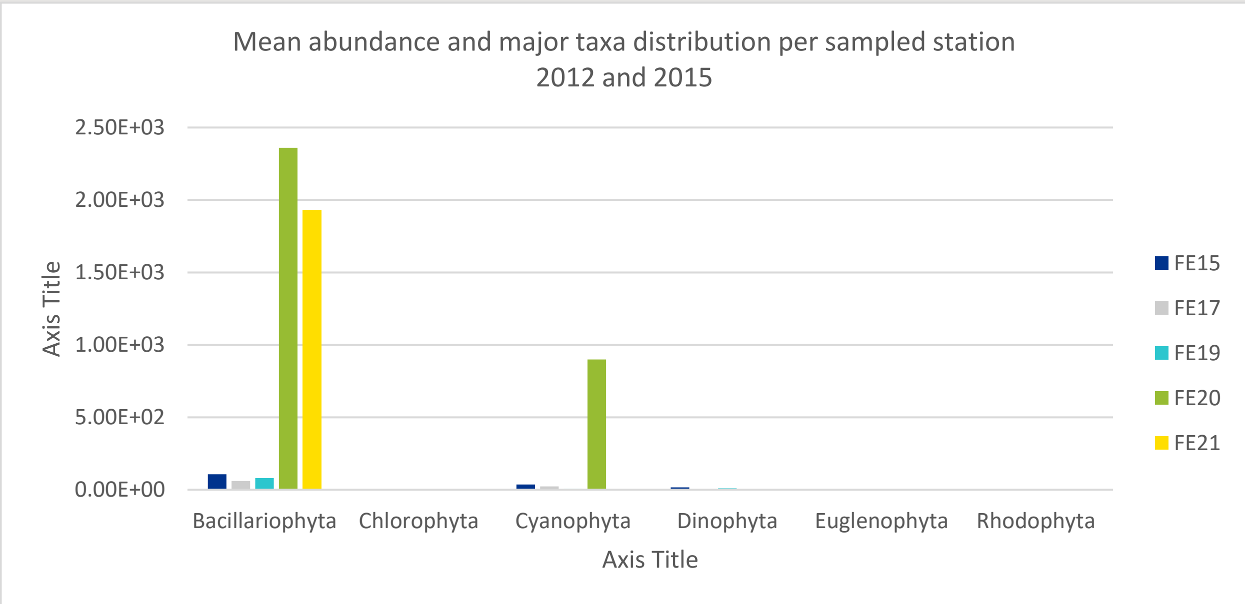
Major Taxonomic Group	Generas Identified									
	2019					2015		2012		
	FE-15	FE-17	FE-19	FE-20	FE-21	FE-20	FE-21	FE-15	FE-17	FE-19
Bacillariophyta	14	12	12	13	11	5	3	3	3	3
Chlorophyta	4	3	7	7	3	0	0	0	1	0
Cyanophyta	0	0	1	1	0	1	0	1	1	1
Dinophyta	3	3	3	3	2	0	0	1	0	1
Euglenophyta	1	1	1	1	1	0	0	0	0	0
Rhodophyta	0	0	0	1	0	0	0	0	0	0
TOTAL	22	19	24	26	17	6	3	5	5	5

Some photos of specimens and key species collected are exhibited in **Table 2.2.3-6**. *Fragilaria sp.* cells charachterized by linear to linear-lanceolate valves containing chloroplasts. This can be distinguished from *Synedra sp.* based on its capability to form colonial chains. Surirella sp. observed from the collected samples ranged from ovate, egg-shaped to wedge shaped solitary cells containing chloroplasts with thickened marginal ribs. A sample of a *Spirogyra sp.* filament is shown below distinguished by long, unbranched cylindrical cells containing helix shaped chloroplasts. Colonies of *Tabellaria sp.* were also observed in the samples as distinguished by their square shape in girdle view forming zigzags when attached valve to valve to each other. *Diadesmis sp.* were found as linear colonies distinguished by biraphid valves containing single, slightly lobed choroplast resting on one side of the girdle in every valve. Solitary *Coscinodiscus sp.* cells were also observed from the samples (Kudela Lab Biological Oceanography; Janse van Vuuren, 2006).

Table 2.2.3-6 Photo documentation of specimen

 *Fragilaria sp.*	 *Surirella sp.*	 *Spirogyra sp.*
 *Tabellaria sp.*	 *Diadesmis sp.*	 *Coscinodiscus sp.*





Note:
FE-15, FE-17 and FE-19 were sampled in 2012
FE-20 and FE-21 were sampled in 2015

Figure 2.2.3-3 Mean abundance and major taxa distribution among retained sampling stations

In various studies, temporal conditions which include nutrients and some physico-chemical parameters were found to be limiting factors for the propagation of plankton (Dixit and Tawari, 2007; Sargaonkar and Deshpande, 2003). Data collected in 2019 and 2012 were processed for their correlation coefficients (***r***). A summary is provided in **Table 2.2.3-7** for the strong positive (***r***=≥0.5) and strong negative (***r***=≤-0.5) correllations found. The strongest correlation was observed between taxa richness with diversity and ammonia. A study conducted by Smith et al. (2014) garnered results that proved phytoplankton competing for ammonia regulated nitrification more than light itself. Another study about ammonium and phytoplankton relationships implied that ammonia and nitrates can be a limiting factor for some dinoflagellates (Berman et al., 1984).

Table 2.2.3-7 Summary of Correlations for Total Mean Abundance, Taxa Richness and Diversity with nutrients and other physico-chemical parameters

<table>
<tr><th colspan="2">Strong Positive
r=≥0.5</th><th colspan="2">Strong Negative
r=≤-0.5</th></tr>
<tr><td>Total Mean Abundance</td><td>Ammonia</td><td rowspan="2">Taxa Richness</td><td>Temperature</td></tr>
<tr><td rowspan="4">Taxa Richness</td><td>Diversity</td><td>Phosphates</td></tr>
<tr><td>Turbidity</td><td rowspan="2">Diversity</td><td>Temperature</td></tr>
<tr><td>TSS</td><td>Phosphates</td></tr>
<tr><td>Ammonia</td><td colspan="2" rowspan="4">Strong Positive Correlation – may suggest that variables are proportionally related with each other. If variable x increases, variable y increases, and vice versa.

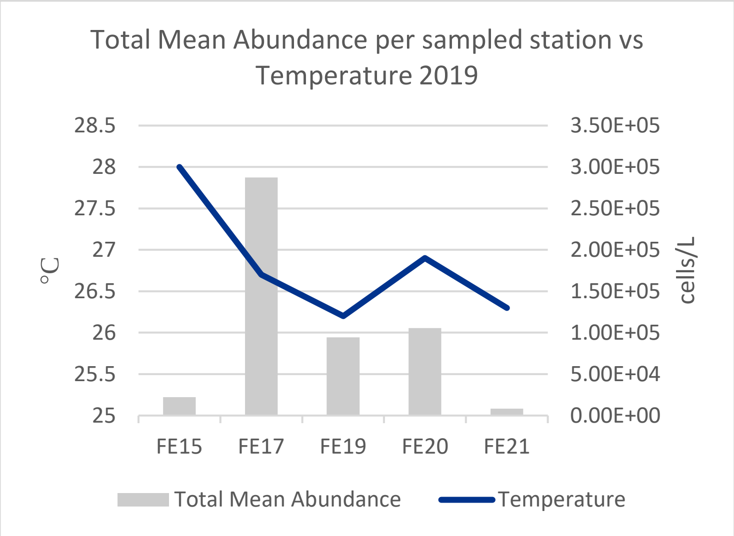
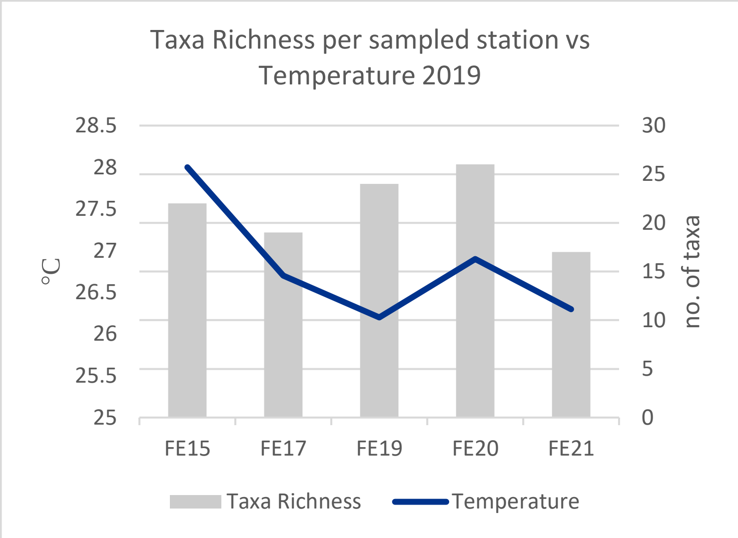
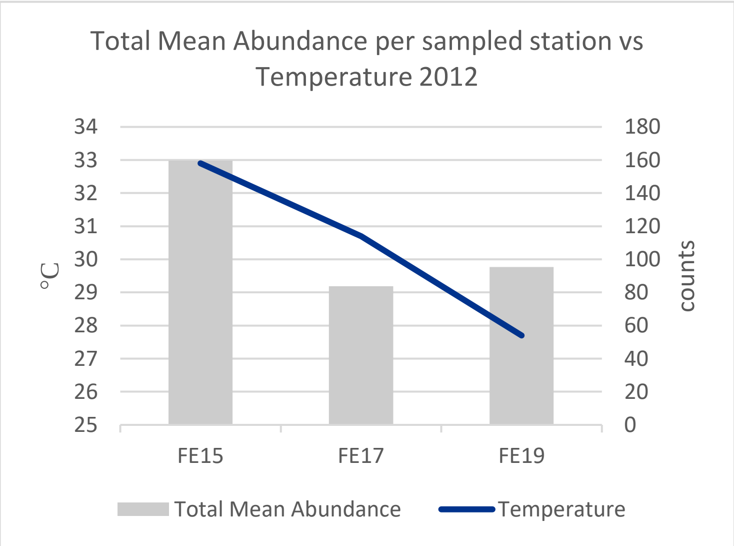
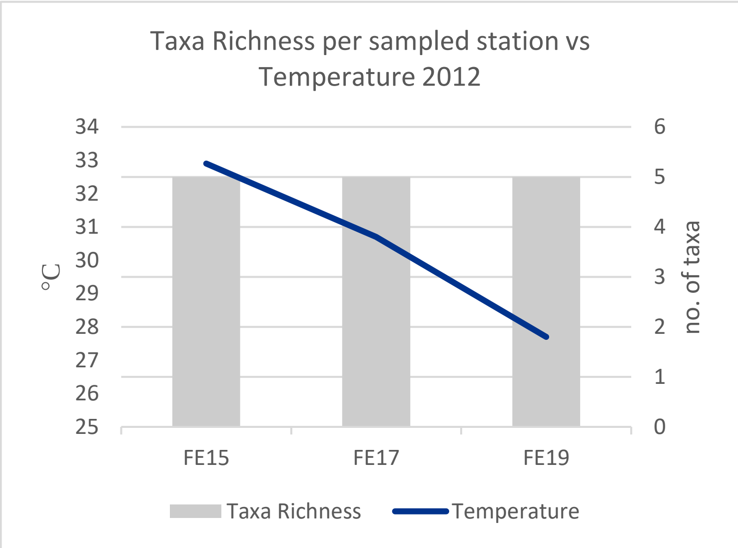
Strong Negative Correlation – may suggest that variables are inversely proportionally related with each other. If variable x increases, variable y decreases, and vice versa.</td></tr>
<tr><td rowspan="3">Diversity</td><td>Turbidity</td></tr>
<tr><td>TSS</td></tr>
<tr><td>Ammonia</td></tr>
</table>

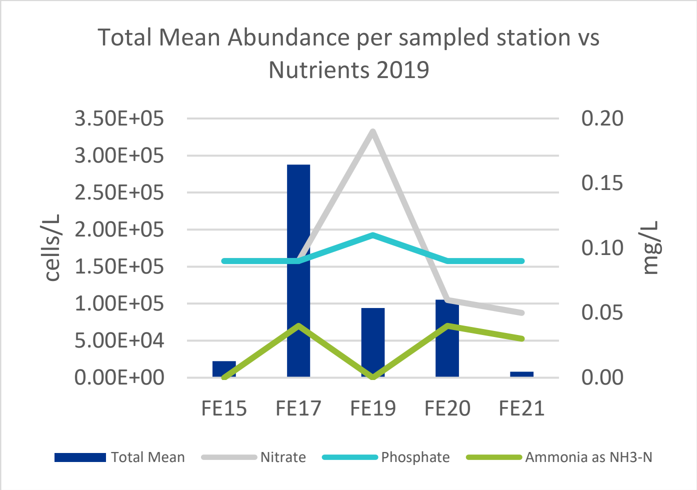
Shannon's diversity indices (*H'*) were calculated per station and ranged from 1.01 to 1.23 for this year's sampling activity which were relatively higher compared to the 2012 and 2015 data which only ranged from 0.2 to 0.95. Evenness values (E_H) were derived from diversity indices values which ranged from 0.327 to 0.387 this year, 0.156 to 0.251 in 2015 and 0.590 in 2012 which suggests that there were more dominant species found during the 2015 study.

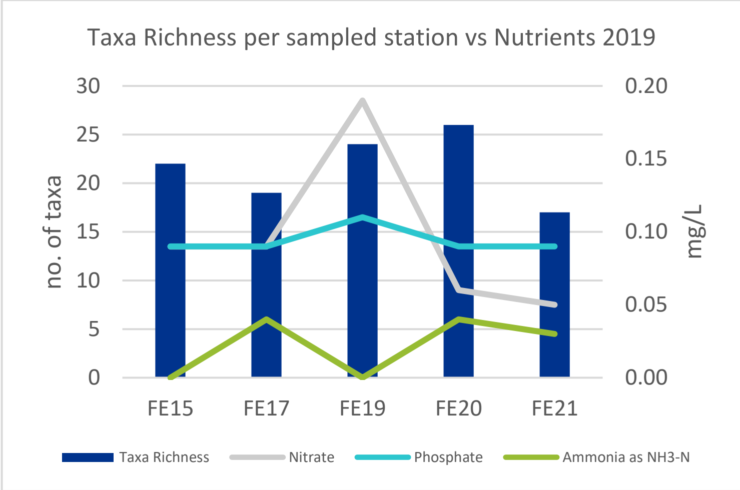
In this year's study, ANOVA was calculated per station and data were found to be significant having *p-values* of ≤0.05. Although there were enough data to perform statistical analyses, it is not sufficient to illustrate trends. Data were plotted as graphs to visualize results instead. **Table 2.2.3-8** provides a visual summary in figures of the total mean abundances and taxa richness of all plankton across all stations overlayed with inorganic non-metallic nutrient parameters (nitrates, phosphates and ammonia) and other physico-chemical parameters. Based on visual analyses of the processed figures, it was observed that surface water velocity primarily influenced the abundance of plankton present in the system. Stations with higher stream flow had low plankton densities while stations with lower stream flow supported high plankton densities. This was consistent with the 2012 and 2019 data. Studies done by Li et al. (2012) also provided evidence that phytoplankton biomass and distribution depend highly on flow conditions but were inconsequential for taxonomic diversity and composition.

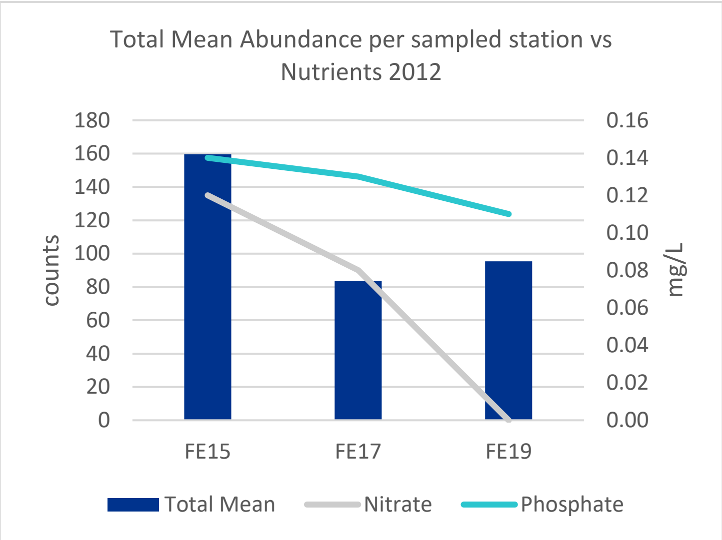
Primary productivity studies were conducted in 2012 for Lake Mainit and Lake Mahukdam but were not conducted during this sampling event as the retained sampling stations did not coincide with stations from these lakes. Hence, no data comparison was performed. Moreover, 2015 plankton data were not plotted as water quality data for this sampling year is not available.

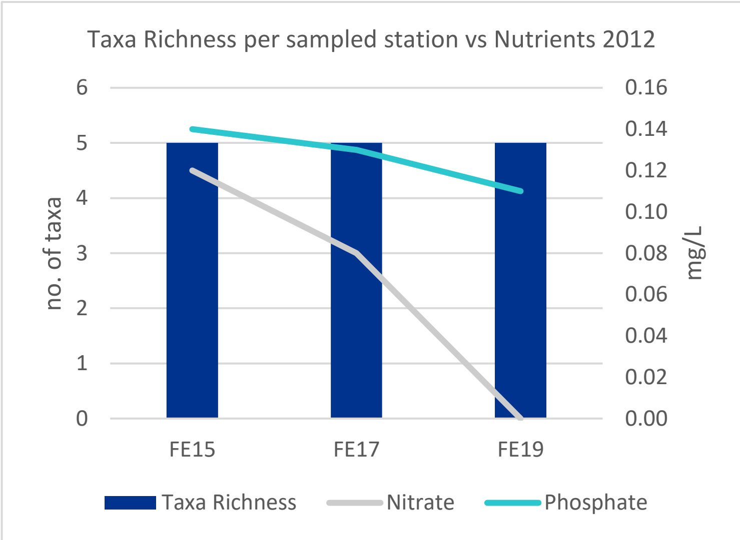
Table 2.2.3-8 Summary in figures of total mean abundances and taxa richness vs nutrients and other physico-chemical parameters

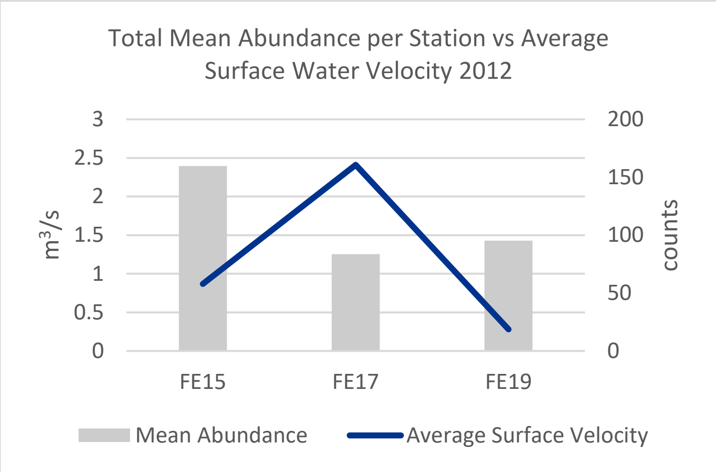
Total Mean Abundance vs other parameters	Taxa Richness vs other parameters
	
	

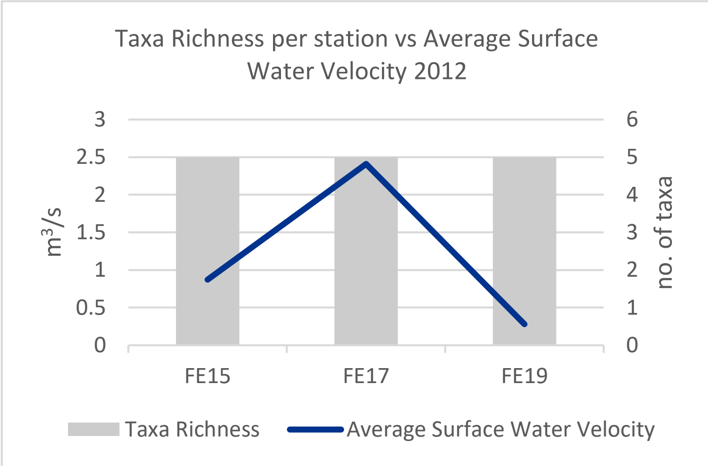

Total Mean Abundance per sampled station vs Nutrients 2019
cells/L
mg/L
3.50E+05
3.00E+05
2.50E+05
2.00E+05
1.50E+05
1.00E+05
5.00E+04
0.00E+00
0.20
0.15
0.10
0.05
0.00
FE15
FE17
FE19
FE20
FE21
Total Mean
Nitrate
Phosphate
Ammonia as NH3-N

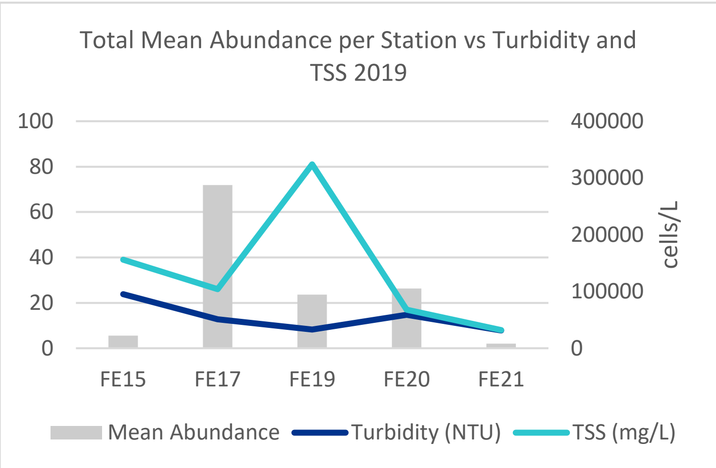

Taxa Richness per sampled station vs Nutrients 2019
no. of taxa
mg/L
30
25
20
15
10
5
0
0.20
0.15
0.10
0.05
0.00
FE15
FE17
FE19
FE20
FE21
Taxa Richness
Nitrate
Phosphate
Ammonia as NH3-N

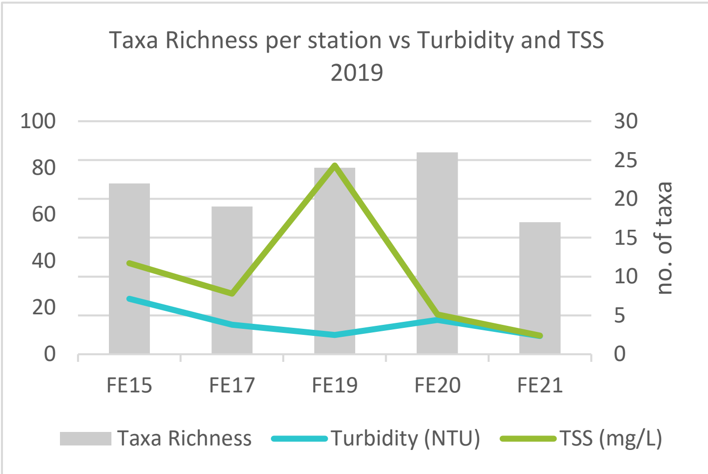

Total Mean Abundance per sampled station vs Nutrients 2012
counts
mg/L
180
160
140
120
100
80
60
40
20
0
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
FE15
FE17
FE19
Total Mean
Nitrate
Phosphate

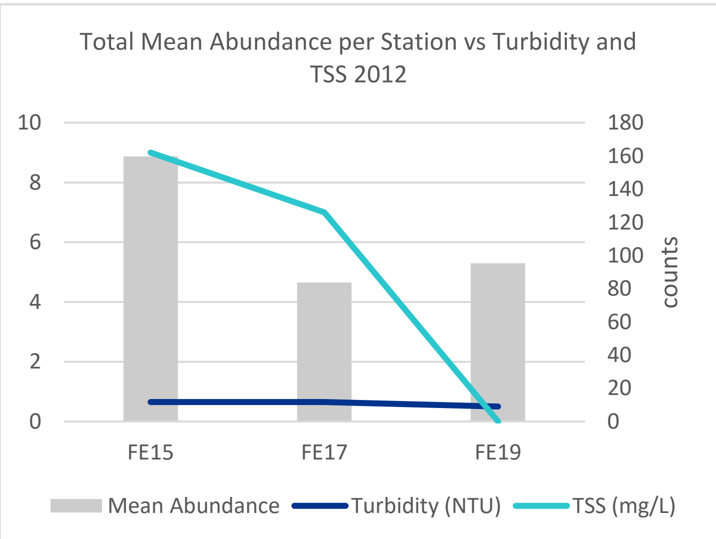

Taxa Richness per sampled station vs Nutrients 2012
no. of taxa
mg/L
6
5
4
3
2
1
0
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
FE15
FE17
FE19
Taxa Richness
Nitrate
Phosphate

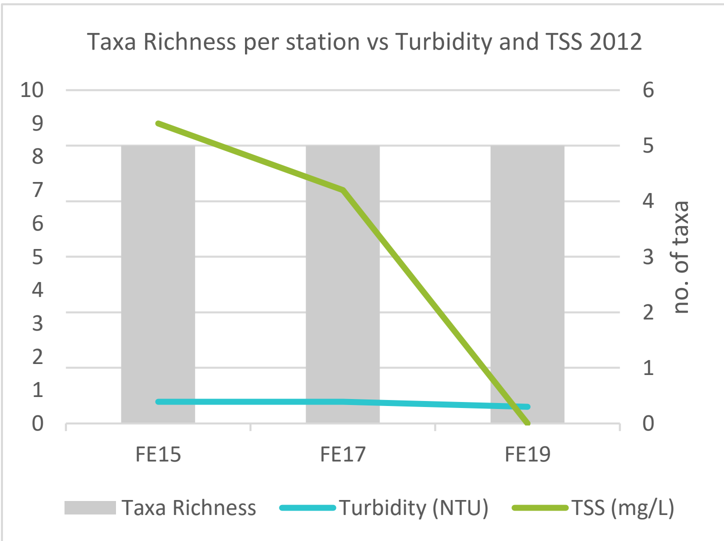

Total Mean Abundance per Station vs Average Surface Water Velocity 2012
m³/s
counts
3
2.5
2
1.5
1
0.5
0
200
150
100
50
0
FE15
FE17
FE19
Mean Abundance
Average Surface Velocity

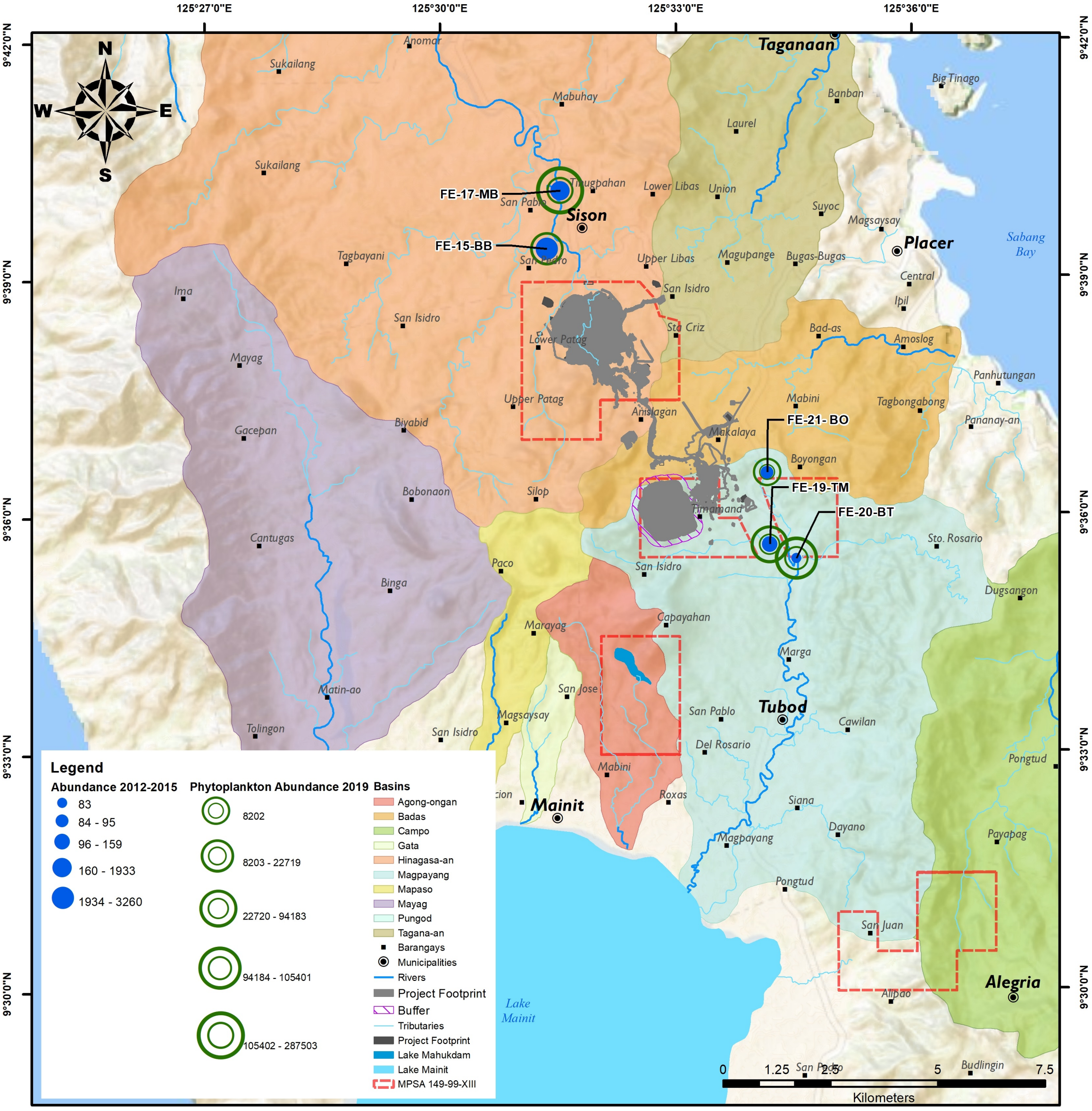

Taxa Richness per station vs Average Surface Water Velocity 2012
m³/s
no. of taxa
3
2.5
2
1.5
1
0.5
0
6
5
4
3
2
1
0
FE15
FE17
FE19
Taxa Richness
Average Surface Water Velocity


Total Mean Abundance per Station vs Turbidity and TSS 2019
cells/L
100
80
60
40
20
0
400000
300000
200000
100000
0
FE15
FE17
FE19
FE20
FE21
Mean Abundance
Turbidity (NTU)
TSS (mg/L)


Taxa Richness per station vs Turbidity and TSS 2019
no. of taxa
100
80
60
40
20
0
30
25
20
15
10
5
0
FE15
FE17
FE19
FE20
FE21
Taxa Richness
Turbidity (NTU)
TSS (mg/L)


Total Mean Abundance per Station vs Turbidity and TSS 2012
counts
10
8
6
4
2
0
180
160
140
120
100
80
60
40
20
0
FE15
FE17
FE19
Mean Abundance
Turbidity (NTU)
TSS (mg/L)


Taxa Richness per station vs Turbidity and TSS 2012
no. of taxa
10
9
8
7
6
5
4
3
2
1
0
6
5
4
3
2
1
0
FE15
FE17
FE19
Taxa Richness
Turbidity (NTU)
TSS (mg/L)



Phytoplankton density (cells/L) distribution in rivers

Silangan Copper-Gold Project

Province of Surigao del Norte

Silangan Mindanao Mining Company Inc.

Scale 1 : 120,000	
PLOTTED : RCA	DATE : 03/05/2019
REVIEWED : MKM	APPROVED : KHG

16F South Tower, Rockwell Business Center Sheridan cor. United St. Mandaluyong City

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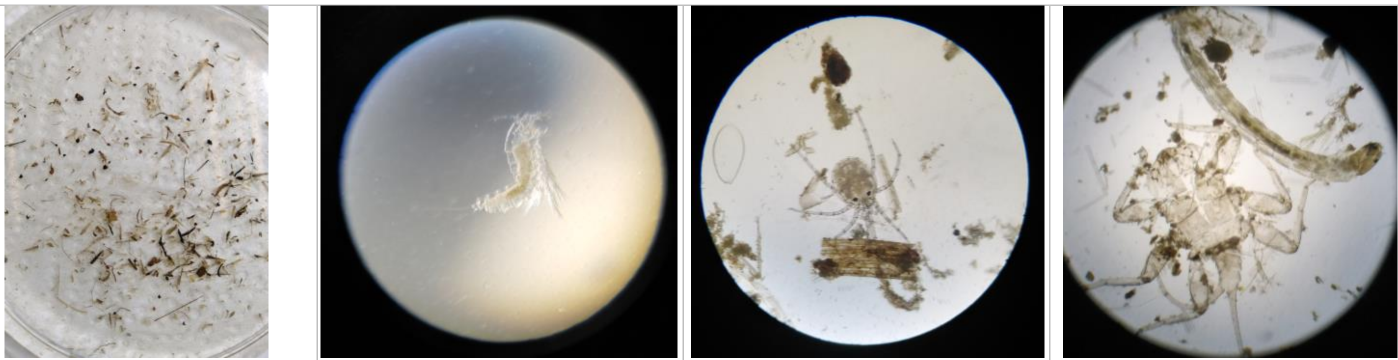
Administrative boundaries are approximate. Therefore it is not authoritative and should be used for planning and visualization purpose only.

Figure 2.2.3-4 Phytoplankton Density (cells/L) Distribution – River Systems

Zooplankton and Macrobenthos

Zooplankton and macrobenthos data were combined in this study as the streams were very shallow and plankton sampling, even with minimal movement in the water, created substrate disturbance lifting macrobenthos. Moreover, many of the taxa observed from plankton samples were also found in the macrobenthos samples and created overlap in data.

Individuals were organized into higher classifications to retain data continuity. A total of 2,399 individuals were identified under 4 classes, 2 subclasses, 1 family and 12 orders in this study with the most abundant individuals being under the PET (Orders *Plecoptera, Ephemeroptera and Trichoptera*) taxa. *Plecopterans* made 64.4%, and *Ephemeropterans* made 21.6% of the community. In 2012, *Trichopterans* were found to dominate the macroinvertebrate community by making up 46.6% of the total assemblage. These pollution-sensitive groups are used to recognize and evaluate the over-all health of fresh water systems (Wahizatul et al., 2011). These insects are considered bioindicators in numerous studies such as this due to their rapid and consistent ability to respond to changes in environmental conditions (Tonkin et al., 2015). Chironomids (*Diptera*), Mayflies (*Ephemeroptera*), and Stoneflies (*Plecoptera*) were consistently found in all five stations for the 2019 study. On the other hand, Caddisflies (Trichoptera), Mayflies (Ephemeroptera), and Chironomids (Diptera), were observed to be the most frequent in the 2012 study wherein they were found in 23, 19 and 17 out of 24 stations, respectively. A comparison of the assemblages from the 2012 and 2019 sampling events are summarized in **Table 2.2.3-9**. As for diversity, highest heterogeneity was observed in FE-20 (Boyongan and Timamana Creeks). Similarly with the observed phytoplankton assemblage, high diversity in this station may be attributed to minimal anthropogenic disturbances. Some zooplankton and microbenthic specimens have been photographed and provided in **Figure 2.2.3-5.**



A collection of a macrobenthic sample	*Amphipoda*	*Hydrachnida*	*Plecoptera and Chironomid*

Figure 2.2.3-1 Some zooplankton and macrobenthic specimes observed

Freshwater zooplankton in the Philippines is naturally few, low in biomass (Mamaril, 2001) and monotonously composed of crustaceans (*Cladocera* and *Copepoda*) (Fernando, 1980). Their abundance in rivers is much lower compared to that of the phytoplankton (Thorp et al. 1994). This low number may be caused by their shorter residence times in rivers. Unlike phytoplankton which is more controlled by river nutrient concentrations rather than hydrologic conditions in their reproduction, the zooplankton reproduces slow and then easily gets carried away by the river flow (Pace et al. 1992). Due to this, the zooplankton density and biomass were not computed.

Table 2.2.3-9 Summary of assemblage details and Frequency

Taxonomic Group		Common Names	2019 (N=5)			2012 (N=24)		
			Mean	Percentage	Frequency	Mean	Percentage	Frequency
O	AMPHIPODA	Scuds; Side Swimmers	0.2	0.0%	1	0	0.0%	0
O	ARANEAE	Spiders	0	0.0%	0	0.08	0.0%	2
C	BIVALVIA	Bivalves	0	0.0%	0	0	0.0%	0
O	CLADOCERA	Daphnia	0.4	0.1%	2	0	0.0%	0
O	COLEOPTERA	Beetles	5.6	1.2%	2	20.38	12.5%	12
SC	COPEPODA	Copepods	1.4	0.3%	3	0	0.0%	0
F	CULICIDAE	Mosquitoes	0.4	0.1%	1	0	0.0%	0
O	DECAPODA	Decapods	2.6	0.5%	3	1.75	1.1%	4
O	DERMAPTERA	Earwigs	0	0.0%	0	0.08	0.0%	2
O	DIPTERA	Flies/Chironomids	40.4	8.4%	5	10.12	6.2%	17
O	EPHEMEROPTERA	Mayflies	103.8	21.6%	5	14.87	9.1%	19
C	GASTROPODA	Snails	0.6	0.1%	3	2.17	1.3%	2
O	HEMIPTERA	True Bugs	0.4	0.1%	2	18.17	11.1%	13
O	HYMENOPTERA	Wasps, Bees and Ants	1	0.2%	2	0.04	0.0%	1
O	LEPIDOPTERA	Butterflies	1.2	0.3%	1	9.3	5.7%	2
O	ODONATA	Dragonflies	0	0.0%	0	2.17	1.3%	9
SC	OLIGOCHAETA	Earthworms	1.2	0.3%	2	0.12	0.1%	2
O	ORTHOPTERA	Grasshoppers	0	0.0%	0	0.04	0.0%	1
C	OSTRACODA	Seed Shrimps	0.2	0.0%	1	0	0.0%	0
O	PLECOPTERA	Stoneflies	309	64.4%	5	8.04	4.9%	15
C	POLYCHAETA	Polychete Worms	3	0.6%	4	0.04	0.0%	1
O	TRICHOPTERA	Caddisflies	7.4	1.5%	3	76.13	46.6%	23
O	TROMBIDIFORMES	Water Mites	1	0.2%	3	0	0.0%	0
C – Class F – Family SC – Subclass O – Order								

Relative percent abundance of PET taxa was found to range from 42-92% in February 2019 while ranging from 9-86% in 2012. Chironomid abundance is also evaluated in this study to calculate for the PET:C ratio per station. These insects are able to easily propagate, identified as pollution-resistant, due to their various charachteristics such as having a high variety in feeding types, having no habitat restrictions and ability to adapt and tolerate changes in environmental conditions (Wahizatul et al., 2011). An ideal PET:C ratio would have higher abundance of PET taxa over the abundance of Chironomids per station, thus, a higher number indicates better conditions and a lower number indicates otherwise. Generally, conditions in 2012 supported higher PET:C ratios than the study conducted this year. A 97.67% decrease in the PET:C ratio found in FE-17 (Mabuhay) may indicate an enormous decline in water conditions. This decrease is to be expected as this station is highly disturbed due to quarrying activities present. FE-19 (Timamana) also exhibited an immense 50% decrease in PET:C ratio. The decline in this station may be attributed to anthropogenic waste rich run-off received by this system as settlements are presenent on both northern and southern sides of the river. On the otherhand, an 82.35% increase in PET:C ratio was found in FE-20 (Boyongan and Timamana Creeks) and may be attributed to less disturbances present in the station. Surrounding this station are grasses, ricefields adjacent to the eastern bank, and trees on the east. This finding is also supported by the highest phytoplankton taxa richness reported in this station which serves as food for a wider variety of invertebrates. High abundance and high diversity in this station may also suggest that it supports a balanced ecosystem and is reflected by the FBI and WQI scores.

Other metrics and indices, such as the Hilsenhoff Family Biotic Index (FBI) and Water Quality Index (WQI), were calculated and compared to previous results. A low FBI corresponds to a higher WQI. Degrees of pollution were then determined based on the WQI score garnered from the results and it was found that all retained stations have some degree of pollution present except for FE-20 (Boyongan and Timamana Creeks), while all were reported to have excellent water quality conditions in 2012. A comparison of the 2012 and 2019 metrics and indices are summarized in **Table 2.2.3-10**.

Table 2.2.3-10 Comparison of 2019 and 2012 Metrics

Metrics	2019					2012				
	FE-15	FE-17	FE-19	FE-20	FE-21	FE-15	FE-17	FE-19	FE-20	FE-21
	Busong-busong	Mabuhay	Timamana	Boyongan and Timamana Creeks	Boyongan Creek	Busong-busong	Mabuhay	Timamana	Boyongan and Timamana Creeks	Boyongan Creek
Total Abundance	138	67	377	1764	53	120	249	217	154	46
% Abundance of PET	57	42	87	92	77	37	86	65	16	9
PET:C	2	1	9	17	8	0	43	18	3	0
FBI	4.48	4.99	3.40	2.86	4.98	1.69	3.66	2.89	2.53	0.93
WQI	Good	Good	Very Good	Excellent	Good	Excellent	Excellent	Excellent	Excellent	Excellent
Degree of Pollution	Some organic pollution probable	Some organic pollution probable	Possible slight organic pollution	Organic pollution unlikely	Some organic pollution probable	Organic pollution unlikely	Organic pollution unlikely	Organic pollution unlikely	Organic pollution unlikely	Organic pollution unlikely

Periphyton

Periphyton percent coverage was observed to range from 0 to 34.17% of the total averaged coverage from the random throws. Coverage from these stations wwere mostly comprised of green algae (*Spirogyra sp.)*, and blue-green algae (*Oscillatoria sp).* Highest periphyton coverage was recorded in the station located in Tiamamana (FE-19). A high periphyte coverage may be attributed to the high total coliform counts in the area, both coming from the surrounding households and grazing animals. A study done by Derlet et al. (2012) provided evidence of high

Figure 2.2.3-2 Rock outcrop observed in station FE-15

periphytic algal biomass in areas where cattles graze, compromising water quality, as compared to water bodies for recreational use and in remote wildlife areas. In FE-15, periphyton coverage was observed at approximately 40% on the big rock outcrop as seen on **Figure 2.2.3-5.**

From the previous study, periphyton samples were taken from Boyongan Creek (FE-21) but periphyton was not observed during the sampling event this year wherein random throws garnered a consistent 0% coverage from this station. This may have been due to the consistent rainfall received by the surrounding water systems as sampling was conducted towards the end of the rainy season. Additionally, Boyongan Creek was observed to show signs of errosion as the depression of the creek bottom from the ground surface has become deeper. An increased stream velocity, especially after strong and/or consistent rainfall events, increases frictional shear in the water and assists in the retardation of periphyton growth in the system (Hroner and Welch, 2011).

Table 2.2.3-11 Periphyton percent coverage per station

	FE-15	FE-17	FE-19	FE-20	FE-21
	Busong-busong	Mabuhay	Timamana	Boyongan and Timamana Creeks	Boyongan Creek
% Coverage per random throw	0	0	40	0	0
	0	30	80	0	0
	0	2	20	0	0
	0	90	40	0	0
	0	10	5	0	0
	0	6	20	0	0
Total % Average	0	23.00	34.17	0	0

Figure 2.2.3-3 Total Abundance (no. of individuals) of Macrobenthos –River Systems

Figure 2.2.3-4 Total Number of Macroinvertebrate Taxa – River Systems

Figure 2.2.3-5 Macroinvertebrate Family Biotic Index – River Systems

Fish

Based on interviews with local residents, four species of fish were recorded to be the most common in the fresh water systems surrounding the study area. These include the Marbled Eel (*Anguilla marmorata),* Tilapia *(Oreochromis niloticus), Eleotid Goby (Hypseleotris agilis), Bareye/White Goby (Glossogobius giuris),* and Snakehead Murrel *(Channa striata)*. Fishing activities of the locals utilized home-made spears, hook and line or “bingwit” and electro-fishing.

Tilapia (Oreochromis niloticus)

Tilapia has been introduced in the Philippines in the 1970s for aquaculture purposes which had a more positive impact on the socio-economic aspect than ecologically (Food and Agriculture Organization of the United Nations, 2019). Numerous studies on tilapia has been conducted in both cotrolled and un-controlled environments for its probability to cause imbalances in natural ecological systems. These studies have provided evidence that tilapias have a high potential of competing with indigenous species as they have less selective feeding habits and highly tolerant to changes in environmental conditions and were recommended to be managed carefully (Ahmad et al., 2010 and Canonico et al., 2005).

Marbled Eel (Anguilla marmorata)

Studies on the population structure of giant molted eels in the pacific showed that it has four genetically different populations located in the North Pacific (Japan Taiwan, Philippines, Sulawesi), South Pacific (Tahiti, Fiji, New Caledonia, Papua New Guinea), Indian Ocean (Réunion, Madagascar), and Guam regions (Minegishi et al., 2008). Histology of these species details migration between freshwater and brackish water systems. Nonetheless, their migratory flexibility may also differ depending on habitat, inter- and intra-specific competition and environmental conditions. (Arai et al., 2010). A study conducted by Luo et al. (2013) concluded that *A. marmorata* thrives in waters having a temperature range of 28-33°C making it suitable for commercial aquaculture. It is locally known as Kasili and highly fished in the area.

Eleotrid goby (Hypseleotris agilis) and Bareye/White Goby (Glossogobius giuris)

H. agilis and *G. giuris,* locally known as *Buguan/Luyab* and *Pijanga,* were found to be endemic in Lake Mainit, Surigao del Norte and are among the most abundant commercial fish caught in the lake. Highest yields for these species were documented in April and September, while the lowest yields were observed during the months of November and December. Nevertheless, spawning of these species were reported to be active throughout the year (Galicia and Lopez, 2001).

H. agilis and *G. giuris* were later accidentally introduced to Lake Lanao in Lanao del Sur in the 1960s (Nacua et al., 2012). These accidental introductions were then hypothesized to be responsible for the decrease in Lake Lanao’s endemic fish species (Guerero III, 2014).

Snakehead Murrel (Channa striata)

C. striata, locally known as *Hayuan/Dalag*, was found to produce maximum yields towards the end of the wet season (Amilhat and Lorenzan, 2005). It has been proven to aid in the reduction of pain and discomfort from clinical operations, as well as for healing of other dermal wounds. This then led to a high demand for its commercial cultivation (Gam et al., 2006).

Summary of Endemicity/Conservation Status

Most econimcally significant fish species evaluated in this study are also found to be widespread all over the Pacific island regions and are commercially cultured or fished. Despite their economic role and extensive exploitation, these fish species are listed as Species of Least Concern under the IUCN Red List. An exception is with *H. aguilis* which has not been widely evaluated. Details about their endemicity, distribution and IUCN Red List Rankings are summarized in **Table 2.2.3-12**.

Table 2.2.3-12 Endemicity, Geographic Range and IUCN Red List Ranking of economically important fish species in the study area

Photo	Binomial Nomenclature	Common Name(s)	Local Name	Endemicity	Geographic Range	IUCN Red List Ranking (Latest Assessment Year)
	*Anguilla marmorata*	Giant Mottled Eel Marbled Eel	Kasili	Pacific Island Regions Indian Coastal Areas East to South Afrrican Coastal Areas		Least Concern (2013)
	*Channa striata*	Snakehead Murrel	Hayuan Dalag	Asia		Least Concern (2009)
	*Glossogobius giuris*	Bareye Goby White Goby	Pijanga	Native to Lake Mainit, Surigao del Norte	Pacific Island Regions Australia East to South Afrrican Coastal Areas	Least Concern (2013)

	*Hypseleotris agilis*	Eleotrid Goby	Buguan Luyab	Native to Lake Mainit, Surigao del Norte	No data	No data
	*Oreochromis niloticus*	Nile Tilapia	Tilapia	Africa	Asia Africa Europe Central and South America	Least Concern (2018)

Pollution Indicator Species

Phytoplankton and Periphyton

Fragilaria sp. was found to dominate the plankton communities in the sampled stations. Moreover, the dominance of this species, and the presence of several pollution indicator species, namely, *Coscinodiscus sp., Navicula sp., Nitzschia sp., Pleurosigma sp., Surirella sp., Spirogyra sp., Aphanizomenon sp., Oscillatoria sp., Ceratium sp., Prorocentrum sp., Protoperidinium sp.,* and *Euglena sp.* have been observed. Although having a higher range of diversity index (*H'*) socres compared to the previous years, low taxonomic evenness (H_E) during this study provided evidence of the existing imbalance of species distribution in the area. Propagation of these pollution-indicator species may be attributed to stream flow rates (Li et al., 2012), and continuous eutrophication due to domestic and other nutrient run-offs received by these water systems. Additionally, these species have the ability to adapt to various and rapid changes in environmental conditions (Nwonumara, 2018; Rai et al., 2008; Singh et al., 2013).

Zooplankton and Macrobenthos

PET (*Orders Plecoptera, Ephemeroptera and Trichoptera*) taxa were evaluated in this study to recognize and evaluate the over-all health of fresh water systems (Wahizatul et al., 2011). These pollution-sensitive bioindicators are able to rapidly and consistently respond to changes in environmental conditions (Tonkin et al., 2015). PET taxa to Chironomid ratios were found to be low, and HFBI scores were high. Although mean abundance of macroinvertebrates was observed to have increased during this study, metric scores calculated for the sampled stations provided evidence that the surrounding water systems in the study area are already under pressure. An increase in the degree of pollution was observed to be most severe in stations FE-17 (Mabuhay) and FE-19 (Timamana). A continuous decrease in water quality and an increase in ecological imbalance are foreseen due to the increasing anthropogenic disturbances in the area.

Sources of Threats to Freshwater Ecology

As aforementioned in **Section 2.2 Water Quality Section** the major sources of threat to the river systems and consequently to the biological communities in these waterways are the untreated domestic discharges and agricultural runoff. Anthropogenic disturbances in the form of subsistence fishing and domestic use were also observed. Moreover, due to the interconnection of various ecological communities both aquatic and on land, changes in the environment may trigger trophic cascades. A simplified illustration of aquatic inter-relationships is perceived in **Figure 2.2.3-6,** while **Figure 2.2.3-7** generally enumerates factors that may influence trophic cascades.

Changes in the surrounding riparian vegetation, sometimes in the form of habitat alterations like deforestation and clearing for agricultural purposes, may influence the abundance and diversity of the aquatic biota present in the system. Pollution and wastes from domestic, industrial and agricultural plots may increase pressure on these systems as both organic and in-organic pollutants may lead to eutrophication and algal blooms causing a ***Bottom-Up trophic cascade*** *(Derlet et al., 2011)*. Additionally, climate change and anthropogenic driven deviations may influence the intensity of each others impacts. On another note, Non-indigenous Invasive Species (NIS) introduced in a natural system may alter the feeding behaviors of certain individuals which may cause eliminations of certain species in the local hierarchy of an ecosystem causing a ***Top-Down trophic cascade*** (Canonico et al., 2005; Walsh et al., 2016).

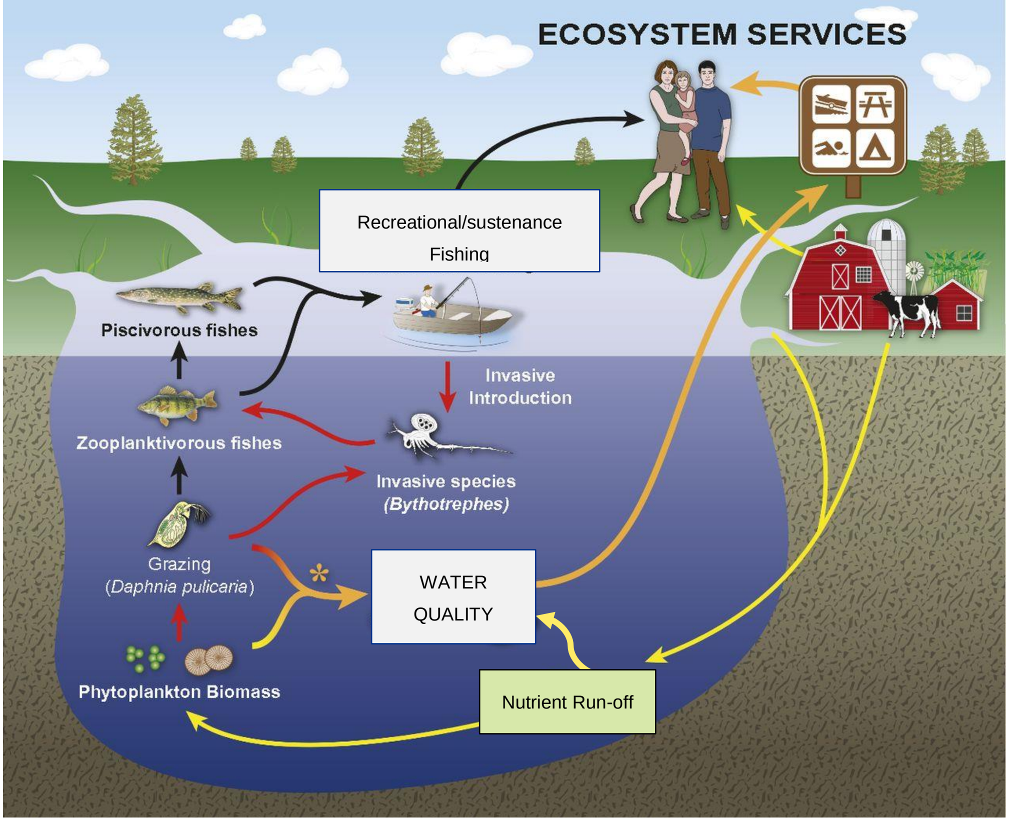


Figure 2.2.3-6 A simplified representation of anthropogenic and aquatic inter-relationships (Walsh et al., 2016)

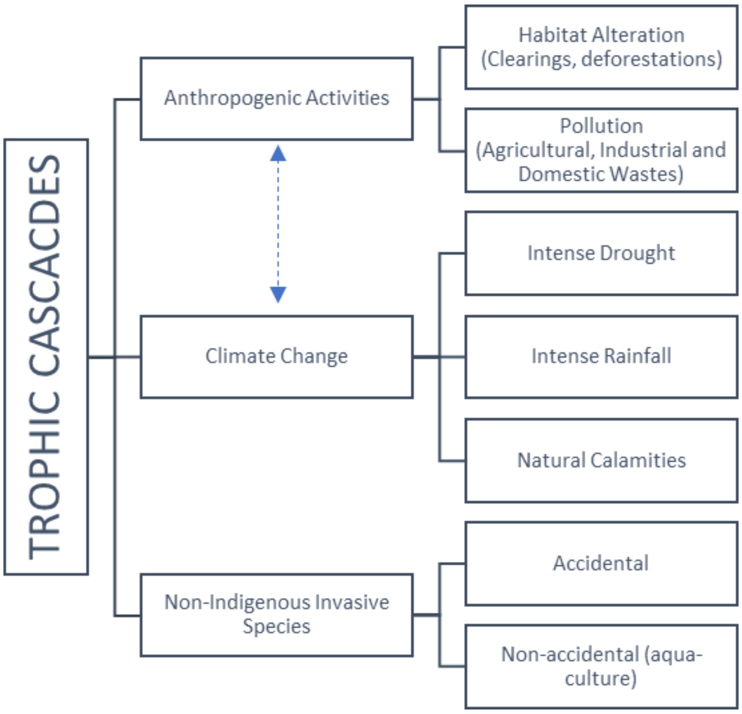


Figure 2.2.3-7 An overview on factors that may lead to Trophic Cascades

Climate Change Impacts Without the Project

The projected increasing extreme precipitation in the whole of Surigao del Norte Province will cause potential flooding of the river systems even without the project. Severe flooding can affect in-stream and riparian habitats and associated aquatic assemblages. While fish, macroinvertebrate, and algal communities have evolved with dynamic conditions and are relatively resilient to extreme hydrologic events, significant reductions in the density and biomass of these communities and shifts in community composition have been documented following severe floods (NYSERDA, 2015). On the other hand, during drier dry periods these river systems are prone to drought that can cause channel reduction. Stream contraction can bring about concentration of solutes, materials, and organisms; separation of populations; reduction of habitat availability; and alteration of ecosystem processes (Stanley et al. 1997). Consequently, even without the project, the river systems surrounding the project site is vulnerable to disturbances.

Baseline Environment for Freshwater Ecology- Lakes

Key findings and conclusions of the lakes studied were presented in this subsection.

Baseline Environment for Freshwater Ecology- Lakes

This subsection presents the key findings of studies on Lake Mahukdam and Lake Mainit and is summarized in **Table 2.2.3-13**.

Table 2.2.3-13 Key Findings and Conclusions – Freshwater Ecology (Lake Mahukdam and Lake Mainit)

Baseline Information	Key Findings and Conclusions
Abundance, frequency, and distribution of species	• Phytoplankters in Lake Mahukdam was dominated by green-algae causing a medium-scale bloom. Eight major taxa of zooplankton were identified, mostly microcrustaceans, which are primarily consisted of copepods (94%). In Lake Mainit, six phytoplankton genera were recorded, primarily composed of *Nitzschia*. Sampling stations at the western side exhibited relatively higher densities compared to the western portion most probably because of relatively more input from the Mayag River draining to this part of the lake. Zooplankton densities exhibited opposite distribution. Zooplankters were composed of copepods in different stages/forms. • The soft-bottom benthos in Lake Mahukdam is naturally depauperate because the lake was formed from a natural depression with no rivers or tributaries that can provide nutrients and organic assemblages to the lake. The four organisms observed were detritus-feeding oligochaete and nematode worms. In Lake Mainit, the benthic assemblage was likewise dominated by the oligochaetes (45%) and the nematodes (17%), which, together with the other six taxa recorded, had a mean density of 418 $\pm$ 224 ind/m^2 in five of the seven sampling stations where organisms were found. • Fish samples from Lake Mainit showed levels of cadmium, lead, mercury, and arsenic that were below the set standard limits for these metals. Levels of copper and zinc were comparable to values found in finfishes in Australian waters.
Presence of ecologically important species	• No potentially toxic plankton organisms were identified in the lakes. • No rare or threatened macrobenthos were observed in the lakes.
Presence of economically important species	• Lake Mainit has a thriving fishery, the most important species of which are the pijanga (*Glossogobius giuris*) and bugwan (*Hypseleotris agilis*). Other important species include the tilapia (*Oreochromis nilotica*), "kasili" (*Anguilla marmorata)* and carp (*Cyprinus carpio*).
Presence of pollution indicator species	• The dominance of detritus-feeding marine worms concurs with the prevalently fine-grained substrate and high sedimentation rates in the lakes.
Current sources of threat to aquatic ecology and observed/assessed capacity of the receiving ecosystem	• Lake Mahukdam, due to its location, is only generally affected by natural disturbances. Lake Mainit, on the other hand, is threatened by unsustainable fishing practices, increasing populations in settlements near the lake, agricultural run-off, domestic waste inputs and conversion of some wetlands into agricultural areas such as rice paddies.

Fish Bioassay

Table 2.2.3-14 shows the results of the bioassay on the fish samples from Lake Mainit. Levels of cadmium, lead, mercury, and arsenic had standards that were all below their limits in all the fish samples. Levels of copper and zinc in the fish samples were comparable to values found in finfishes in Australian waters.

The low levels of heavy metals in the fish tissues show natural background levels. This is the first time that concentrations in fish tissues has been done for some of the fishes caught in Lake Mainit. In terms of levels in water, lead, cadmium and mercury were likewise below the maximum permissible limits (Tumanda et al. 2005).

Table 2.2.3-14 Heavy metal concentrations in fishes caught from Lake Mainit

Analytes (µg/g)	Standards					*Oreochromis niloticus*	*Glossogobius giurus*	*Ophicephalus striatus*
	ANZFA Guideline (Total Metals as µg/g wet weight)	Codex Alimentarius, UNFAO (methyl mercury as µg/g wet weight)	USFDA (methyl mercury as µg/g wet weight)	EC (Total Metals as µg/g wet weight)	UK (Total Metals as µg/g wet weight)			
Cadmium	0.2			0.1		>0.02	>0.02	>0.02
Copper						0.40	0.20	0.20
Lead				1	2.0	>0.1	>0.1	>0.1
Zinc						4.40	4.70	4.20
Mercury	0.5	0.5	1.0	0.5		>0.02	0.05	0.15
Arsenic	1.0					>0.1	>0.1	>0.1

Pollution Indicator Species

No indicator genera and potentially toxic plankton organisms were recorded. On the other hand, the dominance of detritus-feeding benthic groups (e.g. oligochaetes and nematodes) can be indicative of sedimentation and prevalence of fine-grained substrate in the lakes. For future monitoring, the numerical dominance of members of these groups can be used as an indicator of sedimentation in concurrence with the use of pollution-sensitive benthic organisms such as crustaceans.

Sources of Threat to Freshwater Ecology (Lake Mahukdam and Lake Mainit)

Lake Mahukdam, is only generally affected by natural disturbances, with rainfall and surface run-off the primary environmental factors that could alter ambient conditions of the lake. Lake Mainit, on the other hand, is threatened by unsustainable fishing practices, increase in populations in settlements near the lake, agricultural run-off, domestic waste inputs and conversion of some wetlands into agricultural areas such as rice paddies.

Overall Ecology of the Freshwater Ecosystems Studied

The freshwater streams in the area, based on water quality, have been assumed to be classified as Class B which is Recreational Water Class 1 based on DAO 34. Biological parameters measured for each stream also generally show good to excellent water quality with insects dominating the biota. Although no estimates of the biological carrying capacity of the streams have been done, it can be deduced that the carrying capacity of the streams will be reduced with potential change or degradation of water quality that will impact on the present stream biota.

Climate Change without the Project

The general effects of climate change on freshwater systems will likely be increased water temperatures, decreased dissolved oxygen levels, and the increased toxicity of pollutants. In lake systems, eutrophication may be exacerbated or offset, and stratification will likely become more pronounced and stronger, which could alter food webs and change habitat availability and quality (Ficke et al. 2007). Lake Mahukdam is more vulnerable to these effects as water retained in the lake is dependent on rainfall and surface run-off and no rivers or tributaries drain to the lake. Climate change effects on Lake Mainit, on the other hand, will exacerbate the sedimentation in the lake, one of the main concerns on the lake (Tumanda et al N.D). Flooding and inundation due to intensified rainfall will increase sediment input from catchment areas, from agricultural lands and domestic activities. Both lake systems, similar to the river systems, are vulnerable to climate change impacts.

Potential Impacts and Options for Prevention or Mitigation or Enhancements for Freshwater Ecology

This section presents the identified potential impacts of the proposed project to freshwater ecology and the corresponding options for prevention or mitigation or enhancements of the identified potential impacts which are summarized in Table 2.2.3-15

Table 2.2.3-15 Potential Impacts and Options for Prevention or Mitigation or Enhancement – Freshwater Ecology

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
Threat to abundance, frequency and distribution of species					
• Potential impacts on the alteration of hydrological regimes such as change in water flow and volume or size of surface water ways due to inducement of flooding, particularly in the Timamana and Boyongan Creeks during dewatering of the open pit; and Piakle Creek and Bad-as/ Amoslog Creek during discharges from the TSF. Flooding may cause expansion of these natural habitats that could eventually alter aquatic biota (i.e. plankton, periphyton, macrobenthos, and fish) assemblage and abundance.		✓	✓		• A comprehensive monitoring plan in accordance with the environmental monitoring plan in the approved EIS will be implemented to assess the potential impacts of the project on the aquatic habitat and biota during construction and operation phases. • Enhancement of the riparian vegetation along the Timamana and Boyongan Creek will be undertaken in accordance with the Biodiversity Management Plan. Progressive rehabilitation will also be undertaken. • Water management measures will be designed and implemented to intercept and divert surface run-off. • Open pit will be provided with diversion, bench, and contour drains while TSF will be constructed with spillway and diversion drains.
• Potential change in water quality such as increase in TSS and turbidity, reduction in dissolved oxygen levels, and increase in acidity and metal concentrations and possible presence of potentially acid forming (PAF) minerals. Potential change in water quality are anticipated in tributaries of Hinagasa-an River north of the TSF and in tributaries of Magpayang River (i.e. Timamana and Boyongan Creeks). Furthermore, discharge		✓	✓		• A best practice on sediment and erosion control plan (See Section 2.1 The Land) will be designed and implemented prior to construction activities to minimize mine-induced erosion. • The bench and contour drains will convey pit water during dewatering to sedimentation ponds. To mitigate seepage, underdrains and seepage ponds will also installed. • To mitigate leaching from PAFs, whenever encountered during activities, PAFs will be disposed in the TSF.

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
from the TSF will potentially change the water quality of the Piakle Creek, which ultimately drains to the Hinagasa-an River and Sabong Bay due to the discharges from the TSF. Change in water quality can potentially alter species composition and abundance, only favouring those groups of organisms that are tolerant to the physico-chemical changes in their environment.					• Discharges will be treated when necessary to guarantee that the quality of the water discharged to adjacent waterways is in accordance with the DENR standards and will not significantly impact the aquatic biota. • A comprehensive monitoring plan in accordance with the environmental monitoring plan in the approved EIS will be implemented to assess the potential impacts of the project on the aquatic habitat and biota during construction and operation phases. Monitoring stations will be coincident with the water quality monitoring stations.
Loss of important species					
• Potential reduction in volumetric flow of the Timamana and Boyongan Creeks (see Section 2.1.1 Hydrology and Hydrogeology). The sudden drainage of pools or rapid drop in stream flow have localized and significant effects on aquatic organisms sensitive to desiccation and this potential effect is exacerbated on periods of low or no flow during dry season.		✓	✓		• Identification of conservation area for management, where feasible, through ongoing monitoring. • Enhancement of the riparian vegetation along the Timamana and Boyongan Creek will be undertaken in accordance with the Biodiversity Management Plan to maintain flow channel to support continuous pathway for migratory species such as freshwater eels (*Anguilla marmorata*). • Progressive rehabilitation will also be undertaken. • Enhancement of the riparian vegetation along the Timamana and Boyongan Creek will be undertaken
Loss of habitat					
• Potential partial or complete loss of portions of the headwaters of the Hinagasa-an River that are within the location of the TSF and the portions of the Magpayang River and Boyongan Creek that are within the location of the open pit. This potential impact will limit upstream/ downstream migration of aquatic organisms.		✓	✓	✓	• Habitat loss will be unavoidable but will be minimized through proper planning and management (e.g. limit the extent of surface disturbance areas, set buffer zones, and progressive rehabilitation). • A comprehensive monitoring plan in accordance with the approved environmental plan in the EIS will be implemented to assess the potential impacts of the project on the aquatic habitat and biota during construction and operation phases.

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
					Monitoring stations will be coincident with the water quality monitoring stations. • Enhancement of the riparian vegetation along the Timamana and Boyongan Creek will be undertaken in accordance with the Biodiversity Management Plan. Progressive rehabilitation will also be undertaken.
Enhancement of climate change impacts					
• Dewatering of the Open Pit and scheduled releases from the TSF can potentially exacerbate the anticipated flooding brought about by more intense rainfall during wet periods. During intense rains, possible bank scouring, landslides, and mudslides can smother aquatic organisms.					• Enhancement of the riparian vegetation will be undertaken in accordance with the Biodiversity Management Plan. Progressive rehabilitation will also be undertaken. • A best practice on sediment and erosion control plan (See Section 2.1 The Land) will be designed and implemented prior to construction activities to minimize mine-induced erosion.
• During drier dry periods, the scheduled releases from the TSF and dewatering from the Open Pit can inundate waterways and regulate low water levels avoiding desiccation of aquatic organisms. However, the potentially high sediment load from mine waters can increase TSS and turbidity of the waterways.					• A best practice on sediment and erosion control plan (See Section 2.1 The Land) will be designed and implemented prior to construction activities to minimize mine-induced erosion.

2.2.3.5.1 Potential Impacts

Threat to abundance, frequency and distribution of species

Alteration of hydrological regimes

Potential impacts due to the changes in water flow and volume or size of surface water ways brought about by flooding will affect the Timamana and Boyongan Creeks during dewatering of the open pit. The Piakle Creek, which ultimately drains to the Hinagasa-an River, and the Bad-as/Amoslog Creek are likewise prone to inundation due to discharges from the TSF. Main impact of flooding to freshwater ecosystems is habitat expansion which has the potential to change the community structure of aquatic biota. During flood experiments (Sabinne et al. 2008), periphyton biomass had significantly decreased. However, in between flood events, periphyton can rapidly increase their biomass due to their fast recovery. Macrobenthos richness, density, and biomass also decreased after flooding. The shift in macroinvertebrate composition became evident by changes in the abundance of individual species. Baetid mayflies and protonemurid stoneflies are well adapted to disturbance and recovered rapidly after each flood. Fish habitat was, however, improved as the floods effectively removed fine sediments from the system, increasing bed porosity. Nonetheless, the flooding effects on aquatic biota were dependent on flood magnitude and flood frequency.

Change in water quality

Potential changes such as TSS and turbidity increase, dissolved oxygen level reduction, acidity and metal concentrations increase due to possible presence PAF leaching and weathering of minerals will occur. These changes are anticipated to occur in tributaries of Hinagasa-an River north of the TSF and in tributaries of Magpayang River (i.e. Timamana and Boyongan Creeks). In addition, the TSF discharge will also change the water quality of the Bad-as/Amoslog Creek and the Piakle Creek that is adjacent to the TSF Spillway. However, the effect of spillway flow is negligible as discharges from the spillway will follow multiple extreme rainfall events and during these events the discharges are perceived to be already significantly diluted. The potential change in water quality (i.e. increase in TSS and turbidity, reduction in DO levels, increase in acidity and metal concentrations) can potentially alter aquatic biota composition and abundance, only favouring those organisms that are tolerant to the physico-chemical changes in their environment. Possible changes in the aquatic communities could occur at the level of primary producers (i.e. plankton and periphyton) that could ultimately affect the larger organisms such as fish that depend on these organisms as food.

Loss of important species

Reduction in volumetric flow

The potential reduction in volumetric flow will affect both the Timamana and Boyongan Creeks. The sudden drainage of pools or rapid drop in stream flow is only localized but may cause habitat fragmentation which may limit migration of the freshwater eel, *A. marmorata*. Furthermore, this may cause desiccation of sensitive aquatic organisms and effects will worsen during periods of low or no flow during dry season.

Loss of habitat

Partial or complete loss of headwater portions

Partial or complete loss of habitat will potentially affect portions of Hinagasa-an River that are within the location of the TSF and the portions of the Magpayang River and Boyongan Creek that are within the location of the open pit. This will limit upstream/ downstream migration of aquatic organisms, particularly of *A. marmorata*.

Enhancement of climate change impacts

Dewatering of the Open Pit and scheduled releases from the TSF

Dewatering of the open pit and scheduled releases from the TSF will potentially exacerbate the projected flooding. Flooding, due to intensified rainfall during wet periods, will potentially cause bank scouring, landslides, and mudslides, which can smother aquatic organisms. Furthermore, during drier dry periods, the potentially high sediment load from mine waters can increase TSS and turbidity of the waterways.

2.2.3.5.2 Options for Prevention, Mitigation or Enhancement

Threat to abundance, frequency and distribution of species

Alteration of hydrological regimes

A comprehensive monitoring plan in accordance with the environmental monitoring plan in the approved EIS will be implemented to assess the potential impacts of the project on the aquatic habitat and biota during construction and operation phases. Aquatic biota monitoring will include monitoring of abundance and composition of periphyton, macrobenthos, and fish in stations established during the baseline studies, focusing on stations that will be directly affected by the proposed project. Furthermore, to minimize effects of inundation in the Boyongan and Timamana Creeks, enhancement of the riparian vegetation along these creeks will be undertaken in line with the Biodiversity Management Plan. Maintenance of healthy riparian zones are crucial to aquatic ecosystems as they provide sediment filtering, bank stabilization, water storage and release, and aquifer recharge. Also, riparian zones provide important habitat for wildlife. Furthermore, water management measures will be designed and implemented to intercept and divert surface run-off. The diversion drains will be provided in the open pit and bench and contour drains to convey pit water to the sedimentation ponds prior to pumping to the mill or TSF for surplus.

Change in water quality

Change in water quality due to mine-induced erosion will be minimized by following the best practice on sediment and erosion control plan, which will be designed and implemented prior to construction activities. The drainage channel or gallery for dewatering of the open pit will also be provided with impediments to reduce sediment levels prior to discharge to Timamana and Boyongan Creeks. In addition, sediment treatment ponds will be strategically located in the channel to further minimize sediment input to these waterways. Potential leaching from PAFs that in case encountered will be mitigated via disposal in the TSF and TSF and seepage ponds will be established to capture seepage from the waste containment facilities. Wastewater treatment plant will also be constructed to ensure that the quality of the water discharged to adjacent waterways will be in accordance with the DENR standards and will not significantly impact the aquatic biota.

As aforementioned, a comprehensive monitoring plan in accordance with the environmental monitoring plan in the approved EIS will be implemented to assess the potential impacts of the project on the aquatic habitat and biota during construction and operation phases. Monitoring stations will be coincident with the water quality monitoring stations. Monitoring of the Mahukdam and Mainit Lakes and Mapaso will also be conducted in concurrence with the water quality monitoring stations.

Loss of important species

Reduction in volumetric flow

Reduction in volumetric flow is unavoidable but potential impacts will be minimized by identification of conservation areas for management, where feasible, through the aforementioned monitoring plan. Furthermore, enhancement and maintenance of riparian zone along the Timamana and Boyongan Creek will be enhanced according to the Biodiversity Management Plan.

Loss of habitat

Partial or complete loss of headwater portions

Partial or complete loss of headwater portions due to construction of mine facilities is unavoidable but potential impacts will be minimized by offset areas for conservation, progressive rehabilitation and enhancement of riparian vegetation along the Timamana and Boyongan. A comprehensive monitoring plan, in accordance with the approved environmental plan in the EIS will be implemented to assess the potential impacts of the project to both aquatic habitat and biota during construction and operation phases.

Enhancement of climate change impacts

Dewatering of the Open Pit and scheduled releases from the TSF

Mine activities that have the potential to increase the effects of climate change to freshwater habitat and biota are the dewatering of the open pit and the scheduled releases from the TSF. These activities have the potential to exacerbate flooding brought about by projected increasing rainfall. Potential effects will be minimized through the enhancement of the riparian vegetation which will be undertaken in accordance with the Biodiversity Management Plan. However, during drier dry periods, the scheduled releases from the TSF and dewatering from the Open Pit can inundate waterways and regulate low water levels avoiding desiccation of aquatic organisms. However, the potentially high sediment load from mine waters can increase TSS and turbidity of the waterways. To minimize mine-induced erosion, a best practice on sediment and erosion control plan and water management measures will be designed and implemented prior to the different construction activities and operation phase.

Environmental Impact Statement

Section 2.3 The Air

Table of Contents

2.3 The Air 2.3-1

2.3.1 Meteorology and Climatology 2.3-1

2.3.1.1 Background 2.3-1

2.3.1.2 Methodology 2.3-2

2.3.1.2.1 Data Collection and Analysis of Historic and Existing Climate 2.3-2

2.3.1.2.2 Weather Station Data 2.3-4

2.3.1.2.3 Limitations of the Study 2.3-5

2.3.1.3 Baseline Environment for Meteorology and Climatology 2.3-5

2.3.1.3.1 Summary 2.3-6

2.3.1.3.2 General Climate 2.3-7

2.3.1.3.3 Climatological Normals 2.3-10

Season 11 2.3-

Observed Baseline (1971-2000), mm 2.3-

Projected Rainfall in 2020 (2006-2035), mm 2.3-

Projected Rainfall in 2050 (2036-2065), mm 2.3-

2.3.1.3.4 Projection of Extreme Weather Events 2.3-15

2.3.1.3.5 PAGASA Climate Change Projections in the Philippines 2.3-15

2.3.1.4 Potential Impacts and Options for Prevention or Mitigation or Enhancements for Meteorology and Climatology 2.3-17

2.3.1.4.1 Summary 2.3-17

2.3.1.4.2 Potential Impacts 2.3-19

2.3.1.4.3 Options for Prevention, Mitigation or Enhancements 2.3-22

2.3.2 Greenhouse Gas (GHG) Assessment 2.3-23

2.3.2.1 Background 2.3-23

2.3.2.2 Methodology 2.3-23

2.3.2.2.1 Scope Definition 2.3-23

2.3.2.2.2 Calculation Approach for Inventory 2.3-24

Source of Emissions

Formula Used

Emission Factor

Energy Content Factor

Global Warming Potential

Project Phase

2.3.2.2.3 Emission Profile 2.3-26

2.3.2.2.4 Geographical Boundary 2.3-26

2.3.2.2.5 Emission Scope Boundary 2.3-26

2.3.2.2.6 Temporal Scope Boundary 2.3-26

2.3.2.3 Limitations of the Study 2.3-27

2.3.2.3 Baseline Environment for Greenhouse Gas Emissions 2.3-27

2.3.2.4.1 Summary 2.3-27

2.3.2.4.2 Global Greenhouse Gas Profile 2.3-28

2.3.2.4.3 Philippine Greenhouse Gas Profile 2.3-30

2.3.2.5 Potential Impacts and Options for Prevention or Mitigation or Enhancements for Greenhouse Gas Emissions 2.3-31
2.3.2.5.1 Summary 2.3-31
2.3.2.5.2 Potential Impacts 2.3-34
2.3.2.5.3 Options for Prevention, Mitigation or Enhancement 2.3-38
2.3.3 Ambient Air Quality 2.3-40
2.3.3.1 Background 2.3-40
2.3.3.2 Methodology 2.3-40
2.3.3.2.1 Desktop Review of Relevant Air Quality Criteria 2.3-40
2.3.3.2.2 Sources Identification 2.3-40
2.3.3.2.3 Sampling Sites 2.3-41
2.3.3.2.4 Sampling Methodology 2.3-44
2.3.3.2.5 Data Analysis 2.3-45
2.3.3.2.6 Air Dispersion Modelling 2.3-45
2.3.3.3 Scope and Limitation of the Study 2.3-46
2.3.3.4 Baseline Environment for Ambient Air Quality 2.3-47
2.3.3.4.1 Summary 2.3-47
2.3.3.4.2 Ambient Concentration of Particulate Pollutants 2.3-47
2.3.3.4.3 Ambient Concentration of Gaseous Pollutants 2.3-48
2.3.3.4.4 Ambient Concentration of Heavy Metals 2.3-49
2.3.3.4.5 Air Dispersion Modelling 2.3-51
2.3.3.4.6 Sources of Threats to Ambient Air Quality 2.3-53
2.3.3.4.7 Climate Change Impacts Without the Project 2.3-53
2.3.3.5 Potential Impacts and Options for Prevention or Mitigation or Enhancements for Ambient Air Quality 2.3-54
2.3.3.5.1 Potential Impacts 2.3-56
2.3.3.5.2 Options for Prevention, Mitigation or Enhancement 2.3-57
2.3.4 Ambient Noise 2.3-58
2.3.4.1 Background 2.3-58
2.3.4.2 Methodology 2.3-58
2.3.4.3 Baseline Environment for Ambient Noise 2.3-59
2.3.4.3.1 Summary 2.3-59
2.3.4.3.2 Ambient Noise Level 2.3-60
2.3.4.3.3 Possible Noise Pollution Sources 2.3-60
2.3.4.4 Potential Impacts and Options for Prevention or Mitigation or Enhancements for Ambient Noise 2.3-61
2.3.4.4.1 Potential Impacts 2.3-62
2.3.4.4.2 Options for Prevention, Mitigation or Enhancement 2.3-63

List of Tables

Table 2.3-1 Description of the Surigao City Meteorological Station
Table 2.3-2 Key Findings and Conclusions – Meteorology and Climatology
Table 2.3-3 Rainfall in 2020 and 2050 under High-range and Medium-range Emission Scenario Surigao del Norte

Table 2.3-4	Projected change in mean temperature in 2020 and 2050 under the three emission scenario in Surigao del Norte
Table 2.3-5	Projected change in maximum temperature in 2020 and 2050 under the three emission scenario in Surigao del Norte
Table 2.3-6	Projected change in minimum temperature in 2020 and 2050 under the three emission scenario in Surigao del Norte
Table 2.3-7	Frequency of Extreme Weather Events in 2020 and 2050 under medium-range emission scenario in Surigao del Norte
Table 2.3-8	Potential Impacts and Options for Prevention or Mitigation or Enhancement – Meteorology and Climatology
Table 2.3-9	The Philippines' GHG Emission Reduction Strategies
Table 2.3-10	Global Warming Potential and Emission Factors of Common Greenhouse Gases
Table 2.3-11	Calculation Approach
Table 2.3-12	Aboveground biomass densities used in the computation of the Project's projected GHG emissions due to vegetation clearing
Table 2.3-13	Key Findings and Conclusions – Greenhouse Gas Emissions
Table 2.3-14	Summary of anthropogenic GHG emission shares of five economic sectors in 2010
Table 2.3-15	GHG Emissions from the four non-LULUCF sectors of Energy, Industry, Agriculture, and Wastes in the year 2000
Table 2.3-16	Net GHG emissions in the Philippines including the LULUCF sector (in tonnes of CO2-e)
Table 2.3-17	Potential Impacts and Options for Prevention or Mitigation or Enhancement – Greenhouse Gas Emissions
Table 2.3-18	Total disturbance footprint
Table 2.3-19	Annual greenhouse gas emissions by the Project due to the combustion of fossil fuels – by commodity, construction phase (Year 1 to Year 26)
Table 2.3-20	Annual greenhouse gas emissions by the Project due to the combustion of fossil fuels – by commodity, operation phase (Year 3 to Year 27)
Table 2.3-22	Net annual greenhouse gas emissions by the Project due to the combustion of fossil fuels over the life of the mine – by scenario, construction and operation phase (Year 1 to Year 27)
Table 2.3-23	Air pollutants associated with mining activities
Table 2.3-24	Ambient Air Quality and Noise Stations
Table 2.3-25	Methods of Air Sampling and Analysis
Table 2.3-26	Air Quality Indices
Table 2.3-27	Required Input Parameters for the SCREEN3 Model
Table 2.3-28	Key Findings and Conclusions – Ambient Air Quality
Table 2.3-29	
Table 2.3-30	Results of the 24-hour ambient air quality monitoring for TSP and PM10
Table 2.3-32	Results of the 24-hour ambient air quality monitoring for SO2 and NO2
Table 2.3-33 & 2.3-33-1	Results of heavy metal analysis
Table 2.3-34	Input parameters used for the SCREEN3 Model
Table 2.3-35	Summary of predicted PM concentrations in different distances from the point source for 3 different stack heights and potential impact areas for Amihan and Habagat seasons
Table 2.3-36	Summary of predicted NOx concentrations in different distances from the point source for 3 different stack heights and potential impact areas for Amihan and Habagat seasons
Table 2.3-37	Potential Impacts and Options for Prevention or Mitigation or Enhancement

Table 2.3-38 Description of Area Classification for Noise
Table 2.3-39 Classification of Noise Monitoring Stations
Table 2.3-40 Key Findings and Conclusions – Ambient Noise
Table 2.3-42 Results of the four-time period noise measurement
Table 2.3-43 Potential Impacts and Options for Prevention or Mitigation or Enhancement – Ambient Noise

List of Figures

Figure 2.3-1 Location of PAGASA Synoptic Weather Station in Surigao City
Figure 2.3-2 Climatological Map of the Philippines
Figure 2.3-3 Tropical Cyclone Incidence Map of the Philippines
Figure 2.3-4 Total Monthly Rainfall for the PAGASA Synoptic Weather Station in Surigao City
Figure 2.3-5 Monthly Temperature for the PAGASA Synoptic Weather Station in Surigao City
Figure 2.3-6 Monthly Relative Humidity for the PAGASA Synoptic Weather Station in Surigao City
Figure 2.3-7 Monthly Windrose for the PAGASA Synoptic Weather Station in Surigao City from 1981 to 2010
Figure 2.3-8 Total annual anthropogenic GHG emissions (billion tonnes of CO2-e per year) by groups of gases from 1970 to 2010
Figure 2.3-9 Total anthropogenic GHG emissions (billion tonnes of CO2-e per year) by economic sectors in 2010
Figure 2.3-10 Annual greenhouse gas emissions by the Project due to the combustion of fossil fuels over the life of the mine (Year 1 to Year 27)
Figure 2.3-11 Ambient Air Quality and Noise Sampling Stations
Figure 2.3-12 Windrose statistics for Amihan (left) and Habagat (right) seasons integrated into the topographical map of the Project area, used to determine potential impact areas from the point source emission in the mill
Figure 2.3-14 Results of the four-time period noise measurement

List of Plates

Plate 2.3-1 AQM1 – Timamana Elementary School
Plate 2.3-2 AQM2 – Boyongan Elementary School
Plate 2.3-3 AQM3 – Anislagan Elementary School
Plate 2.3-4 AQM4 – Lower Patag Elementary School

2.3 The Air

The results of technical studies for meteorology, climate, greenhouse gas, air quality and noise are provided in this section.

2.3.1 Meteorology and Climatology

This segment exhibits the results of the meteorology and climatology evaluation for the Silangan Copper-Gold Project. The evaluation was done as a requirement of the Philippine EIS perusing agenda for the Project. Presented here are the potential impacts of the project on the baseline conditions as well prevention, mitigation and improvement plan.

2.3.1.1 Background

The Philippine Constitution of 1987 states, in accordance with rhythm and harmony of nature, that it is the State's policy to fully protect and advance people's right to healthy ecology. The Republic Act 9729 (also known as the Act on Climate Change in 2009) is based on that statement. The law was designed primarily to integrate climate change into government policies, to set up Framework Strategy and Climate Change Program, and creation of Commission on Climate Change. The Act acknowledges the Philippines' vulnerability to potential effects of climate change such as increasing sea levels, changed landscape, rising frequencies and seriousness of drought, fires, floods and storms, ecosystem damage and loss of biodiversity.

The Department of Environment and Natural Resources (DENR) has issued DENR - EMB Memorandum Circular No. 2011 - 005 (DRR) with Disaster Risks Reduction and Change Adaptation (CCA) concerns within the Philippine system of EIS with the purpose of promoting Climate Change Adaptation and Disaster risk Reduction at the project level. The enhanced DRR / CCA EIA is a mechanism to ensure that projects are resilient and that their effect on the environment do not worsen the environmental or human and/or natural system risks of climate change.

The Meteorology / Climatic Evaluation was conducted in order to identify and assess the potential project impact on local microclimatic changes in the historical and existing meteorological and climatological conditions on the site of the project. The future climate conditions and the impacts of climate change using the medium- to long - term climate change projections from the Philippine Atmosphere, Geophysical and Astronomical Services Government (PAGASA) have been evaluated as well.

There are no clear wet or dry seasons in the climate in southern Philippines (including Surigao Del Norte), as is the case for the north. Surigao Del Norte has no dry season and no dry month with a very strong rainy period between December and February. The site is situated about 23 km south of Surigao, which stretches from 0 m to 250 m above sea level. The meteorological and climatological evaluations results are shown below.

2.3.1.2 Methodology

Applying medium to long - term climate change projections, this assessment was performed by gathering relevant secondary information from the PAGASA weather station in the study area. Following are the descriptions of the information gathered from these sources.

2.3.1.2.1 Data Collection and Analysis of Historic and Existing Climate

Long term meteorological data of Surigao Del Norte are required by the Environmental Management Bureau (EMB) to represent the meteorological conditions at the project site. Long term climatological normal and extremes were based on PAGASA's latest available data collected from year 1981-2010. The climatological normals from PAGASA were presented on an average 30-yr data collection and were sourced from the nearest PAGASA weather station to the project site located at approximately 23 kilometers (km) north of the project footprint **(Figure 2.3 1 and Table 2.3 1).** These long-term meteorological data are required by EMB to represent the meteorological conditions at the project site.

Table 2-1 Description of the Surigao City Meteorological Station

Station	Location	Coordinates
Surigao City PAGASA Synoptic Weather Station	PAGASA Weather Station, Capitol Site 8400, Surigao City at 0 m elevation	N 9° 48' 0.000" E 125° 30' 0.000"

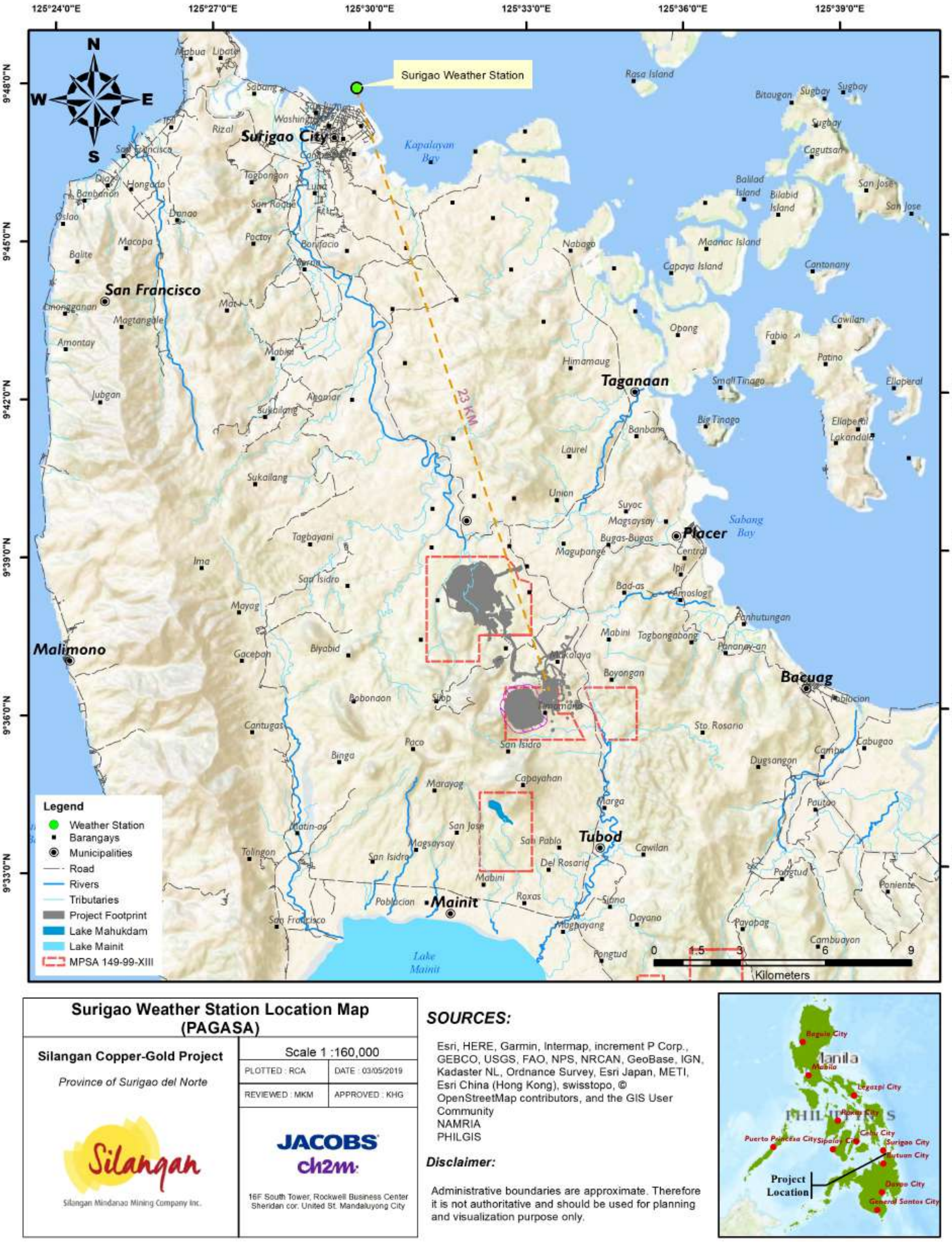


Figure 2-1 Location of PAGASA Synoptic Weather Station in Surigao City

2.3.1.2.2 Weather Station Data

Moisture, temperature, atmospheric pressure, precipitation, air streams, topography and geographical location are all relevant elements and factors affecting the climate in an area. The effects of global climate change, ranging from extreme weather events, periodic droughts and food shortages, are greatly impacted by vulnerable countries such as the Philippines. The United Nations Framework Convention on Climate Change (UNFCCC) climate models and PAGASA climate change projections indicate that all areas in the Philippines will become warmer, more so in the relatively warmer summer months. The Philippines is dominated by two major airstream; the North-East Monsoon (Amihan), which runs between October to April, and the Southwest Monsoon (Habagat) which runs from May to September. Surigao Del Norte is expected to experience more rain between September and February and less rain between March and August based on PAGASA's medium - range climate change projections.

Data from PAGASA and the climate and tropical frequency maps have been collected and reviewed to characterize the meteorological conditions throughout the study area.

Presented in this assessment are the latest climatological normals sourced from PAGASA synoptic weather station in Surigao City. Climatological normals are the period averages of weather parameters computed for a uniform and relative long period consisting of at least three consecutive 10-year periods. The latest climatological normals presented in this assessment are obtained from the PAGASA synoptic weather station in Surigao City (1981 to 2010) (**Annex 2.3-1**).

Climatic extreme conditions are presented in a matrix with the highest or greatest value of recorded weather parameters. It comprises the lowest and highest ambient temperature, the highest daily precipitation and the highest wind rate in a particular weather station. The most recent climate extremes at Surigao City's PAGASA Synoptic Weather Station were shown in (Annex 2.3 - 2).

Windrose PRO3 ®, which is a licensed software that generates wind rose statistics that summarizes the distribution of wind in each of the 16 winter directions and their corresponding speed, analyzed the 30-year (1981 to 2011) wind - data from the Surigao City synoptic weather station PAGASA (Annex 2.3 - 3). The color bands on the rose show the wind ranges while the direction of the rose with the longest spoke represents the direction with the greatest frequency

In the assessment of meteorological conditions of the project site, the PAGASA Climate Change projections in 2020 and 2050 were also considered. The projection for climate change was developed by the Intergovernmental Panel on climate change, using the baseline climatic conditions of the region, and by emissions scenarios. These emission scenarios encompass a range of demographic, societal, economic and technological contexts to define the possible climate of the future. Three emission scenarios were applied for climate simulation with two time frames focused on 2020 (2006-2035) and 2050 (2036-2065), namely high-scale scenarios, medium-scale scenarios and low-range scenarios. High-range emission scenario suggests a society that is based on self-reliance, with continuously growing population, a regionally-oriented economic development but with fragmented per capita economic growth and technological change. In contrast, the medium scenario indicates extremely rapid economic growth accompanied by an increasing population that will peak and decline in the middle of the century. New, more efficient technologies with a balanced energy generation across all sources will also be rapidly introduced.

On the other hand, a low scenario involves a world where local solutions to economic, social and environment sustainability are provided as the world's population continues to increase but compared to high range scenario it is more oriented towards environment protection and social equity, so the rate of economic development and technological change would be lower.

The seasonal variations considered in the projections are DJF (December, January, and February) or northeast monsoon, MAM (March, April, and May) or summer, JJA (June, July, and August) or southwest monsoon and SON (September, October, and November) or transition from southwest to northeast monsoon. The simulation outputs includes projected temperature changes, maximum temperature, minimum temperature, rainfall and frequency of extreme events.

2.3.1.2.3 Limitations of the Study

The historical and existing meteorology and climatology in the study area were confined to the accessible Surigao City's PAGASA weather data. The available source used to describe the most likely climate status of the project site is limited by location and number of data available.

The simulation of the climate change projections is limited to the PAGASA weather station projections that are available near the site. Moreover, the low - range scenario is limited to weather data from 1989 to 2000 and there is no projection in relation to rainfall changes is available. Climate change projections for PAGASA are not based upon locally occurring natural and anthropogenic sources in the Philippines, as climate change is a global phenomenon.

For low - range scenarios, weather data 1989 - 2000 is limited. The projections available at PAGASA's closest climate station are also limited to forecasting climate change projections.

In summary, the following limitations are:

- The historical and present climate and meteorology for the study area were limited to the weather data available from the Surigao - City synoptic weather station PAGASA. Simulations are limited to the available projections conducted by PAGASA for the weather station nearest to the project site.
- The low - range scenario is restricted to weather from 1989 to 2000 and no rainfall variation projections are available; and
- The PAGASA Climate Change Projection is not based on the Philippines and/or project site's natural and anthropogenic local sources.

2.3.1.3 Baseline Environment for Meteorology and Climatology

The following subsections present the baseline environment for Meteorology and Climatology of the Silangan Copper-Gold Mine Project.

2.3.1.3.1 Summary

Table 2-2 Key Findings and Conclusions – Meteorology and Climatology

Baseline Information	Key Findings and Conclusions
General Climate	• This climate type does not have a dry season with very pronounced maximum rainfall period from December to February, which is subject to the Type II Modified Coronas Classifications (Figure 2.3 2).
Climatological Normals	
Monthly Rainfall	• During the month of October, the rainfall begins to increase and subsides during month of April with a maximum rainfall period between November and March. In the PAGASA synoptic weather station at Surigao City, monthly rainfall varies from 133.9 to 609.4 mm. The overall annual rainfall is 3651.8 mm with 220 days or approximately 60% of the annual average number of rainy days.
Temperature	• In the months of May, August or September, the monthly average temperature shows a uniform range of between high 32.7°C and low 23.3°C in January.
Relative Humidity	• The PAGASA Synoptic weather station in Surigao City has an annual average relative humidity of 83 %, while January as the most humid month has an average relative humidity of 88 %, while August and September are the least humid months at 80 %.
Wind Speed and Direction	• In Surigao City, the average wind speed ranges between 2m/s and 3m/s at the PAGASA synoptic weather station. The wind mainly from the southwest occurs between June and August and in September and October it shifts to the west. During months of November and February to May easterly wind transpires with winds going north-east during December and January.
Climatological Extremes (PAGASA Surigao City Synoptic Weather Station)	
Rainfall, Temperature, and Wind	• On 18 December 2003 the highest daily precipitation was 566,4 mm. On 6 June 1987, the highest recorded temperature was 37.5 °C. On February 24, 1905, the lowest was 18.2 °C. On September 1, 1984, the highest wind velocity was 60 m/s.
Natural Disasters	
Tropical Cyclone	• In about one tropical cyclone in a year, 12 cyclones in twelve years pass the region. Typhoon "Nitang" (International Name: Ike) hit Surigao del Norte from 31 August to 5 September 1984, one of the most devastating typhoons in its history. The maximum lasting winds were 220 kph, leading to 1,364 deaths in property damage (unofficial estimate is 1,492–3000+) and PhP 4.1B. Super Typhoon "RUPING" (Mike) hit Surigao del Norte from November 10-14, 1990, also one of the most devastating typhoons in its history. The maximum lasting winds were 220 kph, leading to 748 deaths with PhP 10.846B damage.
PAGASA Climate Change Projections (Surigao del Norte)	
Rainfall	• The medium-range emissions scenario is predicted to bring up to 15 percent in 2020 and to 13 percent in 2050 from the base line of dry days in Surigao del Norte (rainfall days less than 2.5 mm/day). The number of days with extreme rainfall (daily plumes above 200 mm) is expected to grow by 144% and by 322% in 2050 from the baseline. • From March to August Surigao Del Norte will experience less rain and more rain throughout the rest of the year.
Temperature	• Under the medium-range emission scenario, the number of days with extreme temperature (maximum temperature greater than 35°C) in Surigao Del Norte is projected to increase from the baseline by 161% in 2020 and 1,450% in 2050.

2.3.1.3.2 General Climate

The climate on the site falls under the classification of type II modified Coronas as shown in There is no dry season for this classification with a very pronounced period of maximum rain from December to February. This area in Mindanao is dominated by two main airstreams: the Northeast Monsoon (Amihan) prevailing between October to April and the Southwest Monsoon (Habagat), which prevails between May and September.

Frequency of Tropical Cyclones Figure 2.3 2.

In Pacific islands like the Philippines, naturally occurring dangers due to climatic factors such as tropical cyclones often visit. PAGASA classifies a tropical cyclone as it enters the Philippine Responsibility Area (PAR), based on the intensity of its maximum winds. Tropical cyclones, which are known as "tropical depressions," have a maximum surface wind of between 35 and 64 kilometers per hour. When a tropical cyclone reaches 65 and 118 km/h in the surface, a tropical storm is typically called and named. The storm is called a "typhoon" if the surface wind is between 119 and 200 km/h. Around 20 tropical cyclones pass the PAR annually on average. Most disturbances cross the Luzon and Visayas islands, as can be seen in **Figure 2.3 3**. Tropical cyclones rarely cross Mindanao. Around 12 tropical cyclones in 12 years (one tropical cyclone per year) visits the project site.

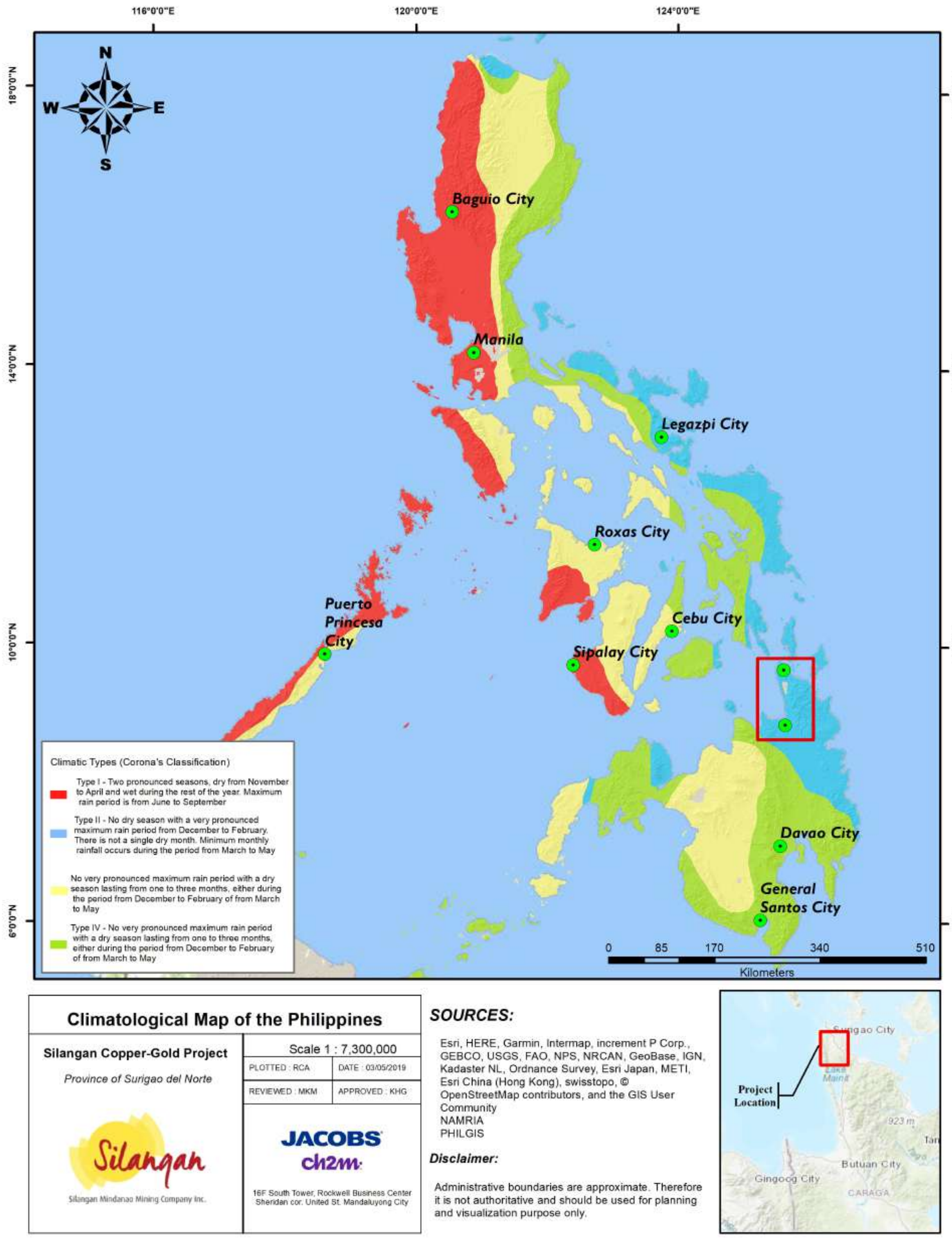


Figure 2-2 Climatological Map of the Philippines

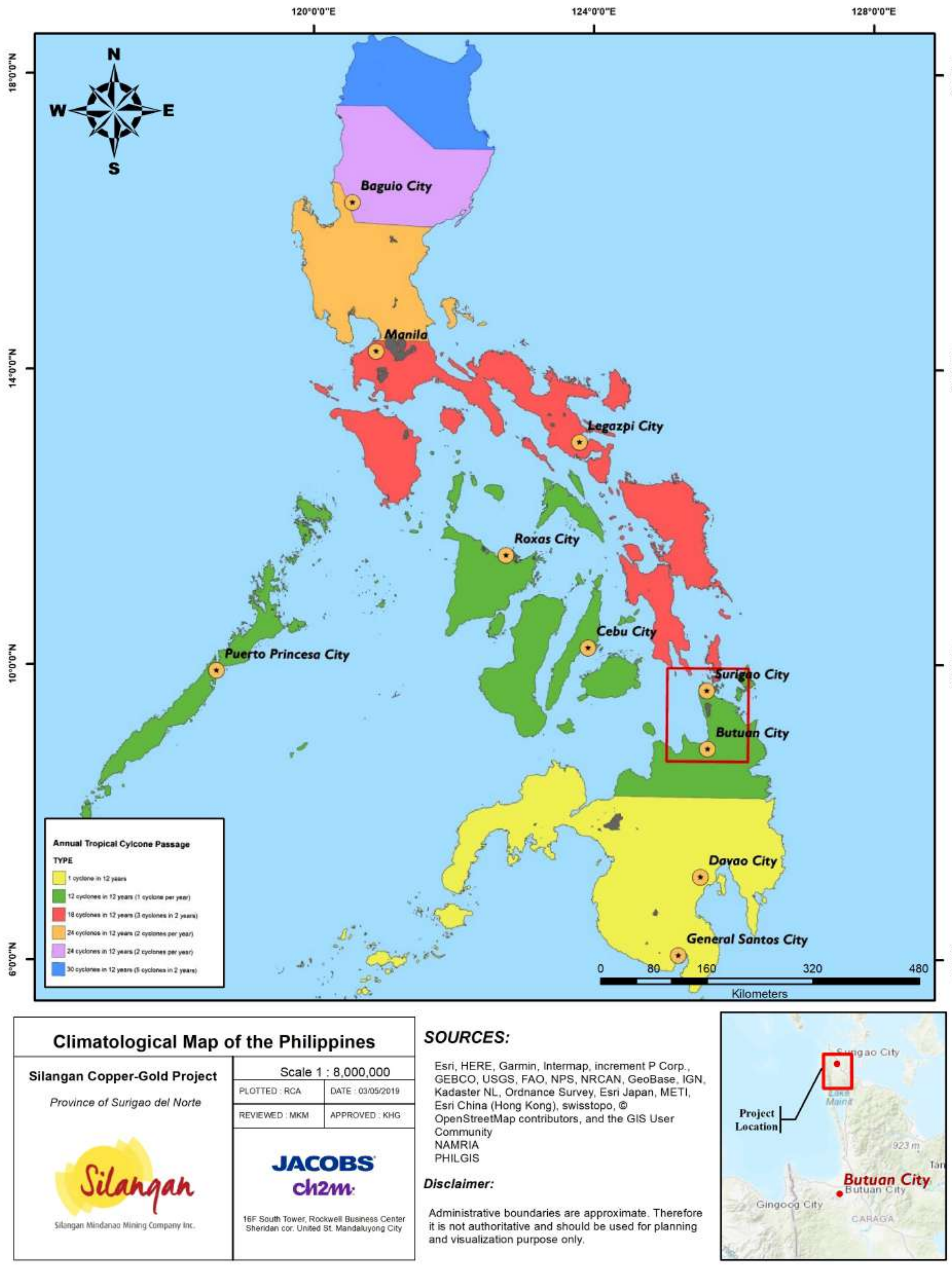


Figure 2-3 Tropical Cyclone Incidence Map of the Philippines

2.3.1.3.3 Climatological Normals

Rainfall

The 30-year PAGASA synoptic Weather Station record for Surigao City reveals a distinct monthly pattern in the rainfall at Surigao Del Norte (**Figure 2.3 4 and Annex 2.3 - 1)**. During October, the number of rainfall begins to increase with the maximum rainfall time between November and March and subsidies in April. This corresponds to the Type II climate description. The monthly precipitation at PAGASA Synoptic Surigao City Weather Station ranges from 133.9 mm to 609.4 mm. The total annual precipitation is 3,651.8 mm, with an average yearly number of rainy days of 220 days or roughly 60% of the year.

The number of rainy days, which is directly proportional to the amount of rainfall, plays a fundamental role to the increase and decrease of rainfall across the years (**Figure 2-4** and **Annex 2.3-1**).

The biggest daily rainfall was 566.4 mm on 18 December 2003 in Surigao del Norte.

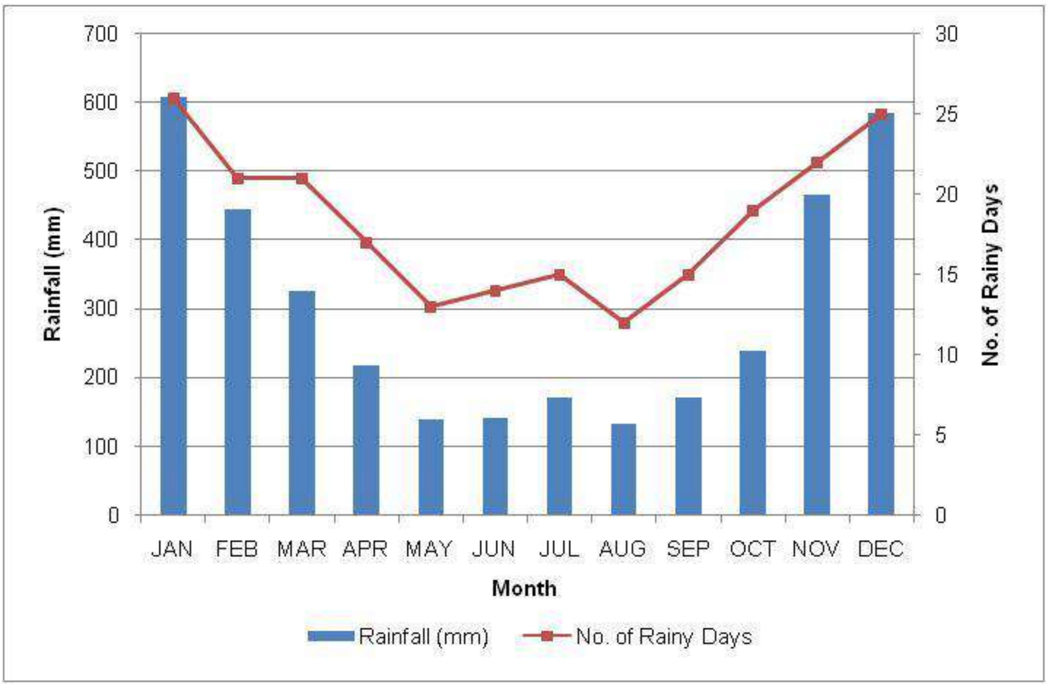


Figure 2-4 Total Monthly Rainfall for the PAGASA Synoptic Weather Station in Surigao City from 1981 to 2010

Under the high and medium - scale emission scenarios, **Table 2.3 3** shows the expected rainfalls of 2020 and 2050. Surigao del Norte will be rainier over the rainy months (DJF and SON), while during the summer and southeast monsoon rainfall is expected to decrease.

Table 2-3 Rainfall in 2020 and 2050 under High-range and Medium-range Emission Scenario Surigao del Norte

Season	Observed Baseline (1971-2000), mm	Projected Rainfall in 2020 (2006-2035), mm		Projected Rainfall in 2050 (2036-2065), mm	
		High-range scenario	Medium-range scenario	High-range scenario	Medium-range scenario
DJF	1,412.00	1,241.1	1,441.7	1,094.3	1,280.9
MAM	639.6	631.3	564.8	440.0	421.7
JJA	448	487.0	433.2	499.5	444.6
SON	837.3	679.1	872.5	759.4	744.2

Source: PAGASA Climate Change Projections

Temperature

In the months of May, August and September the average monthly temperature of Surigao del Norte reaches from 32.7°C to 23.3°C during January **(Figure 2.3 5)**. In Surigao City Weather Station, the highest and lowest mean monthly temperatures are 28.8°C and 26.3°C, respectively, during the months of May and January. The average Surigao del Norte annual temperature is 27.9 ° C with the coldest month in January and the warmest month in May. On 11 September 2008, the highest temperature recorded at Surigao Weather Stations was 38.2 °C, and on 24 February 1905, the coldest was 18.2 °C.

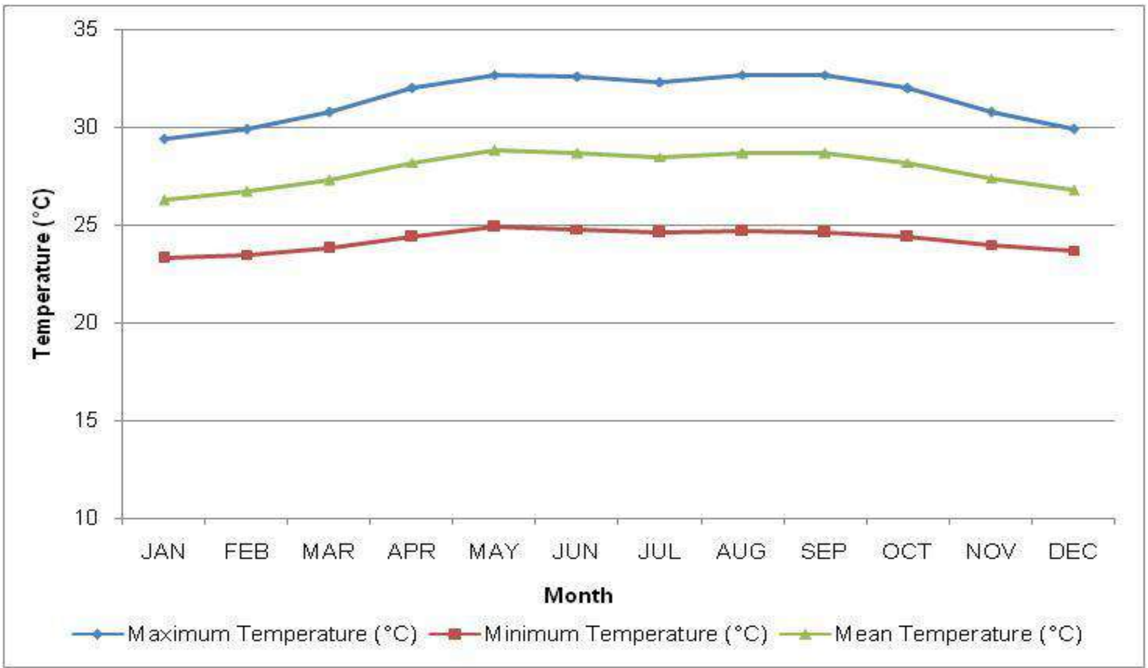


Figure 2-5 Monthly Temperature for the PAGASA Synoptic Weather Station in Surigao City from 1981 to 2010

Table 2.3 4 to Table 2.3 6 shows the expected changes in Surigao del Norte's mean, maximum and minimum temperatures in 2020 and 2050. For the high, medium-range, and low-ranking scenario, the projected temperature values are also indicated. The simulation results show that temperature change increases with time in all emission scenarios. In the future higher ambient temperatures will be experienced in Surigao del Norte.

Table 2-4 Projected change in mean temperature in 2020 and 2050 under the three emission scenario in Surigao del Norte

Season	Observed Baseline (1971-2000), ºC	2020: Change in Mean Temperature (Projected Value), ºC			2050: Change in Mean Temperature (Projected Value), ºC		
		High-range scenario	Medium-range scenario	*Low-range scenario	High-range scenario	Medium-range scenario	*Low-range scenario
DJF	26.3	0.8 (27.1)	0.9 (27.2)	0.3 (26.6)	1.5 (27.8)	1.7 (28.0)	1.3 (27.6)
MAM	27.6	0.7 (28.3)	1.1 (28.7)	0.4 (28.0)	1.8 (29.4)	2.2 (29.8)	1.3 (28.9)
JJA	28.2	0.8 (29.0)	1.3 (29.5)	0.5 (28.7)	1.7 (29.9)	2.6 (30.8)	1.4 (29.6)
SON	27.7	0.8 (28.5)	1.1 28.8)	0.8 (28.5)	1.7 (29.4)	2 (29.7)	1.5 (29.2)

*Note: *Based on 1990 to 2000 Normal Values*
Source: PAGASA Climate Change Projections

Table 2-5 Projected change in maximum temperature in 2020 and 2050 under the three emission scenario in Surigao del Norte

Season	Observed Baseline (1971-2000), ºC	2020: Change in Maximum Temperature (Projected Value), ºC			2050: Change in Maximum Temperature (Projected Value), ºC		
		High-range scenario	Medium-range scenario	*Low-range scenario	High-range scenario	Medium-range scenario	*Low-range scenario
DJF	29.9	0.6 (30.5)	1.0 (30.9)	0.2 (30.1)	1.3 (31.2)	1.8 (31.7)	1.0 (30.9)
MAM	31.8	0.6 (32.4)	1.2 (33.0)	0.5 (32.3)	1.8 (33.6)	2.4 (34.2)	1.2 (33.0)
JJA	32.5	0.7 (33.2)	1.3 (33.8)	0.2 (32.7)	1.6 (34.1)	2.6 (35.1)	1.1 (33.6)
SON	31.9	0.7 (32.6)	1.0 (32.9)	0.6 (32.5)	1.4 (33.3)	2.1 (34.0)	1.3 (33.2)

*Note: *Based on 1990 to 2000 Normal Values*
Source: PAGASA Climate Change Projections

Table 2-6 Projected change in minimum temperature in 2020 and 2050 under the three emission scenario in Surigao del Norte

Season	Observed Baseline (1971-2000), ºC	2020: Change in Minimum Temperature (Projected Value), ºC			2050: Change in Minimum Temperature (Projected Value), ºC		
		High-range scenario	Medium-range scenario	*Low-range scenario	High-range scenario	Medium-range scenario	*Low-range scenario
DJF	20.3	0.7 (21.0)	0.9 (21.2)	0.3 (20.6)	1.7 (22.0)	2.1 (22.4)	1.4 (21.7)
MAM	22.2	0.8 (23.0)	1.0 (23.2)	0.5 (22.7)	1.8 (24.0)	2.1 (24.3)	1.3 (23.5)
JJA	23.0	0.8 (23.8)	1.0 (24.0)	0.6 (23.6)	1.8 (24.8)	2.1 (25.1)	1.4 (24.4)
SON	22.2	0.8 (23.0)	1.0 (23.2)	0.6 (22.8)	1.9 (24.1)	1.9 (24.1)	1.5 (23.7)

*Note: *Based on 1990 to 2000 Normal Values*
Source: PAGASA Climate Change Projections

Relative Humidity

Relative Humidity refers to the percentage of water vapor in air determined by the dry and wet bulb temperature psychometric diagrams as input (Perry, 1973). For a pleasant environment and thus for well-being, relatively high moisture is the most important quantity. Relative humidity generally describes material or people moisture exchange processes with its environment. Data on relative humidity as recorded in Surigao City Weather Station (**Annex 2.3-1**) shows that the annual average dry and wet bulb temperatures are 27.7°C and 25.4°C, respectively. This means the average annual relative humidity is 83% and the averaged relative humidity of January which is the most humid month is 88%, with a minimum humidity of 80% in August and September **(Figure 2.36).**

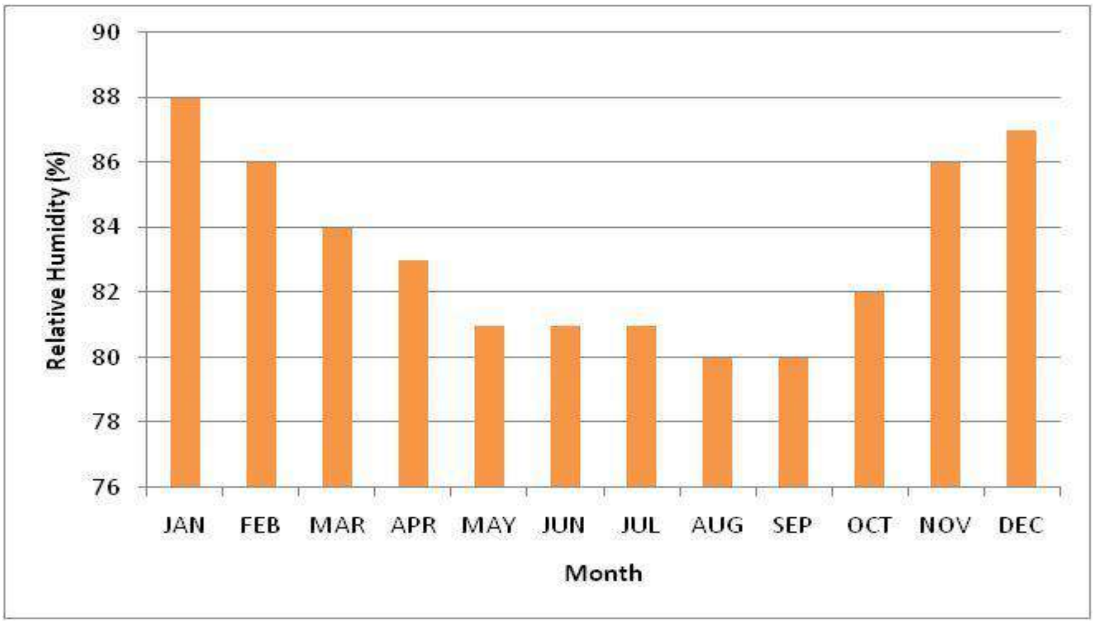
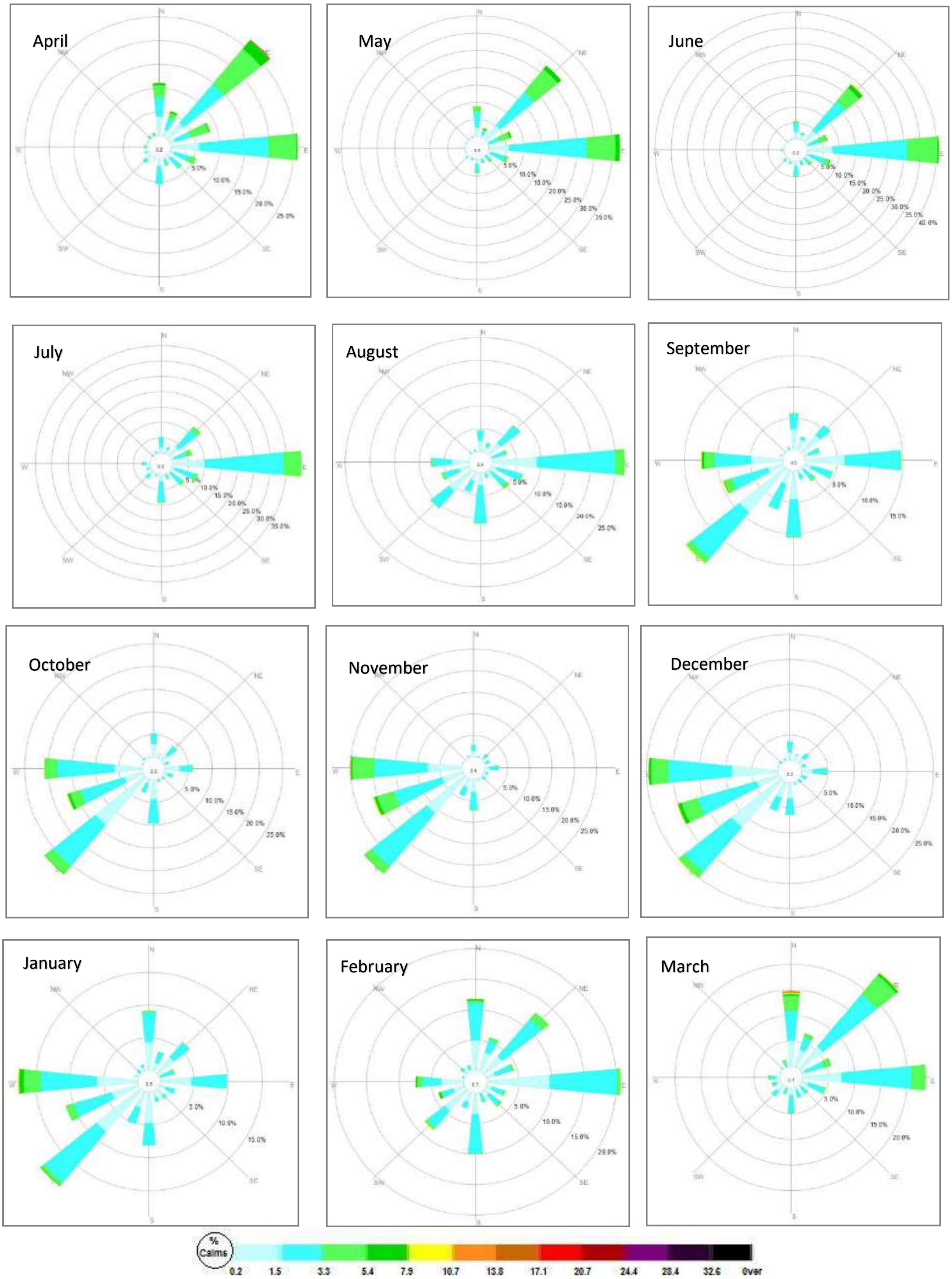


Figure 2-6 Monthly Relative Humidity for the PAGASA Synoptic Weather Station in Surigao City from 1981 to 2010

Wind Speed and Direction

In Surigao City weather station, light breeze blows all year round. Wind speeds ranges between 2 m/s and 3 m/s on average. Windrose PRO3 ®, a licensed software that generates wind rose statistics that summarize distribution of winds in each of the 16 wind directions and their corresponding speed, has been used for the analysis of the 30-year (1981 to 2011) daily wind data from PAGASA surigao weather station (Annex 2.3-3). A wind rose gives a succinct view of how wind speed and direction are typically distributed. Using a polar coordinate system of gridding, the frequency of winds over a long time period is plotted by wind direction, with color bands showing wind ranges. The directions of the rose with the longest spoke show the wind direction with the greatest frequency. Based on **Figure 2.3-7**, it is observed that easterly to north-easterly winds predominantly occur during the months of November to May and shifts to the south-westerly direction in June to October. This is consistent with the two principal airstreams that dominate the Philippines, namely, the Northeast Monsoon (Amihan) which prevails from October to April and the Southwest Monsoon (Habagat) which is prevalent from May to September. On the Surigao City weather station, the highest wind speed recorded was 60 m/s on 1 September 1984.



Figures 2.3-7

Figure 2-7 Monthly Windrose for the PAGASA Synoptic Weather Station in Surigao City from 1981 to 2010

2.3.1.3.4 Projection of Extreme Weather Events

The projected events of extreme weather in Surigao del Norte in the medium-range scenario are shown in Table 2.3 7. The number of days at extremes (maximum temperature above 35° C) is projected to increase by 161% in 2020 and 1.45% in 2050 from the baseline. It is projected that by 2020, dry days or days with rainfall under 2.5 mm/day will grow by 144% and 322% by 2050. In Surigao del Norte, extreme precipitation (over 200 mm rainfall) took place nine times between 1971 and 2000. Daily extreme precipitation is projected to occur 22 times in 2020 and 38 times in 2050, respectively.

Frequency of Tropical Cyclones

There is no sign of an increase in tropical cyclone entering the PAR, according to the PAGASA projection. During El Niño events, however, there can be a very minor increase of stronger tropical cyclones with maximum winds of 150 kph (typhoons).

Table 2-7 Frequency of Extreme Weather Events in 2020 and 2050 under medium-range emission scenario in Surigao del Norte

Weather Event	Observed Baseline (1971-2000)	Projected in 2020	Projected in 2050
No.of Days w/ T_{max} >35 °C	86	225	1333
No. of Dry Days	5286	6054	5975
No. of Days w/ Rainfall >200mm	9	22	38

Source: PAGASA

2.3.1.3.5 PAGASA Climate Change Projections in the Philippines

Climate change is a change in the statistical sharing of weather patterns when the change lasts a longer, decade to million-year period. This may involve changes in average weather conditions or changes to long-term average weather conditions, such as increase or decrease in extreme weather events.

The Philippine climate is influenced by large-scale atmospheric phenomena that bring substantial amounts of rain all year round. However, due to the uneven distribution of rain with respect to time and space and the occurrences of extreme weather events such as floods and droughts, the Philippines' water resources have in the past experienced imbalances in supply and demand (Jose, Francisco, & Cruz, 1993).

Nations such as the Philippine Islands, being surmounted by large bodies of water and highly vulnerable to sea level rise, are among the most vulnerable to the impact of climate change. In addition, the country is 32,000 km long and susceptible to storm waves, one of the longest coastlines in the world. Just like many poor nations in the world, the Philippines has limited resources and is one of the most vulnerable to climate change.

The results of simulations in the medium-range emission scenarios for the future climates in 2020 and 2050 are detailed, solely because future climates over the next 30 to 40 years are already heavily influenced by previous greenhouse gas emissions that are already present. Key findings of the simulation includes:

- In the relatively warmer summer months, all areas of the Philippines will become warmer;
- Average annual (max. and minimum) temperature is expected to rise by average annual temperatures of 0.9 ° C to 1.1 ° C in 2020, and 1.8 ° C to 2.2 ° C in 2050 in all areas of the country.
- In both time slices all mean seasonal temperatures will also increase. These are quite consistent in all provinces for the four seasons (DJF, MAM, JJA, and SON):
- In terms of seasonal rainfall change, generally, there is a substantial spatial difference in the projected changes in rainfall in 2020 and 2050 in most parts of the Philippines, with reduction in rainfall in most provinces during the summer season (MAM) making the usually dry season drier, while rainfall increases are likely in most areas of

Luzon and Visayas during the southwest monsoon (JJA) and the SON seasons, making these seasons still wetter, and thus with likelihood of both droughts and floods in areas where these are projected;

- It is expected that the seasonal rainfall of north-eastern monsoon (DJF) will increase, especially in areas with a type II climate with more flood potential.
- During the southwest monsoon season (JJA), more precipitation is forecast to rise in the Luzon (0.9%-63%) and Visayas provinces (2%-22%) but is expected to deteriorate generally in most Mindanao provinces by 2050.;
- Projections for extreme events in 2020 and 2050 show that hot temperatures (indicated by the number of days with a maximum temperature of more than 35 °C) will continue to increase, the number of dry days (days with less than 2.5 mm of rain) will increase in all parts of the country and heavy daily rainfall events (over 200 mm) will also continue to increase in Luzon and Visayas.

Based on the PAGASA low-range, medium-range, and high-range emission scenarios, Surigao del Norte will experience increases of ambient temperature in 2020 and 2050 (**Table 2-4** to **Table 2-6**). The number of days with rainfall greater than 200 mm is also projected to increase in 2020 and 2050 (**Table 2-7**). Climate changes would result in adverse impacts to agriculture, water resources, health, and coastal areas. There are already trends of increasing number of hot days and warm nights, and decreasing number of cold days and cool nights. Both maximum and minimum temperatures are generally getting warmer (**Table 2-4** to **Table 2-6**). Daily rainfall in Surigao del Norte is also projected to increase in 2020 and 2050 during the months of September to February but will decrease in March to August.

2.3.1.4 Potential Impacts and Options for Prevention or Mitigation or Enhancements for Meteorology and Climatology

2.3.1.4.1 Summary

Table 2-8 Potential Impacts and Options for Prevention or Mitigation or Enhancement – Meteorology and Climatology

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
Impacts in terms of change in local microclimate					
The removal of vegetation, land use change, and topography and hydrology changes within the project site may trigger changes in local microclimate such as temperature, precipitation, and evapotranspiration. The possible effects are as follows: • The microclimate change can have a critical influence in altering the dispersal of air pollutants and affecting the soundwave path. • Changes in local temperature, precipitation and exposure to sunlight caused by the Silangan Copper - Gold Mine Project construction and operation can affect the metabolism and behavior of plants and animals. • The microclimate change could affect farm production and human comfort.		✓	✓		The following mitigation measures for the potential impacts of the project caused by vegetation removal and land use change are in conjunction with the mitigation measures in **Section 2.1.4** (Terrestrial Vegetation) of this EIS: • The infrastructure is designed to reduce vegetation clearing whenever possible. In cases where vegetation clearing is unavoidable, easement should be reduced for the major components, especially pipelines and roads, to keep considerable coverage of vegetation. • Vegetation communities that are known to be derivatives of past residual forests, classified as brush and bush lands should be preserved wherever feasible and rehabilitated for potential sources of propagules for forestry establishments. • The extent of disturbance is clearly indicated on the plannings and on the ground before construction activities to contain the area of disturbance. • All the relevant licenses (e.g. special tree cutting permit) will be secured from the relevant organizations prior to any cutting activities within the statutory requirements of the Department of Environment and Natural Resources (DENR). • Buffer zones should be set in order to protect the remaining propagules sources around identified stepping corridors. • As soon as rehabilitation areas are available, progressive rehabilitation (within or outside the project site) is undertaken. Rehabilitation areas will be at least equivalent to cleared vegetation area. • Forest communities shall be identified outside the project site. Long-term protection shall be provided for identified sites as compensatory actions to offset the impact of the project on the local climate.

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
					The areas identified as offsetting biodiversity should ideally contain communities of vegetation which are similar to areas cleared for the project. • Resident foresters are engaged to monitor and manage regeneration works as required • In order to quantify and better understand the impact of mining activities, reference sites will also be developed. Regular vegetation monitoring within the project site and reference sites will also be undertaken to quantify changes over time. • Following the frequency of ambient air monitoring discussed in Section 2.3.3 of this EIS, changes in local micro-climate will also be monitored.
Enhancement of climate change impacts					
During the years 2006–2035 (centered in 2020) Surigao del norte is projected to have approximately 22 days of rain (> 200 mm) and 38 days during the period 2036–2065 (centered in the period 2050). • Especially during rainy days the release of pumped groundwater from the Underground mining to the Timamana Creek heightens the possibility of flooding downstream. • The discharge of stored TSF water can lead to floods downstream of the Hinagasaan River, especially in severe rainfall.		✓	✓		The following mitigation measures for the potential enhancement of the project to climate change impacts are in conjunction with the mitigation measures in **Section 2.2.1** (Hydrology and Hydrogeology) of this EIS: • All pumped water from the Underground mining will be discharge to detention ponds for use in the mill with the surplus conveyed to the underground mining. Clean water will not be allowed to enter the pit by drainage. Excess water is only released to Timamana Creek when the waterway is able to absorb waste from the detention ponds. Any discharge to the river will be controlled in order to mitigate possible floods. • The discharge of pumped groundwater from the Timamana Creek is controlled and depends on the waterway's capacity. • The TSF has enough freeboard to contain excess flows from the catchments. The facility will also be equipped with control ports to control the release of excess water via Piakle creek to the Hinagasa-an River.
The project may advance aridness and extreme heat. The projection is that Surigao Del Norte would have increases of 161,63% in 2020 and 1450% in 2050 during extreme heat days (Tmax >35oC). In addition, dry days from 1,333 to 6,054 to 2020 will increase from 5,975 on 2050.		✓	✓	✓	The following mitigation measures for the potential enhancement of the project to climate change impacts are in conjunction with the mitigation measures in **Section 2.2.1** (Hydrology and Hydrogeology) of this EIS: • Discharge of pumped water treated from the Underground mining as the construction of the

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
• The underground mining will cross part of the upstream catchment of the Timamana Creek. During the drought, average flow reduction may affect the water users at downstream. • Intercepted groundwater will be drawn to the Underground mining. With the drawdown of water table created by dewatering and the effect of the dry season on groundwater sources, the surrounding catchment areas would experience a reduction in the volumes of groundwater-derived flow.					system progresses compensates the potential reduction in average flow. • Discharge of treated pumped water from the underground mining as the development of this facility progresses, compensates for the possible reduction in flow. • Potential flow reduction due to reduced catchment areas is compensated by increased flow from the installed tailings.

2.3.1.4.2 Potential Impacts

Change in local micro-climate

Removal of vegetation and change in land use could result and impact agriculture, health and ecology changes in local microclimates (Li, Zhao, Motesharrei, Mu, Kalnay, & Li, 2015). Albedo, the amount of the sun's radiation reflected from the Earth's surface, and evapotranspiration, the transport of water into the atmosphere from soil, vegetation, and other surfaces, are identified as the primary drivers of changes in local temperature. The Silangan Copper Gold Mine project comprises approximately 86.07% of the total land area of agroforestry (farmland). Forestlands have a darker surface than agricultural and built-up areas, therefore have a lower albedo which means less solar radiation is reflected and more is absorbed and thus, causes warming. On the other hand, forests absorb more rainwater and transpire it as water vapour later. This phenomenon called evapotranspiration causes cooling (Li, Zhao, Motesharrei, Mu, Kalnay, & Li, 2015). Furthermore, land heats up faster in deforested areas and may reach a higher temperature leading to localized upward motions that may enhance the formation of clouds and ultimately produce more rainfall (NASA, 2004).

The site is surrounded by large forest, grasslands and plantation forests in the municipalities of Placer, Sison, Tagana-an, and Tubod. Change in land use, in particular forests converted into constructed areas, could change local microclimate patterns such as rainfall, temperature and humidity. The project will allow about 2,064,01 hectares of vegetation to be disposed during the lifetime of the mine and could cause changes in the local temperature and precipitation during the project stages.

Change of microclimate in relation to air pollution

A large green space is synergistically helpful in reducing air pollution, the temperature and changes of rainfall type. Therefore, reducing the size of the green area and the percentage of the largest patch negatively impacts air quality, temperature and rainfall type. When air pollutants increase, the formation of rain is more difficult due to the number of cloud droplets increasing while the size of cloud droplets becomes smaller. Therefore, the formation of rain requires a substantially greater number of cloud droplets. Such a situation results in a change in the level of total rainfall and the number of rainy days, decreasing the number of light rainy days while increasing the frequency of torrential rainy days.

In some cases, the change in microclimates may have a critical influence in altering air pollutant dispersal and affecting the path of soundwaves. Formation of inversion layer may effectively trap the ground level pollutants for longer times. The microclimate parameters, most specifically the ambient temperatures, have a strong impact in the velocity and refraction of the sound waves and hence, sound intensity at a given receptor site.

Change of microclimate in relation to ecology

Microclimate variation has a significant impact on plants and animals. In addition, microclimate temperature, wind speed and wind direction may influence the shape, water content of a soil and other abiotic factors of a habitat. The changes caused by the construction and operation of the Silangan Copper-Gold Mine Project in local temperature, rainfall and sunlight can affect the metabolism of plants and their animal behavior. Wind speed changes can also affect the exchange of plant gas in stomatal openings and therefore in the whole metabolism of vegetation.

Impact of the change in microclimate upon humans

Agricultural production and human comfort may be subject to changes in microclimates. Microclimate variations in temperature, rainfall, solar insolation, moisture, and wind speed can influence agricultural yields and crop season. Moisture changes can affect the diffusion of water vapor away from the surface of the leaf. Although moderate wind speeds may increase the metabolic rate of plants, extremely high winds can significantly reduce yields by increasing wind erosion.

Relationship of the change in local microclimate to climate change

Silangan Copper-Gold Project has minimal and potential negligible impacts on the local climate. The climate is influenced by large-scale vegetation or large-scale vegetation clearing. Rainforests play a major role in photosynthesizing atmospheric carbon locking in their vegetation. When forests are cleared or degraded, a great deal of carbon and other greenhouse gases such as nitrous oxides and methane will be emitted into the atmosphere.

Although the project may remove vegetation in an area of 2,064.1 hectares, its contribution to climate change is minimal, as measures for preventing, mitigating and compensating for vegetation removal will be taken during all phases of the project.

Enhancement of climate change impacts

Enhancement of the Project to effects of extreme rainfall

During the 2006-20035 period (centered by 2020), the Surigao Del Norte is expected to have approximately 22 days of extreme precipitation (> 200 mm) and 38 days during the period 2036-2065 (centered at 2050). The Timamana Creek will be discharged of pumped groundwater from the Underground mining. The release of pumped water from the underground mining to the Timamana River can cause downstream flooding, particularly during rainy days. The release of stored water from the TSF could cause flooding, especially during heavy rains downstream of the Hinagasaan River.

Enhancement of the Project to the effects of drought and extreme heat

Surigao del Norte is projected to see an increase of 161.63% in 2020 and 1,450% in 2050, in days of extreme heat (Tmax >35°C). Moreover, from 1,333 to 6,054 days in 2020, dry days will rise to 5,975 in 2050. Part of the upstream catchment of the Timamana Creek will be straddled by the Underground mining. During drought, the reduction of average flow will potentially impact on water users downstream. Intercepted groundwater will be drawn to the Underground mining. The drainage of water table created by dewatering and effect dry season would affect the groundwater supply, also the decrease on the volume of groundwater derived flows in the surrounding catchment areas is expected.

Effects of climate change to the project

The climate is going to have complex impacts in mining projects (Nelson and Schuchard), which include temperature and plant changes and more frequent, and more severe extreme climate events. Infrastructure and equipment stability and efficiency, environmental management and protection, site closure practices and transportation routes can be affected by climatic conditions.

Disturbance to mine infrastructure and operations

More frequent and intense natural disasters may damage mine, transportation, and energy infrastructure and equipment, which in turn may disrupt construction, operations, and production. Heavy rain may affect slope stability of the TSF Embankment. Hotter and drier conditions may cause wildfires that may threaten facilities. Flooding from increased rainfall may interrupt production, and may necessitate additional controls to enhance water treatment capacity. As temperature rises, reduced amounts of water may be available for mining, processing, and refining activities.

More common and intensive natural catastrophes, which in turn can interfere with construction, operations and production, can damage energy infrastructure, transport and equipment. High precipitation could impact the TSF Embankment's slope stability. The conditions that threaten the facilities may result in drier conditions or wildfires. Flows due to higher precipitation may disrupt production, and further controls may be required to increase water treatment capacity. Reduced water quantities for mining, processing and refining are possible with increasing temperatures.

Costs could grow for water treatment before and after use and rising temperatures could increase the demand for energy to cool down the mines. Greater demand and rising prices can entail additional costs, driven by limited natural gas supply and carbon taxation, as well as costly alternative energy sources. Fluctuations in temperature that increase energy demand and lower transmission and distribution capacity can disrupt operational delivery. The reduction in production and profit and commodity prices can result from energy rationing.

Changing access to supply chains and distribution routes

Heavy rain or natural disasters can disrupt roads and road transport. Disruptive supply, or consumables such as diesel, tire, and reactants may cut production or reduce its efficiency, of building materials and processing material such as steel, timber, cement, sulfuric acid, and cyanine. Rising sea-level and frequent storms can affect port access and interfere with timely market transport. As alternative means of transport, demand for road networks may increase and costs may rise.

Challenges to worker health and safety conditions

Increased temperatures could increase the risk of heat related illnesses/diseases and inhibit the decision-making processes, increase the likelihood of injury, accident and death, and decrease productivity. The floods also may affect on-site and road safety for employees. Flooding, natural disasters and drought may jeopardize the health and productivity of workers, and rising temperatures may worsen the lack of water. Higher temperatures are likely to increase the geographical reach of tropical diseases such as dengue.

Challenges to environmental management and mitigation

Water shortages and higher temperatures can make restoring the vegetative cover more difficult and can put stress on other measures to mitigate environmental conditions. Heavy rainfall risks may include failure of the TSF, dumping contaminated water in the vicinity, accompanying remedial costs, increased environmental liability, health and safety impacts on the community and significant reputational damage potential. Additional protection measures for Underground mining, TSF, , and mine facilities can be required for the SMMCI. Costs of environmental liability can increase and responsibilities for monitoring can be extended to ensure that mitigation measures are effectively taken.

2.3.1.4.3 Options for Prevention, Mitigation or Enhancements

Change in local micro-climate

Although the impact of the project on the local climate is minimal and potentially negligible, mitigation actions to further improve the quality of the area will still be implemented. The project's mitigation measures for potential impacts of local microclimate changes are linked to mitigation actions under **Section 2.1.4 (Terrestrial Vegetation)** of this EIS. Measures to mitigate the identified impacts are based on the principles of prevention, mitigation, and compensation. Preventive measures include infrastructure design in order to reduce vegetation clearing. If vegetation clearing is inevitable, eases should be reduced or restricted to the large components especially pipelines and access roads so as to maintain significant coverage of the vegetation. In all places, vegetation groups known to be derivatives of former residual forests classified as brush-and shrubland should be maintained and rehabilitated for possible sources of propagulations for the establishment of forest nurseries.

SMMCI shall contain the area of disturbance, where the extent is clearly indicated in plans and on the floor before the construction works, in order to mitigate the effects of the removal of vegetation. All relevant authorisations (e.g. Special Tree Cutting Autorisations) will be obtained from all the relevant agencies prior to any cutting work as part of the statutory Forest Management Bureau (FMB)-Department of Environment and Natural Resources (DENR). Buffer zones will be set up around identified stepping corridors to protect the remaining propaganda sources. Where remaining vegetation slices (corridor) are not practicable, vegetation patches of approximately 0.5 ha (staging stones) at intervals of approximately 0.5 to 2 km will still be maintained along the limits of the proposed major infrastructure.

As soon as possible, gradual renovation (inside or outside the project site) will be undertaken to compensate for the removal of vegetation from construction and operations of the project. At least areas of rehabilitation will be equivalent to areas of vegetation cleared. Where practicable, open areas and grasslands not affected by the project shall be revegetated. Forest communities shall be identified outside the project site. Long-term protection shall be provided for the sites identified, which act as compensatory measures for local climate impacts of the project. The areas identified to be biodiversity offset should ideally include vegetation communities similar to those for which the project will be cleared. Resident forest workers shall be engaged in monitoring and management of the work of recovery and regeneration as necessary and reference sites shall be created in order to quantify and to understand better the impacts of mining activities. Regular vegetation monitoring within the project site and reference sites are also carried out to quantify the change over time.

Monitoring of change in local microclimate will also be performed, following the frequency of ambient air monitoring as discussed in Section 2.3.3 of this EIS.

Enhancement of climate change impacts

The mitigation measures to enhance the potential impacts of the climate change project are coupled with the mitigation measures in **section 2.2.1** (Hydrology and Hydrogeology) of the EIS.

All pumped water from will be discharged into detention ponds to be used in the mill with an excess conveyed to the underground mining in order to minimize the increase in climate change impacts such as higher precipitation. Diversion drains will prevent clean water coming into the pit. Excess water will be released to Timamana Creek only if the waterway has enough capacity to absorb releases from the detention ponds. Any discharge to the creek is controlled to reduce possible floods.

To minimize the Project’s enhancement to the effects of drought and extreme heat, the potential reduction in average flow will be offset by the discharge of treated pumped water from the Underground mining as the development of this facility progresses. The potential reduction of flow due to decreased catchment area will also be offset by the increase in run-off from the placed tailings.

2.3.2 Greenhouse Gas (GHG) Assessment

This section provides the results of a quantitative greenhouse gas assessment that was undertaken to estimate potential greenhouse gas emissions associated with the construction and operation of the Project. The total contribution of the project to global and Philippine GHG emissions were likewise identified in the assessment, along with the proposed options for prevention, mitigation and/or enhancement measures to minimize the project's impact on global climate change due to GHG emissions. The results of the assessment are presented below.

2.3.2.1 Background

Potential greenhouse gas is emitted through the Silangan Copper Gold Project through vegetation clearing and fossil fuels. Therefore, the project application for a certificate of environmental compliance (ECC) takes into account the GHG emissions of the Project, as recommended by the Philippine EIS Technical Scoping Checklist. As part of the Project's Philippine EIS Scoping Checklist and in accordance with requirements of Equator Principles Performance standard 3, the Greenhouse Gas (GHG) reporting principles under the Greenhouse Gas Protocol and ISO 14064, GHG assessment was carried out.

The Philippines, being a non-Annex I Country Party to the United Nations Framework Convention on Climate Change (UNFCCC), have no binding obligations to reduce or limit its anthropogenic emissions of greenhouse gases. However, as early as 1991, the country has already started its efforts to address the issue of climate change as clearly seen in its thrust to achieve sustainable development (**Table 2-9**). The Philippines adopted a model mitigation plan patterned after previous commitments made by Annex I country parties for the first commitment period (2008-2012) of the Kyoto Protocol to the UNFCCC. The country has adopted a voluntary GHG emission reduction target of 5% by 2012 from the 1990 levels, utilizing similar mechanisms found under the Kyoto Protocol but adapted to the Philippine-setting. For the second commitment period (2013-2017) of the Protocol, however, the Philippines is not committing any GHG emission reduction target to the UNFCCC. Nevertheless, efforts to reduce GHG emissions are still being undertaken.

Table 2-9 The Philippines' GHG Emission Reduction Strategies

Strategy/Activity	Year of Implementation
Formulation of the Philippine Strategy for Sustainable Development (PSSD) and adoption of the Philippine Agenda 21	1991
Creation of the Inter-Agency Committee on Climate Change (IACCC)	1991
Enactment of the Clean Air Act of 1999 (R.A. 8749)	1999
Enactment of the Ecological Solid Waste Management Act of 2000 (R.A. 9003)	2000
Signing of the UNFCCC on June 1992 and ratification on 20 November 2003	2003
Designation of the Department of Environment and Natural Resources (DENR) as the National Authority for Clean Development Mechanism (CDM) by virtue of Executive Order No. 320	2004
Enactment of the Biofuels Act of 2006 (R.A. 9367)	2006
Enactment of the Climate Change Act of 2009 (R.A. 9729)	2009
Signing of the National Framework Strategy on Climate Change (NFSCC)	2010
Signing of the National Climate Change Action Plan (NCCAP)	2011

Source: Environment and Climate Change Division, National Economic and Development Authority (NEDA)-Agriculture Staff

2.3.2.2 Methodology

2.3.2.2.1 Scope Definition

The internationally accepted method of reporting on greenhouse gas emissions is separating emissions into scopes (WBCSD and WRI, 2004). There are three emission scopes:

- Scope 1: Direct GHG Emissions

Emissions where the point of emission release is owned by the proponent, such as production of electricity, heat or steam; company owned vehicles used to transport materials, products, waste and employees; and fugitive emissions.

- Scope 2: Indirect GHG Emissions

  Indirect emissions associated from the purchase/import of electricity, heat or steam which is consumed by the proponent.

- Scope 3: Other Indirect GHG Emissions

  Indirect emissions that are a consequence of the activities of the proponent but occur from sources owned or controlled by another company or known as "sub-contractors". Examples of such are: employee business travel; transportation of products, materials, and waste; and employees commuting to and from work.

The purpose of differentiating between the scopes of emissions is to avoid the potential for double counting. Double counting occurs when two or more organizations assume responsibility for the same emissions. Reporting in line with the GHG Protocol requires that organizations report Scope 1 and Scope 2 emissions, but not Scope 3 emissions. Scope 3 emissions may be reported voluntarily.

2.3.2.2.2 Calculation Approach for Inventory

This GHG calculation is aligned with the 2006 Inter-governmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories. There are three calculation methods: Tier 1, Tier 2, and Tier 3. The Tier 1 approach uses default emission factors. The Tier 2 approach uses country specific emission factors derived from national fuel characteristics. The Tier 3 approach takes into account the fuel type used, combustion technology, operating conditions, and control technology, quality of maintenance and equipment age.

Due to a lack of industry or project specific emissions factors, the calculations in this assessment have adopted the Tier 1 methodology, which allows for the use of readily available national or international statistics in combination with the provided default emission factors and additional parameters. The calculations in this assessment use carbon dioxide equivalent (CO2-e) as it is the universally accepted measure for calculating the global warming potential (GWP) of different greenhouse gases to derive a single greenhouse gas emissions unit. Carbon dioxide is used as the reference gas with a GWP of 1. The GWP of a greenhouse gas is the radiative forcing impact contributing to global warming relative to one unit of carbon dioxide.

Table 2-10 lists the common greenhouse gases together with their corresponding GWP.

Table 2-10 Global Warming Potential and Emission Factors of Common Greenhouse Gases

Common name	Chemical Formula	GWP* for 100-year time horizon	Emission Factor** (kg/TJ) diesel
Carbon Dioxide	CO_2	1	74,100
Methane	CH_4	34	3
Nitrous Oxide	N_2O	298	0.6

Source:
**2013 Inter-governmental Panel on Climate Change (IPCC) Fifth Assessment Report*
***2006 Inter-governmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy*

Table 2-11 outlines the formulas and the associated emission factors used to estimate projected greenhouse gas emissions resulting from combustion of fossil fuels and vegetation clearing during construction and operation of the Project.

Table 2-11 Calculation Approach

Source of Emissions	Formula Used	Emission Factor	Energy Content Factor	Global Warming Potential	Project Phase
Fuel Consumption*	$$Tonnes\ of\ CO_2-e = \frac{Q \times EC \times EF \times GWP}{1000}$$ Where: **Q** = the amount of fuel combusted/consumed (kL) **EC** = energy content factor of fuel used (TJ/kL) **EF** = emission factor of GHG in consideration (kg /TJ) **GWP** = global warming potential	CO_2 – 74,100 CH_4 – 3 N_2O – 0.6	0.0386	CO_2 – 1 CH_4 – 34 N_2O - 298	Construction, Operation
Vegetation Clearing**	$$E_{BiomassLoss}(Tonnes\ of\ CO_2) = (L_{SP,tree} + L_{SP,shrub})\frac{44}{12}$$ And: $$L_{SP,tree} = A_S B_{AB,tree}(1+R_{tree})CF_{tree}$$ $$L_{SP,shrub} = A_S B_{AB,shrub}(1+R_{shrub})CF_{shrub}$$ Where: **A_s** = Area of stratum (hectares) **B_{AB}** = Average above-ground biomass stock of tree or shrub vegetation (as indicated by subscripts in equations) (Td.m./hectare) **R** = Average root:shoot ratio appropriate for biomass stocks, for tree or shrub vegetation (as indicated by subscripts in equations); default values for tree and shrub vegetation, respectively, are: 0.3, 0.4 **CF** = Average carbon fraction of biomass for tree or shrub vegetation (as indicated by subscripts in equations); IPCC default values for tree and shrub vegetation, respectively, are: 0.50, 0.49 (TC/T d.m.) **44/12** = Conversion factor: ratio of molecular weights of CO_2 and C	N/A	N/A	N/A	Construction, Operation

*Sources:*National Greenhouse Accounts Factors, Commonwealth of Australia (Department of Environment) 2014*
***2006 IPCC Guidelines for National Greenhouse Gas Inventory. Volume 4: Agriculture, Forestry and Other Land*

2.3.2.2.3 Emission Profile

The Greenhouse Gas Protocol established an international standard for accounting and reporting GHG emissions. In this project, the GHG emissions estimation has been limited to Scope 1 emissions. For the underground mining, mills, crushing facilities, TSF, haul road, and process plant and camp, the Scope 1 emissions during the construction and operation phases include the consumption of fossil fuels and vegetation clearing.

2.3.2.2.4 Geographical Boundary

The geographical boundary set for the Silangan Copper-Gold Project greenhouse gas assessment covers the emissions associated with the underground mining, mills, crushing facilities, TSF, haul road, process plant and camp, and their associated infrastructure/mobile plant and equipment. The geographical boundary set for the estimation is within the project site. Thus, GHG contribution from electricity generation and product transport were not considered in this assessment.

2.3.2.2.5 Emission Scope Boundary

Boundaries for greenhouse gas emissions have been set with the aim of providing as complete an emissions inventory as possible where SMMCI has operational control. Having operational control means that the company is responsible for the greenhouse gas emissions produced as SMMCI can introduce and implement operational, environmental, and safety policies.

All Scope 1 emissions have been identified and reported as far as possible. Emission sources have been identified based on the size and scale of the project as defined in the Project Description chapter and published reference documents. Sources included and excluded in the emissions inventory are outlined below.

Inclusions:

- Fuel consumption for the Project
- On-site land clearing of vegetation;

Exclusions:

- Emissions from waste processing and landfill activities;
- Power consumption;
- Transmission losses;
- Waste water treatment; and
- Scopes 2 and 3 emissions.

Although some emissions will arise due to on-site waste management activities and fuel consumption of the back-up diesel generators, these have not been considered in this report as they will be minimal. It is considered that these sources will contribute a minor amount to the total greenhouse gas emissions from the site.

Upon the commencement of the project, this data should be collected, and emissions calculated as per the relevant national and international calculation methodologies.

2.3.2.2.6 Temporal Scope Boundary

The temporal boundary is defined as the period of time that the Project's GHG emissions will have an effect on the environment. It is assumed that the potential effect of GHG emissions from the Project will be 50 to 200 years once GHGs are released into the atmosphere, corresponding to the maximum lifetime of CO_2 in the atmosphere (IPCC, 2001). The temporal boundaries of the Project include the following phases:

- Construction (Year 1 to Year 26) – 26 years
- Operation (Year 3 to Year 27) – 25 years
- Closure (Year 28) – 1 year, including decommissioning and reclamation

The Project's GHG assessment will focus on the construction and operation phases as the majority of the emissions will occur during this time. GHG emissions during the closure phase will be negligible in comparison.

2.3.2.3 Limitations of the Study

The estimated rate of fuel consumption of mobile equipment and vehicles were estimated in reference to a comprehensive study on fuel use and emissions of non-road diesel construction equipment (Frey, Rasdorf, & Lewis, 2010) (**Annex 2.3-4**). These estimates are intended to be used to estimate how much fuel burning equipment consumes fuel during operation and are not exact metrics due to various factors that can affect the amount of fuel consumed. The projected GHG emissions of the project from the consumption of fossil fuels during construction and operation were calculated assuming that the equipments are running 24 hours per day at 288 days a year.

The biomass densities (**Table 2-12**) used in the calculation of the GHG emissions due to vegetation clearing were estimated using a study of carbon stocks in agroforestry systems in Bukidnon, Philippines (Labata, Aranico, Tabaranza, Patricio, & Amparado, 2012) and Philippine forest ecosystems(Lasco & Pulhin, 2003). The computed total GHG emissions due to vegetation clearing do not include carbon uptake from SMMCI's proposed revegetation plan. Total GHG emissions (reduction of GHG sequestration) may decrease depending on the extent of revegetation practices throughout the project stages.

Table 2-12 Aboveground biomass densities used in the computation of the Project's projected GHG emissions due to vegetation clearing

Land Cover	Aboveground Biomass Density (tonnes/ha)		
	Tree	Herbaceous/Understory	Litter
Cultivated Area*	78.13	0.16	4.5
Brushland**	-	63.8	-

**Mean value by Banaticla, et al (2007) and Brown (1997) equations as low and high estimates, mentioned by Labata, Aranico, Tabaranza, Patricio, & Amparado, (2012) for a mixed multi-storey agrifrestry system*
***values by Lasco, et al (1999) mentioned by Lasco & Pulhin (2003)*

2.3.2.4 Baseline Environment for Greenhouse Gas Emissions

2.3.2.4.1 Summary

Table 2-13 Key Findings and Conclusions – Greenhouse Gas Emissions

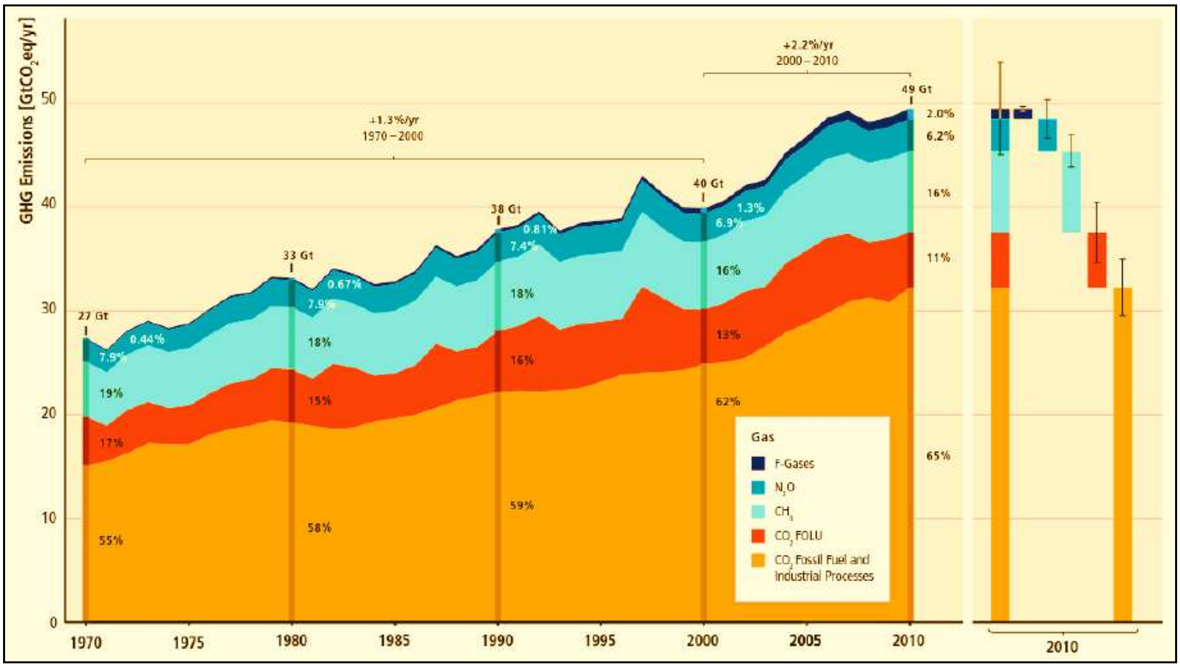
Baseline Information	Key Findings and Conclusions
Global Greenhouse Gas Profile	• Total anthropogenic GHG emissions have continued to increase over 1970 to 2010 with larger absolute decadal increases toward the end of this period. • CO_2 emissions from fossil fuel combustion and industrial processes contributed about 78% of the total GHG emission increase from 1970 to 2010, with a similar percentage contribution for the period 2000-2010. • About half of cumulative anthropogenic CO_2 emissions between 1750 and 2010 have occurred in the last 40 years. • Annual anthropogenic GHG emissions have increased by 10,000 million tonnes of CO_2-e between 2000 and 2010, with this increase directly coming from energy supply (47%), industry (30%), transport (11%), and buildings (3%) sectors. Accounting for indirect emissions raises the contributions of the buildings and industry sectors. • Globally, economic and population growth continue to be the most important drivers of increases in CO_2 emissions from fossil fuel combustion. The contribution of population growth between 2000 and 2010 remained roughly identical to the previous three decades, while the contribution of economic growth has risen sharply. • The IPCC Fifth Assessment Report (AR5) estimated that the worldwide anthropogenic greenhouse gas emissions totalled nearly 49 billion tonnes of CO_2-e in 2010 (Edenhofer, et al.).

Baseline Information	Key Findings and Conclusions
Philippine Greenhouse Gas Profile	• An inventory of GHG emissions conducted in 2000 showed that the Philippines emitted approximately 21.767 million tonnes of CO_2 -e (including LULUCF*) • The Philippine GHG emissions in the year 2000 due to fuel consumption was estimated to be at 69.67 million tonnes of CO_2 –e (excluding LULUCF*) • Carbon sequestration associated with *LULUCF in the Philippines contributed approximately 105.11 million tonnes of CO_2 –e to GHG sequestration (sink)

**LULUCF – Land Use, Land Use Change, and Forestry- is the subset of Agriculture, Forestry and Other Land Use (AFOLU) emissions and removals of GHGs related to direct human-induced land use, land-use change and forestry activities excluding agricultural emissions and removals*

2.3.2.4.2 Global Greenhouse Gas Profile

International anthropogenic GHG emissions can provide an idea of the global context to compare the Project's GHG emissions to. Based on the IPCC 5th Assessment Report, the total anthropogenic greenhouse gas (GHG) emissions have continued to increase over 1970 to 2010 with larger absolute decadal increases toward the end of the period. Despite a growing number of climate change mitigation policies, the annual GHG emissions increased on average by 1 billion tonnes of CO_2-e (2.2%) annually from 2000 to 2010 compared to 0.5 billion tonnes of CO_2-e (1.3%) per year from 1970 to 2000 (**Figure 2-8**). Carbon dioxide emissions from fossil fuel combustion and industrial processes contributed approximately 78% of the total GHG emission increase from 1970 to 2010, having similar percentage contribution for the period of 2000-2010. Fossil-fuel related CO_2 emissions reached approximately 32 (±2.7) billion tonnes of CO_2-e in 2010, and further increased by approximately 3% between 2010 and 2011, and by about 1% to 2% between 2011 and 2012. Of the 49 (±4.5) billion tonnes of CO_2-e per year in total anthropogenic GHG emissions in 2010, CO_2 remains the major anthropogenic GHG accounting for 76% (38±3.8 billion tonnes of CO_2-e per year). Methane (CH_4) accounts for 16% (7.8±1.6 billion tonnes of CO_2-e per year), 6.2% (3.1 ± 1.9 billion tonnes of CO_2-e per year) from nitrous oxides (N_2O), and 2.0% (1.0 ± 0.2 billion tonnes of CO_2-e per year) from fluorinated gases (**Figure 2-8**). Annually, since 1970, approximately 25% of anthropogenic GHG emissions have been in the form of non-CO_2 gases.

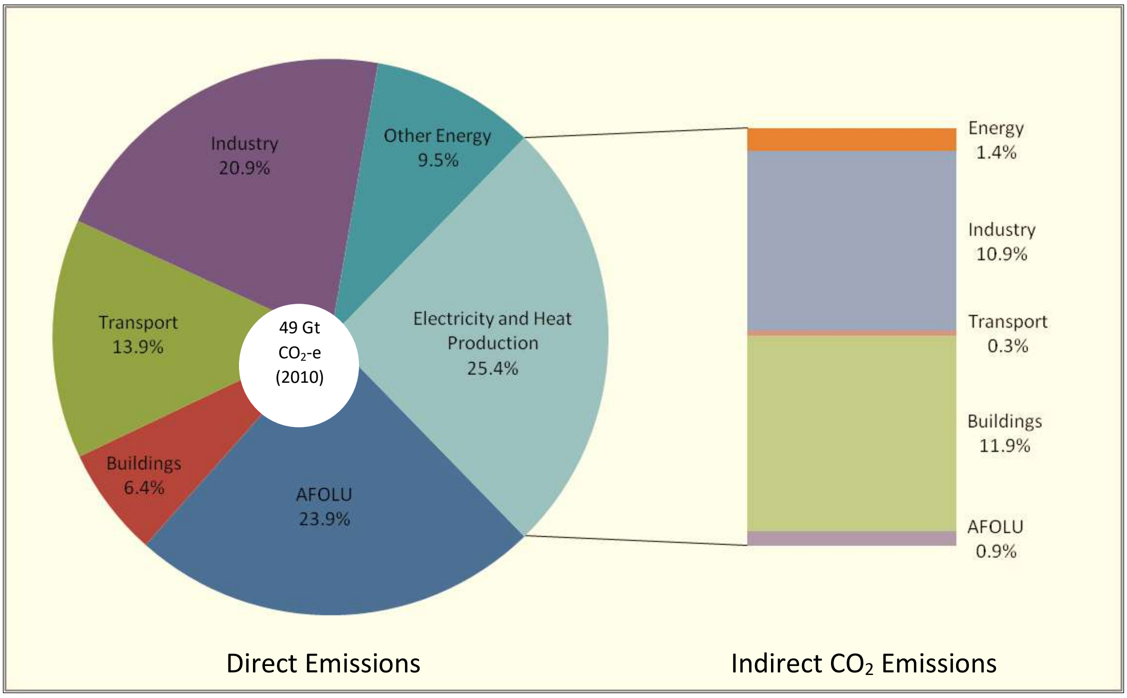


Source: IPCC Fifth Assessment Report

Figure 2-8 Total annual anthropogenic GHG emissions (billion tonnes of CO_2-e per year) by groups of gases from 1970 to 2010

Approximately 50% of the cumulative CO_2 emissions between 1750 and 2010 have occurred in the last 40 years. In 1970, the cumulative CO_2 emissions from fossil fuel combustion, cement production, and flaring since 1750 were 420±35 billion tonnes of CO_2. In 2010, that cumulative total had tripled to 1,300±110 billion tonnes of CO_2. Cumulative CO_2 emissions from Forestry and Other Land Use (FOLU) since 1750 increased from 490±180 billion tonnes of CO_2 in 1970 to 680±300 billion tonnes of CO_2 in 2010.

The annual anthropogenic GHG emissions have increased by 10 billion tonnes of CO_2-e between 2000 and 2010, with the increase directly coming from the energy supply (47%), industry (30%), transport (11%), and buildings (3%) sectors. Accounting for indirect emissions raises the contributions of the buildings and industry sectors. Since 2000, GHG emissions have been growing in all sectors, with the exception of AFOLU. Of the 29 (±4.5) billion tonnes of CO_2-e emissions in 2010, 35% (17 billion tonnes of CO_2-e) of GHG emissions were released in the energy supply sector, 24% (12 billion tonnes of CO_2-e net emissions) in AFOLU, 21% (10 billion tonnes of CO_2-e) in industry, 14% (7.0 billion tonnes of CO_2-e) in transport, and 6.4% (3.2 billion tonnes of CO_2-e) in buildings. Emissions from electricity and heat production are attributed to the sectors that utilize the final energy, the shares of the industry and buildings sectors in global GHG emissions are increased to 31% and 19%, respectively (**Figure 2-9** and **Table 2-14**). Since the Project's potential GHG emissions are projected to be generated by the consumption of fossil fuels, and potential reduction of GHG sequestration from vegetation clearing, the projected Project-related GHG emissions will be compared to the total global GHG emissions, as well as the emissions of the Electricity and Heat Production, Transport, and AFOLU sectors. Annex II.9.1 of the IPCC Fifth Assessment report clearly maps the emission sources to their respective sectors throughout the WGIII AR5. The Electricity and Heat Production sector primarily involves power and heat generation. The Transport sector primarily involves fossil fuels burned for aviation, road, rail, marine transportation, and non-road vehicles. AFOLU on the other hand, primarily includes GHG emissions from vegetation clearing. The IPCC Fifth Assessment Report (AR5) estimated that the worldwide anthropogenic greenhouse gas emissions totalled nearly 49 billion tonnes of CO_2-e in 2010 (Edenhofer, et al.).



Note: Main circle shows direct GHG emission shares (in % of total anthropogenic GHG emissions) of five economic sectors in 2010. Pull-out bar shows how indirect CO_2 emission shares (in % of total anthropogenic GHG emissions) from electricity and heat production.

Source: IPCC Fifth Assessment Report

Figure 2-9 Total anthropogenic GHG emissions (billion tonnes of CO_2-e per year) by economic sectors in 2010

Table 2-14 Summary of anthropogenic GHG emission shares of five economic sectors in 2010

Category	Greenhouse Gas Emissions (in billion tonnes of CO_2-e)	Direct GHG Emission Shares (%)
Electricity and Heat Production	12.446	25.40
AFOLU*	11.711	23.90
Buildings	3.136	6.40
Transport	6.811	13.90
Industry	10.241	20.90
Other Energy	4.655	9.50
Total	49.000	100.00

**Agriculture, Forestry, and Other Land Use*

2.3.2.4.3 Philippine Greenhouse Gas Profile

In 2000, the Philippines emitted 21.76734 million tonnes of CO_2-e due to the combined effect of GHG emissions from the four sectors of Energy, Industry, Agriculture, and Wastes, and the net uptake (sink) of GHGs from the LULUCF sector.

Without the contribution of the LULUCF sector, the national GHG total amounts to 126.87871 million tonnes of CO_2-e. Of the four non-LULUCF sectors responsible for the Philippines' GHG sources, the Energy sector is the most significant, accounting for approximately 55% of the national total. This is followed by the Agricultural sector's contribution of approximately 29%. The Wastes and Industrial Processes sectors follow with respective contributions of 9% and 7% of the total (**Table 2-15**).

In contrast with these four sectors which act as GHG sources, carbon sequestration associated with LULUCF in the Philippines contributed approximately 105.11 million tonnes of CO_2 –e to GHG sequestration (sink) (**Table 2-16**).

The Project's greenhouse gas emissions will be compared to the total Philippine emissions, as well as the Energy and LULUCF categories.

Table 2-15 GHG Emissions from the four non-LULUCF sectors of Energy, Industry, Agriculture, and Wastes in the year 2000

Category	Greenhouse Gas Emissions (in tonnes of CO_2-e)	Direct GHG Emission Shares (%)
Energy	69,667,240	54.91
Industrial Processes	8,609,780	6.79
Agriculture	37,002,690	29.16
Wastes	11,599,000	9.14
Total	126,878,710	100.00

Source: United Nations Framework Convention on Climate Change (UNFCCC) (Greenhouse Gas Inventory Data - Detailed data by Party)

Table 2-16 Net GHG emissions in the Philippines including the LULUCF sector (in tonnes of CO_2-e)

Category	1994	2000
Energy	50,040,330.00	69,667,240.00
Industrial Processes	10,602,930.00	8,609,780.00
Agriculture	33,128,670.00	37,002,690.00
Land Use, Land Use Change, and Forestry (LULUCF)	-126,490.00	-105,111,370.00
Wastes	7,094,780.00	11,599,000.00

Total	100,740,220.00	21,767,340.00

Source: United Nations Framework Convention on Climate Change (UNFCCC) (Greenhouse Gas Inventory Data - Detailed data by Party)

2.3.2.5 Potential Impacts and Options for Prevention or Mitigation or Enhancements for Greenhouse Gas Emissions

2.3.2.5.1 Summary

Table 2-17 Potential Impacts and Options for Prevention or Mitigation or Enhancement – Greenhouse Gas Emissions

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
Contribution in terms of greenhouse gas emissions					
Greenhouse gas emissions due to vegetation removal and land use change • Vegetation removal and land use change due to the construction of the Underground mining, TSF, crushing and mine facilities such as the mill, access roads, offices, and camps may decrease carbon sequestration potential in the project area. The total estimated greenhouse gas emissions of the project due to vegetation removal and land use change is approximately 248,512.9 tonnes of CO_2. This equates to a decrease of 0.2364% to the Philippines' GHG sequestration (sink) potential. Compared to the global AFOLU economic sector, the Project is expected to contribute approximately 0.00212%.		✓	✓		The following mitigation measures for the potential impacts of the project caused by vegetation removal and land use change are in conjunction with the mitigation measures in **Section 2.1.4** (Terrestrial Vegetation) of this EIS: • Wherever feasible, the infrastructure will be designed in such a way that vegetation clearing will be reduced. If vegetation clearing is unavoidable, easement of the major components especially pipelines and access roads should be reduced or limited to maintain considerable amount of vegetation cover. • Wherever feasible, vegetation communities classified as brush and shrub lands that are known to be derivatives of previous residual forests should be maintained and rehabilitated for possible sources of propagules for forest nursery establishment. • To contain the area of disturbance, the extent of disturbance shall be clearly identified on the plans and on the ground prior to construction activities. • As part of the Forest Management Bureau (FMB)-Department of Environment and Natural Resources (DENR) statutory requirements, all relevant permits (e.g. Special Tree Cutting Permit) will be secured from concerned agencies prior to any cutting activities. • Establishment of buffer zones around identified stepping corridors should be done to provide protection to remaining sources of propagules. If strips of remnant vegetation (corridor) will not be feasible, patches of vegetation about 0.5 ha

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
					(stepping stones) with intervals of about 0.5 to 2 km shall be retained along the boundaries of proposed major infrastructure. • Progressive rehabilitation (within or outside the project site) will be undertaken as soon as areas for rehabilitation become available. Rehabilitation areas will at least be equivalent to the areas cleared of vegetation. • Open areas and grasslands that will not be affected by the Project shall be revegetated where feasible. • Forests communities outside the project site shall be identified. Long term protection of the identified sites shall be provided to serve as compensatory measures to offset the project's GHG emissions from vegetation clearing. The areas that shall be identified as biodiversity offset, ideally, shall contain vegetation communities that are similar to areas to be cleared for the project. • Resident forester/s shall be engaged to oversee and manage the revegetation/regeneration works as appropriate. • Establishment of appropriate reference sites to quantify and better understand the impacts resulting from mining activities will also be established. Regular monitoring of vegetation within the project site and reference sites to quantify the change over time will also be implemented.
Greenhouse gas emissions due to the consumption of fossil fuels • The annual greenhouse gas emissions associated with the combustion of fossil fuels of the Silangan Copper-Gold Project (10,915.17 tonnes of $CO_{2\text{-}e}$ per year) is expected to contribute approximately 0.008602% of the annual Philippine emissions (excluding LULUCF) for Years 1 and 2. This equates to approximately 0.0000293 of the global GHG emissions (excluding AFOLU) (**Table 2-20** and **Figure 2-10**).		✓	✓		• Fuel and equipment efficiency will be considered prior to construction and operation activities. • Accounting, reporting, and reduction program/campaign will be undertaken to remove or minimize unnecessary GHG emissions. • Low sulphur fuel will be utilized for use in order to minimize emissions and maximize equipment efficiency. • Fuel efficiency will be maximised through scheduling of vehicle and equipment movements in order to minimise both idle time and distances travelled. • Equipment and vehicle loadings will be optimised through accurate monitoring and calculation of fuel

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
• In Year 3 to Year 26, the annual greenhouse gas emissions associated with the combustion of fossil of the Project fuels (25,994.74 tonnes of $CO_{2\text{-}e}$ per year) is expected to contribute approximately 0.0204% of the annual Philippine emissions (excluding LULUCF) and approximately 0.00006971% of the global GHG emissions (excluding AFOLU) (**Table 2-20** and **Figure 2-10**). • In Year 27, the Project is expected to contribute approximately 0.013% of the annual Philippine emissions (excluding LULUCF) and 0.000044 of the annual global emissions (excluding AFOLU) (**Table 2-20** and **Figure 2-10**) • The combustion of fossil fuels by mobile equipment during construction and operation is expected to contribute approximately 0.024% of the Philippine Energy Sector emissions and 0.00025% of the global Transport sector emissions. • The consumption of fossil fuel by the Project's processing is expected to contribute approximately 0.029% of the Philippine Energy Sector and 0.00016% of the global Electricity and Heat Production economic sector.					requirements in order to reduce fuel weight and improve fuel efficiency. • Vehicles and mining equipment will be regularly maintained in order to increase efficiency, reduce fuel use, and help reduce costs associated with equipment downtime. • Equipment dispatch will be monitored closely in order to eliminate unnecessary use and to increase efficiency of use.
Enhancement of climate change impacts					
Enhancement of the Project to climate change through GHG emissions • The annual greenhouse gas emissions associated with the combustion of fossil fuels of the Silangan Copper-Gold Project is expected to contribute approximately 0.006% in Year 1 and Year 2, approximately 0.0204% Year 3 to Year 26, and 0.013% in Year 27 of the annual Philippine emissions (excluding LULUCF). • The total estimated greenhouse gas emissions of the project due to vegetation removal and land use change is		✓	✓		While the project may emit approximately 10,915.17 to 25,994.0453 tonnes of $CO_{2\text{-}e}$ per year due to consumption of fossil fuels and approximately 0.2364% reduction in the Philippines' potential carbon sequestration, these values are minimal when compared to the annual global and Philippine GHG emissions. The direct impacts of the project to climate change are difficult to determine and estimate since climate change is a global phenomenon. Indirect contributions are far more difficult to determine. Nevertheless, the mitigating measures to address the potential impacts of the Project to the enhancement of

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
approximately 248,512.9 tonnes of CO_2. This equates to a decrease of 0.2364% of the Philippines' potential GHG sequestration (sink). • While the project may release greenhouse gases in the atmosphere, these values are very minimal and potentially negligible when compared to the global and Philippine emissions, and any climate change impacts in the region are not likely to be Project – related. The direct impacts of the project to climate change are difficult to determine and estimate since climate change is a global phenomenon. Indirect contributions are far more difficult to determine.					the effects of climate change in terms of GHG emissions are the same as above.

2.3.2.5.2 Potential Impacts

Contribution in terms of greenhouse gas emissions

Greenhouse Gas emissions due to vegetation removal and land use change

Land-use change GHG emissions are included in this GHG assessment to describe and quantify direct effects of the Project to potential carbon sinks. Maximum subsidence zone (208 Has), Area of the mill (30 Has), TSF area(250) and 5.44 Km the length of haul road from mill to TSF (**Table 2-10**). The CO_2-e tonnage is estimated to be released in the atmosphere upon land clearing of the respective project component areas. The proposed project components are expected to be fully cleared after Year 26.

The total lifetime contribution of the Project to GHG sequestration reduction potential in the Philippines is estimated at 248,512.9 tonnes of CO_2. This equates to approximately 0.00212% of the global AFOLU sector, and reduction of the Philippine GHG sequestration potential by 0.2364%. Based on these values, the Project's GHG emissions when compared to the global AFOLU and Philippine LULUCF sectors is minimal.

Table 2-18 Total disturbance footprint

Project Component	Total Area (with Buffer in hectares)
Maximum area of subsidence zone	208
Area of mill	30

Length of haulroad from mill to TSF	5.44 km
Area of TSF	250
Total	485

Greenhouse gas emissions due to the combustion of fossil fuels

Table 2-19 presents the potential GHG emissions by the Project due to the consumption of fossil fuels during the construction phase (Year 1 to Year 26). The annual greenhouse gas emissions by the Project for the construction phase is expected to contribute approximately 10,915.17 tonnes of CO_2-e per year. This equates to approximately 0.006% of the annual Philippine emissions (excluding LULUCF) and 0.0000293 of the annual global emissions (excluding AFOLU). Of all the commodities handled by the mobile equipment, the mining truck fleet accounts to the highest GHG share (53.34%).

Table 2-19 Annual greenhouse gas emissions by the Project due to the combustion of fossil fuels – by commodity, construction phase (Year 1 to Year 26)

Commodity	Annual GHG Emissions (tonnes of CO_2-e)	Percentage of Annual Emissions to Philippine Emissions (%)*	Percentage of Annual Emissions to Global Emissions (%)**
Ancillary	1,539.99	0.001214	0.000004
Drilling	991.61	0.000782	0.000003
Mining Truck Fleet	5,821.92	0.004589	0.000016
Pioneering Truck Fleet	2,328.77	0.001835	0.000006
Total	10,915.17	0.008419	0.000029

**Excluding Land Use, Land Use Change, and Forestry (LULUCF)*
***Excluding Agriculture, Forestry, and Other Land Use (AFOLU)*

The annual greenhouse gas emissions by the Project due to combustion of fossil fuels for the operations phase (Year 3 to Year 27) is presented in **Table 2-20**. For the operations phase, the total GHG emissions due to combustion of fossil fuels include fuel for mobile equipments and fuel use for processing. The annual GHG emissions by the project in the operations phase for mobile equipments utilizing fossil fuel is approximately 5,879.05 tonnes of CO_2-e per year while the processing accounts to 20,097.69 tonnes of CO_2-e per year. The total GHG emissions due to the consumption of fossil fuel for the operation phase is approximately 25,994.74 tonnes of CO_2-e per year. This accounts to 0.013% of the annual Philippine emissions (excluding LULUCF) and 0.00007% of the global emissions (excluding AFOLU).

Table 2-19 Annual greenhouse gas emissions by the Project due to the combustion of fossil fuels – by commodity, operation phase (Year 3 to Year 27)

Commodity	Annual GHG Emissions (tonnes of CO2-e)	Shares of Annual Emissions to Philippine Emissions* (%)	Shares of Annual Emissions to Global Emissions** (%)
Ancillary	1,772.87	0.001397	0.000005
Drilling	631.02	0.000497	0.000002
Mining Truck Fleet	2,328.77	0.001835	0.000006
Pioneering Truck Fleet	1,164.38	0.000918	0.000003
Processing	20,097.69	0.015840	0.000054
Total	25,994.74	0.020488	0.000070

**Excluding Land Use, Land Use Change, and Forestry (LULUCF)*
***Excluding Agriculture, Forestry, and Other Land Use (AFOLU)*

The net annual GHG emission for the project is presented in **Table 2-20** and **Figure 2-10**. As discussed in the Project Description section of this EIS, construction phase would commence at Year 1 and is expected to finish by Year 26. Operations phase would start at Year 3 and finish by Year 27.

For the construction phase in Year 1 and Year 2, the annual GHG emissions of the Project due to the combustion of fossil fuels is approximately 10,915.17 tonnes of CO_2-e per year. This equates to 0.00842% of the annual Philippine GHG emissions (excluding LULUCF) and 0.0000293 of the annual global emissions (excluding AFOLU). The Project's annual GHG emissions is expected to increase by Year 3 as operations begin. For Year 3 to Year 26, the Project's projected GHG emissions is approximately 36,994.74 tonnes of CO_2-e per year. This equates to 0.029% of the Philippine emissions (excluding LULUCF) and 0.00006971% of the global emissions. Since construction is expected to finish by Year 26, the total Project-related GHG emissions is expected to decrease its annual GHG emissions to 25,994.74 tonnes of CO_2-e by Year 27 as the Project commences its final year of production. This equates to approximately 0.013% of the annual Philippine emissions (excluding LULUCF) and 0.000044 of the global emissions (excluding AFOLU). Based on these values, the annual GHG emissions by the Project relative to the annual Philippine and global emissions is very minimal and potentially negligible.

Table 2-202 Net annual greenhouse gas emissions by the Project due to the combustion of fossil fuels over the life of the mine – by scenario, construction and operation phase (Year 1 to Year 27)

Scenarios	Tonnes of CO_2-e per Year			Emission Shares to Annual Philippine Emissions* (%)	Emission Shares to Annual Global Emissions** (%)
	Annual GHG Emissions, Construction Phase	Annual GHG Emissions, Operation Phase	Net annual GHG Emissions		
Year 1 to Year 2	10,915.17	-	10,915.17	0.008602	0.0000286
Year 3 to Year 26	10,915.17	25,994.74	36,909.91	0.029090	0.00009898
Year 27	-	25,994.74	25,994.74	0.02049	0.0000697

Excluding Land Use, Land Use Change, and Forestry (LULUCF)
***Excluding Agriculture, Forestry, and Other Land Use (AFOLU)*

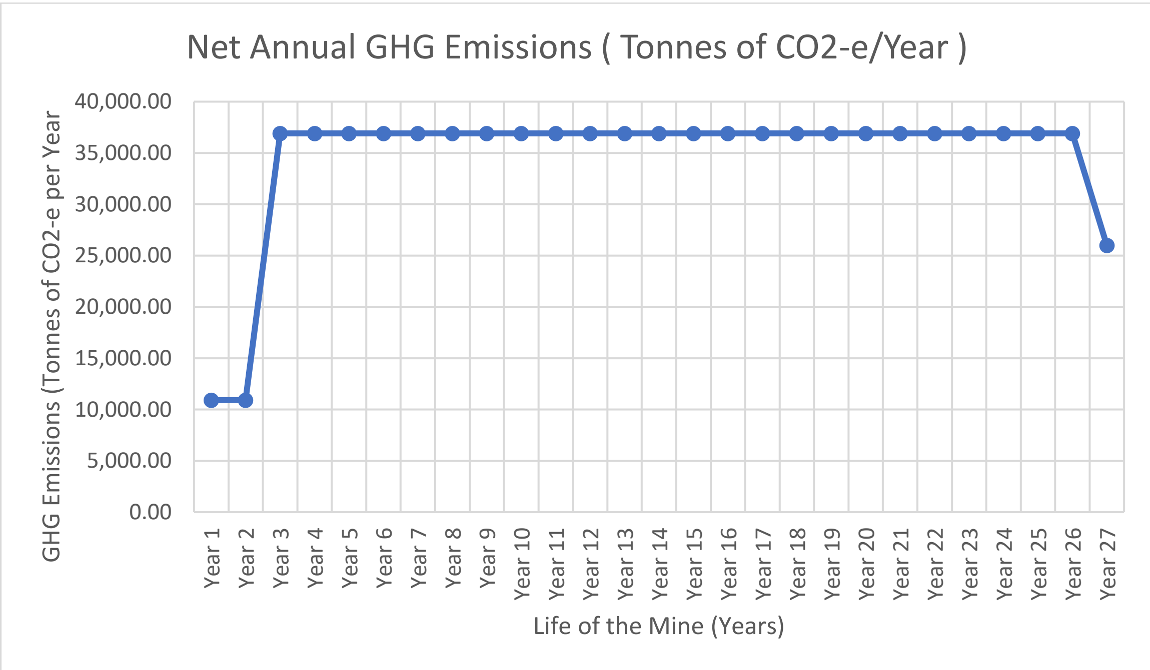


Figure 2-10 Annual greenhouse gas emissions by the Project due to the combustion of fossil fuels over the life of the mine (Year 1 to Year 27)

Enhancement of climate change impacts

The annual greenhouse gas emissions associated with the combustion of fossil fuels of the Silangan Copper-Gold Project is expected to contribute approximately 0.008602% in Year 1 and Year 2, approximately 0.0204% Year 3 to Year 26, and 0.013% in Year 27 of the annual Philippine emissions (excluding LULUCF). The total estimated greenhouse gas emissions of the project due to vegetation removal and land use change is approximately 248,512.9 tonnes of CO_2. This equates to a decrease of 0.2364% of the Philippines' potential GHG sequestration (sink).

While the project may release greenhouse gases in the atmosphere, these values are very minimal and potentially negligible when compared to the global and Philippine emissions, and any climate change impacts in the region are not likely to be Project –related. The direct impacts of the project to climate change are difficult to determine and estimate since climate change is a global phenomenon. Indirect contributions are far more difficult to determine.

2.3.2.5.3 Options for Prevention, Mitigation or Enhancement

Contribution in terms of greenhouse gas emissions

Greenhouse gas emissions over the life of the mine are predominantly from the combustion of fossil fuels. Minimising fuel consumption is an economic as well as an environmental driver for the Project, and a number of good practice measures to achieve this are already accounted for from which the emissions calculations are derived. These measures include:

- Fuel and equipment efficiency will be considered prior to construction and operation activities.
- Accounting, reporting, and reduction program/campaign will be undertaken to remove or minimize unnecessary GHG emissions.
- Low sulphur fuel will be utilized for use in order to minimize emissions and maximize equipment efficiency.
- Fuel efficiency will be maximised through scheduling of vehicle and equipment movements in order to minimise both idle time and distances travelled.
- Equipment and vehicle loadings will be optimised through accurate monitoring and calculation of fuel requirements in order to reduce fuel weight and improve fuel efficiency.
- Vehicles and mining equipment will be regularly maintained in order to increase efficiency, reduce fuel use, and help reduce costs associated with equipment downtime.
- Equipment dispatch will be monitored closely in order to eliminate unnecessary use and to increase efficiency of use.

To mitigate/minimise emissions from vegetation clearing and land use change, SMMCI will:

- Design infrastructure in such a way that vegetation clearing will be reduced. If vegetation clearing is unavoidable, easement of the major components especially pipelines and access roads should be reduced or limited to maintain considerable amount of vegetation cover, wherever possible
- Wherever feasible, vegetation communities classified as brush and shrub lands that are known to be derivatives of previous residual forests should be maintained and rehabilitated for possible sources of propagules for forest nursery establishment.
- To contain the area of disturbance, the extent of disturbance shall be clearly identified on the plans and on the ground prior to construction activities.
- As part of the Forest Management Bureau (FMB)-Department of Environment and Natural Resources (DENR) statutory requirements, all relevant permits (e.g. Special Tree Cutting Permit) will be secured from concerned agencies prior to any cutting activities.
- Establishment of buffer zones around identified stepping corridors should be done to provide protection to remaining sources of propagules. If strips of remnant vegetation (corridor) will not be feasible, patches of vegetation about 0.5 ha (stepping stones) with intervals of about 0.5 to 2 km shall be retained along the boundaries of proposed major infrastructure.
- Progressive rehabilitation (within or outside the project site) will be undertaken as soon as areas for rehabilitation become available. Rehabilitation areas will at least be equivalent to the areas cleared of vegetation.
- Open areas and grasslands that will not be affected by the Project shall be revegetated where feasible.
- Forests communities outside the project site shall be identified. Long term protection of the identified sites shall be provided to serve as compensatory measures to offset the project's GHG emissions from vegetation clearing. The areas that shall be identified as biodiversity offset, ideally, shall contain vegetation communities that are similar to areas to be cleared for the project.
- Resident forester/s shall be engaged to oversee and manage the revegetation/regeneration works as appropriate.

- Establishment of appropriate reference sites to quantify and better understand the impacts resulting from mining activities will also be established. Regular monitoring of vegetation within the project site and reference sites to quantify the change over time will also be implemented.

In addition to these measures, SMMCI will continually seek opportunities in order to reduce further GHG emissions by the Project.

Enhancement of climate change impacts

While the project may emit approximately 10,915.17 to 36,909.91 tonnes of CO_2-e per year due to consumption of fossil fuels, and approximately 0.2364% reduction in the Philippines' potential carbon sequestration, these values are minimal when compared to the annual global and Philippine GHG emissions. The direct impacts of the project to climate change are difficult to determine and estimate since climate change is a global phenomenon. Indirect contributions are far more difficult to determine. The mitigating measures to address the potential impacts of the Project to the enhancement of the effects of climate change in terms of GHG emissions are the same as above.

2.3.3 Ambient Air Quality

Ambient Air Quality is defined by RA 8749 as the general amount of pollution present in a broad area and refers to the atmosphere's average purity as distinguished from discharge measurements taken at the source of pollution. Ambient Air Quality Monitoring (AAQM) was done to monitor the present air quality at the project area, assess the potential impacts of the project and to identify and design the most effective mitigation techniques. On the succeeding sections further details about the baseline assessment, methodologies used, identified potential impacts and mitigation measures will be discussed in detail.

2.3.3.1 Background

As part of the requirement of the Philippine EIS Scoping Checklist for Silangan Copper-Gold Project and with reference to the Philippine Clean Air Act of 1999 (R.A. 8749) and its Implementing Rules and Regulations (DAO 2000-81), AAQM was done on the areas surrounding the project that were identified as sensitive receptors of the pollutants. It was also done to determine the baseline conditions of the ambient air, identify the potential air quality impacts and design measures to mitigate or minimize adverse environmental impacts and to ensure that the project is in compliance with RA 8749.

By conducting Ambient Air Quality and Noise monitoring at the locations identified sensitive receptors, baseline ambient air quality of the places surrounding the project site is assessed. Presented below are the assessment.

2.3.3.2 Methodology

2.3.3.2.1 Desktop Review of Relevant Air Quality Criteria

This assessment included a review of legislation relevant to the Silangan Copper-Gold Project. For the purpose of this assessment, the following Philippine legislations were considered:

Relevant to the Silangan Copper-Gold Project, the ff. legislations were considered for this assessment

- Republic Act 8749, otherwise known as the "Philippine Clean Air Act of 1999"; and
- DENR Administrative Order 2000-81, Implementing Rules and Regulations of the Philippine Clean Air Act of 1999.

The Philippine 1987 Constitution declares that it is the policy of the State to protect and advance the right of the people to a balanced and healthful ecology in accord with the rhythm and harmony of nature while pursuing a policy that balances development and environmental protection and maintaining an air quality that protects human health and welfare. RA 8749 recognizes and outlines these principles and sets out national ambient air quality guidelines for criteria pollutants and national ambient air quality standards for source-specific air pollutants from industrial sources/operations. These guidelines and standards were adopted as criteria for this assessment.

Pursuant to the provisions of Section 51 of RA 8749, the DENR adopted and promulgated DAO 2000-81, otherwise known as the Implementing Rules and Regulations for RA 8749. The purpose of which is to provide guidelines on the operationalization of RA 8749, and lays down the functions and powers of the DENR and other concerned agencies.

2.3.3.2.2 Sources Identification

The identified pollutants for mining activities are presented in **Table 2-21**. Identification of the sources of pollutants from the Project is necessary as excessive exposure of humans to these pollutants may cause adverse environmental and health effects.

Table 2-21 Air pollutants associated with mining activities

Pollutants	Potential Sources	Rationale for the Location of Sampling Stations
Particulate Matter (TSP and PM_{10})	Identified potential sources are soil and road dusts, earth works that includes blasting, drilling and excavation. TSP and PM10 would also be generated by transporting materials using heavy equipment, fuel combustion and wind erosion.	Four (4) ambient air quality monitoring stations were established on densely populated areas near the project site. These sampling stations represent the areas that are prone to the effects and exposure to the identified pollutants.
Particulate metals (Cd, As, Hg, Cu, Pb, Cr, Mn, Ni, V and Sb)	Metal-rich particulate matter liberated from mineralized materials because of mining activities such as ore body blasting, drilling, grinding and material movement through conveyors will increase the ambient concentrations of elements suspended in the air.	
Sulphur dioxide (SO_2)	Associated with the combustion of fossil fuels Main sources of SO2 are emissions from industrial facilities, vehicle and heavy equipment exhaust emissions	
Nitrogen dioxide (NO_2)	Main sources of NO2 are vehicular emissions, power plants and off-road equipment.	

2.3.3.2.3 Sampling Sites

Characterization of baseline ambient air quality was done by conducting 24-hour air sampling at different locations surrounding the project site. The ambient air monitoring for this assessment was conducted last February 27, 2019 to March 03, 2019.

Four (4) monitoring stations were identified to assess the baseline ambient air quality condition of the project site's surrounding environment. The sampling stations were placed in areas with most probable critical receptors and/ or near the project site. The sampling sites are described in **Table 2-22** and illustrated in **Plates 2.3-9** to **2.3-11**. The location of the sampling sites relative to the Project footprint is shown in

Figure 2-11.

Table 2-22 Ambient Air Quality and Noise Stations

Station ID	Location	Coordinates	Description
AQM1	Timamana Elementary School	9°35'56.18"N 125°34'7.37"E	The station is located inside Timamana Elementary school about 5-10 meters away from the barangay road.

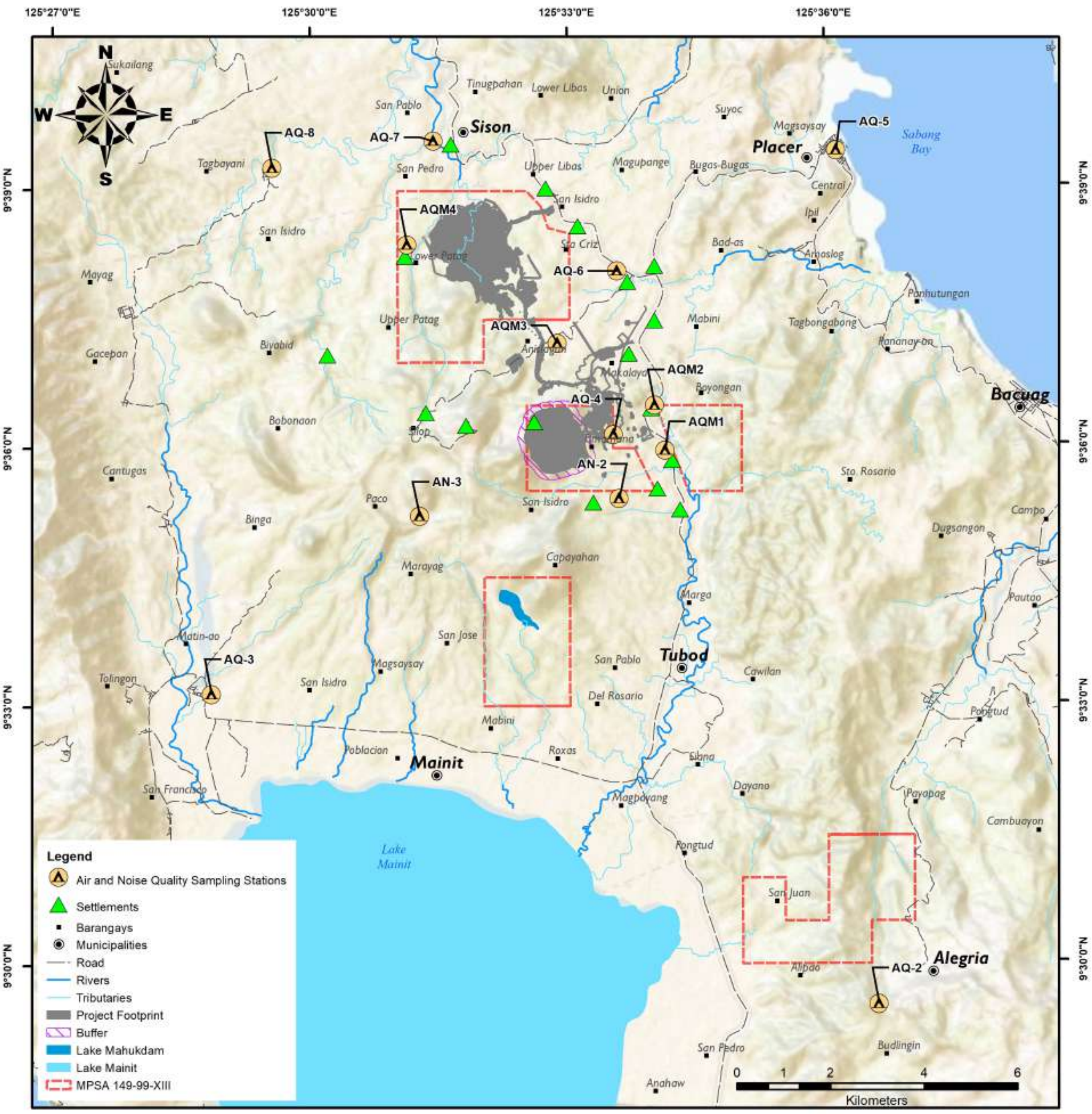
Station ID	Location	Coordinates	Description
AQM2	Boyongan Elementary School	9°36'27.39"N 125°33'59.89"E	The sampling station was placed on the middle of the school playground and approximately 140 meters away from the Boyongan Barangay Hall.
AQM3	Anislagan Elementary School	9°37'18.96"N 125°32'58.86"E	The sampling station was placed on an open area in front of the principal's office approximately 60m away from the main road.
AQM4	Lower Patag Elementary School	9°38'20.00"N 125°31'7.30"E	The sampling station was placed on the middle of an open field near the flagpole 110 meters away from the main road.

AQM1: Timamana Elementary School

AQM2: Boyongan Elementary School

AQM3: Anislagan Elementary School

AQM4: Lower Patag Elementary School



Ambient Air Quality and Noise Sampling Stations

Silangan Copper-Gold Project

Province of Surigao del Norte

Silangan

Silangan Mindanao Mining Company Inc.

Scale 1 :110,000	
PLOTTED : RCA	DATE : 03/05/2019
REVIEWED : MKM	APPROVED : KHG

JACOBS ch2m

16F South Tower, Rockwell Business Center Sheridan cor. United St. Mandaluyong City

SOURCES:

Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community
NAMRIA
PHILGIS

Disclaimer:

Administrative boundaries are approximate. Therefore it is not authoritative and should be used for planning and visualization purpose only.

Figure 2-11 Ambient Air Quality and Noise Sampling Stations

2.3.3.2.4 Sampling Methodology

A 24-hr ambient air quality monitoring was conducted at four (4) monitoring stations for TSP, PM_{10}, SO_2, NO_2, CO, Noise, Cd, As, Hg, Cu, Pb, Cr, Mn, Ni, V and Sb.

Total Suspended Particulates (TSP). An air sampler draws ambient air at a constant flow rate into a specially shaped inlet and through a filter. The sampler flow rate and the geometry of the shelter favors the collection of particles up to 25-50 µm (aerodynamic diameter). Filter samples are then analyzed gravimetrically.

Particulate Matter 10 (PM10). Air is drawn into a covered housing and through a filter by means of a high- flow-rate blower at a flow rate that allows suspended particles having diameter of 10 microns to pass to the filter surface. The mass concentration of suspended particulate is computed by measuring the mass of collected particulate and the volume of the air sampled.

Sulfur Dioxide (SO2). This method is based on the absorption of sulfur dioxide from the air in a solution of potassium tetrachloromercurate. A dichlorosulfitomercurate complex that resists oxidation by oxygen in the air is formed and is made to react with pararosaniline methyl sulfonic acid. The intensity of the color produced is measured by means of a spectrophotometer and is related directly to the amount of sulphur dioxide present in the corresponding air sample by means of calibration curve.

Nitrogen Dioxide (NO2). The nitrogen dioxide is absorbed in an azo dye-forming reagent. A stable pink color is produced within 15 minutes which may be read visually or in appropriate instrument at 550 nm.

Carbon Monoxide (CO) was directly measured using a gas analyzer with electrochemical sensor.

Metals. Ambient air suspended particulate matter is collected on a glass-fiber filter using a high volume sampler. Collected sample is digested and analyzed through Flame AAS

Noise was directly measured using a digital sound level meter.

Quality control and quality assurance of samples collected were consistent with the procedures and requirements of the US EPA, which was adopted by the DENR.

The samples were analysed based on the air sampling and analytical procedures specified in the DENR Administrative Order (DAO) 2000-81 Implementing Rules and Regulation (IRR) of the Philippine Clean Air Act (RA8749). The ambient air monitoring parameters and their corresponding methods of analysis are summarized in **Table 2-23**.

Table 2-23 Methods of Air Sampling and Analysis

Parameter	Analytical Method
TSP	High volume - Gravimetric method
PM_{10}	High volume - Gravimetric method
Heavy Metals Cd, As, Hg, Cu, Pb, Cr, Mn, Ni, V and Sb	High Volume – Atomic Absorption Spectrophotometer (AAS)
SO_2	Gas Bubbler - Pararosaniline method
NO_2	Gas Bubbler - Griess-Saltzman method
CO	Direct Reading – Electrochemical Scensor
Noise	Direct Reading – Sound Level Meter

The 24-hour monitoring period and compared with the National Ambient Air Quality Guideline Values (NAAQGV) of the Implementing Rules and Regulations of the Philippine Clean Air Act of 1999.The NAAQGV are typically used during the baseline studies to assess the air quality of an airshed or a region/locale prior to the implementation of the project.

2.3.3.2.5 Data Analysis

Ambient air quality sampling results were compared with the Philippine Clean Air Act (CAA) standards. The 24-hour readings were compared with the National Ambient Air Quality Guideline Values (NAAQGV) of the CAA. The NAAQGV are typically used during the baseline studies to assess the air quality of an airshed or a region/locale prior to the implementation of the project. The air quality indices that were used to classify existing air quality conditions as specified in DAO 2000-81 are presented in **Table 2-24**. For the parameters with no prescribed criteria under DAO 2000-81 (Cadmium (Cd), Arsenic (As), Mercury (Hg), Copper (Cu), Manganese (Mn), Chromium (Cr), Nickel (Ni), Vanadium (V) and Antimony (Sb), the results were compared to the permissible exposure limit (PEL) issued by Occupational Safety & Health Administration (OSHA).

Table 2-24 Air Quality Indices

Type/Classification	TSP, µg/Ncm (24-hour average)	PM10, µg/Ncm (24-hour average	SO2, ppm* (24-hour average)	NO_2, ppm* (one-hour average)
Good	0 to 80	0 to 54	0.00 to 0.034 **(0 to 88.8)**	**
Fair	81 to 230	55 to 154	0.35 to 0.144 **(91.4 to 376.2)**	**
Unhealthy for sensitive groups	231 to 349	155 to 254	0.145 to 0.244 **(378.8 to 627.4)**	**
Very unhealthy	350 to 599	255 to 354	0.255 to 0.304 **(587.8 to 794.2)**	**
Acutely unhealthy	600 to 899	355 to 424	0.305 to 0.604 (**796.8 to 1,577.9)**	0.65 to 1.24 (**1,220.5 to2,328.3)**
Emergency	900 and above	425 to 504	0.605 to 0.804 **(1580.5 to 2,100.3)**	1.25 to 1.64 **(2,347.0 to 3,079.3)**

Source: Annex A of DAO 2000-81

**Values in parenthesis are expressed in units of µg/Ncm, conversion factor for SO_2: 1 ppm = 2,612.4 µg/Ncm, for NO_2: 1 ppm = 1,877.6 µg/Ncm; DAO 2000-81*

*** No prescribed index*

A complex relationship between air pollution levels and exposure exists. However, the public needs to be well informed of their ill health effects in a manner that is both simple and accurate. To protect public health, safety and general welfare, a set of pollution standard index of air quality, called the Air Quality Index (AQI) was formulated in line with Part II, Rule VII, Section 4 of RA 8749 IRR. For the six criteria pollutants, the air quality can be described in terms of six levels depending on pollutant concentration: Good, Fair, Unhealthy for sensitive groups, Very unhealthy, Acutely unhealthy and Emergency.

2.3.3.2.6 Air Dispersion Modelling

Tiered Approach to Modelling Assessments

DENR-EMB defines the approved air dispersion models using a tiered approach in the DENR-EMB Guidelines for Air Dispersion Modelling (DMC 2008-003). Modelling assessments are usually carried out following a tiered approach to assess contaminant concentrations against DAO 2000-81 standards and guidelines. The tiered approach follows the approach recommended by the USEPA and includes:

- Screening-level dispersion modelling techniques conducted using worst-case input data rather than site specific data; and

- Refined level dispersion modelling techniques conducted using site specific meteorological data or derived meteorological data.

The assumption of the tiered approach to the selection of model is that the simpler modelling techniques always yield more conservative results, and was assumed that the screening level models would always predict higher ground-level concentrations than refined modelling techniques. There are four tiers:

- Tier 1: Screening of single sources
- Tier 2: Refined model using screening meteorological data
- Tier 3: Refined model using EMB meteorological data
- Tier 4: Sophisticated modelling using site specific meteorological data

Since the Philippine EIS Technical Scoping Checklist for the Project doesn't require air dispersion modelling, this assessment will follow the Tier 1 approach in order to define the potential impact areas of the Project's stationary source.

Tier 1 Screening Approach

The dispersion modelling used for the air quality assessment was SCREEN3, a simple screening procedure model to determine if either the source clearly poses no air quality problem or the potential for an air quality problem exists. This has been identified in the DENR-EMB Guidelines for Air Dispersion Modelling (DMC 2008-003) as the recommended modelling tool to use in Tier 1 screening of single sources. The purpose of applying a simple screening procedure is to conserve resources by eliminating from further analysis those sources that clearly will not cause or contribute to ambient concentrations in excess of short-term air quality standards or allowable concentration increments (USEPA, 1992). This is currently the most common approach used in undertaking dispersion modelling assessments in the Philippines (DMC 2008-003). The required input parameters used in the execution of the SCREEN3 model are presented in **Table 2-25**.

Table 2-25 Required Input Parameters for the SCREEN3 Model

Point Source Inputs	Unit
Emission rate	g/s
Stack height	m
Stack inside diameter	m
Stack gas exit velocity	m/s
Stack gas temperature	K
Ambient temperature	K
Receptor height above ground (maybe used to define flagpole receptors)	m

The SCREEN3 model results were all compared to their respective guidelines. The results of the air dispersion modelling will be used to determine the impact areas of the Project.

2.3.3.3 Scope and Limitation of the Study

The description of baseline ambient air quality is limited to the one-time ambient air monitoring in each of the identified station. The varying conditions and ongoing activities in the monitoring stations during the time of sampling are the major factors that may affect the outcome of ambient air monitoring. The high volume sampler can only provide daily average values for the particle concentration as the sampler must collect larger air volumes to accumulate sufficient mass on the filter to be weighed with a reasonable degree of accuracy.

The SCREEN3 model is currently the most common approach used in dispersion modelling assessments in the Philippines which is fine for single sources and when predicted ground level concentrations are low (below 50% of the NAAQGV). However, it is unreliable in handling sites with multiple sources and real time meteorological data. Further, screening-level dispersion modelling techniques uses worst-case input data rather than site-specific data. For the purpose of determining the impact areas of the Project, this assessment will only involve the screening of particulate pollutants (PM) and nitrogen oxides (NO_x). Sulphur dioxide (SO_2) is not included in the assessment since the Project will utilize low sulphur fuels, and any SO_2 emissions by the stationary source may be considered as insignificant.

2.3.3.4 Baseline Environment for Ambient Air Quality

The baseline assessment indicates that the existing quality of the area is typically in good condition. Key baseline findings on ambient air characterization are presented in **Table 2-26**.

2.3.3.4.1 Summary

Table 2-26 Key Findings and Conclusions – Ambient Air Quality

Baseline Information	Key Findings and Conclusions
Ambient Concentration of Particulate Pollutants	• Average backgound levels of particulate pollutants ranges from <5 µg/Ncm to 35 µg/Ncm in terms of Particulate Matter 10 (PM10) and 5 µg/Ncm to 41 µg/Ncm in terms of Total Suspended Particulates. • Ambient Concentration of Particulate Pollutants conforms to DAO 2008-81 NAAQGV. • The baseline conditions in all four (4) stations are classified as "Good" based on Air Quality Indices.
Ambient Concentration of Gaseous Pollutants	• Average backgound levels of gaseous pollutant NO2 ranges from <0.8 µg/Ncm to 1.5 µg/Ncm. • Values range from below detection limits (<4 µg/Ncm for SO_2). • Ambient Concentration of gaseous pollutants conforms to DAO 2008-81 NAAQGV. • The baseline conditions in all four (4) stations in terms of SO2 are classified as "Good" based on Air Quality Indices.
Ambient Concentration of Heavy Metals	• At present DENR – NAAQGV / NAAQS have no standard limits set for metallic pollutants such as Cd, As, Hg, Cu, Cr, Mn, Ni, V and Sb, ambient air concentrations of trace metals are compared to the Permissible Exposure Limit (PEL) established by Occupational Safety and Health Administration (OSHA). • All concentrations of trace metals were below applicable detection limits. • All concentrations of trace metals were below Permissible Exposure Limit (PEL) established by Occupational Safety and Health Administration (OSHA).
Sources of Threats to Air Quality	• The main contributors of ambient air pollutants in and around the project site are anthropogenic sources such as open burning, vehicle exhaust and vegetation clearing.
Climate Change Impacts Without the Project	• Climate change can have a major effect on the dispersal of air pollutants and the formation of inversion layers, thereby effectively trapping ground level pollutants over long periods of time. • Vehicle exhaust releases sulfur dioxide (SO2) and nitrogen oxide (NOx) in the atmosphere that can react with water and oxygen, forming the acid rain which can cause increases run-off.

2.3.3.4.2 Ambient Concentration of Particulate Pollutants

The results of the 24-hour sampling for TSP and PM10 are summarized in **Error! Reference source not found.** and **Table 2-27**, respectively. All particulate pollutants (TSP, Lead and PM10) are within their respective DAO 2000-81 NAAQGV for 24-hour sampling periods. Ambient concentration of heavy metals such as Cd, As, Hg, Cu, Cr, Mn, Ni, V and Sb monitored at four (4) stations conforms to the permissible exposure limit of OSHA (**Table 2-24**). The quality of air in the surrounding area of the Project site in terms of particulate pollutants are generally good based on the air quality indices of DAO 2000-81 (**Table 2-24**).

Particulate Matter (PM_{10})

24-hour Monitoring

Results for PM_{10} concentration after 24-hour monitoring ranges from <5 µg/Ncm to 35 µg/Ncm. AQM1-Timamana Elementary School exhibited the highest PM_{10} concentration among the sampling stations. The PM_{10} concentrations in all stations were within the DAO 2000-81 NAAQGV of 150 µg/Ncm. The baseline conditions in all four (4) stations are classified as “Good” based on Air Quality Indices.

Total Suspended Particulates (TSP)

24-hour Monitoring

For the 24-hour monitoring, TSP varies from 5 µg/Ncm to 41 µg/Ncm. AQM1- Timamana Elementary School showed the highest TSP concentration among the sampling stations. The TSP concentrations in all four (4) stations were within the DAO 2000-81 NAAQGV of 230 µg/Ncm and are classified as “Good” based on Air Quality Indices.

Table 2-27 Results of the 24-hour ambient air quality monitoring for TSP and PM_{10}

Station ID	Locations	TSP, µg/Ncm	PM_{10}, µg/Ncm
AQM1	Timamana Elementary School	41	35
AQM2	Boyongan Elementary School	22	18
AQM3	Anislagan Elementary School	5	<5
AQM4	Lower Patag Elementary School	11	<5
DAO 2000-81 Guideline Value (NAAQGV)		**230**	**150**

2.3.3.4.3 Ambient Concentration of Gaseous Pollutants

Table 2-28 summarizes the results of SO_2 and NO_2 monitoring for 24-hour sampling periods. The concentrations of SO_2 and NO_2 in all four (4) stations for 24-hour monitoring periods were within their respective DAO 2000-81 NAAQGV. The air quality surrounding the project site in terms of gaseous pollutants is “good” based on the DAO 2000-81 air quality indices (**Table 2-24**).

Sulfur Dioxide (SO_2)

Sulfur Dioxide is a reddish-brown gas with an odorless, pungent smell. The main sources of NO2 are vehicular emissions, power plants and off-road equipment. Like SO2, it undergoes chemical reactions in the atmosphere, forming other toxic NOx compounds and nitrate particulates that pose respiratory health risks. If present in the atmosphere in high concentrations, it can react with sunlight in a process called photolysis which leads to ozone formation.

For the 24-hour monitoring, average levels of SO2 in all stations were <4 µg/Ncm and in compliance with the guideline value of 180 µg/Ncm. All monitoring stations conform to the prescribed DAO 2000-81 NAAQGV and are classified as “Good” based on Air Quality Indices.

Nitrogen Dioxide (NO_2)

Nitrogen Dioxide is a reddish-brown gas with an odorless, pungent smell. The main sources of NO2 are vehicular emissions, power plants and off-road equipment. Like SO2, it undergoes chemical reactions in the atmosphere, forming other toxic NOx compounds and nitrate particulates that pose respiratory health risks. If present in the atmosphere in high concentrations, it can react with sunlight in a process called photolysis which leads to ozone formation.

For the 24-hour monitoring, levels of NO2 ranges from 0.8 µg/Ncm to 1.5 µg/Ncm. All stations were in compliance with the guideline value of 150 µg/Ncm. All monitoring stations conform to the prescribed DAO 2000-81 NAAQGV.

Carbon Monoxide (CO)

Carbon monoxide is a colorless, odorless gas that is very toxic when inhaled as it reduces oxygen transport in the body. At very high concentrations, CO can even cause death. The main source of this pollutant is vehicular emissions especially in urban centers.

Table 2-28 Results of the 24-hour ambient air quality monitoring for SO_2 and NO_2

Station ID	Locations	CO ppm	SO_2, µg/Ncm	NO_2, µg/Ncm
AQM1	Timamana Elementary School	<1	<4	1.5
AQM2	Boyongan Elementary School	<1	<4	1.5
AQM3	Anislagan Elementary School	<1	<4	0.8
AQM4	Lower Patag Elementary School	<1	<4	0.8
DENR Standard (NAAQGV)		**9**	**180**	**150**

2.3.3.4.4 Ambient Concentration of Heavy MetalsOccupational Safety and Health (OSHA).

Mining Operation and Mineral Processing

Mining operations and mineral processing such as excavation, drilling, blasting and grinding will be the primary contributor to the increase of heavy metal concentrations in air. The Silangan plant will treat a maximum of 6.5 M dry t/a of ore to produce copper concentrate, copper cathode and gold ore. The overall flowsheet is shown in the figure below.

SMMCI Mineral Process Diagram

Mineral Processing Flow

- Crushing and grinding
- Flotation circuit
- Atmospheric leach and Counter Current
- Decantation (CCD)
- Solvent Extraction
- Raffinate and Raffinate
- Neutralization
- Electrowinning
- Cyanide Leaching
- Cyanide Destruction
- Acid Wash, Elution and Carbon Desorption
- Tailings Thickener

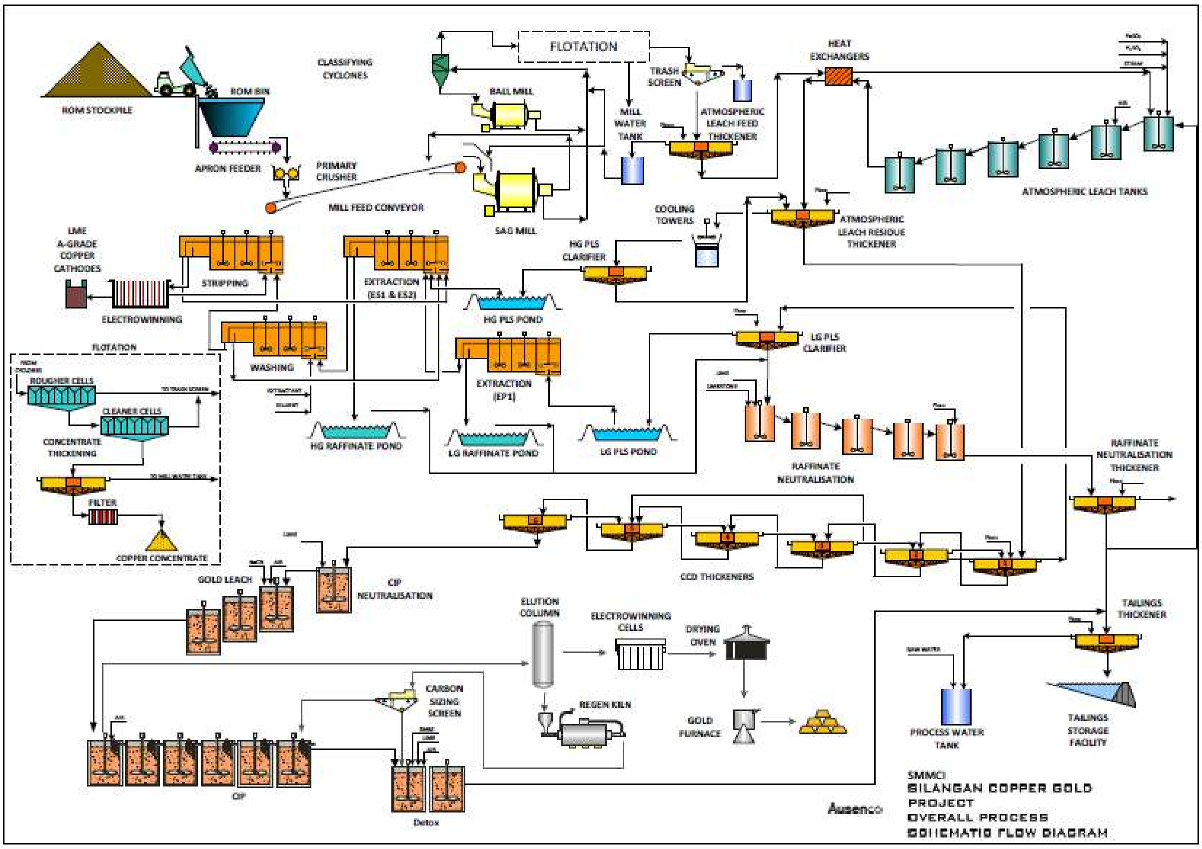
As shown in the mineral process diagram, SMMCI do not have copper smelting, copper conversion or copper refining process, the preferred option was the conventional crush-mill-float technology (copper flotation) to produce copper as concentrate, followed by acid leaching to recover copper and cyanide leaching to recover gold. This process is unlikely to produce air emissions however, flotation waste waters, uncontrolled leachate and heap leach wastes are produced. The tails will be filtered, thickened and processed through tank copper leaching before reaching the TSF.

Table 2-29 to **2.3-33-1** shows the results of the heavy metals monitoring at four (4) sampling stations. The concentrations of heavy metals are almost zero in all monitoring stations and were below permissible exposure limit (PEL) in OSHA. The results of the parameters with no prescribed criteria under DAO 2000-81 were compared to the (PEL) established by Occupational Safety and Health (OSHA).

Mining Operation and Mineral Processing

Mining operations and mineral processing such as excavation, drilling, blasting and grinding will be the primary contributor to the increase of heavy metal concentrations in air. The Silangan plant will treat a maximum of 6.5 M dry t/a of ore to produce copper concentrate, copper cathode and gold ore. The overall flowsheet is shown in the figure below.

SMMCI Mineral Process Diagram



Mineral Processing Flow

- Crushing and grinding
- Flotation circuit
- Atmospheric leach and Counter Current
- Decantation (CCD)
- Solvent Extraction
- Raffinate and Raffinate
- Neutralization
- Electrowinning
- Cyanide Leaching
- Cyanide Destruction
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Table 2-29 Results of heavy metal analysis

Station ID	Location	Concentration (µg/Ncm)				
		Cd	As	Hg	Cu	Pb
AQM1	Timamana Elementary School	<0.00005	<0.00002	<0.000003	<0.05735	<0.0006
AQM2	Boyongan Elementary School	<0.00005	<0.00002	<0.000003	<0.00008	<0.0006
AQM3	Anislagan Elementary School	<0.00005	<0.00002	<0.000003	<0.00008	<0.0006
AQM4	Lower Patag Elementary School	<0.00005	<0.00002	<0.000003	<0.00008	<0.0006
DENR Standard (NAAQGV)		-	-	-	-	1.5
OSHA Standard (PEL)		22.98	500	100	1000	50

Table 2-30-1 Results of heavy metal analysis

Station ID	Location	Concentration (µg/Ncm)				
		Mn	Cr	Ni	V	Sb
AQM1	Timamana Elementary School	<0.00005	<0.0003	<0.0003	<0.003	<0.00008
AQM2	Boyongan Elementary School	<0.00005	<0.0003	<0.0003	<0.003	<0.00008
AQM3	Anislagan Elementary School	<0.00005	<0.0003	<0.0003	<0.003	<0.00008
AQM4	LowerPatag Elementary School	<0.00005	0.0175	<0.0003	<0.003	<0.00008
DENR Standard (NAAQGV)		**-**	**-**	**-**	**-**	**-**
OSHA Standard (PEL)		**5000**	**1000**	**1000**	**50**	**500**

2.3.3.4.5 Air Dispersion Modelling

A quantitative screening approach using SCREEN3 model was performed to identify the potential impacts areas surrounding the project site from the single stationary source of the Project. A summary of the modelled ground level concentrations of PM and NOx, including the projected impact areas are presented in **Table 2-32** and

Table 2-33, and shown in **Figure 2-12**. The input parameters used in the screening is presented in **Table 2-31**

Table 2-31 Input parameters used for the SCREEN3 Model

	Value	Unit
Emission rate	0.047*, 2.8227**	g/s
Stack height	3, 6, and 9	m
Stack inside diameter	0.2032	m
Stack gas flow rate	285.3	m^3/s
Stack gas temperature	681.95	K
Ambient temperature	293	K
Receptor height above ground	0	m

**Emission rate for PM*

***Emission rate for NO_x*

Table 2-32 Summary of predicted PM concentrations in different distances from the point source for 3 different stack heights and potential impact areas for Amihan and Habagat seasons

Distance (m)	3*	6*	9*	Potential Impact Areas	
	Concentration (μg/NCM**)			Amihan (October to April)	Habagat (May to September)
1	0.000001665	0.000001266	0.000000961	Boyongan	-
200	0.003712	0.003308	0.002946	Boyongan	-
400	0.003761	0.003353	0.002987	Boyongan	-
600	0.003820	0.003409	0.003039	Boyongan, Makalaya	-
800	0.003879	0.003463	0.003089	Boyongan, Makalaya	-
1000	0.003929	0.003511	0.003134	Boyongan, Makalaya	-
1200	0.003967	0.003546	0.003167	Boyongan, Makalaya	-
1400	0.004820	0.004793	0.004766	Boyongan, Makalaya	Anislagan
1600	0.006791	0.006768	0.006746	Mabini	Anislagan
1800	0.007310	0.007295	0.007279	Mabini	Anislagan
2000	0.007085	0.007072	0.007060	Mabini	Anislagan
DAO 2000-81 NAAQS	230 μg/NCM				

**- stack height in meters*

***- converted to NCM based on conversion factors of 20 °C at 1,009.8 MBS*

Table 2-33 Summary of predicted NO_x concentrations in different distances from the point source for 3 different stack heights and potential impact areas for Amihan and Habagat seasons

Distance (m)	3*	6*	9*	Potential Impact Areas	
	Concentration (µg/NCM**)			Amihan (October to April)	Habagat (May to September)
1	0.00009996	0.00007606	0.00005772	Boyongan	-
200	0.2230	0.1987	0.1769	Boyongan	-
400	0.2259	0.2014	0.1794	Boyongan	-
600	0.2294	0.2047	0.1825	Boyongan, Makalaya	-
800	0.2330	0.2080	0.1856	Boyongan, Makalaya	-
1000	0.2360	0.2109	0.1881	Boyongan, Makalaya	-
1200	0.2381	0.2129	0.1902	Boyongan, Makalaya	-
1400	0.2894	0.2878	0.2862	Boyongan, Makalaya	Anislagan
1600	0.3001	0.4065	0.4052	Mabini	Anislagan
1800	0.4391	0.4381	0.4372	Mabini	Anislagan
2000	0.4255	0.4248	0.4240	Mabini	Anislagan
DAO 2000-81 NAAQS	260 µg/NCM				

**- stack height*

***- converted to NCM based on conversion factors of 20 °C at 1,009.8 MBS*

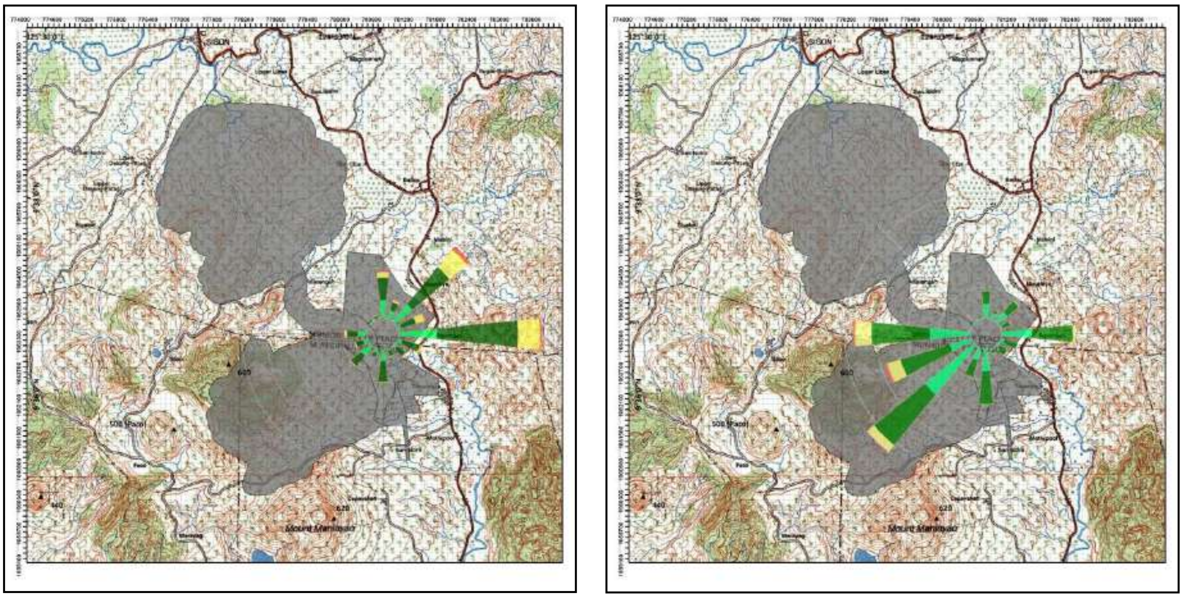

Figure 2-12 Windrose statistics for Amihan (left) and Habagat (right) seasons integrated into the topographical map of the Project area, used to determine potential impact areas from the point source emission in the mill

Based on Screen 3 simulations, the concentrations of PM will would range from 0.007279 ug/ncm to 0.007310 and for NOx it would be around 0.4372 ug/ncm to 0.4255 ug/ncm with a distance of approximately 1.8km from the source. These values are below their respective DAO 2000-81 NAAQGV and NAAQS and any potential impacts to the environment are very minimal and negligible. SCREEN3 results indicate that the projected emissions from the stationary source of the Project are not expected to contribute to the PM and NOx ground levels in the projected impact zones identified (**Table 2-32** and

Table 2-33).

2.3.3.4.6 Sources of Threats to Ambient Air Quality

Vehicle emissions are the most relevant pollutant source within the area, as a site for the project is located next to a major roadway connecting Surigao to the south of Mindanao. Domestic activities are also identified as sources of particulate pollutants, such as burning of solid wastes and the production of charcoal. The threats to a degradation of air quality in the project area by these identified sources are nevertheless minimal. In the Project area, no possible heavy metal sources have been identified.

2.3.3.4.7 Climate Change Impacts Without the Project

As discussed in **Section 2.3.1**, ambient temperatures are expected to increase in 2020 and 2050 (Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA), 2011). Increased precipitation during rainy months and decreased precipitation during dry months are anticipated during these periods. Such climatic changes can have a major influence on air pollutant dispersal and inversion layer formation and can effectively trap ground level pollutants over longer periods of time. Sulphur dioxides (SO_2) and nitrogen oxides (NO_x) released into the atmosphere by vehicular exhaust may react with water and oxygen, forming acid rain. During the wet season where increased rainfall is expected, wet deposition of acidic rain may occur more frequently where acids may fall to the ground in the form of rain. Acid chemicals in the atmosphere can be incorporated into dust during the decreased precipitation over dry seasons and fall into the soil by dry deposition. Rainstorms may wash away dry deposited gases, which can result in increased runoff.

2.3.3.5 Potential Impacts and Options for Prevention or Mitigation or Enhancements for Ambient Air Quality

Table 2-34 Potential Impacts and Options for Prevention or Mitigation or Enhancement – Ambient Air Quality

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
Degradation of Air Quality					
Fugitive Dusts • Fugitive emissions that may be generated from unpaved roads, hauling, storage and handling of materials, underground mine processing, blasting, construction activities, and wind erosion from exposed surfaces, stockpiles, may increase the ground level concentration of particulate metals such as (Cadmium (Cd), Arsenic (As), Mercury (Hg), Copper (Cu), Lead (Pb), Manganese (Mn), Chromium (Cr), Nickel (Ni), Vanadium (V) and Antimony (Sb) TSP and PM10 and may degrade the air quality of the area. • The negative effects in photosynthesis of plants exposed to heavy dust pollution		✓	✓		• Maintaining the allowable speed limit for heavy equipment, trucks and other vehicles also dust suppression using water will prevent the dust particles from going airborne. • In the project site and near sensitive receivers, regular dust monitoring will be carried out. • A buffer zone of at least 200 m will be implemented to alleviate the potential dust emissions. • Erosion control is applied, and stockpiles are vegetated with grass cover to prevent dust from being blown by wind to prevent the dispersion of dust. • Erosion control is applied to avoid dust dispersion from stockpiles and stockpiles are vegetated with grass cover, in order to prevent wind blown dust.; and

Potential Impacts	Phases: Preconstruction	Phases: Construction	Phases: Operation	Phases: Closure	Options for Prevention or Mitigation or Enhancement
may result to the decline / loss of vegetation which may lead to the loss of food and habitat for wildlife. The cover formed by deposition of dust particles decrease the pigmentation of plant leaves.					• Employees shall be given appropriate personal protection equipment to protect them from dusts - related disease, in accordance with BWC - DOLE Occupational Safety and Health Standards (Department of Labor and Employment, 1989).
Emissions due to the consumption of fossil fuels • Burning of fossil fuels in mining equipment, and processing of fossil fuel by vehicles can increase particulate matter (TSP and PM10), NOx, and SOx concentrations at ground level and may degrade air quality in the area. • Sulfur dioxide and nitrogen oxide particles in the air, can create acid rain when they mix with water and oxygen in the atmosphere. These air pollutants come mostly from burning of fossil fuels. When acid rain falls to Earth, it damages plants by changing soil composition that negatively affects the crops; degrades water quality in rivers, lakes and streams therefore greatly affecting humans and wildlife that depends on it		✓	✓		• Sub-contractors will be required to undergo and pass the government vehicle emission tests prior to contract award; • Exhaust fumes from vehicles, mining equipment, and other fuel burning equipment will be managed through the use of low sulphur fuel where possible • Standard occupational health and safety practices will be implemented pursuant to BWC-DOLE Occupational Safety and Health Standards(Department of Labor and Employment, 1989); • The guidelines on traffic management shall be incorporated in the induction seminar of workers and subcontractors. Guidelines will also include the speed control and spraying of road and work sites and transport routes in the vicinity of the host communities; • By scheduling movement of vehicles and equipment the fuel efficiency will be maximized to reduce both idle time and distance travelled. • Equipment and vehicle loadings will be optimised through accurate monitoring and calculation of fuel requirements in order to reduce fuel weight and improve fuel efficiency. • Vehicles and mining equipment will be regularly maintained in order to increase efficiency, reduce fuel use, and help reduce costs associated with equipment downtime. • Equipment dispatch will be monitored closely in order to eliminate unnecessary use and to increase efficiency of use. • Regular air quality monitoring will be conducted within the project site and near the sensitive receptors. The sampling stations as shown in

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
					• **Figure 2-11** may be used as monitoring stations once the project goes into construction and operations phase.
Enhancement of Climate Change Impacts					
• Climate change has the potential to have a critical influence in altering air pollutant dispersal and may frequently form inversion layers that effectively trap ground level pollutants for longer times. By increasing the ground-level concentrations of dusts, particulates, and gaseous pollutants, an inversion can lead to increased pollution such as smog being trapped close to the ground, having possible effects on health. • SOx and NOx emissions in the air could increase the potential for the formation of acid rains. Wet deposition of acidic rain may occur more frequently, and acids may fall to the ground in the form of rain. Dry deposited gases may be washed by rainstorms which can lead to increased run-off. During decreased rainfall in the dry periods, the increased acid chemicals in the atmosphere may be incorporated into the dusts and particulates and fall to the ground through dry deposition.		✓	✓		The project could enhance the impacts of climate change in the area by introducing particulate matter and gasses in the atmosphere. The actions that the projects are taking to minimize their contribution to climate change effects are the same as above.

2.3.3.5.1 Potential Impacts

Fugitive dusts

Airborne emissions occur during each stage of the mine cycle, especially during construction and operational activities. Mining operations mobilize large amounts of material, and waste piles containing small size particles are easily dispersed by wind.

The largest sources of dusts and particulates during construction are fugitive emissions that may be generated from unpaved roads, hauling, storage and handling of materials, mine processing, blasting, construction activities, and wind erosion from exposed surfaces, stockpiles. These may increase the ground level concentration of dusts (TSP and PM_{10}), and particulate metals (Hg, As, Hg, V, Sb, Ni, Cu Pb, Cd, As, and Cr) in the area.

Emissions due to the consumption of fossil fuels

The emission of particulate and gaseous pollutants for both the construction and operation phases is mainly caused by the consumption of fossil fuels from vehicles and mining equipment. Fuel consumption by these, including the mine's processing, may contribute to the increase of particulates (TSP, PM_{10}, Hg, As, Hg, V, Sb, Ni, Cu Pb, Cd, As, and Cr). These emissions may increase the ground level concentrations of particulates, metals and gaseous pollutants.

Enhancement of climate change impacts

Climate change has the potential to have a critical influence in altering air pollutant dispersal. Formation of inversion layers may also effectively trap ground level pollutants for longer times. By increasing the ground-level concentrations of dusts, particulates, and gaseous pollutants, an inversion can lead to increased pollution such as smog being trapped close to the ground, having possible effects on health. Inversion layers may also suppress convection by acting as caps, and if broken, convection of moisture present may form into violent thunderstorms. Emissions of SO_x and NO_x into the atmosphere may increase the potential to form acid rains. Wet deposition of acidic rain may occur more frequently, and acids may fall to the ground in the form of rain. During decreased rainfall in the dry periods, the increased acid chemicals in the atmosphere may be incorporated into the dusts and particulates and fall to the ground through dry deposition. Dry deposited gases may be washed by rainstorms which can lead to increased run-off.

2.3.3.5.2 Options for Prevention, Mitigation or Enhancement

Fugitive emissions

Fugitive emissions by the project is the most significant source of dust and particulate pollutants (trace metals Hg, As, Hg, V, Sb, Ni, Cu Pb, Cd, As, and Cr, TSP, and PM_{10}) during construction and operation phases. Measures to manage this would include:

- Fugitive dust from vehicular traffic and material handling activities will be controlled by management of vehicle speeds and application of regular water suppression to unpaved haul roads and stockpiles whenever visible dust is observed.
- Regular dust monitoring will be conducted within the project site and near the sensitive receptors. The sampling stations as shown in
- **Figure 2-11** may be used as monitoring stations once the project goes into construction and operations phase;
- A buffer zone of at least 200 m for the Underground mining and will be enforced to mitigate potential dust emissions
- To prevent dust dispersion from stockpiles, erosion control will be applied and stockpiles will be vegetated with grass cover to prevent dust from being blown by the wind
- Blasting procedures will ensure that blasts will not be fired during unfavourable weather conditions that would result in dust impacts in nearby communities; and
- Workers will be provided with the appropriate personal protective equipment pursuant to BWC-DOLE Occupational Safety and Health Standards (Department of Labor and Employment, 1989) to protect them from disease associated with dusts.

Emissions due to the consumption of fossil fuels

Particulates and gaseous pollutants may be emitted by the Project through consumption of fossil fuel by vehicles, mining equipment, and processing. Minimising fuel consumption is not only economic; it may also have the potential to reduce GHG emissions and particulate and gaseous pollutants. Measures to achieve this include:

- Requiring sub-contractors to undergo and pass the government vehicle emission tests prior to contract award.
- Exhaust fumes from vehicles, mining equipment, and other fuel burning equipment will be managed through the use of low sulphur fuel where possible.
- Traffic management guidelines will be incorporated in worker's and subcontractor's induction seminar. Guidelines will include control in vehicle speed and spraying of road routes and work sites as well as transport routes near the host communities.

- Fuel efficiency will be maximised through scheduling of vehicle and equipment movements in order to minimise both idle time and distances travelled.
- Equipment and vehicle loadings will be optimised through accurate monitoring and calculation of fuel requirements in order to reduce fuel weight and improve fuel efficiency.
- Vehicles and mining equipment will be regularly maintained in order to increase efficiency, reduce fuel use, and help reduce costs associated with equipment downtime.
- Equipment dispatch will be monitored closely in order to eliminate unnecessary use and to increase efficiency of use.
- Standard occupational health and safety practices will be implemented pursuant to BWC-DOLE Occupational Safety and Health Standards (Department of Labor and Employment, 1989).
- Regular air quality monitoring will be conducted within the project site and near the sensitive receptors. The sampling stations as shown in
- **Figure 2-11** may be used as monitoring stations once the project goes into construction and operations phase.

Enhancement of climate change impacts

The Project may have the potential to enhance climate change impacts in the area by introducing particulates and gaseous pollutants in the atmosphere. Measures to minimize the Projects' contribution to the effects of climate change are the same as above.

2.3.4 Ambient Noise

The baseline ambient noise levels of the surrounding communities were determined by gathering noise readings from four (4) locations within the project site. The noise monitoring for this assessment was conducted simultaneously with the ambient air sampling.

2.3.4.1 Background

The noise impact assessment was undertaken to determine the existing ambient noise levels in the Project area, assess the potential impacts of noise generated during the construction and operational phases of the project on settlements, and identify appropriate measures to avoid, minimize, or mitigate adverse impacts. The results of the assessment are presented below.

2.3.4.2 Methodology

A sound level meter that qualifies the American National Standard Institute (ANSI) S1.4-1983 (R2006) specifications was used in measuring noise levels in the areas coincident with the ambient air sampling stations. The purpose of standardizing the components and functions of sound level meters is to ensure maximum practical accuracy and to reduce to the lowest practical minimum any difference in corresponding measurements obtained when various makes and models of sound level meters are used that meet the standard. Noise sampling was conducted at different periods of the day (i.e. morning, daytime, evening and nighttime) to note any predominant noise source/s. The median of at least seven noise readings taken during monitoring and was compared with the noise standards stipulated in National Pollution Control Commission (NPCC) Memorandum Circular No. 002 Series of 1980 and will be referred to as Philippine noise standards. The median of at least seven noise readings is known as the equivalent noise level (L_{eq}). The L_{eq} is defined as the steady sound level that contains the same amount of acoustical energy at a given time-varying sound over the same measurement period.

In 1978 the Philippine government, thru NPCC, has developed noise standards which are set according to the land use of the area and the time of the day. The Philippine noise standards has not been amended or modified since 1980 and it has been adopted by the DENR as the primary ambient noise standards in the country. The primary objective of any environmental noise assessment is to protect people from the adverse effects of noise. The effect of exposure to excessive noise includes nuisance, sleep deprivation, stress and increased blood pressure, as well as other physical, physiological and psychological effects.

Table 2-35 presents the description of each area classification for noise while **Table** 2-36 shows the area classification of noise monitoring stations.

Table 2-35 Description of Area Classification and Limits for Noise

Legend of Classification based on DENR Ambient Noise Quality Standards Sec 78 Chapter 4 Article 1 of 1978 NPCC Rules and Regulation			
Category	**Day Time 9am-6pm**	**Morning & Evening 5am-9am & 6pm-10pm**	**Night Time (10pm-5am)**
AA - within 100m from school, nursery, hospitals, and special homes for the aged.	50 dB	45 dB	40 dB
A - area which primarily used for residential purposes.	55 dB	50 dB	45 dB
B - area which primarily used for commercial area.	65 dB	60 dB	55 dB
C – area which primarily used as light industrial area.	70 dB	65dB	60 dB
D – area which primarily used as heavy industrial area	75 dB	70dB	65 dB

Source: Rules & Regulations of the National Pollution Control Commission (1978), Section 78, Table 1. Environmental Quality Standards for Noise in General Areas (maximum allowable noise levels in general areas)

Table 2-36 Classification of Noise Monitoring Stations

Station ID	Location	Category of Area
AQM1	Timamana Elementary School	**AA** - within 100m from school, nursery, hospitals, and special homes for the aged.
AQM2	Boyongan Elementary School	
AQM3	Anislagan Elementary School	
AQM4	Lower Patag Elementary School	

2.3.4.3 Baseline Environment for Ambient Noise

2.3.4.3.1 Summary

Table 2-37 Key Findings and Conclusions – Ambient Noise

Baseline Information	Key Findings and Conclusions
Ambient Noise Level	• Most of the stations under Class AA exceeded the DENR/ NPCC Standards for the four-time period monitoring (morning, daytime, evening and night time). However, the noise measured on the duration of sampling is mostly caused by natural sources like wind, rain, and local wildlife since the areas of sampling were mostly forestlands. Generally, their impact is very limited and not very harmful. On the contrary, noise produced by man is persistent, much greater and harmful.
Possible Noise Pollution Sources	• Sources of noise are the residents and the students near the sampling location. • The local wildlife at the sampling areas is one of the main contributors to the noise measured. • Precipitation and blowing winds at the forest. • Domestic activities and vehicular movement around the monitoring sites. • Generally influenced by wildlife noise

2.3.4.3.1 Ambient Noise Level

Four-time period monitoring

The results of the four-time period noise monitoring in four (4) sampling stations is presented in **Table 2-38** and **Figure 2-13**. Most of the Class AA stations exceeded the DENR/ NPCC Standards for the four monitoring periods (morning, daytime, evening and nighttime). As shown in **Table 2-38**, the highest noise readings were observed during daytime monitoring period.

Table 2-38 Results of the four-time period noise measurement

Station ID	Location	Noise Level dB(A)			
		Morning (5 AM to 9 AM)	Daytime (9 AM to 6 PM)	Evening (6 PM to 10 PM)	Nighttime (10 PM to 5 AM)
AQM1	Timamana Elementary School	63	60	53	47
AQM2	Boyongan Elementary School	60	81	56	53
AQM3	Anislagan Elementary School	57	49	56	41
AQM4	Lower Patag Elementary School	42	50	53	41
DENR/ NPCC Standards (Class AA)		45.0	50.0	45.0	40.0

Note: Noise readings in red exceeded the DENR/ NPCC Standards

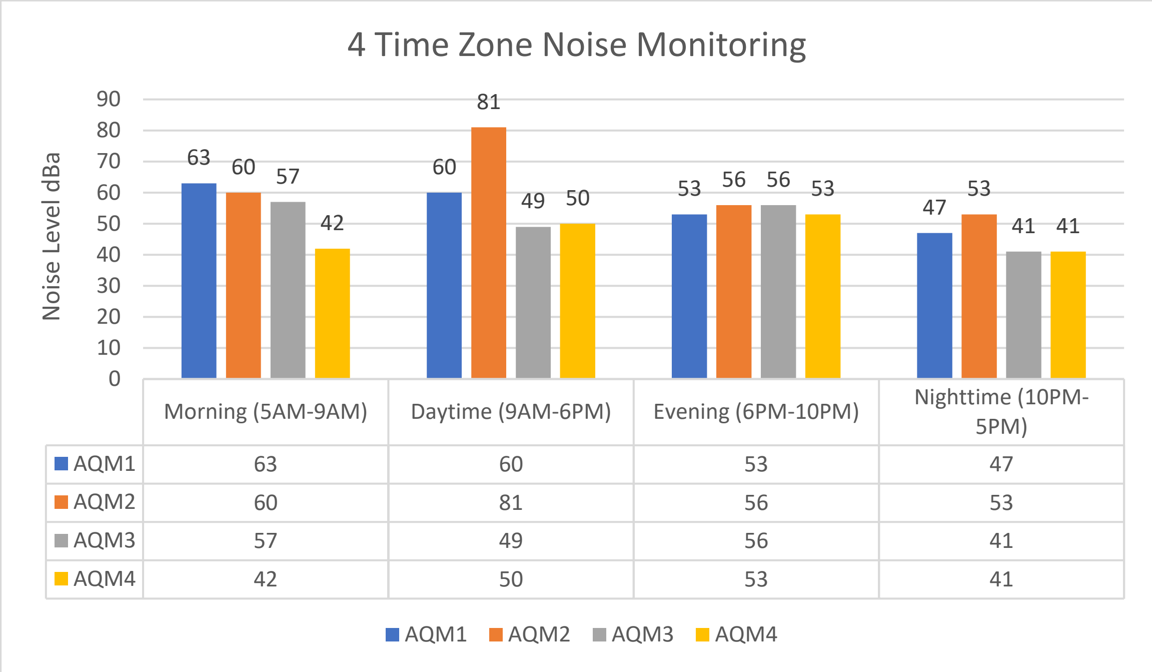

Figure 2-13 Results of the four-time period noise measurement

2.3.4.3.2 Possible Noise Pollution Sources

The sources of noise observed during morning and daytime monitoring in most stations, especially within school sites, were attributed from domestic activities and vehicular movement around the area. For evening and night time monitoring periods, the sources of noise from most stations were attributed to wildlife noise.

2.3.4.4 Potential Impacts and Options for Prevention or Mitigation or Enhancements for Ambient Noise

Table 2-39 Potential Impacts and Options for Prevention or Mitigation or Enhancement – Ambient Noise

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
Increase in ambient noise level					
• Noise levels are expected to increase from baseline levels during construction and mine operation due to blasting operations, vehicular movement, and equipment operations. • Noise associated with blasting activities, heavy earthmoving machineries, vehicle engines, and loading and unloading of rock into steel dumpers/ chutes are noted as the highest contributors of noise. As		✓	✓		• The host communities are kept informed of the time and duration of any noisy building and explosive activities. Movement and blasting activities of equipment are planned to prevent sensitive times as much as possible; • Muffler or silencer will be provided to heavy equipment and machinery that produce high noise levels; • The speed of vehicles is limited on roads and if necessary, the vehicle horn signals are maintained

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
such, activities associated with the Underground mining and haul roads are likely to be the noisiest activities. • Noise from trucks and heavy machineries can interfere with animal communications that is essential for their survival and reproduction. • Behavioral effects of excessive noise to wildlife includes habitat shifts and reduction of time spent on feeding. Decreased responsiveness after repeated noise is usually attributed to habituation.					at a low volume in order to minimize the noise generated by vehicle entry or exit; • Appropriate personal protective equipment (PPE) that conforms to the Procedural Guidelines Governing Occupational Safety and Health in the Construction Industry as per BWC-DOLE DO 1998-13 will be provided to operators and workers who handle heavy equipment that generates high levels of noise; • Work involving handling of noisy and/or vibrating power tools/equipment shall be a maximum of 2 hours per day (for 8-hour work, duty cycle should be 1:4) in conformity to the requirements of BWC-DOLE DO 1998-13 and the Occupational Safety and Health Standards (As Amended, 1989); • Regular maintenance of all vehicles, machinery, and heavy equipment will be ensured and noise generating equipment will be controlled by installation of noise damping barriers/guards; • SMMCI will establish a buffer zone that is a vegetated area or a natural reservoir these will be done to mitigate the noise on noise sensitive wildlife. • Monitoring of the ambient noise level will be performed regularly within the Silangan Copper-Gold Project perimeter and close to the sensitive receptors at sampling stations discussed in the EIS. • **Figure 2-11**) to control noise levels and meet the recommended criterion.

2.3.4.4.1 Potential Impacts

Increase in ambient noise level

The potential impact with regards to noise is limited to potential noise level increase from baseline levels within the project site. During construction and operation, noise associated with blasting activities, earthmoving machineries (bulldozers, backhoes, compactors, front end loaders, etc.), and loading and unloading of rock into steel dumpers/ chutes are noted as the highest contributors of noise. As such, vegetation clearing, rock dumping into crusher hoppers, earthmoving, commissioning activities such as blowing down process air system, and activities in the Underground mining, haul roads, and are likely to be the noisiest activities.

Heavy vehicles transporting construction equipment and personnel in and out of the project site will also cause an increase in ambient noise level. Noise levels are expected to increase from baseline levels during construction and operation due to the ingress and egress of vehicles, heavy equipment, and people. Cumulative impacts of shoveling, ripping, drilling, blasting, transport, crushing, grinding, and stock-piling may affect wildlife and nearby residents.

Non-earthwork activities such as blasting preparation, welding, and installations will contribute to minimal increase in noise levels and are expected to comply with noise standards.

The Potential Impact of Noise in Wildlife

Animals exhibit a variety of responses to noise pollution (also called introduced noise), depending on the characteristics of the noise and the animal’s ability to tolerate or adapt to it. Noise impacts on wildlife can be observed at the individual and population levels.

Individual-Level Impacts

Some of the most dramatic impacts of noise on individuals are acute and need to be distinguished from chronic effects. Acute impacts include physiological damage, masking of communication, disruption of behavior, and startling. The most direct physiological impact affects an animal’s ability to hear, either by permanently damaging the auditory system, in which case it produces what is called a permanent threshold shift (PTS) in hearing, or by causing temporary decreases in hearing sensitivity, which are called temporary threshold shifts (TTS). The noise levels required for PTS and TTS are quite loud, making hearing damage unlikely in most terrestrial situations. Even extremely loud sound sources will only cause PTS and TTS over a small area, because on land sound attenuates very quickly with distance. Therefore, most studies of impacts from highway and urban noise do not directly address PTS and TTS, although they may need to be considered in extremely noisy areas. Other acute impacts of noise, such as masking and behavioral disruption, occur over a much larger area. Masking occurs when the perception of a sound is affected by the presence of background noise, with high levels of background noise decreasing the perception of a sound. One possible consequence of masking is a decrease in the efficacy of acoustic communication. Many animals use acoustic signals to attract and retain mates, settle territorial disputes, promote social bonding, and alert other individuals to predators. Disruption of communication can, therefore, have dramatic impacts on survival and reproduction.

Population Level Impacts

The cumulative impacts of noise on individuals can manifest at the population level in various ways that can potentially range from population declines up to regional extinction. If species already threatened or endangered due to habitat loss avoid noisy areas and abandon otherwise suitable habitat because of a particular sensitivity to noise, their status becomes even more critical.

2.3.4.4.2 Options for Prevention, Mitigation or Enhancement

Increase in ambient noise level

Mitigating measures include constantly informing the host communities of the duration and timing of any noisy construction works and blasting activities. Equipment movement and blasting activities will be scheduled to avoid sensitive times wherever possible. Speed of vehicles will be limited on roads, and vehicle horn signals will be kept at a low volume, if necessary, such that the noise generated by the ingress and egress of vehicles will be minimized.

Appropriate personal protective equipment (PPE) that conforms to the Procedural Guidelines Governing Occupational Safety and Health in the Construction Industry as per BWC-DOLE DO 1998-13 will be provided to operators and workers who handle heavy equipment that generates high levels of noise. Work involving handling of noisy and/or vibrating power tools/equipment shall be a maximum of 2 hours per day (for 8-hour work, duty cycle should be 1:4) in conformity to the requirements of BWC-DOLE DO 1998-13 and the Occupational Safety and Health Standards (As Amended, 1989).

Regular maintenance of all vehicles, machinery, and heavy equipment will be ensured and noise generating equipment will be controlled by installation of noise damping barriers/guards.

To mitigate impacts to noise-sensitive wildlife, SMMCI will establish a buffer zone which is a vegetated area or a natural buffer to accommodate these wildlife. Ambient noise level monitoring will be done regularly within the perimeter of the Silangan Copper-Gold Mine Project and near the sensitive receptors in the baseline sampling stations discussed in this EIS (**Figure 2-11**) to control noise levels and meet the recommended criterion.

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Environmental Impact Statement

Section 2.4 The People

Table of Contents

2.4 The People 2.4-

2.4.1 Socio-Economics 2.4-1
2.4.2 Socioeconomic Profile of Host Communities 2.4-5
2.4.3 Public Health Profile 2.4-40
2.4.4 Perception Survey 2.4-65

2.4 The People

2.4.1 Socio-Economics

This section will provide a description of the socio-economic conditions present in the host communities of the Silangan Copper Gold Project in four municipalities (Placers, Sison, Tagana-an, and Tubod) and eleven barangays of Surigao Del Norte. This section will also provide an assessment of the likely impacts of the project on the population of the host barangays and municipalities coupled with enhancement measures meant to mitigate any negative impacts that may result from the project's implementation.

2.4.1.1 Background

The study area consists of 11 barangays in 4 Municipalities in the Province of Surigao Del Norte: Barangays Anislagan, Boyongan, Macalaya, San Isidro, and Sta. Cruz under the Municipality of Placer; Barangays Lower Patag, San Pedro, and Upper Patag under the Municipality of Sison; Barangay Upper Libas under the Municipality of Taganaan; and the Barangays of San Isidro and Timamana under the Municipality of Tubod, all of which are considered as host communities. Identification of host and neighboring communities was based on the location of the project facilities and the MPSA. Barangays where the project facilities are located were identified as host or direct impact barangays while adjacent barangays where no disturbance will occur are identified as indirect impact barangays. Administrative Region 13 or CARAGA is recognized as a mineralized area and mining region. As of August 22, 2017, there were 26 operating mines in the region extracting metallic minerals such as nickel, gold, silver, and copper and non-metallic resources such as aggregates and limestones.

While the stakeholders from the host and neighboring barangays are generally familiar with mining, the four municipalities remain predominantly agricultural. Copper-gold mines of Manila Mining Corporation and Greenstone Resources, Inc. are situated in the municipalities of Placer and Tubod, respectively. However, both cover significantly smaller areas (and consequently host barangays) and are under Care and Maintenance. SMMCI has undergone the EIA process twice prior to this application due to the shift in mine method from block-cave to open pit. While the project has been issued the ECC corresponding to the open pit and the DMPF, the project did not proceed to construction. Hence, opportunities for employment as discussed in the previous plans were put on hold. Projected benefits for the mine such as livelihood opportunities, implementation of the Social Development and Management Program (SDMP), and payment of taxes to the local government did not materialize.

A household and perception survey was conducted among the host and neighboring barangays to determine if there were any updates or changes from the data collected in previous studies and the CLUPs. Since there are no industries within the municipalities that can provide sufficient income for the stakeholders, economic data remained almost the same as the previous studies. With the reduction in production of coconuts, the primary crop for the host municipalities, the average monthly income remains below the poverty threshold of NEDA (2018). In terms of household number and size, there is minimal change in the average number and size among the host barangays. Household numbers generally grew but the actual residents numbers remained similar to the open pit studies are other households moved away or migrated from the barangays to other areas in the region where they can find livelihood. Similarly, there were no changes with respect to land area, settlements pattern, dwelling, and public services.

2.4.1.2 Methodology

The People section is a result of reviews of Comprehensive Land Use Plans (CLUP), Barangay Development Plans (BDP) whenever available, household and perception surveys (from 2013, 2015, and 2019), and focus group discussions and key informant interviews from participants within the host and neighboring barangays. Since the studies were conducted within a span of 5 years, most of the data from the CLUPs essentially remain unchanged with the exception of population and income updates. The population updates in the CLUPs are actually projections from the National Statistics Office (NSO) annual growth rate and do not constitute actual household surveys. Data from the CLUP are supported by results from the household survey within the discussions. A summary of the various methodologies conducted for the People section is presented below (**Table 2.4-1**).

Table 0-1 Methodologies for Various Studies

Study	Methodology	Source of Information
Socio-economic profiling of the host municipalities and barangays	Review of secondary data, reports, relevant studies and other information Household survey	Comprehensive Land Use Plans (CLUPs) of the of the four host municipalities (2013-2022) Municipal Socio-Economic Profiles (2013-2022) Ecological Profiles (2007-2010) Government websites (e.g. National Statistics Office (NSO) Sample households of direct-impact barangays
	Sectoral/stakeholder consultations Public Scoping sessions Key informant interviews (KII) Focus group discussions (FGD)	Key stakeholders Participants in public scoping sessions Key informants (community leaders and local officials) Focus group discussants (community leaders and local officials)
Land ownership and land value	Review of secondary data Household survey KIIs	CLUPs Household Survey
Perception survey	Household survey Focus group discussions	Sample households of host and neighboring barangays Focus group discussants (community leaders and local officials)
Public health and sanitation	Household survey Review of secondary data Focus group discussions Key informant interviews	Barangay Health Reports (Causes of Morbidity and Mortality, OPT Reports) Municipal Health Reports of the four host municipalities CLUPs Focus group discussants (community leaders and local officials including BHWs) Household Survey 2019
Traffic impact assessment	Review of secondary data Field observations	CLUPs / Socio-Economic Profiles Field visits

A perception survey was mandated as a requirement during the scoping process especially given the circumstances of the change in the mining method for the project as well as the circumstances surrounding the decision and implementation of this change. Additional Focus Group Discussions were held to obtain the general sentiments of the residents of the host communities towards the project and the changes being proposed for its implementation.

The perception survey was held from on December 17, 2018 and from January 21 to February 27 of 2019. A total of 1235 respondents were interviewed on a face-to-face and one-to-one basis to gather basic information about their households and their views on the Silangan Copper Gold Project as well as the changes being proposed for its implementation. The number of respondents surveyed in 2015 was 1033. Respondents were chosen in the following order of preference:

- Household head (who may be male or female but always a resident-household member who makes the major household decisions or is perceived to do so; the household head is usually the father but may also be the mother or the eldest child who is of majority age (18 years old));
- Spouse of the household head;
- Son or daughter who is at least 18 years old of the household head; or
- Other relative who is at least 18 years old of the household head.

Samples were taken from each purok or sitio of each of the 11 host barangays to ensure that the survey would be as comprehensive as possible in terms of its reach. Enumerators were engaged from the host barangays and were assigned to different purok or sitios to avoid duplicity of respondents. The sample size was determined with a margin of error of ± 5 with a confidence interval of 95%.

The interviews were conducted at random to preserve the integrity of the method. The same household respondents in the 2015 EIS were not consciously targeted for the 2019 survey. However, due to the settlement pattern, number of households surveyed, and the composition of each purok and sitio in terms of extended/related families, some respondents in the 2015 survey may have taken part in the 2019 perception survey.

2.4.1.3 Baseline Environment for Socio-Economics

2.4.1.3.1 Summary

Table 0-2 Key Findings and Conclusions – Socio-Economics

Baseline Information	Key Findings and Conclusions
Existing settlements, settlers, and properties within the project site and facility areas	• Settlements tend to be linear following the roads. Houses are of various building materials (strong, light and mixed), owner occupied and single dwelling units. The host barangays are rural, mostly leading to, or themselves in, the mountains and in the interior of the host municipalities. Most of the roads are unsealed with a few sections paved.
Land ownership and land value of the project site	• The vast majority of houses are owner-occupied. Farm holdings tend to be small (less than 3 hectares). Larger farm lands are mostly owned by non-residents. Most farmlands are planted with coconut trees.
Demographic profile of the host communities	• Most households claimed to be of Surigaonon background. Those that trace their ancestry to other provinces in Mindanao, Visayas or Luzon mostly have lived in the barangays for less than two (2) decades. • Households tend to be nucleated, i.e., identical to family size at 5. The lingua franca is a variant of Cebuano, *Surigaonon*. The host barangays have an estimated 2,500 households in total. • There are no members of IPs/ICCs that are indigenous to the project areas and the direct/indirect impact communities. There are, however, IPs who have settled in Barangay Timamana and Silop-Marayag areas in Mainit. These IPs, however, are migrants and are not indigenous in these barangays. For example, the IPs in Barangay Timamana are originally from Barangay Taganito in Claver, Surigao del Norte.
Socio-economic profile of the host communities	• The average household income for all host barangays is PHP69,637 per annum (PHP5,803/mo) with the highest in Boyongan (Placer) at PHP91,475 and the lowest in Upper Patag (Sison) at PHP49,374. Median income is PHP49,984. Sixty percent of households earn less than PHP 5,000 a month for an average PHP2,333 (60% less than the average monthly household cash income for all host barangays). • Poverty is widespread in the host barangays. Seventy-four percent of households are below the poverty line[1] in contrast to 47.9% for Surigao del Norte. Poor households range from 63% (Boyongan) to 84% (Upper Patag). Households below the poverty line on the average earn PHP 3,343/mo (46% of the poverty line; good only for a family size of 2-3 members). The findings suggest that 7.5 of every 10 families cannot afford a standard of living that would keep them out of poverty. • Sixty percent of households are below the food threshold[2] which is the income required in order to buy the right kind and quantity of food to meet daily nutritional requirements. • Families below the poverty line earn an average of PHP2,316/mo (less than half of the poverty line or just enough to meet the food requirements of 2 instead of 5 members of a family).
Basic services	• On the average, 87% of the households get their electricity from the provincial electric cooperative (SURNECO) through individual (own) connection. Only 12% of the houses are not directly connected to SURNECO; instead they share electricity source with their neighbour. • Drinking water is primarily obtained from the community water system. The majority (83%) of the total number of households has individual connection to the community water system. • The host municipalities have 57 day care centers, ten primary schools, 45 elementary schools and nine high schools (public and private). • The peace and order situation in the host communities is relatively stable. Each community has an organized Civilian Volunteer Organization and Barangay at Pulisya Laban sa Krimen which provides support in maintaining peace and order. • Common recreational facilities in the host communities are basketball courts, playgrounds and gymnasiums. The existing recreational facilities are in good condition. • Communication services available in the host municipalities are Smart, Globe Telecoms and Philippine Long Distance Telephone (PLDT) Company. Each municipality has a postal service through the Philippine Post Office (PhilPost).
Perception survey	• About thirty-four percent (34.40%) of respondents are strongly in favor of the Project. There is a considerable body of those who mildly support, are neutral or mildly oppose

[1] Based on official poverty statistics (2009) of the National Statistics Coordination Board (NSCB), the poverty line pertains to the amount of income needed for a family to purchase a normative basket of goods and services (e.g. food, shelter, clothing, education, etc) to be socially functional. The poverty line set by the NSCB for 2009 for Surigao del Norte is PHP17, 261 per capita (Php 86,305/ year for a family of five or PHP7,192/month)

[2] Food threshold, as officially defined by NSCB, is the amount of money a family needs to stay out of hunger. The food threshold set by the NSCB for 2009 for Surigao del Norte is PHP12,053 per capita (PHP60,265/ year for a family of five or PHP5,022/ month)

Baseline Information	Key Findings and Conclusions
	with the vast majority of these respondents expressing neutrality. About twenty-seven percent (27.30%) of respondents are strongly not in favor of the project. • The largest proportion of responses lies within the mild opposition-mild support-neutral spectrum (36.85%), 82.96% of these responses rated their sentiments as Neutral to the project.
Major stakeholder issues and concerns	• The results of the household survey and the FGDs/CCs suggest that the environmental risks and threats perceived by community residents and their leaders are driven by the "fear of the unknown", legacy problems (specifically the past performance of mining operations and reports of incidents from other nearby mining operations), and misinformation from other sources (principally from anti-mining groups). The issues and concerns have a home-grown character in that they pertain to matters of physical (e.g., flooding/landslides) and economic survival (e.g., water for irrigation and livelihood). • Local government officials cited employment and revenues. It was claimed by a number of them that their constituents do not get, or has little chance to be, hired by mining companies. The need to prepare their constituents for job opportunities by mining companies was brought up. • It appears that local governments are well aware regarding the local revenues that are due them from mining operations.
Traffic situation/congestion	• Most traffic through the host barangays consists of light vehicles, e.g., jeepneys, "multi-cabs", and tricycles. Traffic volume is light and intermittent. • The roads are generally unsealed and not paved; these will be subjected to heavier traffic during the construction and operations phases of the project. • During rush hour most passenger vehicles are overloaded, an indication of the inadequacy of means of public transportation. • School zones, markets, church zones, town centers, residential areas are sensitive receptors of traffic volume. • Because of the current light pace of activities, the risks and nuisance associated with increased vehicular traffic are not easily appreciated by local residents.
Health Facilities	• The basic health facilities and services, including manpower requirements, are generally available in the host barangays and meet DOH standards. There are also provisions of some health facilities and personnel by private companies, mainly mining, that augment government facilities. • The health centre is the most frequently accessed health facilities in all host areas.
Water Supply System	• In Placer, the majority (51.6%) of the households have Level III type of water connection. However, there are still 51 households in the host barangays that do not have access to safe water. • In Sison, 64.35% of households have their own community water systems; however, 7% of households do not have access to safe drinking water. • In Barangay Upper Libas (Tagana-an), the majority of the households (60.30%) have their own faucets. • In Tubod, 90%of the households have their own faucets.
Toilet Facilities	• Among households in Placer, 8.71% do not have access to toilet facilities. Among host barangays, 48 (4.24%) households do not have sanitary toilet; most of these are in Anislagan. • In the municipality of Sison, about 7% of households in all barangays do not have toilet facilities. From these percent, 56 households in the host barangays do not have access to this facility. Most of those that have access use water-sealed toilets (80.76%) that are privately used and owned, both in the municipal and barangay level. • About 71% of the total households in Tagana-an who have access to toilet facilities own and exclusively use water-sealed types. In Upper Libas, 87% of those with access own and exclusively use water-sealed toilets. • In the municipality of Tubod, 8.23% of the total households do not have access to toilet facilities. About 70% or 1,867 households that have access use water-sealed toilet facilities that are used exclusively. In host barangays, 5.9% in total do not have access to such facility. However, those that have access (85.39%) among host barangays have their own exclusive use of water-sealed toilet facility.
Sanitation Facilities	• The most commonly used method of waste disposal among host barangays in Placer is burning. • Burning is the most preferred method of disposing wastes in all host barangays of Sison. • The majority of the households in Tagana-an dump their wastes in individual open pits. In Upper Libas, however, burning is the most used method.

Baseline Information	Key Findings and Conclusions
	• Burning is also the most commonly used method of waste disposal in the municipality of Tubod. Households in Barangay San Isidro use burning (36%) more often compared to composting (25%). More than a third of households in Timamana burn their wastes (37.31%).
Morbidity & Mortality Rates	• The most common illness in almost all host areas is upper respiratory tract infection. Pulmonary tuberculosis has not been completely eradicated yet as there are still areas in which the disease is still prevalent. Cardiovascular diseases are also prominent in all host areas. Hypertension belongs to this group of diseases. • Causes of death are mostly those related to the heart, such as hypertension, cardiovascular diseases and cerebrovascular accident. • In the host barangays of Placer, morbidity causes are mostly due to upper respiratory tract infection (URTI), urinary tract infection (UTI) and while hypertension and pulmonary tuberculosis are the leading cause of deaths. • There are equal numbers of cases of various diseases in Sison such as colds, coughs, fever, kidney diseases, UTI, pneumonia, among others. Cardiovascular diseases are the most common causes of deaths in the municipality. • The municipality of Tagana-an have not indicated specific cases of morbidity causes. However, pneumonia and multiple organ failure were identified to be top causes of mortality in the municipality. At the barangay level, however, cough, colds, fever, pulmonary tuberculosis and skin diseases are the most common causes of morbidity while senility is the leading cause of death. • Acute Respiratory Infections have been consistently the top leading cause of morbidity in Tubod. In the 2011 data, acute respiratory infection is still the leading cause of morbidity in host barangays Timamana and San Isidro. Cardiovascular diseases have also been consistent as well as the leading cause of deaths in the municipality. In the barangay level, particularly in host barangays, causes of deaths are varying, i.e. epilepsy, pulmonary tuberculosis, pneumonia, hypertension.
Nutrition Status	• Preschoolers (aged 0-5 years old) in Placer are generally (82.5%) of normal nutritional status in 2009. • More than 90% of the preschoolers in Sison are assessed to be of normal nutritional status in 2009. In host barangays, majority of the weighed preschoolers are also of normal nutritional status. • The number and percentage of preschoolers that are of normal nutritional status was not indicated in Tagana-an except varying degrees of malnutrition. Out of 1,505 preschoolers, about 38% belong to the malnourished category. Banban has the most number of 1st degree malnourished preschoolers (3.46%), Himamaug and Talavera for 2nd degree malnutrition (1.13%). • From 2008-2010, the average percent of preschoolers in Tubod which are assessed to be of normal nutritional status is 82%. Among host barangays, there are 10 who were assessed to be malnourished in San Isidro out of 160 pre-schoolers, and 7 for Timamana out of 209.
Food Security	• The Province of Agusan in general has adequate supply of palay and backyard vegetables. However, because of unpredictable weather there are unequal distribution of palay and vegetable production causing shortage in some areas. • Placer has shortage in their supply of grains/rice (-20.68%), vegetables and legumes (-98.47%), root crops (-5.905%), and meat (-89.22%). • Vegetables and root crops are deficient in supply in the Municipality of Sison by -55.73% and -64.64%, respectively. • The municipality of Tagana-an is also deficient in their supply of rice/cereals (-8.68%), vegetables (-96.04%), meat (-47.79%), root crops (-29.64%), and eggs (-67.97%). • Tubod municipality has shortage in their supply of grains/rice (-47.28%), vegetables (-95.96%), root crops (-94.39%) and meat (-89.77%)

2.4.2 Socioeconomic Profile of Host Communities

The following sections present the socio-economic profile of the host communities and host barangays. Data for the municipal profile are sourced from locally available statistics, largely from the Community Base Monitoring System (CBMS) 2009 and Municipal CLUPs. Barangay profiles are based on the household survey conducted in July 2012. The socio-economic assessment focused on the host communities where main facilities of the proposed mine project are centrally located; these consist of 11 barangays belonging to four municipalities and one province (**Figure 2.4-1**). The four municipalities are within the proximity of major industries in manufacturing such as the Pacific Cement Philippines, Inc. and agri-fishery with Surigao Marine Products as one of the major players. However, the primary industry is mining. The major mining corporations in the area are Taganito Mining Corporation, Hinatuan Mining Corporation, Cagdianao Mining Corporation, PHILNICO Processing Corporation, Manila Mining Corporation, Platinum Group Metals Corporation/Surigao Integrated Res. Corporation and Greenstone Resources Corporation/Red 5 Asia Corporation and a mineral processing plant - Taganito Hydrometallurgical Processing Plant Project -Nickel Asia Corporation.

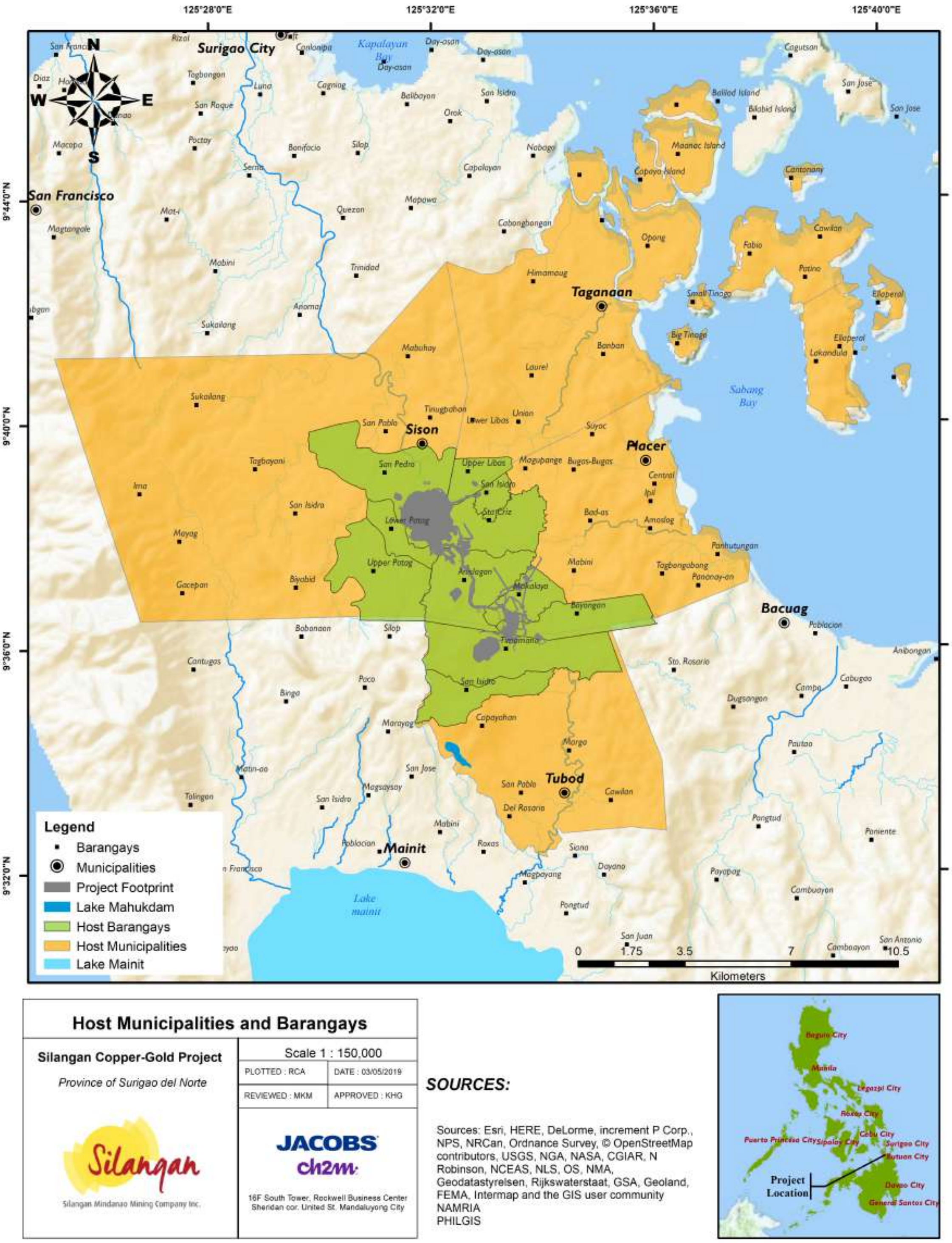

Figure 0-1 Location of Host Municipalities and Barangays

2.4.2.1 Demographic Profile of the Host Communities

Placer Municipality

The municipality of Placer is on the northeast portion of Surigao del Norte. It is bound on the north by Tagana-an, on the west by Sison and on the south by Tubod and Bacuag. Placer is 33 kilometres from Surigao City, the provincial capital. Placer has a total land area of 8,989 hectares, which represents 4.47% of the province's total land area. It is a fourth class municipality and has an annual income that ranges from Php 25 million to Php 35 million.

Placer has an irregular and hilly surface with sloping areas and flat terrain. About 6,670 has of its fertile plains, including rolling terrain, are planted with various agricultural crops. Coconut is the major crop, followed by other crops which include bananas and root crops.

Placer has 20 constituent barangays (five urban and 15 rural). More than half (51%) of the total population live in the urban barangays. The remaining 49% are sparsely distributed in the rural barangays. Placer has total population of 24,600 with a growth rate of 1.34% (2000-2010; NSO 2010) comprising of 5,201 households for an average household size of 4.73 (**Table 2.4-3**).

Placer has been traditionally, a mining area, (as evidenced by the municipality's very name) especially during the American regime. This industry drove the economic progress and development of the town. Mining companies in went into full operation and some even under exploration stages more than readily poured their investments. These included the East Mindanao Mining Company; Mapaso Gold Field; km 73 Mining Company in Layab; and the Suyoc Consolidated Mining Company. It was during this gold boom that Placer became a Mecca of the working class, with people migrating from other places for employment in the mining boomtown.

Barangays Anislagan, Boyongan, Macalaya, San Isidro and Sta. Cruz are envisioned to host the project footprints and will be the directly impacted communities in the municipality (**Table 2.4-4**).

Table 0-3 Key Features: Placer Municipality

Basic Feature	Placer
Population (2010)	24,600
Land Area (ha)	8,989
Built-up area (ha)	264.82
Male	11,632
Female	11,111
Gender Ratio	1.05
Household Population	4,807
Average household size	4.73
Population density, total population/land area (people per ha)	2.74
Built-up density, total population/built-up area (people per ha)	92.89
Average annual growth rate	1.34
Age Groups (Male and Female)	
Less than 15 years old	4,309
15-24 years old	4,298
25-29 years old	1,631
60 and over years old	8,461
Educational attainment	
Completed Elementary	2,714
Completed High School	3,886
Completed College	1,478
Major Commercial Establishments	Bakery, Pharmacy, Public Market, Ice Plant, Fishing Port, Public Utility Jeepney (PUJ) Terminals, Canteens, Cockpit, Gas Station, Hardware store, Medical Clinic; and Water Refilling Station

Basic Feature	Placer
Banking and Financial Institutions	Rural Bank of Placer; and Micro-financing companies

Source: Eco Profile, CBMS and CLUP, 2007-2010

Table 0-4 Basic Information: Host Barangays, Placer

Basic Feature	Anislagan	Boyongan	Macalaya	San Isidro	Sta. Cruz
Land area (ha)	841.24	204.97	342.68	109.05	702.40
Population	1,748	560	873	453	2,543
Male	54%	51%	50%	53%	49%
Female	46%	49%	50%	47%	51%
Male/ Female Ratio	1.56	1.03	1.00	1.13	0.97
Age Groups (Male and Female)					
Less than 15 years old	33%	37%	35%	33%	33%
15-24 years old	21%	18%	19%	17%	18%
25-29 years old	33%	34%	36%	36%	35%
60 and over years old	7%	6%	5%	7%	9%
Age Groups (Male and Female)	6%	5%	5%	7%	5%
Population density (people per ha)	2.08	2.73	2.55	4.15	3.62
Number of Households	380	122	190	98	553
Average household size	4.49	4.56	4.58	4.15	4.94
Civil Status (15 years old and over; Male and Female)					
Single	51.6%	52.3%	58.1%	47%	52.9%
Married	40.5%	41.7%	33.6%	45.4%	38.1%
Widowed	2%	2.5%	2.8%	3.2%	3.4%
Divorced/ Separated	0.5%	-	0.8%	0.8%	0.8%
Common Law/ Live-in	2.6%	1.9%	4.1%	1.2%	3.3%
Unknown	2.8%	1.6%	0.6%	2.4%	1.5%
Ethnicity					
Surigaonon	89%	92%	98%	73%	91.76%
Mamanwa	11%	8%	2%	26%	8%
Others	-	-	-	1%	-
Religious Affiliation					
Roman Catholic	77%	93%	94%	8%	73%
Others	23%	7%	6%	12%	27%
Literacy rate (10 years old and over)	91%	87%	96%	85%	94%

Source: Eco Profile, CBMS and CLUP, 2007-2010

Sison Municipality

Sison, a fifth class municipality, is adjacent to Surigao City. It is bound on the east by the municipalities of Placer and Tagana-an; on the west by the municipality of Malimono; on the north by Surigao City; and on the south by the municipality of Mainit. Sison has rolling hills and medium- sized plains and valleys. It is also endowed with abundant crystal clear mountain springs and streams.

Sison has 12 barangays covering a total land area of 11,241 hectares. Based on NSO 2010 data, it has a total population of 11,377, with an annual growth rate of 1.25 (2000-2010). The three barangays of the municipality are classified as urban (Poblacion, San Pablo and Mabuhay). These urban barangays has a total population of 6,214 representing 55% of the total population of the municipality. The rest of the barangays are rural with a combined population of 5,163. About 45% of the population resides in rural areas and are largely dependent on agriculture. **Table 2.4-5** summarizes the socio-economic profile of Sison municipality.

The municipality has three host barangays namely San Pedro, Lower Patag and Upper Patag (**Table 2.4-6**).

Table 0-5 Key Features, Sison Municipality

Key Feature	Sison
Population (2010)	11,377
Land Area (ha)	11,241
Built-up Area (ha)	256.86
Male	5,825

Key Feature	Sison
Female	5,451
Gender Ratio	1.06
Number of Households	2,323
Average household size	4.85
Population density (people per ha)	1.01
Built-up density (people per ha)	44.29
Average annual growth rate (2000-2010)	1.25
Age Groups (Male and Female)	
Less than 15 years old	4,198
15-24 years old	2,086
25-29 years old	3,781
60 and over years old	628
Age Groups (Male and Female)	583
Educational attainment	
Completed Elementary	1,470
Completed High School	1,596
Completed College	481
Major Commercial Establishments	Sari-sari stores
Banking Institutions	None

Source: Eco Profile, CBMS and CLUP, 2007-2010

Table 0-6 Basic Information, Host Barangays, Sison

Basic Feature	San Pedro	Lower Patag	Upper Patag
Land area (ha)	945.70	207.60	692.20
Population (2010)	3,371	1,003	634
Male	52%	50%	52%
Female	48%	50%	48%
Male/ Female Ratio	1.09	0.99	1.07
Age Groups (Male and Female)			
Less than 15 years old	30%	40%	37%
15-24 years old	18%	20%	20%
25-29 years old	37%	32%	32%
60 and over years old	85	5%	6%
Age Groups (Male and Female)	6%	3%	5%
Population density (people per ha)	3.56	4.83	0.92
Number of Households	713	212	134
Average household size	4.29	5.43	4.87
Civil Status (15 years old and over; Male and Female)			
Single	52%	58%	51%
Married	37%	33%	38%
Widowed	4%	2%	2%
Divorced/ Separated	1%	1%	1%
Common Law/ Live-in	4%	3%	6%
Unknown	2%	2%	2%
Ethnicity			
Surigaonon	89%	73%	87%
Mamanwa	11%	26%	13%
Others	-	1%	-
Religious Affiliation			
Roman Catholic	72%	90%	99%
Others	28%	10%	1%
Literacy Rate	93%	88%	90%

Source: Eco Profile, CBMS and CLUP, 2007-2010

Tubod Municipality

Tubod is an inland municipality in the central part of Surigao del Norte. It is bounded on the north by the municipality of Placer; on the east by the municipality of Bacuag; and on the south and west by the municipality of Mainit. Tubod is 36 kilometres south of Surigao City, the provincial capital, and 88 kilometres away from Butuan City, Agusan del Norte. It features flat lands and rolling hills and mountains. The plains and upland areas, respectively, are mostly cultivated with rice and coconut trees and other crops. The municipality covers a land area of 5,463.7 ha.

Based on NSO 2010, Tubod has a total population of 12,569 with an average growth rate of 1.81 percent (2000-2010). The number of households in 2007 is 2,527 with an average household size of 4.61 slightly lower than the provincial and regional annual averages (**Table 2.4-7**). The population is 79% Roman Catholics, 14% Protestants and seven percent belonging to other religious sects (e.g. Iglesia ni Cristo, Aglipayan Church, Iglesia Filipina Independiente and etc.).

The municipality is basically agricultural with farming as the primary source of income. Only 20% of the population is engaged in trading. The monthly average household income is PHP 5,000 for a family of four.
The host barangays Timamana and San Isidro are within Tubod (**Table 2.4-8**).

Table 0-7 Key Features, Tubod Municipality

Key Feature	Tubod
Population (2010)	12,569
Land Area (ha)	5,463.70
Built-up area (ha)	247.89
Male	5,935
Female	5,720
Gender Ratio	1.04
Number of Households	2,527
Average household size	4.61
Population density (people per ha)	2.30
Built-up density (people per ha)	50.70
Average annual growth rate	1.81
Age Groups (Male and Female)	
Less than 15 years old	4,405
15-24 years old	2,029
25-29 years old	3,794
60 and over years old	721
Age Groups (Male and Female)	706
Educational attainment	
Completed Elementary	1,358
Completed High School	1,616
Completed College	880
Major Commercial Establishments	Public market, Small canteens, Bakeries and Sari- sari stores
Banking and Financial Institutions	None

Source: Eco Profile, CBMS and CLUP, 2007-2010

Table 0-8 Basic Feature, Host Barangays, Tubod

Basic Feature	Timamana	San Isidro
Land area (ha)	1,351	480.70
Population (2010)	1,922	1,176
Male	51%	51%
Female	49%	49%
Male/ Female Ratio	1.03	1.04
Age Groups (Male and Female)		

Basic Feature	Timamana	San Isidro
Less than 15 years old	32%	40%
15-24 years old	19%	15%
25-29 years old	35%	32%
60 and over years old	7%	6%
Age Groups (Male and Female)	7%	6%
Population density (people per ha)	1.42	2.44
Number of Households	441	260
Average household size	4.26	4.34
Civil Status (15 years old and over; Male and Female)		
Single	53.9%	43.6%
Married	38.5%	47.7%
Widowed	3.5%	2.6%
Divorced/ Separated	1.5%	-
Common Law/ Live-in	2.5%	3.2%
Unknown	Less than 1%	2.9%
Ethnicity		
Surigaonon	83.3%	90.5%
Mamanwa	15.5%	9.5%
Others	1.2%	-
Religious Affiliation		
Roman Catholic	75%	73%
Others	25%	27%
Literacy Rate	92%	92%

Source: Eco Profile, CBMS and CLUP, 2007-2010

Tagana-an Municipality

Tagana-an is on the eastern coast of the Province of Surigao del Norte. It is bound on the north by Surigao City; on the south by the municipality of Placer; and on the west by the municipality of Sison. Tagana-an is approximately 29 kilometres from Surigao City. There are 11 islands and several islets of rock formations and mangrove forests. Tagana-an has a land area of 7,917 hectares.

Tagana-an has a total population of 15,266 with an annual average growth rate of 1.41% (2000-2010). It has a total 3,075 households with an average size of 4.62. The population of Tagana-an is relatively young with 38% of population less than 15 years old (**Table 2.4-9**). **Table 2.4-10** presents the basic feature of the host barangay of Tagana-an.

Table 0-9 Key Feature, Tagana-an Municipality

Key Feature	Tagana-an
Population (2010)	15,366
Land Area (ha)	7,917
Built- up Area (ha)	358.30
Male	7,333
Female	6,866
Gender Ratio	1.06
Number of Households	3,075
Average household size	4.62
Population density (people per ha)	2 (1.94)
Built-up density (people per ha)	43 (42.88)
Population growth rate (2000-2010)	1.41
Age Groups (Male and Female)	
Less than 15 years old	5,359
15-24 years old	2,695

Key Feature	Tagana-an
25-29 years old	4,545
60 and over years old	770
Age Groups (Male and Female)	830
Educational attainment	
Completed Elementary	1,358
Completed High School	1,616
Completed College	880
Major Commercial Establishments	Wholesale Trade, Retail Trade, Cockpit Arena, Funeral Service, Welding and Repair Shops, Sound System Service, Telephone Calling Service, Recreation (Billiard, Beta, etc.), and Public Market
Banking and Financial Institutions	None

Source: Eco Profile, CBMS and CLUP, 2007-2010

Table 0-10 Basic Feature, Host Barangay, Tagana-an

Basic Feature	Upper Libas
Land area (ha)	185
Population (2010)	341
Male	52%
Female	48%
Gender Ratio	1.08
Age Groups (Male and Female)	
Less than 15 years old	34%
15-24 years old	18%
25-29 years old	37%
60 and over years old	7%
Age Groups (Male and Female)	4%
Population density (people per ha)	1.84
Number of Households	77
Average household size	4.56
Civil Status (Male and Female)	
Single	53%
Married	33%
Widowed	4%
Divorced/ Separated	1%
Common Law/ Live-in	7%
Unknown	2%
Ethnicity	
Mamanwa	7%
Surigaonon	91%
Others	3%
Religious Affiliation	
Roman Catholic	66%
Others	34%
Literacy Rate	91%

Source: Eco Profile, CBMS and CLUP, 2007-2010

Figure 2.4-2 summarizes the demography of the host municipalities while **Figure 2.4-3** to

Figure 2.4-14 show the settlement maps of the host barangays. Settlement follows generally a linear pattern following or aligning to barangay roads and interior access roads. Whenever feasible, most settlements are clustered near public areas such as schools, the barangay hall and/or covered court, or the barangay health center. In general, settlements also tend to avoid rivers.

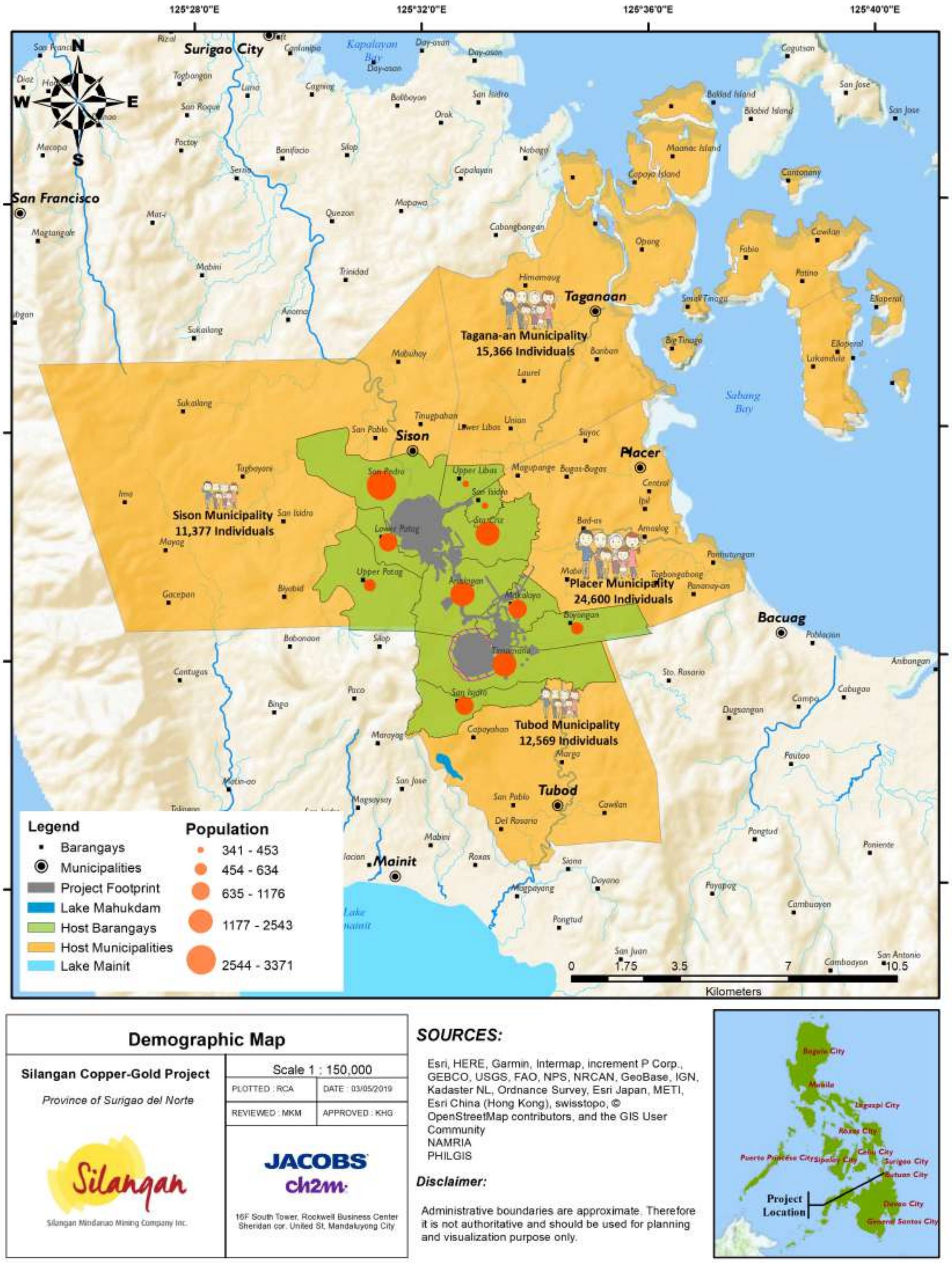

Figure 0-2 Demography of Host Municipalities

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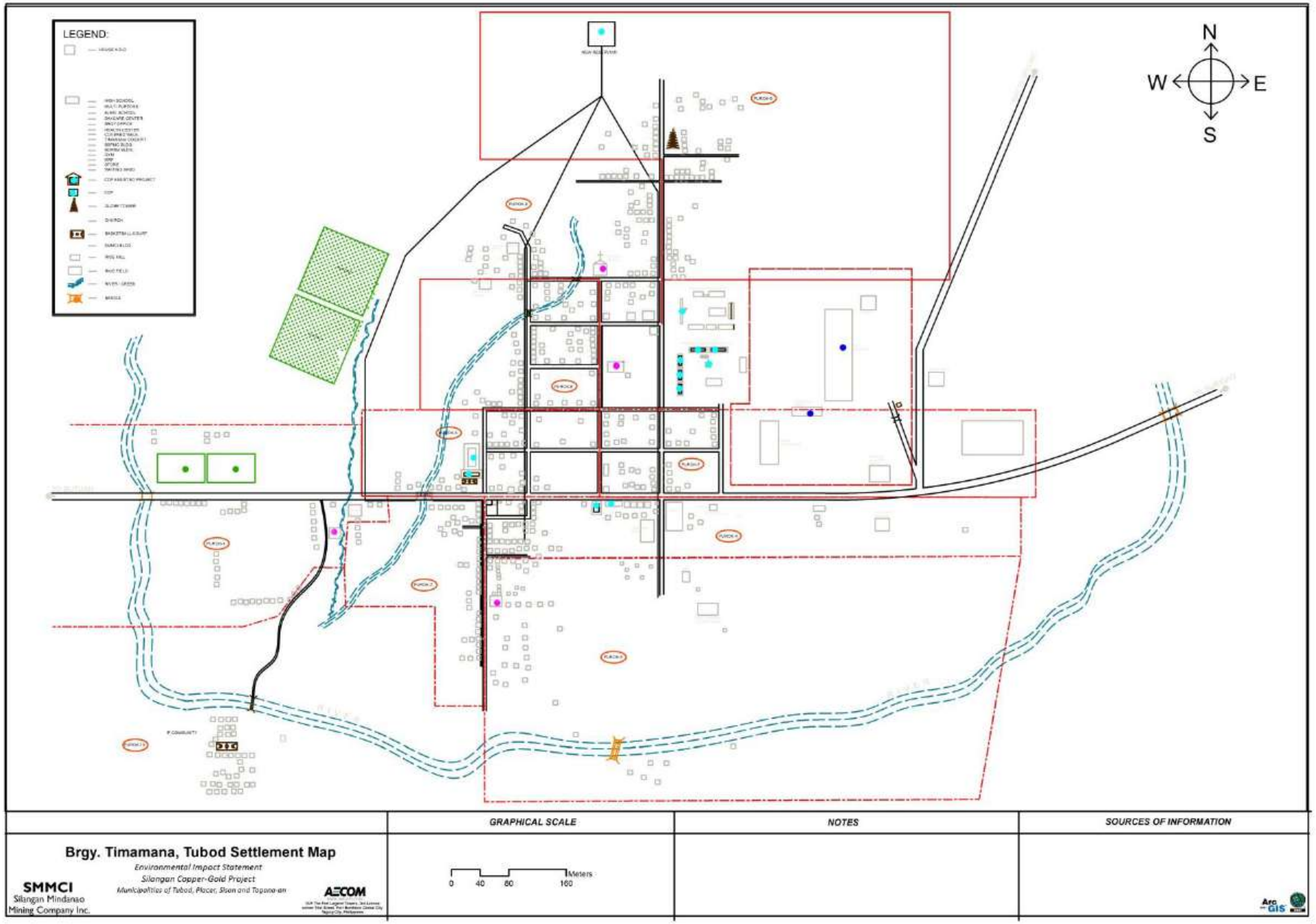


Figure 0-3 Settlement Map of Barangay Timamana, Municipality of Tubod

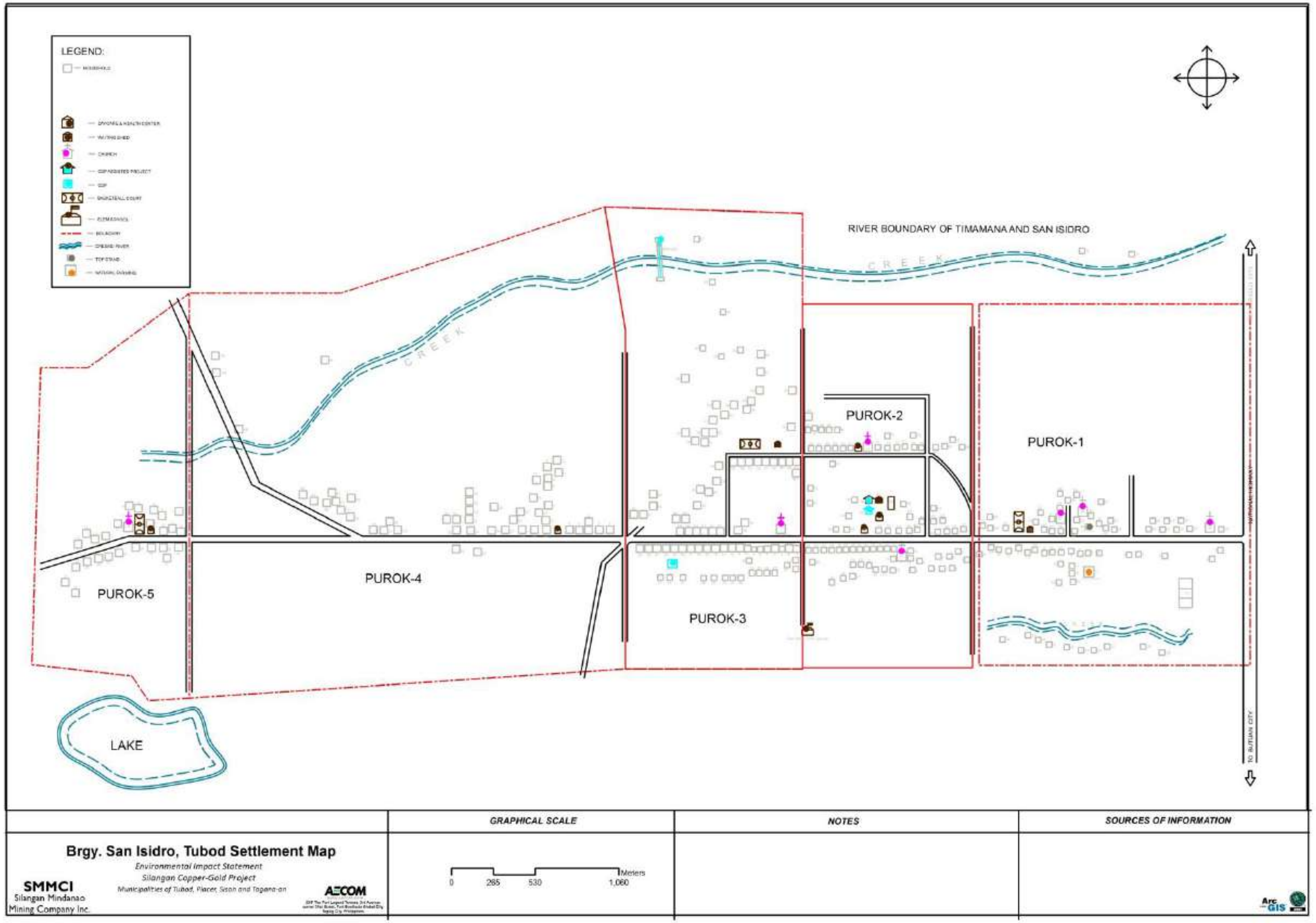


Figure 0-4 Settlement Map of Barangay San Isidro, Municipality of Tubod

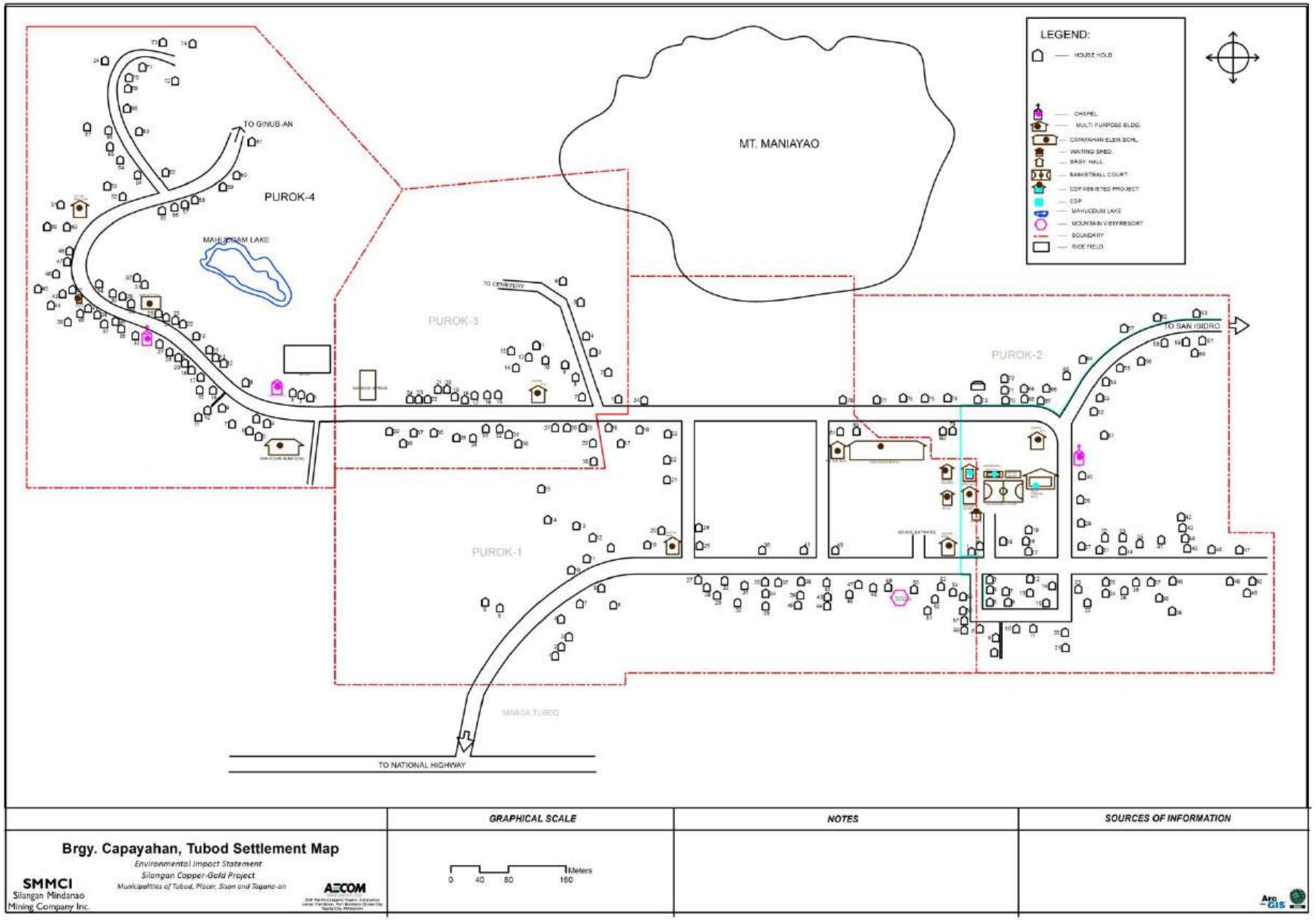


Figure 0-5 Settlement Map of Barangay Capayahan Municipality of Tubod

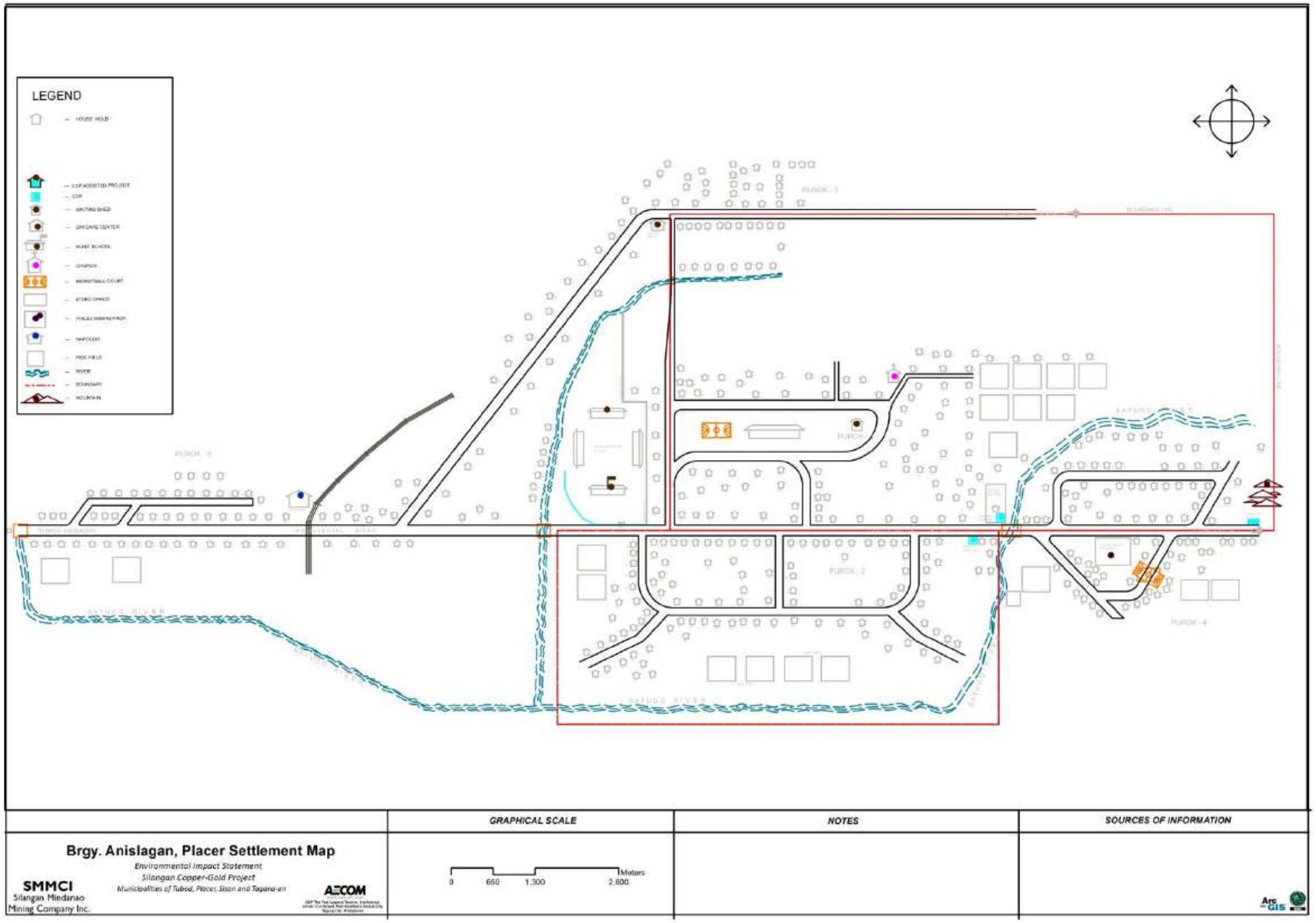

LEGEND
GRAPHICAL SCALE
NOTES
SOURCES OF INFORMATION
Brgy. Anislagan, Placer Settlement Map
Environmental Impact Statement
Silangan Copper-Gold Project
Municipalities of Tubod, Placer, Sison and Tagana-an
SMMCI
Silangan Mindanao
Mining Company Inc.
AECOM
0
650
1,300
2,600
Meters

Figure 0-6 Settlement Map of Barangay Anislagan, Municipality of Placer

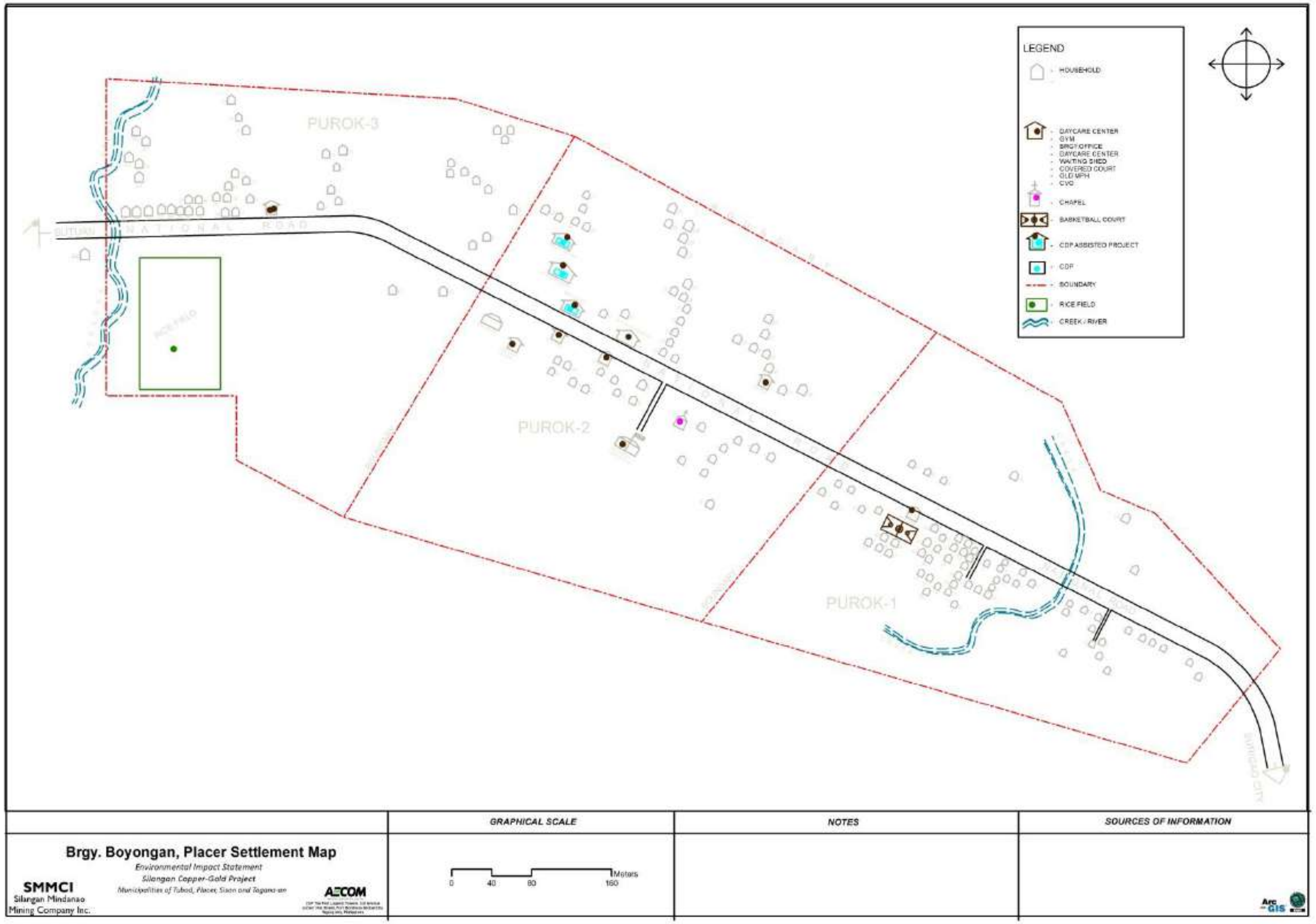
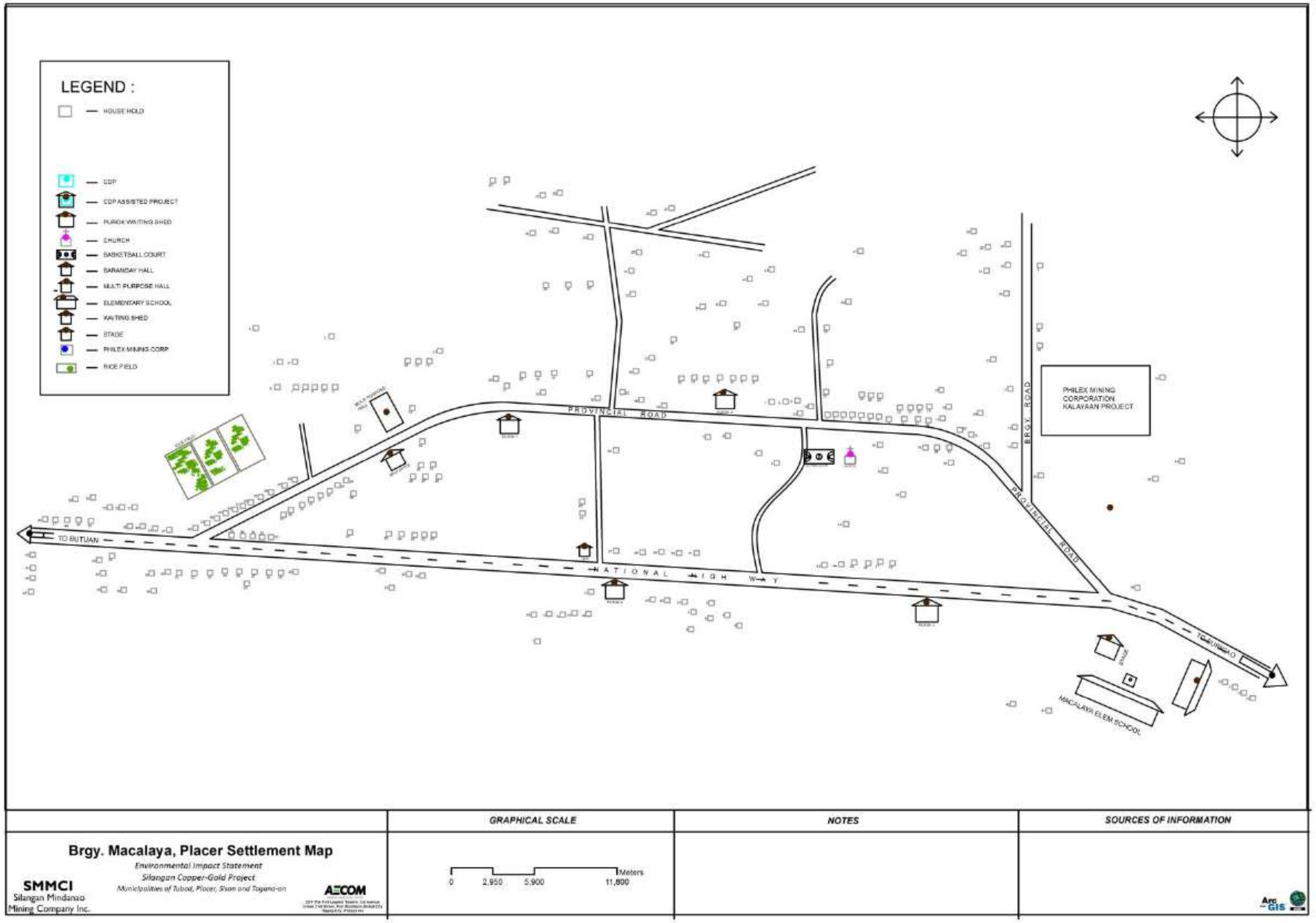


Figure 0-7 Settlement Map of Barangay Boyongan, Municipality of Placer



LEGEND :
HOUSE HOLD
CDP
CDP ASSISTED PROJECT
PUROK WAITING SHED
CHURCH
BASKETBALL COURT
BARANGAY HALL
MULTI PURPOSE HALL
ELEMENTARY SCHOOL
WAITING SHED
STAGE
PHILEX MINING CORP
RICE FIELD
PROVINCIAL ROAD
BRGY. ROAD
PHILEX MINING CORPORATION KALAYAAN PROJECT
TO BUTUAN
NATIONAL HIGH WAY
MACALAYA ELEM SCHOOL
GRAPHICAL SCALE
0
2,950
5,900
11,800
Meters
NOTES
SOURCES OF INFORMATION
Brgy. Macalaya, Placer Settlement Map
Environmental Impact Statement
Silangan Copper-Gold Project
Municipalities of Tubod, Placer, Sison and Tagana-an
SMMCI
Silangan Mindanao Mining Company Inc.
AECOM

Figure 0-8 Settlement Map of Barangay Macalaya, Municipality of Placer

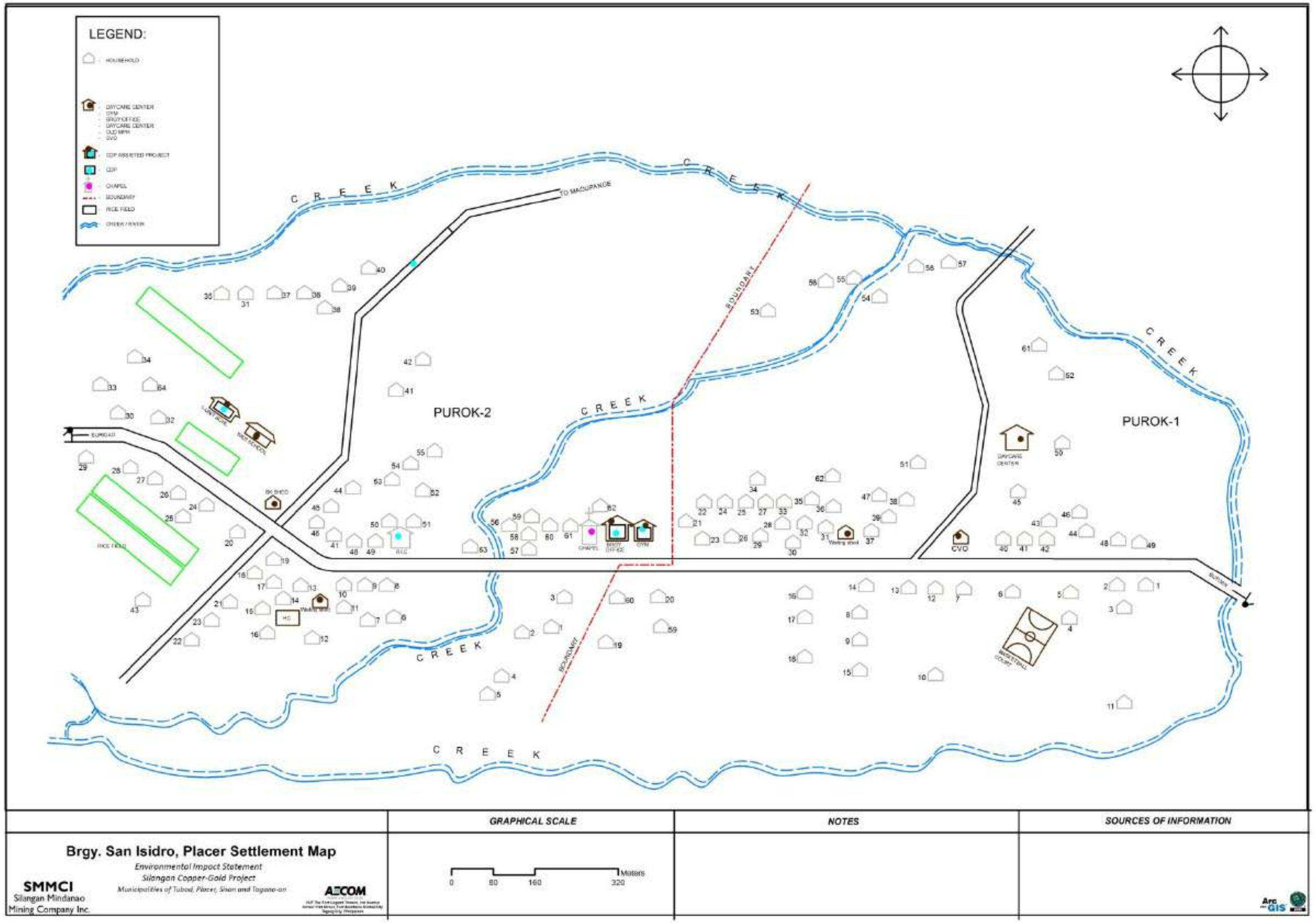


Figure 0-9 Settlement Map of Barangay San Isidro, Municipality of Placer

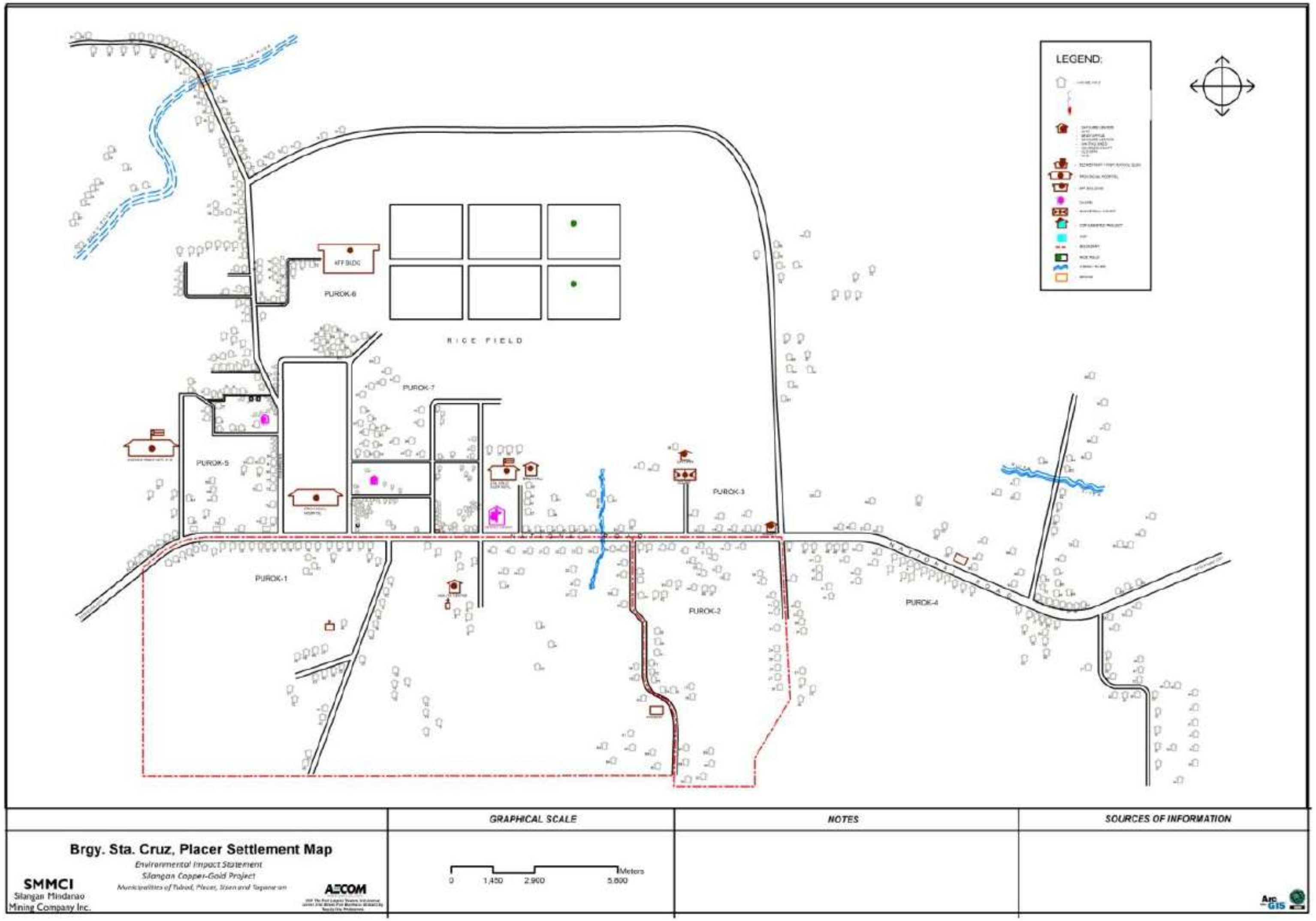


Figure 0-10 Settlement Map of Barangay Sta. Cruz, Municipality of Placer

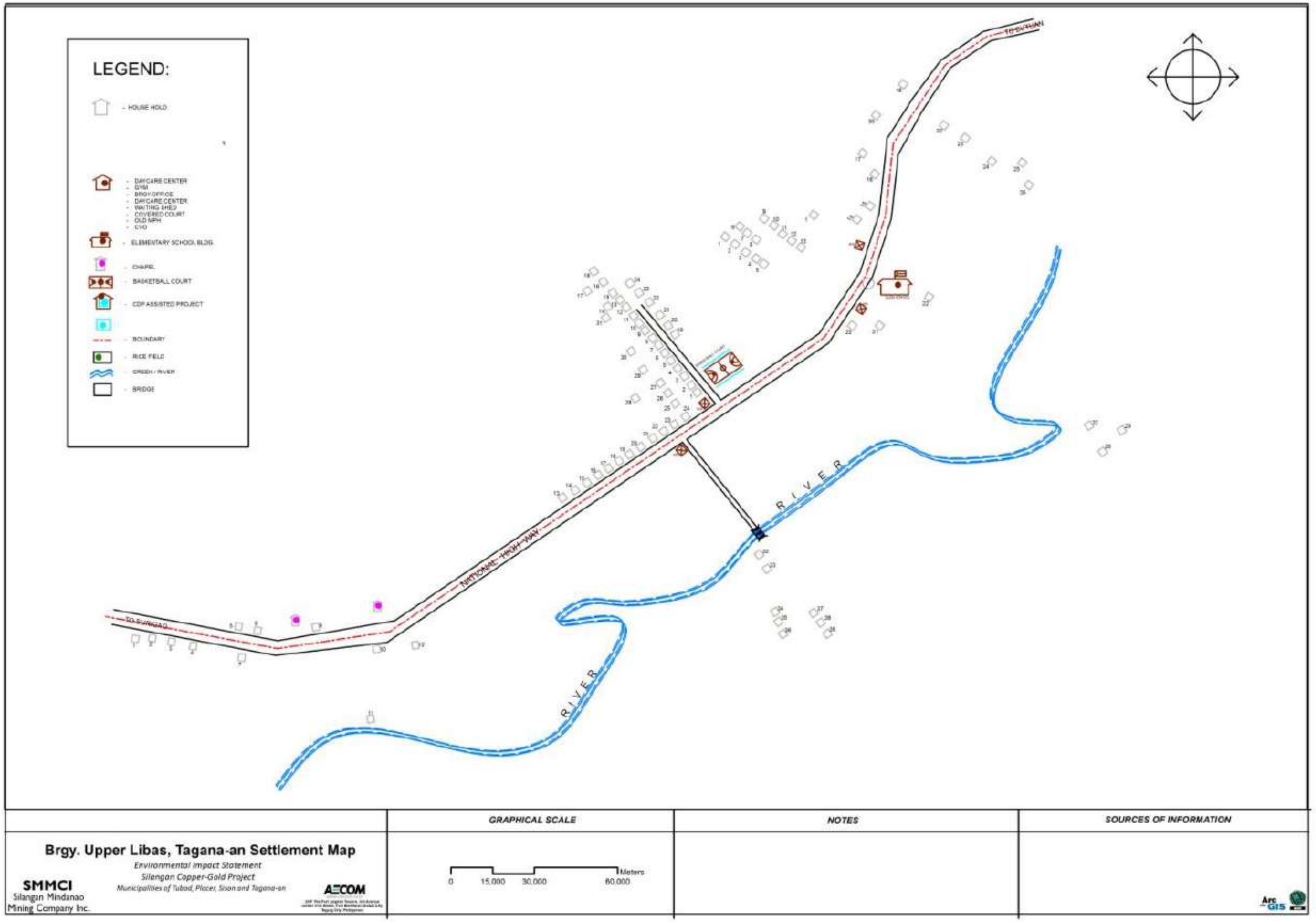


Figure 0-11 Settlement Map of Barangay Upper Libas, Municipality of Tagana-an

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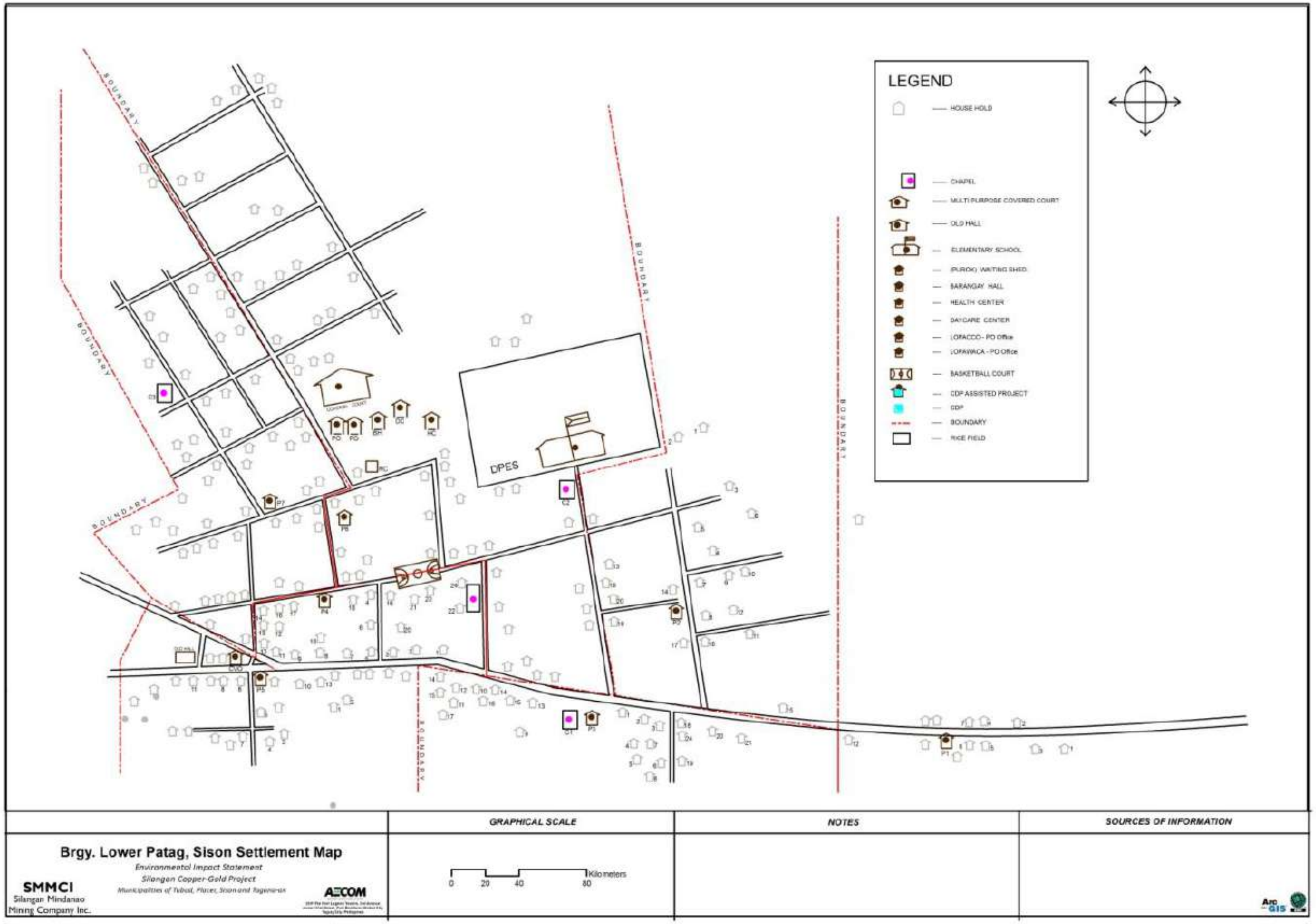


Figure 0-12 Settlement Map of Barangay Lower Patag, Municipality of Sison

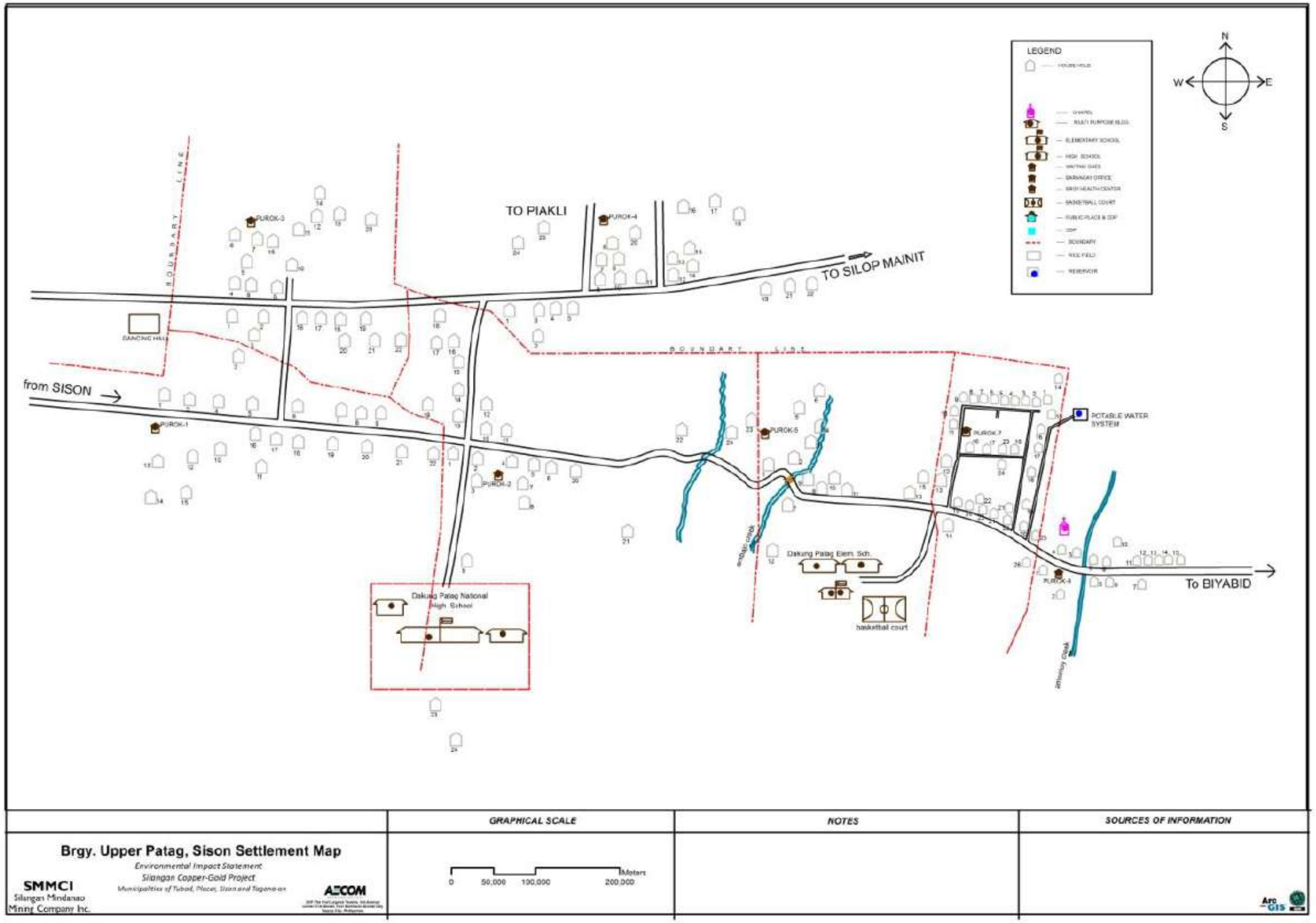


Figure 0-13 Settlement Map of Barangay Upper Patag, Municipality of Sison

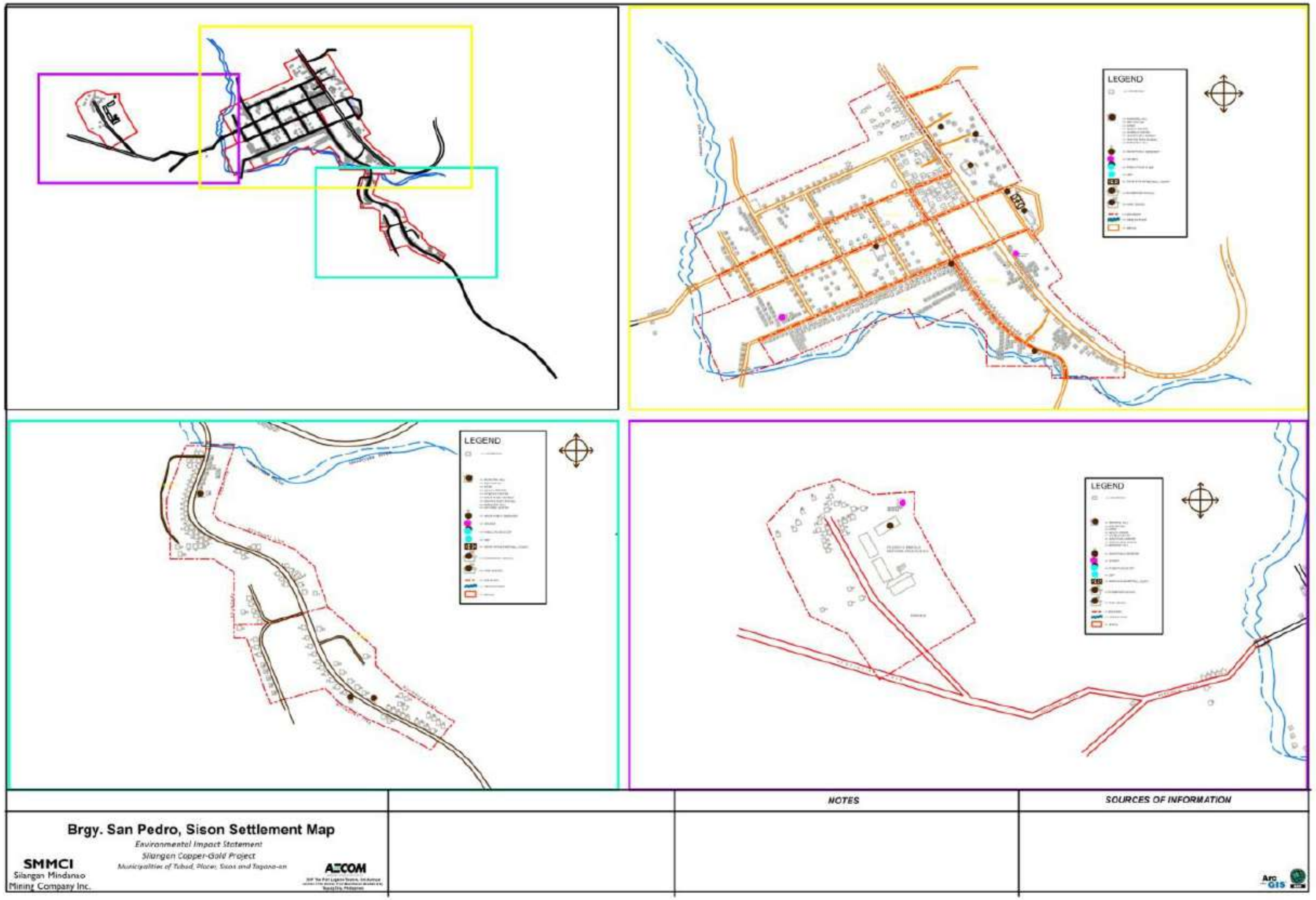


Figure 0-14 Settlement Map of Barangay San Pedro, Municipality of Sison

2.4.2.2 Key Impacts Related to Demographic Profile

Displacement of Settlers

The major project facilities will not encroach any settlements or public infrastructure. The subsidence area at its maximum size will be 2 km away from the nearest settlement in Brgy. Timamana. The TSF embankment will be about a kilometer away from the nearest settlement. Other facilities such as the haul road and mill are estimated to be at least 500 m away from the nearest settlement. Barangay roads and existing access routes of host barangays will also not be impacted by the Project. With the reduction in total project footprint from the open pit design to the sub-level caving, more areas can be used for as buffer to reduce impacts of noise, dust, and other disturbances to the nearest settlements.

Displacement/Disturbance of Properties

Properties and other public infrastructure will not be displaced or disturbed by the project as the mine footprint will not encroach any dwellings, infrastructure or properties.
Change/conflict in land ownership
The entirety of the location of the mine facilities has already been acquired by Silangan since the open pit ECC was approved in 2016. However, there are still issues concerning land ownership that were raised during the consultation meetings and IECs. These concerns are the following:

- Consideration for previous land owners to co-manage land/plantations with SMMCI so they can earn income; and
- Lands leased by SMMCI but are now located outside the mine footprint.

SMMCI management instituted a cooperative/organization called Bansiwag who maintained and managed existing coconut plantations within the project area and earned dividends every end of year. Membership can be extended to previous land-owners so the plantations are managed through the cooperative and participants receive equitable share in the form of dividends. In terms of leased land outside the mine footprint, these areas will be used to fulfill the commitment for the mine forest and National Greening Program (NGP) plantations. Industrial timber plantations are also being considered within these areas for alternative livelihood.

Change/Conflict Right of Way

As discussed, the mine facilities will not encroach any settlement, public infrastructure and land access.

Impact on Public Access

The project will not encroach on public access. No barangay roads and main roads will be affected by the project. SMMCI will construct their own access roads and haul roads for the Project.

Issues with regards to access of land by private land owners were raised during the barangay assemblies and Public Scoping. These concerns pertain to land owners accessing their land to harvest coconuts or timber while the mine is not yet undergoing construction. They were required by SMMCI to register or inform security of their activities as incidences of theft for scraps and wires were previously reported in the site. Stakeholders are not forbidden to access their land as long as they inform SMMCI for safety and security concerns. For tree-cutting, the CENRO and the Philippine Coconut Authority (PCA) stressed that felling of timber and coconuts require permits from their respective offices regardless of type, health, and ownership of the trees.

2.4.2.3 Housing Occupancy and Ownership

Home occupancy of houses and/ or lot includes the following categories:

- Owner, owner-like possession of the house and lot;
- Rent house/ room, including lot;
- Own house, rent- free with owner's consent;
- Own house, rent-free without owner's consent;
- Rent- free house and lot with owner's consent; and
- Rent- free house and lot without owner's consent.

The two principal modes of occupancy in the host barangays are (**Table 2.4-11**):

- Owner, owner-like possession of the house and lot (56%); highest in barangays Anislagan, Macalaya and Timamana at 64% each; lowest at Barangay Upper Patag (39%); and
- Own house, rent-free lot with owner's consent (24%), highest in Barangays Upper Patag at 44%; lowest in Barangay Anislagan (13%).

Table 0-11 Home Occupancy (House and Lot)

Community	Base (No. of Houses)	Percentage of Houses					
		Owner/ owner-like possession of the House and Lot	Rent house/ room, including lot	Own house, rent-free lot with owner's consent	Own house, rent-free lot without owner's consent	Rent-free house and lot with owner's consent	Rent-free house and lot without owner's consent
All Host Barangays	902	56	3	24	7	9	1
Placer							
Anislagan	97	64	2	13	5	15	0
Boyongan	71	55	3	24	8	8	1
Macalaya	80	64	6	15	4	10	1
San Isidro	65	57	3	23	5	11	2
Sta. Cruz	106	58	5	28	2	5	2
Sison							
San Pedro	103	45	1	26	15	12	2
Lower Patag	77	51	8	18	12	12	0
Upper Patag	66	39	2	44	8	8	0
Tubod							
Timamana	94	64	2	22	4	7	0
San Isidro	80	63	1	25	4	6	1
Tagana-an							
Upper Libas	63	52	3	29	6	6	3

Tables 2.4-12, 2.4-13 and **2.4-14** present data on the type of materials used for roofing, walls and flooring. Roofing and walling materials are classified into:

- Strong (at least 75% of dwelling units made of concrete, brick, stone, wood, GI sheets, etc);
- Light (at least 75% of dwelling units made of bamboo, sawali, cogon, nipa, etc);
- Salvaged/makeshift materials (e.g. cardboard, etc);
- Mixed but predominantly strong materials (more than 50% but less than 75% strong materials);
- Mixed but predominantly light materials (more than 50% but less than 75% light materials); and
- Mixed but predominantly salvaged/makeshift materials (more than 50% but less than 75% salvaged/ makeshift materials).

Flooring is categorized according to its predominant material that could be any one of the following materials:

- Earth/ soil;
- Bamboo;
- Lumber; and
- Concrete.

Forty two percent of houses in all the host barangays have roofs that are made of strong materials; 24% light; 2% salvaged/makeshift; 13% mixed but predominantly strong; 12% mixed but predominantly light; and 7% mixed but predominantly salvaged/ makeshift. Barangays Sta Cruz and San Pedro have the highest proportion of houses with strong roofing materials (strong and mixed but predominantly strong) at 64% each, Barangay Upper Libas, the lowest at 26% (**Table 2.4-12**).

Table 0-12 Roofing Materials of the House

Community	Base (No. of Houses)	Percentage of Houses					
		Strong	Light	Salvaged/ Makeshift	Mixed Strong	Mixed Light	Mixed Salvaged
All Host Barangays	884 (885)	42	24	24	13	12	7
Placer							
Anislagan	95	38	31	1	6	10	9
Boyongan	71	29	24	2	6	4	6
Macalaya	74	19	18	6	10	12	9
San Isidro	64	27	19	0	5	8	5
Sta. Cruz	106	46	27	2	18	8	5
Sison							
San Pedro	103	46	17	1	18	17	4
Lower Patag	73	31	13	2	12	10	5
Upper Patag	69	24	14	2	12	11	6
Tubod							
Timamana	94	51	20	3	10	8	2
San Isidro	76	44	11	0	7	11	3
Tagana-an							
Upper Libas	60	17	20	0	9	6	8

Houses with strong walling materials comprise 51%; light, 19%; salvaged/makeshift, two percent; mixed but predominantly strong, 12%; mixed but predominantly light, 10%; and mixed but predominantly salvaged/ makeshift, five percent (**Table 2.4-13**). The highest proportion of houses with strong, including mixed but predominantly strong, materials is in San Pedro (77%); the lowest in Upper Libas (31%).

Table 0-13 Walling Materials of the House

Community	Base (No. of Houses)	Percentage of Houses					
		Strong	Light	Salvaged/ Makeshift	Mixed Strong	Mixed Light	Mixed Salvaged
All Host Barangays	909	51	19	2	12	10	5
Placer							
Anislagan	99	48	30	1	6	10	4
Boyongan	71	55	23	4	6	4	8
Macalaya	80	40	19	4	14	10	14
San Isidro	65	31	15	1	6	10	2
Sta. Cruz	106	62	15	2	13	10	4
Sison							
San Pedro	104	56	10	2	21	13	2
Lower Patag	78	38	11	0	12	12	5
Upper Patag	71	24	16	0	16	12	3
Tubod							
Timamana	94	61	17	1	9	4	2
San Isidro	79	52	12	1	8	4	2

Tagana-an							
Upper Libas	62	24	16	2	7	7	6

More than half (54%) of houses have concrete materials for flooring followed by lumber (22%), earth soil (16%) and bamboo, nine percent (**Table 2.4-14**). Barangay Sta. Cruz has the highest proportion of houses with concrete flooring at 63%; the lowest in Barangay Upper Patag (26%).

Table 0-14 Flooring Materials of the House

Community	Base (No. of Houses)	Percentage of Houses			
		Earth Soil	Bamboo	Lumber	Concrete
All Host Barangays	878	16	9	22	54
Placer					
Anislagan	97	10	16	19	55
Boyongan	67	24	10	16	49
Macalaya	78	9	13	19	37
San Isidro	62	8	6	14	34
Sta. Cruz	102	14	2	23	63
Sison					
San Pedro	102	17	6	28	51
Lower Patag	76	19	13	19	37
Upper Patag	66	21	4	15	26
Tubod					
Timamana	89	8	6	26	49
San Isidro	77	3	3	11	60
Tagana-an					
Upper Libas	61	11	9	11	30

2.4.2.3 Key Impact Relating to Housing Ownership Profile

In-migration or Proliferation of Informal Settlers

In-migration can potentially occur during the pre-construction phase once the Project secures its permits and approvals and a formal declaration is made regarding Project development. Migrants may come from the indirect impact barangays to take advantage of opportunities and benefits allocated to host barangays or to establish business and other livelihood near the mine site. Migrants, particularly miners and other skilled workers, may also come from other areas from Placer and Tubod or other provinces in Region 13 where mining companies are under Care and Maintenance or suspension to secure work with SMMCI.

2.4.2.4 Cultural/Lifestyle Change and Impacts on Physical Cultural Resources

The Project does not encroach any Ancestral Domains, Lands or Claims though there are CADTs within Barangay Cawilan, which is the host barangay of GRC, and the municipality of Alegria, where claims of GRC are also located. Within the host municipality of Tubod, migrant IPs of the Mamanwa tribe are temporarily settled within Barangay Motorpool. The Mamanwas occupy land that is owned by SMMCI. An arrangement was made between the MLGU of Tubod and SMMCI for the MLGU to borrow the land to temporarily house an initial 12 Mamanwa household until the MLGU can find a place for the Mamanwas to permanently resettle. Since then, the number of households have grown adversely impacting the barangay through improper waste disposal and sanitation practices, disorderliness especially after consuming liquor, and disrupting the peace and order in the barangay. SMMCI has included the Mamanwas in IECs specifically for the concerns with regards to the agreement in terms of the use of land and their adherence to the municipal and barangay regulations. As a neighboring community, Barangay Motorpool is also included in the SDP.

Tangible cultural/historical heritage sites include the Northeastern Mindanao Uprising Shrine located in Barangay Timamana and the Barangay Panhutongan Heritage Site in the Municipality of Placer. The Uprising Shrine is the grave site of 65 brave Filipinos who died in defiance of the American Occupation on January 27, 1924. The shrine is located along the National Highway (Maharlika Highway) right in front of the SMMCI mine office. This area will not be encroached by the mine development. The Heritage Site at Barangay Panhutongan was discovered in 1985. It is an archaeological site where 3 boat-shaped wooden coffins with human skulls and bones covered with antique plates, tea cups, small saucers, soup bowls, pots, jewelries, bolos and smoke pipe were unearthed. Wooden posts and remnants of stone slabs were also discovered in the site. Some of the items were donated to the Surigao Heritage Center and the rest were believed to have been bought by unknown persons and are no longer traceable. To preserve the cultural heritage of the town, the MLGU ordered historians, anthropologists, and archeologists to examine and study the origin of the relics. Barangay Panhutongan is a coastal barangay of Placer located about 15 km away from the mine office.

2.4.2.5 Basic Services

Source of Electricity

Table 2.4-15 presents the source of electricity among the host barangays. On the average, 87% of the households get their electricity from the provincial electric cooperative Surigao del Norte Electric Corporation (SURNECO) through individual (own) connection. Barangays San Isidro (Tubod) and Lower Patag have the highest proportion of houses with own electrical connection at 96% and 95%, respectively. The lowest proportion is in barangays Boyongan and Macalaya at 71% each and 12% of the houses share electricity with neighbors.

Table 0-15 Source of Electricity

Community	Base (No. of Houses)	Percentage of Houses	
		Electricity Own Connection	Electricity Shared Connection
All Host Barangays	836	87	12
Placer			
Anislagan	85	86	14
Boyongan	68	71	29
Macalaya	70	71	29
San Isidro	56	91	9
Sta. Cruz	99	90	10
Sison			
San Pedro	99	93	7
Lower Patag	73	95	5
Upper Patag	66	91	9
Tubod			
Timamana	97	86	14
San Isidro	78	96	4
Tagana-an			
Upper Libas	45	91	9

Water Source

Drinking water is primarily obtained from the community water system which is sourced from springs. Data show that 83% of households have individual connection to the community water system. Only 15% of the household population use community water system that is shared with other households (**Table 2.4-16**).

At the barangay level, Barangay Timamana (94%) has the highest proportion of households with individual connection to the community water system at 94% followed by Sta. Cruz (93%) and Anislagan (90%).

Table 0-16 Source of Water

Community	Base (No. of houses)	Percentage of Houses							
		Community water system (own use)	Community water system (shared with others)	Deep well (own use)	Deep well (share d with others)	Artesian well (own use)	Artesian well (shared with others)	Others	No Answer
All Host Barangays	919	83	15	1	0	0	0	1	1
Placer									

Community	Base (No. of houses)	Percentage of Houses							
		Community water system (own use)	Community water system (shared with others)	Deep well (own use)	Deep well (shared with others)	Artesian well (own use)	Artesian well (shared with others)	Others	No Answer
Anislagan	99	90	10	0	0	0	0	0	0
Boyongan	71	86	11	0	0	0	0	2	0
Macalaya	80	71	28	0	1	0	0	0	0
San Isidro	65	86	9	0	2	2	1	0	0
Sta. Cruz	107	93	6	0	0	0	0	0	1
Sison									
San Pedro	104	85	15	0	0	0	0	0	0
Lower Patag	81	75	23	2	0	0	0	0	0
Upper Patag	71	68	30	1	0	0	0	1	0
Tubod									
Timamana	98	94	3	0	0	0	0	0	3
San Isidro	80	86	8	0	1	0	0	4	1
Tagana-an									
Upper Libas	63	60	27	5	0	0	0	6	2

Educational Profile

Educational Facilities

The host municipalities have 57 day care centers, ten primary schools, 45 elementary schools and nine high schools (public and private). The nearest tertiary institutions are in Mainit and Surigao City (**Table 2.4-17**).

Table 0-17 Educational Facilities, Host Municipalities

Municipality	Pre-school	Primary	Elementary	High School
Placer	19	4	15	4
Sison	14	2	11	2
Tubod	10	1	8	2
Tagana-an	14	3	11	1
Total	**57**	**10**	**45**	**9**

Highest Educational Attainment

Highest educational attainment pertains to the highest level of education that an individual has completed. The majority (55%) of the household member population (15 years old and over) have completed high school, 20% are elementary graduates and 15% are college and vocational level graduates (**Table 2.4-18**).

Across host barangays, Timamana and Lower Patag have the highest proportion of household members who completed high school education (62% and 61%). In Barangay Sta. Cruz, 31% of the household members were able to finish college and vocational education. Barangay Upper Patag recorded the lowest proportion of college/ vocational graduates at three percent.

Table 0-18 Highest Educational Attainment

Community	Base (No. of Household Members)	Percentage of Household Members		
		Elementary Graduate	High School Graduate	College/ Vocational Graduate
All Host Barangays	1,432	30	55	15
Placer				
Anislagan	156	32	51	17
Boyongan	100	30	57	13
Macalaya	124	29	60	11
San Isidro	88	42	41	17
Sta. Cruz	206	16	53	31
Sison				
San Pedro	166	28	58	13
Lower Patag	135	35	61	4
Upper Patag	107	50	48	3
Tubod				
Timamana	150	22	62	16
San Isidro	110	35	53	12
Tagana-an				
Upper Libas	90	31	50	19

2.4.2.5.1 Peace and Order

The peace and order situation in the four host municipalities is relatively stable. Each municipality has a police station in the municipal hall grounds. Augmenting the regular police force are peace and order community auxiliaries who are organized into Civilian Volunteer Organizations (CVOs) and Barangay at Pulisya Laban sa Krimen (BPLKs). (See **Annex 2.4-1** for details per municipality).

Based on FGDs, each host barangay has a set of Barangay Public Safety Officers (BPSO) and civilian volunteers, who are mandated to promote and maintain the safety of lives and properties of the community members. They act as police during social activities in the barangays. Barangay councils have also created the Lupong Tagapamayapa to augment the security force of the communities.

2.4.2.5.2 Recreational facilities/ Sports Facilities

The communities in the host municipalities are involved in various sports activities such as basketball and volleyball and swimming in coastal areas. Recreational activities for some community members include cockfighting and billiards. (See **Annex 2.4-2** for detail description of recreational facilities per municipality).

2.4.2.5.3 Communication

Communication services available in the host municipalities are Smart, Globe Telecoms and Philippine Long Distance Telephone (PLDT) Company, PHILCOM, Bureau of Telecom and the Municipal Radio Communication Centre. Each municipality has a postal service through the Philippine Post Office (PhilPost) (**Table 2.4-19**).

Table 0-19 Communication services, Host Municipalities

Municipality	Telecommunication	Postal service
Placer	Smart; Globe Telecoms	PhilPost
Sison	Smart; PLDT;PHILCOM; Bureau of Telecom	
Tubod	Smart; Globe Telecoms; PHILCOM	
Tagana-an	Smart; PLDT; Municipal Radio Communication Center	

2.4.2.6 Income, Livelihood and Employment

The average household income for all host barangays is PHP 69,637 per annum (PHP 5,803/mo) with the highest in Boyongan (Placer) at PHP 91,475 and the lowest in Upper Patag (Sison) at PHP 49,374. Median income is PHP 49,984. **Table 2.4-20** presents household incomes (average and median) and the proportion of households below the poverty line and the food threshold. Sixty percent of households earn less than PHP 5,000 a month for an average PHP 2,333 (60% less than the average monthly household cash income for all host barangays). (**Table 2.4-21**; see also **Annex 2.4-3** for details per barangay).

Table 0-20 Average and Median Household Income and Households below Poverty Line and Food Threshold by Host Barangays

Direct Impact Communities	Average Annual Household Income (PHP)	Median Annual Household Income (PHP)	Average Annual Per Capita Income (PHP)	% Households Below	
				Poverty Line	Food Threshold
All Host Barangays	69,637	48,984	15,171	74	67
Placer					
Anislagan	69,398	53,375	15,456	73	65
Boyongan	91,475	70,304	20,060	63	53
Macalaya	80,888	46,824	17,661	71	65
San Isidro	80,888	46,824	17,661	71	65
Sta. Cruz	73,708	50,148	14,921	72	66
Sison					
San Pedro	73,432	50,530	17,117	73	66
Lower Patag	64,087	40,387	11,802	81	77
Upper Patag	49,374	35,455	10,138	84	79
Tubod					
Timamana	69,683	59,041	16,357	70	60
San Isidro	66,938	53,286	15,424	74	65
Tagana-an					
Upper Libas	74,234	42,607	16,279	74	69

Poverty is widespread and deep in the host barangays where 74% of households are below the poverty line in contrast to 47.9% for Surigao del Norte. Poor households range from 63% (Boyongan) to 84% (Upper Patag). The poverty line set by the National Statistical Coordination Board for 2009 for Surigao del Norte is PHP 17,261 per capita (PHP 86,305/yr for a family of five or PHP 7,192/mo). The current average monthly household income of PHP 5,803 is 19% less than the poverty line and will only be sufficient for a family of four (instead of five) to stay out of poverty.

Households below the poverty line on the average earn PHP 3,343/mo (46% of the poverty line; good only for a family size of 2-3 members). Only Boyongan has an average household income (PHP 91,475) that is above the poverty line; nonetheless 63% of its households are classified poor. The findings suggest that 7.5 of every 10 families cannot afford a standard of living that would keep them out of poverty. The majority of the respondent-households (60%) in the host barangays earn less than PHP 5000/mo. (**Table 2.4-22**).

Sixty percent of households are below the food threshold which is the income required to buy the sufficient quantity and right quality of food to meet daily nutritional requirements. In 2009, the official food threshold for Surigao del Norte was set at PHP 12,053 per capita (PHP 60,265/yr or PHP 5,022/mo for a family of 5). The average household income of PHP 5,803/month (for all income classes) is barely enough to support the food requirements of a family of 5. Families below the poverty line (74% of total families) earn an average of PHP 2,316/mo (less than half of the poverty line or just enough to meet the food requirements of 2 instead of 5 members of a family). Hence, the food budget of 5-8 of every 10 families in the host barangays is insufficient.

The most frequently cited sources of income are employment-private sector (28.92%): highest in Macalaya (Placer) at 49.12% and lowest at Upper Patag at 9.02%, and farming (28.67%): highest in Upper Patag (40.98%) and lowest in Boyongan (15.38%). Other sources of employment include self-employment (18.21%), contract labour (11.05%), employment-government, pension/assistance/remittances and fishing (11.3%). (**Table 2.4-23**).

Table 0-21 Distribution of Households by Monthly Cash Income: All Host Barangays as One Area

Income Class	Households % (Base 919)	Cumulative Percentage
0-999	16.10	16.10
1,000-4,999	43.76	59.86
5,000-9,999	27.66	87.52
10,000-14,999	7.67	95.19
15,000-19,999	2.28	97.47
20,000-24,999	1.18	98.65
25,000-29,999	0.25	98.9
30,000-34,999	0.25	99.15
35,000-39,999	0.17	99.32
40,000-44,999	0.08	99.4
45,000-49,999	0.00	99.4
50,000-54,999	0.00	99.4
55,000-59,999	0.17	99.57
60,000-64,999	0.08	99.65
65,000-69,999	0.00	99.65
70,000-74,999	0.00	99.65
75,000-79,999	0.00	99.65
80,000-84,999	0.08	99.73
85,000-89,999	0.08	99.81
90,000-94,999	0.08	99.89
95,000-99,999	0.00	99.89
100,000-105,000	0.00	99.89
More than 105,000	0.08	100

Table 0-22 Sources of Income and Livelihood of Household Members

Area	Base (No. of respons es)	Employ ment (Private) % Base	Employ ment (Govern ment) % Base	Self-employ ment % Base	Pension, assistan ce, remittan ces % Base	Pakyawa n/ contract % Base	Fishing % Base	Farmin g % Base	Others % Base
ALL Host Barangays	1,186	28.92	7.76	18.21	2.87	11.05	0.67	28.67	1.85
Placer									
Anislagan	118	37.29	5.08	11.02	1.69	9.32	0	35.59	0
Boyongan	78	50	7.69	12.82	1.28	10.26	2.56	15.38	
Macalaya	114	49.12	7.02	12.28	2.63	9.65	0	17.54	1.75
San Isidro	77	24.68	9.09	23.38	2.60	11.69	0	25.97	2.60
Sta. Cruz	130	23.85	11.54	17.69	3.85	12.31	0.77	29.23	0.77
Sison									
San Pedro	143	20.28	10.49	25.87	4.90	10.49	1.40	23.78	2.80
Lower Patag	112	20.54	6.25	18.75	1.79	8.04	0	39.29	5.36
Upper Patag	122	9.02	8.20	13.11	1.64	9.02	1.64	40.98	16.39
Tubod									
Timamana	119	34.45	2.52	21.01	6.72	14.29	0.84	19.33	0.84
San Isidro	113	35.40	2.65	16.81	0	8.85	0	30.09	6.19
Tagana-an									
Upper Libas	81	12.35	14.81	24.69	2.47	17.28	0	28.4	0

There are 1.32 working members per household. The predominant form of employment is short-term/seasonal/contractual (63%). Permanent employment is 25% and itinerant, i.e., day-to-day, 12%) Short-term employment is highest in Upper Patag at 73% and lowest in San Isidro (Tubod) at 55%. Permanent employment ranges from 15% (Upper Patag) to 32% (Sta. Cruz, Placer). Itinerant employment is from 5% (Sta. Cruz) to 23% (San Isidro, Tubod). (**Table 2.4-23**) On three indicators (average household income, sources of employment, and job status), Upper Patag scored lowest.

Table 0-23 Job Status of Working Household Members

Area	Base (No. of working household members)	Permanent	Short-term or seasonal of casual job/business	Itinerant (worked on different jobs on day to day or week to week)
ALL Host Barangays	1,214	25	63	12
Placer				
Anislagan	118	25	62	14
Boyongan	82	27	67	6
Macalaya	112	24	67	9
San Isidro	85	27	61	12
Sta. Cruz	134	32	63	5
Sison				
San Pedro	152	28	62	10
Lower Patag	107	26	62	12
Upper Patag	94	15	73	12
Tubod				
Timamana	125	24	59	17
San Isidro	124	22	55	23
Tagana-an				
Upper Libas	81	27	60	12

2.4.2.4 Transportation and Traffic Conditions

Most traffic through the host barangays consists of light vehicles, e.g., jeepneys, “multi-cabs”, and tricycles. Traffic volume is light and intermittent. The roads are generally rugged and not paved; there is a possibility that these will be subjected to heavier loads during the construction and operations phases of the project. Most passenger vehicles are overloaded with passengers and goods especially during rush hour, an indication of the inadequacy of means of public transportation. School zones, markets, church zones, poblaciones, residential areas are sensitive receptors of traffic volume. The risks and nuisance associated with increased vehicular traffic are not easily appreciated by local residents.

Safety programs for pedestrians and drivers should be undertaken during the pre-construction stage that would orient people to safety signage and other road warning devices, good driving practices, and road rules. Road signs should be installed, traffic wardens trained, and emergency response teams (including first-aid teams) trained and developed for vehicular and pedestrian accidents.

A traffic management plan for the construction and operations phases of the project should be jointly made by local officials at the barangay and municipal levels including community leaders and the project proponent to respond to changing conditions in the host barangays.

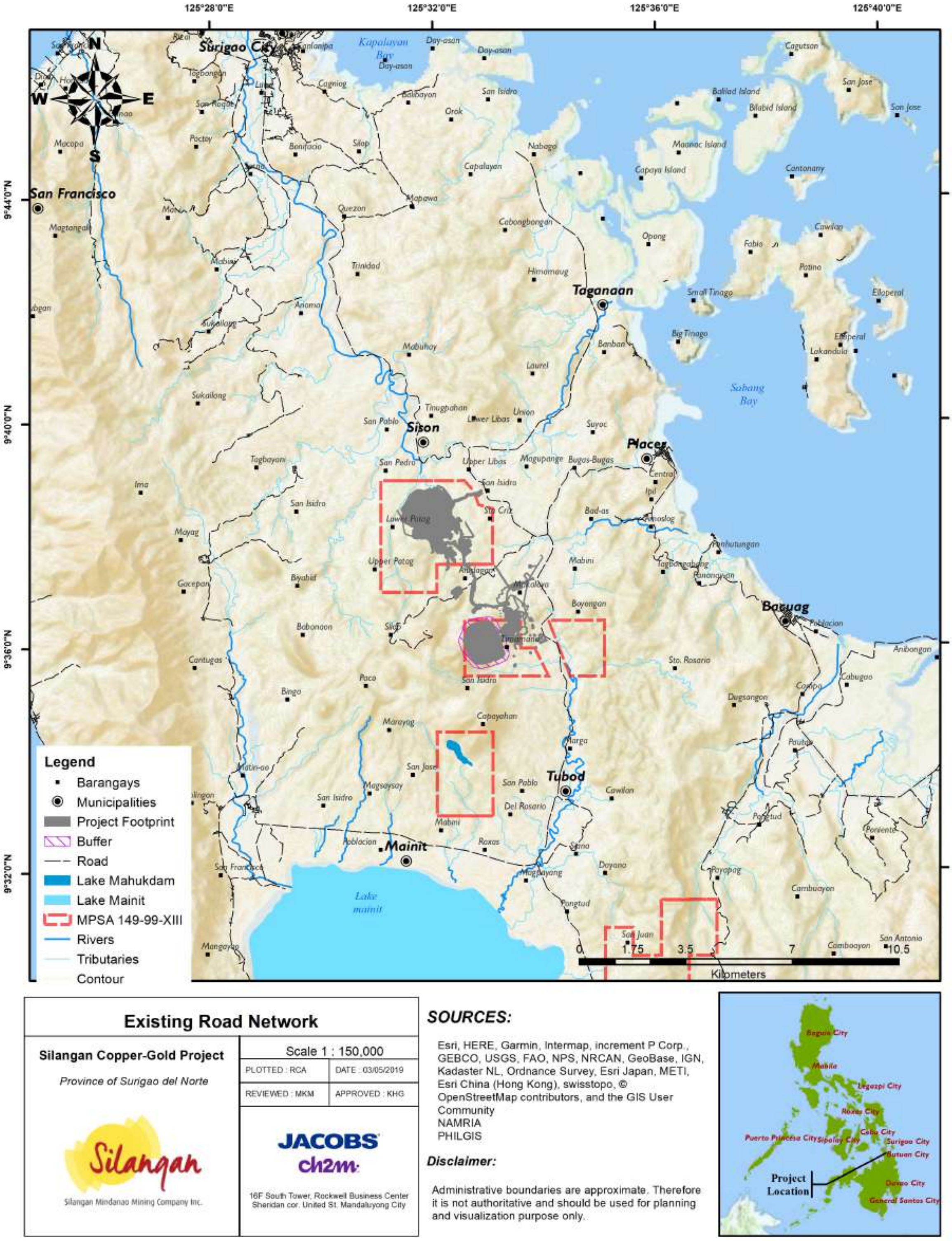


Figure 0-15 Existing Road Network

2.4.3 Public Health Profile

This section of the report discusses the public health conditions of the four host municipalities and their respective direct-impact barangays which includes health facilities and personnel, leading causes of morbidity and mortality, vital health statistics, nutritional status of preschoolers, water and sanitation facilities and waste disposal methods. The public health data for each municipality and direct-impact barangay vary due to the following limitations:

- Focus Group Discussion (FGD) and Key Information Interview (KII) notes and Household Survey results were used for areas where there were no secondary data provided;
- The CBMS Survey Data used were only limited to mortality and morbidity causes, access to toilet and water source facilities. There was no 5-year trend comparison, only a 3-year trend comparison at least for the municipality of Tubod.

2.4.4.1 Place Municipality and Host Barangays

2.4.4.1.1 Municipality Health and Sanitation

The available health facilities for the municipality of Placer are a rural health unit, a district health hospital, 12 barangay health stations, a dental clinic, a private medical clinic, and two private drug stores (**Table 2.4-30**).

Table 0-24 Health Facilities, Placer Municipality

Health Facilities	Number
Public	
Rural health unit	1
District Hospital	1
Barangay Health Station	12
Dental clinic	1
Private	
Laboratory	1
Medical clinic	1
Drug Store/Pharmacy	2

Source: Placer Ecological Profile, 2009

In 2009, the health facilities had four doctors, a dentist, 11 nurses, six nursing attendants, 12 midwives, a medical technologist, a pharmacist, five utility personnel, 211 barangay health workers and nine other personnel (**Table 2.4-31**). The number of personnel exceedingly complies with the Department of Health standard ratio for doctors, nurses, midwives. However, it lacks a rural sanitary health inspector. The DOH standard ratio of Manpower to Population: Rural Health Physician= 1:20,000; Public Health Nurse=1: 20,000; Rural Health Midwife=1:5,000; Rural Health Inspector=1:20,000; Rural Health Dentist=1:50,000.

Table 0-25 Health Personnel, Placer Municipality

Health Personnel	Public	Private	Standard
Doctor	2	2	1
Dentist	1	0	1
Nurse	11	0	1
Nursing Attendant	6	0	0
Midwife	12	0	5
Medical Technologist	1	0	0
Pharmacist	1	0	0
Dental Aide	0	0	0
Sanitary Inspector	0	0	1
Utility Personnel	5	0	0
Barangay Health Workers	211	0	0
Barangay Nutrition Scholars	0	0	0
Trained Birth Attendants	0	0	0
Others	7	2	0

Source: Placer Ecological Profile, 2009

Causes of Morbidity

From 2008 to 2009, the top leading cause of morbidity was the infection of the upper respiratory tract (URTI). This was followed by hypertension, urinary tract infection, pulmonary tuberculosis and pneumonia. Despite the government's provision of free treatment of tuberculosis several cases still prevail in some areas of Placer.

Table 0-26 Leading Causes of Morbidity

Rank	Diseases	2008		Diseases	2009	
		No	%		No	%
1	Upper Respiratory Tract Infection (URTI)	18	15	Upper Respiratory Tract Infection (URTI)	20	22.2
2	Hypertension	16	13.4	Pulmonary Tuberculosis (PTB)	13	14.4
3	Bronchitis	15	12.6	Pneumonia	13	14.4
4	Urinary Tract Infection (UTI)	14	11.8	Urinary Tract Infection (UTI)	12	13.3
5	Pulmonary Tuberculosis (PTB)	12	10.1	Hypertension (HPN)	8	8.9
6	Pneumonia	12	10.1	Wound, all types	6	6.7
7	Acute gastroenteritis (AGE)	10	8.4	Cellulitis	6	6.7
8	Bronchial Asthma	8	6.7	Bronchitis	6	6.7
9	Vascular Headache	7	5.9	Systemic Viral Infection (SVI)	3	3.3
10	Autoimmune Thrombocytopenia	7	5.9	Anemia	3	3.3
	Total No of Cases	119	100	Total No of Cases	90	100

Source: Placer Ecological Profile, 2009

2.4.4.1.2 Causes of Mortality

Deaths in Placer are caused primarily by various cardio-respiratory illnesses followed by unspecified natural causes, cardiovascular diseases, sepsis and other various respiratory diseases as shown in **Table 2.4-33**. The types of illnesses that cause deaths do not differ much in both years except for the number of cases.

Table 0-27 Leading Causes of Mortality

Rank	Diseases	2008		Diseases	2009	
		No	%		No	%
1	Other various cardio-respiratory diseases	12	19.7	Various lung & respiratory diseases	13	24.5
2	Unspecified Natural Death	9	14.7	Unspecified cause of death	8	15.1
3	Cardiovascular Disease (CVD)	6	6.6	Hypertension	7	28.3
4	Sepsis/Septicemia	6	6.6	Cerebrovascular diseases/accidents	6	11.3
5	Pneumonia	6	6.6	Diabetes Mellitus (DM)	5	9.43
6	Various Respiratory Diseases	6	6.6	Pulmonary Tuberculosis (PTB)	3	5.7

7	Cerebrovascular Accident (CVA)	5	8.19	Cancer, all forms	3	5.7
8	Multiple Organ Failure	5	8.19	Cardiac Arrest	3	5.7
9	Cancer , all forms	3	4.9	Various renal diseases	3	5.7
10	Cachexia	3	4.9	Wounds, all forms	2	3.8
	Total No of Cases	61	100	Total No of Cases	53	100

Source: Placer Ecological Profile, 2009

Use of Health Facilities

Out of 422 respondents in the Baseline Household Survey (2012) in Placer, majority or 90% go to health centre for availment of health services (**Table 2.4-34**). About 48% seek the medical services of the nearest government hospital while most of those who are financially capable go to private clinics or hospitals. During the interview/focus group discussion with Barangay Health Workers, traditional medicine such as the use of *hilot* and herbal medicine are typically first-aid measures resorted to by community members who cannot avail of government health services. They mentioned that they normally resort to herbal medicines first to cure ailments such as coughs, colds and fever. The commonly used herbal plants are *sambong, tawa-tawa, lagundi, oregano,* etc. Patients typically get well in three days under herbal medication otherwise; they go to the nearest government hospital.

Table 0-28 Frequently Accessed Health Facility

Health Facilities	Base	Responses			
		Yes	%	No	%
Health Centre	421	379	90.02	42	9.98
Government Hospital	421	202	47.98	219	52.02
Private Clinics/Hospitals	421	63	14.96	358	85.04
Indigenous/Traditional Health Providers	421	44	10.45	377	89.55

Source: Baseline Studies – Households Survey, 2012

Health Statistics

The population of Placer from 2007 to 2009 increased by 1.5%. There were slight increases in infant, maternal and neonatal deaths. However, there was a 32.5% decrease in death rates of 50 years old and above. **Table 2.4-35** presents the health statistics of Placer municipality from 2007 until 2009.

Table 0-29 Health Statistics (2007-2009)

Health Statistics	2007	2008	2009
Population (estimate)	22,743	22,914	23,085
Total Consultation	1,556	1,927	1,676
Total Number of births	482	401	404
Total number of deaths	122	98	123
Total number of infant deaths, under 12 months	0	5	2
Total number of maternal deaths	0	0	2
Total number of neonatal deaths, 1 to 28 days	0	4	1
Total number of deaths, 50yrs & over	83	68	56
Total number of deaths with Medical attendance	13	22	6
Birth Rate	2.12	1.75	1.75
Death Rate	0.54	0.43	0.53
Infant mortality Rate	0	1.25	0.50

Source: Placer Ecological Profile, 2009

Nutritional Status

About 80% of the total number of pre-schoolers weighed in 2008 has normal nutritional status (**Table 2.4-36**). Though the number of weighed preschoolers decreased the following year, the number of nutritionally normal preschoolers is still large compared to those malnourished. Among those who were undernourished, 1st degree malnutrition is more prevalent in both years than 2nd degree and 3rd degree malnutrition combined.

Table 0-30 Nutritional Status of Pre-schoolers

Nutritional Status[3]	2008		2009	
	Number	%	Number	%
1st Degree	514	17.74	442	15.65
2nd Degree	52	1.79	101	3.57
3rd Degree	1	0.034	13	0.46
Normal	2,331	80.54	2,331	82.51
Overweight	10	0.345	38	1.345

Source: Placer Ecological Profile, 2009

Water Supply Systems

All host barangays have Level III water facility. However, for Macalaya, 122 households are still on Level II type of water connection (49 for Boyongan, 65 for Sta Cruz, 303 for Anislagan, and 50 for San Isidro). **Table 2.4-37** presents the type of water facilities per barangay. However, with regard to access to safe drinking water, Barangay Ellaperal has the most number of households which do not have access to safe drinking water, followed by Barangays Magsaysay, Suyoc, Pananay-an, Lakandula and Sani-Sani. The host barangays Anislagan, Boyongan, San Isidro, Sta Cruz and Macalaya has an average of 10 households which do not have access to safe drinking water.

From the total number of 4,926 households in Placer, 99.80% of these account to the percentage of households with access to safe drinking water.

Table 0-31 Type of Water Facilities by Barangay

Barangay	Total No of Households	Level I		Level II		Level III	
		No of HH	%	No of HH	%	No of HH	%
Ipil	197					197	100
Central	333					333	100
Magsaysay	778			91	11.7	687	88.3
Amoslog	261			261	100		
Tagbongabong	133			133	100		
Panhutongan	108			108	100		
Pananay-an	163			163	100		
Suyoc	105			105	100		
Bugas-bugas	173			51	28.0	122	72.0
Ellaperal	258			258	100		
Badas	453			51	11.25	402	88.75
Mabini	242	10	4.13	165	68.18	67	27.69
Macalaya	181			122	67.4	59	32.6
Boyongan	125			49	39.2	76	60.8
Sta. Cruz	532			65	12.21	467	87.79
Anislagan	343			303	88.3	40	11.67
San Isidro	120			50	41.6	70	58.34
Magupange	101			101	100		
Lakandula	181			181	100		

[3] The total number of children are 3,236 (2008) and 3,009 (2009). Total No of Children weighed <1 year old/OPT Coverage 2,898 (2008) and 2,825 (2009).

Barangay	Total No of Households	Level I		Level II		Level III	
		No of HH	%	No of HH	%	No of HH	%
Sani-sani	139			139	100		
Total	**4,926**	**10**	**0.2**	**2,396**	**48.64**	**2,520**	**51.16**

*Source: Placer Ecological Profile, 2009; *Host Barangays*

Out of 1,220 households in host barangays, 51 households or 1.25% do not have access to safe drinking water. Barangay Sta Cruz has the most number of households that do not have access to safe drinking water.

Table 0-32 Access to Safe Drinking Water, Host Barangays

Host Barangays	Total No of Households	No of HH Without Access	%	No of HH With Access	%
Macalaya	156	9	0.22	147	3.64
Boyongan	93	8	0.20	85	2.10
Sta. Cruz	404	11	0.27	378	9.72
Anislagan	396	9	0.22	387	9.57
San Isidro	82	1	0.02	81	2.00
Total	**1220**	**51**	**1.25**	**1154**	**25.91**

Source: CBMS Survey, 2012

2.4.4.1.3 Host Barangays Health and Sanitation

Causes of Morbidity

Upper Respiratory Tract Infections is the leading causes of morbidity for all affected barangays except for Macalaya which is primarily affected with hypertension. The prevailing morbid diseases common in all barangays are hypertension, punctured wound, pulmonary tuberculosis, urinary tract infection, pneumonia, tooth decay, bronchial asthma, and cardiovascular diseases. The leading causes of morbidity are shown on **Table 2.4-39**.

Table 0-33 Leading Causes of Morbidity

Rank	Anislagan	Boyongan	San Isidro	Sta Cruz	Macalaya
1	Upper Respiratory Tract Infection (URTI)	UTI	URTI	URTI	Hypertension
2	Punctured wound	PTB	Pneumonia	Hypertension	Bronchial Asthma Brain injury sec to VA, COPD (Chronic Obstructive Pulmonary Disease)
3	Hypertension, Pulmonary Tuberculosis (PTB), Tooth Decay	URTI Systemic Viral Infection (SVI)	UTI, Sinusitis, PTB, R/O Breast Tumor	UTI, Punctured & Lacerated Wound	
4	UTI, Otitis Externa, Dermatitis			PTB, Tooth Decay	
5	Pneumonia, Gouty Arthritis			Pneumonia, Celllulitis	

Source: Placer Ecological Profile, 2009

Causes of Mortality

Deaths in the host barangays are mostly caused by various diseases such as different kinds of cardiovascular diseases and respiratory/lung diseases such as pulmonary tuberculosis and bronchial asthma. **Table 2.4-40** presents the top causes of mortality in the host barangays.

Table 0-34 Leading Causes of Mortality

Rank	Anislagan	Boyongan	San Isidro	Sta Cruz	Macalaya
1	Hypertension, Simple febrile seizure, HCVD S/P CVD Thrombosis	DOA Asphyxia secondary to Drowning	Pulmonary tuberculosis CAP Unspecified natural cause of death	Hypertension	Hypertension
2					Bronchial asthma Brain injury sec to VA COPD

Source: Placer Ecological Profile, 2009

Use of Health Facilities

Health issues and complaints are addressed in several health facilities available within or near host barangays. Across barangays, the health centre is the most accessed facility (90%) followed by the government hospital (48%) and then private clinics/hospitals (15%) (**Table 2.4-41**).

Barangay Sta. Cruz has the largest percentage of respondents (93%) who go to health centres followed by Anislagan, and Boyongan. Government hospitals are frequented by individuals mostly again from Boyongan (55%), then from Anislagan (49%) and Sta. Cruz (47%).There are still a number of households who resort to indigenous medicine such as herbal medicine. Majority are from Boyongan at 13%.

Table 0-35 Frequently Accessed Health Facilities

Health Facility	Responses	Barangay					Total
		Anislagan	Boyongan	San Isidro	Sta Cruz	Makalaya	
Health Center	Yes	92	64	53	101	69	379
	%	92.93	90.14	82.81	94.39	86.25	90.02
	No	7	7	11	6	11	42
	%	7.07	9.86	17.19	5.61	13.75	9.98
	Base	**99**	**71**	**64**	**107**	**80**	**421**
Government Hospital	Yes	48	39	29	50	36	202
	%	48.48	54.93	45.31	46.73	45.00	47.98
	No	51	32	35	57	44	219
	%	51.52	45.07	54.69	53.27	55.00	52.02
	Base	**99**	**71**	**64**	**107**	**80**	**421**
Private Clinics/Hospitals	Yes	12	9	13	19	10	63
	%	12.12	12.68	20.31	17.76	12.50	14.96
	No	87	62	51	88	70	358
	%	87.88	87.32	79.69	82.24	87.50	85.04
	Base	**99**	**71**	**64**	**107**	**80**	**421**
Indigenous/Traditional Health Providers	Yes	9	9	8	10	8	44
	%	9.09	12.68	12.50	9.35	10.00	10.45
	No	90	62	56	97	72	377
	%	90.91	87.32	87.50	90.65	90.00	89.55
	Base	**99**	**71**	**64**	**107**	**80**	**421**

Source: Baseline Studies – Household Survey, 2012

Nutritional Status

Based on **Table 2.4-42** only Barangay Macalaya, however small in number, has recorded cases of malnutrition.

Table 0-36 Number of Malnourished Children Aged 0-5 Years Old

Barangay	Total No of Children, 0-5 years old	Households		Population	
		No.	%	No.	%
Anislagan	191	0	0	0	0
Boyongan	49	0	0	0	0
Macalaya	69	4	5.8	4	3.6
San Isidro	47	0	0	0	0
Sta Cruz	210	0	0	0	0
Total	566	4	100	4	100

Source: CBMS Survey

Water Supply Systems

Out of 1,131 households in five impacted barangays, 38 households do not have access to safe water as shown in **Table 2.4-43** The most number of households that do not have access to drinking water is in Barangay Sta Cruz.

Table 0-37 Households without Access to Safe Water

Host Barangays	Total No of Households	No of HH Without Access	%	No of HH With Access	%
Macalaya	156	9	0.80	147	13.00
Boyongan	93	8	0.71	85	7.52
Sta. Cruz	404	11	0.97	378	33.42
Anislagan	396	9	0.80	387	34.22
San Isidro	82	1	0.09	81	7.16
Total	**1,131**	**38**	**3.36**	**1,078**	**95.31**

Source: CBMS Survey

In **Table 2.4-44**, on the other hand, illustrates the type of water facility being used by each host barangays. Across host barangays, Sta. Cruz has the most number of households (27.55%) that use the community water system exclusively. Barangay Macalaya has the most number of households that share their water facility with other households.

Table 0-38 Type of Water Facility Used

Water Source Facility	Barangay										Total	
	Anislagan		Boyongan		San Isidro		Sta Cruz		Macalaya			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Community water system (own use)	89	24.52	61	16.80	56	15.43	100	27.55	57	15.70	363	86.019
Community water system (shared with others)	10	19.23	8	15.38	6	11.54	6	11.54	22	42.31	52	12.322
Deep well (shared with others)	0	0	0	0	1	50	0	0	1	50	2	0.474
Artesian Well (own use)	0	0	0	0	1	100	0	0	0	0	1	0.237
Artesian Well (shared with others)	0	0	0	0	1	100	0	0	0	0	1	0.237
Others, specify	0	0	2	100	0	0	0	0	0	0	2	0.474
No Answer	0	0	0	0	0	0	1	100	0	0	1	0.237
Total	99	100	71	100	65	100	107	100	80	100	422	100.00

Source: Baseline Studies – Household Survey, 2012

Excreta Management

Regarding toilet facilities, 4.24% or 48 households are in need of access to such facility (**Table 2.4-45**). Barangay Anislagan has the most number of households that is in need of toilet facility provisions.

Table 0-39 Access to Toilet Facility

Host Barangays	Total No of Households	No of HH Without Access	%	No of HH With Access	%
Macalaya	156	8	5.13	148	94.87
Boyongan	93	1	1.08	92	98.92
Sta. Cruz	404	15	3.71	389	96.29
Anislagan	396	22	5.56	374	94.44
San Isidro	82	2	2.44	80	97.56
Total	**1,131**	**48**	**4.24**	**1,083**	**95.76**

Source: CBMS Survey

Waste Management

Burning is still the most commonly used waste disposal method among impact barangays despite the prohibition of open burning under Section 48 of the Republic Act 9003: Ecological Solid Waste Management Program.

Although recycling is practiced, only 26 out of 695 respondents in five impact barangays recycle. (**Table 2.4-46**). The segregation of recyclables from the household's daily waste is done to be sold to junk shops or mobile junk collectors or *magbobote.* Although the profits from selling junk are not significant, according to interviews with Barangay Health workers the profits add up to the family's daily budget for food.

Table 0-40 Waste Disposal Methods

Disposal Method	No. Of Respondents	Anislagan		Boyongan		San Isidro		Sta Cruz		Macalaya	
		No.	%	No.	%	No.	%	No.	%	No.	%
Burning	214	52	24.30	37	17.29	34	15.89	31	14.49	60	28.04
Composting	136	35	25.74	26	19.12	23	16.91	31	22.79	21	15.44
Recycling	26	8	30.77	0	0.00	7	26.92	8	30.77	3	11.54
Waste Segregation	48	20	41.67	5	10.42	7	14.58	12	25.00	4	8.33
Thrown Anywhere	31	6	19.35	5	16.13	4	12.90	13	41.94	3	9.68
Compost Pit with Cover	41	12	29.27	8	19.51	4	9.76	13	31.71	4	9.76
Compost Pit without Cover	79	24	30.38	18	22.78	15	18.99	14	17.72	8	10.13
Compost Pit	120	36	30.00	26	21.67	19	15.83	27	22.50	12	10.00
Total	695	193		125		113		149		115	

Source: Baseline Studies – Household Survey, 2012

Majority of the respondents said that animal wastes are composted to be used as fertilizer (**Table 2.4-47**). Across host barangays, Anislagan has the most number of respondents (75%) who say that they turn animal waste to compost. A significant number of respondents (172) however dispose their animal waste in unspecified places, majority of which are from Anislagan as well.

Table 0-41 Animal Waste Disposal Methods

Disposal Method	No of Respondents	Anislagan		Boyongan		San Isidro		Sta Cruz		Macalaya	
	No.	No.	%	No.	%	No.	%	No.	%	No.	%
Septic Tank	102	85	83.33	2	1.96	4	3.92	9	8.82	2	1.96
Collected	151	116	76.82	6	3.97	4	2.65	14	9.27	11	7.28
Composting	233	175	75.11	9	3.86	8	3.43	23	9.87	18	7.73
Unattended	59	40	67.80	10	16.95	1	1.69	6	10.17	2	3.39
Thrown	172	126	73.26	9	5.23	14	8.14	16	9.30	7	4.07

Source: Baseline Studies – Household Survey, 2012

2.4.4.2 Sison Municipality and Host Barangays

2.4.4.2.1 Municipal Health and Sanitation

Table 2.4-48. There is no listed hospital for Sison according to the PPDF-DRREP, however, the municipality has access to nearby public and private hospitals in Placer and Surigao City, a Regional Health Unit and two barangay health stations

The Municipality of Sison has below-minimum number of health and medical facilities however, it is attended by a sufficient number of health professionals and trained personnel as shown in **Table 2.4-48.**

Table 0-42 Health Personnel

Health Personnel	Public	Standard
Doctor	1	1
Dentist	1	1
Nurse	1	1
Midwife	3	2
Dental Aide	1	0
Sanitary Inspector	2	1

Health Personnel	Public	Standard
Barangay Health Workers	83	0
Trained Birth Attendants	5	0

Source: PPDF-DRREP, 2012

Causes of Morbidity

The most common causes of morbidity in the municipality are colds, coughs, and fever which are attributed to unpredictable weather. Other diseases in the morbidity list are kidney diseases, urinary tract infection, pneumonia, asthma, diabetes mellitus, diarrhea, sore eyes, chicken pox, pulmonary tuberculosis and dengue. Morbidity and mortality causes indicated were taken from focus group discussions/interviews with Barangay Health Workers and Barangay Nutrition Scholars.

Causes of Mortality

Cardiovascular diseases such as heart attack, stroke and hypertension are the top causes of deaths in the municipality.

Use of Health Facilities

Among health facilities, a larger percentage of the respondents (96%) in Sison commonly go to health centres for availment of health centres more than government hospitals (36%) (**Table 2.4-49**). There are still a few (12%) who use traditional medicine or who go to private clinics (11%).

Table 0-43 Frequently Accessed Health Facilities

Health Facilities	Base	Responses			
		Yes	%	No	%
Health Centre	256	246	96.09	10	3.91
Government Hospital	256	93	36.33	163	63.67
Private Clinics/Hospitals	256	27	10.55	229	89.45
Indigenous/Traditional Health Providers	256	30	11.72	226	88.28

Source: Baseline Studies – Household Survey, 2012

Nutritional Status

In 2006, 80% of 1,599 weighed preschoolers aged 0-71 months old were assessed to be nutritionally normal while 16.5% were considered Below Normal Low (BNL). The population of weighed preschoolers of the same age group increased in 2009 by 4%. There are more than 90% of nutritionally normal preschoolers in 2009. There is an increase of nutritionally normal preschoolers from 2006 to 2009.

Water Supply Systems

The municipality of Sison has 2,270 households (93.34%) that have access to safe drinking water. However, there are still 58 households (6.66%) that do not have access to safe drinking water. Of all the barangays, Upper Patag (2.38%) has the highest number of households without access to water followed by Mabuhay (1.52%) and San Pablo (1.15%). **Table 2.4-50**.

Table 0-44 Access to Safe Drinking Water

Barangays	Total No of Households	No of HH Without Access	%	No of HH With Access	%
Biyabid	98	1	0.04	97	3.99
Gacepan	74	3	0.12	71	2.92
Ima	80	6	0.25	74	3.04
Lower Patag	191	3	0.12	188	7.73
Mabuhay	382	37	1.52	345	14.19
Mayag	200	7	0.29	193	7.94
Poblacion (San Pedro)	696	6	0.25	690	28.37
San Isidro	128	6	0.25	122	5.02
San Pablo	253	28	1.15	225	9.25
Tagbayani	103	4	0.16	99	4.07
TInogpahan	91	3	0.12	88	3.62
Upper Patag	136	58	2.38	78	3.21
Total	**2,432**	**162**	**6.66**	**2,270**	**93.34**

Source: CBMS Survey

In terms of the type of water system facilities, majority of the households (64.35%) in the municipality have their own community water system and 27% are into shared water systems (**Table 2.4-51**). However, a significant number of households still go to rivers and streams for water. Other households depend on wells, bottled water and water rations.

Table 0-45 Source of Drinking Water

Type of Water Facility	No. of Household	%
Community water system-own	1,565	64.35
Community water system, shared	673	27.67
Deep well – own	9	0.37
Deep well – shared	4	0.17
Artesian well – own	0	0
Artesian well – shared	0	0
Dug/shallow well – own	7	0.29
Dug/shallow well – shared	19	0.78
River, stream, lake, spring	105	4.32
Bottled water	19	0.78
Water Ration	23	0.95
Other	0	0
Unspecified	8	0.33
Total	**2432**	**100**

Source: CBMS Survey

Access to Toilet Facilities

About 7% of the total number of households in the municipality of Sison does not have access to toilets. Barangay Mabuhay has the most number of households that do not have access to sanitation facilities, followed by San Pedro, a host barangay (**Table 2.4-52**).

Table 0-46 Access to Toilet Facilities

Barangays	Total No of Households	No of HH Without Access	%	No of HH With Access	%
Biyabid	98	12	0.49	86	3.54
Gacepan	74	11	0.45	63	2.59
Ima	80	9	0.37	71	2.92
Lower Patag	191	2	0.08	189	7.77
Mabuhay	382	41	1.69	341	14.02
Mayag	200	9	0.37	191	7.85
Poblacion (San Pedro)	696	31	1.27	665	27.34
San Isidro	128	9	0.37	119	4.89
San Pablo	253	7	0.29	246	10.12
Tagbayani	103	9	0.37	94	3.87
TInogpahan	91	18	0.74	73	3.00
Upper Patag	136	14	0.58	122	5.02
Total	**2,432**	**172**	**7.07**	**2,260**	**92.93**

Source: CBMS, 2009

Most of the households in Sison have toilet facilities installed in their homes. Most common toilet facility used is the water-sealed type although some households still use open and close pits and other systems of disposal methods (**Table 2.4-53**).

Table 0-47 Type of Toilet Facilities

Type of Toilet Facilities	No. of Household	%
Water-sealed, sewer/septic tank used exclusively by the household	1,964	80.76
Water-sealed, sewer/septic tank shared with other households	114	4.69
Closed Pit (Antipolo Type)	181	7.44
Open Pit	18	0.74
Others (pail system, etc)	146	6
No toilet	1	0.04

Type of Toilet Facilities	No. of Household	%
Unspecified	8	0.33
Total	**2,432**	**100**

Source: CBMS, 2009

2.4.4.2.2 Barangay Health and Sanitation

Morbidity and Mortality Causes by Host Barangays, Municipality of Sison

The most common causes of morbidity in Barangay Upper Patag, Barangay Lower Patag and San Pedro are colds, coughs, and fever which barangay health workers attribute to the unpredictable weather. They have also identified kidney diseases, urinary tract infection, pneumonia, asthma, diabetes mellitus, diarrhea, sore eyes, chicken pox, pulmonary tuberculosis and dengue as other common diseases occurring in their area. Cardiovascular diseases such as heart attack, stroke and hypertension, on the other hand, are the top causes of deaths in their barangays. These were taken from the focus group discussions and interviews with the Barangay Health Workers.

Use of Health Facilities, Host Barangays

The most commonly used health facility among the host barangays is the health center, followed by the government hospital and indigenous/traditional medicine (12%). Lower Patag has the most number of individuals who go to health centres to attend to their health concerns followed by Upper Patag. In terms of access to government hospitals, San Pedro has 41% of its respondents availing of this facility's services. Barangay San Pedro has the largest percentage of respondents (40%) who resort to indigenous or traditional medicine to cure their illnesses. (**Table 2.4-54**).

Table 0-48 Frequently Accessed Health Facilities, Host Barangays, Sison

Health Facility	Base	Lower Patag		Upper Patag		San Pedro	
		No	%	No	%	No	%
Health Centre	219	77	35.16	68	31.05	74	33.79
Government Hospital	93	30	32.26	25	26.88	38	40.86
Private Clinic/Hospital	27	8	29.63	9	33.33	10	37.04
Indigenous/Traditional Medicine	30	9	30.00	9	30.00	12	40.00
Total		**124**	**100**	**111**	**100**	**134**	**100**

Source: Baseline Studies – Household Survey, 2012

Nutritional Status, Host Barangays

At a per barangay level, Barangay San Pedro, which has the highest number of weighed preschoolers aged 0-5 years old, also has the highest number of preschoolers assessed to be normal in terms of nutritional status, while Barangay Lower Patag comes in next (**Table 2.4-55**). Among the three barangays, it has also the lowest percentage of below-normal, both moderate and severe, nutritional status. However, it has recorded 2 cases of above normal preschoolers while the other barangays do not.

Table 0-49 Nutrition Status by Sex by Host Barangays, Municipality of Sison

Barangay	Total	Nutritional Status							
		Above Normal		Normal		Below Normal, moderate		Below Normal, severe	
		No	%	No	%	No	%	No	%
Lower Patag	106	0	0	98	92.4	8	7.6	0	0
Upper Patag	107	0	0	95	89	7	7	5	4.7
San Pedro	415	2	0.48	407	98	6	1.45	0	0

Source: CBMS, 2009

Water Supply System, Host Barangays

About 6% of the total households in four host barangays of Sison do not have access to safe drinking water, wherein 5% of which is mostly in Barangay Upper Patag (**Table 2.4-56**).

Table 0-50 Access to Safe Drinking Water in Host Barangays, Sison

Barangays	Total No of Households	No of HH Without Access	%	No of HH With Access	%
Lower Patag	191	3	0.26	188	16.33
Poblacion (San Pedro)	696	6	0.52	690	59.95
San Isidro	128	6	0.52	122	10.60
Upper Patag	136	58	5.04	78	6.78
Total	**1,151**	**73**	**6.34**	**2,270**	**93.66**

Among the three impact barangays, San Pedro has the highest percentage of households who make use of the community water system that is owned (88%). Upper Patag however has the highest percentage of households who access the community water system that is shared, in comparison with the other two barangays. However, only barangay Upper Patag still make use of deep and shallow wells. A significant number of households (42%) from this barangay also resort to rivers, streams and springs for their source of water (**Table 2.4-57**).

Table 0-51 Source of Drinking Water among Host Barangays, Municipality of Sison

Type of Water Facility	Lower Patag		Upper Patag		San Pedro	
	No	%	No	%	No	%
Community water system – own	153	80.10	38	27.94	616	88.5
Community water system – shared	35	18.32	39	28.68	74	10.6
Deep well – shared	0	0	1	0.74	0	0
Dug/shallow well – own	0	0	1	0.74	0	0
River, stream, lake, spring	0	0	57	41.91	1	0.14
Bottled water	0	0	0	0	0	0
Tanker truck/peddler	1	0.52	0	0	5	0.72
Unspecified	2	1.05	0	0	0	0
Total	**191**	**100**	**136**	**100**	**696**	**100**

Source: CBMS, 2009

Access to Toilet Facilities, Host Barangays

About 5% out of 1,151 households in the four impact barangays of Sison do not have access to sanitation facilities. Barangay Poblacion or San Pedro has the most number at 31 households among households that do not have toilets (**Table 2.4-58**).

Table 0-52 Access to Toilet Facilities in Host Barangays, Sison

Barangays	Total No of Households	No of HH Without Access	%	No of HH With Access	%
Lower Patag	191	2	0.17	189	16.42
Poblacion (San Pedro)	696	31	2.69	665	57.78
San Isidro	128	9	0.78	119	10.34
Upper Patag	136	14	1.22	122	10.60
Total	**1,151**	**56**	**4.87**	**1,095**	**95.13**

Source: CBMS, 2009

Majority of the households have access to water-sealed toilets that are privately-owned. However 10% of the total households in Upper Patag and four percent in San Pedro still use the pail system for human excreta disposal. A household in Lower Patag use open pit and two households in Upper Patag use closed pit as their toilet facility (**Table 2.4-59**).

Table 0-53 Sanitation Facilities among Household Population in Host Barangays, Sison

Type of Toilet Facilities	Lower Patag		Upper Patag		San Pedro	
	No	%	No	%	No	%
Water-sealed, sewer/septic tank used exclusively by the household	188	98.43	119	87.5	652	93.4
Water-sealed, sewer/septic tank shared with other households	0	0	1	0.74	13	1.87
Closed Pit (Antipolo Type)	0	0	2	1.47	0	0
Open Pit	1	0.52	0	0	0	0
Others (pail system, etc)	0	0	14	10.29	30	4.31
No toilet	0	0	0	0	1	0.14
Unspecified	2	1.05	0	0	0	0
Total	**191**	**100**	**136**	**100**	**696**	**100**

Source: CBMS, 2009

Waste Management, Host Barangays

All host barangays in the municipality of Sison practice waste segregation. They have trash bins labelled as *malata* (biodegradable), *di malata* (non-biodegradable) and recyclables. Burning is still the most common waste management method despite the ban under Section 48 of the Republic Act 9003: Ecological Solid Waste Management Program. Composting and recycling came in 2nd and 3rd respectively, as their other methods for waste disposal (**Table 2.4-60**).

Table 0-54 Waste Management in Host Barangays, Sison

Waste Management	No. Of Respondents	Lower Patag		Upper Patag		San Pedro	
		No	%	No	%	No	%
Burning	123	50	40.65	47	38.21	26	21.14
Composting	73	30	41.10	27	24.00	16	22.00
Recycling	24	7	29.17	6	25.00	11	45.83
Waste Segregation	23	8	34.78	5	21.74	10	43.48
Thrown Anywhere	20	10	50.00	7	35.00	3	15.00
Compost Pit with Cover	7	1	14.29	5	71.43	1	14.29
Compost Pit with Cover	34	14	41.18	14	41.18	6	17.65
Total	**304**	**120**		**111**		**73**	

Source: Baseline Studies – Household Survey, 2012

Animal wastes are mainly collected in San Pedro to be turned into and used as fertilizer. This type of waste is also collected and composted. In Lower Patag, animal wastes are mainly thrown away or composted. Majority of the animal wastes in Lower Patag are composted and some are thrown in septic tanks (**Table 2.4-61**).

Table 0-55 Animal Waste Management by Host Barangays, Sison

Waste Management	No of Respondents	Lower Patag		Upper Patag		San Pedro	
		No	%	No	%	No	%
Septic Tank	36	12	33.33	8	22.22	16	44.44
Collected	35	9	25.71	5	14.29	21	60.00
Composting	42	13	30.95	13	30.95	16	38.10
Unattended	9	7	77.78	2	22.22	0	0.00
Thrown	29	7	24.14	14	48.28	8	27.59
Total	**151**	**48**		**42**		**61**	

Source: Baseline Studies – Household Survey, 2012

2.4.4.3 Tagana-an Municipality and Host Barangays

2.4.4.3.1 Municipal Health and Sanitation

The municipality of Tagana-an has a household population of 14,199[4] distributed into 14 barangays. These are being served by the main health centre which is manned by a municipal health officer, a public health nurse, a medical technologist, five rural midwives, and two sanitary inspectors (**Table 2.4-62**). The other three health units serve various other barangays such as Cawilan, Patiño, Talavera, Opong, Himamaug, Banban, Upper Libas, Lower Libas, Union and Laurel.

Table 0-56 Health Personnel, Municipality of Tagana-an

Health Personnel	Public	Standard[5]
Municipal Health Officer	1	
Doctor		1
Dentist		1
Nurse	1	1
Midwife	5	3
Medical Technologist	1	
Sanitary Inspector	2	1

Source: PPDF-DRREP, 2008

[4] 2007 Census
[5] DOH Standard Ratio of Manpower to Population: Rural Health Physician = 1:20,000, Public Health Nurse = 1:20,000, Rural Health Midwife = 1:5,000, Rural Health Inspector = 1:20,000, Rural Health Dentist = 1:50,000.

Causes of Morbidity

There were no illnesses in 2002 specified that caused more than 5,000 general medical consultations and 215 hospitalization cases in the municipality of Tagana-an.

Causes of Mortality

Most of the causes of deaths in the municipality are caused by pneumonia and multiple organ failure. All forms of cancer and cardiovascular diseases also follow. Despite free medicines provided by the government, there are still a number of tuberculosis cases in some parts of Tagana-an (**Table 2.4-63**).

Table 0-57 Leading Causes of Mortality, Municipality of Tagana-an

Diseases	No	%
Pneumonia	11	19
Multiple organ failure	11	19
Cancer	8	14
Cardiovascular Disease	8	14
Tuberculosis	5	8.7
Dehydration	4	7
Wound	3	5
Kidney Failure	3	5
Diabetes	2	3.5
Accident	2	3.5
Total	57	100

Source: Tagana-an MCLUP, 2004-2013

Use of Health Facilities

Health centres are the most frequented health facility at 84% among other health facilities in Tagana-an (**Table 2.4-64**). The second most accessed facility is the government hospital at 41%. Private clinics/hospitals are more prominent in terms of accessibility or use (24%) than traditional medicine (10%).

Table 0-58 Frequently Accessed Health Facility, Municipality of Tagana-an

Health Facilities	Base	Responses			
		Yes	%	No	%
Health Centre	63	53	84.13	10	18.87
Government Hospital	63	26	41.27	37	58.73
Private Clinics/Hospitals	63	15	23.81	48	76.19
Indigenous/Traditional Health Providers	63	6	9.52	57	90.48

Source: Baseline Studies – Household Survey, 2012

Nutritional Status by Barangay

Out of 1,505 pre-schoolers aged 0-5 years old, 39% or 581 pre-schoolers are categorized as malnourished in various degrees (**Table 2.4-65**).

Table 0-59 Nutritional Status of Pre-schoolers by Barangay, Municipality of Tagana-an

Barangay	Number and Percent of Malnourished Children							
	1st Degree		2nd Degree		3rd Degree		Total	
	No.	%	No.	%	No.	%	No.	%
Aurora	35	1.98	10	0.57			45	2.54
Azucena	52	3.27	12	0.76			64	4.03
Banban	50	6.79	10	1.36			60	8.15
Cawilan	32	3.40	8	0.85			40	4.25
Fabio	15	3.90	3	0.78			18	4.68
Himamaug	31	2.39	17	1.31	2	0.15	50	3.85
Laurel	26	5.95	3	0.69			29	6.64
Lower Libas	40	4.51	11	1.24	2	0.23	53	5.98
Opong	49	5.25	11	1.18	1	0.11	61	6.53
Patiño	34	4.75	13	1.82	2	0.28	49	6.84
Sampaguita	20	2.26	2	0.23			22	2.48
Talavera	43	2.37	17	0.94	1	0.06	61	3.37
Union	5	1.35	2	0.54	2	0.54	9	2.43
Upper Libas	18	7.41	2	0.82			20	8.23
Total	**450**	**3.46**	**121**	**0.93**	**10**	**0.07**	**581**	**4.46**

Source: Tagana-an MCLUP, 2004-2013

Waste Management System

The most common methods of waste disposal in the municipality are dumping in individual open pits, which are practiced by about 40% of the total households (**Table 2.4-66**). About 33% have their wastes picked up by garbage trucks and the rest at 27% burn their wastes. There are no records in Tagana-an on waste segregation whether at source or the dump site, and composting.

Table 0-60 Waste Management System, Municipality of Tagana-an

Waste Management	No. of Households	%
Picked up by service garbage trucks/carts	839	32.7
Dumping in individual open pit	1,023	39.9
Burning	698	27.2
Total	**2,560**	**100**

Source: Tagana-an MCLUP, 2002

Access to Toilet Facilities

All households in Tagana-an make use of the water-sealed type of toilet. About 71% have their exclusive toilets while about 2% share the facility with other households (**Table 2.4-67**).

Table 0-61 Households with Toilet Facilities, Municipality of Tagana-an

Type of Toilet Facilities	No. of Household	%
Water-sealed, sewer/septic tank used exclusively by the household	1,820	71.09
Water-sealed, sewer/septic tank shared with other households	10	0.39
Water-sealed, other depository shared with other households	40	1.56
None	690	26.95

Source: Tagana-an MCLUP, 2002

2.4.4.3.2 Barangay Health and Sanitation

Morbidity and Mortality Causes, Barangay Upper Libas

Through the Municipal Health Data, as confirmed by the Barangay Health Workers through focus group discussions and interviews, the most common illnesses in barangay Upper Libas are cough, colds and fever which are ascribed to fickle weather, pulmonary tuberculosis, skin diseases that are fungal in nature, and ulcer. Deaths in the barangay were mainly of natural causes, i.e. senility or old age.

Use of Health Facilities, Barangay Upper Libas

Among different types of health facilities, the health centre is the most primarily accessed health facility by respondents in Upper Libas (53%) (**Table 2.4-68**). The government hospital ranks second at 26% and private clinics/hospitals is third at 15%. There are still a number of households (6%) who rely on indigenous medicine in curing their simple ailments.

Table 0-62 Frequently Accessed Health Facilities, Barangay Upper Libas, Tagana-an

Health Facility	No of Respondents	Upper Libas			
		Yes	%	No	%
Health Center	63	53	84.13	10	15.87
Government Hospital	63	26	41.27	37	58.73
Private Clinics/Hospitals	63	15	23.81	48	76.19
Indigenous/Traditional Health Providers	63	6	9.52	57	90.48

Source: Baseline Studies – Household Survey, 2012

Nutritional Status, Barangay Upper Libas

In 2002, the Municipality of Tagana-an has recorded 18 cases (1.2%) of 1st degree malnutrition and 2 (0.13%) cases of 2nd malnutrition from 1,505 preschoolers aged 0-5 years old.

Access to Safe Drinking Water, Barangay Upper Libas

Majority of the households or 60% in Barangay Upper Libas have their own faucets and about 27% share them with other households (**Table 2.4-69**).

Table 0-63 Access to Safe Drinking Water in Barangay Upper Libas, Tagana-an

Water Source Facility	No.	%
Community water system (own use)	38	60.3
Community water system (shared with others)	17	26.98
Deep Well (own use)	3	4.76
Deep well (shared with others)	0	0
Artesian Well (own use)	0	0
Artesian Well (shared with others)	0	0
Others, specify	4	6.35
No Answer	1	1.59
Total	**63**	**100**

Source: Baseline Studies – Household Survey, 2012

Access to toilet facilities, Barangay Upper Libas

Most of the respondents in Upper Libas (87%) have their own water-sealed toilet while 3.2% share flush toilets with others. There are still those, however, who use close pits to dispose off their human excreta while 1 household does not have a toilet facility (**Table 2.4-70**).

Table 0-64 Sanitation Facilities of Barangay Upper Libas, Municipality of Tagana-an

Facility	No.	%
Flush/water-sealed toilet – owned	55	87
Flush/water-sealed toilet-shared	2	3.2
Compose pit	5	8
No Toilet/Open field	1	1.5
Total	**63**	**100**

Source: Barangay Development Plan

Waste Management, Barangay Upper Libas

From the 100 total number of respondents for Upper Libas, 40% practice burning as their most common method of waste disposal while 22% practice composting and 19% throw their wastes in uncovered compost pits (**Table 2.4-71**).

Table 0-65 Waste Management in Barangay Upper Libas, Tagana-an

Method of Disposal	No of Respondents	%
Burning	40	40
Composting	22	22
Recycling	5	5
Waste Segregation	4	4
Thrown Anywhere	3	3
Compost Pit with Cover	7	7
Compost Pit without Cover	19	19
Total	**100**	**100**

Source: Baseline Studies – Household Survey, 2012

Animal wastes are commonly composted (22%) by community members to make fertilizers. Some are thrown in septic tanks (20.5%) or thrown in unspecified places (15%) (**Table 2.4-72**).

Table 0-66 Animal Waste Disposal Methods in Barangay Upper Libas, Tagana-an

Method of Disposal	No. Of Respondents	%
Septic tank	8	20.5
Collected	2	5
Composting	22	56.4
Unattended	1	2.6
Thrown	6	15.4
Total	**39**	**100**

Source: Baseline Studies – Household Survey, 2012

2.4.4.4 Tubod Municipality and Host Barangays

2.4.4.4.1 Municipal Health and Sanitation

As shown in **Table 2.4-73**, the municipality of Tubod has a rural health unit, a barangay health station, a birthing home and two private medical clinics which are owned and manned by the mining companies to support the medical services of the Rural Health Unit. These facilities cater to a population of more than 11,000.[6]

Table 0-67 Health Facilities, Municipality of Tubod

Health Facilities	Number
Public	
Rural health unit	1
Barangay Health Station	1
Birthing Home	1
Private	
Medical clinics	2

Source: Ecological Profile, 2011

The aforementioned health facilities have a public doctor and two from the mining companies such as SMMCI and Greenstone Mining Company. Other health personnel included in the health work force are a dentist, nurse, a medical technologist, a sanitary inspector, a DOH representative and three midwives (**Table 2.4-74**). There are a number of barangay health workers and barangay nutrition scholars however the exact and current number was not in record.

Table 0-68 Health Personnel, Municipality of Tubod

Health Personnel	Public	Private	Standard[7]
Doctor	1	2	1
Dentist	1	0	1
Nurse	1	1	1
Midwife	3	0	2
Medical Technologist	1	0	0
Sanitary Inspector	1	0	1
DOH Representative	1	0	0

Source: Ecological Profile, 2011

Causes of Morbidity

From 2008-2010, the number one cause of morbidity was acute respiratory infection (**Table 2.4-75**). This is followed by unspecified types of injuries, influenza and various kinds of skin diseases. Urinary tract infection, peptic ulcer and hypertension were also prevalent in those three years at different number of cases and rates.

Table 0-69 Leading Causes of Morbidity, Municipality of Tubod

Rank	2008			2009			2010		
	Diseases	No	%	Diseases	No	%	Diseases	No	%
1	Acute Respiratory Infections	2,175	58.69	Acute Respiratory Infections	1,939	56.02	Acute Respiratory Infections	2,611	60.89
2	Influenza	386	10.42	Injuries	486	14.04	Influenza	372	8.67
3	Skin Diseases	280	9.10	Skin Diseases	285	8.23	Injuries	342	7.97
4	Injuries	271	7.31	Influenza	305	8.81	Skin Diseases	252	5.88
5	Parasitism	133	3.59	Urinary Tract Infection	185	5.35	Urinary Tract Infection	184	4.29
6	Urinary Tract Infection	131	3.53	Peptic Ulcer Disease	88	2.54	Hypertension	156	3.64

[6] 2007 Census

[7] DOH Standard Ratio of Manpower to Population: Rural Health Physician = 1:20,000; Public Health Nurse = 1:20,000; Rural Health Midwife = 1:5,000; Rural Health Inspector = 1:20,000; Rural Health Dentist = 1:50,000

Rank	2008			2009			2010		
	Diseases	No	%	Diseases	No	%	Diseases	No	%
7	Hypertension	96	2.59	Hypertension	54	1.56	Peptic Ulcer Disease	153	3.57
8	Peptic Ulcer Diseases	79	2.13	Peripheral Neuropathy	52	1.50	Anemia	79	1.84
9	Peripheral Neuropathy	78	2.10	Pulmonary TB	38	1.10	Acute Gastroenteritis	75	1.75
10	Anemia	77	2.08	Diarrhea	29	0.84	Schistosomiasis	64	1.49
Total		**3,706**	**100**		**3,461**	**100**		**4,288**	**100**

Source: Ecological Profile, 2011

Causes of Mortality

Deaths in the municipality were mainly caused by non-communicable diseases such as various types of cardiovascular diseases. These diseases were consistently in the top spot from 2008 to 1010 (**Table 2.4-76**). Other diseases related to cardiovascular diseases which are coronary artery disease and congestive heart failure were also among that caused deaths in the municipality. All forms of cancer, diabetes mellitus, and gunshot and stab wounds are also among the non-communicable illnesses in the list. Communicable diseases prevalent in these three years are pneumonia, septicaemia, and pulmonary tuberculosis.

Table 0-70 Leading Causes of Mortality, Municipality of Tubod

Rank	2008			2009			2010		
	Diseases	No	%	Diseases	No	%	Diseases	No	%
1	Cardiovascular Diseases	10	22.22	Cerebrovascular Accident	20	27.03	Cerebrovascular Diseases	10	20
2	Cancer, all forms	6	13.33	Congestive Heart Failure	12	16.22	Coronary Artery Disease	10	20
3	Penumonia	6	13.33	Cancer, all forms	11	14.86	Septicemia	6	12
4	Diabetes Mellitus	5	11.11	Renal Failure	8	10.81	Diabetes Mellitus	5	10
5	Septicemia	5	11.11	Pulmonary TB	5	6.76	Cancer, all forms	4	8
6	Pulmonary TB	4	8.88	Pneumonia	5	6.76	Pulmonary Tuberculosis	4	8
7	Accidents	3	6.66	Septicemia	5	6.76	Pneumonia	3	6
8	Schistosomiasi s	2	4.44	Stab Wound/Gunshot Wound	4	5.405	Stab Wound	3	6
9	Liver Cirrhosis	2	4.44	Diabetes Mellitus	2	2.702	Bleeding Peptic Ulcer	3	6
10	Bleeding Peptic Ulcer	2	4.44	Schistosomiasis	2	2.702	Vehicular Accident	2	4
Total		**45**			**74**	**100**		**50**	

Source: Ecological Profile, 2011

Use of Health Facilities

In terms of access to health facilities, respondents from the municipality mostly refer to the health centre as their most immediate and accessible health facility (91%). However, 41% go to government hospitals and 18% in indigenous of traditional health providers. Only 11% go to private clinics or hospitals (**Table 2.4-77**).

Table 0-71 Frequently Accessed Health Facilities, Municipality of Tubod

Health Facilities	Base	Responses			
		Yes	%	No	%
Health Centre	176	161	91.48	15	8.52
Government Hospital	176	73	41.48	103	58.52
Private Clinics/Hospitals	176	20	11.36	156	88.64
Indigenous/Traditional Health Providers	176	31	17.61	145	82.39

Source: Baseline Studies – Household Survey, 2012

Nutritional Status of Preschool Children

The municipality has recorded an average of 1,580 preschoolers aged 0-5 years old from 2008 to 2010. In 2008, the actual OPT (Operation Timbang) coverage was 83% and 100% in 2010. However, the OPT coverage in 2009 exceeded at 110%.
There was a dramatic decrease of about 21% of the percentage of preschoolers who are nutritionally assessed to be normal from 2008 to 2009. However, it went back up to about 22% in 2010. The percentage rate of malnutrition at varying degrees was also erratic. Those categorized to be underweight – Low increased to almost 8% in 2010, a 50% increase from 2009. Severely underweight – Very Low malnutrition was highest in 2008 but has decreased greatly to 0.8% in 2010 as well as the rate of overweight preschoolers. **Table 2.4-78** presents the nutritional status of preschool children.

Table 0-72 Nutritional Status of Preschool Children, Municipality of Tubod

Nutritional Status[8]	2008			2009			2010		
	Actual	Male	Female	Actual	Male	Female	Actual	Male	Female
Normal	1,156	605	550	1,506	798	708	1,426	721	705
%, normal	87.91%	88.84%	86.75%	69.27%	84.89%	86.66%	88.96%	89.23%	91.44%
Underweight, Low	87	41	46	230	134	96	127	71	56
%, underweight, low	6.62%	6.02%	7.25%	4.21%	14.25%	11.75%	7.91%	8.79%	7.26%
Severely Underweight, very low	64	30	35	13	4	9	13	7	6
%, severely underweight, very low	4.87%	4.41%	5.52%	1.37%	0.42%	1.101%	0.8%	0.86%	0.78%
Overweight	8	4	4	8	4	4	13	9	4
%, overweight	0.61%	4.41%	5.52%	0.91%	0.42%	0.49%	0.8%	1.11%	0.52%

Source: Ecological Profile, 2011

Access to Toilet Facilities

The municipality had recorded 220 or 8.2% of the total number of households which do not have access to a toilet facility. Barangay Motorpool has the highest number of households which do not have access to sanitation facilities (**Table 2.4-79**).

Table 0-73 Access to Toilet Facilities, Municipality of Tubod

Barangays	Total No of Households	No of HH Without Access	%	No of HH With Access	%
Capayahan	202	22	0.82	180	6.73
Cawilan	306	36	1.35	270	10.10
Del Rosario	251	7	0.26	244	9.13
Marga	279	20	0.75	259	9.69
Motorpool	350	53	1.98	297	11.11
Poblacion	336	15	0.56	321	12.01
San Isidro	260	20	0.75	240	8.98
Timamana	418	20	0.75	398	14.89
San Pablo	271	27	1.01	244	9.13
Total	**2,673**	**220**	**8.23**	**2,453**	**91.77**

Source: CBMS Survey

In terms of the type of toilet facility, the most common is the water-sealed type and 70% of the total number of households in Tubod use this exclusively (**Table 2.4-80**). However, there are still 17.5% households that use closed pit types more than those that share water-sealed toilets (4.5%).

Table 0-74 Types Toilet Facilities, Municipality of Tubod

Toilet Facility	No. Of Households	Percent
Water-sealed, sewer/septic tank - Used exclusively	1,867	70
Water-sealed, sewer/septic tank - Shared	120	4.5
Closed pit	466	17.5
Open pit	47	1.8
No toilet	166	6.2

[8] Total No. Of Children, 0-5 years old 1,583 (2008-2010). Total No. Of Children Weighed, 0-5 years old: Actual 1,315 (2008), 1, 583 (2009) and 1,579 (2010).

Toilet Facility	No. Of Households	Percent
Others	1	0.003
Total	**2,667**	**100**

Source: Ecological Profile, 2011

Water Supply Systems

All households in barangay Cawilan have access to safe drinking water, among all other barangays in Tubod. Barangay Motorpool, however, has 12 households followed by Barangay Marga which has 9 households which do not have access to safe drinking water (**Table 2.4-81**).

Table 0-75 Access to Safe Drinking Water, Municipality of Tubod

Barangays	Total No of Households	No of HH Without Access	%	No of HH With Access	%
Capayahan	202	2	0.07	200	7.48
Cawilan	306	0	0.00	306	11.45
Del Rosario	251	1	0.04	250	9.35
Marga	279	9	0.34	270	10.10
Motorpool	350	12	0.45	338	12.64
Poblacion	336	3	0.11	333	12.46
San Isidro	260	2	0.07	258	9.65
Timamana	418	3	0.11	415	15.53
San Pablo	271	4	0.15	267	9.99
Total	**2,673**	**36**	**1.35**	**2,637**	**98.65**

Source: CBMS Survey

Majority of the households in Tubod have their own faucets (90%) while about 5% share it with other households (**Table 2.4-82**).

Table 0-76 Source of Drinking Water, Municipality of Tubod

Water Source Facility	No	%
Community water system (own use)	161	90.45
Community water system (shared with others)	9	5.06
Deep Well (own use)	0	0
Deep well (shared with others)	1	0.56
Artesian Well (own use)	0	0
Artesian Well (shared with others)	0	0
Others, specify	3	1.68
No Answer	4	2.25
Total	**178**	**100**

Source: Ecological Profile, 2011

Waste Management

The local government unit of Tubod had conducted several activities supporting the implementation of the Ecological Solid Waste Management (ESWM) of the municipality. They have conducted an orientation as well as seminar and planning workshop for the implementation of the program. The municipality had designated Barangay Timamana as the pilot barangay in the implementation of the said program. They are envisioning the other barangays to follow with the practice.

With regard to the solid waste management program, the municipality has a Material Recovery Facility (MRF) in barangays Marga and Timamana. This facility collects biodegradable and non-biodegradable materials. Biodegradable materials will be used in fertilizer production.

The municipality has a dump truck for garbage collection and also has 314 City/Municipal garbage collectors, 17 barangay garbage collectors, and 277 private garbage collectors. At present, the municipality is in the process of acquiring a large area of land to contain non-biodegradable materials and an Eco Park.

Burning is the most common method of garbage disposal in Tubod (49.4%) followed by dumping in individual pit and burying at 16.4% each (**Table 2.4-83**).

Table 0-77 Manner of Garbage Disposal, Municipality of Tubod

Waste Management	No. Of Households	Percent
Picked-up by Garbage Truck	314	7.9
Dumping in individual pit (not burned)	652	16.4
Burning	1960	49.4
Composting (later used as fertilizer)	245	6.2
Burying	651	16.4
Feeding to Animals	71	1.8
Others	71	1.8
Total	**3,964**	**100**

Source: Ecological Profile, 2011

The conducted household survey in host barangays reveals that a larger percentage (58%) in San Isidro resorts to burning as their method of waste management. (**Table 2.4-84**). San Isidro practices recycling and composting more than Timamana. However, the larger population that thrown their wastes anywhere is also from San Isidro. The next most commonly used methods of waste disposal are waste segregation and composting.

Table 0-78 Manner of Garbage Disposal in Host Barangays, Tubod

Waste Disposal Methods	No. Of Respondents	San Isidro		Timamana	
		No	%	No	%
Burning	59	34	57.63	25	42.37
Composting	36	23	63.89	13	36.11
Recycling	10	7	70.00	3	30.00
Waste segregation	20	7	35.00	13	65.00
Thrown anywhere	7	4	57.14	3	42.86
Compost pit	29	19	65.52	10	34.48
Total	**161**	**94**		**67**	

Source: Baseline Studies – Household Survey, 2012

Animal wastes in Barangay San Isidro are mostly collected. In barangay Timamana, animal wastes are either collected or thrown anywhere (**Table 2.4-85**).

Table 0-79 Manner of Animal Waste Disposal in Host Barangays, Tubod

Waste Disposal Methods	San Isidro		Timamana	
	No	%	No	%
Septic Tank	9	17.31	9	14.75
Collected	15	28.8	18	29.51
Composted	13	25	14	22.95
Unattended	1	1.92	2	3.28
Thrown	14	26.9	18	29.51
Total	**52**	**100**	**61**	**100**

Source: Baseline Studies – Household Survey, 2012

2.4.4.4.2 Barangay Health and Sanitation

Causes of Morbidity

Of the total number of disease cases recorded for 2011, acute respiratory infection accounted for about 58% of the most common disease acquired by residents of Timamana. This communicable disease is followed by urinary tract infections (8%), injuries (7%), and influenza and skin diseases (6.85%). Acute respiratory infection is also the leading cause of morbidity in San Isidro (63%) followed by influenza (8.9%) and Urinary Tract Infection (5.3%). **Table 2.4-86** presents the leading causes of morbidity in barangays Timamana and San Isidro.

Table 0-80 Leading Causes of Morbidity in Host Barangays, Tubod

Illnesses	Timamana		Illnesses	San Isidro	
	No of Cases	%		No of Cases	%
Acute Respiratory Infection	295	57.73	Acute Respiratory Infection	284	63.1
Urinary Tract Infection	43	8.41	Influenza	40	8.9
Injuries, all kinds	38	7.44	Urinary Tract Infection	24	5.3
Influenza	35	6.85	Injuries	21	4.7
Skin Diseases	35	6.85	Skin Diseases	18	4
Anemia	27	5.28	Anemia	16	3.5
Arthritis	14	2.74	Periodontitis	14	3.1
Periodontitis	9	1.76	Arthritis	13	2.9
Acute cystitis	8	1.56	Hypertension	10	2.2

Illnesses	Timamana		Illnesses	San Isidro	
	No of Cases	%		No of Cases	%
Peptic ulcer	7	1.37	Acute Gastroenteritis	10	2.2
Total	**511**	**100**	Total	**450**	**100**

Source: Barangay Health Worker Records, 2011

Causes of Mortality

Deaths in Barangay Timamana have been caused by illnesses particularly epilepsy, pulmonary tuberculosis, pneumonia, cachexia, heart failure and colon cancer. In San Isidro, five illnesses such as pneumonia, hypertension, and renal failure have caused deaths (**Table 2.4-87**).

Table 0-81 Leading Causes of Mortality

Rank	Illnesses	Timamana		Illnesses	San Isidro	
		No of Cases	%		No of Cases	%
1	Epilepsy	1	16.7	Pneumonia	2	40
2	Pulmonary Tuberculosis	1	16.7	Pneumothorax	1	20
3	Pneumonia	1	16.7	Hypertension	1	20
4	Cachexia	1	16.7	Renal failure	1	20
5	Heart Failure	1	16.7			
6	Colon Cancer	1	16.7			
	Total	**6**	**100**	**Total**	**5**	**100**

Source: Baseline Studies – Household Survey, 2012

Access to Health Facilities in Host Barangays

As shown in **Table 2.4-88,** majority (56%) of the residents in barangays San Isidro and Timamana go to health centres as primary health facility followed by government hospital.

Table 0-82 Frequently Accessed Health Facility in Host Barangays, Tubod

Health Facility	San Isidro		Timamana		Total	
	No	%	No	%	No	%
Health Centre	74	56.77	89	56.64	163	56.69
Government Hospital	31	23.85	42	26.75	73	25
Private Clinic/Hospital	12	9.23	8	5.09	20	6.97
Indigenous/Traditional Medicine	13	10	18	11.46	31	10.8
Total	**130**	**100**	**157**	**100**	**287**	**100**

Source: Baseline Studies – Household Survey, 2012

Nutritional Status

Of the 160 preschoolers aged 0-5 years old in San Isidro, 6.25% or 10 were assessed to be malnourished. Timamana has 3% of 209 preschoolers considered to be malnourished (**Table 2.4-89**).

Table 0-83 Nutritional Status of Preschoolers in Host Barangays, Tubod

Barangay	Total No of Preschoolers, Aged 0-5 years old	Total No of Malnourished Children, Aged 0-5 years old	%
San Isidro	160	10	6.25
Timamana	209	7	2.87

Source: CBMS Survey

Access to Sanitation Facilities

In terms of access to sanitation facilities, Barangays San Isidro and Timamana have the same number of households (20) that do not have access to such facilities (**Table 2.4-90**).

Table 0-84 Access to Toilet Facilities among Households in Host Barangays, Tubod

Barangays	Total No of Households	No of HH Without Access	%	No of HH With Access	%
San Isidro	260	20	2.95	240	35.40
Timamana	418	20	2.95	398	58.70
Total	**678**	**40**	**5.90**	**638**	**94.10**

Source: CBMS Survey

Among households that have sanitation facilities, the most common facility installed in both host barangays is the flush or water-sealed toilet. About 86% households in San Isidro and 85% in Timamana have their own flush toilets (**Table 2.4-91**). However, there are still 19 households in both barangays that use closed pit as their facility in disposing their human wastes.

Table 0-85 Access to Sanitation Facilities among Household Population of Host Barangays, Tubod

Toilet Facility	Barangay				Total	
	San Isidro		Timamana			
	No	%	No	%	No	%
Flush/Water-sealed toilet (owned)	69	86.25	83	84.69	152	85.39
Flush/Water-sealed toilet (shared)	1	1.25	2	2.04	3	1.68
Closed Pit	9	11.25	10	10.20	19	10.67
No Answer	1	1.25	3	3.06	4	2.25
Total	**80**	**100**	**98**	**100**	**178**	**100**

Source: Baseline Studies – Household Survey, 2012

Water Supply Systems

Almost all households in the host barangays (99%) have access to safe drinking water, except for 2 in San Isidro and 3 in Timamana (**Table 2.4-92**).

Table 0-86 Access to Safe Drinking Water Among Household Population in Host Barangays, Tubod

Barangays	Total No of Households	No of HH Without Access	%	No of HH With Access	%
San Isidro	260	2	0.29	258	38.05
Timamana	418	3	0.44	415	61.21
Total	**678**	**36**	**0.74**	**673**	**99.26**

Source: CBMS Survey

Regarding water source facility, 86% of the households in San Isidro have private use of the community water system while 7.5% share it with other households. In Timamana, about 94% have their own faucet while 3% share it with other households (**Table 2.4-93**).

Table 0-87 Source of Drinking Water Among Household Population in Host Barangays, Tubod

Water Source Facility	Barangay				Total	
	San Isidro		Timamana			
	No	%	No	%	No	%
Community water system (own use)	69	86.25	92	93.88	161	90.45
Community water system (shared with others)	6	7.5	3	3.06	9	5.06
Deep Well (own use)	0	0	0	0	0	0
Deep well (shared with others)	1	1.25	0	0	1	0.56
Artesian Well (own use)	0	0	0	0	0	0
Artesian Well (shared with others)	0	0	0	0	0	0
Others, specify	3	3.75	0	0	3	1.68
No Answer	1	1.25	3	3.06	4	2.25
Total	**80**	**100**	**98**	**100**	**178**	**100**

Source: Baseline Studies – Household Survey, 2012

Waste Management

In San Isidro, composting ranked first (28%) among the most commonly practiced waste disposal method, followed by burning (27%). In Timamana, however, burning is very much practiced (37.7%) while composting and waste segregation (19%) ranked second (**Table 2.4-94**).

Table 0-88 Waste Disposal Methods in Host Barangays

Waste Management	San Isidro		Timamana		Total	
	No	%	No	%	No	%
Burning	27	27	37	37.75	64	32.32
Composting	28	28	19	19.39	47	23.74
Recycling	8	8	4	4.08	12	6.06
Waste Segregation	8	8	19	19.39	27	13.64
Thrown Anywhere	5	5	4	4.08	9	4.54
Compost Pit with Cover	5	5	6	6.12	11	5.56

Waste Management	San Isidro		Timamana		Total	
	No	%	No	%	No	%
Compost Pit without Cover	19	19	9	9.18	28	14.14
Total	**100**	**100**	**98**	**100**	**198**	**100**

Source: Baseline Studies – Household Survey, 2012

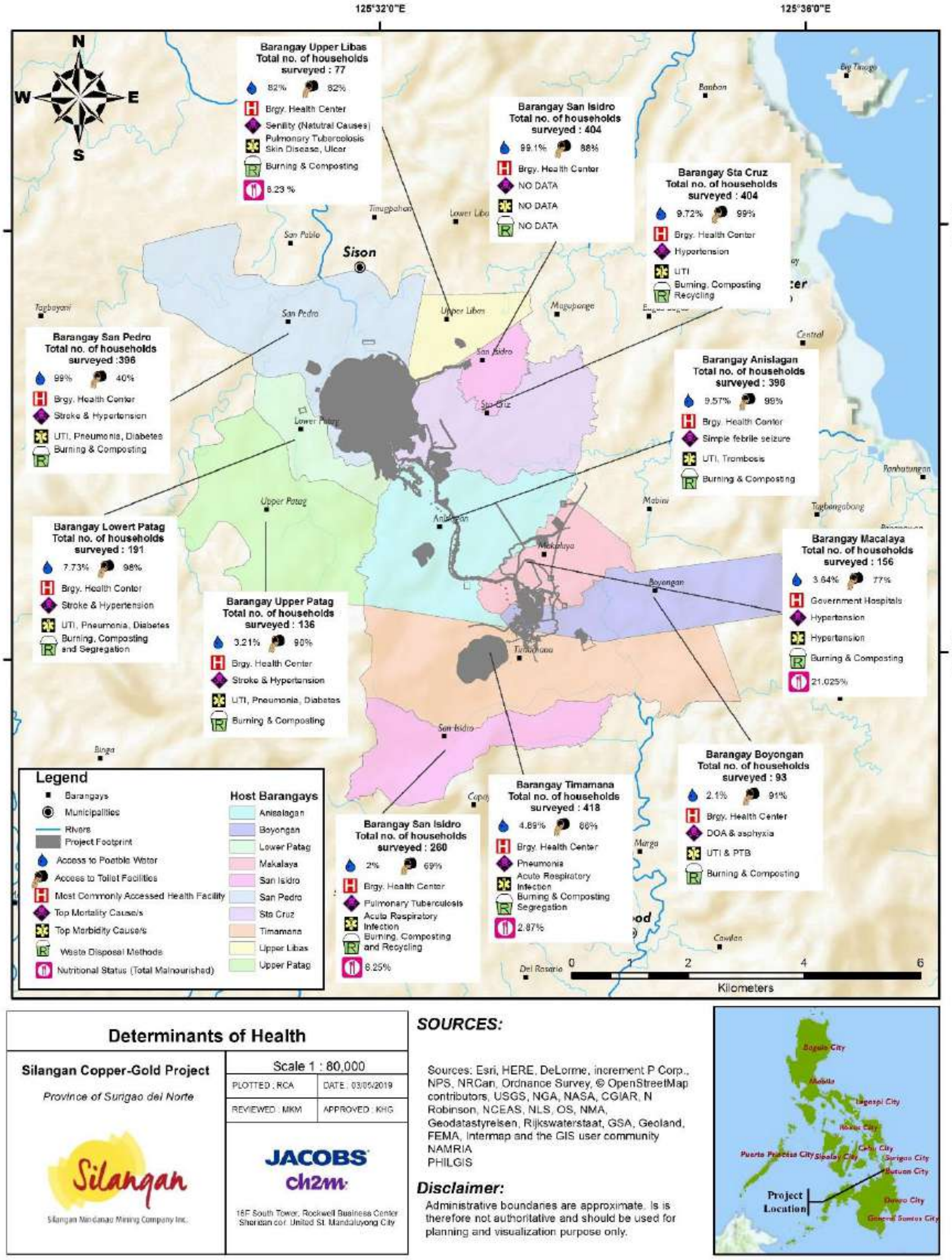
Animal wastes in San Isidro are mostly just thrown (45%) in no specified dumping areas while residents in Timamana will either collect or throw them away (29.5%) (**Table 2.4-95**).

Table 0-89 Animal Waste Disposal Methods in Host Barangays, Tubod

Waste Management	San Isidro		Timamana		Total	
	No	%	No	%	No	%
Septic Tank	4	12.9	9	14.75	13	14
Collected	4	12.9	18	29.5	22	23.9
Composting	8	25.8	14	22.95	22	23.9
Unattended	1	3.2	2	3.27	3	7.97
Thrown	14	45	18	29.5	32	34.78
Total	**31**	**100**	**61**	**100**	**92**	**100**

Source: Baseline Studies – Household Survey, 2012

Figure 2.4-16 presents key findings of public health.


125°32'0"E
125°36'0"E
9°40'0"N
9°36'0"N
N
W
E
S
Barangay Upper Libas
Total no. of households surveyed : 77
82% 82%
Brgy. Health Center
Senility (Natural Causes)
Pulmonary Tuberculosis
Skin Disease, Ulcer
Burning & Composting
8.23 %
Barangay San Isidro
Total no. of households surveyed : 404
99.1% 88%
Brgy. Health Center
NO DATA
NO DATA
NO DATA
Barangay Sta Cruz
Total no. of households surveyed : 404
9.72% 99%
Brgy. Health Center
Hypertension
UTI
Burning, Composting
Recycling
Barangay San Pedro
Total no. of households surveyed :396
99% 40%
Brgy. Health Center
Stroke & Hypertension
UTI, Pneumonia, Diabetes
Burning & Composting
Barangay Anislagan
Total no. of households surveyed : 398
9.57% 99%
Brgy. Health Center
Simple febrile seizure
UTI, Trombosis
Burning & Composting
Barangay Lowert Patag
Total no. of households surveyed : 191
7.73% 98%
Brgy. Health Center
Stroke & Hypertension
UTI, Pneumonia, Diabetes
Burning, Composting and Segregation
Barangay Upper Patag
Total no. of households surveyed : 136
3.21% 90%
Brgy. Health Center
Stroke & Hypertension
UTI, Pneumonia, Diabetes
Burning & Composting
Barangay Macalaya
Total no. of households surveyed : 156
3.64% 77%
Government Hospitals
Hypertension
Hypertension
Burning & Composting
21.025%
Barangay Boyongan
Total no. of households surveyed : 93
2.1% 91%
Brgy. Health Center
DOA & asphyxia
UTI & PTB
Burning & Composting
Barangay Timamana
Total no. of households surveyed : 418
4.89% 86%
Brgy. Health Center
Pneumonia
Acute Respiratory Infection
Burning & Composting Segregation
2.87%
Barangay San Isidro
Total no. of households surveyed : 260
2% 69%
Brgy. Health Center
Pulmonary Tuberculosis
Acute Respiratory Infection
Burning, Composting and Recycling
6.25%
Sison
San Pablo
Timugpahan
Lower Libas
Upper Libas
San Pedro
Tagbayani
Mapaporge
San Isidro
Sta Cruz
Lower Patag
Upper Patag
Anislagan
Makalaya
Boyongan
Timamana
San Isidro
Central
Mabini
Bonbon
Biaga
Del Rosario
Cawilan
Legend
Barangays
Municipalities
Rivers
Project Footprint
Access to Potable Water
Access to Toilet Facilities
Most Commonly Accessed Health Facility
Top Mortality Cause/s
Top Morbidity Cause/s
Waste Disposal Methods
Nutritional Status (Total Malnourished)
Host Barangays
Anislagan
Boyongan
Lower Patag
Makalaya
San Isidro
San Pedro
Sta Cruz
Timamana
Upper Libas
Upper Patag
0 1 2 4 6
Kilometers
Determinants of Health
Silangan Copper-Gold Project
Province of Surigao del Norte
Silangan
Silangan Mindanao Mining Company Inc.
Scale 1 : 80,000
PLOTTED : RCA
DATE : 03/06/2019
REVIEWED : MKM
APPROVED : KHG
JACOBS
ch2m
16F South Tower, Rockwell Business Center Sheridan cor. United St. Mandaluyong City
SOURCES:
Sources: Esri, HERE, DeLorme, increment P Corp., NPS, NRCan, Ordnance Survey, © OpenStreetMap contributors, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community
NAMRIA
PHILGIS
Disclaimer:
Administrative boundaries are approximate. Is is therefore not authoritative and should be used for planning and visualization purpose only.
Project Location
Baguio City
Legaspi City
Puerto Princesa City
Cebu City
Surigao City
Butuan City
Davao City
General Santos City

Food Security

In Surigao del Norte, supplies such as vegetables and spices mostly come from Cagayan de Oro, Davao, Agusan del Norte and Agusan del Sur. The people usually purchase their supply of vegetables and spices in "Tabo-tabo" or the local informal market that is held weekly each town and at Surigao City Public Market. While supplies are generally sufficient the unpredictable weather in the region makes the supplies in some areas low (Bureau of Agricultural Statistics, 2012).

In terms of supply, Placer has the highest production of grains (rice), root crops, fish and meat. However, Sison ranks far first in vegetable production among other host municipalities. Consequently, Placer has the highest number of per capita requirement per annum and demand for all food groups. Inspite of having the highest food production, Placer is still deficient in its terms of grains (-20.68%), vegetables (-98.47%), root crops (-5.9%) and meat (-89.22%). Similarly, Tagana-an also has deficit in grains (-8.68%), vegetables (-96.04%), root crops (-29.64%), meat (-47.79%) and eggs (-67.97%). Supply for all major food groups in Tubod is also deficit. Sison is deficit of vegetables and root crops.

For all host municipalities taken as one area, 60% of households are below the food threshold (PHP5,022/month for a family of five) inspite of an average family income of PHP5,803/month. Food security, however, is reckoned not only in terms of the actual physical production of a staple such as rice in a community (e.g., Placer) but also and just as equally in the ability of families to buy the right quality and quantity of food to meet their daily nutritional requirements.

Annex 2.4-4 presents food supply and demand per municipality.

Climate Change and Disaster Risk Preparedness

The entire province of Surigao del Norte is very vulnerable to different hazards because of its location along the Pacific Ring of Fire, Philippine Fault and the Philippine Deep, presence of several inland bodies of waters and absence of dry season. Natural hazards such as tropical cyclones, storm surges, liquefaction and tsunamis have increased the exposure of people and development to disaster risks. Other hazards related to climate change, such as El Nino and La Nina events, have also threatened the living conditions of the people in the province. Damage to agricultural produce, infrastructure facilities and services, fatalities, diseases and crippled economy were among the adverse impacts of these events to the community.

The Provincial Government of Surigao del Norte prepared a Disaster Risk Assessment (DRA) which was integrated in the updated Provincial Development and Physical Framework Plan. The document will be used as a guide to decision making process risk responsive and will ensure that development strategies, economic policies, programs and plans are risk sensitive from all forms of natural hazards.

2.4.4 Perception Survey

The following question was asked respondents to measure their degree of support or opposition to the Silangan Copper-gold Project: “*Let’s say in a scale of 0-10 where “10” means you are strongly in favor of the Silangan Copper-Gold Project and “0” that you are strongly against it, where do you stand?”*

0 Strongly Against	1	2	3	4	5	6	7	8	9	10 Strongly in Favor
Strong Opposition				Mild Opposition-Neutral-Mild Support			Strong Support			

The scale helps measures the breadth and depth of support or opposition and has three regions: (a) strong opposition (low rating): 0-3, b) mild opposition-neutral-mild support (moderate rating): 4-6) and c) strong support (high rating): 7-10. Overall, i.e., all host barangays as one geographical unit or unit of study:

- 47% of households are strongly in favor of the Silangan Copper-Gold Project;
- 38%, mildly not in favour, mildly in favour or support or neutral; and
- 15%, strongly against

Table 2.4-24 presents the degree of support/opposition to the silangan copper-gold project (row percentages).

Table 0-90 Degree of Support/Opposition to the Silangan Copper-Gold Project (Row Percentages)

Area	Base	Strongly Against % Base	Mildly Against/In Favor and Neutral % Base	Strongly in Favor % Base
All Host Barangays	1,243	15	38	47
Placer				
Anislagan	98	33	27	41
Boyongan	98	3	18	77
Macalaya	80	4	55	41
San Isidro	120	5	31	84
Sta Cruz	105	24	48	29
Sison				
San Pedro	104	21	37	42
Lower Patag	154	19	84	51
Upper Patag	103	17	56	30
Tubod				
Timamana	238	33	98	107
San Isidro	80	25	36	39
Tagana-an				
Upper Libas	63	5	41	54

Upper Libas (Tagana-an) reported the highest proportion of respondents who strongly support the project (54%), closely followed by Lower Patag (52%). Support was lowest in Sta. Cruz at 29%. Opposition is proportionately highest in Anislagan (33%); San Isidro ([Tubod]; 25%), Sta. Cruz and Upper Patag (each at 24%).

There is a large body of mild oppositors and supporters and neutrals (38%); 84% of these rated the project 5 ("neutral"). Unless further informed by way of IEC engagement, this large body of "neutrals" (or a significant portion of it) could potentially turn into strong oppositors. A more focused engagement could also make them strong supporters.

The most frequently mentioned fears and apprehensions of communities pertain to the danger and risks the project poses to the environment and people's health (54%). There are no differences with respect to those who are strongly against, neutral, or strongly in favor of the project. However, those who rated the project high (i.e., strongly in favor) the fear that the project would bring in more people and settlers to their communities is as important as the other two fears and apprehensions cited earlier. (**Table 2.4-25;** see also **Annex 2.4-5** for barangay-level data).

Table 0-91 Fears and Apprehensions by Degree of Support Opposition to the Silangan Copper-Gold Project (Column Percentages)

Fears and Apprehensions	All Ratings (Base: 1580 multiple responses)	Strongly Against (Base: 432)	Mildly Against/In Favor and Neutral (Base: 569)	Strongly Against (Base: 579)
Dangerous / too risky; might cause pollution; might poison the environment; might cause sickness	23	28	23	20
Might bring in more people and settlers to our communities	12	5	9	21
Will negatively affect my source of livelihood/less earnings/damage crops	12	13	13	10
Might cause flooding/landslides	31	24	36	32
Displacement of families and natives; loose our houses and farmlands	6	10	5	4
Might affect our way of life/culture	10	10	8	12
Might bring in illegal logging/activities	6	9	6	2

Perceived benefits of the projects overwhelmingly include "more businesses and industries" and "more earnings for the community". (**Table 2.4-26;** see **Annex 2.4-6** for barangay-level data).

Table 0-92 Expected Benefits from the Silangan Copper-Gold Project (Column Percentages)

Benefits	All Ratings	Strongly Against	Mildly Against/In Favor and Neutral	Strongly in Favor
	% Base 995	% Base 153	% Base 362	% Base 480
Will generate more employment opportunities	14	14	11	16
Will generate more businesses and industries	28	37	21	30
Will generate more earnings for the community	57	45	67	53
Will generate more community projects and assistance: roads, infrastructures; assistance to school, health, livelihood and development training	1	3	1	1

2.4.4.1 Previous Perception Survey

A previous perception survey was performed in an attempt to quantify the perceptions and views of the residents of the host communities towards the project during the open pit amendment which was submitted and approved in 2015. The survey aimed to measure any discernible changes between the perceptions of the host communities' residents as recorded from the original EIS submission.

Like the present survey, respondents were asked to rate their support or opposition to the project on a scale between 0 and 10.

0 Strongly Against	1	2	3	4	5	6	7	8	9	10 Strongly in Favor
Strong Opposition				Mild Opposition-Neutral-Mild Support			Strong Support			

Responses were then placed along a scale with three regions: a) a low rating of 0-3 which is rated as strong opposition, b) a moderate rating of 4-6 marked as mild opposition-neutral-mild support, and c) a high rating of 7-10 marked as strong support. As before, when taken as one unit of study:

- 34.30% of households are strongly in favour of the Silangan Copper-Gold Project;
- 36.85% mildly against or mildly in favour or neutral; and
- 27.30% of households feel strongly against the project.

Table 2.4-27 presents the degree of support/opposition to the Silangan copper-gold project (row percentages).

Table 0-93 2015 Perception Survey Degree of Support/Opposition to the Silangan Copper-Gold Project (Row Percentages)

Areas	Base	Strongly Against % Base	Mildly Against / In Favor and Neutral % Base	Strongly in Favor % Base
All Host Barangays	**1099**	**27.30**	**36.85**	**34.30**
Placer				
Anislagan	103	46.60	30.10	18.45
Boyongan	100	19	26	54
Macalaya	105	16.19	23.81	60
San Isidro	115	13.91	32.17	53.04
Sta. Cruz	102	26.47	41.18	32.35

Areas	Base	Strongly Against % Base	Mildly Against / In Favor and Neutral % Base	Strongly in Favor % Base
Sison				
San Pedro	119	30.25	36.13	32.77
Lower Patag	82	19.51	45.12	35.37
Upper Patag	105	25.71	41.9	31.43
Tubod				
San Isidro	77	50.65	28.57	12.99
Timamana	93	47.31	32.26	20.43
Tagana-an				
Upper Libas	98	11.22	69.39	17.35

Macalaya had the highest proportion of respondents who were strongly in favour of the project (60%), followed closely by Boyongan (54%) and San Isidro (Placer) (53.04%). Strong support for the project was lowest in San Isidro (Brgy Tubod) at only 12.99%, at Upper Libas with only 17.35% and in Anislagan at 18.45%. Opposition to the project was strongest at San Isidro (Brgy Tubod) at 50.65%, closely followed by Timamana at 47.31% and Anislagan at 46.60%.

The largest proportion of responses lies within the mild opposition-mild support-neutral spectrum (36.85%), 82.96% of these responses rated their sentiments as Neutral to the project.

The most frequently rated fear over the project when taking all the communities as a whole is that of the Project being too dangerous or risky, might cause pollution and illness (49.48%). Those who feel strongly against the project chose the same fear at a rate of 64.79% while just over half (51.76%) of those who feel mildly against/mildly for or neutral towards the project chose the same response. Those who feel strongly in favour of the project only chose this fear at a rate of 35.79%.

Table 0-94 2015 Perception Survey Fears and Apprehensions by Degree of Support Opposition to the Silangan Copper-Gold Project (Column Percentages)

Fears and Apprehensions	All Ratings (Base:1053)	Strongly Against Base=284	Mildly Against / In Favor and Neutral Base = 398	Strongly in Favor Base = 366
Dangerous / too risky; might cause pollution; might poison the environment; might cause sickness	49.48	64.79	51.76	35.79
Might bring in more people and settlers to our communities	8.93	2.82	7.79	15.03
Will negatively affect my source of livelihood/less earnings/damage crops	7.12	9.15	4.52	8.47
Might cause flooding/landslides	25.36	19.01	25.88	30.05
Displacement of families and natives; loose our houses and farmlands	5.41	2.82	6.53	6.28
Might affect our way of life/culture	2.75	2.82	2.76	2.73
Might bring in illegal logging/activities	0.95	0.35	0.75	1.64

Generating community projects, infrastructure, assistance for education, health, livelihood was the overwhelming choice as the main benefit of the project across the spectrum of those who participated in the perception survey.

Table 0-95 2015 Perception Survey Expected Benefits from the Silangan Copper-Gold Project (Column Percentages)

Benefits	All Ratings (Base:1035)	Strongly Against Base=275	Mildly Against / In Favor and Neutral Base = 388	Strongly in Favor Base = 372
Will generate more employment opportunities	31.59	21.09	34.79	36.02
Will generate more businesses and industries	4.73	4.36	3.61	6.18
Will generate more earnings for the community	8.02	9.09	7.47	7.80
Will generate more community projects and assistance: roads, infrastructures; assistance to school, health, livelihood and development training	50.34	51.27	51.03	48.92
Others	5.31	14.18	3.09	1.08

2.4.4.2 Major Stakeholder Issues and Concerns

During the course of this study, a series of stakeholder engagement activities were performed in each of the 11 impact barangays and the Municipal LGUs of Placer, Sison, Tubod, and Tagana-an, all of which have interest in the EIS process and for the actual development of the project itself.

These activities provide a venue for all stakeholders to present their views and concerns about the project while at the same time allows them to understand the scope of the project, identify how the project will impact their lives and their families and most importantly, provides them with the opportunity to address these concerns with the Proponent. In the final analysis, these sessions provides the stakeholders to take part in the actual development of the project itself.

Successfully identifying stakeholders and engaging them in the development process at such an early stage is very important. It allows for more rapid identification or even prediction of potential issues that could come from the start of the project, its implementation and operations, its conclusion and up to decommissioning. It allows for more effective facilitation of the management of these issues, ensuring that negative impacts are lessened and positive impacts are strengthened.

During the course of the consultation activities, several major issues came to the fore consistently across multiple venues and settings: 1) Legacy issues on employment and land agreements; 2) the consequences of the sublevel mining method on their communities' water supply for both domestic and agricultural use; and 3) The need for additional employment or livelihood sources in each of their communities.

2.4.4.5 Potential Impacts and Options for Prevention or Mitigation or Enhancements for Socio-Economics

Table 0-96 Potential Impacts and Options for Prevention or Mitigation or Enhancement – Socio-Economics

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
Displacement of settlers					
No settlers will be displaced for the sublevel caving plan. For the previous open pit proposal, approximately 250 households will be displaced most of which are located in the proposed	✓	✓	✓	✓	While there will be no settlers and infrastructure that will be displaced, legacy land banking issues would still need to be considered and addressed to foster a harmonious relationship between SMMCI

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
WRD (San Isidro, Tubod) and the TSF. At the current plan, the surface facilities have significantly reduced in size or have been eliminated (WRD). Land for the entire project footprint including buffers have also been acquired by Silangan. We recognize however, that legacy land banking issues are still present. These land banking issues include the following: • Recognition of the rightful land owners; • Prioritization of land owners for employment (previous agreements); • Co-management of land by SMMCI and previous owner/caretaker; • Future land use.					and its stakeholders. To address concerns, the following should be conducted: • Institute and implement the grievance mechanism process to receive concerns in the SMMCI site office or at barangays, review and respond to these concerns within a specific timeline, and provide a complete and understandable response to the complainant. • Review previous agreements rolled out by previous HR and land banking managers, review current agreements, and harmonize the system such that agreements are uniform and fair to all parties concerned. A database of existing agreements should be managed and aligned with the site GIS system for rapid retrieval of data. • SMMCI to regularly coordinate with DA, DAR, municipal assessors and planning officers, CENRO and PCA for land use, classification and tenure concerns.
In-migration					
• Migration to the host municipalities/barangays in search of jobs and mining related economic opportunities is expected. These migrants will consist of single persons or families • As a consequence of uncontrolled migration, there would be informal settlements and other forms of non-conforming land-uses • Significant numbers of migrants could also diminish social cohesiveness and diminish traditional mechanisms of social control in host communities		✓	✓		• Strengthen value-formation among current residents of host communities through seminars and other culturally-appropriate forms of meetings
Cultural / lifestyle change					
• Local cohesion may be affected because of the presence of local migrant workers • Introduction of new forms of entertainment that might affect traditional family and community life		✓	✓		• Provide protocols and guidelines for worker behavior and conduct especially in local host communities • Strengthen value-formation among current residents of host communities through seminars and other culturally-appropriate forms of meetings
Impacts on physical cultural resources					
• Implementation of the Project may uncover artifacts or objects of physical cultural value		✓	✓	✓	• The proponent will commit to following a protocol for chance finds and coordinate with the National Museum
Threat to delivery of basic services / resource competition					

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
• It is possible that public services may be stretched because of the influx of newcomers in search of employment opportunities • New comers (whether hired or not) may also compete with established local residents in the use of resources, e.g., springs, sources of firewood, game, etc. • Agricultural land may be reduced and consequently affect food production. However, such a situation may be made-up by increase in family income (conservatively elevate at 39%) at current levels; such increase will enlarge the food budget of families.		✓	✓		• The SDMP, among other means of assistance, will augment social services provided by government agencies • Local government revenues will also increase because of mining operations and can be used to expand public services • With the objective to exert best efforts to locally hire at least 50% of the operations workforce from the host communities, families below the poverty threshold will be reduced by 65%; consequently families below the food threshold will be also reduced by even a larger proportion (no less than 65%). Local-hiring will result to increased income (up by 39% from current levels) that will allow families to purchase more food, particularly rice, even if this staple has to be supplied from sources other than the host municipalities.
Threat to public health and safety					
• Increase of human and non-human wastes due to in-migration • Prevalence and spread of communicable diseases due to in-migration • Prevalence of respiratory diseases due to likely increase of dust during various phases of mine activities • Increase in vehicle-related and work-related accidents • Potential occurrence/prevalence of sexually-transmitted diseases Possible increase in pollution particularly of air, water and land due to influx of people and vehicles and start of mine activities		✓	✓		• Enhance existing waste disposal systems and methods within communities and also within the plant and construction area by strict compliance to the provisions of RA 9003. This will include proper handling, storage and disposal of all kinds of wastes especially those produced by the plant and/or construction area. • Establish Material Recovery Facilities (MRFs) in key barangays, .e.g. Timamana • Create a purok or barangay herb, vegetable or ornamental garden to utilize organic fertilizers produced from compost • Increase provision and/or installation of sanitation or toilet facilities. • Conduct Air Quality Monitoring initially and every quarter. • Prepare a Water Management Plan which will include Water Quality Monitoring. • Conduct a Health Impact Assessment (HIA) to identify potential health implications on local communities and the management measures to be carried on. • Establish programs such as Occupational Safety and Health Program, Hazardous Waste Management Program and Emergency Response Program to all workers and conduct activities in relation to these programs. This will include the creation of an Emergency Response Team, • Conduct IECS on safety, hygiene and sanitation to prevent diseases. • Provide training to all workers on how to perform First Aid. • Provide appropriate training to personnel who will be assigned to operate a particular equipment or machinery

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
Indirect Health Impacts • Inadequacy or disruption of social and health services • Community dislocation brought about by development caused by various factors such in migration due to employment opportunities • Increased demand for limited health resources • Increased incidences of crime • Prevalence of social problems such as drugs, alcohol, gambling and prostitution.		✓	✓		• Design and implement a SDMP considering/addressing the local needs and requirements of a community on a sustainable basis. The plan may include investments in health and social services. • Enhance security within communities. Make visible the presence of police, *barangay tanods* and other agents of peace and order.
Generation of local benefits from the Project					
• About 1800 workers are projected to be hired for the construction phase; 1600 for operations. This does not yet include contractors and suppliers who will be working for the project as well. Assuming that one-half of the construction and operations work force are source from the local host communities (respectively at 900 and 800), the impact on employment, income, and poverty reduction will be significant. • Average monthly family income (currently at PHP5,803/mo) will increase by 39%% to PHP9490 assuming a daily wage of PHP350/day for 26 working days per month. Such increase will allow families greater access to goods and services and consequently improve the quality of life and standard of living. • Poverty in the host barangays (currently at 74% of all families and ranging from 63-84% across barangays) will be reduced by 28 % and 65% during construction and operation respectively because of local hiring. The number of families below the food threshold will also be reduced. Food budgets will be adequate to meet the daily nutritional requirements of families where one member is hired by the project proponent. • During the operations stage, PHP55M will be infused into the immediate local economy (mostly host communities) by way of expenditures on food and food-related items (FFRI) of 1,250		✓	✓		• SMMCI instituted the Barangay Employee Services Office (BESO) with the host barangays. Initial screening of applicants is done through the BESO composed of three barangay representatives. Applicants endorsed by the BESO undergo evaluation by SMMCI. • Assist the local governments (particularly at the municipal and provincial levels) to develop and to assist their respective Public Employment Services Offices (PESOs). Institute a system of verification regarding local residency in respect to hiring. • Training programs for required skills for residents of host communities • Training programs for local governments on revenue generation and management

Potential Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
locally-hired employees from the host communities; such an amount will have a business turn-over of 6.6 times generating PHP368M to various levels of the economy inclusive of PHP102M to the immediate local economy and PHP176M to the local to the provincial economies. • FFRI expenditures will result to 96,685 employment days for the local economies (host communities to the provincial level) for the equivalent of 269 full-time jobs inclusive of 153 in the host communities. • Locally hired residents will gain additional and marketable skills • Local revenues and other forms of payments (e.g., royalties) will flow to host communities because of mining operations. Local shares of national taxes will also increase.					
Traffic congestion					
• Most traffic through the host communities are light vehicles e.g., (jeepneys, “multi-cabs”, tricycles). Volume of traffic is also light and intermittent. • During the construction and operations stages, there will be a significant increase of traffic volume involving heavy vehicles • Sensitive receptors of heavy traffic will be areas where population centers, e.g., school areas, commercial/trading areas, church areas, residential centers, etc. that will be subject to nuisance like noise, vehicle emissions, dust, and the risk of vehicular and pedestrian accidents • Movement of hazardous materials through communities will pose a risk to people • Local roads will be subject to heavier loads mining-related vehicles		✓	✓		• Draw up a traffic management plan with local authorities at barangay and municipal levels that includes the participation of community leaders, e.g., local school heads, establish appropriate signages, i.e., road warning devices, undertake safety education for drivers of vehicles and pedestrian and regular maintenance of roads • Post road and traffic wardens in population centers • Establish speed limits for vehicles • Impose time periods for transport of hazardous vehicles; draw up emergency response time for incidents involving hazardous materials • Equipped and train local communities in first-aid and emergency response measures

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Environmental Impact Statement

Section 3. Environmental Management Plan

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Table of Contents

3.0 Environmental Management Plan 3-1

List of Tables

Table 3-1: Summary of the Potential Impacts and Proposed Mitigation Measures 3-2

3.0 Environmental Management Plan

In consonance with its environmental policy statement, SMMCI is committed to the continual improvement of its operations, to minimize adverse environmental impacts of the project, to comply with applicable legislations and other relevant statutory requirements, and to promote environmental awareness and commitment among its workers at all levels. The mitigation and enhancement measures will be implemented continually during the different phases of the project as part of the overall Environmental Management Plan. These potential impacts and the proposed mitigating measures are summarized and highlighted per in the Environmental Management Plan (EMP) as presented in **Table 3-1Error! Reference source not found.**.

Table 0-1 Summary of the Potential Impacts and Proposed Mitigation Measures

Project Phase / Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Prevention or Mitigation* or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
THE LAND						
Pre-construction, Construction, Operation, Closure	Land Use	• Short-term (equivalent to Project life) or temporary land use change will occur in areas that will be occupied by the access and haul roads, process plant, associated pipelines and conveyors to and from the process plant, topsoil and rock stockpile, sewage treatment plant, water refilling station, WTP for Processing, WTP for TSF discharge, switchyards, sedimentation ponds, seepage collection ponds, administration buildings, accommodation units, recreational facilities, landfill, assay laboratory, helipad, core farm, solid waste storage, clinic, religious center, warehouse, maintenance workshop, motorpool, security/ safety quarters, mess hall/ kitchen, laundry area, and other support facilities. • Permanent land use change will occur in areas defined by the underground mine, subsidence area, water dam, and Tailings Storage Facility (TSF).	• Rehabilitation and closure planning will be conducted in accordance with the FMRDP in consultation with the key stakeholders to arrive at feasible options for the final land use of the underground mine, subsidence area, and TSF. • Buffer zones and physical barriers will be set around the subsidence area to secure and limit access and disturbance. • The perimeter of the water dams shall be structurally reinforced, rehabilitated and re-graded to match the surrounding landforms. • A rainfall-shedding cover will be adapted for the TSF with a gravel layer to serve as a capillary break to limit the upward movement of contaminants from the tailings. The overlying layer will also serve as a filter to limit the migration of fine sediments into cover. Eventually the cover will be overlain with soil and rock to provide erosion protection while allowing the establishment of suitable long-term vegetation for the TSF. The TSF's final gradient and profile at closure will be planned and engineered to facilitate efficient surface drainage at sufficiently low velocities to reduce potential for long-term erosion. The options for final land use of the TSF will be consulted with the stakeholders and may include future land use such as grazing/pasture land or cropping area for fruit trees or highland crops depending on suitable vegetation. Vegetation or crops that may be applied during closure may be included as part of the research proposals for the mine's Environmental Protection and Enhancement Program (EPEP).	SMMCI	Php 5,750,000	EGF EPEP FMRDP

Construction, Operation	Land	• Landslides and mass wasting may be induced by construction and operation activities on high angle slopes. • Loss of topsoil due to ground preparation activities and vehicular and human movement.	• Observance of safe working slope gradient and placement of landslide control measures. • Soils that will be removed will be conserved and stockpiled in a delegated area for use in rehabilitation and backfilling activities. • The stockpile shall be covered with coconut matting and graded to a stable relief. • Permaculture practices such as planting of vetiver grass will be applied • Progressive rehabilitation shall be undertaken in applicable areas such as stockpile areas.	SMMCI	Php 2,550,000	EPEP EGF EMF
Construction, Operation	Landform, Geomorphology	• Alteration of the natural terrain of the area due to clearing, re-grading and construction of mine facilities. • Formation of man-made lakes and change in the geomorphology of the rivers and drainage networks due to the construction of WSD and TSF.	• The FMRDP for the Project will provide an integrated approach to the geomorphic and topographic rehabilitation of affected areas where applicable. • Geomorphology of the affected river courses and drainage networks will be restored as close as possible to the original characteristics. • Engineering measures will be implemented to restore part of its original geomorphic characteristics. • An FMRDP will be prepared to provide an integrated approach in the geomorphic and topographic rehabilitation of disturbed land after mine closure.	SMMCI	Php 12,000,000	EGF FMRDP
Construction, Operation	Land subsidence	• Land subsidence will occur resulting from underground bulk mining. • Removal of the subsurface materials may induce differential settling, surface instability and subsurface collapse (cave-in events).	• Provision of sufficient buffer on predicted impact areas. • Predicted impact areas will be off-limits to human access and infrastructure construction. • Provision of compensation for an allowable subsidence rate until the closure of the underground mine assumes stability. • Engineering measures such as rock bolts, pillar supports, shotcreting, wire meshes, post tensioning and structural reinforcing will be applied to areas where structural weaknesses are expected.	SMMCI	Php 1,550,000	EPEP
Operation, Closure	Flooding Potential	• Potential downstream flood magnitude will increase during peak flood conditions wherein	• Flood management schemes will be developed as part of the operational systems of the TSF and WSD. • Peak flood regimes will be accounted in the design of the TSF and WSD.	SMMCI	Php 12,950,000	EMF EPEP

		water will need to be released from the impoundments (WSD and TSF) • Integrity failure of the impoundments may cause flooding risks downstream of these structures.	• All the impoundment structures will be designed considering seismic and structural parameters • Structural integrity will be monitored for the duration of operation of these facilities and beyond mine closure. • Underground diversion drains will be installed to channel runoff water away from mine components and into natural waterways. The TSF will be designed to stand against a 100-year flood event. It will have a spillway that can release excess water. The TSF design will follow local and international requirements. • Regular monitoring of the TSF will be conducted throughout its lifetime. • A complete flood model will be developed to identify potential issues • A detailed Emergency Response Plan will be developed to handle unlikely occurrence of impoundment failure and downstream flooding.			
Construction	Soil Quality	• Possible increase in surface erosion and down slope sedimentation brought about by mine development activities • Earthworks, construction activities, and movement of heavy equipment will weaken and induce the natural erosion susceptibility of the soil cover	• Progressive conduct of round preparation and clearing to minimize the total area of soil cover and land that will be disturbed at any one time • Erosion and sedimentation controls will be implemented to manage surface erosion and the consequent down slope or downstream sedimentation. These will include: ○ Re-grading of the soil stockpile to stable configurations. ○ Installation of drainage networks or channels within the vicinity of stockpile and work areas. ○ Installation of sumps or sedimentation ponds at the toe of work areas. ○ Installation of silt traps or sediment control devices such as coconut matting when needed. ○ Erosion permaculture measures such as the planting of vetiver grass.	SMMCI Contractor and sub-contractors	Php 2,350,000	EPEP

			• Progressive soil rehabilitation will be conducted in disturbed or cleared areas that will not be used for further development over the course of the project.			
Construction	Soil Quality	• Removal of soil will occur due to earthworks for the development of mine infrastructures, ancillary facilities and service roads.	• Soils that will be removed during the clearing, re-grading, and ground preparation activities before construction will be conserved and stockpiled in a delegated topsoil stockpile area for use in rehabilitation activities or backfilling of service roads. • Ground preparation and clearing will be conducted progressively to minimize the total area of soil cover and land that will be disturbed at any one time. • Progressive soil rehabilitation will be conducted in disturbed or cleared areas that will not be used for further development over the course of the project to reduce the potential amount of soil cover that may be exposed and eroded. • A detailed Topsoil Management Plan (TMP) will be developed and implemented to address topsoil stripping methods and depths, stockpiling, the development of topsoil inventories for the Project's rehabilitation activities. • Decommissioning of infrastructure and restoration of disturbed areas will be conducted in accordance with the Project's FMRDP. This will include the rehabilitation and soil respreading and re-grading at closure to match the surrounding landform.	SMMCI	Php 4,200,000	EPEP FMRDP
Construction, Operation	Soil Quality	• Soil quality will decrease in the progressively rehabilitated areas if not managed appropriately.	• TMP will be developed and implemented prior to construction. The TMP will address topsoil stripping methods and depths, stockpiling, the development of topsoil inventories for the project site, re-spreading, soil amelioration, and seedbed preparation.	SMMCI	Php 1,650,000	EPEP
Construction, Operation	Soil Quality	• Soil contamination due to accidental chemical spills from the concentrator and mine assay lab.	• Proper handling of potentially contaminated materials will be observed at all times during the mine life. Periodic training of all personnel involved with transport of ore and non-ore materials will be required. This will ensure safe and effective	SMMCI Contractor and sub-contractors	Php 6,800,000	EMF EPEP

			material transport operations and reduce contamination risks. An emergency containment and clean-up program will be developed to handle any occurrences of soil contamination.			
Construction, Operation	Soil Quality	• Soil contamination due to accidental hydrocarbon spills from vehicles and equipment may occur.	• Waste oils, lubricants, and chemicals will be placed in designated storage tanks. Disposal of these wastes will be managed in accordance with the project's waste management plan for non-mine wastes that will be developed prior to construction. This will include procedures for hydrocarbon collection, containment and disposal including spills management. Spill kits will also be available for use in the management of such spill occurrences • Contaminated soils will be removed and subject to decontamination processes prior to rehabilitation (when possible) or disposal to the TSF or offsite.	SMMCI Contractor and sub-contractors	Php 6,800,000	EGF EPEP
Construction, Operation	Soil Quality	• Improper disposal of domestic wastes may contaminate the soil at the immediate and adjacent areas of disposal	• All domestic wastes will be disposed of in accordance with the construction and operations waste management plan that will be developed.	SMMCI Contractor and sub-contractors	Php 6,800,000	EMF EPEP
Construction, Operation	Soil Quality	• Soil quality in the recommended soil stockpile may decrease due to unfavourable conditions in storage and stockpiling and erosion and consistency loss during storage and presence of vehicles and heavy equipment. • Soil quality may be impacted due to passage of vehicles and heavy equipment over the course of the project.	• A detailed TMP will be developed and implemented prior to construction. The TMP will address topsoil stripping methods and depths, stockpiling, the development of topsoil inventories for the project site, respreading, soil amelioration, and seedbed preparation. • Stockpile soil quality will be improved through conservation management programs and soil quality improvement processes during stockpiling to prevent or reduce soil degradation during the storage period. • Vegetative cover will be used during rehabilitation to expedite and enhance the recovery of soil quality. Rehabilitated sites will be conditioned prior to seeding with native trees, shrubs, and grass (where applicable) to enhance successful germination and improve plant survival rate.	SMMCI Contractor and sub-contractors	Php 6,350,000	EGF EPEP FMRDP

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<td>Species that will be used are those that are endemic to the area or highly tolerant of recovering or marginal environments.
Soils in rehabilitated sites will be subject to re-spreading, amelioration, and seedbed preparation prior to revegetation to improve soil quality.</td>
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<tr>
<td>Pre-construction, Construction, Operation, Closure</td>
<td>Terrestrial Ecology</td>
<td>The project site has a total area of 532 ha. Removal of vegetation within this entire area is unavoidable.
It should be noted that the project site has been commercially logged until the 1950s. Subsequently, cleared areas were converted to coconut and falcata plantations, and agricultural areas (rice paddies).
Recorded vegetation types or communities based on this assessment strongly correspond to the past and on-going disturbances in the project site.
More than half (59%) of the project is dominated by Perrenial crops mostly for Agroforestry.
The breakdown of vegetation types or communities that would be cleared are presented below:
<table>
<tr><th>Vegetation Types/ Communities</th><th>Total Area to be Cleared (ha)</th></tr>
<tr><td>Agroforest (Perennial Crops)</td><td>312.96</td></tr>
<tr><td>Agricultural Areas (Annual Crops)</td><td>74.60</td></tr>
<tr><td>Brush/Shrublands</td><td>113.80</td></tr>
<tr><td>Open Areas with Built-Up Portions</td><td>7.12</td></tr>
<tr><td>Residual Forest</td><td>23.52</td></tr>
<tr><td>Total</td><td>532.00</td></tr>
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<td>Clearly delineating and containing the extent of vegetation removal on plans and on the ground prior to removal activities.
A tree cutting permit will be secured form the DENR. Replacement of cut trees will be in accordance to DENR Memorandum Order (DMO) 2012-02.
Wherever feasible, easement of the major components especially pipelines and access roads should be reduced or limited to maintain considerable amount of vegetation cover.
Development and implementation of a pre-clearing plan prior to construction. The plan should contain detailed clearing and cutting protocols to reduce impacts to the surrounding areas. It would contain handling/ translocation procedures for wildlife and other transportable habitat features such as logs and boulders. Also, it will include handling and management procedures of the cut logs and/or sustainable practices in disposing vegetation waste as per DMO 2013-02.
Provision of offset sites for all areas that will be cleared. Offset site/s will at least be equivalent in area affected by the Project and would jointly be identified by SMMCI and DENR. They will be strategically located to serve as corridors to reconnect fragmented forest habitats surrounding the project site. Offset site can be existing conservation or forest regeneration areas with similar vegetation and wildlife assemblage with that of the affected areas.
Appropriate measures and continuous management of offset sites through access restrictions, weed control and monitoring.
Development of a Biodiversity Management Program (BMP) prior to construction and operation. It will serve as the guideline and framework for the management of potential risks to biodiversity brought about by the activities of the Project during construction, operation and decommissioning phases. Also, it will aim to determine the scale of the ecological impact on species and habitats and quantify the</td>
<td>SMMCI</td>
<td>Php 1,000,000</td>
<td>EMF
EGF
FMRDP</td>
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			change in biodiversity over time through monitoring activities in the project site.			
Construction, Operation, Closure	Terrestrial Ecology	• Vegetation removal could include plant communities and associations, which can be valuable habitat for endemic and/or threatened plant species. At least 100 species of plants and wildlife are endemics while 27 species are under various threat categories. • Vegetation removal and loss of habitat due to development of mine facilities	• Wherever feasible, the infrastructure will be designed in such a way that vegetation clearing will be reduced • Easement of the major components especially pipelines and access roads shall be reduced or limited to maintain considerable amount of vegetation cover • Establishment of buffer zones around identified stepping corridors shall be done to provide protection to remaining sources of propagules. • To contain the area of disturbance, the extent of disturbance shall be clearly identified on the plans and on the ground prior to construction activities. • As part of the FMB- DENR statutory requirements, all relevant permits (e.g. Special Tree Cutting Permit) will be secured from concerned agencies prior to any cutting activities. • Clearing of vegetation will be conducted progressively to allow and optimize seed collection of Threatened and/or endemic species. Also, it will allow migration of highly mobile wildlife species to nearby similar vegetation types or communities. • Provision of offset sites for all areas that will be cleared. Offset site/s will at least be equivalent in area affected by the Project and would jointly be identified by SMMCI and DENR. Offset sites could be rehabilitation areas outside of the project site. • Known remnant native vegetation that will not be affected by development works shall be regenerated. • Identified threatened and or important species of plants/trees shall be earthballed and relocated outside the potential subsidence area. • Long term protection of the identified forest communities outside the project site shall be provided to serve as compensatory measures to offset the project's impacts to overall biodiversity. The areas that shall be identified as biodiversity offset, ideally, shall contain vegetation communities that are similar to areas to be cleared for the project. • Nurseries that will raise seedlings and wildlings of important species for future revegetation requirements shall be established. • Resident forester/s shall be engaged to oversee and manage the revegetation/regeneration works. • Appropriate reference sites to quantify and better understand the impacts resulting from mining activities shall be	SMMCI Contractor and sub-contractors	Php 4,000,000	EMF EGF EPEP FMRDP

			established. Regular monitoring of vegetation within the project site and reference sites to quantify the change over time will be implemented. • Development of a Biodiversity Management Program (BMP) prior to construction and operation. It will serve as the guideline and framework for the management of potential risks to biodiversity brought about by the activities of the Project during construction, operation and decommissioning phases. Also, it will aim to determine the scale of the ecological impact on species and habitats and quantify the change in biodiversity over time through monitoring activities in the project site.			
Construction, Operation, Closure	Terrestrial Ecology	• Surface vegetation removal that may brought about by heavy and sustained rainfall resulting in soil erosion and potentially large-scale land slips	• Management measures to control soil erosion associated to project operation will be in place.	SMMCI Contractor and sub-contractors	Php 1,650,000	EMF EPEP
Construction, Operation, Closure	Terrestrial Ecology	• Development of project facilities would drive away highly mobile wildlife species. Those which are less mobile or have limited dispersal abilities may have difficulties escaping any changes and would be subjected to disturbances caused by the Project	• Impacts and restrictions to the movement of animals may only be temporary as activities would be limited to certain vegetation communities, times and days. • Identification and containing the extent of disturbance both on the plans and on the ground prior to construction. • Implementation of no hunting and/or collecting policy for mine personnel. • Importance of wildlife conservation will be included as part of the IEC programs of the Project. • A pre-clearing protocol will be established and implemented for all tree clearing to minimize impacts to resident fauna • Disturbance to vegetation will be limited to the minimum necessary for each stage of the clearing. Limits of clearing will be marked and the construction footprint area delineated prior to construction activities commencing in order to avoid unnecessary vegetation and habitat removal. • A wildlife rescue center will be established to cater to injured or sick animals encountered in the clearing and site preparation activities. It will temporarily house injured or sick individuals to stabilize their condition before turning them over to DENR authorities. • Provision of biodiversity offsets (either on site or off-site) as compensation for vegetation to be removed. • Implementation of regeneration (this will include Assisted Natural Regeneration)/revegetation activities.	SMMCI	Php 2,360,000	EMF EGF EPEP FMRDP

Construction, Operation, Closure	Terrestrial Ecology	• Habitat fragmentation will primarily occur between development areas (e.g. TSF, access roads and pipelines). • Genetic isolation may result as populations of species become physically isolated from other individuals.	• Small fragments of vegetation will remain between the developments. Present vegetation outside the site developments will be retained. • Wildlife corridors will be established, enhanced and maintained, particularly in areas of remnant vegetation that occur between forested areas of high conservation value. • A monitoring program for wildlife will be implemented to determine possible influence of the project particularly on identified noteworthy species. • An environmental education package in partnership with the LGU will be developed. This will highlight the importance of the biodiversity within the project site and its surrounding areas.	SMMCI	Php 4,310,000	EMF EGF EPEP FMRDP
Construction, Operation, Closure	Terrestrial Ecology	• *Fugitive dust* – generated during various development activities (e.g. excavations, operation of heavy equipment and vehicles, etc). It may inhibit physiological plant processes (e.g. photosynthesis, transpiration, respiration) and potentially cause physical damage. These will affect wildlife that depend on specific plants for food or the vegetation community that serve as their habitat.	• Fugitive dust is not expected to be a significant problem as the area experiences regular rainfall, which will wash off any dust • Sprinkling of access and haul roads including other exposed soils will be implemented during dry weather. • Vehicle idling and traffic on exposed soils will be minimized.	SMMCI Contractor and sub-contractors	Php 6,300,000	EMF EPEP
tPre-construction, Construction	Terrestrial Ecology	• *Anthropogenic noise* – generated during various development activities may affect the physiology, behavior, reproduction and the long-term survival of wildlife in the project site.	• Whenever practicable there will be revegetation of development area edges to muffle noise during construction and operation phases. • Replacement of standard, tonal reversing beepers on mobile equipment with a lower impact beeper (e.g. “Backalarm” broadband beeper). • Ensuring all vehicles, plant and machinery are maintained in proper working order to avoid unnecessary engine, motor or muffler noise. • Making sure all vehicle and equipment operators are aware of the location of key wildlife habitat and the measures required for limiting noise where possible.	SMMCI	Php 6,650,000	EMF EPEP
Pre-construction, Construction, Operation, Closure	Terrestrial Ecology	• *Light* – can potentially affect wildlife behavior, disrupt seasonal day cues, cause temporary blindness, and disrupt predator-prey relationships.	• Effects from night lighting will likely be localized close to the sub level cave area, with only limited glare into the surrounding natural vegetation. • If feasible, anti-glare lighting will be used to minimize disruption to vision of nocturnal wildlife (e.g. bats, owls, cloud rats). • Use of anti-glare sleeves or shields to control/manage direction of light from vehicle’s headlights.	SMMCI Contractor and sub-contractors	Php 600,000	EMF EPEP

			• For certain areas, use of light source with directional lighting and screens to concentrate light on operations. • Most wildlife species are expected to habituate to the periodic disturbance and light pollution. Any wildlife individuals that may become attracted to lighting source and may accidentally venture into any development facilities will be carefully removed and brought back into its natural habitat, away from any facilities.			
Construction, Operation, Closure	Terrestrial Ecology	• Anthropogenic noise may affect an animal's physiology, behavior, reproduction, and long-term survival	• Impacts from noise will likely be localized close to the block cave area and will be unlikely to have a significant, long-term impact on wildlife populations.	SMMCI		
Pre-construction, Construction, Operation, Closure	Terrestrial Ecology	• *Vehicle strike* – on various wildlife species could occur along access roads during the construction and operation phases of the project.	• Appropriate driving policies will be implemented and signage will be deployed at key areas for driver's awareness and reduce accidents. Road rules will be clearly conveyed through driver training and strictly enforced as a component of the project safety policies and procedure. • Specific mitigation to be designed and implemented if required for possible areas where frequency of wildlife strikes is high. Wildlife accident trends will be monitored to determine species prone to vehicular strikes, specific areas where accidents commonly take place and at what time. Drivers will have to report incidents concerning wildlife – areas with high incident reports will require specific mitigation (e.g. exclusion fence, culvert crossing, suppression of attractive vegetation that could provide food, shelter or nesting sites, etc.).	SMMCI Contractor and sub-contractors	Php 600,000	EMF EPEP
Construction, Operation, Closure	Terrestrial Ecology	• *Increased weed invasion* – opportunistic invasive and exotic weeds might occupy cleared areas and compete with existing vegetation species along the project site especially endemic and/or threatened species.	• Appropriate control measures of weeds will be incorporated in the BMP. • Regular brushing, cutting and maintenance of open areas. • All vehicles will be washed down prior to entering the project site to prevent possible introduction of weeds.	SMMCI Contractor and sub-contractors	Php 400,000	EMF EPEP
Closure	Terrestrial Ecology	• Absence of management and non-continuation of rehabilitation programs during decommissioning may lead to failure to regenerate disturbed areas and can further lead to degradation of existing vegetation assemblage.	• SMMCI will implement mitigation/enhancement measures based on approved EIS. Development of a decommissioning plan together with various stakeholders during the operation of the project. • Management of offset sites, and rehabilitated and conservation areas will be turned over to DENR, local government units and people's organizations.	SMMCI LGU DENR Other Government Agencies		

THE WATER						
Construction, Operation, Closure	Drainage Morphology	• With construction of the TSF, the existing shape of the river channel for the section straddled by this mine facility will significantly change. Part of headwaters of the Hinagasa-an River will be submerged. This reduces vegetation cover. The surface area of the water body will increase. This increases evaporation losses.	• The proponent has been conducting reforestation activity since the start of exploration not only to compensate any loss of vegetation cover attributed to mine development but to also increase the present forest cover in the area. • The loss of water due to increased evaporation and potential reduction of base flow due to decreased catchment area is offset by the increase in run-off from the TSF and water from placed tailings.	SMMCI	Php 2,150,000	MWTF EPEP
Construction, Operation, Closure	Stream Water Depth	• Discharge of excess water from the TSF spillway will increase flows along the Hinagasa-an River which may potentially cause flooding downstream.	• The catchment area of the Hinagasa-an River will remain the same. The change in vegetation cover from sparsely vegetated to TSF area will only contribute about equal or less than 1% increase in volumetric rate of flow which can be considered as insignificant. • The TSF is provided with sufficient freeboard to contain any excess flows from the catchments. This will also be provided with spillway with control gates to regulate the release of excess water to the Hinagasa-an River.	SMMCI		
Construction, Operation, Closure	Stream Volume Flow	• Potential reduction of the surface flow at Hinagasa-an River due to encroachment of the catchment areas by the TSF.	• The potential reduction of flow due to decreased catchment area is offset by the increase in run-off from the TSF and WSD. • Interception channel will be provided along the periphery of the TSF to intercept surface runoff from adjacent catchment. This will then be diverted to the Hinagasa-an River downstream of the TSF.	SMMCI	Php 17,100,000	MWTF EPEP

Construction, Operation, Closure	Water Resource Use	• Part of the headwaters of Hingasa-an River will be affected on the construction of the TSF. • Groundwater levels at spring sources may decline, particularly the water sources located proximal to the boundary of the sub level caved area.	• For the water bodies affected by the TSF, headwaters of Hinagasa-an river will be diverted to connect to the river. The sub level caved area is not expected to affect any surface water. • The water pumped from the underground mine to the WSD and the TSFs are designed to provide the water demand of the project. • In the unlikely event it becomes apparent that the water supply from the WSD and pumped water from underground mine may not be available to satisfy the project water requirements and maintain the current natural variations in river flows, this will be known well in advance. Close consultation with the NIA and the various irrigators' associations will be carried out to come at a mutually agreeable solution. • During the initial stages of underground mining operation, water will be pumped from the underground workings to the WSD. • All of the existing villages within the project site will be resettled to new residential areas outside of the project site. In order to mitigate any impacts, any affected community groundwater supplies e.g. springs will be provided with alternative water supply source.	SMMCI	Php 17,100,000	MWTF EPEP
Construction, Operation, Closure	Groundwater Flow	• Groundwater levels in areas adjacent to the underground mine will experience a drawdown due to inflow to the sublevel caved area during operations and to the final void post closure. • A decline in spring flow and stream base flow in some catchments is expected to occur due to inflow to the sublevel caved area and final void.	• In the event that there are springs and other domestic water sources impacted by the mine, alternative water sources will be provided by SMMCI.	SMMCI	Php 1,000,000	EGF EPEP
Construction, Operation	Surface Water Quality	• The preparation, earthmoving activities, stockpiling, and maintenance of the mine area and facilities may release soil, sediments, rocks, minerals and windblown debris which may affect the water quality of the streams and creeks within the Hinagasa-an River. The construction activities may also affect the stream water depth, volume and flow.	• Sediment and erosion control measures which include: ▪ River bank and slope stabilization strategies in affected waterways ▪ Establishment of silt traps, settling ponds and other sediment control measures across waterways or gullies ▪ Rehabilitation of exposed area (i.e. planting of erosion-control crops) • Use of vegetation to reduce and regulate the change in stream water depth, volume and flow • Earthworks will be undertaken preferably during dry weather.	SMMCI Contractor and sub-contractors	Php 2,750,000	EGF EMF EPEP

			• Stockpiles will be placed away from the water courses and protected against natural elements to prevent the transport of soil and sediment. • Drainage canals that will direct runoff to silt traps and settling ponds will be built around the stockpile to prevent sedimentation of nearby water bodies. • Water-sprinkling of dirt roads during construction will be implemented to reduce debris during the construction phase. • Upstream diversions channels will be established to prevent excessive runoff and prevent significant amount of water away from the tailings area. • Regular monitoring of the affected and adjacent creeks and streams prior, during, and even after the construction phase to monitor the water quality and ensure the continuous conformance of the water bodies to their respective water quality criteria. Water quality monitoring will be conducted on a monthly basis during the construction phase and quarterly during the operation phase of the project.			
Construction	Surface Water Quality	• Soil and rock will be disturbed during ground preparation, earthmoving activities, construction and maintenance of the mine facilities. The erosion of the exposed soils and rocks may transport significant amounts of sediment into nearby streams and rivers straddled by the mine footprint.	• A sediment and erosion control plan will be implemented for the project even before construction begins. This will involve: ○ Implementation of river bank and slope stabilization strategies in affected. ○ Waterways before earth moving activities are conducted. ○ Establishment of silt traps, settlement ponds and other sediment control measures across waterways or gullies. ○ Revegetation of exposed areas such as planting of soil cover crops. • Access roads will be concreted and provided with drainage systems to limit erosion. • Construction activities shall be limited during heavy rainfall or windy periods.	SMMCI Contractor and sub-contractors	Php 4,900,000	EPEP EGF
Construction	Surface Water Quality	• Construction of the TSF will result to siltation which will affect the water quality of nearby, water bodies. The construction of the TSF will cut through the channels of creeks and streams, thus hindering the continuous natural flow of water.	• Diversion channels of affected creeks and streams will be built prior to the construction of the TSF. • A sediment and erosion control plan will be implemented for the project even before construction begins. • To prevent transport of sediments downstream, drainage canals that will direct run-off to silt traps and settling ponds will be built around the stockpile. A water management plan will be implemented to maintain the integrity of impacted water bodies. The plan will include regular monitoring of the affected and adjacent creeks and streams prior, during, and	SMMCI	Php 2,150,000	EMF EPEP

			even after the construction phase to monitor the water quality and ensure the continuous conformance of the water bodies to their respective water quality criteria.			
Operation	Surface Water Quality	• Headwaters of Hinagasa-an river may come in contact with contaminated water of the TSF.	• Piakle Creek which will be encroached by the construction of the TSF area, will be diverted to go around the TSF and reconnect to Hinagasa-an river.	SMMCI		
Operation	Surface Water Quality	• During extreme rainfall events, the TSF and WSD may exceed their capacities which will entail release of effluents. Release of these effluents may degrade the water quality of the receiving and nearby water bodies.	• Site water management strategies will be implemented to ensure that effluents that will be discharged to the environment will comply with existing local standards and guidelines. This will involve: ○ Through a mine water management plan, the use of reclaim water from the TSF and mine will be maximized. ○ A wastewater treatment facility will be constructed to guarantee that discharge water quality is consistent with the receiving water body use. • Regular water quality monitoring will be conducted on locations where there is discharge from on-site sources, on-site water bodies and water bodies downstream from the site and background reference sites to substantiate the water quality impacts of the mine operation.	SMMCI	PHp 850,000	EMF EPEP
Construction, Operation	Surface Water Quality	• Chemicals in the TSF may become unstable overtime. Therefore, any potential seepage from the TSF may affect the water quality of streams nearby.	• TSF seepage and management monitoring shall be established which include: ▪ Pumped understorage system; ▪ Filter/drainage zones of the low permeability core; ▪ Seepage collection towers. • Regular surface water quality monitoring shall be conducted at established sampling stations even during the post closure phase. Water quality monitoring will be conducted quarterly during the operation phase of the project.	SMMCI	Php 8,000,000	EMF MWTF EPEP
Operation, Closure	Surface Water Quality	• The spillway of the TSF could induce flooding in the headwaters of Hinagasa-an river, thus altering water quality.	• The spillway will be designed to withstand extreme rainfall and flood events. Engineering design of the spillway will adhere to acceptable standards. • Regular monitoring of the affected and adjacent creeks and streams prior, during, and even after the construction phase to monitor the water quality and ensure the continuous conformance of the water bodies to their respective water quality criteria. Water quality monitoring will be conducted quarterly during the operation phase of the project.	SMMCI	Php 10,400,000	EMF EPEP
Operation, Closure	Surface Water Quality	• Effluent from the TSF and processed waste from the process plant may affect nearby water bodies.	• Contact water from the mine process facilities will be collected and stored in the TSF for chemical dilution and degradation. • Effluent from the TSF will undergo appropriate water treated prior to discharge to water bodies.	SMMCI	Php 10,400,000	EMF EPEP

			• Cyanide will be disintegrated in the TSF prior to discharge. • Regular effluent and surface water quality monitoring of the affected and adjacent creeks and streams.			
Operation, Closure	Surface Water Quality	• Dam breach and overtopping may cause contamination of streams within the headwaters of Hinagasa-an River.	• The TSF will be designed to meet internationally accepted standards on safe design and operating standards, while considering seismicity, potential geohazards, and rainfall and flood events. • Monitoring the integrity of these structures will be implemented regularly even after mine closure and rehabilitation. • An emergency response plan will be in place to manage any possible failure in the future. • Regular monitoring of the water quality of the surrounding water bodies will be established to ensure the integrity of the surrounding water bodies. Water quality monitoring will be conducted quarterly during the operation phase of the project.	SMMCI	Php 10,400,000	EGF EPEP
Construction, Operation, Closure	Surface Water Quality	• Hydrocarbon leaks, spills from vehicles, fuel tanks, used oil storage and oil-contaminated materials from the access roads, mine and process plant areas, maintenance workshops, motorpool and other support facilities may contaminate surface runoff, leading to surface water contamination. Such event may also occur during the storage, handling and transport of chemicals and reagents used in the process plant process, assay laboratory, and TSF.	• Motorpool area, maintenance workshop, and fuel storage area will be provided with proper drainage, Bunds and sorbents will be placed in the fuel and oil storage areas. • Proper handling of hydrocarbons and other hazardous materials and implementation of good housekeeping practices will be enforced to workers. • Waste oils, oily water and other hazardous wastes will be collected and disposed offsite by an accredited third-party waste hauler and treater. • Monitoring systems will be in place to immediately address any leakage.	SMMCI Contractor and sub-contractors	Php 7,350,000	EMF EPEP
Construction, Operation	Surface Water Quality	• Non-mine wastewater including domestic sewage discharges and residues from the administration and accommodation may contaminate the nearby streams if not properly handled.	• Sewage and other domestic discharges will not be treated onsite; Storage will be in the form of septic tanks and hauled by an accredited third-party hauler. • A Waste Management Plan for non-mine wastes will be implemented to address collection, handling, transport, treatment and disposal of generated wastes.	SMMCI Contractor and sub-contractors	Php 400,000	EMF EPEP
Operation, Closure	Groundwater Quality	• Dam breach and overtopping may cause contamination of the springs and other groundwater sources.	• The TSF will be designed to meet internationally accepted standards on safe design and operating standards, while considering seismicity, potential geohazards, and rainfall and flood events.	SMMCI	Php 7,200,000	EGF EMF EPEP

			• Monitoring the integrity of these structures will be implemented regularly even after mine closure and rehabilitation. • An emergency response plan will be in place to manage any possible failure in the future. • Site water management strategies will be established to ensure the integrity of the surrounding water bodies.			
Construction, Operation	Aquatic Ecology	• Potential impacts on the alteration of hydrological regimes such as change in water flow and volume or size of surface water ways due to inducement of flooding, particularly in the headwaters of Hinagasa-an River during discharges from the TSF. Flooding may cause expansion of these natural habitats that could eventually alter aquatic biota (i.e. plankton, periphyton, macrobenthos, and fish) assemblage and abundance.	• A comprehensive monitoring plan in accordance with the environmental monitoring plan in the approved EIS will be implemented to assess the potential impacts of the project on the aquatic habitat and biota during construction and operation phases. • Enhancement of the riparian vegetation along the upstream tributaries of Hinagasa-an River will be undertaken in accordance with the Biodiversity Management Plan. Progressive rehabilitation will also be undertaken. • Water management measures will be designed and implemented to intercept and divert surface run-off.	SMMCI	Php 1,350,000	EMF EPEP
Construction, Operation	Aquatic Ecology	• Potential change in water quality such as increase in TSS and turbidity, reduction in dissolved oxygen levels, and increase in acidity and metal concentrations and possible presence of PAF and weathering of minerals. Potential change in water quality are anticipated in tributaries of Hinagasa-an River north of the TSF. Furthermore, discharge from the TSF will potentially change the water quality of the Piakle and Hinapuyan Creek, which ultimately drains to the Hinagasa-an River due to the discharges from the TSF. Change in water quality can potentially alter species composition and abundance, only favouring those groups of organisms that are tolerant to the physico-chemical changes in their environment.	• A best practice on sediment and erosion control will be designed and implemented prior to construction activities to minimize mine-induced erosion. • The bench and contour drains will convey pit water during dewatering to sedimentation ponds. To mitigate seepage, underdrains and seepage ponds will also installed. • To mitigate leaching from PAFs, whenever encountered during activities, PAFs will be disposed in the TSF. • Wastewater treatment plant will be constructed to guarantee that the quality of the water discharged to adjacent waterways is in accordance with the DENR standards and will not significantly impact the aquatic biota. • A comprehensive monitoring plan in accordance with the environmental monitoring plan in the approved EIS will be implemented to assess the potential impacts of the project on the aquatic habitat and biota during construction and operation phases. Monitoring stations will be coincident with the water quality monitoring stations.	SMMCI	Php 1,750,000	EMF EPEP
Construction, Operation	Aquatic Ecology	• Potential reduction in volumetric flow Hinagasa-an river due to the diversion of its tributary (Hinapuyan Creek). The sudden drainage of pools or rapid drop in stream flow have localized and significant effects on aquatic	• Identification of conservation area for management, where feasible, through ongoing monitoring. • Enhancement of the riparian vegetation along the Piakle and Hinapuyan Creeks will be undertaken in accordance with the	SMMCI	Php 1,750,000	EMF EPEP

		organisms sensitive to desiccation and this potential effect is exacerbated on periods of low or no flow during dry season.	Biodiversity Management Plan to maintain flow channel to support continuous pathway for aquatic species. • Progressive rehabilitation will also be undertaken.			
Construction, Operation	Aquatic Ecology	• Potential partial or complete loss of portions of the headwaters of the Hinagasa-an River that are within the location of the This potential impact will limit upstream/ downstream migration of aquatic organisms.	• Habitat loss will be unavoidable but will be minimized through proper planning and management (e.g. limit the extent of surface disturbance areas, set buffer zones, and progressive rehabilitation). • Portion of the Hinagasa-an River headwaters where TSF will be placed will be diverted. • A comprehensive monitoring plan in accordance with the approved environmental plan in the EIS will be implemented to assess the potential impacts of the project on the aquatic habitat and biota during construction and operation phases. Monitoring stations will be coincident with the water quality monitoring stations. • Enhancement of the riparian vegetation along the Timamana and Boyongan Creek will be undertaken in accordance with the Biodiversity Management Plan. Progressive rehabilitation will also be undertaken.	SMMCI	Php 1,750,000	EGF EMF EPEP
Construction, Operation	Aquatic Ecology	• Potential partial or complete loss of water resources due to the formation of open cracks and fissure during subsidence and sudden drainage of pools or rapid drop in stream flow may have localized and significant effects on aquatic organisms sensitive to desiccation. • Potential increase in the incidence of bank scouring that will eventually alter the physical characteristics of the aquatic habitats.	• Habitat loss will be unavoidable but will be minimized through proper planning and management (e.g. limit the extent of surface disturbance areas, set buffer zones). • Revegetation will be undertaken in accordance with the rehabilitation plan.	SMMCI	Php 1,750,000	EMF EPEP FMRDP

THE AIR						
Construction, Operation	Micro-climate	• Surigao Del Norte is projected to have approximately 22 days of extreme rainfall (>200mm) during the 2006-2035 period (centered at 2020) and 38 days during the 2036-2065 period (centered at 2050).	• The following mitigation measures for the potential enhancement of the project to climate change impacts are in conjunction with the mitigation measures in Section 2.2.1 (Hydrology and Hydrogeology) of this EIS: ▪ All pumped water from the underground mine will be discharge to water storage/sediment ponds for use in the process plant with the surplus conveyed to the TSF. Clean water will be prevented from entering the underground mine through diversion drains. ▪ The TSF is provided with sufficient freeboard to contain any excess flows from the catchments. This facility will also be provided with spillway with control gates to regulate the release of excess water to the Hinagasa-an River via the Piakle Creek.	SMMCI	Php 6,300,000	EGF EMF EPEP MWTF
Construction, Operation	Greenhouse Gas	Greenhouse gas emissions due to vegetation removal and land use change • Vegetation removal and land use change due to the construction of the Underground mining, TSF, crushing and mine facilities such as the mill, access roads, offices, and camps may decrease carbon sequestration potential in the project area. The total estimated greenhouse gas emissions of the project due to vegetation removal and land use change is approximately 256,499.90 tonnes of CO_2. This equates to a decrease of 0.2% to the Philippines' GHG sequestration (sink) potential. Compared to the global AFOLU economic sector, the Project is expected to contribute approximately 0.0022%.	• Wherever feasible, the infrastructure will be designed in such a way that vegetation clearing will be reduced. If vegetation clearing is unavoidable, easement of the major components especially pipelines and access roads should be reduced or limited to maintain considerable amount of vegetation cover. • Wherever feasible, vegetation communities classified as brush and shrub lands that are known to be derivatives of previous residual forests should be maintained and rehabilitated for possible sources of propagules for forest nursery establishment. • To contain the area of disturbance, the extent of disturbance shall be clearly identified on the plans and on the ground prior to construction activities. • As part of the Forest Management Bureau (FMB)-Department of Environment and Natural Resources (DENR) statutory requirements, all relevant permits (e.g. Special Tree Cutting Permit) will be secured from concerned agencies prior to any cutting activities. • Establishment of buffer zones around identified stepping corridors should be done to provide protection to remaining sources of propagules. If strips of remnant vegetation	SMMCI	Php 6,300,000	EMF EPEP

			(corridor) will not be feasible, patches of vegetation about 0.5 ha (stepping stones) with intervals of about 0.5 to 2 km shall be retained along the boundaries of proposed major infrastructure. • Progressive rehabilitation (within or outside the project site) will be undertaken as soon as areas for rehabilitation become available. Rehabilitation areas will at least be equivalent to the areas cleared of vegetation. • Open areas and grasslands that will not be affected by the Project shall be revegetated where feasible. • Forests communities outside the project site shall be identified. Long term protection of the identified sites shall be provided to serve as compensatory measures to offset the project's GHG emissions from vegetation clearing. The areas that shall be identified as biodiversity offset, ideally, shall contain vegetation communities that are similar to areas to be cleared for the project. • Resident forester/s shall be engaged to oversee and manage the revegetation/regeneration works as appropriate. • Establishment of appropriate reference sites to quantify and better understand the impacts resulting from mining activities will also be established. Regular monitoring of vegetation within the project site and reference sites to quantify the change over time will also be implemented.			
Construction, Operation	Greenhouse Gas	Greenhouse gas emissions due to the consumption of fossil fuels • The annual greenhouse gas emissions associated with the combustion of fossil fuels of the Silangan Copper-Gold Project (8,011.72 tonnes of CO2-e per year) is expected to contribute approximately 0.008% of the annual Philippine emissions (excluding LULUCF) for Years 1 and 2. This equates to approximately	• Fuel and equipment efficiency will be considered prior to construction and operation activities. • Accounting, reporting, and reduction program/campaign will be undertaken to remove or minimize unnecessary GHG emissions. • Low Sulphur fuel will be utilized for use in order to minimize emissions and maximize equipment efficiency. • Fuel efficiency will be maximized through scheduling of vehicle and equipment movements in order to minimize both idle time and distances travelled.	SMMCI Contractor and sub-contractors	Php 6,300,000	EMF EPEP

		0.000022% of the global GHG emissions (excluding AFOLU) • In Year 3 to Year 26, the annual greenhouse gas emissions associated with the combustion of fossil of the Project fuels (27,507.77 tonnes of CO2-e per year) is expected to contribute approximately 0.021% of the annual Philippine emissions (excluding LULUCF) and approximately 0.000073% of the global GHG emissions (excluding AFOLU) • In Year 27, the Project is expected to contribute approximately 0.013% of the annual Philippine emissions (excluding LULUCF) and 0.000044 of the annual global emissions (excluding AFOLU) • The combustion of fossil fuels by mobile equipment during construction and operation is expected to contribute approximately 0.024% of the Philippine Energy Sector emissions and 0.00025% of the global Transport sector emissions. • The consumption of fossil fuel by the Project's processing is expected to contribute approximately 0.029% of the Philippine Energy Sector and 0.00016% of the global Electricity and Heat Production economic sector.	• Equipment and vehicle loadings will be optimised through accurate monitoring and calculation of fuel requirements in order to reduce fuel weight and improve fuel efficiency. • Vehicles and mining equipment will be regularly maintained in order to increase efficiency, reduce fuel use, and help reduce costs associated with equipment downtime. • Equipment dispatch will be monitored closely in order to eliminate unnecessary use and to increase efficiency of			
Construction, Operation	Greenhouse Gas	Enhancement of the Project to climate change through GHG emissions • The annual greenhouse gas emissions associated with the combustion of fossil fuels of the Silangan Copper-Gold Project is expected to contribute approximately 0.006% in Year 1 and Year 2, approximately 0.021% Year 3 to Year 26, and 0.013% in Year 27 of the annual Philippine emissions (excluding LULUCF).	• While the project may emit approximately 8,011.72 to 27,682.43 tonnes of CO2-e per year due to consumption of fossil fuels and approximately 0.2% reduction in the Philippines' potential carbon sequestration, these values are minimal when compared to the annual global and Philippine GHG emissions. The direct impacts of the project to climate change are difficult to determine and estimate since climate change is a global phenomenon. Indirect contributions are far more difficult to determine. Nevertheless, the mitigating measures to address the potential impacts of the Project to	SMMCI	Php 13,800,000	EMF EPEP

		• The total estimated greenhouse gas emissions of the project due to vegetation removal and land use change is approximately 256,499.90 tonnes of CO2. This equates to a decrease of 0.2% of the Philippines' potential GHG sequestration (sink). • While the project may release greenhouse gases in the atmosphere, these values are very minimal and potentially negligible when compared to the global and Philippine emissions, and any climate change impacts in the region are not likely to be Project –related. The direct impacts of the project to climate change are difficult to determine and estimate since climate change is a global phenomenon. Indirect contributions are far more difficult to determine.	the enhancement of the effects of climate change in terms of GHG emissions are the same as above.			
Construction, Operation	Air quality	• Fugitive emissions that may be generated from unpaved roads, hauling, storage and handling of materials, mine processing, , construction activities, and stockpiles, may increase the ground level concentration of particulates (particulate metals (Hg, Pb, Cd, As, and Cr),TSP, and PM_{10} and may degrade the air quality of the area.	• Fugitive dust from vehicular traffic and material handling activities will be controlled by management of vehicle speeds and application of regular water suppression to unpaved haul roads and stockpiles whenever visible dust is observed. • Regular dust monitoring will be conducted within the project site and near the sensitive receptors. • A buffer zone of at least 200 m for the subsidence and mine facilities will be enforced to mitigate potential dust emissions • To prevent dust dispersion from stockpiles, erosion control will be applied, and stockpiles will be vegetated with grass cover to prevent dust from being blown by the wind • Workers will be provided with the appropriate personal protective equipment pursuant to BWC-DOLE Occupational Safety and Health Standards to protect them from disease associated with dusts.	SMMCI Contractor and sub-contractors	Php 6,300,000	EMF EPEP
Construction, Operation	Air quality	• Combustion of fossil fuel by vehicles, mining equipment, and processing may increase the ground level concentrations of particulate matter (TSP and PM_{10}), NO_x, and SO_x and may degrade the air quality of the area.	• Sub-contractors will be required to undergo and pass the government vehicle emission tests prior to contract award; • Exhaust fumes from vehicles, mining equipment, and other fuel burning equipment will be managed through the use of low sulphur fuel where possible • Standard occupational health and safety practices will be implemented pursuant to BWC-DOLE Occupational Safety and Health Standards; • Traffic management guidelines will be incorporated in worker's and subcontractor's induction seminar. Guidelines	SMMCI Contractor and sub-contractors	Php 6,300,000	EMF EPEP

			will include control in vehicle speed and spraying of road routes and work sites as well as transport routes near the host communities; and • Fuel efficiency will be maximised through scheduling of vehicle and equipment movements in order to minimise both idle time and distances travelled. • Equipment and vehicle loadings will be optimised through accurate monitoring and calculation of fuel requirements in order to reduce fuel weight and improve fuel efficiency. • Vehicles and mining equipment will be regularly maintained in order to increase efficiency, reduce fuel use, and help reduce costs associated with equipment downtime. • Equipment dispatch will be monitored closely in order to eliminate unnecessary use and to increase efficiency of use. • Regular air quality monitoring will be conducted within the project site and near the sensitive receptors. The sampling stations may be used as monitoring stations once the project goes into construction and operations phase.			
Construction, Operation	Air quality	• Climate change has the potential to have a critical influence in altering air pollutant dispersal and may frequently form inversion layers that effectively trap ground level pollutants for longer times. By increasing the ground-level concentrations of dusts, particulates, and gaseous pollutants, an inversion can lead to increased pollution such as smog being trapped close to the ground, having possible effects on health. • Emissions of SO_x and NO_x into the atmosphere may increase the potential to form acid rains. Wet deposition of acidic rain may occur more frequently, and acids may fall to the ground in the form of rain. During decreased rainfall in the dry periods, the increased acid chemicals in the atmosphere may be incorporated into the dusts and particulates and fall to the ground through dry deposition. Dry deposited gases may be washed by rainstorms which can lead to increased run-off.	• The Project may have the potential to enhance climate change impacts in the area by introducing particulates and gaseous pollutants in the atmosphere. Measures to minimize the Projects' contribution to the effects of climate change are the same as above.	SMMCI	Php 6,300,000	EMF EPEP

Construction, Operation	Ambient noise	• Noise levels are expected to increase from baseline levels during construction and mine operation due to blasting operations, vehicular movement, and equipment operations. • Noise associated with heavy earthmoving machineries, vehicle engines, and loading and unloading of rock into steel dumpers/ chutes are noted as the highest contributors of noise. Haul roads are likely to be the noisiest activities.	• The host communities will be kept informed of the duration and timing of any noisy construction works and blasting activities. Noisy activities will be scheduled to avoid sensitive times wherever possible; • Heavy equipment and machineries that produce high levels of noise will be fitted with mufflers or silencers; • Speed of vehicles will be limited on roads, and vehicle horn signals will be kept at a low volume, if necessary, such that the noise generated by the ingress and egress of vehicles will be minimized; • Appropriate personal protective equipment (PPE) that conforms to the Procedural Guidelines Governing Occupational Safety and Health in the Construction Industry as per BWC-DOLE DO 1998-13 will be provided to operators and workers who handle heavy equipment that generates high levels of noise; • Work involving handling of noisy and/or vibrating power tools/equipment shall be a maximum of 2 hours per day (for 8-hour work, duty cycle should be 1:4) in conformity to the requirements of BWC-DOLE DO 1998-13 and the Occupational Safety and Health Standards (As Amended, 1989); • Regular maintenance of all vehicles, machinery, and heavy equipment will be ensured and noise generating equipment will be controlled by installation of noise damping barriers/guards; • To mitigate impacts to noise-sensitive wildlife, SMMCI will establish a buffer zone which is a vegetated area or a natural buffer to accommodate these wildlife; and • Ambient noise level monitoring will be done regularly within the perimeter of the Silangan Copper-Gold Mine Project and near the sensitive receptors in the baseline sampling stations discussed in this EIS to control noise levels and meet the recommended criterion.	SMMCI Contractor and sub-contractors	Php 6,300,000	EMF EPEP
THE PEOPLE						
Construction, Operation, Closure	People	• Potential displacement of households. • Apprehensions regarding issues of right-of-way and disturbance to properties, daily living and livelihood brought about by construction and operations activities may occur.	• There will be no physical displacement of families from their residences. The whole area is already bought by SMMCI. All households that needed to be relocated were already relocated during the pre-construction phase of the previous ECC.	SMMCI LGU	Php 100,000	SDP/SDMP

			• Conduct an IEC program among displaced families, updating them on the mining operations and changes on the mining operations. Continuous IEC will be conducted to help them cope with their new living environment. The IEC campaign will also include topics regarding right-of-way acquisition and compensation for disturbance will also be included. • Preparation and implementation of a Community Development Plan (CDP) during pre-construction and construction, and Social Development Management Plan (SDMP) for the operation phase.			
Construction, Operation	People	• Uncontrolled in-migration may occur due to people seeking jobs and mining-related economic opportunities. There may be informal settlements and other forms of non-conforming land-uses	• Some previous landowners were allowed to stay inside the area owned by SMMCI and in return they secure and protect the area from trespassers and stop informal settlers from entering.	SMMCI Stakeholders		
Construction, Operation	People	• Migration to the host municipalities/barangays in search of jobs and mining related economic opportunities is expected. These migrants will consist of single persons or families • As a consequence of uncontrolled migration, there would be informal settlements and other forms of non-conforming land-uses • Significant numbers of migrants could also diminish social cohesiveness and diminish traditional mechanisms of social control in host communities	• Strengthen value-formation among current residents of host communities through seminars and other culturally-appropriate forms of meetings. • Forward land-use planning and zoning by LGUs in anticipation of migration. Strict enforcement of land-use and zoning regulations. Monitoring of potential sites where migrants could settle. • Provision of accommodation by project proponent for migrant workers. Institute guidelines regarding the conduct of workers (local and migrant) regarding conduct in local communities.	SMMCI	Php 100,000	SDP/SDMP
Construction, Operation	People	• Local cohesion may be affected because of the presence of local migrant workers • Introduction of new forms of entertainment that might affect traditional family and community life	• Provide protocols and guidelines for worker behavior and conduct especially in local host communities • Strengthen value-formation among current residents of host communities through seminars and other culturally-appropriate forms of meetings	SMMCI Contractor and sub-contractors	Php 100,000	SDP/SDMP

Construction, Operation	People	• It is possible that public services may be stretched because of the influx of newcomers in search of employment opportunities • New comers (whether hired or not) may also compete with established local residents in the use of resources, e.g., springs, sources of firewood, game, etc.	• The SDMP, among other means of assistance, will augment social services provided by government agencies • Local government revenues will also increase because of mining operations and can be used to expand public services • With the objective to exert best efforts to locally hire at least 50% of the operations workforce from the host communities, families below the poverty threshold will be reduced by 65%; consequently families below the food threshold will be also reduced by even a larger proportion (no less than 65%). Local-hiring will result to increased income (up by 39% from current levels) that will allow families to purchase more food, particularly rice, even if this staple has to be supplied from sources other than the host municipalities.	SMMCI Contractor and sub-contractors LGU	Php 100,000	SDP/SDMP
Construction, Operation	People	• Increase of human and non-human wastes due to in-migration • Prevalence and spread of communicable diseases due to in-migration • Prevalence of respiratory diseases due to likely increase of dust during various phases of mine activities • Increase in vehicle-related and work-related accidents • Potential occurrence/prevalence of sexually-transmitted diseases • Possible increase in pollution particularly of air, water and land due to influx of people and vehicles and start of mine activities	• Enhance existing waste disposal systems and methods within communities and also within the plant and construction area by strict compliance to the provisions of RA 9003. This will include proper handling, storage and disposal of all kinds of wastes especially those produced by the plant and/or construction area. • Establish Material Recovery Facilities (MRFs) in key barangays. e.g. Timamana • Create a purok or barangay herb, vegetable or ornamental garden to utilize organic fertilizers produced from compost • Increase provision and/or installation of sanitation or toilet facilities. • Conduct Air Quality Monitoring initially and every quarter. • Prepare a Water Management Plan which will include Water Quality Monitoring. • Conduct a Health Impact Assessment (HIA) to identify potential health implications on local communities and the management measures to be carried on. • Establish programs such as Occupational Safety and Health Program, Hazardous Waste Management Program and Emergency Response Program to all workers and conduct activities in relation to these programs. This will include the creation of an Emergency Response Team,	SMMCI Contractor and sub-contractors	Php 300,000	EMF SDP/SDMP

Construction, Operation	People	• Inadequacy or disruption of social and health services • Community dislocation brought about by development caused by various factors such in migration due to employment opportunities • Increased demand for limited health resources • Increased incidences of crime • Prevalence of social problems such as drugs, alcohol, gambling and prostitution.	• Design and implement a SDMP considering/addressing the local needs and requirements of a community on a sustainable basis. The plan may include investments in health and social services. • Enhance security within communities. Make visible the presence of police, *barangay tanods* and other agents of peace and order.	SMMCI LGU	Php 100,000	SDP/SDMP
Construction, Operation	Local Economy	• One thousand and fifty-two workers are projected to be hired for the construction phase; 2,401 for operations. Assuming that one-half of the construction and operations work force are source from the local host communities (respectively at 526 and 1,200), the impact on employment, income, and poverty reduction will be significant. • Average monthly family income (currently at PHP5,803/mo) will increase by 39%% to PHP9490 assuming a daily wage of PHP365/day for 26 working days per month. Such increase will allow families greater access to goods and services and eeconsequently improve the quality of life and standard of living. • Poverty in the host barangays (currently at 74% of all families and ranging from 63-84% across barangays) will be reduced by 28 % and 65% during construction and operation respectively because of local hiring. The number of families below the food threshold will also be reduced. Food budgets will be adequate to meet the daily nutritional requirements of families where one member is hired by the project proponent. • During the operations stage, PHP55M will be infused into the immediate local economy (mostly host communities) by way of expenditures on food and food-related items (FFRI) of 1,200 locally-hired employees from the host communities; such an amount will have a business turn-over of 6.6 times generating PHP368M to various levels of the economy inclusive of PHP102M to the immediate local	• Assist the local governments (particularly at the municipal and provincial levels) to develop and to assist their respective Public Employment Services Offices (PESOs). Institute a system of verification regarding local residency in respect to hiring. • Training programs for required skills for residents of host communities • Training programs for local governments on revenue generation and management	SMMCI Contractor and sub-contractors LGU	Php 100,000	SDP/SDMP

		economy and PHP176M to the local to the provincial economies. • FFRI expenditures will result to 96,685 employment days for the local economies (host communities to the provincial level) for the equivalent of 269 full-time jobs inclusive of 153 in the host communities. • Locally hired residents will gain additional and marketable skills • Local revenues and other forms of payments (e.g., royalties) will flow to host communities because of mining operations. Local shares of national taxes will also increase.				

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Environmental Impact Statement

Section 4. ERA

Table of Contents

4.0 Environmental Risk Assessment and Environmental Response Policy and Guidelines 4-1
4.1 Background 4-1
4.2 Conceptual Framework, Approach and Methodology 4-1
4.2.1 Terminologies Used 4-1
4.2.2 Conceptual Framework 4-2
4.2.3 Approach and Methodology 4-2
4.3 Hazards Identification 4-4
4.3.1 Physical Hazards 4-4
4.3.1.1 Geologic Hazards 4-4
4.3.1.2 Climactic and Atmospheric Hazards 4-7
4.3.1.3 Geotechnical Hazards 4-8
4.3.2 Chemical Hazards 4-11
4.3.2.1 Explosives 4-12
4.3.2.2 Flammable Substances 4-13
4.3.2.3 Corrosive Substances 4-13
4.3.2.4 Oxidizing Substances ....
4.3.2.5 Toxic Substances 4-14
4.3.3 Occupational Hazards 4-14
4.3.3.1 Working Underground 4-14
4.3.3.2 Mechanical Hazards 4-14
4.3.3.3 Electrical Hazards 4-15
4.3.3.4 Pressure Hazards 4-15
4.3.3.5 Temperature Hazards 4-15
4.3.3.6 Biological Hazards 4-15
4.3.3.7 Radiation Hazards 4-16
4.3.3.8 Noise Hazards 4-16
4.3.3.9 Gravity Hazards 4-16
4.3.3.10 Motion Hazards 4-17
4.3.3.11 Insurgency 4-17
4.4 Risk Assessment 4-17
4.4.1 Quantitative Risk Assessment 4-17
4.4.1.1 Consequence Analysis 4-17
4.4.1.2 Frequency Analysis 4-19
4.4.1.3 Risk Estimation 4-20
4.4.2 Qualitative Risk Assessment 4-21

4.5 Risk Management 4-28
4.5.1 Chemical Hazards 4-28
4.5.2 Physical Hazards 4-29
4.5.2.1 Design Considerations 4-29
4.5.2.2 Monitoring 4-30

4.0 Environmental Risk Assessment and Environmental Response Policy and Guidelines

4.1 Background

The Environmental Risk Assessment (ERA) for the Silangan Copper-Gold Mine Project is prepared based on the requirements of the Philippine EIS Systems (PEISS), Annex 2-7e of the Revised Procedural Manual (RPM) of Department of Environment and Natural Resources (DENR) Administrative Order 30 series of 2003 (DAO 2003-30), and the scope listed in the Technical Scoping Checklist (TSC) signed last March 11, 2019. The scope includes:

- Discussions of safety risks such as fire, explosion, and release of toxic substances;
- Description of conditions, events and circumstances which could be significant in bringing about identified safety risks and physical risks;
- Description and assessment of the possible accident scenarios posing risk to the environment;
- Description of the hazards, both immediate (acute effects) and delayed (chronic effects) for man and the environment posed by the release of toxic substance, as applicable;
- Description of conditions, events, and “trigger” which could bring about identified physical risks;
- Assessing the project location’s vulnerability to extreme climate events for the years 2020 and 2050 that could contribute in triggering identified scenarios such as heavy rainfall or elevated temperature; and
- Discussion of safety and emergency policies consistent with the Mines and Geosciences Bureau (MGB) requirements and also considers natural hazards to the infrastructures and facilities.

4.2 Conceptual Framework, Approach and Methodology

4.2.1 Terminologies Used

Table 4-1 enumerates and defines the different terms used in preliminary risk screening study for the Silangan Copper/Gold Mine Project.

Table 4-1 Terminology for the Environmental Risk Assessment

Term	Definition
Hazard	Physical situation with a potential for human injury, damage to the environment, damage to property, or a combination of these. It is the potential for an agent or process to cause harm.
Risk	The possibility that a harmful event (death, injury or loss) arising from exposure to a chemical or physical agent may occur under specific conditions; or alternatively, the expected frequency of occurrence of a harmful event (death, injury or loss) arising from exposure to a chemical or physical agent under specific conditions (UNEP/IPCS, 2000).
Hazard Identification	It comprises the determination of all possible events or processes that could lead to disastrous or fatal incidents, defining inherent and potential hazards of the substances/materials used, also the process hazards with potential to adversely affect project personnel, the public and the environment.
Risk Assessment	The identification and quantification of the risk resulting from a specific use or occurrence of a chemical or physical agent, taking into account possible harmful effects on individual people or society of using the chemical or physical agent in the amount and manner proposed and all the possible routes of exposure. Quantification ideally requires the establishment of dose-effect and dose-response relationships in likely target individuals and populations (UNEP/IPCS, 2000).

Term	Definition
Risk Estimation	Determination of the outcome of an activity taking into account the probability of occurrence. To obtain risk, the product function of the frequency and consequence analyses must be determined.
Risk Management	Logical and systematic method of identifying, analyzing, assessing, mitigating, monitoring and communicating risks associated with any activity, function or process in a manner that would enable the proponent to minimize losses and maximize opportunities.

4.2.2 Conceptual Framework

Risk assessment is the scientific determination of the levels of risk related to situations and recognized threats inherent to a project, with the ultimate objective of proposing management solutions to bring risk exposure to acceptable and manageable levels. It involves three basic steps:

- Identification of hazards such as substances, activities, processes and natural phenomena that may cause harm or deterioration of safety;
- Evaluation of the magnitude and frequency occurrence of hazards, and their possible consequences to the environment; and
- Determination of appropriate measures to eliminate or control the hazards.

A conceptual flow diagram for ERA is shown in **Figure 4-1**.

Figure 4-1 Conceptual flow diagram for qualitative risk assessment

The levels of hazardous substances present at the project site warrants only the preparation of a risk screening study. Faults will be tabulated in a matrix along with the consequences and outcomes of such faults. The probability of such consequences and outcomes are identified in an unmitigated scenario. The probability is repeated after safety and mitigation measures are applied. See **Annex 4-1** for the risk register for the Silangan Copper/Gold Mine Project.

4.2.3 Approach and Methodology

This risk assessment is based on the ERA procedural guidelines prescribed in Annex 2-7e of the Revised Procedural Manual of DAO 2003-30 (**Annex 4-2)**. Projects are categorized based on the hazardous substance inventory to be used in project operations and related activities. There are three threshold levels of coverage and scoping requirements detailed in Procedural Guidelines for Scoping of ERA.

- **Level 2** – Requires to prepare a Quantitative Risk Assessment (QRA) and an Emergency/Contingency Plan;
- **Level 1** – Requires to prepare an Emergency/Contingency Plan only; and
- **Risk Screening Level** – Requires conducting a risk screening study.

Table 4-2 below lists the hazardous substances expected to be used and/or produced by the Silangan Copper-Gold Mine Project.

Table 4-2 Threshold levels of hazardous substances for the Silangan Copper-GoldProject

Hazard Category	Threshold (MT)		Storage Inventory (MT)	Coverage
	Level 1	Level 2		
Explosives	10	50	1,500	Level 2
Flammable substances	5,000	50,000	5,503	Level 1
Highly flammable substances	50	200	12	Will not reach threshold. Risk screening only.
Extremely flammable substances	10	50	119	Level 2
Oxidising substances	50	200	15	Will not reach threshold. Risk screening only.
Toxic substances (low)	50	200	18,962	Level 2
Toxic substances (medium)	10	50	175	Level 2
Toxic substances (high)	5	20	417	Level 2
Toxic substances (very high)	0.2	1	none	n/a
Toxic substances (extreme)	0.001	0.1	none	n/a
Unclassified Type A (substances or preparations that react violently with water)	100	500	none	n/a
Unclassified Type B (substances or preparations which release or liberate toxic gas in contact with water)	50	200	none	n/a

Explosives are in the form of ANFO and emulsion which will be used to blast the sublevel caves during the construction and operations phases. Explosives may also be used during the construction of the TSF when unrippable rocks are encountered. It is estimated that 1,500 MT of explosives and accessories will be stored on site at any given time which exceeded the Level 2 threshold inventory. Diesel will be used as fuel for all the generators and heavy equipment that will be used in the project. It is estimated that a maximum 3,527 MT of diesel fuel will be stored at any given time. Methyl Isobutyl Carbinol (MIBC) which is a highly flammable substance will be stored at a level of 5 MT at any given time and will not exceed the Level 1 threshold inventory. All materials considered flammable added up to 5,503 MT which exceeded the Level 1 threshold inventory. Low, medium and highly toxic substances will be stored at the project at any given time at 18,962 MT, 175 MT and 417 MT respectively and all will exceed Level 2 threshold inventory. Maximum on-site storage of sulphuric acid and cyanide will reach 10,000 MT and 234 MT respectively. For a detail list of toxic substances, see **Table 4-5**. Lead-acid batteries and used oil will also be produced during the regular maintenance of the generators and heavy equipment but are expected to be minimal and should not reach Level 1 threshold level.

Based in Annex 2-7e of DAO 2003-30, much of the hazardous materials and chemicals to be stored at any given time for the Silangan Copper-Gold Mine Project exceeds Level 2. Thus, a Level 2 ERA must be conducted to satisfy the requirements in the TSC.

4.3 Hazards Identification

Hazard is defined as a physical situation with a potential for human injury, damage to the environment, damage to property, or a combination of these. The hazards identified in the Project are categorized under physical, chemical and occupational hazards:

- Physical hazards include naturally occurring phenomena or events that are triggered by natural physical conditions that pose as threats people and the environment;
- Chemical and process hazards involve materials that can induce hazardous chemical processes that threat the physical safety of people and the environment; and
- Occupational hazards are objects, events or conditions that may cause physical, emotional, and mental harm to personnel.

4.3.1 Physical Hazards

4.3.1.1 Geologic Hazards

Geologic hazards are natural phenomena that arise from different earth processes resulting in adverse effects on life and property when exposed to these events. This section presents an abbreviated discussion of findings presented in **Section 2.1.2.3.6** (“Geohazards”).

Of the common types of geologic hazards, the following have been identified to have possible occurrences and impacts on the project:

- Ground Shaking;
- Ground Rupture;
- Liquefaction
- Earthquake-induced slope failures and mass wasting;
- Rain-induced slope failures and mass wasting;
- Flooding;
- Volcanic Hazards; and
- Differential Settlement.

4.3.1.1.1 Ground Shaking

Ground shaking is the most common hazard associated with seismic activity. Vertical and horizontal movements of the ground are a manifestation of the propagation of surface waves emanating from an earthquake source, typically active faults and trenches. The heaving and lurching of the ground causes existing foundations and structures to shift and settle from a previously stable static state. Buildings can lean or tip over. Foundations can subside or be thrust upward. The ground can liquefy or rupture. Ground shaking itself can be a trigger for these other seismic hazards.

Several active tectonic structures bound the project site, including the Philippine Fault and the Philippine Trench. The historical instrumental seismicity map generated for the Project (**Figure 2.1-10**) shows that a majority of the inland seismic events are found along the Surigao Segment of the Philippine Fault, with a nearest distance of 8 km west of the project site. There are much more numerous events that originated offshore, attributed to the Philippine Trench located some 140 km to the northeast. Both these structures have been assessed by PHIVOLCS as capable of generating M8.0 events.

Using the attenuation formula developed by Fukushima and Tanaka (1990) and assuming a M8.0 Philippine Fault Surigao Segment source (the nearest active fault with documented seismicity), computed average peak ground acceleration values can range from 0.317 (rock) to 0.49soft soil) *g*. The calculated peak ground acceleration (PGA) values for this earthquake scenario is equivalent to a Modified Mercalli Intensity rating of VII – IX (moderate to violent) having Destructive to Very Destructive impacts as classified under the PHIVOLCS Earthquake Intensity Scale. Probabilistically, as indicated in the Thenhaus et al. (1994) and USGS (2009) seismic hazard maps, the proposed project site can anticipate PGAs of 0.29 to 0.49 *g* (2.8 to 4.8 m/s^2) in 475 years, assuming bedrock foundation for the Thenhause et al. (1994) computation (0.29 *g*).

The TSF seismicity design criteria is presented in Table 4-3. The seismicity design criteria exceeds the MGB requirement of 0.15g for OBE and 0.25 g for MCE.

Table 4-3 TSF Design Criteria - Seismicity

Parameter	Value
Design earthquake loadings (minimum)	
Operating Base Earthquake (OBE)	0.61g (Equivalent to M7.55 event, occurring 3.3 km east of the site on the Philippine Fault Zone, at a depth of 10 km)
Maximum Design Earthquake (MDE)	0.68g (Equivalent to M7.60 event, occurring 3.3 km east of the site on the Philippine Fault Zone, at a depth of 5 km)
Post Closure	Maximum Credible Earthquake (MCE)
Allowable deformation under seismic loading	Deformation will not cause severing of filter or drains. Deformation < available freeboard

4.3.1.1.2 Ground Rupture

Ground rupture is the breakage of ground surface as a result of ground movement along a fault. It may occur suddenly during an earthquake, or gradually, as an effect of fault creep progression. The ground is displaced on either side of a ground rupture: dip-slip faulting have surface ruptures that feature vertical offset, while strike-slip faulting has a lateral displacement. It is also possible to have movement that is the combination of horizontal and vertical slippage. Ground ruptures almost always follow pre-existing faults. Developments along identified or hidden fault zones are at risk of structural damage if old fault lines are reactivated.

Written accounts of the 1879 Surigao earthquake, attributed to the Surigao Segment of the Philippine Fault, indicate that approximately half a meter drop was observed across the plains located south of Lake Mainit in Augsan del Norte, while aerial photograph interpretation and field mapping revealed offset streams and fault scarps (Perez, Tsutsumi, Ishimira, Cahulogan, & Cabanlit, 2009). Measurement of offset river terraces believed to be related to the 1879 event indicates horizontal displacement of 5.7 ± 1 m, while fault scarp profiling yielded a vertical displacement estimate of 0.5 to 1.0 m (Perez, Tsutsumi, Ishimira, Cahulogan, & Cabanlit, 2009). Further trench investigation suggested that for the past 1,300 years, two to four seismic events produced displacements along the Surigao Segment.

4.3.1.1.3 Liquefaction

Liquefaction is the process wherein unconsolidated and water-saturated sand or soil is transformed into a suspension during an earthquake or other rapid loading phenomenon. The occurrence of these trigger events causes pore water pressure in saturated substrates to build up, exceeding the effective stress of grains. This results in the loss of shear stress which causes the ground material to fail and behave like a liquid. This reduces the ability of the soil to support buildings and other structures, causing these to “sink” or tip over.

The volcanic and carbonate rock units underlying the project area are fairly consolidated, and thus not susceptible to liquefaction. A liquefaction potential map released by PHIVOLCS shows that the northern coastal area of Lake Mainit, and the floodplains along the Hinagasa-and River and Magpayang River south and north of the project area, respectively, are prone to this geohazard. This is mostly due to the loose and saturated sediments deposited in these areas.

4.3.1.1.4 Earthquake-induced Slope Failures and Mass Wasting

Failure of slope faces of topographically high land features such as mountains can be triggered during earthquakes. Ground shaking destabilizes slopes, causing landslides and rockfalls. Earthquake ruptures along steep mountain faces may also cause mass wasting if the substrate comprising displaced blocks break apart and lose strength. Secondary landslides may develop due to increased water penetration and saturation resulting from the formation of wider cracks and weaker intergranular cohesion bonds after an earthquake. Structures built on the side or at the foot of unstable slopes may face significant damage when foundations fail or are directly hit with landslide debris.

Geohazard reconnaissance of the area did not reveal evidence of large, deep-seated earthquake-induced landslides.

4.3.1.1.5 Rain-induced Slope Failures and Mass Wasting

There are three rainfall patterns that trigger different types of landslides: (1) short duration, high intensity events such as sudden downpours that typically trigger very fast debris flows and flash flooding; (2) moderate duration and intensity typhoon rains that produce many shallow landslides and a few large landslides that rapidly fail; and (3) long duration monsoon rains with cumulative precipitation in excess of mean rainfall, that is often associated with the reactivation of pre-existing large landslides and a few rapid shallow failures. The second and third rainfall patterns may occur during the maximum rain period in the project site, which happens from December to January.

Geologic factors also contribute to the susceptibility of a slope to landslides. Substrates composed of unconsolidated grains or those that contain distinct bedding planes, fracture sets, and fault zones can easily be infiltrated with water, which could further reduce shear strength and increase the likelihood of a landslide. The degree of erodibility, and therefore landslide vulnerability, is dictated by lithology. For example, rocks with considerably clay alteration are soft are more prone to weathering, whereas areas underlain with sturdy bedrock are less likely to fail.

Finally, slope gradient also influences failure susceptibility. The angle of repose, which is the steepest angle of descent or dip of the slope relative to the horizontal plane when material on the slope face is on the verge of sliding, varies for different kinds of substrates and if conditions are wet or dry. In lieu of detailed geotechnical assessment of slopes in the area, as a rule of thumb, slopes with smaller gradients are more resistant to landslide movement. The topography within the project area ranges from flat in the lowland valley, to steep towards the volcanic domes that host the prospect. Slope rating based on digital elevation modelling classifies the slope gradients in the project area between very low (0 to 8% gradient) to very high (greater than 50% gradient).

4.3.1.1.6 Flooding

Aside from inundation by high water, flooding can also bring about torrential flows that collide with objects in its path, erode riverbeds and riverbanks, and deposit large amounts of debris. It is common in low-lying floodplains or along river channels following intense precipitation brought by typhoon, monsoon or intermittent rains. Flooding is one of the costliest natural disasters in the Philippines, causing displacement of people, and partial to complete structural and property damage.

The presence of volcanic domes and eruption deposits around the Maniayao volcanic complex contributes to the loosely conical topography of the area, with a steep center radiating outward to gentler / flatter land. Due to this configuration, flood-prone areas are limited to the outermost portions of the volcanic complex, typically along the floodplains of Magpayang River to the east and Mayag River to the west. The moderate to steep slopes of the rivers radiating outward Maniayao volcanic complex provides sufficient gradients for water to drain out rapidly to lower elevations, thus preventing the occurrence of extensive flooding along these channels. However, it can be expected for occasional flash floods to take place in these radial gulleys and river channels. Flooding risk is especially higher during months of maximum precipitation, from December to January.

4.3.1.1.7 Volcanic Hazards

Volcanic processes prior, during and succeeding eruptions give rise to numerous volcanic hazards that can have different types and magnitudes of impacts on people and property. Commonly known volcanic hazards such as lava flows, pyroclastic flows, lahars, ground rumbling, ashfalls, and volcanic landslides typically affect areas immediately surrounding active volcanoes where these originate. In less frequent instances, the effects of a volcanic eruption may reach great distances, especially if the eruption is powerfully explosive, and physical conditions are optimal for widespread dispersion.

There are no active volcanoes classified by PHIVOLCS around the project area. However, the area within the project site is largely volcanic in origin, derived from ancient eruptions of the inactive Neogene Paco resurgent dome within the Maniayao volcanic complex, located east of the Surigao Segment of the Philippine Fault. Indicating residual volcanic activity in area are the presence of warm springs with neutral alkali chloride waters (Barnet, Delfin, & Española, 1985) and fumarolic emissions (Smithsonian Insitution Global Volcanism Program, 2013). Such activities do not pose imminent threat to surrounding areas. There is, however evidence of volcanic edifice failure in the past. Terrain maps generated from satellite imagery show indications of at least two breached or collapsed calderas. Although dome collapse is unlikely because volcanism is not active within the site, rockfalls and landslides from steep volcanic edifices such as Paco volcano may potentially affect the area if massive slope failure occurs.

4.3.1.1.8 Differential Settlement

Substrate materials having different geomechanical properties from one another may have distinct weight-bearing responses when subjected to similar loads. If the ground in a particular area is composed of heterogeneous materials of varying thickness, the surface may settle unevenly, as some constituents may be more compressible to overburden stress than others. Voids, discontinuities and lithologic inclination may also contribute to horizontal variations in substrate strength. In almost all developments, some settlement can be expected after construction. Proper distribution of loads through careful engineering can prevent leaning or tipping over of structures which can lead to total structural destruction.

Differential settlement is especially critical in the design of the Tailings Storage Facility and the Waste Rock Storage, underlain by various lithologies such as Maniayao andesites, andesite tuff, Tugunan clastics, Motherlode turbidites and alluvial deposits. In both project components, significant building up of load from tailings and waste rock will happen as extraction and processing of ore progresses throughout the mine life. Since the ground is underlain by heterogenous rock types, it is possible for these to behave differently under induced stresses from the operation of these components.

4.3.1.2 Climactic and Atmospheric Hazards

4.3.1.2.1 Tropical Cyclones

Tropical cyclones are the costliest natural hazards in the Philippines, destroying billions of pesos worth of goods and infrastructure, and displacing millions of individuals yearly. The occurrence of other atmospheric and climatic hazards is almost always coincident with tropical cyclones.

A tropical cyclone is categorized by PAGASA based on the intensity of its maximum winds when it enters the Philippine Area of Responsibility (PAR). Tropical cyclones with maximum sustained surface winds between 35 and 64 kilometers per hour (kph) are called “tropical depressions”. Once a tropical cyclone reaches surface wind strengths between 65 and 118 kph, it is called a “tropical storm”. If the surface winds reach 119 to 200 kph, the storm is called a “typhoon”.

Natural hazards attributed to climatic factors, such as tropical cyclones, frequently visit the Philippines. On average, approximately 20 tropical cyclones pass through the PAR annually. Around one tropical cyclone a year crosses the region where the project is located. One of the most devastating typhoons that hit Surigao del Norte was Typhoon “Nitang” (International Name: Ike) which battered the province from 31 August to 04 September 1984. It packed maximum sustained winds of 220 kph that resulted to 1,364 deaths (official toll) and PHP 4.1 B in property damage.

4.3.1.2.2 Heavy Rainfall

Intense precipitation brought forth by monsoons and tropical cyclones often bring other destructive phenomena like flooding and landslides which could affect project operations, facilities and staff. Dam overflowing and breaching can potentially cause catastrophic consequences if the planned design is not able to accommodate rapid water accumulation by heavy rainfall.

The 30-year rainfall record from the PAGASA Surigao City Synoptic Weather Station shows that monthly rainfall starts to increase in October and peaks from December to January. The highest daily rainfall was recorded on 18 December 2003, having a gauge reading of 566.4 mm.

4.3.1.2.3 Strong Wind

Strong winds are often caused by the quick movement of air from an area of high atmospheric pressure to an area of low pressure over short distances. They are usually associated with tropical cyclones, although sudden gusts may also occur randomly especially in high elevations. Strong winds have the capacity to uproot trees and fell transmission towers and poles, blocking access to facilities, causing power connection disruptions, and destroying buildings and causing injury or death where heavy, wind-blown objects may land.

Light breeze blows all throughout the year in the PAGASA Surigao City Synoptic Weather Station. The average wind speed ranges from 2- 3 m/s. Based on the 30-year daily wind data from the PAGASA weather station, easterly to north-easterly winds predominantly occur during the months of November to May, and shifts to the south-westerly direction in June to October. The highest wind speed recorded in the area was 60 m/s on 01 September 1984.

4.3.1.3 Geotechnical Hazards

Structural components within the project area may be impacted by inherent natural hazards or induced geological hazards caused by the modification of existing conditions. The most crucial and vulnerable project components are those that will involve earthworks, particularly the Tailings Storage Facility and the maintenance of the grade of the Subsidence Zone.

4.3.1.3.1 Tailings Storage Facility Failure

Dams constructed to contain mining waste must stand in perpetuity as the catastrophic release of voluminous quantities of mine tailings could cause long-term environmental damage. Long-term failure mechanisms for tailings dam include cumulative damage, geologic hazards, static load-induced liquefaction, and changing weather patterns (Chambers & Higman, 2011). According to the International Commission on Large Dams (ICOLD) (2001), the three primary causes for tailings dam incidents are slope stability, earthquakes and overtopping. Between 1980 and 1996, almost all TSF failures were attributed to water action, through seepage or internal erosion, or overtopping due to blockage or inadequate design of spillway systems (Fourie, 2009).

Catastrophic failures of tailings storage facilities have been known to have caused serious social and environmental short-, medium- and long-term consequences. Immediately after a TSF dam collapse, large amounts of water and mine tails may cause flooding and significant sediment deposition in areas located downstream of the containment facility, potentially causing loss of life from drowning or suffocation, and property damage from direct force impact or inundation. Increased rates of pathology and mortality as an effect of chemical contamination or ingestion, may be observed on people, livestock or natural biota immediately after a TSF collapse along the direct path of the spill, or weeks to years after a catastrophic failure as a cumulative consequence of exposure or as mine tails travel farther from the source.

According to the International Commission on Large Dams (ICOLD Bulletin 121), majority of recorded tailings dam incidents globally (>40%) occur for dams that are constructed using upstream techniques. The upstream embankment construction starts with a free draining starter dam. The tailings are discharged from the top of the dam crest to create a tailings beach that will support future embankment raises. The upstream construction method relies on the segregation of coarse tails, which will settle closest to embankment, and fine tails, which will be carried further from the embankment. If the tailings are suitable, this segregation occurs and compaction is not required or may be conducted through earthmoving equipment. Segregation does not always occur properly however, for thickened tailings. With this scheme, the common failure mode of upstream embankment types is a static/transient load induced liquefaction flowslide event due to the tailings' low density and water saturation as a consequence of inadequate water management with the upstream tailings deposition method (www.tailingsinfo.com). This risk can be further exacerbated by earthquakes to which the project site is susceptible to.

The Silangan Project TSF will be a downstream embankment type. The downstream embankment construction method was developed by ICOLD and United Nations Environment Programme (UNEP) in 2001 to address risks associated with upstream construction tailings dam failures particularly when subjected to earthquakes. The main advantage of a downstream embankment type is its unrestricted height since the dam's progressive construction does not compromise its stability and the dam is structurally independent from its tailings (www.tailingsinfo.com), unlike the upstream method.

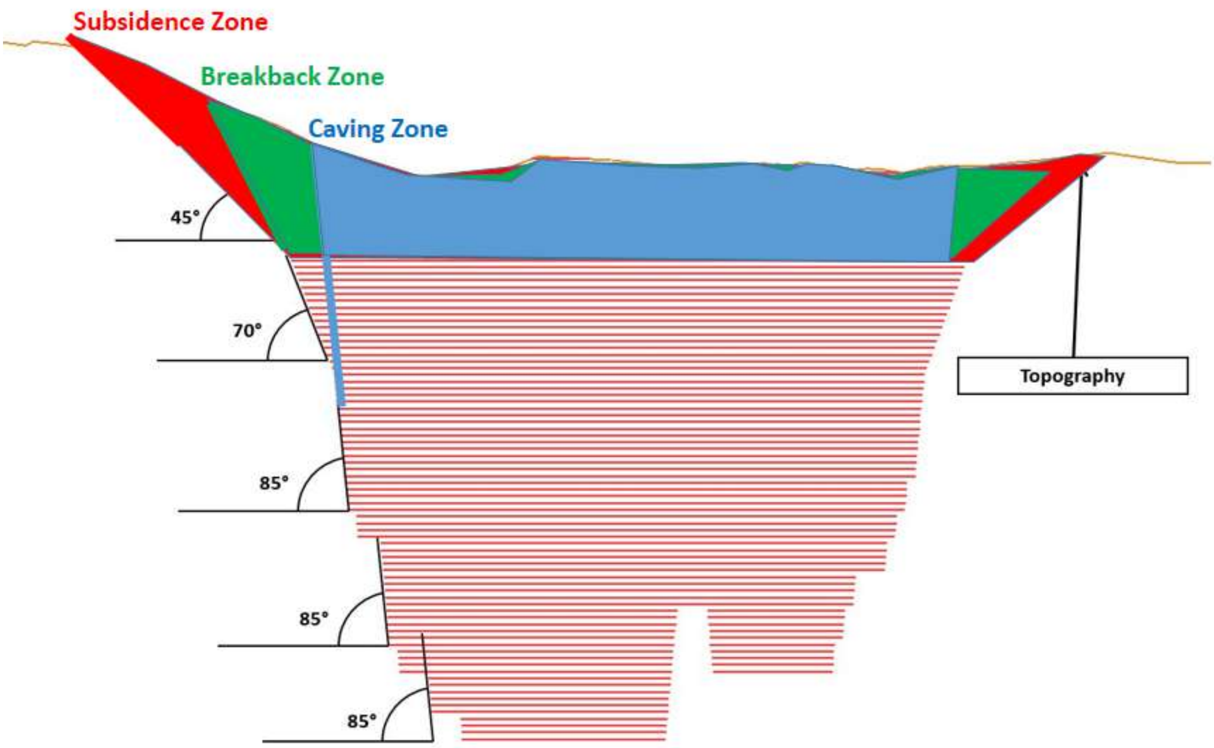
TSF potential failure modes are presented in **Table 4-4**. These failure modes are mainly structural in nature and may be exacerbated by other factors such as seismicity and operational failures. Other design considerations for the TSF to address potential geotechnical issues are presented in **Section 4.5.2.1.**

Table 4-4 TSF Potential Failure Modes

Description	Mechanism	Design Mitigation
Embankment Stability (~48% of failures)	• Excessive pore water pressures in the embankment fill; • A seismic event which exceeds the design acceleration; • Construction flaw in the embankment; and • Failure / instability of the embankment foundation.	• Geotechnical design using lower bound parameters. • Filters and drainage systems to lower phreatic surface. • QA/QC inspection and testing plan. • Extensive monitoring systems • Operating manual.
Overtopping (~18% of failures)	• Extreme rainfall in excess of pond and/or spillway capacity. • Embankment instability reducing freeboard. • Landslide into pond causing large wave.	• Freeboard and spillways designed for PMP event. • Geological hazard assessment of basin slopes and (if required) remedial works to slopes.
Internal Erosion (~12% of failures)	Internal erosion or 'piping' due to: • Poor filter compatibility between fill materials • Penetrations through the embankment or foundation. • Concrete deterioration due to high acidity of waters. • Dislocation along joints of commercially available RC pipes. • Clogging of filter and drains due to formation of iron hydroxide gels from oxidation of iron sulfide (pyrite)	• Design and specification of filter zones in the fill. • No penetrations through embankment or foundation. • Use proper concrete mix. • Prohibit use of commercially available RC pipes. Conduits should be cast-in-place concrete/HDPE pipes • Use proper concrete mix; proper decommissioning of decant; regular monitoring of decant proper selection of construction material; avoid gravel with pyrite as filter material; maintenance
Structural Failure of Gravity Decants (~7% of failures)	• Structural failure of element of decant system which is subject to high loading conditions. • Lack of access for inspections, maintenance and corrective works. • Blocking of spillway by log jam or landslides • Stop log failure.	• Gravity decants are not to be used. • No penetrations through embankment or foundation. • All infrastructure accessible for inspections and maintenance. • Prohibit use of temporary wooden stop logs. • Maintain spillways

4.3.1.3.2 Subsidence Zone Slope Failures and Mass Wasting

Subsidence zone is defined as the maximum area of surface disturbance caused by the sub level cave mine based on the geotechnical properties of the rock units. The diagram below shows the three zones that dictates the surface manifestation of the sub level cave operations.



The caving zone is defined by an angle of 85 degrees from the horizontal plane and is the direct effect of caving operations. In terms of surface manifestation, this area is estimated to around 50 ha. All throughout the operations, this will be the active area subsiding. The next zone is the break back zone and is defined as 75 degrees from the paleo-surface horizontal plane. It is characterized by the maximum zone of surface slip failures due to mining. The estimated area within this zone is around 130 ha. The widest will be the subsidence zone which is around 208 ha. Beyond the break back zone and within the subsidence zone, possible surface cracks may occur. All surface facilities will be situated beyond the subsidence zone.

All zones will be actively backfilled with suitable materials to maintain a gradient of -4% for water to flow outside of the pit floor. Diversions drains will be constructed on the slopes beyond the break back zone to divert water away from the pit floor. Pore pressure monitoring instruments will be installed at the slopes and in the pit floor to monitor any rise of phreatic pressure. Progressive rehabilitation will be applied when possible.

4.3.2 Chemical Hazards

The identification of chemical hazards associated with the Silangan Copper-Gold Mine Project is based on the physicochemical properties of the chemicals and substances that will be used, stored, handled, consumed and produced during the operation of the mine. Amounts of combustion products carbon monoxide, sulfur dioxide and nitrogen monoxide produced were determined by using US EPA AP-42 5th Ed.

Table 4-5 List of substances to be used or produced in the Silangan Copper-Gold Mine Project

Chemical	CAS Number	Category	Per Annum Consumption (MT/annum)	Storage Quantity (MT)	Use
Diesel	68334-30-5	Flammable Liquid	50,750	3,527	Fuel
Heavy Fuel Oil	64741-62-4	Flammable Liquid	8100	935	Fuel
LPG (Propane)	74-98-6	Flammable Gas	1,718	119	Fuel
Cu, LIX 984N		Flammable Liquid	38	2	Extractant
Used Motor Oil		Flammable Liquid/Toxic	Minimal	Minimal	Engine Oil
Used Auto Batteries		Toxic/Corrosive	Minimal	Minimal	Automotive Battery
Busted Fluorescent Lamps		Toxic	Minimal	Minimal	Illumination
ANFO+Primer	71751-41-2	Explosive	18,000	1,250	Quarrying/Mining
Potassium Amyl Xanthate	2720-73-2	Toxic, Low/Flammable	490	20	Collector
Methyl Isobutyl Carbinol (MIBC)	108-11-2	Flammable Liquid	105	5	Frother
Sodium Cyanide	143-33-9	Toxic, High	6083	234	Cyanide leaching
Sodium Hydroxide	1310-73-2	Toxic, Low	175	7	Elution stripper
Sodium Metabisulfite	7681-57-4	Toxic, Low	8000	308	Cyanide Destruction
Hydrochloric Acid	7647-01-0	Toxic, Medium	130	3	Pre-elution Treatment
Cobalt Sulphate	10026-24-1	Toxic, Low	16	1	Electrowinning
Guar Gum	9000-30-0	Toxic, Low	5	1	Electrowinning
Sulphuric Acid	7764-93-9	Toxic, Low	134,000	10,000	Acid Leaching
Nitrogen Monoxide	10102-43-9	Toxic Gas	4,134[a]	11.33[b]	Combustion Gas
Sulfur Dioxide	7446-09-5	Toxic Gas	280[a]	0.77[b]	Combustion Gas
Carbon Monoxide	630-08-0	Toxic Gas	929[a]	2.54[b]	Combustion Gas

a – combustion products, by US EPA AP-42 5th Ed.; b – Daily generation

4.3.2.1 Explosives

An explosive is defined as a substance or preparation which creates the risk of expansion by shock, friction, fire or other sources of ignition (DAO 2003-30). Explosives in the form of ammonium nitrate/fuel oil (ANFO) will be used in the blasting activities during the operational phase of the project where the area is relatively dry. ANFO in itself is not considered a high explosive and generally requires the use a primer (blasting cap) and booster to detonate.

As described in Section 2.3, the project falls under a Type I climate which has two pronounced seasons: dry from November to April and wet during the rest of the year. Furthermore, humidity in the area swings from 77% to 91%. ANFO is extremely hygroscopic and also has poor water resistance which means water can render ANFO useless.

Emulsions will be utilized where ANFO is not suitable. It has a putty-like consistency and packed in low static plastic wrapper. It has high detonation velocity and excellent water resistance. The explosive is packed by a modern cartridge machine into thermally and mechanically resistant foil with high quality welding. The explosive is used for small and large diameter blastholes for blasting works in wet or water environments. It is applied for blasting works performed under the ground. In many cases, this type and all the other types of emulsion explosives are a more economical alternative to classical dynamites

The probability of occurrence of an accidental explosion is low if explosives safety is followed strictly. This means limiting the exposure to a minimum number of well-trained personnel, for a minimum amount of time, to the minimum amount of explosives consistent with safe and efficient operations

The Silangan Copper-Gold Mine Project will maintain one above ground explosives magazine and one underground magazine.

The purchase, use and transport of explosives and explosive ingredients are strictly monitored and regulated by the Mines and Geosciences Bureau (MGB) as well as the Firearms and Explosives Division of the Philippine National Police (PNP). SMMCI will follow applicable regulations and requirements in the purchase, handling, and use of explosives.

4.3.2.2 Flammable Substances

Flammables substances are substances are substances and preparations having a flashpoint of less than or equal to 55˚C (DAO 2003-30). Flammable liquids are categorized into three classes in DAO 2003-30: flammable, highly flammable and extremely flammable. The flammability of a liquid can be determined flash point using either the closed-cup or open-cup method. Criteria for degrees of flammability used to categorize flammable substances is in Annex 2.7e of DAO 2003-30.

The flammable substance expected to be utilized in volume for the Silangan Copper/Gold Mine Project is diesel use in vehicles, heavy equipment and generators. Both the construction and operational phases of the project will require the use of diesel fuel. It is estimated that 3,527 MT of diesel will be used annually. The diesel fuel will be stored either in underground fuel storage tanks or above ground fuel storage tanks. Heavy fuel oil will also be stored at any given time and used by the project at a level of 1,745 MT. The Project will store 119 MT of liquefied petroleum gas (LPG). Kerosene needed for the extraction of copper was estimated to be 220 MT per year with only 15 MT being stored on-site at any given time. Methyl Isobutyl Carbinol (MIBC) is a flammable substance that will be used in the project and stored at a level of 12 MT at any given time. MIBC is a frother and it is used to separate minerals that are hydrophobic from a hydrophilic gangue material. Potassium Amyl Xanthate (PAX) is a slightly flammable substance that will also be by the Project and will store 61 MT at any given time. PAX is a strong and selective collector typically used for copper. **Table 4-5** lists all flammable substances in the projects and its quantities.

4.3.2.3 Corrosive Substances

Corrosive substances are typically acids and bases (pH less than or equal to 2 or greater than or equal to 12.5) that are capable of corroding metal containers, such as storage tanks, drums, and barrels.

The Silangan Copper/Gold Mine Project will have these corrosive chemicals in its inventory: hydrochloric acid, sulfuric acid, sodium hydroxide, sodium hydrosulfide and used automotive batteries. Of the five, the first three will be used in significant amounts mainly as pre-treatment for the ore. Sodium hydrosulfide will only used in small amounts typically to depress copper from the ore concentrate allowing for conventional metal separation via flotation. Used automotive batteries will be produced during the regular maintenance of vehicle and equipment fleet albeit it is expected to be minimal and intermittent. Waste batteries should be brought by a DENR accredited hauler to a DENR accredited transport, storage and disposal facility (TSD) for proper treatment.

4.3.2.4 Toxic Substances

Toxic substances are harmful or fatal when ingested or absorbed (EPA, 2013). Toxic substances are divided into five classifications based on the level of its toxicity, these are: low toxicity, medium toxicity, high toxicity, very high toxicity and extreme toxicity. Toxicity level of a substance is dictated by its chemical state, vapor pressure, boiling point and lethal concentration 50 (LC50). LC50 is the standard measure of the toxicity of the surrounding medium that will kill half of the sample population of a specific test-animal in a specified period through exposure via inhalation (DAO 2003-30). Toxicity is defined through a laboratory procedure called the Toxicity Characteristic Leaching Procedure (TCLP) (Method 1311). TCLP helps identify wastes likely to leach concentrations of contaminants that may be harmful to human health or the environment (EPA, 2013).

A list of substances considered toxic is listed in **Table 4-5**. The most toxic in the list is sodium cyanide which is typically used in mining to dissolve and separate gold from its ore. It is estimated that around 234 MT will be stored at the Project site at any given time. The second most toxic substance to be stored in the Project site are sulfuric and hydrochloric acids where maximum on-site storage will be 10,000 MT and 3 MT respectively. Low toxicity substances, detailed in **Table 4-5**, will be stored at the Project site with a total inventory of 18,962 MT at any given time. Toxic gases such as carbon monoxide (CO), nitric oxide (NO) and sulfur dioxide (SO_2) may arise from the regular use of vehicles, heavy equipment and generators due to incomplete combustion of diesel. These a gases are not expected to in concentrations harmful to human health as it expected to be diluted in the large volume of atmosphere. A well-maintained engine will also produce less of these produce less of these toxic gases. A small amount of lead wastes may be expected to be generated from spent acid-lead batteries from vehicles, heavy equipment and generators. Also, a small amount of mercury wastes from busted fluorescent lamps from offices and a small amount of waste motor oil from vehicle and equipment fleet maintenance is expected to be generated.

4.3.3 Occupational Hazards

Occupational hazards are the threats to the physical, emotional or mental health of personnel involved. Occupational hazards are expected to be present in all phases of the Silangan Copper-Gold Mine Project. The identification of potentially hazardous activities and conditions in all areas of the project site follows.

4.3.3.1 Working Underground

Underground works is expected to be part of the works to be performed in the Silangan Copper-Gold Mine Project. Working underground brings about a multitude of hazards which include working in confined spaces, lack of ventilation, low light level and the use of explosives among others. Workers assigned to this task should be well trained and well aware of the health and safety standards and they should be working under supervision. Visitors to the site should also be very aware of the site health and safety policies and should be supervised during the visit.

4.3.3.2 Mechanical Hazards

Mechanical hazards encountered during the operation of an apparatus or tool of a mechanical nature. A multitude of hazardous mechanical hazards may be present during the Project especially in the labor intensive construction and operational phases. These hazards vary from movement of rotating arms and members, moving belts, meshing gears, cutting teeth, shearing parts and any parts may cause mechanical injury. Mechanical hazards present in the Project include generators, crushers, mixers, pumps, compressors, water pipe lines and moving engine parts which may cause injuries such as crushed hands and arms, severed fingers, lacerations, cuts and even blindness.

Effective and proper machine guarding can help reduce or even eliminate mechanical injuries. Machine guarding is a covering for the hazardous areas of a machine to prevent contact with body parts or to control projectile hazards exiting the machine. Some of the guard types that can be used are: fixed guards, interlocked guards, presence sensing device, automatic guards, adjustable guards, self-adjusting guards, distance guards and partial guard.

4.3.3.3 Electrical Hazards

Electrical hazards are hazards caused by electricity. Electrical hazards present in the Project include power lines, transformers, generators, substations, energized equipment, wiring, and batteries. The severity of electrical injury ranges from just a faint shock to severe burns or even cardiac arrest and possibly even death. The most common electricity related injuries are burns suffered in electrical accidents which may be classified into three types: electrical burns, arc burns, and thermal contact burns. All three types of burns could possibly occur simultaneously.

In electrical burns, tissue damage is caused by the heat generated by the current flow through the body. Arc or flash burns, on the other hand, are the result of high temperatures occurring near exposed tissues and are produced by an electric arc or explosion. Finally, thermal contact burns (related to temperature hazards) are those normally experienced when the skin comes in contact with hot surfaces of overheated electric conductors, conduits, or other energized equipment (OSHA 1997). There is a multitude of method for protecting people from the hazards brought about by electricity. These include insulation, guarding, grounding, wearing electrical protective equipment and safe work practices.

Electric and magnetic fields (EMF) are emitted any electrical device such as power lines, turbines and generators. Magnetic fields pass through most materials and are difficult to shield. Both electric and magnetic fields decrease rapidly with distance (NIEHS, 2002). There is no empirical data demonstrating adverse health effects from exposure to typical EMF levels from power transmissions lines and equipment. While the evidence of adverse health risks is weak, it is still sufficient to warrant limited concern (ICNIRP, 2001 and NIEHS, 2002).

To properly manage EMF exposures, it is recommended to disseminate information regarding on perceived EMF risks and the levels to be encountered around EMF emitting equipment and devices, identify areas with expected elevated EMF levels and establish safety zones and train workers in the identification of occupational EMF levels and hazards.

4.3.3.4 Pressure Hazards

Pressure hazards include pipes, pressurized vessels, heated vessels, hoses, pumps, explosives and pneumatic and hydraulic equipment. Potential sources of pressure hazards in the Project are pumps, pipes and storage vessels. These hazards can be minimized by wearing the proper personal protective equipment and employing safe work practices. During blasting operations, pressure or shock waves can adversely affect workers near enough an explosion.

4.3.3.5 Temperature Hazards

Working outside in the heat especially in the summer can bring about hazards related to temperature. Personnel working in enclosed spaces with running machinery may also be vulnerable to temperature related hazards. The four environmental factors which determine heat stress are temperature, humidity, ventilation and radiant heat. In many operations, combinations of these factors may result in serious heat stress to the workers, who may be performing heavy work, and producing large amounts of body heat, thus also exacerbating the heat stress problem.

The most common types of heat disorders are heat stroke, cramps, dehydration and heat exhaustion. This hazard may be minimized by regular crew rotation, provision appropriate ventilation/air conditioning if possible and having access to drinking water.

4.3.3.6 Biological Hazards

Biological hazards are hazards that include animals, plants, bacteria, viruses, insects, etc. During the construction period of the Project, much of the project area is heavily wooded or forested. This brings about hazards from encounters with poisonous plants and animals during this phase. Communicable diseases or sickness can be brought about by bacteria, viruses or their carriers such as certain insects, animals, ill individuals and unsanitary conditions.

To mitigate such hazards, workers assigned to clearing or excavation, for example, should wear appropriate personal protective equipment. The wearing of insect or animal repellent should also help minimize such hazards. In terms of communicable diseases or sickness, the Project area should maintain good sanitary conditions to help reduce bacteria, viruses and their carriers. Workers should vacate blasting area to an appropriate distance prior to blasting. Workers who are ill should also be advised not to come to work until they are well if possible to minimize the transmission of the contagion to healthy workers

4.3.3.7 Radiation Hazards

Radiation hazards include lighting, welding arcs, solar radiation, microwaves, lasers, x-rays, etc. Lack of adequate illumination can present safety problems because obstacles may not be easily identified when visibility is poor. Conversely, too much illumination can cause injuries such as stress and blindness. Activities such as welding can increase illumination to injurious levels and can be mitigated by wearing appropriated tinted goggles or face mask. While working outside, workers are exposed to solar radiation and should wear protection from solar rays either by wearing long sleeved clothing or lotion with UV protection properties.

4.3.3.8 Noise Hazards

Hazards brought about noise or sound includes equipment noise, impact noise, vibration, high-pressure release, etc. Workers in blasting operations are often exposed to high noise levels emitted by such equipment as drilling equipment, loaders, scoop-trams, trucks and explosions from blasting itself. Continuous exposure to intense noise may cause hearing loss, whether temporary or irreversible. Ear protection, such as ear plugs, should be provided to all employees who work in any situation where high noise levels may be encountered.

Vibration hazards may be encountered in blasting or excavation operations during the use of hand pneumatic tools. Localized vibrations may lead to neurovascular alterations in the hands, bone alterations, including formation of cysts on some of the bones of the hand, weakness and atrophy, etc. Vibration hazards may be minimized by regular breaks and shift change.

The Silangan Copper-Gold Mine Project will perform blasting operations. Blasting may expose workers to a high noise and vibration environment. Practicing proper noise control techniques while blasting can help mitigate the adverse impacts of noise. Controlling the following parameters may significantly help reduce the adverse impacts of noise on the workers and the surrounding community: charge/delay, spacing & burden, direction of initiation, stemming amount and delay interval (Dhekne, 2015). Blasting will mostly be confined underground during the construction and operations and at a limited coverage during the construction of the TSF. While blasting will be limited to the underground and at the TSF during the construction phase only, proper bilateral communication with the workers and nearest communities should be enforced to warn sensitive receptors of potential noise and vibration that may be generated from these activities.

4.3.3.9 Gravity Hazards

Gravity hazards are a group of hazards that include falling objects, collapsing roof, and a person tripping or any hazard exacerbated by the pull of gravity. These types of hazards are very common in almost any workplace but in blasting operations during the construction phase of the project these may be rocks falling from the shaft roof or tools improperly stored overhead. Working at heights is also a gravity hazard. Gravity hazards can be easily mitigated by implementing a policy of strictly wearing hard hats, harnesses and strict policies against unsafe work habits.

4.3.3.10 Motion Hazards

Motion hazards include vehicles, moving equipment, flowing water, wind, and poor work ergonomics. To avoid vehicular accidents, dedicated and well-marked crosswalks should be installed for pedestrians, vehicular speed should be reduced, traffic signs should be installed, driving should be prohibited under the influence of alcohol and other mind altering substances, headlights should be used during the dark or during rain and workers should be required to wear reflector vests. Moving equipment should be clearly marked so that worker will know to avoid the area. The shafts and tunnels that could potentially become conduits for moving water should be installed with alarms to warn worker of approaching danger. As for work ergonomics, training for proper lifting, pulling, lifting postures and other working procedures should be implemented and reaffirmed regularly.

4.3.3.11 Insurgency

Insurgents are known to operate in the vicinity of the Project site. Insurgent attacks have occurred in the recent past, most notably the raid that occurred in 2014 in the municipality of Alegria (which is part of a neighboring mine's tenement) and in April 2018 in the municipality of Gigaquit. The military has units and assets deployed in the area to help control the insurgents and to make safe the residents and establishments. The SMMCI mine site is also situated near the national highway and is surrounded by its host communities.

However, despite these, measure there is a still a risk of sabotage, raids and risk of workers encountering insurgents. All worker movements and headcount should be reported and coordinated with the military especially during the pre-construction and construction phases. Ensure all the workers are briefed with the latest security protocols. A security barricade such as a high wall or a fence should be built around the perimeter of the Project

4.4 Risk Assessment

Risk assessment involves three different analyses: consequence analysis, frequency analysis and risk estimation. Consequence analysis involves the estimation and/or assessment of the effects of a hazard to people, assets and the environment. It uses various models beginning with release rates calculation to dispersion modelling. Frequency analysis is defined as the estimation of the likelihood of occurrence of the identified hazards. Risk estimation determines the outcome of an activity taking it account the probability of occurrence where risk is the product of impact and probability.

Under the ERA Guidelines in Annex 2-7e of the DAO 2003-30, a Level 2 risk assessment is warranted for this study. For projects whose hazardous chemical inventory exceeds the Level 2 threshold, a Quantitative Risk Assessment (QRA) must be conducted and an Emergency/Contingency Plan must be prepared based on the results of the QRA. The methodology used for QRA was the method prescribed under IAEA-TECDOC-727. Please note that the method emphasizes that the results of the assessment will be an indicative estimate only. Only the risks posed by hazardous substances at fixed installations were considered. The list of the hazardous chemical inventory can be found in **Table 4-5**.

For physical and occupational hazards a Qualitative Risk Assessment was conducted utilizing the risk matrix found in the risk levels were estimated and presented in **Table 4-10**. The risk levels are based on qualitative assessment only and were not lifted from existing standards that require quantitative assessment.

4.4.1 Quantitative Risk Assessment

4.4.1.1 Consequence Analysis

Consequence analysis involves the quantification of consequences of potential incidents involving the hazardous chemical inventory of a project. The estimation of the adverse effects of these incidents involves the calculation of its physical effects. Generally, the parameters considered for the consequence analysis are the area of effect and the population density. **Equation 1** was adapted from Section 4 of the IAEA-TECDOC-727. Using **Equation1**, the consequences of potential incidents are quantified in number of potential fatalities that may result are shown below.

Equation 1:

$$C_i = A \times \delta \times f_A \times f_m$$

where:

A	=	affected area, hectares
δ	=	population density in defined populated areas, person/ha
f_A	=	correction factor for populated areas
f_m	=	correction factor for mitigation effects

The reference numbers and effect categories for each of the hazardous substances considered were taken from Table IV(a) of the IAEA-TECDOC-727. Similarly, the area of effect was taken from Table V of the IAEA-TECDOC-727. The population density, δ, was based on the population densities of the municipalities within the project site,

Most of the project footprint lies in Tubod. However, the population density for Tubod was not used because the distance of population centers from the storage of the magazine to store the explosives and the warehouse where the chemicals would be stored. Instead, a population density of 1.09 was used which is based on the population of the Project during its operational phase and the footprint of the Project. For the mitigation factor, f_m, it was assumed based on the potential mitigation scenarios where an f_m = 1 means an unmitigated scenario. The area correction factor, f_a, and the distance corrector, f_d, were assumed to be 0.1 for the explosives since the magazine will be located away from the Mill and Camp Areas. However, since the warehouses are located within the Mill and Camp Areas the values for f_a and f_d were both placed at 1.

Table 4-6 Population densities of municipalities within the project site

Municipality	Built-Up Area (Ha)	Population Density (Person/Ha)
Placer	165.6123	149
Sison	256.86	44
Tubod	247.89	51
Taganaan	358.296	43
Mine Footprint	**532**	**1.09**

Table 4-7 Results of QRA for the hazardous substance inventory of Silangan Copper/Gold Mine Project

Hazardous Chemical	Ref No.a	Effect Categoryb	Area of Effect (Ha)c	Area Corr. Factor, fa	Distance Corr. Factor, fd	Mitigation Factord, fm	Number of Fatalities (fatalities /accident)
ANFO + Primer Emulsion + Primer	14	DI	12	0.1	0.1	1	0.131

Figure 4-2 Risk Map showing extent of effect of catastrophic explosion or chemical release

Hazardous Chemical	Ref No.a	Effect Categoryb	Area of Effect (Ha)c	Area Corr. Factor, fa	Distance Corr. Factor, fd	Mitigation Factord, fm	Number of Fatalities (fatalities /accident)
Diesel	1	BI	0.8	1	1	0.1	0.087
Heavy Fuel Oil	1	AI	0.2	1	1	0.1	0.022
LPG	13	CI	3	1	1	0.1	0.327
Cu, LIX 984N	1	e	e	e	e	e	e
Potassium Amyl Xanthate	17	AII	0.1	1	1	0.1	0.011
MIBC	3	AI	0.2	1	1	0.1	0.022
Sodium Cyanide	25	EIII	8	1	1	0.1	0.87
Sodium Hydroxide	17	AIII	0.02	1	1	0.1	0.002
Sodium Metabisulfite	17	CII	1.5	1	1	0.1	0.164
Hydrochloric Acid	21	EIII	8	1	1	0.1	0.872
Cobalt Sulphate	17	e	e	e	e	e	e
Guar Gum	17	e	e	e	e	e	e
Sulphuric Acid	17	CII	1.5	1	1	0.1	0.164
Nitrogen Monoxide	44	CIII	0.3	1	1	0.1	0.008
Sulfur Dioxide	44	e	e	e	e	e	e
Carbon Monoxide	44	AII	0.1	1	1	0.1	0.003

a & b – taken from Table IV(a) IAEA-TECDOC-727; c – taken from Table V of IAEA-TECDOC-727; d – taken from Table VIII of IAEA-TECDOC-727; e – ignorable effects based on the quantities of hazardous substances

4.4.1.2 Frequency Analysis

Frequency analysis involves the estimation of the likelihood of occurrence of the consequences computed in the previous section. Factors such as frequency of failure or failure probabilities in the operations are used in the analysis. The estimation method is based on the average frequencies as observed in other countries, correction factors related to the differences between industrial activities and actual practices, and the use of related probability number concept.

Equation 2, from Section 5 of the IAEA-TECDOC-727 is used to determine the frequency of the consequences. This is represented by the term $N_{i,s}$ which is the average probability number for substance and handling facility. The term $N^{*}_{i,s}$ is called the average probability number and can be found in Table IX of the IAEA-TECDOC-727 which is based on the reference number determined for each substance from Table IV(a) of the IAEA-TECDOC-727. The term n_l describes the correction factor based on the number of loading and unloading events for a hazardous substance and can be found in Table X(a) in the IAEA-TECDOC-727. The parameter n_f is not considered since none of the hazardous substances described are flammable gases. The parameter n_o describes correction factor for organizational safety which is assumed as “0” which is the value assigned for “average industry practice” for organizational safety as described in Table XII of the IAEA-TECDOC-727. Finally, the term n_p describes the correction parameter for wind direction towards populated areas.

The methodology defines N as "probability number". This "probability number" has always attached to it an equivalent frequency value P in terms of accidents/year. The relationship between N and P is described in **Equation 3**.

Equation 2:

$$N_{i,s} = N^*_{i,s} + n_l + n_f + n_o + n_p$$

where:

$N^*_{i,s}$ = average probability no. for the installation and substance

n_l = probability number correction parameter for the frequency of loading/unloading operations;

n_f = probability number correction parameter for the safety conditions;

n_o = probability number correction parameter for the organization and management safety;

n_p = probability number correction parameter for wind direction towards the populated area.

Equation 3:

$$N = |\, log\ P\, |$$

Table 4-8 Frequency of accident events on a per year basis for the Project chemical inventory

Hazardous Chemical	Reference Number a	Effect Category b	Probability Number, Ni,s	Frequency, P (accidents/year)
ANFO/Emulsion	14	DI	7.5	3x10-8
Diesel	1	BI	8.5	3x10-9
HFO	1	AI	8.5	3x10-9
LPG	13	DI	6	1x106
PAX	17	AII	6	1x106
MIBC	3	AI	8.5	3x10-9
Sodium Cyanide	25	EIII	6	1x106
Sodium Hydroxide	17	AIII	6	1x106
Sodium Metabisulfite	17	CII	6	1x106
Hydrochloric Acid	21	EIII	6	1x106
Sulphuric Acid	17	CII	6	1x106
Nitrogen Monoxide	44	FIII	4	1x10-4
Sulfur Dioxide	44	FIII	4	1x10-4
Carbon Monoxide	44	FIII	4	1x10-4

a & b – taken from Table IV(a) IAEA-TECDOC-727;

4.4.1.3 Risk Estimation

The estimation of risk considered for this particular study depends mainly on the detrimental effects to the public of the accidental release of hazardous materials due to failure of containments or storage. The estimation of risks to the workers/personnel brought about by occupational hazards is beyond the scope of this study. Nevertheless, they are likewise significant and will be addressed properly through the different phases of the project. The risk levels are estimated for each of the hazardous substance by using **Equation 4**.

Equation 4:

$$Estimated\ Risk = C_i * P$$

Table 4-9 Results of risk estimations for Silangan Copper/Gold Mine Project

Hazardous Chemical	Consequence, C_i (fatalities/accident)	Frequency, P (accidents/year)	Estimated Risk, (fatalities/year)
ANFO/Emulsion	0.131	$3x10^{-8}$	$3.92x10^{-9}$
Diesel	0.087	$3x10^{-9}$	$2.62x10^{-10}$
HFO	0.022	$3x10^{-9}$	$6.54x10^{-11}$
LPG	0.327	$1x10^{6}$	$3.29x10^{-7}$
PAX	0.011	$1x10^{6}$	$1.09x10^{-8}$
MIBC	0.022	$3x10^{-9}$	$6.54x10^{-11}$
Sodium Cyanide	0.872	$1x10^{6}$	$8.72x10^{-7}$
Sodium Hydroxide	0.002	$1x10^{6}$	$2.18x10^{-9}$
Sodium Metabisulfite	0.164	$1x10^{6}$	$1.64x10^{-7}$
Hydrochloric Acid	0.872	$1x10^{6}$	$8.72x10^{-7}$
Sulphuric Acid	0.164	$1x10^{6}$	$1.64x10^{-7}$
Nitrogen Monoxide	0.008	$1x10^{-4}$	$8.18x10^{-7}$
Carbon Monoxide	0.003	$1x10^{-4}$	$2.72x10^{-7}$

Table 4-9 shows that all of the risks posed by the chemicals and explosives stored in the proposed Project are below than the internationally accepted safety risk criteria of 1×10^{-6} fatalities/year (or 0.000001). This low risk assessment is due to the distances of these storage areas from population centers and the small area of effect in case of an accidental spill or explosion compared to the overall footprint of the Project.

4.4.2 Qualitative Risk Assessment

For physical and occupational risks, a risk screening or a qualitative risk assessment was conducted. Using the risk matrix provided in **Figure 4-3**, the risk levels were estimated and presented in **Table 4-10**. The risk levels are based on qualitative assessment only and were not lifted from existing standards that require quantitative assessment.

Impact → Probability ↓	Negligible	Minor	Moderate	Significant	Severe
Very Low	Minimal Risk	Minimal Risk	Low Risk	Moderate Risk	High Risk
Low	Minimal Risk	Low Risk	Low Risk	Moderate Risk	High Risk
Medium	Minimal Risk	Low Risk	Moderate Risk	High Risk	High Risk

High	Minimal Risk	Low Risk	Moderate Risk	High Risk	Extreme Risk
Very High	Low Risk	Moderate Risk	High Risk	Extreme Risk	Extreme Risk

Figure 4-3 Risk Matrix for Qualitative Risk Assessment

Table 4-10 Qualitative risk assessment for Silangan Copper/Gold Mine Project

Hazard / Threat	Cause / Fault / Failure	Consequence Event(s)	Outcomes	Potential Probability (Unmitigated)	Safety Measure and Mitigation	Potential Probability (Mitigated)
Physical Hazards						
Geological Hazards						
Ground shaking	• Earthquake	• Shaking of foundation, structures • Ground rupture • Liquefaction • Slope failure	Injury or death	Moderate Risk	• Avoid building on ground with high seismic attenuation potential • Design and construct dam, tunnels and other facilities according to acceptable standards based on realistic earthquake scenarios • Use strong containment materials/methods for storage of chemicals and flammable/explosive substances • Establish an Earthquake Emergency Response Plan	Low Risk
			Dam breach or collapse	High Risk		Low Risk
			Tunnel collapse	High Risk		Low Risk
			Damage / destruction of pipelines	High Risk		Low Risk
			Damage / destruction of other facilities	High Risk		Low Risk
			Loss / reduction of access	High Risk		Low Risk
			Explosion or fire	Moderate Risk		Low Risk
Ground rupture	• Earthquake	• Formation of ground cracks • Uplifting/subsidence of ground	Injury or death	Moderate Risk	• Avoid building on active or inactive fault lines • Design and construct dam, tunnels and other facilities according to acceptable standards based on realistic earthquake scenarios • Use strong containment materials/methods for storage of chemicals and flammable/explosive substances • Establish an Earthquake Emergency Response Plan • Use strong containment materials/methods for storage of chemicals and flammable/explosive substances	Low Risk
			Dam breach or collapse	Moderate Risk		Low Risk
			Tunnel collapse	Moderate Risk		Low Risk
			Damage / destruction of pipelines	Moderate Risk		Low Risk
			Damage / destruction of other facilities	Moderate Risk		Low Risk
			Loss / reduction of access	Moderate Risk		Low Risk
			Explosion or fire	Moderate Risk		Low Risk
Liquefaction	• Earthquake	• Loosening of ground stability	Injury or death	Low Risk	• Avoid building on ground with high liquefaction susceptibility • Design and construct dam, tunnels and other facilities according to acceptable standards based on realistic earthquake scenarios • Use strong containment materials/methods for storage of chemicals and flammable/explosive substances • Establish an Earthquake Emergency Response Plan Use strong containment materials/methods for storage of chemicals and flammable/explosive substances • Use strong containment materials/methods for storage of chemicals and flammable/explosive substances	Minimal Risk
			Dam breach or collapse	Low Risk		Minimal Risk
			Tunnel collapse	Low Risk		Minimal Risk
			Damage / destruction of pipelines	Low Risk		Minimal Risk
			Damage / destruction of other facilities	Low Risk		Minimal Risk
			Loss / reduction of access	Low Risk		Minimal Risk
			Explosion or fire	Low Risk		Minimal Risk
Earthquake-induced landslide	• Earthquake	• Slope failure	Injury or death	Moderate Risk	• Avoid building on highly fractured steep slopes • Design and construct dam, tunnels and other facilities according to acceptable standards based on realistic earthquake scenarios • Use strong containment materials/methods for storage of chemicals and flammable/explosive substances • Establish an Earthquake Emergency Response Plan • Use strong containment materials/methods for storage of chemicals and flammable/explosive substances	Minimal Risk
			Dam breach or collapse	Low Risk		Minimal Risk
			Damage / destruction of pipelines	Low Risk		Minimal Risk
			Damage / destruction of pipelines	Low Risk		Minimal Risk
			Damage / destruction of other facilities	Moderate Risk		Minimal Risk
			Loss / reduction of access	Moderate Risk		Minimal Risk
			Explosion or fire	Low Risk		Minimal Risk
Rain-induced slope failure	• High pore water pressure	• Slope failure	Injury or death	Moderate Risk	• Avoid building in areas with previously recorded rain-triggered landslides • Avoid building in areas with steep slopes • Provide appropriate drainage systems to reduce water saturation in ground • Engineer stable slopes • Set up piezometers and other groundwater / seepage monitoring systems	Minimal Risk
			Dam breach or collapse	Low Risk		Minimal Risk
			Tunnel collapse	Low Risk		Minimal Risk
			Damage / destruction of pipelines	Low Risk		Minimal Risk
			Damage / destruction of other facilities	Moderate Risk		Minimal Risk
			Loss / reduction of access	Moderate Risk		Minimal Risk

	Hazard / Threat	Cause / Fault / Failure	Consequence Event(s)	Outcomes	Potential Probability (Unmitigated)	Safety Measure and Mitigation	Potential Probability (Mitigated)
	Flooding	• Intense rainfall	• Inundation of facilities • Erosion of river banks • Heavy sedimentation in distal downstream areas	Injury or death	Low Risk	• Avoid building in low-lying areas and natural drain ways of floods • Construct bunds and other flood control works • Install an early warning system for floods • Plan spillway releases in both reservoirs	Minimal Risk
				Dam breach or collapse	Low Risk		Minimal Risk
				Damage / destruction of pipelines	Low Risk		Minimal Risk
				Damage / destruction of other facilities	Low Risk		Minimal Risk
				Loss / reduction of access	Low Risk		Minimal Risk
	Differential settlement	• Earthquake • Compression of different substrate materials	• Unevenness of ground	Injury or death	Low Risk	• Conduct detailed geomechanical investigation prior to construction • Design and construct facilities according to geomechanical properties of the rock. • Use strong containment materials/methods for storage of chemicals and flammable/explosive substances	Minimal Risk
				Dam breach or collapse	Low Risk		Minimal Risk
				Tunnel collapse	Low Risk		Minimal Risk
				Damage / destruction of pipelines	Low Risk		Minimal Risk
				Damage / destruction of other facilities	Low Risk		Minimal Risk
				Loss / reduction of access	Low Risk		Minimal Risk
Atmospheric Hazards	Tropical cyclones	• Weather systems	• Intense rainfall • Flooding • Strong winds • Slope failure	Injury or death	Moderate Risk	• Keep updated with the latest weather bulletin • Design and maintain sufficient freeboard • Monitor ground pore water pressure • Design spillway that can accommodate extreme weather discharges • Limit exposure to the elements during extreme weather	Minimal Risk
				Dam breach or collapse	Low Risk		Minimal Risk
				Tunnel collapse	Low Risk		Minimal Risk
				Damage / destruction of pipelines	Low Risk		Minimal Risk
				Damage / destruction of other facilities	Moderate Risk		Minimal Risk
				Loss / reduction of access	Moderate Risk		Minimal Risk
	Heavy rainfall	• Tropical cyclones • Monsoon rains	• Flooding • Slope failure	Injury or death	Low Risk	• Keep updated with the latest weather bulletin • Design and maintain sufficient freeboard • Monitor ground pore water pressure • Design spillway that can accommodate extreme weather discharges • Provide sufficient drainage system • Limit exposure to the elements during extreme weather	Minimal Risk
				Dam breach or collapse	Low Risk		Minimal Risk
				Tunnel collapse	Low Risk		Minimal Risk
				Damage / destruction of pipelines	Low Risk		Minimal Risk
				Loss / reduction of access	Moderate Risk		Minimal Risk
Geomechanical Hazards	Dam failure	• Earthquake / fault movement • Seepage / leakage • Heavy rainfall • Spillway damage • Poor design or construction	• Inundation of immediate downstream areas • Riverbank erosion • Landslides in embankment slopes	Injury or death	High Risk	• Avoid building on ground with high seismic attenuation potential • Design and construct dam according to acceptable standards based on realistic earthquake scenarios • Use strong containment materials/methods for storage of chemicals and flammable/explosive substances • Establish an Earthquake Emergency Response Plan • Maintain acceptable freeboard • Design spillway that can accommodate extreme weather discharges • Restrict access to the dam • Include the following parameters for TSF monitoring: ○ Piezometric levels presented in linear graph with rainfall and operational pond water level. ○ Visual indications of displacement, creep, deformation on embankment ○ Visual inspection of spillway, seepage collection pond, and other hydraulic structures ○ Tailings level ○ Operational pond level ○ Freeboard level ○ In situ water quality for TSF discharge, seepage collection pond and groundwater (pH, turbidity)	Low Risk
				Massive flooding	High Risk		Low Risk
				Damage / destruction of other facilities	High Risk		Low Risk
	Subsidence Zone Failure	• Earthquake / fault movement • Heavy rainfall • High angle of pit slopes	• Slope failure • Ingress of groundwater into subsidence zone	Injury or death	High Risk	• Conduct detailed geomechanical investigation prior to construction • Design and construct facilities according to geomechanical properties of the rock.	Low Risk

Hazard / Threat	Cause / Fault / Failure	Consequence Event(s)	Outcomes	Potential Probability (Unmitigated)	Safety Measure and Mitigation	Potential Probability (Mitigated)
		• Propagation of tension cracks • Impoundment of water at pit floor • Inundation of sublevel caves	Damage / destruction of equipment	High Risk	• Monitor groundwater around the open pit • Monitor deformation of slopes • Provide appropriate drainage and/or dewatering system • Provide slope protection, if necessary	Low Risk
			Ingress of water underground	High Risk		Low Risk
			Damage / destruction of equipment	Moderate Risk		Minimal Risk
				Moderate Risk		Minimal Risk
Occupational Hazards						
Underground hazards	• Confined space • Poor ventilation • Low illumination • Explosives • Tunnel collapse • Poor protection	• Loss / reduction of access / movement	Injury or death	Moderate Risk	• Provide sufficient illumination • Provide ventilation • Allow ample space for mobility • Require personal protective equipment for all workers going underground • Provide first aid kits • Provide emergency medical evacuation • Safety training for all employees working underground • Report incidents	Minimal Risk
			Heat stress	Moderate Risk		Minimal Risk
			Difficulty to breath	Moderate Risk		Minimal Risk
			Limited mobility	Moderate Risk		Minimal Risk
			Fatigue	Moderate Risk		Minimal Risk
Mechanical hazards	• Forceful movement of sharp/blunt mechanical parts • Equipment malfunction • Human error • Poor quality of machines • Poor protection	• Fire / smoke emission / explosion (from burnt machinery) • Water leakage (from broken pipes / hydraulic pumps) • Oil leakage (from faulty machinery) • Increase in noise levels • Increase in heat emissions	Injury or death	Moderate Risk	• Require personal protective equipment for all workers handling mechanical equipment • Provide first aid kits • Provide emergency medical evacuation • Provide sufficient ventilation • Proper maintenance of machinery and equipment • Restrict usage of mechanical equipment to experienced workers • Provide fire suppression systems • Report incidents and faulty equipment	Minimal Risk
			Heat stress	Moderate Risk		Minimal Risk
			Fatigue from repetitive movement	Low Risk		Minimal Risk
			Loss of hearing	Low Risk		Minimal Risk
Electrical hazards	• Fire / explosion • Mechanical malfunction • Electromagnetic surges • Poor quality of electric wirings / power lines • Exposed wirings • Human error • Poor protection	• Fire / explosion (when in contact with combustible / explosive substances) • Power outage • Mechanical breakdown	Injury or death	Moderate Risk	• Require personal protective equipment for all workers • Provide first aid kits • Provide emergency medical evacuation • Proper maintenance of machinery and equipment • Restrict usage of electrical equipment to experienced workers • Provide fire suppression systems • Report incidents and faulty equipment • Establish buffer area around switchyard / transformer areas	Minimal Risk
			Electrocution	Moderate Risk		Minimal Risk
			Exposure to electromagnetic fields	Moderate Risk		Minimal Risk
Pressure hazards	• Overpressure of pneumatic and hydraulic equipment	• Fire / explosion • Mechanical breakdown	Injury or death	Low Risk	• Require personal protective equipment for all workers • Provide first aid kits	Minimal Risk

Hazard / Threat	Cause / Fault / Failure	Consequence Event(s)	Outcomes	Potential Probability (Unmitigated)	Safety Measure and Mitigation	Potential Probability (Mitigated)
	• Poor protection • Explosions	• Increase in temperature	Heat stress	Low Risk	• Provide emergency medical evacuation • Proper maintenance of machinery and equipment • Provide sufficient ventilation • Ensure that pressure gauges, valves, and monitors are all working • Restrict usage of mechanical equipment to experienced workers • Provide fire suppression systems • Report incidents and faulty equipment	Minimal Risk
Temperature hazards	• Increase in natural ambient temperature • Operation of heat-emitting equipment • Confined space with little ventilation • Fire / explosion • Equipment malfunction • Poor protection	• Fire / explosion (of faulty equipment or when in contact with combustible / explosive substances) • Mechanical breakdown	Injury or death	Moderate Risk	• Require personal protective equipment for all workers handling mechanical equipment or working in exposed environments • Provide first aid kits • Provide emergency medical evacuation • Provide sufficient ventilation • Proper maintenance of machinery and equipment • Restrict usage of mechanical equipment to experienced workers • Provide fire suppression systems • Report incidents and faulty equipment	Minimal Risk
			Heat stress	Moderate Risk		Minimal Risk
Biological hazards	• Animal / insect bites • Contamination by pathogens • Contact with poisonous plants • Poor hygiene • Ingestion of spoiled food	• Outbreak (for highly contagious diseases) or contamination • Loss / reduction of movement / mobility	Allergic reactions	Low Risk	• Maintain personal hygiene • Confinement / quarantine for infected personnel • Provide animal bite kits • Provide emergency medical evacuation • Wear appropriate protective equipment when conducting work in highly vegetated areas • Orient workers with dangerous flora and fauna in project site • Avoid contact with unfamiliar plants and animals • Report incidents	Minimal Risk
			Vomiting / upset stomach from ingested plants	Low Risk		Minimal Risk
			Contraction of communicable diseases	Low Risk		Minimal Risk
			Pain from animal bites	Low Risk		Minimal Risk
			Poisoning from animal bites and toxic plants	Low Risk		Minimal Risk
Radiation hazards	• Intense illumination • Radiation-emitting devices • Poor protection • Human error	• Intensification of light levels • Increase in temperature	Injury or death	Low Risk	• Require personal protective equipment for all workers handling equipment or working in exposed environments • Provide first aid kits • Provide emergency medical evacuation • Provide sufficient ventilation • Proper maintenance of machinery and equipment • Restrict usage of radiation-emitting equipment to experienced workers • Provide fire suppression systems • Report incidents and faulty equipment	Minimal Risk
			Heat stress	Low Risk		Minimal Risk
			Permanent or temporary blindness	Low Risk		Minimal Risk
Noise hazards	• Explosions • Operation of equipment • Faulty equipment • Poor protection	• Increase in ambient noise	Temporary or permanent deafness	Moderate Risk	• Provide ear mufflers for workers exposed to loud operational environments • Proper maintenance of machinery and equipment • Restrict usage of mechanical equipment to experienced workers • Provide noise buffers • Operate noise-generating equipment only at designated areas and during assigned schedule	Minimal Risk

Hazard / Threat	Cause / Fault / Failure	Consequence Event(s)	Outcomes	Potential Probability (Unmitigated)	Safety Measure and Mitigation	Potential Probability (Mitigated)
Gravity hazards	• Falling objects • Collapse of foundation / roofing • Loss of support • Shifting of center of gravity • Poor protection	• Impact / collision	Injury or death	Moderate Risk	• Secure objects used at height • Provide sufficient support / footing of scaffolds / ladders, etc. • Provide early warning signs around activities conducted at elevation • Require personal protective equipment for all workers • Provide first aid kits • Provide emergency medical evacuation • Safety training for all employees • Report incidents	Minimal Risk
Motion hazards	• Loss of control • Poor ergonomics / posture • Poor illumination • Poor protection	• Impact / collision	Injury or death	Low Risk	• Provide signages and other early warning signs • Require personal protective equipment for all workers • Provide sufficient illumination • Follow traffic rules • Maintain vehicles regularly • Restrict operation to capable workers • Safety training for all employees • Report incidents	Minimal Risk
			Fire or explosion	Low Risk		Minimal Risk
Insurgency	• Political / economic instability	• Restriction of ground movement / access	Injury or death	Low Risk	• Be aware of security risks outside the project area • Inform Safety Officer or designated personnel of whereabouts at all times • Provide security escort, if necessary • Secure property when working outside project perimeter	Minimal Risk
			Loss of property	Moderate Risk		Minimal Risk

4.5 Risk Management

4.5.1 Chemical Hazards

All hazardous substances to be used at the Silangan Copper-Gold Project will be stored, and handled in compliance with all applicable Philippine and international regulations. SMMCI is committed to preventing, to the greatest extent possible, both inadvertent release of these hazardous substances to the environment and accidents resulting from mishandling or mishap.

In order to insure that hazards or risks that may be posed by the project are further minimized, the following measures are recommended:

- Institute programs for employee training, facility inspection, periodic drills to test systems, and procedural review to address deficiencies, accountability, and continuous improvement objectives.
- Actively work towards minimizing the generation of hazardous wastes by investigating alternatives to the use of hazardous materials, by recycling products and containers wherever feasible, and by treating wastes using state-of-the-art technologies before any release to the environment.
- All employees will be expected to comply with all applicable precautions and handling procedures with regard to hazardous materials. Employees are also expected to report any concerns to their supervisors, the Health and Safety Committee, or senior site management. All staff is encouraged to bring forward suggestions for improvements that can be incorporated into procedure revisions as appropriate.

There should be a detailed procedure on the management of hazardous substances/materials for the Silangan Copper/Gold project should also be in place to ensure the safe use, storage of disposal of hazardous substance in the project. The following should be incorporated in the management procedure:

- Purchasing controls – control of shipping methods, appropriate packaging, shipping schedules, etc.;
- Inventory controls on site – periodic inventory of materials in storage on site to determine usage and to identify and manage any unexpected loss;
- Compliance to local permits which control certain chemicals such as the control of explosive materials and precursor materials by the Philippine National Police – Firearms and Explosives Office (PNP-FEO) and the control of chemical precursor to drugs by the Philippine Drug Enforcement Agency (PDEA);
- Maintenance of current safe handling and storage procedures (i.e. Material Safety Data Sheet) and these should available to those in contact throughout the operational site;
- Characterization of potential environmental hazards posed by hazardous substances;
- Allocation of clear responsibility for managing shipment, storage, handling and use of potentially hazardous substances;
- Defined methods for transport, storage, handling, and use;
- Identification of disposal methods for hazardous waste generated from use of these products;
- Preparation of contingency and emergency response plans;
- Adequate type and delivery of training for management, workers, and contractors whose responsibilities include handling potentially hazardous materials;
- Maintenance and review of records of hazardous material consumption and incidents in order to anticipate and avoid impacts on personal health and the environment; and

- Procedures to track and manage wastes generated through use of these products, including regular shipments of potentially hazardous waste to appropriate licensed disposal facilities following the provisions set forth by Republic Act 6969 (Toxic Substances and Hazardous and Nuclear Wastes Control Act of 1990).

4.5.2 Physical Hazards

4.5.2.1 Design Considerations

The TSF is one of the most environmentally critical components of the Project. To prevent catastrophic failure of the facility, several design criteria were considered. This is discussed in more detail in **Section 1.5.3.1.2**, but to summarize, **Table 4-11** lists the different considerations incorporated in the TSF design.

Table 4-11 Design criteria for the TSF

Parameter	Value
Hydrology / Hydraulics	
Design flood for temporary works	5 year Average Recurrence Interval (ARI)
Design flood for operational pond	100 year ARI
Design flood for spillway design	Probable Maximum Flood (PMF) plus wave freeboard to be determined through risk assessment
Minimum contingency freeboard	1:50 Annual Exceedance Probability (AEP) wind/wave run-up plus 0.5 m
Seismicity	
Operating Base Earthquake (OBE)	1:1,000 AEP
Maximum Design Earthquake (MDE)	1:10,000 AEP
Post Closure	Maximum Credible Earthquake (MCE)
Allowable deformation under seismic loading	Deformation will not cause severing of filter or drains. Deformation < available freeboard
Factors of Safety	
Long-term drained	1.5
Short-term undrained (potential loss of containment)	1.5
Short-term undrained (no potential loss of containment)	1.3
Post-seismic	1.0 to 1.2

Failure modes unique to the TSF were considered in this study. These failure modes have corresponding control measures incorporated into the design, and eventually, the operational emergency plan that will be implemented for the Project. The summary of failure modes and corresponding controls are tabulated below.

Table 4-12 Potential TSF failure modes and correspoding design mitigation

Description	Mechanism	Design Mitigation
Embankment Stability (~48% of failures)	• Excessive pore water pressures in the embankment fill; • A seismic event which exceeds the design acceleration;	• Geotechnical design using lower bound parameters. • Filters and drainage systems to lower phreatic surface.

	• Construction flaw in the embankment; and • Failure / instability of the embankment foundation.	• QA/QC inspection and testing plan. • Extensive monitoring systems • Operating manual.
Overtopping (~18% of failures)	• Extreme rainfall in excess of pond and/or spillway capacity. • Embankment instability reducing freeboard. • Landslide into pond causing large wave.	• Freeboard and spillways designed for PMP event. • Geological hazard assessment of basin slopes and (if required) remedial works to slopes.
Internal Erosion (~12% of failures)	Internal erosion or 'piping' due to: • Poor filter compatibility between fill materials • Penetrations through the embankment or foundation	• Design and specification of filter zones in the fill. • No penetrations through embankment or foundation.
Structural Failure of Gravity Decants (~7% of failures)	• Structural failure of element of decant system which is subject to high loading conditions. • Lack of access for inspections, maintenance and corrective works.	• Gravity decants are not to be used. • No penetrations through embankment or foundation. • All infrastructure accessible for inspections and maintenance.

4.5.2.2 Monitoring

Routine maintenance and regular monitoring should be conducted during construction and operations to ensure that project facilities are functioning properly. Some of the maintenance and monitoring activities that should be performed include:

- Periodic inspection of surface conditions of the dam and pipelines for early detection of leaks and cracks;
- Regular maintenance of machines and equipment to ensure proper function and safe operations;
- Regular inspection of all containment devices for the safe storage of flammable, explosive, oxidizing, corrosive and toxic substances;
- Periodic inspection and testing of control and protective equipment (e.g. pressure limiting devices, regulators, controllers and relief valves) to ensure they are in good and reliable condition and are functioning properly;
- Clearing or trimming of vegetation as required to maintain a safe clearance between electric lines, pump inlets and trails/roads to maintain accessibility;
- Regular training of workers and staff in updated policies in environment, health and safety;
- Provision of adequate and appropriate personal protective equipment to all workers assigned to work in potentially hazardous conditions; and
- Regular briefing of workers in updated policies in environment, health and safety.

An indicative monitoring plan for the TSF and engineered slopes is found in **Table 4-13**.

Table 4-13 Indicative monitoring plan for the TSF and engineered slopes

Module	Environmental Sector	Parameters to be Monitored	Sampling and Measurement			Lead Person	Annual Estimated Cost	EQPL Management Scheme					
			Methods	Frequency	Location			EQPL range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
Construction													
The Land	Stability of TSF	Descriptive parameters only. Final list of parameters to be monitored will appear in the TSF Surveillance and Monitoring Plan, which will be prepared after Potential Mode Failure Analysis is performed based on final design of the TSF. Based on U.S. Federal Energy Regulatory Commission Dam minimum recommended instrumentation for proposed significant- and high-hazard potential embankment dams.	Indicative methods only. Final list of methods and instrumentation will be presented in the TSF Surveillance and Monitoring Plan. Based on Feasibility Report and/or U.S. Federal Energy Regulatory Commission Dam minimum recommended instrumentation for proposed significant- and high-hazard potential embankment dams	Indicative frequencies only. Final frequency of monitoring will depend on requirements set forth in the TSF Surveillance and Safety Monitoring Plan. Based on U.S. Federal Energy Regulatory Commission Dam minimum recommended instrumentation for proposed significant- and high-hazard potential embankment dams. Inspection and reading should be performed after every significant seismic, meteorological, etc. event on top of regular monitoring.	Indicative locations only. Final locations of monitoring will depend on requirements set forth in the TSF Surveillance and Safety Monitoring Plan. Based on Feasibility Report and/or U.S. Federal Energy Regulatory Commission Dam minimum recommended instrumentation for proposed significant- and high-hazard potential embankment dams.	Dam Construction Contractor	Included in the dam construction cost. Additional monitoring costs will depend on recommendations of TSF designer.	Descriptive levels only. Limits will be set by TSF design consultant, after final design and baseline data collection is completed. EQPLs will be included in the TSF Surveillance and Monitoring Plan.			Indicative management measures only. Final EQPL management responses will be included in the TSF Surveillance and Monitoring Plan.		
								Design level	Warning level, which is approached when measurements exceed design levels.	Alarm level, which is approached when measurements exceed the warning level.	Initiate rapid investigation while continuing construction works.	Perform detailed investigations while continuing construction works.	Halt construction works and perform remediation and mitigation measures. Consider permanent abandonment if necessary.
		○ Visual appearance	○ Visual observation	Construction Daily 1st Filling Daily 1Y after Filling Weekly Y2-3 Monthly	○ TSF, abutment and adjacent structures								

Module	Environmental Sector	Parameters to be Monitored	Sampling and Measurement			Lead Person	Annual Estimated Cost	EQPL Management Scheme					
			Methods	Frequency	Location			EQPL range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
		○ Tailwater level	○ TSF level gage	Construction - 1st Filling Daily-Weekly 1Y after Filling Semi-monthly and at the same time as other measure-ments Y2-3 Monthly and at the same time as other measure-ments	○ TSF								
		○ Drain flow	○ Discharge measurements	Construction - 1st Filling Daily-Weekly 1Y after Filling Weekly-Monthly Y2-3 Monthly	○ Spillway								
		○ Seepage / leakage flow	○ Seepage collection and spillage measuring weirs	Construction Monthly 1st Filling Daily-Weekly 1Y after Filling Weekly-Monthly Y2-3 Monthly	○ Near seepage collection system								

Module	Environmental Sector	Parameters to be Monitored	Sampling and Measurement			Lead Person	Annual Estimated Cost	EQPL Management Scheme					
			Methods	Frequency	Location			EQPL range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
		○ Pore / uplift pressure	○ Vibrating wire piezometers	Construction Daily-Weekly 1st Filling Daily-Weekly 1Y after Filling Monthly Y2-3 Monthly	○ Within drainage layer at horizontal TSF bottom ○ Within TSF foundation below and downstream of dam axis ○ At downstream TSF toe or near vicinity								
		○ Surface settlement	○ Visual observation ○ Magnetic settlement measurement	Construction - 1st Filling Monthly 1Y after Filling Quarterly Y2-3 Semi-annually to annually	○ Upstream and downstream slopes of TSF								
		○ Surface alignment	○ Visual observation ○ Alignment survey	Construction - 1st Filling Daily-Monthly 1Y after Filling Quarterly Y2-3 Semi-annually to annually	○ One or more lines of measuring points along the crest and on slopes parallel to crest								

Module	Environmental Sector	Parameters to be Monitored	Sampling and Measurement			Lead Person	Annual Estimated Cost	EQPL Management Scheme					
			Methods	Frequency	Location			EQPL range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
		○ Foundation movement	○ Precise surveys ○ Inclinometers ○ Extensometers	Construction Weekly 1st Filling Weekly-Monthly 1Y after Filling Quarterly Y2-3 Semi-Annually	○ Near dam foundation								
	Ground and slope stability	Indicative parameters only. Ground and slope stability monitoring can be reactionary, depending on site conditions. Some basic parameters to be monitored are: • Slope movement • Ground subsidence • Groundwater level	Indicative methods only. Ground and slope stability monitoring can be reactionary, depending on site conditions. Some monitoring instruments that can be used include: • Vibrating wire piezometers • Inclinometers and tiltmeters • Extensometers • Time domain reflectometry	Indicative frequencies only. Actual frequency will depend on recommendations made by the project civil engineer during construction: • Weekly to monthly • Inspection and reading should be performed after every significant seismic, meteorological, etc. event on top of regular monitoring	Indicative locations only. Ground and slope stability monitoring during construction will depend on recommen-dations made by the project civil engineer: • On engineered slopes surrounding upper reservoir • Over tracks of tunnels	Project Construction Contractor	PHP 50,000 (visual inspection) to 500,000 (deployment of instrumentation and modelling)	Descriptive levels only. Construction limits will be set by project civil engineer, after final design is completed.			Indicative management measures only.		
								Design level, wherein magnitude of slope movement and subsidence fall within limits in line with that predicted during design.	Warning level, which is approached when the magnitude of slope movement and subsidence exceed the design level.	Alarm level, which is approached when slope movement and subsidence exceed the warning level and threat to safety is imminent.	Initiate rapid investigation while continuing construction works.	Perform detailed investigations while continuing construction works.	Halt construction works and perform remediation and mitigation measures. Consider permanent abandonment if necessary.
Operations													
The Land	Stability of TSF	Indicative parameters only. Final list of parameters to be monitored will appear in the TSF Surveillance and Monitoring Plan, which will be prepared after	Indicative methods only. Final list of methods and instrumentation will be presented in the TSF	Indicative frequencies only. Final frequency of monitoring will depend on requirements set forth in the TSF	Indicative locations only. Final locations of monitoring will depend on requirements set forth in the TSF	Operations and Maintenance Team	Most of the monitoring activities can be performed in-house. Some, such as seismic loading	Indicative levels only. Limits will be set by TSF design consultant, after final design and baseline data collection is completed. EQPLs will be included in the TSF Surveillance and Monitoring Plan.			Indicative management measures only. Final EQPL management responses will be included in the TSF Surveillance and Monitoring Plan.		

Module	Environmental Sector	Parameters to be Monitored	Sampling and Measurement			Lead Person	Annual Estimated Cost	EQPL Management Scheme					
			Methods	Frequency	Location			EQPL range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
		Potential Mode Failure Analysis is performed based on final design of the TSF Based on U.S. Federal Energy Regulatory Commission Dam minimum recommended instrumentation for proposed significant- and high-hazard potential embankment dams	Surveillance and Monitoring Plan. Based on Feasibility Report and/or U.S. Federal Energy Regulatory Commission Dam minimum recommended instrumentation for proposed significant- and high-hazard potential embankment dams	Surveillance and Safety Monitoring Plan. Inspection and reading should be performed after every significant seismic, meteorological, etc. event on top of regular monitoring. Based on U.S. Federal Energy Regulatory Commission Dam minimum recommended monitoring frequency for proposed significant- and high-hazard potential embankment dams:	Surveillance and Safety Monitoring Plan. Based on Feasibility Report and/or U.S. Federal Energy Regulatory Commission Dam minimum recommended instrumentation for proposed significant- and high-hazard potential embankment dams		monitoring (if appropriate) may require engagement of third-party specialists or subcontractors.	Baseline level on which design is based.	Warning level, which is approached when measurements exceed baseline levels.	Baseline level on which design is based.	Initiate rapid investigation while continuing normal operations.	Perform detailed investigations while continuing normal or scaled down operations.	Halt operations and perform immediate remediation and mitigation measures. Consider permanent abandonment if necessary.
		○ Visual appearance	○ Visual observation	○ Monthly	○ TSF, abutment and adjacent structures								
		○ Tailings water operating level (dry and wet season)	○ TSF level gage	○ Monthly to quarterly and at the same time as any other measurements	○ TSF								
		○ Drain flow	○ Discharge measurements	○ Monthly to quarterly	○ Spillway								
		○ Seepage / leakage flow	○ Seepage collection and spillage measuring weirs	○ Monthly to quarterly	○ Near seepage collection system								
		○ Pore / uplift pressure	○ Vibrating wire piezometers	○ Monthly to quarterly	○ Within drainage layer at horizontal reservoir bottom ○ Within dam foundation below and downstream of dam axis ○ At downstream dam toe or near vicinity								

Module	Environmental Sector	Parameters to be Monitored	Sampling and Measurement			Lead Person	Annual Estimated Cost	EQPL Management Scheme					
			Methods	Frequency	Location			EQPL range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
		○ Surface settlement	○ Visual observation ○ Magnetic settlement measurement	○ Semi-annually to annually	○ Upstream and downstream slopes of dam								
		○ Surface alignment	○ Visual observation ○ Alignment survey	○ Semi-annually to annually	○ One or more lines of measuring points along the crest and on slopes parallel to crest								
		○ Foundation movement	○ Precise surveys ○ Inclinometers ○ Extensometers	○ Semi-annually to annually	○ Near TSF foundation								
		○ Seismic load	○ Accelerograph	○ Triggered by strong seismic events	○ Foundation, crest, abutments								
	Ground and slope stability	Indicative parameters only. Ground and slope stability monitoring can be reactionary, depending on site conditions. Some basic parameters to be monitored are: • Slope movement • Ground subsidence • Groundwater level	Indicative methods only. Ground and slope stability monitoring can be reactionary, depending on site conditions. Some monitoring instruments that can be used include: • Vibrating wire piezometers • Inclinometers and tiltmeters • Extensometers • Time domain reflectometry	Indicative frequencies only. Actual frequency will depend on recommendations made by the project civil engineer after construction: • Semi-annually to annually • Inspection and reading should be performed after every significant seismic, meteorological, etc. event on top of regular monitoring	Indicative locations only. Ground and slope stability monitoring during operations will depend on recommen-dations made by the project civil engineer: • On engineered slopes surrounding upper reservoir • Over tracks of tunnels	Operations and Maintenance Team	PHP 50,000 (visual inspection) to 500,000 (deployment of instrumentation and modelling)	Descriptive levels only. Operational limits will be set by project civil engineer, after final design is completed.			Indicative management measures only.		
								Design level, wherein magnitude of slope movement and subsidence fall within limits in line with that predicted during design	Warning level, which is approached when the magnitude of slope movement and subsidence exceed the design level	Alarm level, which is approached when slope movement and subsidence exceed the warning level and threat to safety is imminent	Initiate rapid investigation while continuing operations	Perform detailed investigations while continuing operations	Halt operations and perform remediation and mitigation measures Consider permanent abandonment if necessary

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Environmental Impact Statement

Section 5. Social Development Plan

Table of Contents

5. Indicative Social Development Framework and Information Education and Communication Framework **5-1**

5.1 Social Development Framework and Information Education and Communication Framework 5-1

5.2 Information, Education and Communication Framework 5-9

5.2.1 Previous IECs Conducted 5-9

5.2.2 Proposed IEC Framework 5-12

Additional Information

Perception Survey Sample Questionnaire with answers

5. Social Development Plan/Framework (SDP) and Information Education and Communication (IEC) Framework

5.1 Social Development Plan/Framework

During the Exploration Phase and up to present (considered as Care and Maintenance Phase), SMMCI has implemented Community Development Programs (CDP) focusing on human resources and skills training, enterprise development or livelihood training, assistance to infrastructure development and support services, assistance to education and educational support programs, assistance in the improvement of health services, health facilities and health professionals, and respect and preservation of socio-cultural values through sponsorships of festivals and other cultural events. The various CDPs implemented since 2013 are appended to this document (**Annex 5.1**). SMMCI has not yet started construction since the open pit approvals were awarded therefore, the initial version of the SDMP was not implemented.

During operations, mining companies are required to devote 1.5% of their operating cost for the Social Development and Management Program (SDMP), a five-year comprehensive plan by the project proponent and impact areas to improve the living standards stakeholder communities (particularly the host barangays). The allocation of the fund for the SDMP is as follows: a) the development of host and neighboring communities (1.125% or 75% of 1.5%), b) development of mining technology and geosciences (0.15%, or 10% of 1.5%), and c) promotion of public awareness and education on mining technology and geosciences (0.225%, or 15% of 1.5%). The Social Development Plan provides an initial outline of the programs that can be included in the SDMP as the development of the SDMP is initiated after the issuance of the ECC. The intention of the SDMP is to ensure sustainable improvement in the living standards of the host and neighboring communities by implementing programs and projects that will empower the communities to be self-reliant and responsible such that the communities continue to thrive through on-mining means. The SDMP is also implemented to ensure the communities continue to thrive even when the mine closes by utilizing the benefits from mining to other productive use.

The Social Development Plan/Framework (SDF) serves as the initial form of the SDP. The programs presented in this section where drafted to meet the following goals:

- Help meet the minimum basic needs of the host and neighboring communities;
- Optimize the advancement of human resources and people empowerment to achieve a self-reliant community;
- Provide opportunities for livelihood to decrease the dependency on mining;
- Promote conservation and intelligent use of the environment; and
- Respect and protect the socio-cultural values of the community amidst economic improvement and livelihood advancement.

The programs included in the initial plan focus on the following:

- Gender Responsive Livelihood, Enterprise, and Employment Development;
- Health and Safety;
- Education and Recreation;
- Environment;
- Waste Management and Sanitation;
- Public Infrastructure;
- Peace and Order; and
- Socio-Cultural and Spiritual.

Since the project was previously awarded an ECC for the open pit and a DMPF, an initial SDMP was drafted but this was not implemented as the Project did not proceed to construction and operations. The SDMP also needs to be revised as the mine plan and cost has been revised. Other programs presented below (**Table 5.1-1**) were added as part of this submission in consideration of issues and concerns raised during the IECs, FGDs and KIIs for this Project.

Table 5.1-1 Indicative SDP for the Municipalities of Placer, Sison, Tubod and Taganaan

Concern	Programs and Projects	Specific Activities	Responsible Community Member/ Beneficiary	Government Agency/ Non-government Agency and Services (indicate specific services)	Proponent	Indicative Timeline	Source of Fund
Gender Responsive Livelihood, Enterprise, and Employment Development	Skills Development	1. Promotion of community and home based training. 2. Facilitate access to basic and secondary education opportunities. 3. Facilitate participation in vocational training. 4. Assist with the developent of business skills. 5. Facilitate training in mainstream and/or specialized institutions. 6. Link skills development to programs and activities to Self-help Groups.	Host and Neighboring Communities	TESDA, PESO, LGUs, Non-government organizations, RHNC, other stakeholders identified in the couse of project implementation.	Community Relations Officer	Construction Operation	LGU-IRA, Proponent
Gender Responsive Livelihood, Enterprise, and Employment Development	Self-Employment	1. Identification of market opportunities. 2. Matching of socio-economic activities to the environment. 3. Encourage and support persons with disabilities, especially women, poor and marginalized individuals and family. 4. Build partnership with local government and mainstream organizations. 5. Facilitate start-up capital. 6. Link self-employment to programs and activities to Self-help Groups.	Host and Neighboring Communities	TESDA, PESO, LGUs, Non-government organizations, RHNC, other stakeholders identified in the couse of project implementation.	Community Relations Officer	Construction Operation	LGU-IRA, Proponent
Gender Responsive Livelihood, Enterprise, and Employment Development	Financial Services	1. Capability building on sound financial management and savings mechanism. 2. Identification of role-models. 3. Development of financial services. 4. Facilitate access to mainstream financial services.	Host and Neighboring Communities	TESDA, PESO, LGUs, Non-government organizations, RHNC, other stakeholders identified in the couse of project implementation.	Community Relations Officer	Construction Operation	LGU-IRA, Proponent

Concern	Programs and Projects	Specific Activities	Responsible Community Member/ Beneficiary	Government Agency/ Non-government Agency and Services (indicate specific services)	Proponent	Indicative Timeline	Source of Fund
		5. Link financial services to programs and activities to Self-help Groups.					
Gender Responsive Livelihood, Enterprise, and Employment Development	Social Protection	1. Ensure poor and marginalized, including persons with disabilities, are included under existing provisions. 2. Facilitate poor and marginalized, including persons with disabilities access to basic and general services of SMMCI's SDMP. 3. Ensure personal assistance when required.	Host and Neighboring Communities	TESDA, PESO, LGUs, Non-government organizations, RHNC, other stakeholders identified in the couse of project implementation.	Community Relations Officer	Construction Operation	LGU-IRA, Proponent
Health and Safety	Health Promotion and Prevention of Common Illnesses	1. Health promotions and prevention campaigns e.g. but not limited to wellness program for senior citizens, feeding of malnourished children including children with disabilities. 2. Strengthen individual and community knowledge and skills on health promotion and prevention such as, but not limited to, TB DOTS, Dengue, Effects of Smoking and Life style-related promotions. 3. Link health promotion and prevention to programs and activities to Self-help Groups. 4. Facilitate access to existing prevention programs of the government e.g. but not limited to maternal and child health care, improvement of health centers, population development. Encourage immunization. 5. Promotion of healthy behaviors and lifestyles, clean water and sanitation.	Host and Neighboring Communities	Local Health Workers, Municipal Health Officer, other stakeholders needed as the program develops and SMMCI	Community Relations Officer	Construction Operation	LGU-IRA, Proponent
Health and Safety	Medical Care	1. Gathering of baseline for medical care. 2. Facilitate access and early treatment of health condition by provision of medicines and medical equipment. 3. Facilitate access to surgical care. 4. Establish relationship with medical care providers.	Host and Neighboring Communities	Local Health Workers, Municipal Health Officer, other stakeholders needed as the program develops and SMMCI	Community Relations Officer	Construction Operation	LGU-IRA, Proponent

Concern	Programs and Projects	Specific Activities	Responsible Community Member/ Beneficiary	Government Agency/ Non-government Agency and Services (indicate specific services)	Proponent	Indicative Timeline	Source of Fund
Health and Safety	Rehabilitation and Assistive Devices	1. Baseline of rehabilitation and assistive devices services and programs. 2. Establish referral and follow-up mechanisms. 3. Facilitate rehabilitation activities in the community. 4. Provide early intervention activities for child development. 5. Facilitate access to assistive devices.	Host and Neighboring Communities	Local Health Workers, Municipal Health Officer, other stakeholders needed as the program develops and SMMCI	Community Relations Officer	Construction Operations	LGU-IRA, Proponent
Education and Recreation	Early Childhood Care and Education	1. Identification of early childhood needs especially children with disabilities. 2. Support for early learning at home and commuities especially children with disabilities. 3. Facilitate inclusive preschools. 4. Develop access to specialist services for early childhood are and development. 5. Link early childhood care and development to programs and activities to Self-help Groups.	Host and Neighboring Communities	DepEd, RHNC, Academe, Non-government organizations and others to be identified.	Community Relations Officer	Construction Operations	LGU-IRA, Proponent
Education and Recreation	Primary Education	1. Improve learning and education centers in the community. 2. Assist access in primary education that is accessible, welcoming and creates learning environment. 3. Support poor, marginalized and children with disabilities in primary education. 4. Link primary education to programs and activities to Self-help Groups.	Host and neighboring communities	DepEd, RHNC, Academe, Non-government organizations and others to be identified.	Community Relations Officer	Construction Operations	LGU-IRA, Proponent
Education and Recreation	Secondary and Tertiary Education	1. Facilitate involvement between self-help groups and the community in collaboration for education. 2. Facilitate family and community support for education. 3. Facilitate creation and development of inclusive learning environment.	Host and neighboring communities	DepEd, CHED, RHNC, Academe, Non-government organizations and others to be identified.	Community Relations Officer	Construction Operations	LGU-IRA, Proponent

Concern	Programs and Projects	Specific Activities	Responsible Community Member/ Beneficiary	Government Agency/ Non-government Agency and Services (indicate specific services)	Proponent	Indicative Timeline	Source of Fund
		4. Support access to secondary and higher education especially the poor, marginalized and persons with disabilities.					
Environment	Conservation of endemic vegetation and wildlife	1. Establishment of a local wildlife rescue facility. 2. Promotion of conservation education and wildlife protection. 3. Tree planting activities within target reforestation areas of the municipality	Host and neighboring communities	DENR 13, CENRO, MENRO, MPDOs, RHNC, Academe, Non-government organizations and others to be identified.	MEPEO	Construction Operations	LGU-IRA, Proponent
Waste Management and Sanitation	Improvement of waste management and sanitation services	1. Improvement of facilities such as MRFs and waste segregation bins. 2. Support to local waste management and sanitation programs. 3. Provision for improvement of waste management facilities in relation to the development of the CWPs	Host and neighboring communities	Municipal Engineering, RHNC and other organizations identified in the course of project implementation.	Community Relations Officer	Construction Operations	LGU-IRA, Proponent
Public Infrastructure	Improvement of access to basic services and general welfare facilities.	1. Improvement of facilities for basic services such as, but not limited to, educational, health, human development. 2. Support to Disaster Risk and Reduction Response programs. 3. Construction or improvement of general welfare facilities e.g., but not limited to, water system, canal, electricity, materials recovery facility. 4. Improvement of socio-cultural and value formation institutions e.g., churches, covered courts, parks community education avenues.	Host and neighboring communities	Municipal Engineering, RHNC and other organizations identified in the course of project implementation.	Community Relations Officer	Construction Operations	LGU-IRA, Proponent
Public Infrastructure	Support for socio-economic and micro-enterprise development.	1. Construction of facilities for improvement or advancement of livelihood opportunities e.g., but not limited to, farming and copra. 2. Improvement of government-constructed facilities that support improvement of livelihood opportunities, e.g., but not limited to, irrigation system, solar pavements, stock facilities.	Host and neighboring communities	Municipal Engineering, RHNC and other organizations identified in the course of project implementation.	Community Relations Officer	Construction Operations	LGU-IRA, Proponent

Concern	Programs and Projects	Specific Activities	Responsible Community Member/ Beneficiary	Government Agency/ Non-government Agency and Services (indicate specific services)	Proponent	Indicative Timeline	Source of Fund
Peace and Order	Value formation and collective consciousness raising	1. Assessment of current community values and barriers in achieving participation. 2. Facilitate development of community and group consciousness. 3. Understanding social, economic, cultural and political dynamics.	Host and neighboring communities	Church, RHNC, Academe, Community-based organizations, humanitarian agencies and other stakeholders to be identified in the course of the project.	Community Relations Officer	Construction Operations	LGU-IRA, Proponent
Peace and Order	Building of self-help groups and community organizing (for social, economic and political participation)	1. Facilitate community-needs assessment and leadership development and community planning based on the assessed community needs. 2. Self-help groups capability building and monitoring and mentoring. 3. Forging partnerships with other community-based organizations.	Host and neighboring communities	Church, RHNC, Academe, Community-based organizations, humanitarian agencies and other stakeholders to be identified in the course of the project.	Community Relations Officer	Construction Operations	LGU-IRA, Proponent
Peace and Order	Community participation development	1. Capability building and continuing education of project management skills of self-healp groups and people's organization geared to realization of SMMCI's overall objective. 2. Promote partnership and collaboration in community affairs such as, but not limitied to, general assembly, State of Barangay Affairs and planning. 3. Facilitate sharing of knowledge and experiences in community participation and continious challenge of identified participation barriers.	Host and neighboring communities	Church, RHNC, Academe, Community-based organizations, humanitarian agencies and other stakeholders to be identified in the course of the project.	Community Relations Officer	Construction Operations	LGU-IRA, Proponent
Socio-cultural and Spiritual	Values formation and preservation	1. Assessment of current state of values in the communities. 2. Formation of values that promote family relationships.	Host and neighboring communities	Church, Academe, Non-government organizations, humanitarian agencies and other organization to be identified in the course of program implementation.	Community Relations Officer	Construction Operations	LGU-IRA, Proponent

Concern	Programs and Projects	Specific Activities	Responsible Community Member/ Beneficiary	Government Agency/ Non-government Agency and Services (indicate specific services)	Proponent	Indicative Timeline	Source of Fund
Socio-cultural and Spiritual	Promotion of values on cooperation and collaboration.	1. Participation in community affairs that support and uphold nationalism, community volunteerism, environment enhancement and responsible citizen. 2. Development of avenues for community affairs and participation.	Host and neighboring communities	Church, Academe, Non-govenrment organizations, humanitarian agencies and other organization to be identified in the course of program implementation.	Community Relations Officer	Construction Operations	LGU-IRA, Proponent
Socio-cultural and Spiritual	Participation and support to community affairs.	1. Support and participation to community and institution festivities, spiritual gatherings, foundation days. 2. Support to community participation outside their locale for activities such as, but not limited to, festivities, spiritual gathering, cooperation and collaboration.	Host and neighboring communities	Church, Academe, Non-government organizations, humanitarian agencies and other organization to be identified in the course of program implementation.	Community Relations Officer	Construction Operations	LGU-IRA, Proponent
Socio-cultural and Spiritual	Community Education	1. Faciliate enhancement of existing community education programs. 2. Creation of curriculum that is practical and relevent, such as, but not limited to gender, disability, diversity, corellation. 3. Enhance and support home-based learning.	Host and neighboring communities	Church, Academe, Non-government organizations, humanitarian agencies and other organization to be identified in the course of program implementation.	Community Relations Officer	Construction Operations	LGU-IRA, Proponent

5.2 Information, Education and Communication Framework

5.2.1 Previous IECs conducted

IECs were conducted from 2018 to 2019 to inform the stakeholders of the change in mine method and project schedule. Prior to the 2018 to 2019, other IECs conducted were primarily on the accomplishments of the Community Development Programs (CDP), development of the SDMPs, presentations on responsible mining, "lakbay-aral" or educational tours of active mine areas and other projects of PMC, and broadcasts of testimonials from project stakeholders and CDP beneficiaries that highlight the best practices of SMMCI in terms of community engagement, community outreach, and other programs. The summary of IECs conducted from 2018 to present are tabulated below while the IECs conducted from 2012 to 2016 are appended to this section (**Annex 5.2**)

Target Sector Identified as Needing Project IEC	Major Topic/s of Concern in Relation to Project	IEC Scheme/ Strategies/ Methods	Information Material	Date and Location	Indicative Cost in PhP
Barangay Timamana, Tubod	Change in mine method and project schedule/updates Presentation of the new project footprint compared with the open pit disturbance area Community water supply	Barangay Assembly PowerPoint presentation with Open Forum Video/Animation of Sublevel caving	Presentation of company profile, project history updates on project status and change in mine method, comparison of project footprint for the open pit and sub-level caving, accomplishments in terms of CDPs and CSRs, and presentation of updates on Community Water Project	January 12, 2019 2:00 p.m Barangay Timamana covered court	300,000.00
Barangay Anislagan, Placer	Change in mine method and project schedule/updates Presentation of the new project footprint compared with the open pit disturbance area	Barangay Assembly PowerPoint presentation with Open Forum Video/Animation of Sublevel caving	Presentation of company profile, project history updates on project status and change in mine method, comparison of project footprint for the open pit and sub-level caving, and accomplishments in terms of CDPs and CSRs	January 11, 2019 2:00 p.m Barangay Anislagan gymnasium/covered court	
Barangay San Isidro, Placer	Change in mine method and project schedule/updates Presentation of the new project footprint compared with the open pit disturbance area	Barangay Assembly PowerPoint presentation with Open Forum Video/Animation of Sublevel caving	Presentation of company profile, project history updates on project status and change in mine method, comparison of project footprint for the open pit and sub-level caving, and accomplishments in terms of CDPs and CSRs	January 11, 2019 9:00 a.m Barangay San Isidro covered court	
MLGU Tubod	Change in mine method and project footprint, results of hydrological studies, and updates on the Community Water Project (CWP)	PowerPoint presentation with Open Forum	Presentation of company profile, project history updates on project status and change in mine method, comparison of project footprint for the open pit and sub-level caving, accomplishments in terms of CDPs and CSRs, hydrological basis for the assessment of potential impact or absence thereof on Songkoy Spring and Lake Mahucdam, and updates on the CWP	January 9, 2019 4:00 p.m Bastie Resto and Coffee Shop, Surigao City	
MLGU Sison	Change in mine method and project updates, TSF design considerations,	PowerPoint presentation with Open Forum	Presentation of company profile, project history updates on project status and change in mine method, comparison of	January 9, 2019 1:00 p.m	

Target Sector Identified as Needing Project IEC	Major Topic/s of Concern in Relation to Project	IEC Scheme/ Strategies/ Methods	Information Material	Date and Location	Indicative Cost in PhP
	and engagement of MLGU for a structural/geotechnical contractor		project footprint for the open pit and sub-level caving, accomplishments in terms of CDPs and CSRs, TSF reduction in footprint and design basis	Bastie Resto and Coffee Shop, Surigao City	
Representatives of Host and Neighboring Communities (RHNC), Municipality of Sison	Change in mine method and project updates, TSF design considerations	PowerPoint presentation with Open Forum	Presentation of company profile, project history updates on project status and change in mine method, comparison of project footprint for the open pit and sub-level caving, accomplishments in terms of CDPs and CSRs, TSF reduction in footprint and design basis	January 8, 2019 8:00 a.m Boardroom, SMMCI Site Office, Timamana, Tubod	
BLGU Lower Patag, Sison	Change in mine method and project updates, TSF design considerations	PowerPoint presentation with Open Forum	Presentation of company profile, project history updates on project status and change in mine method, comparison of project footprint for the open pit and sub-level caving, accomplishments in terms of CDPs and CSRs, TSF reduction in footprint and design basis	December 29, 2018 1:30 p.m Bastie Resto and Coffee Shop, Surigao City	
BLGU Upper Patag, Sison	Change in mine method and project updates, TSF design considerations	PowerPoint presentation with Open Forum	Presentation of company profile, project history updates on project status and change in mine method, comparison of project footprint for the open pit and sub-level caving, accomplishments in terms of CDPs and CSRs, TSF reduction in footprint and design basis	December 29, 2018 10:00 a.m Bastie Resto and Coffee Shop, Surigao City	
BLGU Boyongan, Placer	Change in mine method and project updates, employment opportunities	PowerPoint presentation with Open Forum	Presentation of company profile, project history updates on project status and change in mine method, comparison of project footprint for the open pit and sub-level caving, and accomplishments in terms of CDPs and CSRs	December 28, 2018 10:00 a.m Bastie Resto and Coffee Shop, Surigao City	
BLGU Sta.Cruz, Placer	Change in mine method and project updates	PowerPoint presentation with Open Forum	Presentation of company profile, project history updates on project status and change in mine method, comparison of project footprint for the open pit and sub-level caving, and accomplishments in terms of CDPs and CSRs	December 27, 2018 3:00 p.m Bastie Resto and Coffee Shop, Surigao City	
BLGU Anislagan, Placer	Change in mine method, project updates and schedule, updates on the Community Water Project (CWP) for Anislagan	PowerPoint presentation with Open Forum	Presentation of company profile, project history updates on project status and change in mine method, comparison of project footprint for the open pit and sub-level caving, accomplishments in terms of CDPs and CSRs, design basis for the TSF, and updates on the CWP for Anislagan	December 27, 2018 10:00 a.m Bastie Resto and Coffee Shop, Surigao City	
BLGU Macalaya, Placer	Change in mine method and project updates	PowerPoint presentation with Open Forum	Presentation of company profile, project history updates on project status and change in mine method, comparison of project footprint for the open pit and sub-level caving, and accomplishments in terms of CDPs and CSRs	December 22, 2018 10:00 a.m Bastie Resto and Coffee Shop, Surigao City	

Target Sector Identified as Needing Project IEC	Major Topic/s of Concern in Relation to Project	IEC Scheme/ Strategies/ Methods	Information Material	Date and Location	Indicative Cost in PhP
BLGU Timamana, Tubod	Change in mine method, project schedule and footprint, and updates on the Community Water Projects (CWPs)	PowerPoint presentation with Open Forum	Presentation of company profile, project history updates on project status and change in mine method, comparison of project footprint for the open pit and sub-level caving, accomplishments in terms of CDPs and CSRs, and the status of the CWPs	December 21, 2018 10:30 a.m Bastie Resto and Coffee Shop, Surigao City	
BLGU Upper Libas, Tagana-an	Change in mine method, project schedule, and project footprint retained in Upper Libas, Tagana-an	PowerPoint presentation with Open Forum	Presentation of company profile, project history updates on project status and change in mine method, comparison of project footprint for the open pit and sub-level caving, and accomplishments in terms of CDPs and CSRs	December 20, 2018 3:10 p.m Parkway, Surigao City	
BLGU San Isidro, Placer	Change in mine method and project schedule, comparison of project footprint from open pit to sublevel caving, and employment opportunities	PowerPoint presentation with Open Forum	Presentation of company profile, project history updates on project status and change in mine method, comparison of project footprint for the open pit and sub-level caving, and accomplishments in terms of CDPs and CSRs	December 20, 2018 2:00 p.m Parkway, Surigao City	
BLGU San Isidro, Tubod	Change in mine method and project schedule, comparison of project footprint from open pit to sublevel caving, and employment opportunities	PowerPoint presentation with Open Forum	Presentation of company profile, project history updates on project status and change in mine method, comparison of project footprint for the open pit and sub-level caving, and accomplishments in terms of CDPs and CSRs	December 20, 2018 10:00 a.m Parkway, Surigao City	
MLGU of Placer	Change in mine method and project schedule, comparison of project footprint from open pit to sublevel caving, and employment opportunities	PowerPoint presentation with Open Forum	Presentation of company profile, project history updates on project status and change in mine method, comparison of project footprint for the open pit and sub-level caving, accomplishments in terms of CDPs and CSRs, and presentation of the Community Water Projects (CWP) to address the potential impacts on water supply	December 19, 2018 3:40 p.m Bastie Resto and Coffee Shop, Surigao City	
MLGU Sison	Project updates and change in mine method, reduction of project footprint particularly the TSF, and concerns on the safety and potential impacts of the TSF	PowerPoint presentation with Open Forum	Presentation of company profile, project history updates on project status and change in mine method, comparison of project footprint for the open pit and sub-level caving, accomplishments in terms of CDPs and CSRs, and presentation of the Tailings Storage Facility (TSF) design considerations	December 19, 2018 1:30 p.m Bastie Resto and Coffee Shop, Surigao City	
BLGU San Pedro, Sison	Change in mine method and project updates/schedule	PowerPoint presentation with Open Forum	Presentation of company profile, project history updates on project status and change in mine method, comparison of project footprint for the open pit and sub-level caving, and accomplishments in terms of CDPs and CSRs	December 20, 2018 4:00 p.m Parkway, Surigao City	
MLGU of Tagana-an	Project updates, change in mine method, project footprint within the	PowerPoint presentation with Open Forum	Presentation of company profile, project history updates on project status and change in mine method, comparison of project footprint for the open pit and sub-	December 18, 2018 12:55 p.m	

Target Sector Identified as Needing Project IEC	Major Topic/s of Concern in Relation to Project	IEC Scheme/ Strategies/ Methods	Information Material	Date and Location	Indicative Cost in PhP
	municipality with the change in mine method		level caving, accomplishments in terms of CDPs and CSRs, and the ECC amendment	SB Hall, Second Floor, Tagana-an Municipal Hall	
Mine Rehabilitation Fund Committee (MRFC)	Application for ECC amendment due to change in mine method; and advance information to MRFC about succeeding amendments to the SDMP, EPEP, and FMRDP	PowerPoint presentation with Open Forum	Presentation of company profile, project history updates on project status and change in mine method, comparison with the open pit and block-cave methods, indicative timeline of permitting applications and other approvals, accomplishments in terms of CDPs and CSRs, and next activities (SDMP, ECC Amendment, EPEP, FMRDP and DMPF amendments)	December 17, 2018 3:40 p.m. Mines and Geosciences Bureau (MGB) R13 Regional Office Session Hall, Surigao City, Surigao del Norte	
Sangguniang Panlalawigan, Surigao del Norte	Change of mine method	PowerPoint presentation with Open Forum	Presentation of company profile, project history updates on project status and change in mine method, comparison with the open pit and block-cave methods, accomplishments in terms of CDPs and CSRs, and responses to concerns on water resources	December 17, 2018 3:00 p.m. SB Session Hall, 3rd Floor, Capitol Building, Surigao City, Surigao del Norte	
SMMCI Employees	Change of mine method and project schedule	PowerPoint presentation with Open Forum	Information included corporate organization, project history, project status and updates including the change in mining method, comparative discussion of the open pit and sub-level caving mine methods, and the CDPs, CSRs, and environmental programs of the company to date.	December 14, 2018 7:30 a.m Right wing SMMCI Admin Building Timamana, Tubod, Surigao del Norte	
Municipal LGU of Tubod, Surigao del Norte	Change of mine method and project Schedule; Status of Community Water Projects (CWPs); Lack of impact of the Project to existing water sources such as Songkoy Spring	PowerPoint Presentation with Open Forum	Information included corporate and project background project status and updates including the change in mining method, comparative discussion of the open pit and sub-level caving mine methods, and the CDPs, CSRs, environmental programs of the company to date, and the CWPs to address apprehension about water supply are addressed.	December 13, 2018 7:30 a.m Municipal Hall of Tubod, Tubod, Surigao del Norte	

5.2.2 Proposed IEC Framework

The Information, Education and Communication (IEC) Framework like the SDP sets the broad features for the promotion of public awareness and education on mining technology and geosciences. Creditable activities and expenditures include:

- Establishment, enhancement, and maintenance of information and publicity centers for stakeholders to access information on the performance of mining operations
- Publication of IEC materials on social, environmental and other issues and concerns regarding mineral resources development and responsible mining operations
- Continuing public awareness and education campaign such as radio and web-based broadcasts, publications, and other forms of mass communications on mining-related information, issues and concerns

- Equipment and capital outlay as assistance to the institutionalization of public awareness and education on mining technology and geosciences

The IEC plan envisions to capacitate people in the host and neighboring communities and other stakeholders to a) develop a balanced view of mining operations, b) be their resources and problems including corresponding opportunities, and c) adopt and cope with, through behavior-based training and interventions, life in a mining community. **Table 5.2-1** presents the indicative IEC plan.

Table 5.2-1 Indicative Information, Education and Communication (IEC) Plan

Target Sector Identified as Needing Project IEC	Major Topic/s of Concern in Relation to Project	IEC Scheme/ Strategies/ Methods	Information Material	Indicative Timelines and Frequency	Indicative Cost in PhP per year
Project Stakeholders which includes: - Host and neighboring communities - Non-government organizations - Peoples organizations - Religious organizations - Academe - Business/Private sector	Mining 101 (Introduction to Mining)	PowerPoint Presentations and AVP, brochures/leaflets Interactive 3D model	• Interactive 3D scale model • PowerPoint presentation discussing basic details on mineral resources, mining methods, and how these relate to project • Project brief in the form of brochures or leaflets • Mine tours	Pre-construction to Construction phase, semi-annually	2,000,000.00
Project Stakeholders which includes: - Host and neighboring communities - Non-government organizations - Peoples organizations - Religious organizations - Academe - Business/Private sector	Project updates	Social Media	• SMMCI Facebook Page that provides weekly updates on Project Schedule, Important Announcements, etc.	Pre-Construction to Operations Phase	Integrated in labor cost for ComRel
Project Stakeholders which includes: - Host and neighboring communities - Non-government organizations - Peoples organizations - Religious organizations - Academe - Business/Private sector	Campaign for Social Acceptability, Environment Compliance and Safety and Health	1. Development of IEC materials, presentations, AVP, media millage, souvenirs and advocacy materials. 2. Regular IEC sessions, conferences and engagements. 3. Participation of activities of external stakeholders focusing on environment, safety and health and social responsibility. 4. Support to Disaster Risk and Reduction initiatives of pratners astakeholders.	• PowerPoint materials and other AVP • Television and radio ads • Posters, pamphlets, flyers • Souvenirs and other advocacy materials such as shirts and ecobags • Conferences and symposia	Pre-construction to operations phase, Semi-annual	2,000,000.00
Host communities	Project updates, schedule, employment opportunities and other issues and concerns	Barangay Assembly	• PowerPoint materials or other visual aids • Posters in barangay halls	Pre-Construction to Operations Phase, Quarterly	1,200,000.00
Host and neighboring communities	Capability-building and continuing education of Representatives of	1. Development of road-map for collaboration and participation of SDMP management.	• PowerPoint presentation and other AVPs	Pre-Construction to Operations	2,000,000.00

Target Sector Identified as Needing Project IEC	Major Topic/s of Concern in Relation to Project	IEC Scheme/ Strategies/ Methods	Information Material	Indicative Timelines and Frequency	Indicative Cost in PhP per year
	Host and Neighboring Communities and Local Government Officials and identified stakeholders.	2. Organization diagnosis and training needs assessment of stakeholders based on the road-map. 3. Participation to MGB-initiated activities and other symposiums and conventions that is relevant to the road-map. 4. Mentoring and continuing education based on the acquired knowledge and skills.	• Workshops and creation of written framework and planning tools • Symposia and conferences • Mine tours	Phase, semi-annual	

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Panimula:

Maayong buntag / hapon, ako po si ______________________________. Magahimo unta mi ug survey dri sa inyua para makapangutana mi dri sa mga tawo,mahitungod sa konsultasyon nga gihimo dri sa inyo barangay bahin sa Environmental Impact Assessment (EIA) ng Silangan Underground Copper-Gold Mine Project nga himuon ni SMMCI. Mukabat ra kini ug 10 hangtod 20 ka minuto Unya ang mga impormasyong nga amo makuha, ay konpidensyal lang.

Boluntaryo ang paglakip niño ani nga survey. Kung naay mga pangutana nga dili niño gusto tubagon, ingna laman ko para mudung ta sa sunod nga pangutana. Pwede sad ug ano undangon ang pagpangutana, depende ra sa inyua. Pero maninguha mi nga kamo musalig kanamo kay inyo paglakip ani nga survey importante sa atong tanan ug sa maong proyekto. Naa pakay laing pangutana?

Pwede nata magsugod?

NO .... End of Interview
~~YES~~ .... Record date and time and begin interview

Munisipalidad	[redacted]	**Barangay**	[redacted]	**Sitio / Purok**	[redacted]
Pangalan sa Ga-interview:	[redacted]	Oras Gasugod:	2:10 PM	Oras Nahuman:	2:30 PM

1.0 PAGKAKAKILANLAN SA KAPANAYAM

1.1 Unsa imo ngalan? (Pinakataas ug Ranggo sa Balay)	[redacted]		
	APELYIDO (SURNAME)	NGALAN (GIVEN NAME)	MIDDLE INITIAL
1.2 Kasarian	1 Lalaki	2 Babae	

1.3 Dis-a ka gi-anak?	1	Dinhi sa barangay	2	sa laing lugar pero naa ra sa Surigao del Norte	3	Sa ubang probinsya sa Luzon (Anong probinsya) ______	4	Sa Visayas (Anong probinsya) ______ ______	5	Sa Mindanao (Anong probinsya) ______ ______
1.4 Lakip mo sa grupong etniko?	1	Hindi	2	Oo:	3	Iba pa:			

1.5 Pilay imo edad?	1	15-20	2	21-30	3	31-40	4	41-50	5	51-60	6	61-70	7	71 -pataas

1.6 Unsa man imo estado sibil?	1	Dalaga / Binata	2	May asawa / Live-in	3	Byuda / Byudo / Balo	4	Hiwalay / Separada

1.7 Unsay ngan sa imo asawa/ bana kung naa kay asawa?	[redacted]		
	APELYIDO (SURNAME)	NGALAN (GIVEN NAME)	MIDDLE INITIAL
1.8 Kasarian ng asawa	1 Lalaki	2 Babae	

1.9 Kung naa moy anak, pila na kabook?	1 Lalake (Ilagay kung ilan)	1	2 Babae (Ilagay kung Ilan)	7	3 Total	7

1.10 Lakip ka, pila ang membro sa inyong household?	1	1-5	2	6-10	3	11-15	4	16 – higit pa

1.11 Unsa inyong relihiyon?	1 Katoliko	2 Iglesia ni Kristo	3 Protestant	4 Aglipayan	5 Islam	6 Iba pa: ______	7 Wala

2.0 PANINIRAHAN/ MIGRATION/ SETTLEMENT HISTORY

2.1 Pila namo ka tuig gapuyo diri sa barangay?	1	1-10	2	11-20	3	21-30	4	31-40	5	41-50	6	51-60	7	61-higit pa

2.2 Dis-a mo gapuyo sauna sa wala pa mo niabot diri sa	(Ibutang ang pangalan sa barangay, munisipyo / siyudad, ug probinsya): [redacted]

barangay?	

3.0 ANTAS NG PAG-AARAL

3.1 Unsay kinatas-ang antas sa pagtuon nga inyong naabot?	1	Wala	
	2	Elementarya (Ano ang pinakamataas na antas na natapos?)	
	3	High School (Ano ang pinakamataas na antas na natapos?)	
	4	Vocational (Ano ang pinakamataas na antas na natapos?)	
	5	Kolehiyo (Ano ang pinakamataas na antas na natapos?)	
	6	Post-Graduate (Ano ang pinakamataas na antas na natapos?)	

3.2 Naa pay membro dri sa inyo household nga ga-eskwela?	1	Meron	2	Wala

3.3 Kung naa pa, pila kabuok sila ga-eskwela ug unsang mga graduha?	1 Pre-school (Ilan): ____	2 Elementarya (Ilan): I	3 High School (Ilan): I	4 Vocational (Ilan): I	5 Kolehiyo (Ilan): I	6. Post-Graduate (Ilan): ____	7 Total: 4

3.4 Scholar bas a Silangan Mining ang mga ga-eskwela sa inyo balay?	1	Oo	2	Dili

4.0 KINABIBILANGANG MGA ORGANISASYON SA KOMUNIDAD

4.1 Lakip ba kamo sa isa ka organisasyon o sectoral group?	1	Oo (pangalan ng organisasyon): ____	2	Wala

4.2 Kung lakip mo sa sa isa ka organisasyon o sectoral group, unsay mga benepisyo inyo nakuha nyo maingung organisasyong?	1. ____ 2. ____ 3. ____
4.3 Unsa man sa tan-aw nimo ang angay pa tarungon para mas mumaayo pa ang estado sa inyo grupo?	1. ____ 2. ____ 3. ____

5.0 PAGMAMAY-ARI AT KATANGIAN NG TIRAHAN

5.1 Kamo bay tag-iya ani inyo gipuy-an? (Isa ray pwede nga tubag)	1	Owner, Owner-like possession of House and Lot
	2	Rent House/ Room, including Lot
	3	Own House and Rent-free Lot with Lot Owner's Consent
	4	Own House, Rent-free Lot without Owner's Consent
	5	Rent-free House and Lot with Owner's Consent
	6	Rent-free House and Lot without Owner's Consent
	7	Iba pa (Specify) ____
5.2 Unsang dokumentuha ang naa ninyo para makaingun mo nga inyua gyud ni or kamo gyud ang ga-renta ani nga balay ug yuta?	1	Torrens Titles
	2	Tax Declaration
	3	Deed of Sale
	4	DAR Certificate
	5	Deed of Donation
	6	Iba pa (Specify) ____

5.3 Unsa man nga materyales hinimo inyo sawg?	1 Lupa (Earth/Soil)	2 Kawayan (Bamboo)	3 Kahoy (Lumber)	4 Semento o Konkreto	5 Iba pa (Anong materyales?): ____

5.4 Unsa nga materyales hinimo	1	Lig-on (Semento / Konkreto / Bato / Bricks / Hollow blocks / Kahoy / Lumber)

inyo bong-bong?	2	Dili kayo lig-on (Kawayan / Sawali / Kogon / Nipa)
	3	Salvaged/Makeshift nga materyales
	4	Sagol (Mixed) pero mas daghan ang lig-on nga materyales
	5	Sagol (Mixed) pero mas daghan ang ga-an nga materyales
	6	sagol (Mixed) pero mas daghan ang salvaged / makeshift nga materyales
	7	Uban pa: ______
5.5 Unsa man nga materyales hinimo inyo atup?	1	Lig-on (Yero / Semento / Konkreto / Bato / Tiles / Kahoy / Lumber)
	2	Dili kayo lig-on (Kawayan / Sawali / Kogon / Nipa)
	3	Salvaged/Makeshift na materyales
	4	Sagol (Mixed) pero mas daghan ang lig-on nga materyales
	5	Sagol (Mixed) pero mas daghan ang ga-an nga materyales
	6	Sagol (Mixed) pero mas daghan ang salvaged / makeshift nga materyales
	7	Uban pa: ______
5.6 Unsa may tan-aw nimo nga kondisyon ani inyo balay?	1	Wala nanginahanglan ug repair
	2	Nanginahanglan ug gamay nga repair
	3	Nanginahanglan ug dako nga repair
	4	Pirme gi-ayo

6.0 MGA GAMIT O PASILIDAD

6.1 Unsay pamaagi ninyo sa inyo pag-CR? (Isa ra pwede itubag)	1	Flush nga Inidoro	2	Bubu-an nga Inidoro	3	Unyo balay naay buslot sa yuta para adto ilabay	4	Magkubkob lng sa yuta	5	Wala

6.2 Asa gikan inyo tubig?	1	Community / Municipal Water System	1.1	Naay kaugalingon nga gripo, koneksyon o metro
			1.2	Nakigamit sa isang common / shared nga gripo
	2	Deep Well	2.1	Naay kaugalingon nga deep well
			2.2	Nakikigamit sa isang common/shared nga deep well
	3	Artesian Well o Spring	3.1	Naay kaugalingon nga artesian well o spring
			3.2	Nakigamit sa isa ka common/shared na artesian well o spring
	4	Dug/ Shallow Well	4.1	Naay kaugalingon nga dug / shallow well
			4.2	Nakigamit sa isa ka common/shared na dug/shallow well
	5	Gakuha sa sapa		
	6	Bottled water o water refilling station		
	7	Uban pa: ______		

6.3 Kayo po ba ay nagbabayad ng tubig?	1	Oo	2	Wala								
6.4 Kung gabayad mo ug tubig, pila inyo ginabayaran kada buwan?	1	Ubos pa sa PhP 100	2	PhP 101 - 500	3	PhP 501 – 1,000	4	PhP 1,001 – 1,500	5	PhP 1,501 – 2,000	6	Dako pa sa PhP 2,000
6.5 Ang ginakuhaan ba ninyo ug tubig sakto ra sa inyo gikinahanglan?	1	Oo	2	Dili								
6.6 Naa moy kuryente?	1	Naa	2	Wala								

6.7 Asa gikan inyo kuryente? (Isa ray pili-on nga tubag)	1	Electric Company, kaugalingon nga koneksyon o metro
	2	Electric company, shared connection
	3	Generator / Genset
	4	Battery
	5	Uban pa (Ibutang kung unsa nga klase):______

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6.8 gabayad ba mo ug kurente?	1	Oo	2	Wala							
6.9 Kung gabayad mo ug kurente, pila inyo ginabayad kada buwan?	1	Ubos pa sa PhP 100	2	PhP 101 - 500	3	PhP 501 – 1,000	4	PhP 1,001 – 1,500	5	PhP 1,501 – 2,000	6	Dako pa sa PhP 2,000
6.10 Kuntento namo sa serbesyo sa kurente sa inyo lugar?	1	Kuntento kaayo	2	Medyo kuntento	3	Neutral	4	Medyo Hindi Kuntento	5	Hindi Kuntento		

6.11 Unsay kasagaran inyo ginasakyan padulong sa inyo bayan?	1	Jeep	2	Bus	3	Van o Shuttle	4	Truck
	5	Tricycle	6	Bicycle	7	Motor, habal-habal o kolong-kolong	8	kaugalingong awto
	9	Galakaw lang	10	Iba pa: ____				

6.12 Ang inyo bang balay naay ingani nga mga gamit:	1 TV ____	2 Cable Connection_ ____	3 DVD player ____	4 AM / FM Radio ____	5 MP3 Player ____	6 Refrigerator / Freezer ____
	7 Electric Iron / Plantsa ____	8 Washing Machine ____	9 Gas Stove ____	10 Microwave Oven ____	11 Desktop Computer / Laptop ____	12 Internet Connection ____
	13 Aircon ____	14 Landline Phone ____	15 Cellphone ____	16 Electric Fan ____	17 Sewing Machine ____	18 Generator /Genset ____	19 Motorcycle / Vehicle ____

6.13 Unsay ginagamit ninyo sa pagluto?	1 Gas Stove	2 Charcoal Stove (Uling)	3 Electric Stove	4 Firewood (Kahoy)	5 Iba pa (Pakilagay ang uri): ____

6.14 Naa bas a inyo panimalay nakatag-iya ani nga mga negosyoha / livelihood means?	1	Sari-sari Store
	2	Hotel / Inn / Resort
	3	Cellphone load business
	4	Restaurant / Kantina / Karinderya
	5	Computer Shop
	6	Ukay-ukay o wagwagan
	7	Vegetable Farm
	8	Rice / Corn Farm
	9	Poultry
	10	Piggery
	11	Iba pa (Pakilagay kung ano):____

7.0 PINAGMUMULAN NG KITA NG SAMBAHAYAN

7.1 Kinsay kinadak-an ug kita sa inyo panimalay?

1	Ang gadumala ana inyo panimalay	2	Asawa	3	Anak nga lalaki
4	Anak nga babae	5	Kamag-anak nga lalaki	6	Kamag-anak nga babae

7.2 Unsay pangita sa tubag sa 7.1?

1	Empleyo / Sweldo mula sa Pribadong Kompanya	2	Empleyo / Sweldo mula sa Gobyerno	3	Self-Employed / Negosyo
4	Pagsasaka	5	Pangingisda	6	Pensyon / Assistance

7	Remittance	8	Contractor / Subcontractor	9	Pagtitinda
10	Iba pa (Ilagay kung anong uri): ______				

7.3 Unsang negosyoha / industriya / sektor gatrabaho ang tubag sa 7.1?

1	Agrikultura	2	Pangingisda o Aquaculture	3	Forestry
4	Manufacturing	5	Construction	6	Mining and Quarrying
7	Electricity, Gas and Water	8	Wholesale, Retail Trade	9	Transport and Storage
10	Communications	11	Community, Social and Personal Services	12	Financing, Insurance, Real Estate
13	Business Process Outsourcing (BPO)	14	Arts and Entertainment	15	Iba pa (Ilagay ang uri): ______

7.4 Unsay status sa pag-empleyo sa tubag sa 7.1?	1	Permanente	2	Contractual / Short-term / Casual	3	Itinerant (Iba-iba ang trabaho kada araw o lingo)

7.5 Naay miyembro diri sa inyo panimalay nga empleyado o contractor sa **Silangan Mining**?	1	Naa (Ilagay ang posisyon): Heavy equipment operator		Wala

7.6 Sa inyong tan-aw, pilay binuwan nga kita ng inyong panimalay?

1	Ubos sa PhP 1,000	2	Php 1,001 – PhP 4,999	3	PhP 5,000 – PhP 9,999
4	PhP 10,000 – PhP 14,999	5	PhP 15,000 – PhP 19,999	6	PhP 20,000 – PhP 24,999
7	Taas pa sa PhP 25,000				

7.7 Mga gastos sa panimalay (Ibutang lang ang tantya nga kantitad para sa lahi-lahing klase sa pagkakagastusan)

Item	Amount	Item	Amount	Item	Amount
Pagkaon (Food) kada araw / buwan	10.000	Baon sa Eskuwelahan (School Allowance) kada araw / buwan	1000	Sigarilyo (Cigarettes) kada araw / buwan	
Sinina (Clothing) kada araw / buwan		Kuryente (Electricity) kada araw / buwan	700	Panginom / Alak / Beer (Liquor) kada araw / buwan	
Tambal (Medicine) kada araw / buwan		Plite (Transportation/Fare) kada araw / buwan		Loans / amortization kada araw / buwan	
Gasolina / Diesel (Fuel) kada araw / buwan		Pangluto (Cooking Fuel) kada araw / buwan		Cable/ internet kada araw / buwan	100
Genset for lighting kada araw / buwan		Cellphone Load / Landline kada araw / buwan		Iba pa (Pakilagay kung ano at kung magkano kada araw/buwan): ______	

7.8 Kung trabahante ka sa Silangan Mininig kuntento ka sa imo trabaho?	1	Oo	2	Dili
7.9 Kung Oo ang sagot sa 7.8, mas nabintaha ba ang imong kahimtang o inyong kinabuhi tungod kay nakatrabaho mo sa Silangan Mining?	1	Oo	2	Dili
7.10 Kung dili kuntento ang sagot sa 7.8, bakit?	______			

8.0 PANGANGASIWA NG DUMI O BASURA AT PANANAW SA KAPALIGIRAN

8.1 Unsa ninyo paglabay sa inyo mga basura? (Pili bisag pila)	1	Ginahakotsa Provincial / Municipal Waste Collection
	2	Ginasunog
	3	Composting
		3.1 Pit without Cover
		3.2 Pit with Cover
	4	Recycling
	5	Waste Segregation
	6	Ginalabay bisag-asa
	7	Iba pa (ilagay ang pamamaraan):________________

8.2 Kapila ginahakot inyo basura diri sa inyo lugar?	1	Kada adlaw	2	Kaduha o katulo sa isa ka semana	3	Kas-a sa is ka semana
	4	Dili mahibaw-an pirme	5	Uban pa:		

8.3 Nituo ba mo sa giingun nga mas maayo pa nga mukita maski nga madaot ato kinaayuhan?	1	Tuo kaayo
	2	Mituo
	3	Medyo mituo
	4	Wa kasigurado
	5	Medyo wala mituo
	6	Wala mituo
	7	Wa gyud Mituo
8.4 Nituo mo nga pwede mukita ug kwarta unya ato pung kinaayuhan dili madaot?	1	Tuo kaayo
	2	Mituo
	3	Medyo mituo
	4	Wa kasigurado
	5	Medyo wala mituo
	6	Wala mituo
	7	Wa gyud Mituo
8.5 Nituo ba mo nga ang paglabay ug basura bisag-asa makadaot sa ato kinaiyahan?	1	Tuo kaayo
	2	Mituo
	3	Medyo mituo
	4	Wa kasigurado
	5	Medyo wala mituo
	6	Wala mituo
	7	Wa gyud Mituo

8.6 Ganahan ba mo nga maayos inyo kapaligiran?	1	Oo	2	Dili	
8.7 Kung ang inyong sagot ay Oo sa 8.6 sa imo tan-aw, unsaon kaha nato pagpaayo sa kinaiyahan?	dili basta maglabay ug basura, dili magputol ug kahoy, atimanon ang kinaiyahan				

9.0 KALUSUGAN AT NUTRISYON

9.1 Karong tuiga, diha bay nagkasakit sa inyo panimalay?	1	Diha (ibutang kung pila)	2	Wala
9.2 Unsang klaseng mga sakita?	1	Pagtatae (diarrhea), gastrointestinal diseases	5	Sakit sa kasukasuan, rayuma, arthritis
	2	Sipon, Ubo, Upper Respiratory Infection	6	Stroke
	3	Pneumonia, Tuberculosis o iba pang sakit sa baga	7	Sakit sa balat

	4	Sakit sa puso, hypertension, high blood	8	Pagkapilay, pagkabali ng buto, sprain at iba pang injury dulot ng aksidente
	5	Iregular na menses o pagdurugo	9	Iba pa (ilagay ang uri): ______________

9.3 Asa man mo mudulong kung muadto manghinanglan mo ug tambal ug serbisyo sa health?	1	Balay ra; palit lang ug tambal
	2	Barangay Health Center
	3	Puericulture Center
	4	Government Hospital
	5	Private Clinic / Hospital
	6	Albularyo/ Herbalists/ Indigenous o tradisyunal na pagamutan / manggagamot
	7	Uban pa:______________

9.4 Kuntento naba mo sa serbisyo gihatag sa inyo barangay health center?	1	Kuntentong -kuntento	2	Medyo kuntento	3	Dili sigurado	4	Medyo Dili Kuntento	5	Dili Kuntento

9.5 Asa mo gapalit ug tambal?	1	Botika o Drugstore	3	Municipal / Rural Health Center	5	Sari-sari Store o Grocery
	2	Barangay Health Center	4	Ospital	6	Iba pa (ilagay kung saan):__________

9.6 Naa bay programa pangkalusugan inyo lugar?	1	Naa (unsa man): __________	2	Wala	

9.7 Asa mo mangayo ug tabang sa panahon sa disgrasya sa kaiyahan?	1	Gobyerno
	2	Barangay kapitan
	3	Non-Government Organizations (NGOs)
	4	Simbahan / Religious Leaders
	5	Parente / Silingan
	6	Uban pa:______________

9.8 Kuntento naba mo sa serbisyo ginahatag sa barangay ninyo kung sa panahon sa kalamidad?	1	Kuntentong -kuntento	2	Medyo kuntento	3	Dili sigurado	4	Medyo Dili Kuntento	5	Dili Kuntento

9.9 Kapila mo mangaon sa isa ka adlaw?	1	2	3	4	5	6

9.10 Kapila mo mangaon ani nga mga pagkaona? (Lagyan ng X ang sagot para sa bawat uri ng pagkain)

Pagkain	Araw-araw	Isang beses kada dalawang araw (Every other day)	Tatlong beses sa isang linggo	Dalawang beses sa isang lingo	Isang beses kada lingo	Hindi nakakakain
Kanin	✓					
Tinapay, iba pang uri ng starch, cereal	✓					
Camote o iba pang root crops					✓	
Gulay	✓					
Prutas			✓			
Karneng Baboy o Baka			✓			
Isda at iba pang lamang tubig/dagat	✓					
Itlog	✓					

Gatas, keso at iba pang dairy products	✓					
Processed food (hotdog, bacon, tocino, etc.) at de lata					✓	

9.11 Asa mo gapalit ug pagkaon?	1	Merkado	2	Sari-sari Store	3	Supermarket / Grocery	4	kaugalingong taniman / farm/ garden

10.0 COMMUNITY AWARENESS

10.1 Unsa sa imo tan-aw ang pinakadakong problema gi-atubang sa inyo barnagy ron? ***VERBATIM RESPONSE***	1. Kawat. 2. 3.
10.2 Unsay mga programa sa inyo barangay nga ila ginahimo para matubag ng giingung problema sa 10.1? ***VERBATIM RESPONSE***	1. roking. 2. 3.

10.3 Interesado ba mo nga muapil sa mga programa sa inyo barangay para mutabang ug solbad sa problema nga ila gina-atubang karon hangtod sa lima pa ka tuig?	1	Oo	2	Dili	3	Di sigurado
10.4 Naa kay mga training nga gusto nimo lakipan?	1	Naa (unsa man):	2	Wala		
10.5 Naa kay nahuna-hunaan nga programa bahin sa kinaiyahan nga gusto nimo ipahimo sa imo barangay?	1	Naa (unsa man):	2	Wala		

11.0 PROYEKTONG PANGINABUHI, COMMUNITY DEVELOPMENT PROGRAMS, AT UBAN PA NA NAAPILAN GIKAN SA SILANGAN MINING

11.1 Kahibaw bam o sa mga Community Development Programs sa Silangan Mining?	1	Oo	2	Wala

12.1 Kung kahibaw mo, unsa man nga mga programa ang inyo nahibaw-an? (Isulat ang ngalan ng proyekto	Lagyan Check (√) ang sagot	
1. Pag-eskwela 2. Medical mission 3. 4. 5. 6.	Nakaapil? ✓ ✓	Wala Nakaapil?

12.2 Ngano wala nakaapil?

12.3 Kung niapil, nakapahimos pa mo aning mga programa nga inyo nahibaw-an?	1	Oo	1	Dill

SOCIO-ECONOMIC, PUBLIC HEALTH AND PERCEPTION SURVEY FORM

12.4 Kung Oo, unsa ang natabang?

Ka libre, sa gasto sa Dental, ug sa school supply

12.5 Aduna ka bay laing ikahatag na suhestiyon kun unsa pa proyekto para sa komunidad?

libre nga kuryente, livelihood para sa mga Kertanhon

12.0 CLIMATE CHANGE ADAPTATION AND DISASTER RISK REDUCTION

12.1	Nakasuway na ba kamo dinhi sang lig-on kaayo na ulan ug baha sa nangagi lima ka tuig?	Na-a ✓ Wala
12.2	Nakasuway na ba kamo sang lig- on kaayo na linog sa nangagi na lima ka tuig?	✓ Na-a Wala
12.3	Unsa inyong ginabuhat kon nakasuway mo sang lig-on kaayo na ulan o baha?	Dili naga gawas sa bayay Molalin ug moadto sa mga paryente Molalin ug moadto sa evacuation centers
12.4	Unsa inyong ginabuhat kung nakasuway mo sang lig-on kaayo na linog?	Dili naga gawas sa bayay Molalin ug moadto sa mga paryente Molalin ug moadto sa evacuation centers

Butangi ug check (✓) ag pinakahabalak-an o dili ka-ayo sa listahan:

		Waya nagakaba laka (Not worried at all)	Morag nagakaba laka (Somewhat worried)	Nagakabalaka kaayo Very worried	(Waya nakahibalo) Don't Know/ No Response
12.5	Mohugaw o molapas ug tinubdan sa gi inom na tubig *Pollute/destroy sources of drinking water*		✓		
12.6	Mohugaw o molapas ang mga suba ug linaw *Destroy/pollute streams, lakes and springs*		✓		
12.7	Mohugaw o molapas ang hangin *Pollute the air*		✓		
12.8	Moguba ang mga tanom sa basakan ug ma apektohan ang mga ani *Destroy crops/negative impacts on harvests*		✓		
12.9	Hinungdan sa baha ug pgdahili sa yuta *Cause flood and landslides*			✓	
12.10	Paphaon ang mga tao sa ila yuta ug kinabuhian *Displace people from land/livelihoods*			✓	
12.11	Magadala ug mga sakit *Give rise to illnesses*			✓	

13.0 PERCEPTION SURVEY

13.1 Nahibaw baka bahin aning sa Silangan Gold-Copper Mine Project na Underground	1	Oo	2	Wala

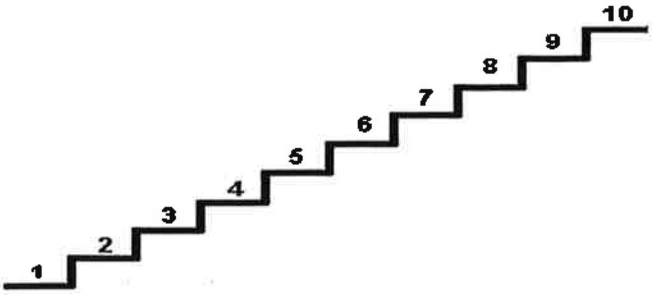
13.2 Kung Oo imo tubag sa 11.1, dis-a ka nakakuha sa impormasyon?	1	IEC ng SMMCI	2	Public Scoping
	3	Pagpupulong sa barangay / Barangay Officials	4	Munisipyo / Mayor's Office
	5	Radyo	6	Telebisyon
	7	Mga kamag-anak	8	Mga kapitbahay

	9	SMMCI	10	Iba pa:____________________

13.3 Sa imo tan-aw, unsay positibo nga mahimo ang proyekto diri sa inyo lugar?	1	makatrabaho ang mga tawo
	2	Makahatag ug panginabuhian
	3	maka- eskwela ang mga bata
	4	
	5	
13.4 Sa imo tan-aw, unsay negatibo nga mahimo ang proyekto diri sa inyo lugar?	1	mag baha
	2	mag landslide
	3	mawala ang tinubdan sa tubig
	4	dili makatrabaho kay taga laing lugar
	5	ra ang makatrabaho

14.0 KALIDAD NG BUHAY NG HOUSEHOLD/SAMBAHAYAN

Ang sunod nga pangutana bahin sa imong kahimtang sa imo kinabuhi hasta imo pamilya. Sa kani nga pagtuon ang kalidad sa kinabuhi mao ang nay maayong panglawas, wa galisod sa pamilya (UN 1991), ug matod sa NEDA 1992, mayo ang panglawas, naka-eskwela ang mga bata, walay gubot sa lugar nga gipuy-an.



Unsa imo mahatag nga grado bahin sa kalidad sa inyo kinabuhi ? 4

Ngano ing-ana imo gigrado? makakaon kew kulang pa ang kita alang sa pang nabalagan.

15.0 GENERAL ASSESSMENT

Let's say in a scale of 0 to 10 where "10" means that you are strongly in favour of Silangan Copper-Gold Project and "0" that you are strongly against it, where do you stand?

***Kung sa 0 asta 10, kung "0" dili gyud ka pabor/uyon sa Silangan Copper-Gold Project, kag 10 pabor/uyon* nimo, asa ka man mabarog/unsa man nimo tinindugan?**

0 Strongly Against	1	2	3	4	5	6	7	8	9	10 Strongly in Favor
					/					

Let's say in a scale of 0 to 10 where "10" means that your neighbour is strongly in favour of Silangan Copper-Gold Project and "0" that he/she is strongly against it, where do you think does he/she stand?

***Kung sa 0 asta 10,kung 0 dili gyud pabor/uyon , kag 10 pabor/uyon, sa imong opinion, asa mubarog/unsa man* tinundugan sang imo silingan hantod sa Silangan Copper-Gold Project?**

0 Strongly Against	1	2	3	4	5	6	7	8	9	10 Strongly in Favor
					/					

--- **DAGHANG SALAMAT SA IMO ORAS** ---

Signature sa gi-interbyu: [redacted] Petsa sa Interbyu: [redacted]

Ga-interbyu : [redacted] Petsa sa Interbyu:

Ngalan at Lagda

[redacted]

DRAFT

Environmental Impact Statement

Section 6. Environemntal Compliance Monitoring

Contents

6 Environmental Compliance 6-1

6.1 Multi-sectoral Monitoring Framework 6-1

6.2 Environmental Guarantee and Monitoring Funds 6-2

6.2.1 Mine Rehabilitation Fund (MRF) 6-2

6.2.2 Mine Waste and Tailings Fees (MWTF) 6-2

6.2.3 Environmental Protection and Enhancement Program (EPEP) 6-2

6.2.4 Final Mine Rehabilitation and Decommissioning Fund (FMRDF) 6-3

6.3 Self-Monitoring Plan 6-3

Table 6.3-1 Self-Monitoring Plan Matrix 6-4

Appendix A. Additional Information

6. Environmental Compliance Monitoring

The framework for environmental compliance monitoring and environmental performance indicators, as required by DAO 2003-30, includes a Multi-sectoral Monitoring Framework, Environmental Guarantee and Monitoring Fund Commitment, and the Self-monitoring Plan. These frameworks and performance indicators are discussed in detail in the succeeding sections.

6.1 Multi-sectoral Monitoring Framework

Relative to the DAO 2010-21 (Implementing Rules and Regulations of RA 7942) Section 182 entitled The Mine Rehabilitation Fund (MRF) Committee, an MRF Committee (MRFC) shall be created in each region where active mining operation exists. MRFC's duties and responsibilities include deputizing a Multi-Partite Monitoring Team (MMT) to serve as its monitoring arm. The formation of the MMT is required under Section 185 of the Philippine Mining Act of 1995 (DAO 2010-21). The MMT is a multi-sectoral team convened to encourage public participation by the Project's stakeholders and to monitor and validate the proponent's compliance to environmental conditions stipulated in the ECC, the Environmental Management Plan/Program, the approved Environmental Protection and Enhancement Program (EPEP) and subsequent Annual Environmental Protection and Enhancement Plan (AEPEP), and to other relevant environmental laws and regulations.

Based on Section 17 of DAO 2017-15 "Guidelines on Public Participation under the PEIS System," the MMT has the chief responsibility of validating SMMCI's environmental performance, with the following specific functions:

- Conduct of quarterly ocular site visit to validate the project's compliance with the conditions stipulated in the ECC and EMMoP;
- Conduct of closing meeting after every site visit to discuss findings with SMMCI;
- Validate SMMCI's conduct of self-monitoring;
- Make regular and timely submission of the Compliance Monitoring and Validation Report (CMVR) based on the EMB-prescribed format in DAO 2003-30. The CMVR is to be submitted to EMB Central Office and EMB Regional Office (EMB R13) semi-annually. CMVR will be submitted not later than July 30 of the year and January 30 of the following year covering 1st and 2nd semester, respectively; and
- Institute an environmental emergency and complaints receiving and management mechanism which shall include systems for transmitting recommendations for necessary regulatory action to EMB in a timely manner to prevent adverse environmental impacts.

The MMT for the Silangan Copper-Gold Project will be deputized by the Mine Rehabilitation Fund (MRF) Committee to serve as the monitoring arm of the said committee. The MMT shall be composed of the following:

- Representatives from LGU:
    - 1 representative from each Municipality/City and resource officer from MENRO/CENRO and PENRO;
    - The Rural Health Unit (RHU) Chief; and
    - Concerned Barangay Captain.
- 1 representative from the LGU-accredited local NGOs with mission(s) specifically related to environmental management; and
- Maximum of 3 representatives from government agencies with related mandate on the type of project.

The criteria used in the identification of the MMT members are primarily from their legitimate interest in the project and based on the guideline requirement set in DAO 2017-15. These include physical location (e.g. direct impact area and indirect impact area); presence of community-based activities (e.g. organizations who are locally active); and agencies who have mandates over the project area.

Annex 6-1 shows a draft template of a Memorandum of Agreement for the MMT based from DAO 2003-30. It includes the proposed MMT role, and scope of MMT responsibilities/activities. The proposed monitoring plan is in **Table 6.3-1**.

This monitoring plan will be further discussed and agreed upon among the members of the MMT before the start of the monitoring activities.

6.2 Environmental Guarantee and Monitoring Funds

Consistent with DAO 2010-21, the proponent is committed to institutionalize an environmental guarantee fund mechanism to be known collectively as the Contingent Liability Rehabilitation Fund (CLRF). The CLRF is composed of the Mine Rehabilitation Fund (MRF), Mine Waste and Tailings Fees (MWTF) and the Final Mine Rehabilitation and Decommissioning Fund (FMRDF). The MRF is, in turn, composed of the Monitoring Trust Fund (MTF) and Rehabilitation Cash Fund (RCF). The FMRDF funds the implementation of the Final Mine Rehabilitation and Decommissioning Plan (FMRDP) during the closure phase.

6.2.1 Mine Rehabilitation Fund (MRF)

The MRF shall be deposited as a trust fund in a government depository bank and shall be used for physical and social rehabilitation of areas and communities affected by mining operations and for research on social, technical, and preventive aspects of rehabilitation. It shall be in two forms and shall be maintained in a distinct and separate book of records:

- Monitoring Trust Fund (MTF) –The MTF shall be established by SMMCI for the exclusive use in the monitoring program approved by the Mine Rehabilitation Fund Committee. The MTF shall be in cash and amount to at least PhP150,000 to cover maintenance and other operating budget for the transportation and travel expenses, cost of laboratory analysis, cost of supplies and materials, cost of communication services, cost of consultancy work and other reasonable expenses incurred by the monitoring team.
- Rehabilitation Cash Fund (RCF) – SMMCI shall also set up a RCF, which is equivalent to 10% of the total amount needed to implement the EPEP or five million pesos (P5,000,000), whichever is lower, to ensure compliance with the approved rehabilitation activities and schedules for specific mining project phase, including research programs.

6.2.2 Mine Waste and Tailings Fees (MWTF)

The MWTF shall be PhP 0.50 per metric tonne of mine waste produced and PhP 0.10 per metric tonne of mill tailings generated from the milling operation, except where such mine waste were utilized in several manners as stipulated in Section 190 of DAO 2010-21. It shall be collected semi-annually and the amount of fees collected shall accumulate to a Mine Waste and Tailings Reserve Fund, which is deposited in a government depository bank to be used for a payment of compensation for damages caused by any mining operations or for research projects duly approved by the CLRF Steering Committee. The Project is estimated to generate 200 Mt of tailings that will translate to a potential collection from the project of about PhP 21.1 million of mill tailings fees.

6.2.3 Environmental Protection and Enhancement Program (EPEP)

As provided in DAO 2010-21 Section 169 (Environmental Protection and Enhancement Program), SMMCI shall allocate for its initial environment-related capital expenditures an amount that shall approximate ten percent (10%) of the total capital/project cost or such other amount depending on the environmental/geological condition, nature and scale of operations and technology employed. Initial environment related capital expenditures may include environmental studies and design cost, waste area preparation, tailings/slime containment/disposal system, mine waste disposal system, wastewater/acid mine drainage treatment plants, dust control equipment, air pollution control facilities, drainage system and other environment-related mitigating measures and capital expenditures.

In essence the EPEP serves as the operational plan for the environmental monitoring and management programs presented in this section. The EPEP will provide a detailed presentation of the environmental compliance monitoring program that will eventually be annualized as part of the annual EPEP submissions. At present, the total EPEP cost amounts to PhP 257,964,590.00 but this cost will be revised to reflect the change in method for open pit and additional activities not accounted for under the block cave DMPF.

6.2.4 Final Mine Rehabilitation and Decommissioning Fund (FMRDF)

A FMRDP will be prepared to outline the mine closure plans of the project including cost for its implementation. The FMRDP is a prerequisite for the issuance of the Declaration of Mine Project Feasibility (DMPF). The implementation of the FMRDP will be funded by the FMRD Fund (FMRDF). The accrual of the FMRDF is established by MGB in such a way that the full cost of the approved FMRDP is deposited in before the end of the mine operations. Annual cash provisions shall be made by SMMCI to the FMRDF based on the following formula:

Annual cash provision = Cost of implementing the approved FMRDP x Percentage required (per implementing rules and regulations on FMRDP)

The FMRDF will be deposited as a trust fund in a government depository bank after the EPEP and FMRDP of the mine has been approved. The fund shall be used solely for the implementation of the approved FMRDP of SMMCI. A Mine Rehabilitation Fund Committee (MRFC) will be created as the authorized body to disburse the MRF while the CLRF Steering Committee will approve the release of the FMRDF upon recommendation of the MRFC. Both committees will be formed post-ECC issuance. The fund will be subject to regular audits by the MGB.

6.3 Self-Monitoring Plan

The primary purpose of the self-monitoring plan is to ensure that the identified project impacts are addressed with the proposed management measures and the project remains compliant with the relevant regulatory requirements. Two monitoring reports will be submitted to EMB once the project commences:

- ECC Compliance Monitoring Report (CMR) – A semi-annual report of the project’s compliance with the conditions of the ECC submitted to both EMB Central Office and EMB Region XIII Office; and,
- Self-Monitoring Report – A quarterly report of the project’s compliance to environmental standards specific to environmental laws (e.g. DAO 1990-34) submitted to EMB Region XIII Office.

Table 6.3-1 presents the proposed self-monitoring plan for the project. The purpose of monitoring is to ensure the strict implementation of the environmental management plan. A notarized completed Project Environmental Monitoring and Audit Prioritization Scheme (PEMAPS) Questionnaire is presented in **Annex 6-2**. The PEMAPS serves as a guide for EMB to determine the monitoring strategy and rank/classify projects based on their priority in terms of monitoring.

Table 6.3-1 Self-Monitoring Plan

Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
								EQPL Range			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
Construction													
Clearing of vegetation	Loss of habitats due to vegetation clearing as a result of development of Underground mine, TSF, Processing Plant, and Support Facilities	Success rate, survival rate and growth rate of reforestation/rehabilitation areas and re-colonization of wildlife	Periodic inventory of planted seedlings Photo-transect Survival rate Systematic and scientific sampling computation Growth rate computation	Semi-annually	Offset areas and areas that will be progressively rehabilitated	Pollution Control Officer/ Environmental Officer	Approximately PhP 80,000.00 per hectare	Decline (~10%) in the abundance, frequency and distribution of vegetation monitored compared to initial seedlings planted.	Evident decline (~15%) in the abundance, frequency, and distribution of vegetation monitored compared to initial seedlings planted.	Highly evident decline (~20%) in the abundance, frequency and distribution of vegetation monitored compared to initial seedlings planted. Successive decline in the abundance, frequency and distribution of vegetation monitored across monitoring period.	Investigate possible cause of the observed decline in the parameters being monitored	Investigate cause of decline in parameters being monitored. Check success rate of mitigation measures, rehabilitation programs (i.e. reforestation, revegetation). Improve reforestation and revegetation measures.	Investigate cause of decline in parameters being monitored and coordinate with the PAMBs, LGUs and MMT (Multipartite Monitoring Team) the possible cause/s of the decline. Increase frequency in monitoring parameters exhibiting highly evident declines. Review rehabilitation (i.e. reforestation / revegetation) program strategy and apply changes for enhancement as necessary.

Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
								EQPL Range			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
Construction activities may potentially contaminate waterways with solid wastes, hydrocarbons, and other contaminants Siltation from the earth moving activities Increased run-off from wet deposited dusts	Ambient Surface Water Quality *Additional parameters may be included if deemed necessary during construction	Parameters from DAO 2016—08: PSIC Code 0722 and 0729 pH, TSS, Nitrate, Sulfate, Cyanide, Dissolved Copper, Zinc, Arsenic, Mercury, Lead, Iron, and Cadmium *Additional parameters: • Hexavalent Chromium (Cr^{+}) • Oil and Grease (O&G) • COD • BOD_5 • Total and Fecal Coliform (TC & FC) • Dissolved Oxygen (DO) • Temperature • Boron • Phosphates • Surfactants	AS/NZS 5667.1 (ISO 5667-1 & 6) Water Quality Monitoring Manual for Ambient Water Quality Monitoring (DENR-EMB, 2008) DENR-approved laboratory methods	Monthly	Baseline sampling stations in the primary impact catchments (Sison, Tagana-an, Placer and, Tubod) and selected stations in the secondary impact catchments	Pollution Control Officer/ Environmental Officer Pollution Control Officer/ Environmental Officer	50,000/ sampling station	Minor change in the aesthetic quality of water (i.e. visible discoloration, turbid water)	DAO 2016-08 Class A Monthly: pH – 5.5 to 9 TSS – 40mg/L NO_3-N – 5mg/L Sulfate – 225mg/L Cyanide as cyanide – 0.8mg/L Dissolved Cu –0.01mg/L Zinc – 1.8mg/L As – 0.03mg/L Hg – 0.0005mg/L Pb – 0.004mg/L Iron – 1.3mg/L Cd – 0.001mg/L Additional parameters: BOD_5 – 4mg/L TC – 1 mg/L FC – 1 mg/L DO – 5mg/L O&G – 0.1ug/L Temp – 3 °C change COD – 45mg/L Cr^{+6} – 0.005mg/L	DAO 2016-08 Class A Monthly: pH – 6.5 to 8 TSS – 45mg/L NO_3-N – 6mg/L Sulfate – 240mg/L Cyanide as cyanide – 0.9mg/L Dissolved Cu –0.015mg/L Zinc – 1.9mg/L As – 0.05mg/L Hg – 0.0005mg/L Pb – 0.005mg/L Iron – 0.9mg/L Cd – 0.002mg/L Additional parameters: BOD_5 – 4.5mg/L O&G – 0.1ug/L TC – 1.1 mg/L FC – 1.1 mg/L DO – 4.5mg/ Temp – 3 °C change COD – 50mg/L Cr^{+6} – 0.0055mg/L	Check and monitor the performance of sediment control traps, and settling ponds Manage stockpiles	Identify the source of TSS, oil and grease and other aesthetic parameters Strict implementation of good housekeeping and waste management measures; Check the performance of the drainage system Increase frequency of monitoring as necessary	Identify if the project is the source of contamination; If yes, temporarily stop the construction activities near the affected waterway and conduct clean-up Increase frequency of monitoring

Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
			Method	Frequency	Location			EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
	Lake Water Quality *Additional parameters may be included if deemed necessary during construction	Parameters from DAO 2016—08: PSIC Code 0722 and 0729 • pH, TSS, Nitrate, Sulfate, Cyanide, Dissolved Copper, Zinc, Arsenic, Mercury, Lead, Iron, and Cadmium *Additional parameters: • Hexavalent Chromium (Cr^+) • O&G • COD • BOD_5 • TC & FC • Dissolved Oxygen (DO) • Temperature • Boron • Phosphates • Surfactants	AS/NZS 5667.1 (ISO 5667-1 & 4) Water Quality Monitoring Manual for Ambient Water Quality Monitoring (DENR-EMB, 2008) DENR-approved laboratory methods	Quarterly	Station Lake Mahukdam	Pollution Control Officer/ Environmental Officer Pollution Control Officer/ Environmental Officer	50,000/ sampling station	Minor change in the aesthetic quality of water (i.e. visible discoloration, turbid water)	DAO 2016-08 Class A Monthly: pH – 5.5 to 9 TSS – 40mg/L NO_3-N – 5mg/L Sulfate – 225mg/L Cyanide as cyanide – 0.8mg/L Dissolved Cu – 0.01mg/L Zinc – 1.8mg/L As – 0.03mg/L Hg – 0.0005mg/L Pb – 0.004mg/L Iron – 1.3mg/L Cd – 0.001mg/L Additional parameters: BOD_5 – 4mg/L TC – 1 mg/L FC – 1 mg/L DO – 5mg/L O&G – 0.1ug/L Temp – 3 °C change COD – 45mg/L Cr^{+6} – 0.005mg/L	DAO 2016-08 Class A Monthly: pH – 6.5 to 8 TSS – 45mg/L NO_3-N – 6mg/L Sulfate – 240mg/L Cyanide as cyanide – 0.9mg/L Dissolved Cu – 0.015mg/L Zinc – 1.9mg/L As – 0.05mg/L Hg – 0.0005mg/L Pb – 0.005mg/L Iron – 0.9mg/L Cd – 0.002mg/L Additional parameters: BOD_5 – 4.5mg/L O&G – 0.1ug/L TC – 1.1 mg/L FC – 1.1 mg/L DO – 4.5mg/ Temp – 3 °C change COD – 50mg/L Cr^{+6} – 0.0055mg/L	Check and monitor the performance of sediment control traps, and settling ponds Manage stockpiles	Identify the source of TSS, oil and grease and other aesthetic parameters Strict implementation of good housekeeping and waste management measures Check the performance of the drainage system Increase frequency of monitoring as necessary	Identify if the project is the source of contamination; If yes, temporarily stop the construction activities near the affected waterway and conduct clean-up Increase frequency of monitoring

Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
			Method	Frequency	Location			EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
	Ambient Groundwater Quality *Additional parameters may be included if deemed necessary during construction	Parameters from DAO 2016—08: PSIC Code 0722 and 0729 pH, TSS, Nitrate, Sulfate, Cyanide, Dissolved Copper, Zinc, Arsenic, Mercury, Lead, Iron, and Cadmium *Additional parameters: • Hexavalent Chromium (Cr^{+}) • O&G • COD • BOD_5 • TC & FC • Dissolved Oxygen (DO) • Temperature • Boron • Phosphates • Surfactants	AS/NZS 5667.1 (ISO 5667-1 & 4) Water Quality Monitoring Manual for Ambient Water Quality Monitoring (DENR-EMB, 2008) DENR-approved laboratory methods	Monthly	Baseline sampling stations (Sison, Tagana-an, Placer, and Tubod,)	Pollution Control Officer/ Environmental Officer Pollution Control Officer/ Environmental Officer	50,000/ sampling station	PNSDW 2007 pH - 5.8 - 6.0, 8.5 – 8.7 Color – 7 TCU Turbidity – 2.0 NTU TDS – 400 mg/L BOD_5 –4mg/L DO – 5mg/L TSS – 35mg/L O&G – 0.1ug/L FC – 1 mg/L TC – 1 mg/L Hg – 0.0005mg/L Pb – 0.003mg/L Cd – 0.0005mg/L As – 0.03mg/L Cr^{+6} – 0.0055mg/L	PNSDW 2007 Monthly: pH – 5.7 – 5.5, 8.7 – 8.8 Color – 8 TCU Turbidity – 3.0 NTU TDS – 450 mg/L BOD_5 – 4.5mg/L DO – 5mg/L TSS – 40mg/L O&G – 0.1ug/L FC – 1.1 mg/L TC – 1.1 mg/L Hg – 0.0005mg/L Pb – 0.004mg/L Cd – 0.001mg/L As – 0.04mg/L Cr^{+6} – 0.007mg/L	PNSDW 2007 Monthly: pH – 5.4 – 5.2, 8.8 – 8.9 Color – 9 TCU Turbidity – 4.0 NTU TDS – 480 mg/L BOD_5 – DO – 5mg/L TSS – 45 O&G – 0.1ug/L FC – 1.1 mg/L TC – 1.1 mg/L Hg – 0.0005mg/L Pb – 0.005mg/L Cd – 0.002mg/L As – 0.05mg/L Cr^{+6} – 0.005mg/L	Check and monitor the performance of gullies	Identify the source of contamination Strict implementation of good housekeeping and waste management measures Check the performance of gullies Increase frequency of monitoring as necessary	Identify if the project is the source of contamination; If yes, temporarily stop the construction activities and conduct clean-up Increase frequency of monitoring.

Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
								EQPL Range			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
	Freshwater biota • Periphyton • Macroinvertebrates • Fish	Abundance and composition of aquatic organisms Presence of pollution indicator taxa Status of endemic species (i.e. *Anguilla marmorata*)	Scientifically approved methods used for wadeable streams (kick-net and periphyton sampling).	Semi-annual covering the wet and dry season	Stations in the primary impact areas (Sison, Tagana-an, Placer and, Tubod) that are concurrent with the water quality stations covered during the baseline. Lake Mahukdam station will be monitored as secondary impact areas. The proposed monitoring stations but may be adjusted as necessary.	Pollution Control Officer/ Environmental Officer	50,000/ sampling station	Significant decrease (based on applicable statistical test) in the abundance relative to the previous monitoring period covering the same season. Appearance of pollution indicator taxa.	Significant decrease (based on applicable statistical test) for the two consecutive monitoring periods covering the same season. Dominance of pollution indicator taxa.	Significant decrease (based on applicable statistical test) for the two consecutive monitoring periods covering the same season. Dominance of pollution indicator taxa. Change in color (in TCU) of the surface water.	Continue monitoring and investigate possible cause of decrease.	Continue monitoring. Coordinate with MMT in the investigation of the cause of decline.	Investigate if cause of decline is the project. If not, continue the monitoring activities at the same frequency. If source of decline is project, temporarily stop activities in the vicinity of the monitoring station where adverse impact was observed and implement clean-up measures. Riparian rehabilitation or other efforts necessary to revert the condition to baseline conditions.
Large construction activities, including the exposure to heavy equipment by the employees, and to some degree, the community and other visitors	Generation of particulate matter (PM), NO_x, SO_x, and CO from fuel combustion of stationary sources	• Particulate Matter (PM) • SO_x • NO_x • CO • Pb *For Generator Sets with capacity lower than 350 kVA, isokinetic sampling (PM) is not required.	US EPA Method 1 to 5 / Gravimetric US EPA Method 1 to 4 SOx – Method 6/8 NOx – Method 7/Phenol-disulfonicacid CO – US EPA Method 3/10 Orsat analysis or NDIR	Quarterly, or as required by EMB	Generator set/s	Pollution Control Officer	PhP 900,000	PM – 60 mg/Ncm SO_x – 235 mg/Ncm NO_x – 666 mg/Ncm CO – 166 mg/Ncm Pb – 3 mg/Ncm	PM – 75 mg/Ncm SO_x – 350 mg/Ncm NO_x – 1000 mg/Ncm CO – 250 mg/Ncm Pb – 7 mg/Ncm	PM -100mg/Ncm SO_x – 500 mg/Ncm NO_x – 1500 mg/Ncm CO – 400 mg/Ncm Pb – 9 mg/Ncm	Continue monitoring	Continue monitoring; Investigate cause of complaint, determine and address the root cause Check maintenance condition of stationary sources	Continue monitoring; Investigate cause of complaints, determine and address the root cause Check maintenance condition of stationary sources Consider installation of pollution control devices, as necessary

Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
								EQPL Range			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
	Fugitive dusts (Trace metals, TSP, and PM_{10}) emissions	Particulates • TSP • PM_{10} • Pb • Trace metals: Cd, As, Hg, Cu, Pb, Cr, Mn, Ni, V and Sb * Parameters such as Cd, As, Hg, Cu, Cr, Mn, Ni, V and Sb; were not included in the DENR (NAAQS and NAAQGV) therefore, we used the permissible exposure limit (PEL) established by Occupational Safety and Health Administration (OSHA).	Hi-volume/ Gravimetric/ AAS/ ICP/ UV-VIS 24-hour & 1-hour averaging (TSP and PM_{10}) 30-minute averaging (Trace metals)	Quarterly, or as required by EMB	Existing ambient air quality and noise monitoring stations	Pollution Control Officer	PhP 2,000,000	Noticeable dust and/ or presence of haze or 24hr (µg/Ncm) TSP – 200 PM_{10} – 110 Pb – 0.75 1hr (µg/Ncm) TSP – 250 PM_{10} – 150 OSHA (8HR-PEL) Cd – 15.98 ug/Ncm As – 250 ug/Ncm Hg – 50 ug/Ncm Cu – 500 ug/Ncm Mn – 2500 ug/Ncm Cr – 500 ug/Ncm Ni – 500 ug/Ncm V – 25 ug/Ncm Sb – 250 ug/Ncm	Complaint lodged by community or Concentration at 24hr (µg/Ncm) TSP – 210 PM_{10} – 130 Pb – 1 1hr (µg/Ncm) TSP – 275 PM_{10} – 175 OSHA (8HR-PEL) Cd – 20.98 ug/Ncm As – 275 ug/Ncm Hg – 75 ug/Ncm Cu – 750 ug/Ncm Mn – 3750 ug/Ncm Cr – 750 ug/Ncm Ni – 750 ug/Ncm V – 37 ug/Ncm Sb – 375 ug/Ncm	Multiple complaints lodged by community or Concentration at 24hr (µg/Ncm) TSP – 220 PM_{10} – 140 Pb – 1.1 1hr (µg/Ncm) TSP – 285 PM_{10} – 185 OSHA (8HR-PEL) Cd – 21.98 ug/Ncm As – 400 ug/Ncm Hg – 90 ug/Ncm Cu – 850 ug/Ncm Mn – 4000 ug/Ncm Cr – 850 ug/Ncm Ni – 850 ug/Ncm V – 40 ug/Ncm Sb – 400 ug/Ncm	Continue monitoring Implement dust suppression	Continue monitoring Investigate cause of complaint, determine and address the root cause; Increase frequency of dust suppression	Continue monitoring; Investigate cause of complaints, determine and address the root cause; Increase frequency of dust suppression
Emissions due to the consumption of fossil fuels from mobile equipment	Particulates TSP PM_{10}	Hi-volume/ Gravimetric 24-hour & 1-hour averaging	Quarterly, or as required by EMB	Existing ambient air quality and noise monitoring stations	Pollution Control Officer	PhP 2,000,000	Noticeable dust and/ or presence of haze or 24hr (µg/Ncm) TSP – 200 PM_{10} – 110 1hr (µg/Ncm) TSP – 250 PM_{10} – 150	Complaint lodged by community or 24hr (µg/Ncm) TSP – 210 PM_{10} – 130 1hr (µg/Ncm) TSP – 275 PM_{10} – 175	Multiple complaints lodged by community or Concentration at 24hr (µg/Ncm) TSP – 220 PM_{10} – 140 1hr (µg/Ncm) TSP – 285 PM_{10} – 185	Continue monitoring Implement dust suppression	Continue monitoring Investigate cause of complaint, determine and address the root cause Increase frequency of dust suppression	Continue monitoring; Investigate cause of complaints, determine and address the root cause Increase frequency of dust suppression	Continue monitoring; Investigate cause of complaints, determine and address the root cause; Increase frequency of dust suppression

Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
								EQPL Range			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
		Gaseous pollutants SO_2 NO_2	Gas Bubbler/ Pararosaniline Method (SO_2) Gas Bubbler Griess-Saltzman Method (NO_2) 24-hour & 1-hour averaging or Measured in Automatic air monitoring station					Noticeable dust and/ or presence of haze or 24hr (µg/Ncm) SO_2 – 120 NO_2 – 70 1hr (µg/Ncm) SO_2 – 250 NO_2 – 170	Complaint lodged by community or 24hr (µg/Ncm) SO_2 – 140 NO_2 – 100 1hr (µg/Ncm) SO_2 – 275 NO_2 – 200	Multiple complaints lodged by community or Concentration: at 24hr (µg/Ncm) SO_2 – 150 NO_2 – 130 1hr (µg/Ncm) SO_2 – 300 NO_2 – 210			
	* Parameters such as Cd, As, Hg, Cu, Cr, Mn, Ni, V and Sb; were not included in the DENR (NAAQS and NAAQGV) therefore, we used the permissible exposure limit (PEL) established by Occupational Safety and Health Administration (OSHA).	Trace metals: • Cd • As • Hg • Cu • Mn • Cr • Ni • V • Sb	Gravimetric / Atomic Absorption Spectrometry					Noticeable dust and/ or presence of haze or OSHA (8HR-PEL) Cd –15.98-ug/Ncm As – 250 ug/Ncm Hg – 50 ug/Ncm Cu – 500 ug/Ncm Mn – 2500 ug/Ncm Cr – 500 ug/Ncm Ni – 500 ug/Ncm V – 25 ug/Ncm Sb – 250 ug/Ncm	Complaint lodged by community or OSHA (8HR-PEL) Cd –20.98 ug/Ncm As – 275 ug/Ncm Hg – 75 ug/Ncm Cu – 750 ug/Ncm Mn – 3750 ug/Ncm Cr – 750 ug/Ncm Ni – 750 ug/Ncm V – 37 ug/Ncm Sb – 375 ug/Ncm	Multiple complaints lodged by community or OSHA (8HR-PEL) Cd – 21.98 ug/Ncm As – 400 ug/Ncm Hg – 90 ug/Ncm Cu – 850 ug/Ncm Mn – 4000 ug/Ncm Cr – 850 ug/Ncm Ni – 850 ug/Ncm V – 40 ug/Ncm Sb – 400 ug/Ncm	Continue monitoring Implement dust suppression	Continue monitoring Investigate cause of complaint, determine and address the root cause Increase frequency of dust suppression	Continue monitoring; Investigate cause of complaints, determine and address the root cause Increase frequency of dust suppression

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(Per Project Phase)</th><th rowspan="3">Potential Impacts (per environmental sector)</th><th rowspan="3">Parameter to be Monitored</th><th colspan="3">Sampling and Measurement Plan</th><th rowspan="3">Lead Person</th><th rowspan="3">Estimated Cost (PHP)</th><th colspan="6">EQPL Management Scheme[i]</th></tr>
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<td>Increase in ambient noise level</td>
<td>Noise level, dB</td>
<td>Approved method of noise measurement
(AS 1055.1-1998)</td>
<td>Quarterly, or as required by EMB</td>
<td>Existing ambient air quality and noise monitoring stations</td>
<td>Pollution Control Officer</td>
<td>PhP 10,000 per sampling event</td>
<td>Negative feedback reported
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<td>Complaint lodged by community and/or by contractor or employees
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<td>Multiple complaints lodged by community and/or by contractor or employees
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<td>Investigate or inspect subject of negative feedback</td>
<td>Investigate or inspect cause of complaint, determine and address the root cause</td>
<td>Conduct noise audit of equipment and machineries that generate noise

Consider installation of noise suppression devices to equipment and machineries that generate noise</td>
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Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
								EQPL Range			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
	Community	Perception survey of the community on the construction activities	Community coordination Community responses through the MMT.	Quarterly	Impact barangays	Community Relations or Stakeholder Engagement Officer	Approximately PhP 70,000 per quarter to run IEC campaigns, perception surveys, and coordination meetings	Negative verbal feedback to the Proponent	Formal complaint lodged by the community through Grievance Center	Multiple complaints by the community captured by local media organizations	Proponent to investigate/ inspect subject of negative feedback Coordinate with barangay	Investigate cause of complaint, determine and address the root cause Coordinate with LGUs and MMT	Release an official statement for the affected communities and local media organizations and coordinate with MMT Conduct regular consultation with relevant and concerned stakeholders of the community until the subject of the complaints are properly resolved
	SDMP	Projects initiated by the Proponent under the SDMP	Community Coordination and Regular Project Evaluation through Stakeholder Consultations Community responses through the MMT.	Quarterly to annually, or as required by EMB	Impact barangays	Community Relations Officer or Stakeholder Engagement Officer	Approximately PhP 1,000,000 eper annum	Negative verbal feedback to the Proponent	Formal complaint lodged by the community	Multiple complaints by the community captured by the local media organizations	Proponent to investigate/ inspect subject of negative feedback. Coordinate with barangay.	Investigate cause of complaint, determine and address the root cause. Coordinate with LGUs, BGUs and MMT.	Release official statement for general consumption and employees of SMMCI and to address the issue to the affected communities. Conduct regular consultation with relevant and concerned stakeholders of the community. Coordinate with and update MMT regarding the resolution of the issues and concerns and include in the regular monitoring reports as required.

Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
								EQPL Range			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
	Information, Education, and Communication	Implementation of IEC activities	Community Coordination and Maintenance of Information Center Community responses through the MMT.	Semi-annually to annually	Impact barangays	Community Relations Officer or Stakeholder Engagement Officer	Approximately PhP 120,000 per annum	Negative verbal feedback to the Proponent	Formal complaint lodged by the community	Multiple complaints by the community captured by the local media organizations	Proponent to investigate/ inspect subject of negative feedback. Coordinate with barangay.	Investigate cause of complaint, determine and address the root cause. Coordinate with LGUs, BGUs and MMT.	Release official statement for general consumption and employees of SMMCI and to address the issue to the affected communities. Conduct regular consultations and IECs with relevant and concerned stakeholders of the community. Regularly update MMT regarding the conduct of the IEC activities and reflect these activities in the monitoring reports as required.
Operations													
Operation of the underground mine, process plant, and TSF	Vegetation and wildlife	Species richness, abundance, and ecological indices (diversity, evenness, dominance and importance value) Success rate, survival rate and growth rate of reforestation/ rehabilitation areas and re-colonization of wildlife	Periodic inventory of planted seedlings Photo-transect Survival rate Systematic and scientific sampling computation Growth rate computation	Semi-annually	Offset areas and areas that will be progressively rehabilitated	Pollution Control Officer/ Environmental Officer	Approximately PhP 80,000.00 per hectare	Decline (~10%) in the abundance, frequency and distribution of vegetation monitored compared to initial seedlings planted.	Evident decline (~15%) in the abundance, frequency, and distribution of vegetation monitored compared to initial seedlings planted.	Highly evident decline (~20%) in the abundance, frequency and distribution of vegetation monitored compared to initial seedlings planted. Successive decline in the abundance, frequency and distribution of vegetation monitored across monitoring period.	Investigate possible cause of the observed decline in the parameters being monitored	Investigate cause of decline in parameters being monitored. Check success rate of mitigation measures, rehabilitation programs (i.e. reforestation, revegetation). Improve reforestation and revegetation measures.	Investigate cause of decline in parameters being monitored and coordinate with the PAMBs, LGUs and MMT (Multipartite Monitoring Team) the possible cause/s of the decline. Increase frequency in monitoring parameters exhibiting highly evident declines. Review rehabilitation (i.e. reforestation / revegetation) program strategy and apply changes for enhancement as necessary.

Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
								EQPL Range			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
	Ambient Surface Water Quality *Results will be compared with the baseline results *Additional parameters may be included if deemed necessary	Parameters from DAO 2016—08: PSIC Code 0722 and 0729 pH, TSS, Nitrate, Sulfate, Cyanide, Dissolved Copper, Zinc, Arsenic, Mercury, Lead, Iron, and Cadmium PSIC Code 24210 Temprture, pH, COD, TSS, Ammonia, Nitrate, Sulfate, Flouride, Chloride, Cyanide, Barium, Chromium, Manganese, Iron, Nickel, Zinc, Cadmium, Mercury, Lead, O&G, Phenol and Phenolic Substance (2-chlorophenol, 2,4 dichlorophenol and 2,4,6 trichlorophenol) *Additional parameters: • BOD_5 • Total and Fecal Coliform (TC & FC) • Dissolved Oxygen (DO) • Boron • Phosphates • Surfactants	AS/NZS 5667.1 (ISO 5667-1 & 6) Water Quality Monitoring Manual for Ambient Water Quality Monitoring (DENR-EMB, 2008) DENR-approved laboratory methods	Quarterly	Baseline sampling stations in the primary impact catchments (Sison, Tagana-an, Placer and, Tubod) and selected stations in the secondary impact catchments	Pollution Control Officer/ Environmental Officer Pollution Control Officer/ Environmental Officer	50,000/ sampling station	Minor change in the aesthetic quality of water (i.e. visible discoloration, turbid water)	DAO 2016-08 Class A Monthly: pH – 5.5 to 9 TSS – 40mg/L NO_3-N – 5mg/L Sulfate – 225mg/L Cyanide as cyanide – 0.8mg/L Dissolved Cu – 0.01mg/L Zinc – 1.8mg/L As – 0.03mg/L Hg – 0.0005mg/L Pb – 0.004mg/L Iron – 1.3mg/L Cd – 0.001mg/L O&G – 0.1ug/L Temp – 3 °C change COD – 45mg/L Cr^{+6} – 0.005mg/L Fluoride – 1mg/L Cl- – 315mg/L Ba – 0.5mg/L Mn – 1mg/L Fe – 3.5mg/L Ni – 0.055mg/L Phenol & Phenolic Substances – 0.003mg/L Additional parameters: BOD_5 – 4mg/L TC – 1 mg/L FC – 1 mg/L DO – 5mg/	DAO 2016-08 Class A Monthly: pH – 6.5 to 8 TSS – 45mg/L NO_3-N – 6mg/L Sulfate – 240mg/L Cyanide as cyanide – 0.9mg/L Dissolved Cu – 0.015mg/L Zinc – 1.9mg/L As – 0.05mg/L Hg – 0.0005mg/L Pb – 0.005mg/L Iron – 0.9mg/L Cd – 0.002mg/L O&G – 0.1ug/L Temp – 3 °C change COD – 50mg/L Cr^{+6} – 0.0055mg/L Fluoride – 1.5mgL Cl- – 325mg/L Ba – 1mg/L Mn – 1.5mg/L Fe – 4mg/L Ni – 0.05mg/L Phenol & Phenolic Substances – 0.005mg/L Additional parameters: BOD_5 – 4.5mg/L O&G – 0.1ug/L TC – 1.1 mg/L FC – 1.1 mg/L DO – 4.5mg/	Check and monitor the performance of sediment control traps, and settling ponds Manage stockpiles	Identify the source of TSS, oil and grease and other aesthetic parameters Strict implementation of good housekeeping and waste management measures; Check the performance of the drainage system Increase frequency of monitoring as necessary	Identify if the project is the source of contamination; If yes, temporarily stop the construction activities near the affected waterway and conduct clean-up Increase frequency of monitoring

Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
								EQPL Range			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
	Lake Water Quality *Results will be compared with the baseline results	Parameters from DAO 2016—08: PSIC Code 0722 and 0729 pH, TSS, Nitrate, Sulfate, Cyanide, Dissolved Copper, Zinc, Arsenic, Mercury, Lead, Iron, and Cadmium PSIC Code 24210 Temprture, pH, COD, TSS, Ammonia, Nitrate, Sulfate, Flouride, Chloride, Cyanide, Barium, Chromium, Manganese, Iron, Nickel, Zinc, Cadmium, Mercury, Lead, O&G, Phenol and Phenolic Substance (2-chlorophenol, 2,4 dichlorophenol and 2,4,6 trichlorophenol) *Additional parameters: • BOD_5 • Total and Fecal Coliform (TC & FC) • Dissolved Oxygen (DO) • Boron • Phosphates • Surfactants *Additional parameters may be included if deemed necessary	AS/NZS 5667.1 (ISO 5667-1 & 4) Water Quality Monitoring Manual for Ambient Water Quality Monitoring (DENR-EMB, 2008) DENR-approved laboratory methods	Quarterly	Station in Lake Mahukdam	Pollution Control Officer/ Environmental Officer Pollution Control Officer/ Environmental Officer	50,000/ sampling station	Minor change in the aesthetic quality of water (i.e. visible discoloration, turbid water)	DAO 2016-08 Class A Monthly: pH – 5.5 to 9 TSS – 40mg/L NO_3-N – 5mg/L Sulfate – 225mg/L Cyanide as cyanide – 0.8mg/L Dissolved Cu – 0.01mg/L Zinc – 1.8mg/L As – 0.03mg/L Hg – 0.0005mg/L Pb – 0.004mg/L Iron – 1.3mg/L Cd – 0.001mg/L O&G – 0.1ug/L Temp – 3 °C change COD – 45mg/L Cr^{+6} – 0.005mg/L Fluoride – 1mg/L Cl- – 315mg/L Ba – 0.5mg/L Mn – 1mg/L Fe – 3.5mg/L Ni – 0.055mg/L Phenol & Phenolic Substances – 0.003mg/L Additional parameters: BOD_5 – 4mg/L TC – 1 mg/L FC – 1 mg/L DO – 5mg/L	DAO 2016-08 Class A Monthly: pH – 6.5 to 8 TSS – 45mg/L NO_3-N – 6mg/L Sulfate – 240mg/L Cyanide as cyanide – 0.9mg/L Dissolved Cu – 0.015mg/L Zinc – 1.9mg/L As – 0.05mg/L Hg – 0.0005mg/L Pb – 0.005mg/L Iron – 0.9mg/L Cd – 0.002mg/L O&G – 0.1ug/L Temp – 3 °C change COD – 50mg/L Cr^{+6} – 0.0055mg/L Fluoride – 1.5mgL Cl- – 325mg/L Ba – 1mg/L Mn – 1.5mg/L Fe – 4mg/L Ni – 0.05mg/L Phenol & Phenolic Substances – 0.005mg/L Additional parameters: BOD_5 – 4.5mg/L O&G – 0.1ug/L TC – 1.1 mg/L FC – 1.1 mg/L DO – 4.5mg/L	Check and monitor the performance of the TSF	Identify the source of contamination Check the performance of the drainage system Check for any seepage Increase frequency of monitoring as necessary	Identify the source of contamination Check the performance of the drainage system Check for any seepage Increase frequency of monitoring as necessary

Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
			Method	Frequency	Location			EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
	Ambient Groundwater Quality *DAO 2016-08 was used because it is more stringent than PNSDW standard *Results will be compared with the baseline results *Additional parameters may be included if deemed necessary	Parameters from DAO 2016—08: PSIC Code 0722 and 0729 pH, TSS, Nitrate, Sulfate, Cyanide, Dissolved Copper, Zinc, Arsenic, Mercury, Lead, Iron, and Cadmium PSIC Code 24210 Temprture, pH, COD, TSS, Ammonia, Nitrate, Sulfate, Flouride, Chloride, Cyanide, Barium, Chromium, Manganese, Iron, Nickel, Zinc, Cadmium, Mercury, Lead, O&G, Phenol and Phenolic Substance (2-chlorophenol, 2,4 dichlorophenol and 2,4,6 trichlorophenol) *Additional parameters: • BOD_5 • TC & FC • DO • Boron • Phosphates • Surfactants	AS/NZS 5667.1 (ISO 5667-1 & 6) Water Quality Monitoring Manual for Ambient Water Quality Monitoring (DENR-EMB, 2008) DENR-approved laboratory methods	Quarterly	Baseline sampling stations in the primary impact catchments (Sison, Tagana-an, Placer and, Tubod) and selected stations in the secondary impact catchments	Pollution Control Officer/ Environmental Officer	50,000/ sampling station	DAO 2016-08 Class A Monthly: pH – 5.8 & 8 TSS – 35mg/L NO_3-N – 4mg/L Sulfate – 215mg/L Cyanide as cyanide – 0.5mg/L Dissolved Cu – 0.005mg/L Zinc – 1.5mg/L As – 0.02mg/L Hg – 0.0005mg/L Pb – 0.002mg/L Iron – 2mg/L Cd – 0.001mg/L O&G – 0.1ug/L Temp – 3 ^{o}C change COD – 40mg/L Cr^{+6} – 0.017mg/L Fluoride – 1mg/L Cl- – 305mg/L Ba – 0.3mg/L Mn – 0.7mg/L Fe – 3mg/L Ni – 0.057mg/L Phenol & Phenolic Substances – 0.002mg/L Additional parameters: BOD_5 – 3mg/L TC – 1 mg/L FC – 1 mg/L DO – 4.5mg/L	DAO 2016-08 Class A Monthly: pH – 5.5 to 8 TSS – 40mg/L NO_3-N – 5mg/L Sulfate – 225mg/L Cyanide as cyanide – 0.7mg/L Dissolved Cu – 0.05mg/L Zinc – 1.8mg/L As – 0.03mg/L Hg – 0.0005mg/L Pb – 0.004mg/L Iron – 2.5mg/L Cd – 0.002mg/L O&G – 0.1ug/L Temp – 3 ^{o}C change COD – 45mg/L Cr^{+6} – 0.015mg/L Fluoride – 1mg/L Cl- – 315mg/L Ba – 0.5mg/L Mn – 1mg/L Fe – 3.5mg/L Ni – 0.055mg/L Phenol & Phenolic Substances – 0.003mg/L Additional parameters: BOD_5 – 4mg/L TC – 1 mg/L FC – 1 mg/L DO – 4mg/L	DAO 2016-08 Class A Monthly: pH – 6.5 & 8.5 TSS – 45mg/L NO_3-N – 6mg/L Sulfate – 240mg/L Cyanide as cyanide – 0.9mg/L Dissolved Cu – 0.07mg/L Zinc – 1.9mg/L As – 0.05mg/L Hg – 0.0005mg/L Pb – 0.005mg/L Iron – 3mg/L Cd – 0.003mg/L O&G – 0.1ug/L Temp – 3 ^{o}C change COD – 50mg/L Cr^{+6} – 0.01mg/L Fluoride – 1.5mgL Cl- – 325mg/L Ba – 1mg/L Mn – 1.5mg/L Fe – 4mg/L Ni – 0.05mg/L Phenol & Phenolic Substances – 0.005mg/L Additional parameters: BOD_5 – 4.5mg/L TC – 1.1 mg/L FC – 1.1 mg/L DO – 5mg/L	Check and monitor the performance of the TSF	Identify the source of contamination Check the performance of the drainage system Check for any seepage Increase frequency of monitoring as necessary	Identify the source of contamination Check the performance of the drainage system Check for any seepage Increase frequency of monitoring as necessary

Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
			Method	Frequency	Location			EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
	Acid Mine Drainage *Additional parameters may be included if deemed necessary	Parameters from DAO 2016—08: PSIC Code 0722 and 0729 pH, TSS, Nitrate, Sulfate, Cyanide, Dissolved Copper, Zinc, Arsenic, Mercury, Lead, Iron, and Cadmium PSIC Code 24210 Temprture, pH, COD, TSS, Ammonia, Nitrate, Sulfate, Flouride, Chloride, Cyanide, Barium, Chromium, Manganese, Iron, Nickel, Zinc, Cadmium, Mercury, Lead, O&G, Phenol and Phenolic Substance (2-chlorophenol, 2,4 dichlorophenol and 2,4,6 trichlorophenol) *Additional parameters: • BOD$_5$ • Total and Fecal Coliform (TC & FC) • Dissolved Oxygen (DO) • Boron • Phosphates • Surfactants	AS/NZS 5667.1 (ISO 5667-1 & 6) Water Quality Monitoring Manual for Ambient Water Quality Monitoring (DENR-EMB, 2008) DENR-approved laboratory methods	Quarterly	Acid Mine Drainage	Pollution Control Officer/ Environmental Officer	50,000/ sampling station	DAO 2016-08 Class A Monthly: pH – 5.8 & 8 TSS – 35mg/L NO$_3$-N – 4mg/L Sulfate – 215mg/L Cyanide as cyanide – 0.5mg/L Dissolved Cu – 0.005mg/L Zinc – 1.5mg/L As – 0.02mg/L Hg – 0.0005mg/L Pb – 0.002mg/L Iron – 2mg/L Cd – 0.001mg/L O&G – 0.1ug/L Temp – 3 °C change COD – 40mg/L Cr^{+6} – 0.017mg/L Fluoride – 1mg/L Cl- – 305mg/L Ba – 0.3mg/L Mn – 0.7mg/L Fe – 3mg/L Ni – 0.057mg/L Phenol & Phenolic Substances – 0.002mg/L Additional parameters: BOD$_5$ – 3mg/L TC – 1 mg/L FC – 1 mg/L DO – 4.5mg/L	DAO 2016-08 Class A Monthly: pH – 5.5 to 8 TSS – 40mg/L NO$_3$-N – 5mg/L Sulfate – 225mg/L Cyanide as cyanide – 0.7mg/L Dissolved Cu – 0.05mg/L Zinc – 1.8mg/L As – 0.03mg/L Hg – 0.0005mg/L Pb – 0.004mg/L Iron – 2.5mg/L Cd – 0.002mg/L O&G – 0.1ug/L Temp – 3 °C change COD – 45mg/L Cr^{+6} – 0.015mg/L Fluoride – 1mg/L Cl- – 315mg/L Ba – 0.5mg/L Mn – 1mg/L Fe – 3.5mg/L Ni – 0.055mg/L Phenol & Phenolic Substances – 0.003mg/L Additional parameters: BOD$_5$ – 4mg/L TC – 1 mg/L FC – 1 mg/L DO – 4mg/L	DAO 2016-08 Class A Monthly: pH – 6.5 & 8.5 TSS – 45mg/L NO$_3$-N – 6mg/L Sulfate – 240mg/L Cyanide as cyanide – 0.9mg/L Dissolved Cu – 0.07mg/L Zinc – 1.9mg/L As – 0.05mg/L Hg – 0.0005mg/L Pb – 0.005mg/L Iron – 3mg/L Cd – 0.003mg/L O&G – 0.1ug/L Temp – 3 °C change COD – 50mg/L Cr^{+6} – 0.01mg/L Fluoride – 1.5mgL Cl- – 325mg/L Ba – 1mg/L Mn – 1.5mg/L Fe – 4mg/L Ni – 0.05mg/L Phenol & Phenolic Substances – 0.005mg/L Additional parameters: BOD$_5$ – 4.5mg/L TC – 1.1 mg/L FC – 1.1 mg/L DO – 5mg/L	Check and monitor the performance of the TSF	Identify the source of contamination Check the performance of the drainage system Check for any seepage Increase frequency of monitoring as necessary	Identify if the project is the source of contamination; If yes, temporarily stop the operation and conduct clean-up; Increase frequency of monitoring; If the values exceed the standard limit, stop the operation and conduct clean-up

Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan: Method	Sampling and Measurement Plan: Frequency	Sampling and Measurement Plan: Location	Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i] – EQPL Range: Alert	EQPL Range: Action	EQPL Range: Limit	Management Measure: Alert	Management Measure: Action	Management Measure: Limit
	Freshwater Biota Periphyton Macroinvertebrates Fish	Abundance and composition of aquatic organisms Presence of pollution indicator taxa Status of endemic species (i.e. *Anguilla marmorata*)	Scientifically approved methods used for wadeable streams (kick-net and periphyton sampling).	Semi-annual covering the wet and dry season	Stations in the primary impact areas (Sison, Tagana-an, Placer and, Tubod) that are concurrent with the water quality stations covered during the baseline. Lakes Mainit and Mahukdam and as well as Mapaso stations will be monitored as secondary impact areas. The proposed monitoring stations but may be adjusted as necessary.	Pollution Control Officer/ Environmental Officer	50,000/ sampling station	Significant decrease (based on applicable statistical test) in the abundance relative to the previous monitoring period covering the same season. Appearance of pollution indicator taxa.	Significant decrease (based on applicable statistical test) for the two consecutive monitoring periods covering the same season. Dominance of pollution indicator taxa.	Significant decrease (based on applicable statistical test) for the two consecutive monitoring periods covering the same season. Dominance of pollution indicator taxa. Change in color (in PCU) of the surface water.	Continue monitoring and investigate possible cause of decrease.	Continue monitoring. Coordinate with MMT in the investigation of the cause of decline.	Investigate if cause of decline is the project. If not, continue the monitoring activities at the same frequency. If source of decline is project, temporarily stop activities in the vicinity of the monitoring station where adverse impact was observed and implement clean-up measures. Riparian rehabilitation or other efforts necessary to revert the condition to baseline conditions.
		Heavy metals in fish tissues Cadmium Copper Lead Zinc Mercury Arsenic	Ashing-Acid Digestion Inductively Coupled Plasma Spectrophotometry, Acid Digestion Cold Vapor AAS Hydride Vapor Generation AAS	Semi-annual covering the wet and dry season	Boyongan and Timamana Creeks; Bad-as/ Amoslog River	Pollution Control Officer/ Environmental Officer	50,000/ sampling station	Heavy metals detected in fish tissues	Heavy metals detected in fish tissues for two consecutive sampling	Heavy metals in fish tissues exceeded their respective limits	Continue monitoring and investigate possible cause of contamination.	Continue monitoring. Coordinate with MMT in the investigation of the cause of contamination	Investigate if cause of contamination is the project. If not, continue the monitoring activities at the same frequency. If source of decline is project, temporarily stop activities in the vicinity of the monitoring station where adverse impact was observed and implement clean-up measures

Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
								EQPL Range			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
	Change in local microclimate due to vegetation clearing	Species richness, abundance, and ecological indices (diversity, evenness, dominance and importance value) Success rate, Survival rate and growth rate of reforestation/ rehabilitation areas	Flora Plots and Quadrats Random Meander survey Periodic inventory of planted seedlings Survival rate (%) Growth rate in terms of basal area or height	Quarterly, or as required by EMB	Same Location with Terrestrial Flora	Pollution Control Office or Environmental Officer	Concurrent with terrestrial vegetation monitoring	Decline (~10%) in the abundance, frequency and distribution of vegetation monitored compared to baseline data	Evident decline (~15%) in the abundance, frequency, and distribution of vegetation monitored compared from baseline data	Highly evident decline (~20%) in the abundance, frequency and distribution of vegetation monitored compared from baseline data Successive decline in the abundance, frequency and distribution of vegetation monitored across monitoring period	Investigate possible cause of the observed decline in the parameters being monitored	Investigate cause of decline in parameters being monitored Check success rate of mitigation measures, rehabilitation programs (i.e reforestation, revegetation) Improve reforestation and revegetation measures	Investigate cause of decline in parameters being monitored and coordinate with the PAMBs, LGUs and MMT (Multipartite Monitoring Team) the possible cause/s of the decline Check success rate of revegetation/reforesta tion programs Increase frequency in monitoring parameters exhibiting highly evident declines Review rehabilitation (i.e. reforestation / revegetation) program strategy and apply changes for enhancement as necessary Improve rehabilitation measures
	Generation of particulate matter (PM), NO_x, SO_x, and CO from fuel combustion of stationary sources	PM) SO_x NO_x CO	US EPA Method 1 to 5 / Gravimetric US EPA Method 1 to 4 and: SOx – Method 6/8 NOx – Method 7/Phenol-disulfonicacid CO – US EPA Method 3/10 Orsat analysis or NDIR	Quarterly, or as required by EMB	Generator set/s	Pollution Control Officer	PhP 900,000	PM – 60 mg/Ncm SO_x – 235 mg/Ncm NO_x – 666 mg/Ncm CO – 166 mg/Ncm	PM – 75 mg/Ncm SO_x – 350 mg/Ncm NO_x – 1000 mg/Ncm CO – 250 mg/Ncm	PM -100 mg/Ncm SO_x – 500 mg/Ncm NO_x – 1500 mg/Ncm CO – 400 mg/Ncm	Continue monitoring	Continue monitoring; Investigate cause of complaint, determine and address the root cause Check maintenance condition of sttionary sources	Continue monitoring; Investigate cause of complaints, determine and address the root cause Check maintenance condition of stationary sources Consider installation of pollution control devices, as necessary

Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
								EQPL Range			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
	Fugitive dusts (Trace metals, TSP, and PM_{10}) emissions	Particulates • TSP • PM_{10} • Trace metals: Cd, As, Hg, Cu, Pb, Cr, Mn, Ni, V and Sb * Parameters such as Cd, As, Hg, Cu, Cr, Mn, Ni, V and Sb; were not included in the DENR (NAAQS and NAAQGV) therefore, we used the permissible exposure limit (PEL) established by Occupational Safety and Health Administration (OSHA).	Hi-volume/ Gravimetric/ AAS/ ICP/ UV-VIS 24-hour & 1-hour averaging (TSP and PM_{10}) 30-minute averaging (Trace metals)	Quarterly, or as required by EMB	Existing ambient air quality and noise monitoring stations	Pollution Control Officer	PhP 2,000,000	Noticeable dust and/ or presence of haze or concentration at: 24hr (µg/Ncm) TSP – 200 PM10 – 110 Pb – 0.75 1hr (µg/Ncm) TSP – 250 PM10 – 150 OSHA (8HR-PEL) Cd – 15.98 ug/Ncm As – 250 ug/Ncm Hg – 50 ug/Ncm Cu – 500 ug/Ncm Mn – 2500 ug/Ncm Cr – 500 ug/Ncm Ni – 500 ug/Ncm V – 25 ug/Ncm Sb – 250 ug/Ncm	Complaint lodged by community or Concentration at 24hr (µg/Ncm) TSP – 210 PM10 – 130 Pb – 1 1hr (µg/Ncm) TSP – 275 PM10 – 175 OSHA (8HR-PEL) Cd – 20.98 ug/Ncm As – 275 ug/Ncm Hg – 75 ug/Ncm Cu – 750 ug/Ncm Mn – 3750 ug/Ncm Cr – 750 ug/Ncm Ni – 750 ug/Ncm V – 37 ug/Ncm Sb – 375 ug/Ncm	Multiple complaints lodged by community or Concentration at 24hr (µg/Ncm) TSP – 220 PM_{10} – 140 Pb – 1.1 1hr (µg/Ncm) TSP – 285 PM_{10} – 185 OSHA (8HR-PEL) Cd – 21.98 ug/Ncm As – 400 ug/Ncm Hg – 90 ug/Ncm Cu – 850 ug/Ncm Mn – 4000 ug/Ncm Cr – 850 ug/Ncm Ni – 850 ug/Ncm V – 40 ug/Ncm Sb – 400 ug/Ncm	Continue monitoring Implement dust suppression	Continue monitoring; Increase frequency of dust suppression	Continue monitoring; Increase frequency of dust suppression

<table>
<tr><th rowspan="3">Key Environmental Aspects
(Per Project Phase)</th><th rowspan="3">Potential Impacts (per environmental sector)</th><th rowspan="3">Parameter to be Monitored</th><th colspan="3">Sampling and Measurement Plan</th><th rowspan="3">Lead Person</th><th rowspan="3">Estimated Cost (PHP)</th><th colspan="6">EQPL Management Scheme[i]</th></tr>
<tr><th rowspan="2">Method</th><th rowspan="2">Frequency</th><th rowspan="2">Location</th><th colspan="3">EQPL Range</th><th colspan="3">Management Measure</th></tr>
<tr><th>Alert</th><th>Action</th><th>Limit</th><th>Alert</th><th>Action</th><th>Limit</th></tr>
<tr><td></td><td>Increase in ambient noise level</td><td>Noise level, dB</td><td>Approved method of noise measurement
(AS 1055.1-1998)</td><td>Quarterly, or as required by EMB</td><td>Existing ambient air quality and noise monitoring stations</td><td>Pollution Control Officer</td><td>PhP 10,000 per sampling event</td>
<td>Negative feedback reported
Or
Noise levels reach:
<table><tr><th colspan="2">Daytime</th></tr><tr><td>Area Class</td><td>Noise Level</td></tr><tr><td>AA</td><td>50</td></tr><tr><td>A</td><td>45</td></tr><tr><td>B</td><td>55</td></tr><tr><td>C</td><td>60</td></tr><tr><td>D</td><td>65</td></tr></table>
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<td>Investigate or inspect subject of negative feedback</td><td>Investigate or inspect cause of complaint, determine and address the root cause</td><td>Conduct noise audit of equipment and machineries that generate noise
Consider installation of noise suppression devices to equipment and machineries that generate noise</td></tr>
</table>

Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
								EQPL Range			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
	SDMP	Projects initiated by the Proponent under the SDMP	Community Coordination and Regular Project Evaluation through Stakeholder Consultations Community responses through the MMT.	Quarterly to annually, or as required by EMB	Impact barangays	Community Relations Officer or Stakeholder Engagement Officer	Approximately PhP 2,000,000 per annum	Negative verbal feedback to the Proponent	Formal complaint lodged by the community	Multiple complaints by the community captured by the local media organizations	Proponent to investigate/ inspect subject of negative feedback. Coordinate with barangay.	Investigate cause of complaint, determine and address the root cause. Coordinate with LGUs, BGUs and MMT.	Release official statement for general consumption and employees of SMMCI and to address the issue to the affected communities. Conduct regular consultation with relevant and concerned stakeholders of the community. Coordinate with and update MMT regarding the resolution of the issues and concerns and include in the regular monitoring reports as required.
	Information, Education, and Communication	Implementation of IEC activities	Community Coordination and Maintenance of Information Center Community responses through the MMT.	Semi-annually to annually	Impact barangays	Community Relations Officer or Stakeholder Engagement Officer	Approximately PhP 120,000 per annum	Negative verbal feedback to the Proponent	Formal complaint lodged by the community	Multiple complaints by the community captured by the local media organizations	Proponent to investigate/ inspect subject of negative feedback. Coordinate with barangay.	Investigate cause of complaint, determine and address the root cause. Coordinate with LGUs, BGUs and MMT.	Release official statement for general consumption and employees of SMMCI and to address the issue to the affected communities. Conduct regular consultations and IECs with relevant and concerned stakeholders of the community. Regularly update MMT regarding the conduct of the IEC activities and reflect these activities in the monitoring reports as required.

Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
								EQPL Range			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
	Compliance to commitments/agreements, Community relations	Number of complaints lodged and amount of time these complaints were resolved or answered	Implementation of Grievance Mechanism/Protocol Community Coordination	Weekly	All stakeholders (LGUs, government agencies, and impact barangays)	Community Relations Officer or Stakeholder Engagement Officer	Approximately PhP 120,000 per annum	Negative verbal feedback to the Proponent	Formal complaint lodged by the community	Multiple complaints by the community captured by the local media organizations	Proponent to investigate/ inspect subject of negative feedback. Coordinate with barangay.	Investigate cause of complaint, determine and address the root cause. Coordinate with LGUs, BGUs and MMT.	Release official statement for general consumption and employees of SMMCI and to address the issue to the affected communities. Conduct regular consultations and IECs with relevant and concerned stakeholders of the community. Regularly update MMT regarding the conduct of the IEC activities and reflect these activities in the monitoring reports as required.

Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
								EQPL Range			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
Operation of the processing plant (mill)	Ambient Surface Water Quality *Additional parameters may be included if deemed necessary	Parameters from DAO 2016—08: PSIC Code 0722 and 0729 pH, TSS, Nitrate, Sulfate, Cyanide, Dissolved Copper, Zinc, Arsenic, Mercury, Lead, Iron, and Cadmium PSIC Code 24210 Temprture, pH, COD, TSS, Ammonia, Nitrate, Sulfate, Flouride, Chloride, Cyanide, Barium, Chromium, Manganese, Iron, Nickel, Zinc, Cadmium, Mercury, Lead, O&G, Phenol and Phenolic Substance (2-chlorophenol, 2,4 dichlorophenol and 2,4,6 trichlorophenol) *Additional parameters: • BOD_5 • Total and Fecal Coliform (TC & FC) • Dissolved Oxygen (DO) • Boron • Phosphates • Surfactants	AS/NZS 5667.1 (ISO 5667-1 & 6) Water Quality Monitoring Manual for Ambient Water Quality Monitoring (DENR-EMB, 2008) DENR-approved laboratory methods	Quarterly	Baseline sampling stations in the primary impact catchments (Sison, Tagana-an, Placer and, Tubod) and selected stations in the secondary impact catchments	Pollution Control Officer/ Environmental Officer Pollution Control Officer/ Environmental Officer	50,000/ sampling station	Minor change in the aesthetic quality of water (i.e. visible discoloration, turbid water)	DAO 2016-08 Class A Monthly: pH – 5.5 to 9 TSS – 40mg/L NO_3-N – 5mg/L Sulfate – 225mg/L Cyanide as cyanide – 0.8mg/L Dissolved Cu – 0.01mg/L Zinc – 1.8mg/L As – 0.03mg/L Hg – 0.0005mg/L Pb – 0.004mg/L Iron – 1.3mg/L Cd – 0.001mg/L O&G – 0.1ug/L Temp – 3 ^{o}C change COD – 45mg/L Cr^{+6} – 0.005mg/L Fluoride – 1mg/L Cl- – 315mg/L Ba – 0.5mg/L Mn – 1mg/L Fe – 3.5mg/L Ni – 0.055mg/L Phenol & Phenolic Substances – 0.003mg/L Additional parameters: BOD_5 – 4mg/L TC – 1 mg/L FC – 1 mg/L DO – 5mg/L	DAO 2016-08 Class A Monthly: pH – 6.5 to 8 TSS – 45mg/L NO_3-N – 6mg/L Sulfate – 240mg/L Cyanide as cyanide – 0.9mg/L Dissolved Cu – 0.015mg/L Zinc – 1.9mg/L As – 0.05mg/L Hg – 0.0005mg/L Pb – 0.005mg/L Iron – 0.9mg/L Cd – 0.002mg/L O&G – 0.1ug/L Temp – 3 ^{o}C change COD – 50mg/L Cr^{+6} – 0.0055mg/L Fluoride – 1.5mgL Cl- – 325mg/L Ba – 1mg/L Mn – 1.5mg/L Fe – 4mg/L Ni – 0.05mg/L Phenol & Phenolic Substances – 0.005mg/L Additional parameters: BOD_5 – 4.5mg/L O&G – 0.1ug/L TC – 1.1 mg/L FC – 1.1 mg/L DO – 4.5mg/L	Check and monitor the performance of the TSF	Identify the source of contamination; Check the performance of the drainage system; Check for any seepage; Increase frequency of monitoring as necessary	Identify if the project is the source of contamination; If yes, temporarily stop the operation and conduct clean-up; Increase frequency of monitoring.

Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
								EQPL Range			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
	Ambient Groundwater Quality *Additional parameters may be included if deemed necessary	Parameters from DAO 2016—08: PSIC Code 0722 and 0729 pH, TSS, Nitrate, Sulfate, Cyanide, Dissolved Copper, Zinc, Arsenic, Mercury, Lead, Iron, and Cadmium PSIC Code 24210 Temprture, pH, COD, TSS, Ammonia, Nitrate, Sulfate, Flouride, Chloride, Cyanide, Barium, Chromium, Manganese, Iron, Nickel, Zinc, Cadmium, Mercury, Lead, O&G, Phenol and Phenolic Substance (2-chlorophenol, 2,4 dichlorophenol and 2,4,6 trichlorophenol) *Additional parameters: • BOD_5 • Total and Fecal Coliform (TC & FC) • Dissolved Oxygen (DO) • Boron • Phosphates • Surfactants	AS/NZS 5667.1 (ISO 5667-1 & 6) Water Quality Monitoring Manual for Ambient Water Quality Monitoring (DENR-EMB, 2008) DENR-approved laboratory methods	Quarterly	Baseline sampling stations in the primary impact catchments (Sison, Tagana-an, Placer and, Tubod) and selected stations in the secondary impact catchments	Pollution Control Officer/ Environmental Officer	50,000/ sampling station	DAO 2016-08 Class A Monthly: pH – 5.8 & 8 TSS – 35mg/L NO_3-N – 4mg/L Sulfate – 215mg/L Cyanide as cyanide – 0.5mg/L Dissolved Cu – 0.005mg/L Zinc – 1.5mg/L As – 0.02mg/L Hg – 0.0005mg/L Pb – 0.002mg/L Iron – 2mg/L Cd – 0.001mg/L O&G – 0.1ug/L Temp – 3 ^{o}C change COD – 40mg/L Cr^{+6} – 0.017mg/L Fluoride – 1mg/L Cl- – 305mg/L Ba – 0.3mg/L Mn – 0.7mg/L Fe – 3mg/L Ni – 0.057mg/L Phenol & Phenolic Substances – 0.002mg/L Additional parameters: BOD_5 – 3mg/L TC – 1 mg/L FC – 1 mg/L DO – 4.5mg/L	DAO 2016-08 Class A Monthly: pH – 5.5 to 8 TSS – 40mg/L NO_3-N – 5mg/L Sulfate – 225mg/L Cyanide as cyanide – 0.7mg/L Dissolved Cu – 0.05mg/L Zinc – 1.8mg/L As – 0.03mg/L Hg – 0.0005mg/L Pb – 0.004mg/L Iron – 2.5mg/L Cd – 0.002mg/L O&G – 0.1ug/L Temp – 3 ^{o}C change COD – 45mg/L Cr^{+6} – 0.015mg/L Fluoride – 1mg/L Cl- – 315mg/L Ba – 0.5mg/L Mn – 1mg/L Fe – 3.5mg/L Ni – 0.055mg/L Phenol & Phenolic Substances – 0.003mg/L Additional parameters: BOD_5 – 4mg/L TC – 1 mg/L FC – 1 mg/L DO – 4mg/L	DAO 2016-08 Class A Monthly: pH – 6.5 & 8.5 TSS – 45mg/L NO_3-N – 6mg/L Sulfate – 240mg/L Cyanide as cyanide – 0.9mg/L Dissolved Cu – 0.07mg/L Zinc – 1.9mg/L As – 0.05mg/L Hg – 0.0005mg/L Pb – 0.005mg/L Iron – 3mg/L Cd – 0.003mg/L O&G – 0.1ug/L Temp – 3 ^{o}C change COD – 50mg/L Cr^{+6} – 0.01mg/L Fluoride – 1.5mgL Cl- – 325mg/L Ba – 1mg/L Mn – 1.5mg/L Fe – 4mg/L Ni – 0.05mg/L Phenol & Phenolic Substances – 0.005mg/L Additional parameters: BOD_5 – 4.5mg/L TC – 1.1 mg/L FC – 1.1 mg/L DO – 5mg/L	Check and monitor the performance of the TSF	Identify the source of contamination; Check the performance of the drainage system; Check for any seepage; Increase frequency of monitoring as necessary	Identify if the project is the source of contamination; If yes, temporarily stop the operation and conduct clean-up Increase frequency of monitoring.

Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
								EQPL Range			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
	Freshwater biota Periphyton Macroinvertebrates Fish	Abundance and composition of aquatic organisms Presence of pollution indicator taxa Status of endemic species (i.e. *Anguilla marmorata*)	Scientifically approved methods used for wadeable streams (kick-net and periphyton sampling).	Semi-annual covering the wet and dry season	Stations in the primary impact areas (Sison, Tagana-an, Placer and, Tubod) that are concurrent with the water quality stations covered during the baseline. Lake Mahukdam station will be monitored as secondary impact areas. The proposed monitoring stations but may be adjusted as necessary.	Pollution Control Officer/ Environmental Officer	50,000/ sampling station	Significant decrease (based on applicable statistical test) in the abundance relative to the previous monitoring period covering the same season. Appearance of pollution indicator taxa.	Significant decrease (based on applicable statistical test) for the two consecutive monitoring periods covering the same season. Dominance of pollution indicator taxa.	Significant decrease (based on applicable statistical test) for the two consecutive monitoring periods covering the same season. Dominance of pollution indicator taxa. Change in color (in TCU) of the surface water.	Continue monitoring and investigate possible cause of decrease.	Continue monitoring. Coordinate with MMT in the investigation of the cause of decline.	Investigate if cause of decline is the project. If not, continue the monitoring activities at the same frequency. If source of decline is project, temporarily stop activities in the vicinity of the monitoring station where adverse impact was observed and implement clean-up measures, Riparian rehabilitation or other efforts necessary to revert the condition to baseline conditions.
	Generation of particulate matter (PM), NO_x, SO_x, and CO from fuel combustion of stationary sources	• Particulate Matter (PM) • SO_x • NO_x • CO	US EPA Method 1 to 5 / Gravimetric US EPA Method 1 to 4 SOx – Method 6/8 NOx – Method 7/Phenol-disulfonicacid CO – US EPA Method 3/10 Orsat analysis or NDIR	Quarterly, or as required by EMB	Generator set/s	Pollution Control Officer	PhP 900,000	PM – 60 mg/Ncm SO_x – 235 mg/Ncm NO_x – 666 mg/Ncm CO – 166 mg/Ncm	PM – 75 mg/Ncm SO_x – 350 mg/Ncm NO_x – 1000 mg/Ncm CO – 250 mg/Ncm	PM-100mg/Ncm SO_x – 500 mg/Ncm NO_x – 1500 mg/Ncm CO – 400 mg/Ncm	Continue monitoring	Continue monitoring; Investigate cause of complaint, determine and address the root cause Check maintenance condition of stationary sources	Continue monitoring; Investigate cause of complaints, determine and address the root cause Check maintenance condition of stationary sources Consider installation of pollution control devices, as necessary

Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
								EQPL Range			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
	Increase in ambient noise level	Noise level, dB	Approved method of noise measurement (AS 1055.1-1998)	Quarterly, or as required by EMB	Existing ambient air quality and noise monitoring stations	Pollution Control Officer	PhP 10,000 per sampling event	Negative feedback reported Or Noise levels reach: **Daytime** Area Class / Noise Level AA / 40 A / 45 B / 55 C / 60 D / 65 **Morning & Evening** Area Class / Noise Level AA / 35 A / 40 B / 50 C / 55 D / 60 **Nighttime** Area Class / Noise Level AA / 30 A / 35 B / 45 C / 50 D / 55	Complaint lodged by community and/or by contractor or employees Or Noise levels reach: **Daytime** Area Class / Noise Level AA / 45 A / 50 B / 60 C / 65 D / 70 **Morning & Evening** Area Class / Noise Level AA / 40 A / 45 B / 55 C / 60 D / 65 **Nighttime** Area Class / Noise Level AA / 35 A / 40 B / 50 C / 55 D / 60	Multiple complaints lodged by community and/or by contractor or employees Or Noise levels reach: **Daytime** Area Class / Noise Level AA / 47 A / 52 B / 62 C / 67 D / 72 **Morning & Evening** Area Class / Noise Level AA / 42 A / 47 B / 57 C / 62 D / 67 **Nighttime** Area Class / Noise Level AA / 37 A / 42 B / 52 C / 57 D / 62	Investigate or inspect subject of negative feedback	Investigate or inspect cause of complaint, determine and address the root cause	• Conduct noise audit of equipment and machineries that generate noise • Consider installation of noise suppression devices to equipment and machineries that generate noise

Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
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			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
Operations of the TSF	TSF Stability	Piezometric levels presented in linear graph with rainfall and operational pond water level. Visual indications of displacement, creep, deformation on embankment Visual inspection of spillway, seepage collection pond, and other hydraulic structures Tailings level Operational pond level Freeboard level In situ water quality for TSF discharge, seepage collection pond and groundwater (pH, turbidity	Visual inspection by licensed structural or geotechnical engineer Piezometer level recordings AS/NZS 5667.1 (ISO 5667-1, 4, 6 & 9); Water Quality Monitoring Manual for Ambient Water Quality Monitoring (DENR-EMB, 2008); DENR-approved laboratory methods for water quality monitoring at seepage collection ponds and TSF discharge	Visual inspections to be conducted weekly. Water quality monitoring and piezometric measurements to be conducted quarterly. Visual inspections may be conducted daily after an earthquake or major storm event while water quality monitoring, particularly at the seepage collection ponds, may be conducted post event.	TSF piezometer locations, seepage collection ponds and TSF impoundment	Licensed structural or geotechnical engineer for visual assessment Pollution Control Officer/ Environmental Officer for water quality collection at TSF discharge, seepage collection ponds, and groundwater	50,000/ sampling station	There need not be any visual change or physical change in any of the parameters to be monitored. Alert levels are automatically applied after the occurrence of earthquakes and typhoons from signal no. 1 and above.	Change of concentrations/levels of water quality for seepage collection pond, groundwater, and TSF discharge from normal operations levels.	Visual indications of displacement or deformation of embankment. Significant change (~ 0.3 m) in operational pond water and piezometric level and increased turbidity in seepage collection ponds and groundwater	Inspect piezometer levels and water quality post event Increase frequency of visual inspection until water quality and piezometer measurement indicate no change from normal operating conditions	Increase monitoring frequency and investigate until source of change is discovered or monitoring values normalize.	Stop operations embankment is repaired and reinforced, spillway repaired and reinforced and stability issues are addressed. Monitoring of water quality parameters and piezometric levels will be conducted monthly until values return to normal operational levels.

Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
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	Ambient Surface Water Quality *Additional parameters may be included if deemed necessary	Parameters from DAO 2016—08: PSIC Code 0722 and 0729 pH, TSS, Nitrate, Sulfate, Cyanide, Dissolved Copper, Zinc, Arsenic, Mercury, Lead, Iron, and Cadmium PSIC Code 24210 Temprture, pH, COD, TSS, Ammonia, Nitrate, Sulfate, Flouride, Chloride, Cyanide, Barium, Chromium, Manganese, Iron, Nickel, Zinc, Cadmium, Mercury, Lead, O&G, Phenol and Phenolic Substance (2-chlorophenol, 2,4 dichlorophenol and 2,4,6 trichlorophenol) *Additional parameters: • BOD_5 • Total and Fecal Coliform (TC & FC) • Dissolved Oxygen (DO) • Boron • Phosphates • Surfactants	AS/NZS 5667.1 (ISO 5667-1 & 6) Water Quality Monitoring Manual for Ambient Water Quality Monitoring (DENR-EMB, 2008) DENR-approved laboratory methods	Quarterly	Baseline sampling stations in the primary impact catchments (Sison, Tagana-an, Placer and, Tubod) and selected stations in the secondary impact catchments	Pollution Control Officer/ Environmental Officer Pollution Control Officer/ Environmental Officer	50,000/ sampling station	Minor change in the aesthetic quality of water (i.e. visible discoloration, turbid water)	DAO 2016-08 Class A Monthly: pH – 5.5 to 9 TSS – 40mg/L NO_3-N – 5mg/L Sulfate – 225mg/L Cyanide as cyanide – 0.8mg/L Dissolved Cu – 0.01mg/L Zinc – 1.8mg/L As – 0.03mg/L Hg – 0.0005mg/L Pb – 0.004mg/L Iron – 1.3mg/L Cd – 0.001mg/L O&G – 0.1ug/L Temp – 3 °C change COD – 45mg/L Cr^{+6} – 0.005mg/L Fluoride – 1mg/L Cl- – 315mg/L Ba – 0.5mg/L Mn – 1mg/L Fe – 3.5mg/L Ni – 0.055mg/L Phenol & Phenolic Substances – 0.003mg/L Additional parameters: BOD_5 – 4mg/L TC – 1 mg/L FC – 1 mg/L DO – 5mg/L	DAO 2016-08 Class A Monthly: pH – 6.5 to 8 TSS – 45mg/L NO_3-N – 6mg/L Sulfate – 240mg/L Cyanide as cyanide – 0.9mg/L Dissolved Cu – 0.015mg/L Zinc – 1.9mg/L As – 0.05mg/L Hg – 0.0005mg/L Pb – 0.005mg/L Iron – 0.9mg/L Cd – 0.002mg/L O&G – 0.1ug/L Temp – 3 °C change COD – 50mg/L Cr^{+6} – 0.0055mg/L Fluoride – 1.5mgL Cl- – 325mg/L Ba – 1mg/L Mn – 1.5mg/L Fe – 4mg/L Ni – 0.05mg/L Phenol & Phenolic Substances – 0.005mg/L Additional parameters: BOD_5 – 4.5mg/L O&G – 0.1ug/L TC – 1.1 mg/L FC – 1.1 mg/L DO – 4.5mg/L	Check and monitor the performance of the TSF	Identify the source of contamination; Check the performance of the drainage system Check for any seepage Increase frequency of monitoring as necessary	Identify if the project is the source of contamination; If yes, temporarily stop the operation and conduct clean-up Increase frequency of monitoring;

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	Ambient Groundwater Quality *Additional parameters may be included if deemed necessary	Parameters from DAO 2016—08: PSIC Code 0722 and 0729 pH, TSS, Nitrate, Sulfate, Cyanide, Dissolved Copper, Zinc, Arsenic, Mercury, Lead, Iron, and Cadmium PSIC Code 24210 Temprture, pH, COD, TSS, Ammonia, Nitrate, Sulfate, Flouride, Chloride, Cyanide, Barium, Chromium, Manganese, Iron, Nickel, Zinc, Cadmium, Mercury, Lead, O&G, Phenol and Phenolic Substance (2-chlorophenol, 2,4 dichlorophenol and 2,4,6 trichlorophenol) *Additional parameters: • BOD_5 • Total and Fecal Coliform (TC & FC) • Dissolved Oxygen (DO) • Boron • Phosphates • Surfactants	AS/NZS 5667.1 (ISO 5667-1 & 6) Water Quality Monitoring Manual for Ambient Water Quality Monitoring (DENR-EMB, 2008) DENR-approved laboratory methods	Quarterly	Baseline sampling stations in the primary impact catchments (Sison, Tagana-an, Placer and, Tubod) and selected stations in the secondary impact catchments	Pollution Control Officer/ Environmental Officer	50,000/ sampling station	DAO 2016-08 Class A Monthly: pH – 5.8 & 8 TSS – 35mg/L NO_3-N – 4mg/L Sulfate – 215mg/L Cyanide as cyanide – 0.5mg/L Dissolved Cu – 0.005mg/L Zinc – 1.5mg/L As – 0.02mg/L Hg – 0.0005mg/L Pb – 0.002mg/L Iron – 2mg/L Cd – 0.001mg/L O&G – 0.1ug/L Temp – 3 $^{\circ}$C change COD – 40mg/L Cr^{+6} – 0.017mg/L Fluoride – 1mg/L Cl- – 305mg/L Ba – 0.3mg/L Mn – 0.7mg/L Fe – 3mg/L Ni – 0.057mg/L Phenol & Phenolic Substances – 0.002mg/L Additional parameters: BOD_5 – 3mg/L TC – 1 mg/L FC – 1 mg/L DO – 4.5mg/L	DAO 2016-08 Class A Monthly: pH – 5.5 to 8 TSS – 40mg/L NO_3-N – 5mg/L Sulfate – 225mg/L Cyanide as cyanide – 0.7mg/L Dissolved Cu – 0.05mg/L Zinc – 1.8mg/L As – 0.03mg/L Hg – 0.0005mg/L Pb – 0.004mg/L Iron – 2.5mg/L Cd – 0.002mg/L O&G – 0.1ug/L Temp – 3 $^{\circ}$C change COD – 45mg/L Cr^{+6} – 0.015mg/L Fluoride – 1mg/L Cl- – 315mg/L Ba – 0.5mg/L Mn – 1mg/L Fe – 3.5mg/L Ni – 0.055mg/L Phenol & Phenolic Substances – 0.003mg/L Additional parameters: BOD_5 – 4mg/L TC – 1 mg/L FC – 1 mg/L DO – 4mg/L	DAO 2016-08 Class A Monthly: pH – 6.5 & 8.5 TSS – 45mg/L NO_3-N – 6mg/L Sulfate – 240mg/L Cyanide as cyanide – 0.9mg/L Dissolved Cu – 0.07mg/L Zinc – 1.9mg/L As – 0.05mg/L Hg – 0.0005mg/L Pb – 0.005mg/L Iron – 3mg/L Cd – 0.003mg/L O&G – 0.1ug/L Temp – 3 $^{\circ}$C change COD – 50mg/L Cr^{+6} – 0.01mg/L Fluoride – 1.5mgL Cl- – 325mg/L Ba – 1mg/L Mn – 1.5mg/L Fe – 4mg/L Ni – 0.05mg/L Phenol & Phenolic Substances – 0.005mg/L Additional parameters: BOD_5 – 4.5mg/L TC – 1.1 mg/L FC – 1.1 mg/L DO – 5mg/L	Check and monitor the performance of the TSF	Identify the source of contamination Check the performance of the drainage system Check for any seepage Increase frequency of monitoring as necessary	Identify if the project is the source of contamination; If yes, temporarily stop the operation and conduct clean-up Increase frequency of monitoring;

<table>
<tr><th rowspan="3">Key Environmental Aspects
(Per Project Phase)</th><th rowspan="3">Potential Impacts (per environmental sector)</th><th rowspan="3">Parameter to be Monitored</th><th colspan="3">Sampling and Measurement Plan</th><th rowspan="3">Lead Person</th><th rowspan="3">Estimated Cost (PHP)</th><th colspan="6">EQPL Management Scheme[i]</th></tr>
<tr><th rowspan="2">Method</th><th rowspan="2">Frequency</th><th rowspan="2">Location</th><th colspan="3">EQPL Range</th><th colspan="3">Management Measure</th></tr>
<tr><th>Alert</th><th>Action</th><th>Limit</th><th>Alert</th><th>Action</th><th>Limit</th></tr>
<tr><td></td><td>Freshwater biota

Periphyton,

Macroinvertebrates

Fish</td><td>Abundance and composition of aquatic organisms

Presence of pollution indicator taxa

Status of endemic species (i.e. Anguilla marmorata)</td><td>Scientifically approved methods used for wadeable streams (kick-net and periphyton sampling).</td><td>Semi-annual covering the wet and dry season</td><td>Stations in the primary impact areas (Sison, Tagana-an, Placer and, Tubod) that are concurrent with the water quality stations covered during the baseline.

Lakes Mainit and Mahukdam and as well as Mapaso stations will be monitored as secondary impact areas.

The proposed monitoring stations but may be adjusted as necessary.</td><td>Pollution Control Officer/ Environmental Officer</td><td>50,000/ sampling station</td><td>Significant decrease (based on applicable statistical test) in the abundance relative to the previous monitoring period covering the same season.

Appearance of pollution indicator taxa.</td><td>Significant decrease (based on applicable statistical test) for the two consecutive monitoring periods covering the same season.

Dominance of pollution indicator taxa.</td><td>Significant decrease (based on applicable statistical test) for the two consecutive monitoring periods covering the same season.

Dominance of pollution indicator taxa.

Change in color (in PCU) of the surface water.</td><td>Continue monitoring and investigate possible cause of decrease.</td><td>Continue monitoring

Coordinate with MMT in the investigation of the cause of decline.</td><td>Investigate if cause of decline is the project. If not, continue the monitoring activities at the same frequency. If source of decline is project, temporarily stop activities in the vicinity of the monitoring station where adverse impact was observed and implement clean-up measures. Riparian rehabilitation or other efforts necessary to revert the condition to baseline conditions.</td></tr>
<tr><td></td><td>Heavy metals in fish tissues</td><td>Cadmium

Copper

Lead

Zinc

Mercury

Arsenic</td><td>Ashing-Acid Digestion

Inductively Coupled Plasma Spectrophotometry

Acid Digestion

Cold Vapor AAS

Hydride Vapor Generation

AAS</td><td>Semi-annual covering the wet and dry season</td><td>Boyongan and Timamana Creeks; Bad-as/ Amoslog River</td><td>Pollution Control Officer/ Environmental Officer</td><td>50,000/ sampling station</td><td>Heavy metals detected in fish tissues</td><td>Heavy metals detected in fish tissues for two consecutive sampling</td><td>Heavy metals in fish tissues exceeded their respective limits</td><td>Continue monitoring and investigate possible cause of contamination.</td><td>Continue monitoring. Coordinate with MMT in the investigation of the cause of contamination.</td><td>Investigate if cause of contamination is the project. If not, continue the monitoring activities at the same frequency. If source of decline is project, temporarily stop activities in the vicinity of the monitoring station where adverse impact was observed and implement clean-up measures</td></tr>
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Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
								EQPL Range			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
	Generation of particulate matter (PM), NO_x, SO_x, and CO from fuel combustion of stationary sources	• Particulate Matter (PM) • SO_x • NO_x • CO	US EPA Method 1 to 5 / Gravimetric US EPA Method 1 to 4 and: SOx – Method 6/8 NOx – Method 7/Phenol-disulfonicacid CO – US EPA Method 3/10 Orsat analysis or NDIR	Quarterly, or as required by EMB	Generator set/s	Pollution Control Officer	PhP 900,000	PM – 60 mg/Ncm SO_x – 235 mg/Ncm NO_x – 666 mg/Ncm CO – 166 mg/Ncm	PM – 75 mg/Ncm SO_x – 350 mg/Ncm NO_x – 1000 mg/Ncm CO – 250 mg/Ncm	PM -100mg/Ncm SOx – 500 mg/Ncm NOx – 1500 mg/Ncm CO – 400 mg/Ncm	Continue monitoring	Continue monitoring; Investigate cause of complaint, determine and address the root cause Check maintenance condition of stationary sources	Continue monitoring; Investigate cause of complaints, determine and address the root cause Check maintenance condition of stationary sources Consider installation of pollution control devices, as necessary

<table>
<tr><th rowspan="3">Key Environmental Aspects
(Per Project Phase)</th><th rowspan="3">Potential Impacts (per environmental sector)</th><th rowspan="3">Parameter to be Monitored</th><th colspan="3">Sampling and Measurement Plan</th><th rowspan="3">Lead Person</th><th rowspan="3">Estimated Cost (PHP)</th><th colspan="6">EQPL Management Scheme[i]</th></tr>
<tr><th rowspan="2">Method</th><th rowspan="2">Frequency</th><th rowspan="2">Location</th><th colspan="3">EQPL Range</th><th colspan="3">Management Measure</th></tr>
<tr><th>Alert</th><th>Action</th><th>Limit</th><th>Alert</th><th>Action</th><th>Limit</th></tr>
<tr><td></td><td>Increase in ambient noise level</td><td>Noise level, dB</td><td>Approved method of noise measurement
(AS 1055.1-1998)</td><td>Quarterly, or as required by EMB</td><td>Existing ambient air quality and noise monitoring stations</td><td>Pollution Control Officer</td><td>PhP 10,000 per sampling event</td>
<td>Negative feedback reported
Or
Noise levels reach:
<table><tr><th colspan="2">Daytime</th></tr><tr><td>Area Class</td><td>Noise Level</td></tr><tr><td>AA</td><td>40</td></tr><tr><td>A</td><td>45</td></tr><tr><td>B</td><td>55</td></tr><tr><td>C</td><td>60</td></tr><tr><td>D</td><td>65</td></tr></table>
<table><tr><th colspan="2">Morning & Evening</th></tr><tr><td>Area Class</td><td>Noise Level</td></tr><tr><td>AA</td><td>35</td></tr><tr><td>A</td><td>40</td></tr><tr><td>B</td><td>50</td></tr><tr><td>C</td><td>55</td></tr><tr><td>D</td><td>60</td></tr></table>
<table><tr><th colspan="2">Nighttime</th></tr><tr><td>Area Class</td><td>Noise Level</td></tr><tr><td>AA</td><td>30</td></tr><tr><td>A</td><td>35</td></tr><tr><td>B</td><td>45</td></tr><tr><td>C</td><td>50</td></tr><tr><td>D</td><td>55</td></tr></table></td>
<td>Complaint lodged by community and/or by contractor or employees
Or
Noise levels reach:
<table><tr><th colspan="2">Daytime</th></tr><tr><td>Area Class</td><td>Noise Level</td></tr><tr><td>AA</td><td>45</td></tr><tr><td>A</td><td>50</td></tr><tr><td>B</td><td>60</td></tr><tr><td>C</td><td>65</td></tr><tr><td>D</td><td>70</td></tr></table>
<table><tr><th colspan="2">Morning & Evening</th></tr><tr><td>Area Class</td><td>Noise Level</td></tr><tr><td>AA</td><td>40</td></tr><tr><td>A</td><td>45</td></tr><tr><td>B</td><td>55</td></tr><tr><td>C</td><td>60</td></tr><tr><td>D</td><td>65</td></tr></table>
<table><tr><th colspan="2">Nighttime</th></tr><tr><td>Area Class</td><td>Noise Level</td></tr><tr><td>AA</td><td>35</td></tr><tr><td>A</td><td>40</td></tr><tr><td>B</td><td>50</td></tr><tr><td>C</td><td>55</td></tr><tr><td>D</td><td>60</td></tr></table></td>
<td>Multiple complaints lodged by community and/or by contractor or employees
Or
Noise levels reach:
<table><tr><th colspan="2">Daytime</th></tr><tr><td>Area Class</td><td>Noise Level</td></tr><tr><td>AA</td><td>47</td></tr><tr><td>A</td><td>52</td></tr><tr><td>B</td><td>62</td></tr><tr><td>C</td><td>67</td></tr><tr><td>D</td><td>72</td></tr></table>
<table><tr><th colspan="2">Morning & Evening</th></tr><tr><td>Area Class</td><td>Noise Level</td></tr><tr><td>AA</td><td>42</td></tr><tr><td>A</td><td>47</td></tr><tr><td>B</td><td>57</td></tr><tr><td>C</td><td>62</td></tr><tr><td>D</td><td>67</td></tr></table>
<table><tr><th colspan="2">Nighttime</th></tr><tr><td>Area Class</td><td>Noise Level</td></tr><tr><td>AA</td><td>37</td></tr><tr><td>A</td><td>42</td></tr><tr><td>B</td><td>52</td></tr><tr><td>C</td><td>57</td></tr><tr><td>D</td><td>62</td></tr></table></td>
<td>Investigate or inspect subject of negative feedback</td><td>Investigate or inspect cause of complaint, determine and address the root cause</td><td>Conduct noise audit of equipment and machineries that generate noise
Consider installation of noise suppression devices to equipment and machineries that generate noise</td></tr>
</table>

Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
								EQPL Range			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
	SDMP	Projects initiated by the Proponent under the SDMP	Community Coordination and Regular Project Evaluation through Stakeholder Consultations Community responses through the MMT.	Quarterly to annually, or as required by EMB	Impact barangays	Community Relations Officer or Stakeholder Engagement Officer	Approximately PhP 2,000,000 per annum	Negative verbal feedback to the Proponent	Formal complaint lodged by the community	Multiple complaints by the community captured by the local media organizations	Proponent to investigate/ inspect subject of negative feedback. Coordinate with barangay.	Investigate cause of complaint, determine and address the root cause. Coordinate with LGUs, BGUs and MMT.	Release official statement for general consumption and employees of SMMCI and to address the issue to the affected communities. Conduct regular consultation with relevant and concerned stakeholders of the community. Coordinate with and update MMT regarding the resolution of the issues and concerns and include in the regular monitoring reports as required.
	Information, Education, and Communication	Implementation of IEC activities	Community Coordination and Maintenance of Information Center Community responses through the MMT.	Semi-annually to annually	Impact barangays	Community Relations Officer or Stakeholder Engagement Officer	Approximately PhP 120,000 per annum	Negative verbal feedback to the Proponent	Formal complaint lodged by the community	Multiple complaints by the community captured by the local media organizations	Proponent to investigate/ inspect subject of negative feedback. Coordinate with barangay.	Investigate cause of complaint, determine and address the root cause. Coordinate with LGUs, BGUs and MMT.	Release official statement for general consumption and employees of SMMCI and to address the issue to the affected communities. Conduct regular consultations and IECs with relevant and concerned stakeholders of the community. Regularly update MMT regarding the conduct of the IEC activities and reflect these activities in the monitoring reports as required.

Key Environmental Aspects (Per Project Phase)	Potential Impacts (per environmental sector)	Parameter to be Monitored	Sampling and Measurement Plan			Lead Person	Estimated Cost (PHP)	EQPL Management Scheme[i]					
								EQPL Range			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
	Compliance to commitments/agreements, Community relations	Number of complaints lodged and amount of time these complaints were resolved or answered	Implementation of Grievance Mechanism/Protocol Community Coordination Community responses through the MMT.	Weekly	All stakeholders (LGUs, government agencies, and impact barangays)	Community Relations Officer or Stakeholder Engagement Officer	Approximately PhP 120,000 per annum	Negative verbal feedback to the Proponent	Formal complaint lodged by the community	Multiple complaints by the community captured by the local media organizations	Proponent to investigate/ inspect subject of negative feedback. Coordinate with barangay	Investigate cause of complaint, determine and address the root cause. Coordinate with LGUs, BGUs and MMT.	Release official statement for general consumption and employees of SMMCI and to address the issue to the affected communities. Conduct regular consultations and IECs with relevant and concerned stakeholders of the community. Regularly update MMT regarding the conduct of the IEC activities and reflect these activities in the monitoring reports as required.

Appendix A. Additional Information

[i] EQPL-Environmental Quality Performance Levels (DAO 2003-30)

- Alert or Red Flag : early warning
- Action Level : point where management measures must be employed so as not to reach the regulated threshold or limit level, or to reduce deterioration of affected environmental component to pre-impact or optimum environmental quality
- Limit Level: regulated threshold of pollutant (standard that must not be exceeded); point where emergency response measures must be employed to reduce pollutants to lower than standard limit.

The proposed action levels is based on the current guidelines, the limit levels will be agreed upon among the members of the MMT prior to start of monitoring activities.

DRAFT

Environmental Impact Statement

Section 7. ERP

Table of Contents

7. Emergency Response Policy and Guidelines 7-1
7.1 Comprehensive Safety and Health Program 7-1
7.2 Management of Hazardous and Oxidising Substances 7-4

7. Emergency Response Policy and Guidelines

SMMCI commits to utilize its resources to implement the highest health and safety control standards to prevent personal injury, property damage, assets loss, and protect the project's environment as a whole. SMMCI's manner in dealing with hazard identification and control is through proactive safety culture in compliance to the existing government laws and regulations for the mutual benefit of all.

7.1 Comprehensive Safety and Health Program

A Comprehensive Safety and Health Program has been formulated by SMMCI which serves as a framework of the company's safety plan with the following elements:

- Leadership and administration;
- Planned inspections;
- Accident/incident investigation
- Organization rules;
- Employee trainings;
- Personal protective equipment (PPE);
- Health control and services;
- Emergency preparedness;
- Purchasing and engineering control; and
- Records and reports.

The SMMCI-Central Safety and Health Council (CSHC) oversees the overall implementation of the plan which aims to ensure that the project attains the highest degree of safety awareness, and strengthen the implementation of the plan in compliance to the mine safety and health standards in the country. Specifically, SMMCI adopts the Standard Operating Procedures (SOP) and Standard Job Procedures (SJP) stipulated in the Mine Safety and Health Standards of the DENR-AO 2000-98. In addition, the Comprehensive Safety and Health Program was also prepared based on the existing manuals for occupational safety and health, international safety rating, and other various company rules and regulations.

SMMCI provides each employee a safety orientation which covers first aid and basic life support, including the following aspects:

- Basic safety rules and regulations;
- How and when to report injuries;
- Where first aid facilities are located;
- How to report substandard practices and conditions;
- What to do in an emergency during fire, earthquake and typhoons/floods, including how to exit the workplace;
- Identification of hazardous chemicals used in the project area;
- Use and care of required personal protective equipment (PPE); and
- On-the-job-training on how to perform the job safely.

Further, SMMCI requires every personnel to attend a training program to enhance the workforce's safety and efficiency in the performing their respective tasks in the project site. This training program covers a range of training courses such as first aid, fire safety, proper job analysis, and rescue and recovery on a regular basis.

SMMCI establishes an Emergency Preparedness and Response Program, including a Disaster Management Program as part of the Comprehensive Safety and Health Program. One of the highlights of the program is the formation of the Emergency Response Team and the formulation of the Emergency Response Plan. The Emergency Response Plan contains evacuation maps and plans in case of fire, flooding, typhoon and other natural disasters.

Figure 7.1-1 and **Figure 7.1-2** show the emergency response organization and emergency response flowchart, respectively.

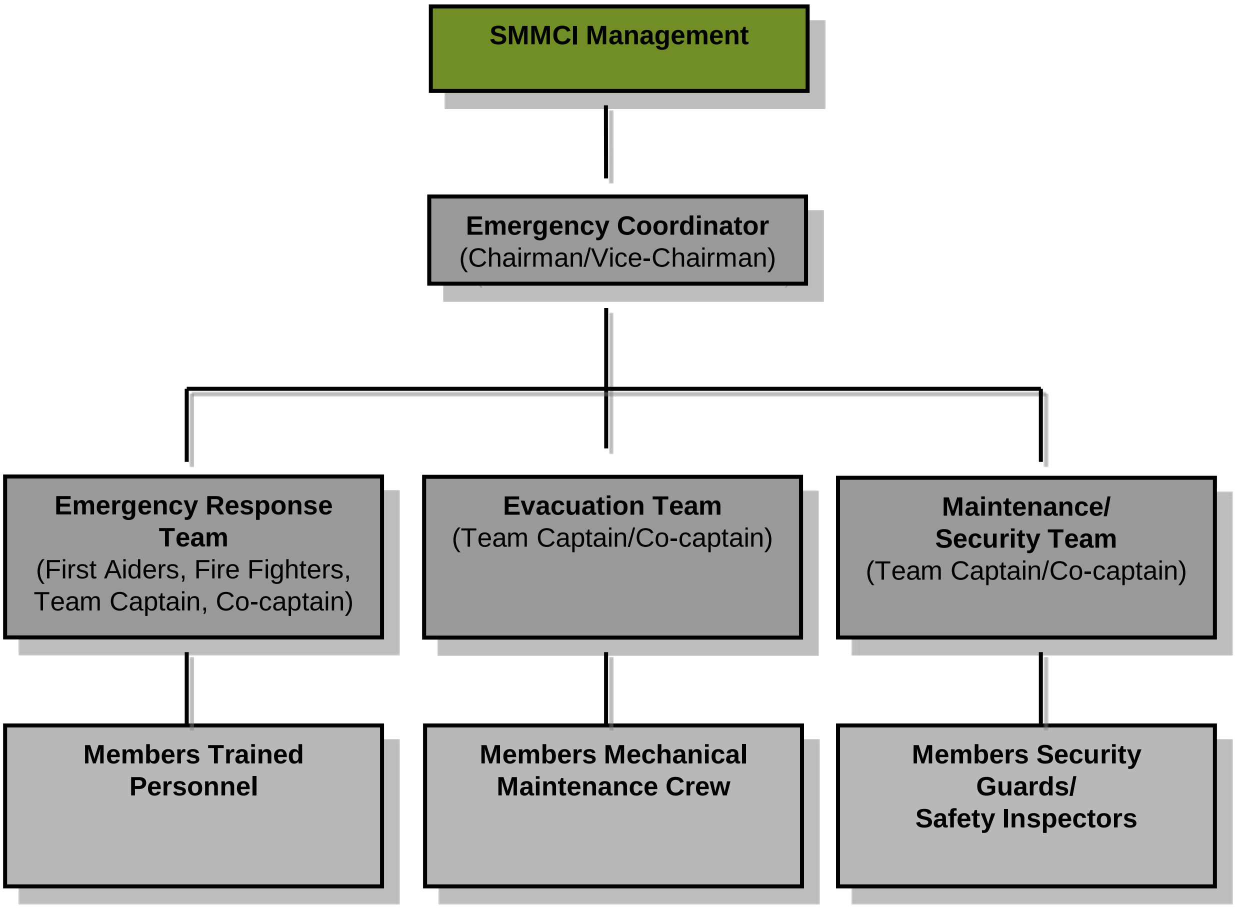

Figure 7.1-1 SMMCI Emergency Response Organization

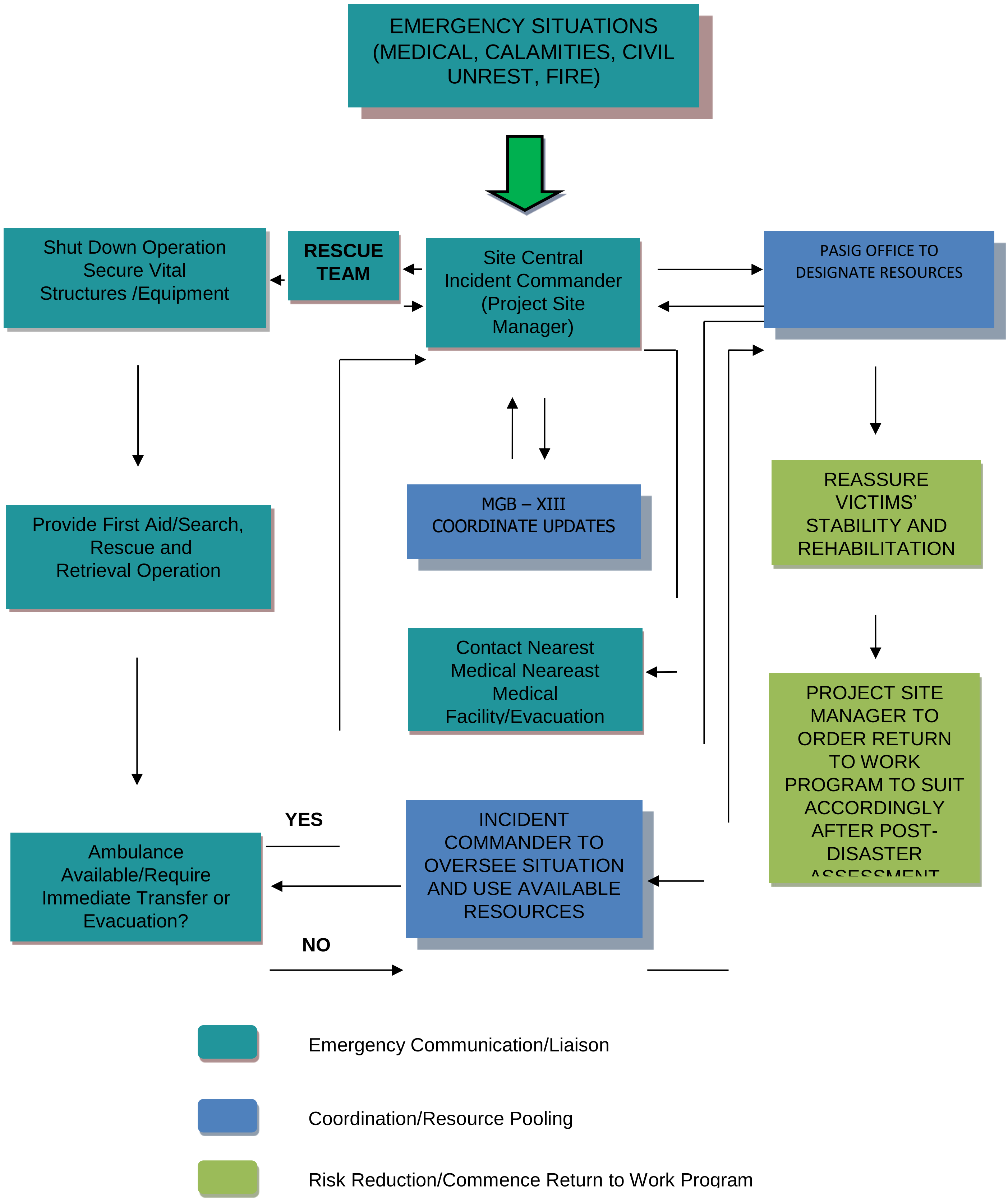

Figure 7.1-2 Emergency Preparedness and Response Flowchart

7.2 Management of Hazardous and Oxidising Substances

The storage, handling and management of hazardous and oxidising substances identified in **Section 4.0** (Environmental Risk Assessment) will be in accordance to the corresponding MSDS requirements of the substance (**Annex 7-1**). Response in the event of a breach in containment, exposure, or fire for flammable substance and explosives will also be tailored in accordance to the recommended fire-fighting measures and extinguishing media specified in the MSDS.

To avoid the occurrence of hazards associated with the storage and handling of these substances safety measures and protocols will be in place prior to the requisition of hazardous and oxidising substances. Emplacement of storage facilities adequate for the maintenance of the benign and non-reactive state of the substances will be done prior to operations. Emergency equipment for spill, fire-fighting and damage control for the substances will also be in place prior to the procurement of the reagents. Regular trainings of safe handling, storage and response for incidents related to hazardous and oxidising substances will be an integral part of the emergency response plan and will be relayed to the primary responders or quick response teams. Throughout the project life, close coordination with the appropriate government agencies such as the regional Bureau of Fire Protection will be undertaken and maintained.

DRAFT

Environmental Impact Statement

Section 8. Institutional Plans

Table Contents

8. Institutional Plans for EMP Implementation 8-1

8. Institutional Plans for EMP Implementation

8.1 Institutional Plans for EMP Implementation

The establishment of the Institutional Plan aims to set-up an organizational structure over-seeing the effective implementation of the project's proposed EMP. This institutional arrangement is also responsible to improve and reinforce the relationship between the project proponent and the various stakeholders.

As stipulated in DAO 2003-30, setting-up an Environment Unit is essential or a designated Environmental Officer to maintain the environmental compliance of the project vis-a-vis conditions stipulated in the ECC, EMP and the actual impacts of the project's operation against the potential impacts identified in the EIS.

Figure 10-1 shows the environmental management structure of SMMCI which is composed of three divisions, namely: solid waste management, pollution control management, and forest management headed each division by an Environmental Supervisor. These three supervisors are under direct management of the Assistant Manager who is directly reporting to the Department Manager on Environment. The Department Manager is being supervised by the Vice President for Environment and Community Relations.

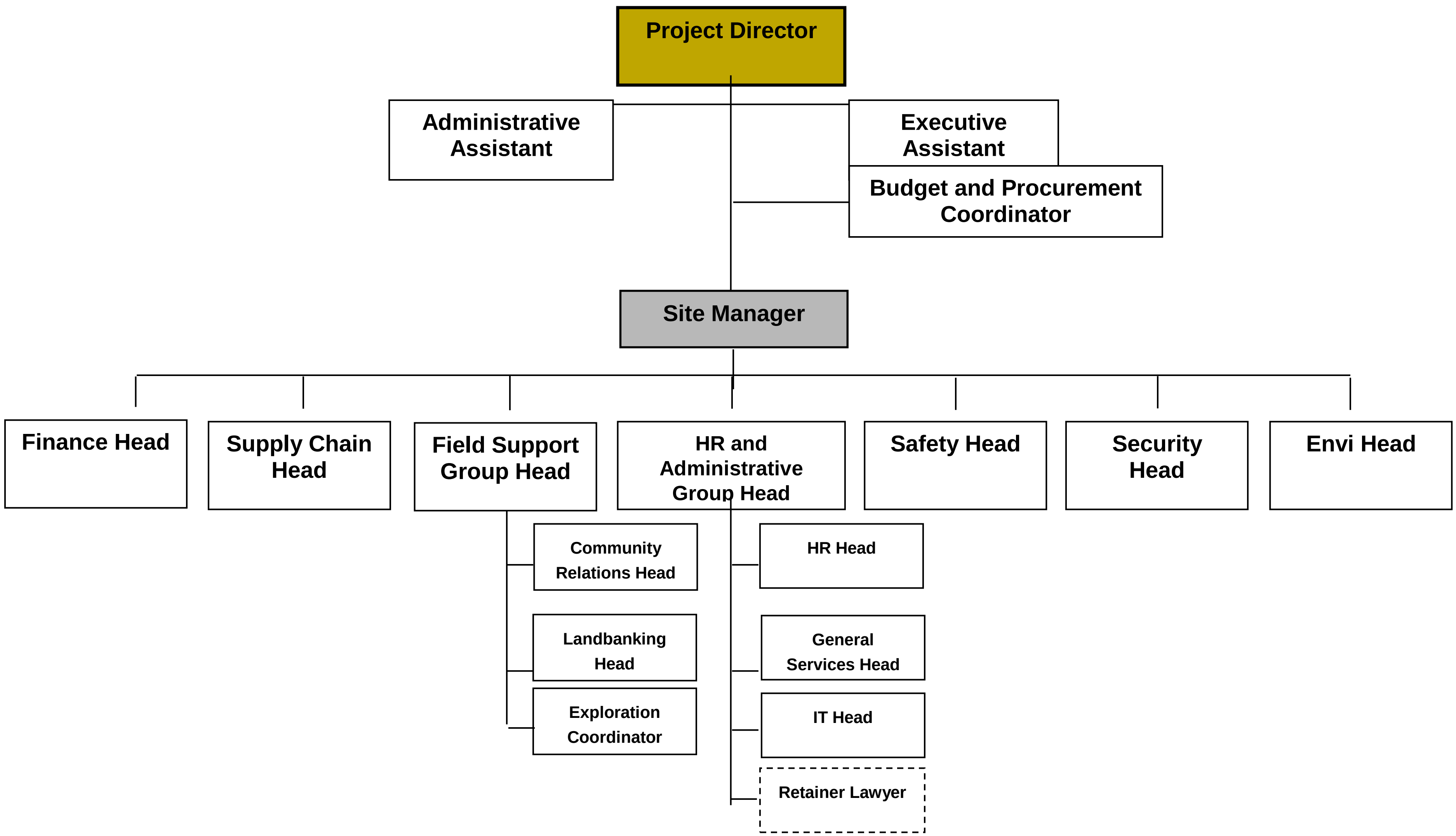

Figure 8-1 The SMMCI Environmental Management Structure

8.2 Grievance Mechanism

This grievance mechanism procedure will apply to all project stakeholders but distinction will be given to internal stakeholders (defined as groups or individuals who work directly within the project such as employees and contractors) and external stakeholders (defined as groups or individuals not directly employed by the project but are impacted by the project). A grievance is defined as an issue, concern, or claim (perceived or actual) by a stakeholder that is required to be addressed by SMMCI in a formal manner. Grievance Mechanism is defined as a formalized procedure to receive issues, concerns, or claims concerning adverse impacts of the Project to its stakeholders.

8.2.1 Grievance Reporting Channels

Grievance reporting channels are the media by which issues and complaints are received. The reporting channels will be improved and expanded as the project is developed but for the meantime, the reporting channels consists of the following:

- Telephone

Stakeholders can call SMMCI trunkline Tel No.: (+63 2) 631-1381

- Facebook Page

Messages can be sent to Silangan Updates (@silanganupdates)

- Face to Face

Stakeholders can voice their concerns to the Site Manager, Community Relations Officer, or to any SMMCI employee who will then relay their concerns to the appropriate officials using the grievance mechanism process.

8.2.2 Roles and Responsibilities

The Community Relations Lead is the default contact officer and manager of the grievance procedure. Grievances received should be communicated to the ComRel Lead who will then assign a grievance owner, maintain the register and monitor the actions taken, report findings to management, ensure that the grievance mechanism is followed strictly, and regularly raise awareness in terms of grievance mechanism procedure. On the other hand, the Grievance Owner will be appointed to investigate the concern by liaising and documenting interactions with stakeholders involved, develop recommendations and actions along with other officials of the project, and track the progress and close out the grievance. The Grievance Owner may be an existing official of the project (e.g. Human Resources if HR issue) as long that he or she is not the one to whom the grievance is directed to. Other employees may receive the grievance in behalf of SMMCI as long as the grievance is formally endorsed to the ComRel and documented. For documentation, a template should be provided by SMMCI and used as the official Grievance Form.

8.2.3 Grievance Mechanism Procedure

The procedure is shown below (**Figure 8.2**).

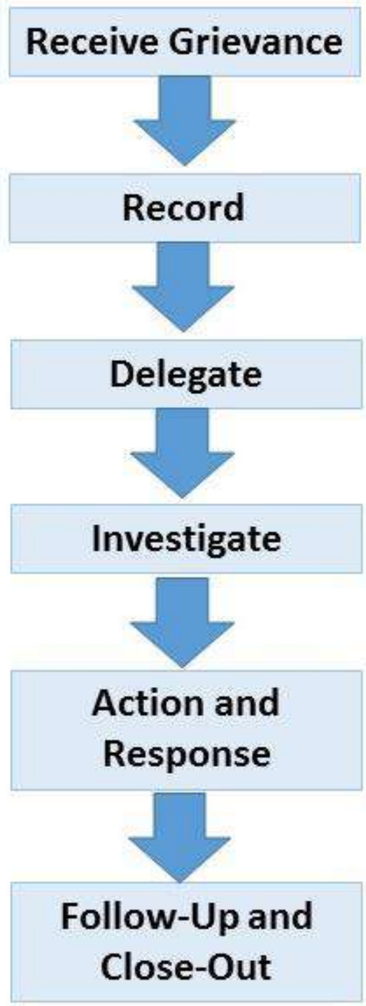

Figure 8-2 Grievance Mechanism Procedure

If a grievance is received face to face or over the phone, it is the responsibility of the employee who initially received the complaint to record it in the Grievance Form. Once the form is filled out, it will be forwarded to the Community Relations Lead. Complaints received via the Facebook page will be forwarded by the page manager to the ComRel Lead after filling out the Grievance Form. All filled out forms will be recorded in a Grievance Logbook/Register. Once the grievances are recorded, the issue or complaint is evaluated and delegated to a Grievance Owner. The Grievance Owner shall then liaise with the stakeholders and concerned parties. High profile issues and concerns that may impact the operations and reputation of SMMCI in a large scale can be escalated immediately to management or executive level for immediate response.

Prior to the investigation of a grievance, the issue or complaint should be summarized with the method of resolution and the estimated timeframe for the issue to be resolved. This summary will be written and given to the concerned stakeholders for their record and confirmation. If there are no more comments or corrections, the Grievance Owner may conduct investigation by interviewing concerned parties, conducting site validation, consulting other stakeholders, and other methods to resolve the issue. All proceedings will be recorded and all information gathered will be reviewed and analyzed to arrive at a resolution to the grievance. Once the method to resolve the grievance (including steps to be conducted and entities to handle) have been discussed, agreed upon, and approved, an action plan outlining steps and responsible staff will be created. Once all actions have been completed and the aggrieved stakeholder is satisfied with the resolution, a report will be drafted to acknowledge the closing of the concern. A follow-up may also be conducted within two weeks to ensure no residual issues are left before final close-out of the grievance.

If the stakeholder is unhappy with the results of the action plan or the issue remains unresolved, the matter may be escalated to management. All reports and resolutions will be kept confidential with the final document owners being the Community Relations Department.

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Environmental Impact Statement

Section 9. Abandonment Plan

Table of Contents

9. Abandonment/Decommissioning/Rehabilitation Policies and Guidelines

9.1 Closure Objectives and Scenarios

9.1.1 Closure Objectives

9.1.2 Closure Scenarios

9.2 Conceptual Closure Plan – Final Land Use

9.2.1 FMRDP Development History

9.2.2 Open Pit

9.2.3 TSF

9.2.4 Waste Rock Dumps

9.2.5 Process Plant

9.3 Emergency Controls and Emergency Response Plan at Closure

9. Abandonment/Decommissioning/Rehabilitation Policies and Guidelines

This section discusses the decommissioning and rehabilitation plan for the project and is also an excerpt of the approved Final Mine Rehabilitation and/or Decommissioning Plan (FMRDP). The FMRDP is a document produced to anticipate for the eventual decommissioning and rehabilitation of the mine-disturbed area once the mine has ceased commercial production. Aside from being one of the conditions of the ECC, the FMRDP is a requirement of the revised implementing rules and regulations of the Philippine Mining Act (DAO 1996-40), particularly the Contingent Liability and Rehabilitation Fund (CLRF); DAO 2005-07, the Final Mine Rehabilitation and Decommissioning Plan (FMRDP); and Section 187 of the Revised Implementing Rules and Regulations of Republic Act No. 7942 (DAO 2010-21). The FMRDP is founded on the guiding principle within Executive Order No. 270 (The National Policy Agenda on Revitalizing Mining in the Philippines) concerning the protection of the environment in every stage of mining operations. SMMCI aligns its governing policy with this principle, being "a socially and environmentally responsible Filipino company striving for excellence in mineral resource development committed to the continual improvement of its operations by minimizing adverse environmental impacts, complying with applicable legislations and other requirements, and promoting environmental awareness and commitment among its workers at all levels." The intent of the FMRDP is to plan for a sustainable post-mining land use for areas that will be impacted by the mine even before the mine closes. The FMRDP is drafted to complete the Declaration of Mine Project Feasibility (DMPF) along with the Environmental Protection and Enhancement Program (EPEP), which is the expanded Environmental Management Plan (EMP) for the life of mine, and the Social Development and Management Program (SDMP).

The Contingent Liability and Rehabilitation Fund (CLRF) is composed of the Mine Wastes and Tailings Fees (MWTF) and the Mine Rehabilitation Fund (MRF). The CLRF was established to ensure there is sufficient fund for the implementation of mine rehabilitation and closure. MWTF are fees collected semi-annually depending on the amount of tailings generated within an operational period. The amount of fees collected are accrued to a Mine Waste and Tailings (MWT) Reserve Fund and deposited in a Government depository bank to be used for a payment of compensation for damages caused by mining operations. The MWT Reserve Fund is also utilized for research projects duly approved by the CLRF Steering Committee which are deemed necessary for the promotion and furtherance of its objectives. The MWTF is computed as Php 0.50/MT of mine waste produced and Php 0.10/MT of processed tailings generated from milling operation. The MRF is composed of the Rehabilitation Cash Fund (RCF), the Monitoring Trust Fund (MTF), and the Environmental Trust Fund (ETF). The RCF is equivalent to 10% of the total amount needed to implement the Environmental Protection and Enhancement Plan (EPEP) or Php 5,000,000.00 whichever is lower. It is deposited as a Trust Fund in a mutually agreed government depository bank in 4 equal quarterly deposits following the approval of the EPEP. In the event of withdrawals from RCF, the proponent shall annually replenish the RCF so as to maintain the minimum required amount. The MTF is not less than Php 50,000.00 to cover maintenance and other operating budget for the transportation and travel expenses, cost of laboratory analysis, cost of supplies and materials, cost of communication services, cost of consultancy work and other reasonable expenses incurred by the monitoring team. Authorization for the disbursement from the MTF is only given by the designated representatives of both the MRF Committee and the proponent. Replenishment of this amount shall be done monthly to correspond to the expenses incurred by the monitoring team for the month. The ETF is established to pay for mining related compensable damages other than those caused by mine waste and processed tailings. ETF is pegged at a minimum of Php 50,000.00.

The FMRDP is an integrated (environmental and social) approach for the preparation and implementation of environmental and social programs during the closure and rehabilitation phase of the mine. Mine closure planning is started early, even before the mine operates, to identify the potential risks associated with mine closure, identify the long-term potential impacts of mine closure, incorporate methodologies and measures to convert the mine-disturbed land to an environmentally stable condition, and identify post-mining beneficial and sustainable land uses of the land and surrounding areas. Turn-over of secondary facilities such as roads, offices, accommodation buildings, and others to the host communities are also considered in the planning of the FMRDP. The present FMRDP is the third version of the rehabilitation and decommissioning plan for the Project. The first version of the FMRDP was submitted for the block-cave mine methodology in 2013. The Declaration of Mine Project Feasibility (DMPF) was approved in the same year following the issuance of the Environmental Compliance Certificate (ECC-CO-1212-0028) on May 24, 2013. Project development commenced after DMPF issuance and submission of the block-cave Environmental Protection and Enhancement Program (EPEP) and the FMRDP. Due to issues in decline development schedule and safety, SMMCI revisited the mine methodology and decided to proceed with open pit mining. The ECC for the open pit mine (ECC-CO-1510-0026) was issued on March 15, 2016. This was shortly followed by the issuance of the open pit DMPF with the submission and approval of the open pit EPEP and FMRDP.

The sublevel caving FMRDP was recently presented to the Mine Rehabilitation Fund Committee (MRFC) Region 13. It has been endorsed to the MGB Central Office. This section contains a summary of the FMRDP document.

9.1 Closure Objectives and Scenarios

The general intent of the Conceptual Mine Closure and Rehabilitation Plan is, at a minimum, to prevent or eliminate long-term environmental impacts by ensuring the project footprint is environmentally stable and have possible beneficial use for the stakeholders. The following sections present the closure objectives and the closure scenarios considered for the conceptual plan.

9.1.1 Closure Objectives

Mineral extraction impacts the environment due to the nature of a mine's operations and the mine wastes that are generated. It is therefore necessary to ensure that a mine is decommissioned and closed properly to ensure the stability of the facilities that contain mine wastes and those that will permanently alter the land use. Closure planning is also done to prevent any potential hazards to the environment and public health and safety even after the mine ceases to operate. Planning for closure starts even before the operations end, to ensure that the socio-economic benefits of the mine to the immediate community are sustained and that the impact communities will continue to thrive after mine closure.

The project's environmental management and progressive rehabilitation activities that will be undertaken during mine operation, through its Environmental Protection and Enhancement Program (EPEP), and the empowerment of communities to be economically will ensure that closure issues will be addressed as early as the operations phase. What is critical after mine closure is the sustainability and long-term outcomes of rehabilitation and protection measures. This plan therefore gave primary emphasis to strengthening the gains from the EPEP implementation and to monitoring and evaluation after mine closure. It will be attentive to any undesirable eventualities and carry out the necessary and appropriate response measures to ensure that the objectives of this plan will be achieved.

"The Silangan Mindanao Mining Company, Inc. (SMMCI), as a socially and environmentally responsible Filipino company striving for excellence in mineral resource development, is committed to the continual improvement of its operations, to minimize adverse environmental impacts, to comply with applicable legislations and other requirements; and to promote environmental awareness and commitment among its workers at all levels".

This policy serves as the Company's overall framework in defining, among others, mine closure actions and in setting the following FMRDP objectives:

1. To come up with a quick and cost effective transformation of mine-affected land to a physically and chemically stable and self-sustaining ecosystem. It shall also approximate to the original land use or to a pre-agreed productive alternative land use that is suitable and acceptable to the community;

2. Fully protect public and environmental health and safety and ensure that any potential discharges during re-mining/dredging operation and following project closure will be managed to prevent harm to the receiving environment or to the public;

3. Ensure a government-approved reclamation and closure plan, prepared by the contractor/operator, to return the project site to a viable and, wherever practical, self-sustaining ecosystem is in place prior to project operation/development;

4. Ensure any approved reclamation and closure plan is updated by the mine operator periodically to reflect results of new information, such as ongoing environmental and technical studies, changes to operations, and progressive rehabilitation/reclamation, and that this updated plan is approved by the government and that financial security requirements are adjusted accordingly; and

5. Ensure mine operators provide financial assurance in the form of Mine Rehabilitation and Decommissioning Fund (MRDF) and that the cost of rehabilitation/reclamation (including but not limited to shutdown, closure and post-closure, and related environmental monitoring in the approved FMRDP is met by SMMCI.

The attainment of the above objectives and subsequently the implementation of the corporation environmental policies shall ensure that closure of the project site is achieved economically, while minimizing future environmental and societal impacts and compliant with legal requirements.

For the Mine Closure Plan, the general intent is, at a minimum, to revert the conditions of the land to the natural characteristics of the surrounding environment under baseline conditions. The final land use plan along with the social features, in addition, requires stakeholders' participation to come up with better measures and developments to arrive at a sustainable environment.

The mine closure plan should also provide long-term geochemical stabilization of the project components such as the tailings storage facility to prevent any adverse effects to the environment and to public health. Based on international best practice and the Mines and Geosciences Bureau (MGB) guidelines, the specific objectives include the following:

- Establish the project area's post-closure land use capability;
- Develop post mine-generated benefits that is sustainable;
- Build local community capacity to enable efficient utilization of mine resources post-closure;
- Prevent or minimize risks to public health and safety; and,
- Prevent or minimize physical and chemical deterioration of the tailings storage facility.

Specific closure objectives of the Project relating to the major components are as follows:

- To ensure that the tailings are safely and securely stored within the TSF;
- To ensure that the quality of outflow from the tailings meet the applicable surface water quality standards of DENR;
- To ensure that the Mill has caused no chemical contamination to the area through proper and well-managed dismantling procedures and decommissioning process;
- To ensure that the underground mine is appropriately closed and stabilized;
- To ensure the subsidence zone is stabilized and appropriately rehabilitated;
- To ensure that on-site infrastructures that need decommissioning are properly dismantled and identified structures for future use, through consultations, are suitable and stable which would cause no risk in the future;
- To ensure that off-site infrastructures (roads, water system, and power lines) are properly established and, if these will be turned over the communities, that these structures are properly handed to the local government unit or government agencies that will manage and maintain these structures.

In line with these objectives, the environmental goals for the project-affected areas include the following:

- Progressive rehabilitation will be implemented wherever applicable during the mine operations;
- Surfaces requiring rehabilitation will be vegetated with local species or those suitable for preferred end land use;
- Water quality of all affected surface water and groundwater match the baseline water quality or its best usage; and
- Surface and groundwater supply is assured for the downstream communities after closure.
- In some instances, operations may cease temporarily due economic reasons (depreciation of ore against cost of operations), environmental conditions (accidents or natural hazards), non-compliance to government regulations, or other events. For such cases, the project is placed under care and maintenance until operations resume. As with the final mine closure, the above-mentioned objectives will still be attained to ensure the project area is secure and stable.

9.1.2 Closure Scenarios

The conceptual mine closure and rehabilitation plan considers the following scenarios:

- **Planned Closure** – Planned closure occurs when the mining operations cease as a result of economic or operational requirements or when the ore reserve is completely mined out. The closure and rehabilitation plan will be implemented as the operations end and upon completion of the decommissioning stage.
- **Unplanned Closure** – this is a scenario wherein the mine closes prematurely due to unforeseen circumstances:
  - Temporary suspension of mining operations – Temporary suspension (unplanned closure) may occur as a result of financial constraints or if the proponent is instructed to stop operations due to non-conformance to regulatory requirements. Temporary suspension may last from a few weeks to several months. Measures that may be implemented include continued rehabilitation and other activities that can be carried out within a relatively short-term disruption of operations.
  - State of Inactivity (Care and Maintenance) – This scenario results from economic or operational constraints and entails a care and maintenance stage, taking into account the potential for future operations of the project. The measures that may be carried out include activities associated with long-term suspension of mining operations such as the maintenance of the TSF and Subsidence Zone, progressive rehabilitation, and continued waste management for the remaining workforce until the planned end date.

9.2 Mine Closure Plan

Short term or temporary land use change (equivalent to Project life) will occur in areas that will be occupied by Project support facilities and infrastructure such as service roads, mill, associated pipelines and conveyors to and from the mill, soil stockpiles, administration buildings and accommodation units. These facilities are considered temporary in the context that can be decommissioned and removed from site if no further use is recognized. On the other hand, permanent land use change is anticipated for the areas defined by the Subsidence Zone and the TSF.

9.2.1 Final Land Use for Major Project Components

Mining, forestry, agriculture, recreation, housing and infrastructures all compete for land use within the mining site. After ore extraction and the completion of the Silangan Copper-Gold Project, SMMCI intends to adopt sustainable final land use program that is in harmony with the future land use plans of the host municipalities. Based on initial consultations with project stakeholders, the proposed land use plans for the major mine facilities are mostly geared toward revegetation, agro-forestry, or agri-silvipasture. The proposed final land use for the major project facilities are presented in **Table 9-1**.

Table 9-1 Final land use of the different mine components

Mine Component	Area by first year of closure	Final Land Use	Cropping Model
Subsidence Zone	~208 ha	Reforested or revegetated with a free draining pit floor to ensure stability of subsidence zone and prevent seepage to the underground.	None
TSF	250 ha	TSF to be drained with remaining ponding areas to be planted with suitable crops and periphery converted to agroforestry	Agri-silvipasture Model
Mill Area	30 ha	Mill decommissioned and removed from site. Area will be revegetated with coconut to match baseline use or revegetated to match surroundings	None
Pipeline Route	Approximately 5.44 km	Dismantle pipeline and rehabilitate	None
Mine access roads and haul roads		Depending on location and upon consultations with host communities, some roads will be turned over to barangays while minor haul roads will be rehabilitated and revegetated to match the surrounding environment	None

Agro-forestry has been adopted as a sustainable and profitable upland activity for the TSF and mill. It is an integrated and sustainable system combining agriculture, forestry, horticulture and livestock management. It is considered to be the most suitable technology for increasing total productivity of food, feed and fuel. Of the many models available, the agri-silvi pasture system wherein perennial woody trees are integrated with crops and pasture with the objective of providing food for humans, feeds for the animals and income to humans, is most preferable. This integration of livestock with crops maximizes the economic return of the disturbed lands through time. In order to determine the viability of this land use for the Project, a market study has been conducted for agro-forestry. The outcome of the market study is integrated in the relevant succeeding sections.

9.2.2 Mill

Some of the key units of the mill operation areas are the process plant, water supply and associate buildings.

Some of the major closure issues to be taken into consideration for these units and other facilities within the mill operations include: contamination of structures, land contamination, disposal of sludge and products from any contaminated works, disposal of residual chemicals, public safety of remaining structures, land form stability, and erosion control and its connection to the TSF (via the tailings pipeline).

Among the options for responsible closure of the mill operations is the decommissioning of the process plant installation. The mill area, process plant installation, mill pipelines and supports could either be removed and sold off, or disposed. Before the decommissioning or removal of these facilities is conducted, clean-up of the facility will be conducted such that no products, wastes, and chemicals are left within the mill. The content of the tailings pipeline will also be cleaned prior to removal.

Decommissioning will be conducted by the contractor who provided and assembled the components of the mill. Removable components such as metal and wires can be scrapped and sold. Other components such as the concrete and panelling may be hauled as waste and disposed in a solid waste disposal facility or hauled offsite. Containers that previously contained reagents, bulbs and fuel can be removed by hazardous waste contractors.

Once the mill is decommissioned, hard ground and its foundations will be fragmented and removed to expose the soil. Environmental site assessment will be conducted to determine that there are no more contaminants left on the soil.

The mill area will cover approximately 30 ha. The intended final land use is tree plantation or revegetation to mimic the surrounding environment. The visual rendition of the final land use of the mill area is presented in **Figure 6.2-1** to **Figure 6.2-3.**

Figure 6.2-1 Mill Area at Year 21 of Operations

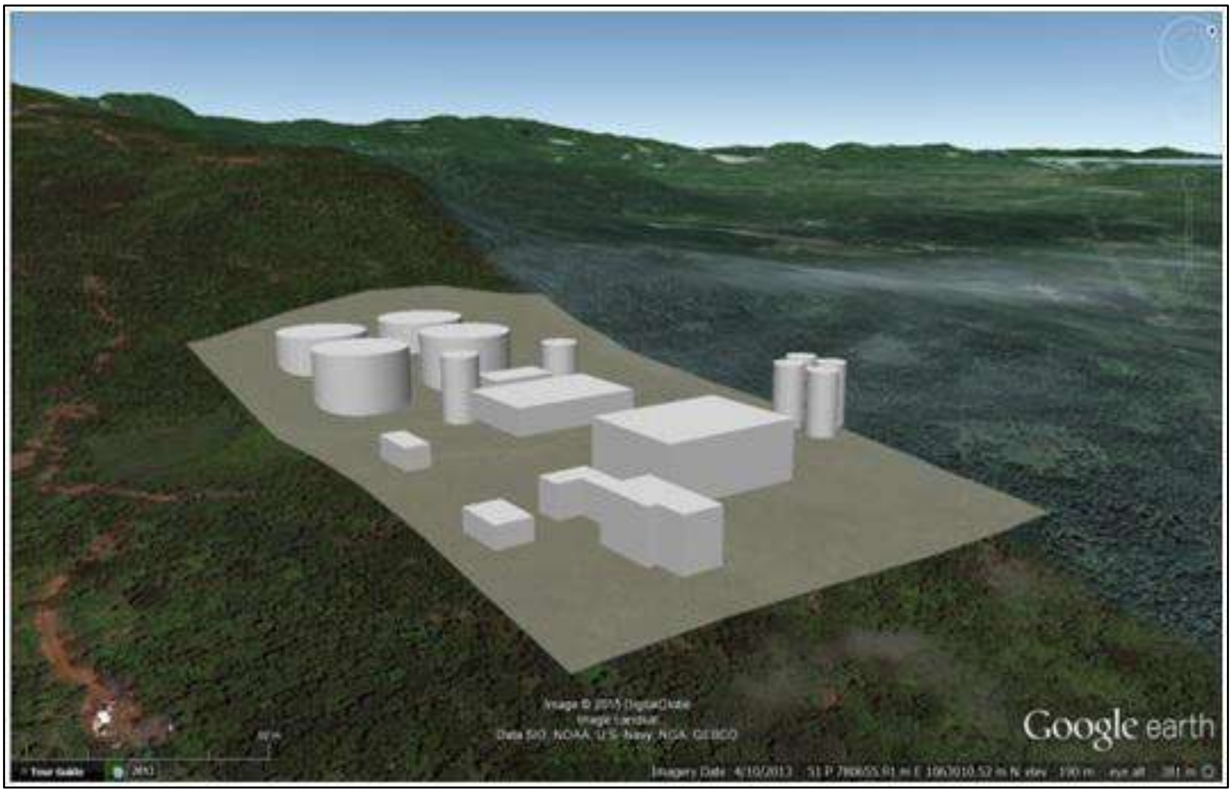

Figure 6.2-2 Decommissioning of Mill Area. Once the mill is dismantled (details of dismantling presented in Section 6.4.3), hard ground and its foundations will be fragmented and removed to expose the soil.

Environmental site assessment will be conducted to determine that there are no more contaminants left on the soil.

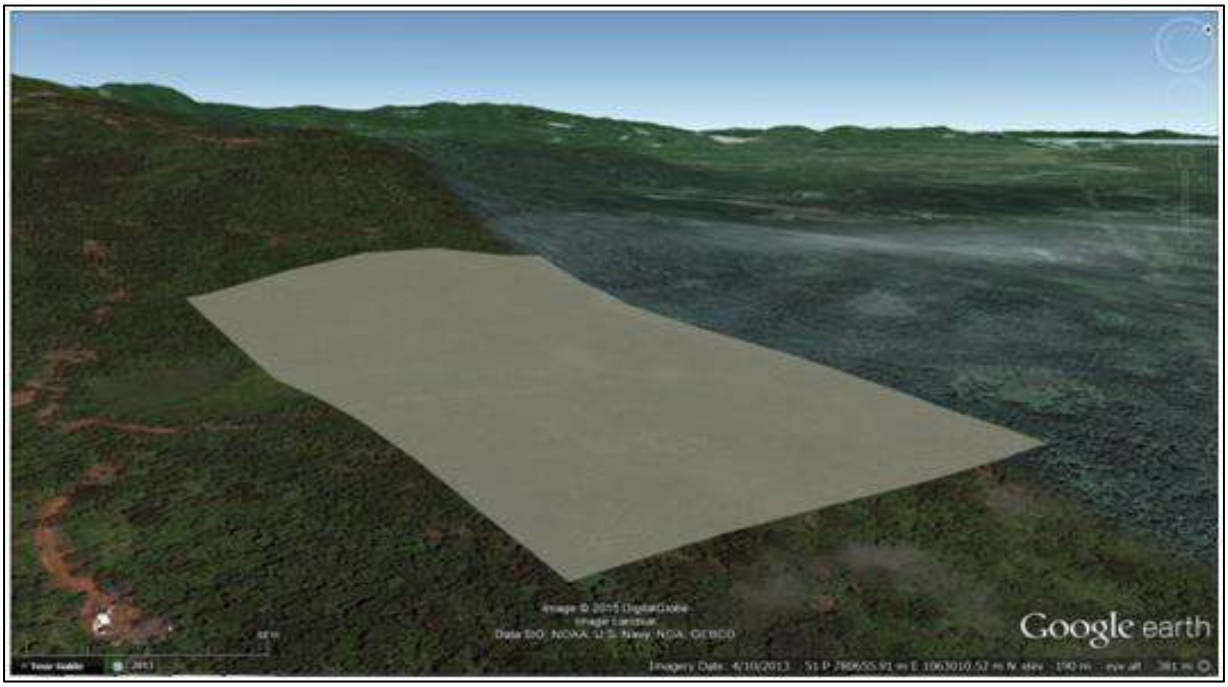

Figure 6.2-3 Final Land Use of Mill Area is presented as tree plantation or revegetation to match the surrounding environment

9.2.3 Pipeline and Haul Roads

The tailings pipeline system will be decommissioned by ensuring that its connection with the mill and the TSF has been closed and decommissioned. The contents of the TSF pipeline system will removed and the pipeline components dismantled. The pipeline may be disposed offsite or sold for scrap. The TSF footprint will be regraded such that topsoil is exposed and revegetated to mimic its surroundings.

Haul roads, if there will be no further use, will be regraded and revegetated to match its surroundings.

9.2.4 Support Facilities and Off-lease Infrastructure

Some of the support facilities are the housing areas, recreational facilities, utility services and other infrastructures. Closure issues to be taken into consideration include the need for continued maintenance of services, safety of remaining structures, and land and water contamination. Roads, administration buildings, barracks, quarters, offices, and water treatment facilities, and other structures that are deemed useful to the community will be maintained at site and will be properly turned over to the community.

Several options for responsible closure could be undertaken in consultation with relevant stakeholders to help in decision making. It is anticipated that housing areas and its services need to be consolidated into an area more appropriate to the anticipated long-term population. Where there is a need, unwanted house could be removed to alternative locations. As with the mill, upon exposure of hardground, the vegetation that would be able to grow are endemic trees.

Associated fuel storage and supply system could be decommissioned, decontaminated and removed. Where facilities and buildings are removed and all disturbed areas can be re-vegetated with options for orchards, tree plantation, or forestland

Water treatment and supply systems could also be decommissioned, unless required by the Government and alternative appropriate water systems introduced to the remaining housing area.

Contractor facilities could also be decontaminated prior to contractor departure and sanitary landfill could be decommissioned according to the management plan that will be prepared. Alternative disposal areas for future use need to be allocated.

All unwanted transmission lines and towers could be removed, footings covered with soil and the surface vegetated. All unwanted communication facilities could also be removed and footings left in situ. Access road (pipeline route) maybe left as is, in situ and transfer responsibilities for its maintenance to appropriate Government authority.

9.2.5 Other Operations or Facilities

Some of the key units of other operations or facilities include the administration complex, motorpool, mine explosive/magazine bodega, mobile equipment, accommodations, and off-lease facilities that are yet to be determined. Some of the major closure issues to be taken into consideration for these facilities are the lease period (if applicable), management at closure, post closure monitoring, possible turn-over of facilities to host LGUs or other stakeholders, and determine post-closure need if any.

9.2.6 Tailings Facility and its Environs

The progressive rehabilitation of the tailings pond and the surrounding impoundment beach will strengthen the stability of the embankment at closure. The 974.41-hectare TSF will be subjected to final land use adopting both Agri-Silvi Pasture and Alley Cropping models on progressive phases.

Figure 6.2-6 Stage 1. The stage 1 area will be developed for alley cropping of Narra with Robusta (coffee). The remaining areas be planted with grass. The red portions refer to the tailings beach. It is expected that water cover within the TSF will be reduced over time.

Figure 6.2-7 Stage 2. By Stage 2 the tailings beach would be shown in the previous figure will be covered with grass to allow the tailings beach to transition into more consolidated ground.

Figure 6.2-8 Stage 3. This will be covered with grass. It is envisioned that the agri-silvipasture component will progress to the remaining areas.

9.2.6.1 Agri-Silvipasture Component

Visual renderings of the final land use for the subsidence area are shown in **Figure 6.2-9**. A discussion of the proposed final land use follows.

9.2.6.1.1 Goat and Citrus

The Agri-Silvipasture component of TSF will be inhabited by goat and citrus.

9.2.6.1.2 Goat

The Philippine native goat's characteristics are summarized by Bondoc in “Animal Breeding: Principles and Practice in the Philippine Context”. The Philippine native goat has an average weight of 20 kilograms, body length of 51 centimeters, girth of 64 centimeters, and wither height of 55 centimeters. Its kidding rate is an estimated 81% with a twinning rate of 29%.

An article published by the Australian Centre for International Agricultural Research titled “Management of internal parasites in goats in the Philippines” further discusses the goat industry of the Philippines and describes it as one of the worthwhile industries in the country due to the low investment cost and high reward involved. Interestingly, the government also promotes the goat farming industry as one of many options to ease poverty among families.

The industry also presents an opportunity to become a steady supplier of goat meat in the market. The opportunity is born from the fact that goat meat prices are high but readily available supply is lacking. The article indicates that most of the production of goats in the country is focused on consumption of the families who grow them in their backyards. In addition to becoming a supplier, it should be noted as well that the profitability of the goat farming industry is not limited to goat meat alone. Amundson, in “How to Raise Goats: Everything You Need to Know, Updated & Revised” discusses that the industry can expand and create a demand for goat milk, goat hide, goat leather, and even goat horns.

9.2.6.1.3 Forage

Grasses such as rensonii (*Desmodium resonii*), flemingia (*Flemingia macrophylla*) and Madre de Cacao will be the major feed grasses of goats. In addition to their feed and nutritive value for animals, these will serve as contour hedgerows for erosion control and soil fertility maintenance within the subsidence area.

9.2.6.1.4 Citrus (Calamansi)

The calamansi (citrus madurencis) is considered as one of the major fruit crops indigenous to the Philippines.

Calamansi is easy to cultivate and thrives well in cool and elevated areas and in sandy soils rich in organic matter. Grafted calamansi will be planted on site with a planting distance of 4 m by 4 m. The trees will start to bear fruit four years after planting and have an average productive life of seven years. According to the Bureau of Agricultural Statistics (BAS), this fruit crop has contributed greatly in the export market at a value of US$ 238.85 thousand for the year 2005, either in the form of fresh fruit, juice, or concentrate.

Costs of producing calamansi starts at planting. Grafted planting materials shall be sourced from local nurseries at PhP 75 each at the rate of PhP 625 trees per hectare. Additional costs include labor for planting, organic and inorganic fertilizers, labor for holing, planting, and staking.

The average yield per hectare of land is estimated at 3,750 kilograms per hectare and the average area of harvested bearing trees is 60% per hectare. Data from BAS shows that the average farm-gate price is PhP 12/kg. This translates to PhP 281,250 of revenue per hectare of Calamansi. These are however based on optimal and favourable market conditions at the time the market study was conducted. Other plantations or cover may be suitable by the time the mine approaches closure.

9.3 Emergency Controls and Emergency Response Plan at Closure

During operations, emergency measures or fail-safe mechanisms may be in place that would provide immediate control for accidental spills, breach, overtopping or failure of the TSF. With a full operations workforce, it is also expected that emergency response and/or evacuation, if necessary, would be addressed without concerns for resources or timeliness of response. However, during closure when essentially the mine’s workforce is reduced and the project footprint is gradually reverted to pre-mining conditions, emergency controls and response will be reduced.

At closure, necessary to apply controls to guarantee that no adverse environmental impacts will occur from risks associated with the TSF and WRD. The emergency response plan will be modified for the closure phase to consider the organizations or entities that will now enforce the plan namely the Mine Rehabilitation Fund Committee (MRFC), LGUs, remaining SMMCI workforce, and impact communities. It is important that trainings or capacity building on safety, security and emergency response during the operations phase be implemented and modified for the closure phase. These will include programs and trainings that are part of the operational emergency response. A permanent alarm system will also be installed during the operations to warn the downstream settlements to the TSF and WRD in the event of an emergency. The alarm system will remain in place until closure specifically when the rehabilitation activities are successfully completed and the desired final land use has been achieved.