EXECUTIVE SUMMARY

1. Project Fact Sheet

Project Proponent	Riverbend Consolidated Mining Corporation
Office Address	Unit 1602, 16th Flr., 139 Corporate Center, 139 Valero St., Bel-Air, Makati
Authorized Representative	Mr. Nicanor L. Escalante
Contact Person	Mr. Nicanor L. Escalante Director Contact No. : 0977-8078720 Email Address : nickescalante_phil@yahoo.com
Authorized Representative for ECC application	Mr. Joel A. Espineli Philkairos, Inc. JE Business Center Pinesville Road corner Ortigas Avenue Extension Barangay Dolores, Taytay, Rizal Telephone Number: (02) 8706-4008 Email Address: admin@philkairos.com
Project Name	Proposed Banaybanay Nickel Laterite Mining Project
Project Location	Barangays Puntalinao, Causwagan, Pintatagan, Maputi, Panikian, and Mahayag Municipality of Banaybanay, Province of Davao Oriental
Project Type	Resource Extractive Industry (Mining Project)
MPSA Number	No. 263-2008-XI Amended-IB with Amendment Order dated 24 June 2016
Project Area	6,363.3368 hectares (MPSA) / 1,072.20 hectares for partial declaration (disturbed area)
ECC Reference Number	New Application
Project Components	Nickel Mine Pits Stockpiles Waste Dumps Siltation Ponds, Interceptor canals, Drainage lines Haul / Access Roads Work Camps Field and Administration Office Motorpool and Equipment Depot
Extraction Capacity	9,600,000 WMT per annum

2. Brief Project Background

The project is covered by the MPSA 263-2008-XI-Amended-IB which includes areas covered by ExPA 000267-XI (now Parcel II of the MPSA) and ExPA 000252-XI (now Parcel III of the MPSA), containing an area of 6,023.89 has and 339.45 has, respectively. The northern portion of the amended MPSA area is located in Barangays Napnapan and Fuentes, Municipality of Pantukan, Province of Compostela Valley, whereas the rest of the tenement areas is located in Barangays Pintatagan, Puntalinao, Maputi, Mahayag and Causwagan, all in the Municipality of Banaybanay, Province of Davao Oriental. The amended MPSA tenement is bounded by geographic coordinates: 7° 01' 30" and 7° 09' 30" north latitudes and 125° 58' 00" and 126° 03' 00" east longitudes.

The Parcels II and III of MPSA 263-2008-XI-Amended-IB occur in the Southern Pacific Cordillera of the eastern Mindanao terrain, characterized by distinct occurrence of Copper-Gold prospects and deposits. The most prominent deposits include the Diwalwal Gold rush area in the north and the Kingking Copper-Gold in the south. The Southern Pacific Cordillera is also characterized by ophiolite rocks, which host chromite and nickel laterite occurrences, specifically the terrains in the Municipalities of Banaybanay and Lupon, City of Mati and the entire Pujada Peninsula.

This study covers an initial 1,072 hectare mine operating area which will be subject of a partial declaration application with the MGB. Two open pit mines, each located at Puntalinao and Causwagan areas, will be developed during the planned mine operation.

3. Process Documentation of the Conduct of EIA Study

The Environmental Impact Statement (EIS) is the result of the Environmental Impact Assessment (EIA) conducted for the Nickel Project located at Barangays Puntalinao, Causwagan, Pintatagan, Maputi, Panikian, and Mahayag, Municipality of Banaybanay, Province of Davao Oriental.

Both primary and secondary data were considered during the conduct of the environmental impact assessment study. Based on the standard EIA procedures, collection of secondary data were sourced from the following agencies and offices: Baseline and socio-economic profile of the municipality of Carrascal, province of Surigao del Sur – National Statistics Office (NSO); Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) – climatological data; Philippine Institute of Volcanology and Seismology (PHIVOLCS) for hazards; and Mines and Geosciences Bureau (MGB) - geological data.

Primary Data Gathering Matrix		
Methodology	**Source Person/s**	**Gathered Data**
Interview / Consultation	EIA Study Team and Proponent	Plans, Schedule, Clearance and Permits, Results of Related Studies, Compliance Report
Ocular Inspection	EIA Study Team	Site Condition
Field Survey	EIA Study Team	Terrestrial, freshwater and Geologic surveys
Research	EIA Study Team	Environmental data, compliance and performance of the existing project
Consultations	LGUs and communities of Barangays Puntalinao, Causwagan, Pintatagan, Maputi, Panikian, and Mahayag	Perception of the Project

Secondary Data Gathering Matrix		
Methodology	**Agencies**	**Gathered Data**
Research	National Statistics Office (NSO)	Socio-Economic and

Secondary Data Gathering Matrix		
Methodology	**Agencies**	**Gathered Data**
		Demographic Profile of Banaybanay, Davao Oriental
Research	PAGASA, Project NOAH	Climatological Normal and Extremes
Research	EMB-DENR	Existing Data for Air and Water Quality
Research	Mines and Geosciences Bureau	Geological Data
Research	NCIP	Status of FPIC Documents
Research	PHIVOLCS / MGB	Hazards

4. EIA Team

Riverbend Consolidated Mining Corporation (RCMC), the proponent of the Project has contracted the services of a third party environmental consultant, Philkairos, Inc. in the preparation of the EIS. The members of the EIA team are as follows:

Joel A. Espineli (IPCO-088)	Project Director
Maria Luisa M. Guiterrez (IPCO-097)	Project Manager
Hillel Cabria	Geology and Geohazards
Raymond Rodolfo	Geology and Geohazards Environmental Impact Assessment
Reynaldo Baloloy	Hydrology
Felixberto H. Roquia (IPCO-028)	Socio - Anthropologist
Rodolfo Romarate Jr.	Terrestrial and Aquatic Ecology Specialist
Jan Julio A. Espiritu	Environmental Impact Assessment
Ana Karmela S. Miranda (IPCO-070)	Research
Rexadi Roy Zamora	Research and Mapping

5. EIA Study Schedule

The overall schedule of activities is presented as follows:

Activities	**Month**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1. Planning with Technical Experts								
2. Gathering of project and environmental information								
3. Interpretation and analysis								
4. Public Scoping								
5. EIS Report Preparation								
6. EIS Review and Evaluation								
7. Public Consultations (presentation of the EIA result)								
8. Issuance of ECC								

6. EIA Study Area

The areas within the MPSA are all considered as primary impact areas (pink boundary) since the whole MPSA area is mineralized with lateritic deposit. Different locations have different quality and grades but all are expected to be developed and mined in the future. The secondary impact areas (n red) are those which may experience and affected by the residual effect of the mining operation, such as but not limited to sedimentation and siltation, dust pollution and intolerable sound due to the operation of heavy equipment and machinery.

7. EIA Methodology

The preparation of the EIA is in accordance with the steps indicated in the Revised Procedural Manual (RPM) for DAO 2003 – 30. The following are the steps undertaken by the consultants, as prescribed in the RPM:

1. Public Scoping with Community
2. 1st Level: Project Briefing Meeting with Review Team
   2nd Level: Technical Scoping with Review Team
3. Final Approval of Scoping Checklist
4. EIA Study and Report Preparation
5. Submission of Draft EIS

The EIA Team followed the Participatory Impact Assessment Method (PIAM) wherein the stakeholders were involved in the conduct of the EIA through project briefing, focused group discussion, and formal scoping meeting.

The EIA study consists of the following activities:

- Review of relevant laws, rules, regulations, pertinent guidelines and reports;
- Preliminary site inspection/reconnaissance-level survey by the relevant EIA team members;
- Review of available information and identify any gaps relative to addressing the Terms of Reference (TOR);
- Design and implementation of required field studies;
- Provision of baseline information;
- Identification, prediction and evaluation of impacts; and
- Formulation of mitigation measures, management practices and monitoring work integrating these into an Environmental Management Plan (EMP).

The Information, Education and Communication (IEC) campaign was conducted with the pre-scoping, perception survey and distribution of IEC materials on the EIA process as presented in the table below.

Activity	Date Conducted
Public Scoping	December 2016
Public Hearing (Presentation of EIA Results)	To be scheduled

The Social Development Management Plan (SDMP) was done through a consultation with the decision makers of the project affected Municipality and Barangays, the Barangay Chairpersons and the members of Local Government Units (LGUs), Indigenous Peoples groups and representatives of Riverbend Consolidated Mining Corporation (RCMC).

During the Public Scoping conducted in December 2016, the following stakeholders were invited to participate:

- LGU officials from the Municipality of Banaybanay (Executive Offices – Mayor, Vice Mayor, Municipal Council)
- Department Heads of the Municipal Government (Municipal Planning, Agriculture, Health, Social Welfare and Development, Municipal Environment)
- Barangay Council
- NCIP
- Through the Barangay council, sectoral representatives were also invited (PWDs, Senior Citizens, Health Units, IP Groups, Women's Sector, etc.)

Summarized below are the issues and concerns raised during the Public Scoping:

PARTY WHO RAISED THE ISSUE / SECTOR REPRESENTED	CONCERN / ISSUE	RESPONSE (Responding Party / Response)
Land Module		
1. Municipal Councilor Eva Juliege - VChairman on Environment sa SB	Banaybanay has been the target of mining since the 70s but not a single one has prospered. Should mining be pushed through ny Riverbend, my concern is that Banaybanay is a rice area. I hope that an intensive study should be done to assess and protect the rice area as it is the staple food of the community. Likewise, I hope that the marine environment be protected and safeguarded too. I hope that it will not be like Golden Summit before that there were a lot of issues concerning them. In the end, I hope that all the sectors would support the plan of development. My proposal is since Riverbend has successfully complied with all the requirements, I suggest that Riverbend will take us to Tawi-Tawi for a visit to their sister company so that we can see the actual operation.	Mr. Nick Escalante - President, Riverbend Mining Having an MPSA means you are a legal miner. We are the only mining company that has the Big Permit. Don't worry our consultants will do a study on the rice granary area. Ma'am Malou Gutierrez Your question is being noted upon. We might consider the Lakbay-Aral program so that we can fine-tune the barangay stakeholders about the good mining practices. Doc Joji Roquia We capacitate and build the people in the LGU that is being affected by letting them answer a methodology that I created. In this manner, we could ask Riverbend if they could facilitate the process.
Water Module		
2. Ester Solango – Municipal Agriculturist of Banaybanay	Banaybanay is a strong agricultural municipality. We have existing projects in agriculture like the Pagkain and Kita program of the province and Alang sa Dugang Ani of the municipality. Now I'm worried that these projects might be affected. Likewise, we have coastal programs for our marginal fisherfolks. There are farms and fish ponds in the area. But we also had projects before that got greatly affected like the	Doc Joji Roquia We will be doing an EIA and with that, we will be coordinating with your office, ma'am. You also have projects that perhaps can also be a part of the Social Development Plan. Follow-up answer:

PARTY WHO RAISED THE ISSUE / SECTOR REPRESENTED	CONCERN / ISSUE	RESPONSE (Responding Party / Response)
	Holothuria project of our women sector and the BuB program. Our municipality is pushing for a more sustainable agriculture. One more thing that I see as a conflict later is that our uplands were being surveyed for possible upland rice production areas, irrigation system would be placed. On that note, I hope that a deeper assessment would be done regarding the pros and cons of the project. The marginal fisherfolks and farmers should come into play because they are also stakeholders.	Ma'am Malou Gutierrez May we endorse our marine filed expert Jayr Romarate as he is going to coordinate with you and is also going to visit your office for an interview. We will also be doing a separate interview with MPDC and MENRO. Agriculture programs may also come in handy as perhaps we can take a look into it and adopt it into our SDMP. Follow-up answer: Doc Joji Roquia We will also be in close monitoring with the Disaster council.
3. Municipal Councilor Abelito Cordova – Chairman, Disaster and Preparedness, Municipality of Banaybanay	I laud the preparations you made in order that this Public Scoping would be successful and useful. I hope that you would be consulting the barangays affected. According to the reports made by Vice Mayor Teves, the shell products (seafoods) were affected by the cyanide apparently found in nickel.	Doc Joji Roquia Noted. Ma'am Malou Gutierrez Noted. We will let our geologist visit your office one time so that he can check on the veracity of the report.
4. Valerio Literal – Senior Citizen, Barangay Punta Linao	My concern as a fisherfolk is about the strict implementation like if ever the mining would push through, I hope that they would really uphold and take care of the environment, that they would have a sound waste water facility and that they would not dispose of their waste to the seas.	Doc Joji Roquia With that being said, Riverbend has assured us that they would follow all the correct procedures and they would implement good mining practices in the area.
People Module		
5. Brgy. Captain Ariel D. Sison – Punong Barangay, Barangay Maputi	I have some knowledge in mining because we had chromite mining operations before with Golden Summit in Maputi and Causwagan. I also know about the sharing proportions because we were also given shares by Golden Summit. I was able to buy ambulance and dumptruck for my barangay. So going back, in the video that you showed, I fear for the municipality and the 5 affected barangays. You can just imagine that in Tawi-Tawi, it's open already. It's a different scenario here. We still have farms, fishing areas and plenty of trees. My concern is that should this push through, I suggest that scoping	Doc Joji Roquia Your suggestion and comments are being noted. Mr. Nick Escalante - President, Riverbend Mining Thank you Chairman for your suggestions. For the information of everybody, Riverbend Mining already has the MPSA. But then again, we still need the Environmental Compliance Certificate that is why we are hiring the expertise of Philkairos

PARTY WHO RAISED THE ISSUE / SECTOR REPRESENTED	CONCERN / ISSUE	RESPONSE (Responding Party / Response)
	should be done in the barangay level, in all the barangays affected so that the people would be the one to decide if we would allow it. Today, in this Scoping, there are only a few who attended. The religious sector is not even here. They should have been invited. Likewise, I also know about those taxes that the mining proponent would be paying. Should there be mining operations here in our municipality, stringent safety measures would apply.	as they are technically competent to do the Environmental Impact Assessment of the study. EIA is done in order to study, assess, and mitigate any possible effects of mining to land, air, water and people. Talking about benefits, it is true that Riverbend will be paying excise tax of 2 percent for every shipment or cargo being transported by ship. That is quite a lot of money that the barangay will benefit for its own.
6. Barangay Chairman Roel Quijano Dula, Sr. - Punong Barangay, Barangay Causwagan	I suggest that there should be a public scoping in every affected barangay as the people must be consulted first before anything else.	Doc Joji Roquia In order to avoid the bad experience brought about by Golden Summit, EIA should strictly be followed.
7. Barangay Captain Chavez – Punong Barangay, Barangay Mahayag	What I can say is that public scoping in every barangay level should be done. I got curious in the video presentation you showed us. Perhaps, the proponent can show us through Lakbay-Aral their Tawi-Tawi site to give us a much clearer picture on what to do.	Mr. Nick Escalante - President, Riverbend Mining Thank you for your suggestion. We will be doing that so we can come up with a more positive and favorable endorsement from all the stockholders. Doc Joji Roquia The barangay council is the one that is going to give an endorsement for a project to proceed next.
8. Councilor Consuelo Cabrera SB Representative – Barangay Pintatagan	In behalf of Barangay Pintatagan, our voices are one with you in saying that we strongly suggest that there should be a barangay scoping to be facilitated in first. Our people must be consulted.	Doc Joji Roquia Just to set things clear, the endorsement would only come after all the assessment studies have been completed. The EIA is not a permit, rather, it is a procedural tool done in a scientific way, the process of assessing the likely environmental impacts of a proposal and identifying options to minimize the effects of environmental damage.
9. Rosalie Chula – Barangay Kagawad, Barangay Causwagan	Our barangay has been unfortunate to experience worst problems during the operations of Golden Summit. It was nightmare. People were complaining day and night. Then Riverbend Mining comes into the picture. I hope you understand our situation. Should the mining	Doc Joji Roquia Noted. Follow-up answer:

PARTY WHO RAISED THE ISSUE / SECTOR REPRESENTED	CONCERN / ISSUE	RESPONSE (Responding Party / Response)
	operation start, we want a more responsible mining company with good mining practices. My only hope is that you would adhere to your commitment of helping us take care of our environment, providing safety and protection, and providing for us jobs and employment. I also hope that there will be barangay scoping first, like there is a need for the barangay constituents to know more about this project.	Mr. Nick Escalante – President, Riverbend Mining We understand the many problems you had encountered while Golden Summit had its operations here. I can assure you that we will not be like Golden Summit. We are committed to giving you good mining practices.

8. Environmental Management and Monitoring Plan

Environmental Aspect / EIA Module	Potential Impact	Proposed Management and Monitoring Plan	Residual Effects
Land Use, Compatibility, tenure and Visual Aesthetics	Compatibility with existing land use. Based on the 2010 Land Use Map from the NAMRIA, the major land use or vegetative cover of the area includes open forest, shrubs/grasslands and perennial crops.	The proponent will secure proper clearances prior to the development of the project to address land compatibility.	Nil
	Compatibility with classification as ECA The project is in a cultural/social and geologic hazard areas and frequently visited or hard-hit by typhoons	The proponent has undergone the Free, Prior and Informed Consent (FPIC process) that eventually forged a Memorandum of Agreement (MOA) with the IP group/s. The proponent will follow abide by the stipulations of the MOA to ensure the safety and general well-being of the IP community. The corresponding geohazard assessment findings shall be taken into account in the planning, day to day operations and the eventual rehabilitation of mining areas. Disaster Preparedness and Response Teams shall address emergencies.	Temporary. Repair/rehabilitation efforts will follow.

Environmental Aspect / EIA Module	Potential Impact	Proposed Management and Monitoring Plan	Residual Effects
	Existing land tenure issue/s	The proponent is undergoing the process of securing the Free, Prior and Informed Consent with the Mandaya tribe in the community. After series of community consultative assemblies, consensus building and decision meeting, an NCIP endorsement will be issued to the proponent. A Memorandum of Agreement (MOA) was forged between the tribal representatives and the proponent.	Temporary. The stipulations of the aforementioned MOA will be enforced for the duration of the project to give what is due to the Mandaya tribe in the host communities.
	Visual aesthetics	The mining activity to operate in stages and immediately rehabilitate the mined-out areas to lessen the visual impact. Vegetation buffer, consisting of suitable fast-growing trees, could also be maintained around the mine sites to shield the view.	Temporary. The area will be restored after closure.
Solid waste management	Increased generation of solid waste, disposal and related impacts	Waste minimization and segregation practices shall be enforced. Waste recycling and timely waste collection and disposal are just a few of the numerous techniques that will be used in the Project site. Likewise, proper machine maintenance of equipment involves regular maintenance check-up, timely fuel and oil change, and proper machine handling to minimize the risk of soil contamination. A designated machine shed and fuel/oil depot with oil collectors and proper floor protection further minimizes soil contamination. As much as possible, major	Moderately significant as improper practice will lead to soil and water contamination.

Environmental Aspect / EIA Module	Potential Impact	Proposed Management and Monitoring Plan	Residual Effects
		maintenance works for equipment will be done outside the project area. Each worker shall also be given instructions on the proper storage, use and disposal of supplies used.	
Geology	Changes in landform / geomorphology / topography / terrain / slope	Stabilize landslide areas by constructing benches or retaining structures combined with revegetation Plan road alignment properly to avoid passing on very steep and unstable slopes; Conduct slope stability analysis to be guide in slope design; Decrease slope angle by constructing benches; Consider the existing geologic hazard conditions in the area in the design of roads and mine facilities;	Insignificant. There won't be any substantial changes in landform and topography.
Geology	Susceptibility to natural hazards	The structural design for the project should strictly follow other specifications set by the National Structural Code for Buildings (NSCB) and other relevant requirements specified in the National Building Code of the Philippines (NBCP). To mitigate this problem, the road should be properly compacted during construction or rehabilitation. If possible, the hauling route should not pass through the built-up areas and a separate road should be used for hauling laterite. Construction of other mine infrastructures such as buildings in earthquake prone areas need careful planning. Apply ground improvement techniques such as densification, solidification, replacement, lowering of groundwater table, dissipation of	Temporary. Immediate restoration of damaged facilities.

Environmental Aspect / EIA Module	Potential Impact	Proposed Management and Monitoring Plan	Residual Effects
		excess pore water pressure and applying shear strain restraint (Orense, 2003). Damage to structures could be reduced by applying the appropriate type of foundation. Artificial fill should be sufficiently compacted prior to construction of structures.	
Geology	Soil erosion	Proper water management in active mining areas and other disturbed areas such as along access roads and other infrastructures is critical in erosion and sediment control. It typically consists of upslope diversion ditches, onsite collection ditches, and a large sediment pond or series of ponds throughout the mine site; typically, at the point of lowest elevation. Noncontact drainage should also be diverted around the mine site. Surface runoff is minimized, thereby limiting the potential for rill and gully development on disturbed landscapes and saturation of the soil at specific areas, which can produce deep seated slope failures in unstable grounds. In non-active areas, such as cut and fill slopes along roads, establishing self-sustaining vegetation is the most effective erosion control.	Moderately significant as without strict control it will pollute the waters
Terrestrial Ecology	Loss of Vegetation, important species, hindrance to wildlife access, disturbance to terrestrial environment	-Ensure that buffer areas and green belts are incorporated in the plan. **Top soil removed during construction will be stored separately and reused.** - Remove only vegetation that is absolutely necessary	Temporary. Will be revegetsted.

Environmental Aspect / EIA Module	Potential Impact	Proposed Management and Monitoring Plan	Residual Effects
Oceanography	Inducement of flooding	Properly designed storm water drainage system; rehabilitation and/or maintenance dredging of existing canals and waterways draining near the project area. Erosion and sediment control structures should be constructed around the stockyards to prevent transport and siltation when it is inundated during coastal flooding. Ring dikes could act as containment structure	Temporary. Not significant - can be contained
	Impact on depth of water, wave and current pattern	Maintenance dredging of the waterways and canals. .	Insignificant as there is no permanent change in the configuration of the coast as there is no physical development to be introduced downstream of the project area
Ground Water	Depletion of water resources / competition in water use	It is recommended that an in-depth study on the groundwater availability and quality be undertaken in order to guide the communities. Utilization of groundwater resource in the area should also be regulated	Moderately significant. Moderately significant. There may be a cumulative effect on water uses
Fresh Water	Degradation of freshwater quality	Develop communal water supply systems for affected communities. • Protection of spring water sources in the mine site. Use of spring waters rather than ground water source. • Coordinate for the regulation of ground water extraction especially in critical areas.	Moderately significant. There may be a cumulative effect on water uses.
Marine Water	Degradation of marine water quality (Contamination, Increased Turbidity, improper disposal of wastes, etc)	Proper structures of existing and proposed mitigating measures are **strongly recommended to ensure the confine**ment of the suspended material during the construction and operational phase of the project in case of say, accidental spillage of siltation ponds, stockpiled materials, high sediment laden flows during strong rainfall events, during	Moderately significant. Fugitive contaminants mat have a cumulative adverse effect on marine water quality'

Environmental Aspect / EIA Module	Potential Impact	Proposed Management and Monitoring Plan	Residual Effects
		transport of materials, etc. for maintaining the environmental integrity of the downstream coastal zone.	
Marine Ecology		Strict solid waste management policy shall be implemented within the project site. • The environmental unit of the company shall conduct an information, education and communication drive to all workers to make fully aware of the proper waste segregation. Drainages shall be properly be designed where potential water ways will be directed to a centralized settling pond. • The settling pond shall be carefully designed that would accommodate the volume of water with silt and allow silt to settle.	Moderately significant. Fugitive contaminants mat have a cumulative adverse effect on marine ecology.
Greenhouse gas emission	Degradation of Air quality – increased CO2 emission	Inventory of mobile vehicles, power consumptions and stationary facilities that are run by fossil fuel shall be surveyed. Mobile emissions would include the company owned vehicles, heavy equipment and other mobile vehicles. Power generations would include generators and other energy producing facilities. Carbon emission for purchased electricity may be computed using the greenhouse emission factor of 0.59 GHG coefficient for Mindanao. :Low fuel consuming equipment (new) to be used.. Power conservation.	Temporary. Will cease after closure of the mine.
Air quality	Degradation of Air quality - Dispersion of dust particles, effects of emission from equipment	Dust Generation • Air pollution due to mining and related activities can be minimized by planning the activities in such a manner that the generation of the pollutants is minimum possible. In addition, provisions may be made for arresting the dust by making suitable green belts or buffer zones. Some of the	Temporary. Will cease after closure of the mine.

Environmental Aspect / EIA Module	Potential Impact	Proposed Management and Monitoring Plan	Residual Effects
		measures are:. • Generation of dust in the removal of the vegetation and soils can be minimized by maintaining adequate moisture in the soil via regular water sprinkling along the ore staging area, haul roads, and access roads. • Proper maintenance of the haul roads can minimize the generation of air borne dust. • Covering the trucks with tarpaulin or canvass thus enclosing the mineral handling and preparation units tend to reduce the contribution of dust to the atmosphere. Increase in Gaseous Emissions • Gas emissions will be minimized by using properly maintained motor vehicles and heavy equipment and by utilizing higher grade motor fuel during the construction and operations phases. • Clean automotive diesel oil shall be used as fuel for all diesel-fueled vehicles. Regular maintenance of engines shall be implemented to ensure optimum engine performances. • Regular maintenance of dump trucks and heavy equipment to reduce gaseous emissions of NO_X and CO.	
Noise level	Increased Noise levels	Restriction of Hours of Activity Proper Maintenance of Vehicles and Equipment Establishment of buffer zones in the motor pool area Sound Insulation for Generator Sets	Temporary. Will cease after closure of the mine.
Socio-economic	Displacement of settlers	There are no settlers that will be displaced	Nil
	In-migration	The area will be secured by the proponent to prevent possible illegal settlement within the area. While local qualified residents will be prioritized for employment, workforce that will be engaged from other areas will be	Temporary.

Environmental Aspect / EIA Module	Potential Impact	Proposed Management and Monitoring Plan	Residual Effects
		provided with living quarters at designated facilities in the project site. The community has sufficient housing facilities for rent to accommodate migrants.	
Socio-economic	Cultural/Lifestyle change (especially indigenous people if any)	RCMC intends to abide by the provision of the law particularly in the preservation of local culture of the IP community and intends to implement programs to protect, preserve and enhance the lifestyle and culture of the local IPs. It has taken into consideration the provisions of the IPRA law in formulating an Indicative Indigenous Peoples Development Plant (IPDP), which will be finalized in coordination with the local IPs, the LGU and the NCIP.	There have been cases, however, wherein IPs had intermingled with the locals in thecommunity.
	Physical cultural resources	RCMC intends to partner with the local tourism office as well as other tourism agencies in programs that will enhance the municipality's cultural resources through its Social Development Programs. Similarly, the proponent through responsible mining practices, it aims to set an example to the host community and encourage other stakeholders to support their programs on responsible mining and environmental protection. The company will put up a Community Relations Office that will facilitate the community extension program of the company to the community. This office will be responsible in seeing that no major detrimental alterations in any cultural values and practices will occur in the area.	The enhancement may remain permanent depending on the leadership ans cooperation of the community.

Environmental Aspect / EIA Module	Potential Impact	Proposed Management and Monitoring Plan	Residual Effects
	Resource competition - Delivery of basic services	The Municipality's residents are fortunate enough to enjoy a very abundant water supply from both the shallow, deep well and spring sources. In the level I water supply, sources are deep well and springs which are generally located and used in the rural areas where houses are thinly scattered. For level II the communal faucets where houses are densely clustered a piped distribution system for every 6-8 households are provided with faucets. Currently, level III local waterworks system that is operating in the Municipality are located in the barangays of Piso, Pintatagan and Puntalinao. The Municipality has existing watersheds and surface water areas which support the irrigation system for domestic and agricultural areas particularly the rice production areas of the Municipality. To ensure continuous supply of power, the proponent will have stand-by generators for its operation especially in remote areas of the mine site	Temporary. There won't be any competition after closure of the mine.
	Threat to public health and safety	RCMC will establish its Health and Safety Unit and implement a Safety and Health policy that aims to address, protect and ensure the general well-being of its workers as well as its host community. An Emergency Response Team (ERT) will be formed by the proponent to develop and implement emergency response action plans with the intent to partner with the LGU in terms of Emergency response, training and enforcement. The ERT will operate in coordination with the Government Agencies	Temporary. But may stop after closure of the mine.

Environmental Aspect / EIA Module	Potential Impact	Proposed Management and Monitoring Plan	Residual Effects
		such as National Disaster Risk Reduction Team, the local PNP and the Barangay and Municipal Health Units.	
Socio-economic	Generation of Local Benefits from the project	Main Sources of Income Enhancement of employment and livelihood opportunities Increased revenue of LGUs	Significant residual impact as it will tend to enhance the economy of the Area.
Socio-economic	Traffic congestion	A detailed traffic management strategy will be formulated to include schedule of work shifts, traffic route to and within the mine pits, deliveries and other related elements. Sufficiency of haul roads will be assessed to ensure that increased traffic volume is accommodated. Corresponding traffic signages such as directional, speed control & limits will be put up to guide the workforce. Maintenance of haul roads will also be programmed to assure optimum and safe movement of all equipment. Likewise, the main access to the project site will be evaluated to assess sufficiency of its carriage to accommodate increased traffic volume during transport of mined materials. Specific routes will be monitored and in coordination with the LGU, will be maintained. It is proposed that alternative routes where public traffic will be very minimal be sourced to minimize effects to the community. Similarly, signages will be installed along public access to ensure safety. Public awareness and behavioral modification programs will be included in the proponent's IEC plan, to include public awareness to traffic signs and road rules and related concerns.	Temporary but will clear up after closure of the mine.

Risks and Uncertainties

In terms of climate change, weather is more unpredictable than before making it hard to determine a clear dry season for shipment. Mindanao is an area where rain fall can be expected all year round with pronounced heavy rain from November to April. Given the suspension or potential suspension of a number of mines, there may be a rush on the operating mines to get out as much cargo as possible. This may mean cargo comes direct from the mines to the loading barges as opposed to being allowed time in the open to dry (during good whether periods).

The price for nickel ore has increased given the recent Government audit activity and China is reportedly stockpiling the cargo in anticipation of reduced volume and or an outright ban. This too may mean mines take short cuts and more wet cargo is produced for loading on vessels.

PROJECT DESCRITPION

Project Information

Project Proponent	Riverbend Consolidated Mining Corporation (RCMC)
Office Address	Unit 1602, 16th Flr., 139 Corporate Center, 139 Valero St., Bel-Air, Makati
Contact Person	Mr. Nicanor L. Escalante Director Contact No. : 0977-8078720 Email Address : nickescalante_phil@yahoo.com
Authorized Representative for ECC application	Mr. Joel A. Espineli Philkairos, Inc. JE Business Center, Pinesville Rd., Ortigas Ave. Extn., Taytay, Rizal Telephone Number: (02) 8727-9005 Email Address: admin@philkairos.com
Project Name	Proposed Banaybanay Nickel Laterite Mining Project
Project Location	Barangays Puntalinao, Causwagan, Pintatagan, Maputi, Panikian, and Mahayag Municipality of Banaybanay, Province of Davao Oriental
Project Type	Resource Extractive Industry (Mining Project)
MPSA Number	No. 263-2008-XI Amended IB with Amendment Order dated 24 June 2016
Project Area	6,363.3368 hectares (MPSA) / 1,072.20 hectares for partial declaration (area to be disturbed)
ECC Reference Number	**New Application**
Project Components	• Nickel Mine Pits • Stockpiles • Waste Dumps • Siltation Ponds, Interceptor canals, Drainage lines • Haul / Access Roads • Work Camps • Field and Administration Office • Motorpool and Equipment Depot
Extraction Capacity	9,600,000 WMT per annum

The MPSA 263-2008-XI-Amended-IB includes the areas pertaining to ExPA 000267-XI (Parcel II of the MPSA) and ExPA 000252-XI (Parcel III of the MPSA). This MPSA amended area is composed of 75 contiguous blocks, containing a total area of 6,363.33 hectares (has). The area has been explored for nickel laterite mineralization, with extensive exploration in Barangays Pintatagan, Puntalinao and Causwagan. The exploration has eventually delineated a large nickel laterite zone at the central to southern portion of the tenement.

Two open pit mines, each located at Puntalinao and Causwagan areas, will be developed during the planned mine operation.

1. Project Location and Area

a) Map showing sitio, barangay, municipality, province, region boundaries, vicinity.

The MPSA 263-2008-XI-Amended-IB includes areas covered by ExPA 000267-XI (now Parcel II of the MPSA) and ExPA 000252-XI (now Parcel III of the MPSA), containing an area of 6,023.89 has and 339.45 has, respectively. Mining area 1 and mining area 2 has a total area to 500 hectares each. The northern portion of the amended MPSA area is located in Barangays Napnapan and Fuentes, Municipality of Pantukan, Province of Compostela Valley, whereas the rest of the tenement areas is located in Barangays Pintatagan, Puntalinao, Maputi, Mahayag and Causwagan, all in the Municipality of Banaybanay, Province of Davao Oriental. The amended MPSA tenement is bounded by geographic coordinates: 7º 01' 30" and 7º 09' 30" north latitudes and 125º 58' 00" and 126º 03' 00" east longitudes.

The Parcels II and III of MPSA 263-2008-XI-Amended-IB occur in the Southern Pacific Cordillera of the eastern Mindanao terrain (**Fig. 1.1**), characterized by distinct occurrence of Copper-Gold prospects and deposits. The most prominent deposits include the Diwalwal Gold rush area in the north and the Kingking Copper-Gold in the south. The Southern Pacific Cordillera is also characterized by ophiolite rocks, which host chromite and nickel laterite occurrences, specifically the terrains in the Municipalities of Banaybanay and Lupon, City of Mati and the entire Pujada Peninsula.

b) Geographic coordinates (shape file data) of project area (use WGS 84 datum - GPS setting)

The corner points that constitute the combined area pertaining to Parcels II and III of MPSA 263-2008-XI-Amended-I, are defined by their metes and bounds (**Table 1.1a and Table 1.1b**) as follows (**Fig. 1.2, Fig. 1.3a and Fig. 1.3b**):

Table 1.1.a Parcel II - Corner points and corresponding geographic coordinates.

Corner	Latitude	Longitude
1	7º 09' 30"	125º 58' 30"
2	7º 09' 30"	126º 00' 00"
3	7º 09' 00"	126º 00' 00"
4	7º 09' 00"	126º 01' 30"
5	7º 08' 30"	126º 01' 30"
6	7º 08' 30"	126º 00' 00"
7	7º 08' 00"	126º 00' 00"
8	7º 08' 00"	126º 02' 00"
9	7º 07' 30"	126º 02' 00"
10	7º 07' 30"	126º 01' 30"
11	7º 07' 00"	126º 01' 30"
12	7º 07' 00"	126º 02' 00"
13	7º 06' 30"	126º 02' 00"
14	7º 06' 30"	126º 01' 30"
15	7º 05' 30"	126º 01' 30"
16	7º 05' 30"	126º 02' 00"
17	7º 05' 00"	126º 02' 00"
18	7º 05' 00"	126º 01' 30"
19	7º 03' 30"	126º 01' 30"
20	7º 03' 30"	126º 03' 00"
21	7º 01' 30"	126º 03' 00"
22	7º 01' 30"	126º 01' 00"
23	7º 02' 30"	126º 01' 00"
24	7º 02' 30"	126º 01' 30"
25	7º 03' 00"	126º 01' 30"
26	7º 03' 00"	125º 59' 00"
31	7º 06' 00"	125º 59' 00"
32	7º 06' 00"	126º 00' 00"

Corner	Latitude	Longitude
33	7° 07’ 30’’	126° 00’ 00”
34	7° 07’ 30’’	125° 59’ 00”
35	7° 08’ 00’’	125° 59’ 00”
36	7° 08’ 00’’	125° 59’ 30”
37	7° 08’ 30’’	125° 59’ 30”
38	7° 08’ 30’’	125° 58’ 30”

Table 1.1b Parcel III - Corner points and corresponding geographic coordinates.

Corner	Latitude	Longitude
27	7° 02’ 30’’	125° 59’ 00”
28	7° 02’ 30’’	125° 58’ 00”
29	7° 03’ 30’’	125° 58’ 00”
30	7° 03’ 30’’	125° 59’ 00”

Table 1.1c.1 Area 1 Mining Area

Corner	Latitude	Longitude
1	7° 03’ 00’’	125° 58’ 30”
2	7° 03’ 30’’	125° 58’ 30”
3	7° 03’ 00’’	125° 59’ 00”
4	7° 04’ 30’’	125° 59’ 00”
5	7° 04’ 30’’	126° 00’ 00”
6	7° 03’ 30’’	126° 00’ 00”
7	7° 03’ 30’’	125° 59’ 30”
8	7° 03’ 00’’	125° 59’ 30”

Table 1.1c.2 Area 2 Mining Area

Corner	Latitude	Longitude
1	7° 01’ 30’’	126° 01’ 00”
2	7° 02’ 30’’	126° 01’ 00”
3	7° 02’ 30’’	126° 01’ 30”
4	7° 03’ 00’’	126° 01’ 30”
5	7° 03’ 00’’	126° 02’ 30”
6	7° 02’ 00’’	126° 02’ 30”
7	7° 02’ 00’’	126° 01’ 30”
8	7° 01’ 30’’	126° 01’ 30”

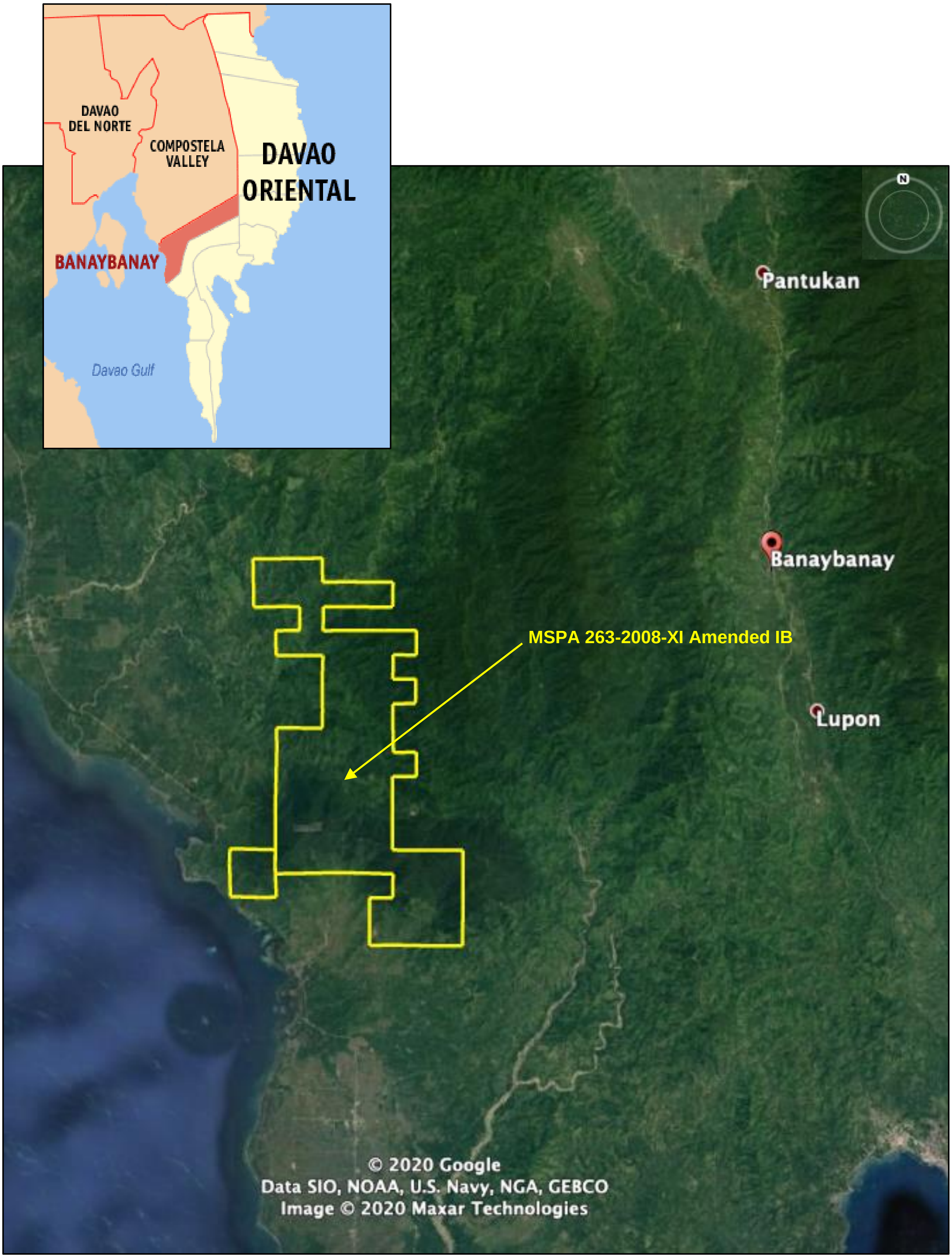


Figure 1.1 – Location and Map of MPSA 263-2008-XI AMENDED IB
(Source: Google Earth, 2020)

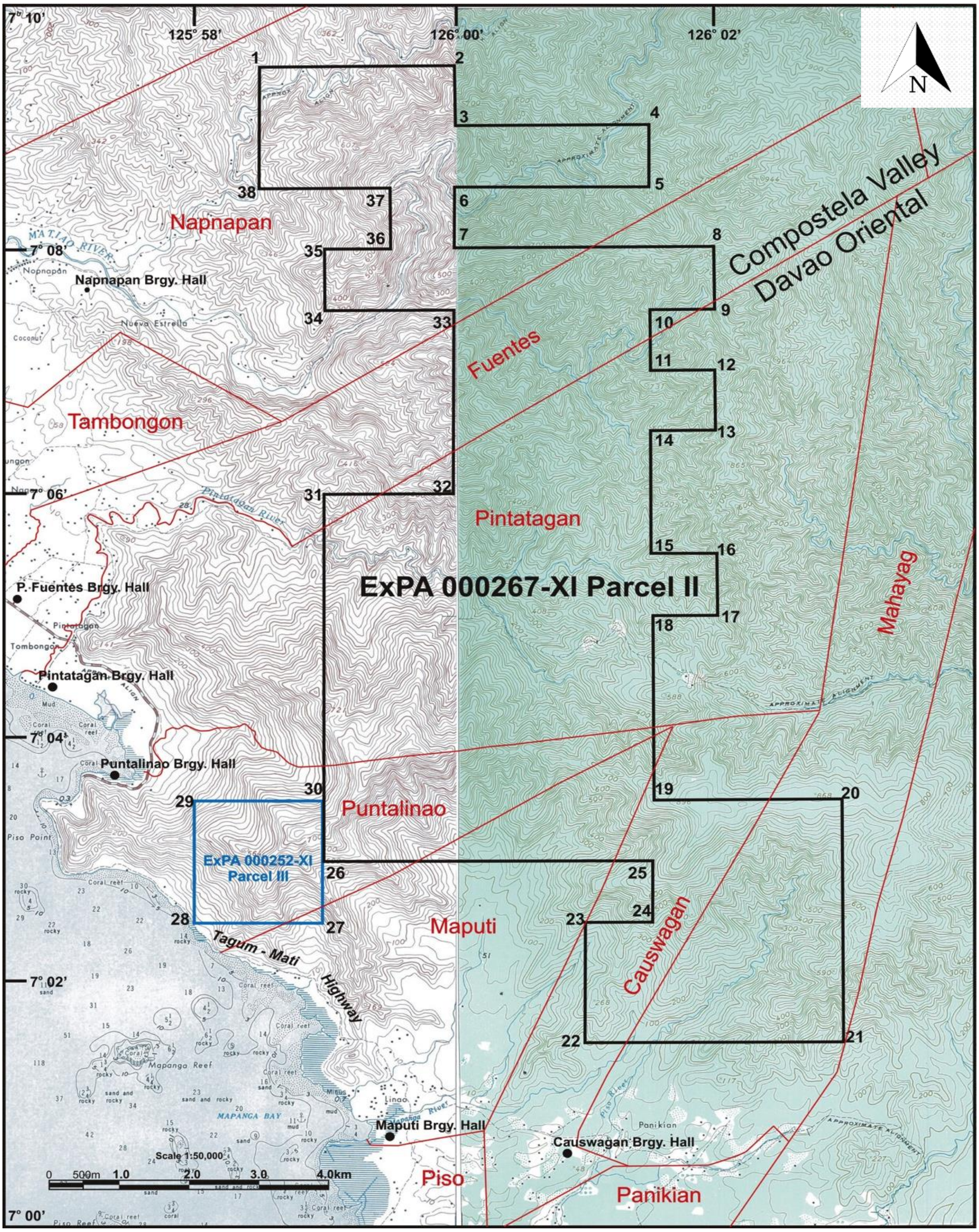


Figure 1.2 : Map of the MPSA AREA *(Source: NAMRIA)*

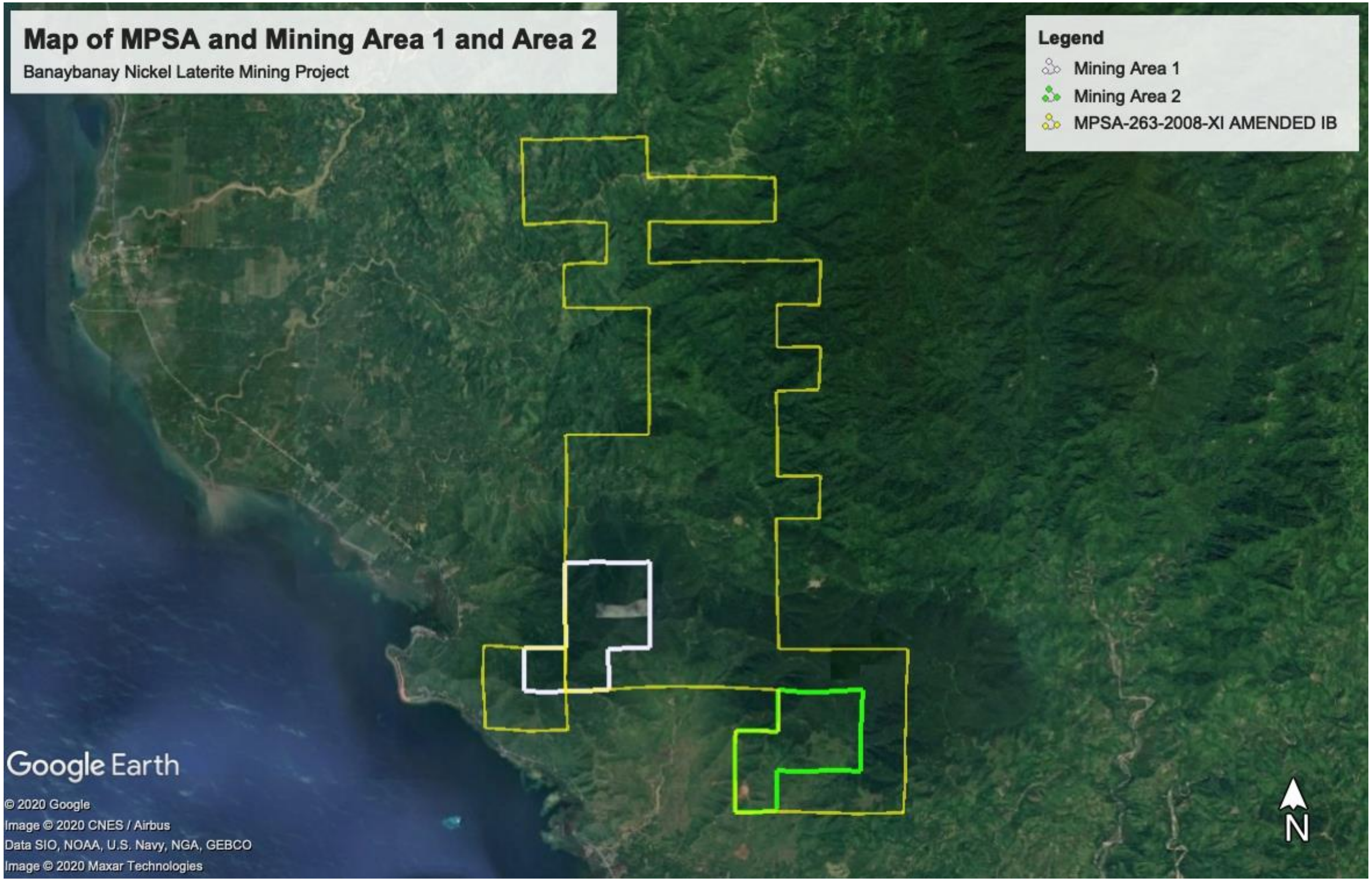
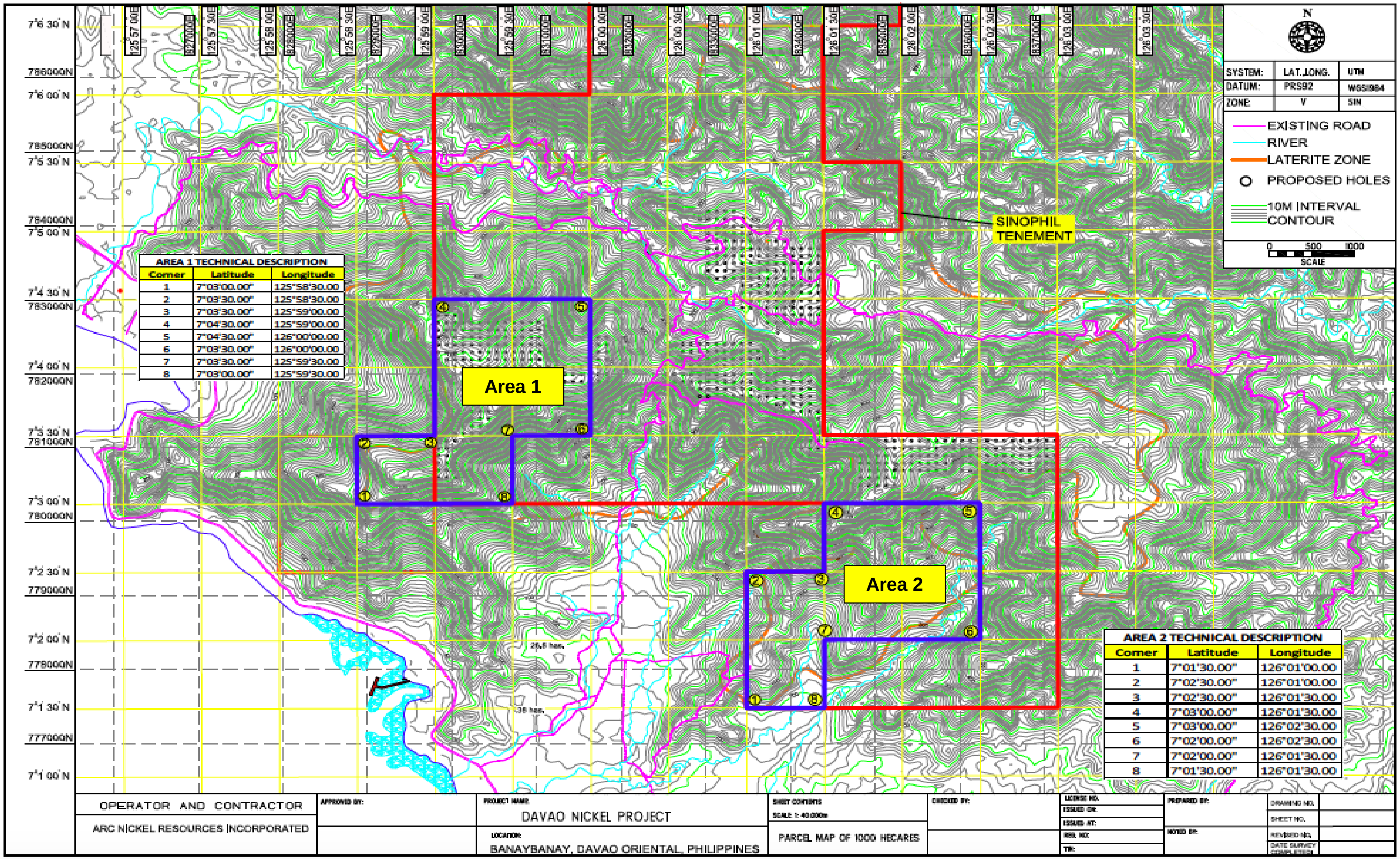


Figure 1.3a: Map of the Mining Area showing the whole MPSA area (yellow), Mining Area 1 (white), and Mining Area 2 (green)
(Source: Google Earth, 2020)



AREA 1 TECHNICAL DESCRIPTION

Corner	Latitude	Longitude
1	7°03'00.00"	125°58'30.00
2	7°03'30.00"	125°58'30.00
3	7°03'30.00"	125°59'00.00
4	7°04'30.00"	125°59'00.00
5	7°04'30.00"	126°00'00.00
6	7°03'30.00"	126°00'00.00
7	7°03'30.00"	125°59'30.00
8	7°03'00.00"	125°59'30.00

AREA 2 TECHNICAL DESCRIPTION

Corner	Latitude	Longitude
1	7°01'30.00"	126°01'00.00
2	7°02'30.00"	126°01'00.00
3	7°02'30.00"	126°01'30.00
4	7°03'00.00"	126°01'30.00
5	7°03'00.00"	126°02'30.00
6	7°02'00.00"	126°02'30.00
7	7°02'00.00"	126°01'30.00
8	7°01'30.00"	126°01'30.00

Figure 1.3b : Enlarged Map of the Mining Area *(Area 1 & Area 2)*

c) *Describe the vicinity and the accessibility of the project site/area*

The northern portion of Parcel II is located in Barangays Napnapan and Fuentes, Municipality of Pantukan, Province of Compostela Valley, whereas the rest of Parcel II and Parcel III are located in Barangays Pintatagan, Puntalinao, Maputi, Mahayag and Causwagan, all in the Municipality of Banaybanay, Province of Davao Oriental. The MPSA area is bounded in the North by the Provincial boundary of Davao Oriental and Compostela Valley, to the East is Lupon, down South is the town of San Isidro and on the setern portion is Davao Gulf. The project area is about 180 kilometers away from Davao City via the Pan-Philippine Highway. It is 28 kilometers to the City of Mati. Across Davao Gulf is teh Island Garden City of Samal.

The project area is accessible through the National Road, the Tagum-Davao Highway, passing through the Barrio road. There are existing dirt roads to the project site, developed from a previous operation of another company which can still be utilized. A few residences can be found along the way particularly at the low lying areas near the National Road. The area is covered with mostly secondary forest growth.

Rationale for selection primary & secondary impact areas

In accordance with Annex 2-2 of the Revised Procedural Manual (RPM), Sec 3.a, the Direct Impact Area (DIA) is initially delimited at the pre-EIA stage as “the area where ALL project facilities are proposed to be constructed/situated and where all operations are proposed to be undertaken.” Based on that definition, the DIA is the 2,237-hectare project area.

Potential Indirect Impact Areas (IIA) at the pre-EIA stage can be assumed or qualitatively determined using secondary data, maps, and information from key informant interviews. The table below shows how to estimate the IIAs according to component.

Table 1.2: Guide matrix for Indirect Impact Area delineation

Component	Details
Air	Areas where maximum ground-level concentrations (GLC) of air pollutants are predicted to occur. Significant during operation phase of Project with the use of equipment and generator sets.
Water	Areas along the river and river tributaries within and around the the project site where silt may be deposited due to earth moving and surface run-off
Land	Location of Support Facilities, Staging areas, traffic and Haul routes
Socio-economics	Impacts of the Project in terms of relevant socio-economic parameters particularly in the host and surrounding communities

The secondary impact areas are those which may experience and affected by the residual effect of the mining operation, such as but not limited to sedimentation and siltation, dust pollution and intolerable sound due to the operation of heavy equipment and machinery. Estimated range of the secondary impact is about 1.0 kilometer from the periphery of the direct impact area.

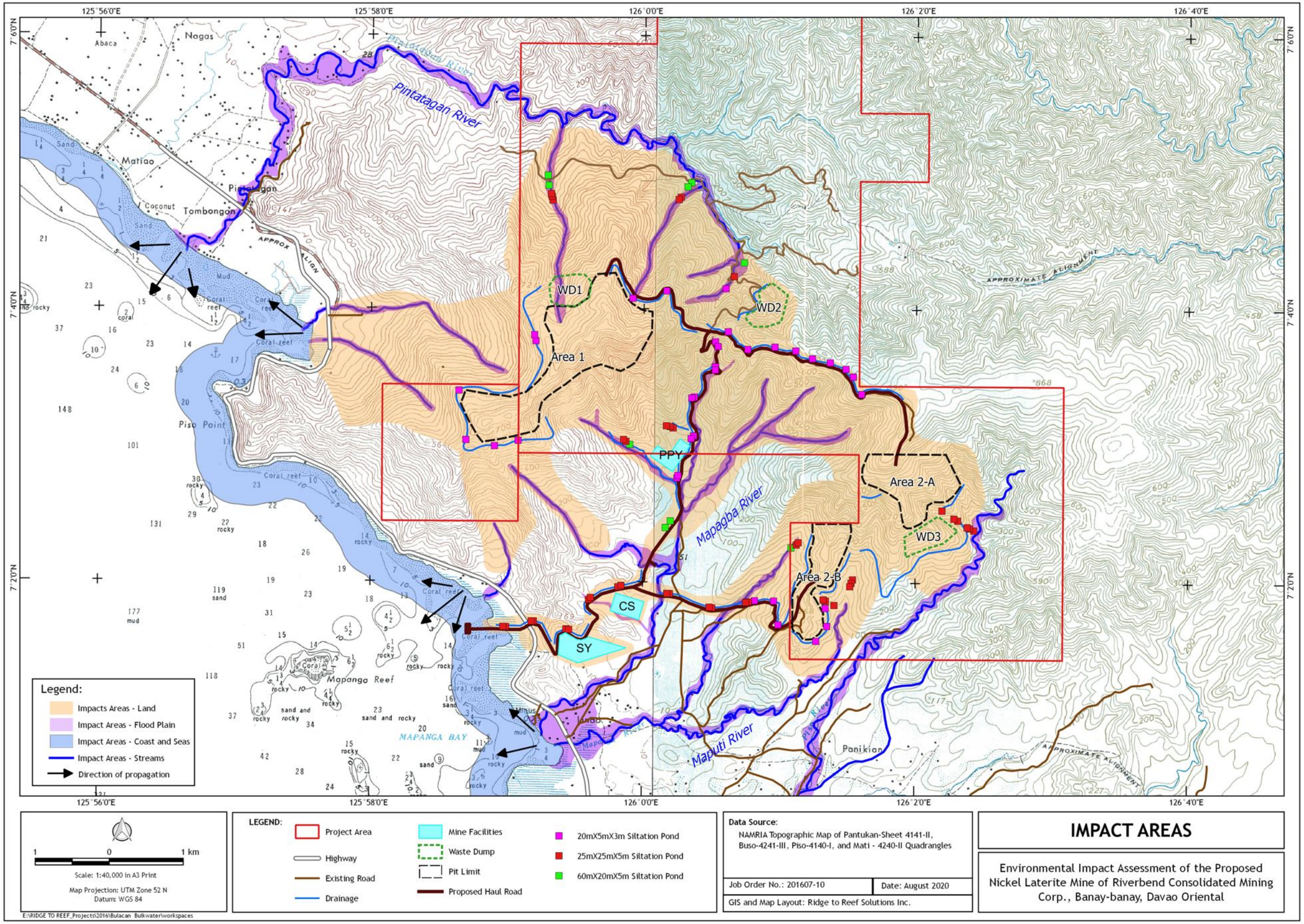
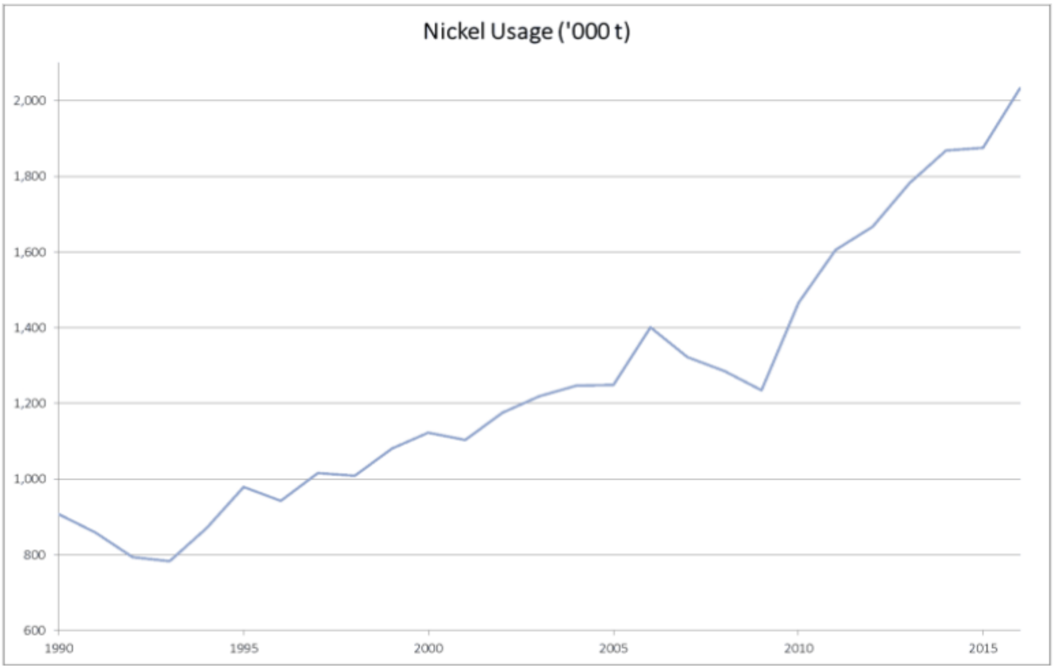


Figure 1.4: Impact Areas

2. Project Rationale

Nickel usage

Usage of nickel has increased over time and is correlated with economic development. World nickel demand increased from 1.123 in 2000 to 1.465 million tonnes in 2010 and surpassed 2.000 million tonnes in 2016, with an annual average growth rate of 3.8% since 2000. Since then the strong growth recorded by the Chinese economy has further accelerated the increase in nickel demand that, from 2010 until 2016 grew at an average rate of 5.6%. Asia is now by far the largest regional market for nickel, representing 73% of total world demand. China alone now accounts for close to 54% of world nickel demand compared with 5.5% in 2000 and 39% in 2010.



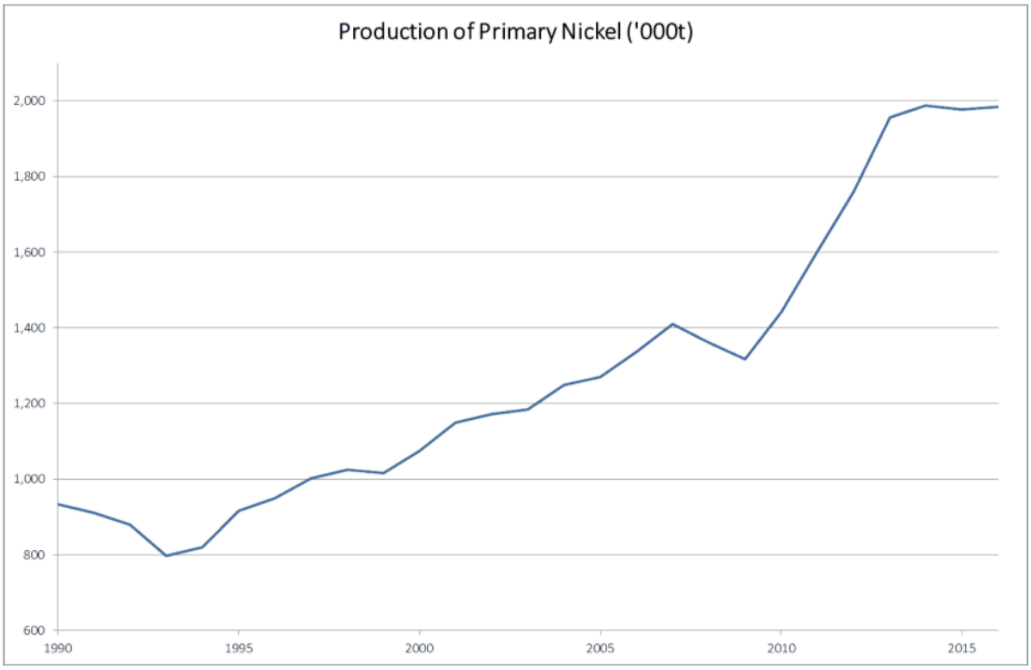
Source: INSG, 2016

Figure 1.5. Nickel Usage

Nickel Production

Strong world economic growth until 2007 supported rising production of primary nickel metal. In 2007 world primary production stood at 1.411 million tonnes. However, the economic crisis led to lower worldwide nickel production in the period 2008 to 2009 and production of primary metal declined to 1.316 million tonnes in the latter year. Production rapidly recovered in 2010 to 1.442 million tonnes and increased further to 1.602 million tonnes in 2011. On an annual average the growth in production between 2000 and 2010 was 3%. A new product – nickel pig iron (NPI) – started to be produced in China in 2005 in different forms and grades. Production increased slowly in the first few years but in 2010 production was estimated at over 160,000 tonnes and in 2016 at about 380,000 tonnes. Indonesia started NPI production in 2014. With rapid project developments and quick ramp-ups, it reached 89,000 tonnes of nickel contained in NPI by 2016 with further growth projected for the near future. Basically all of this product is used in China and Indonesia in the production of stainless steel and has replaced traditional products like nickel metal and stainless steel scrap.

In addition to new NPI production in China and Indonesia, several other nickel projects around the world started. Examples are Ambatovy in Madagascar, with a capacity of 60,000 tonnes which has started operations. Myanmar has its first nickel project in Tagaung Taung, which started production in 2013. In New Caledonia, Vale's Goro project with a capacity of 57,000 is currently in a ramp up phase. The world primary nickel production totalled 1.983 million tonnes in 2016 reaching in the period 2010-2016 an average annual growth rate of 5.5%.



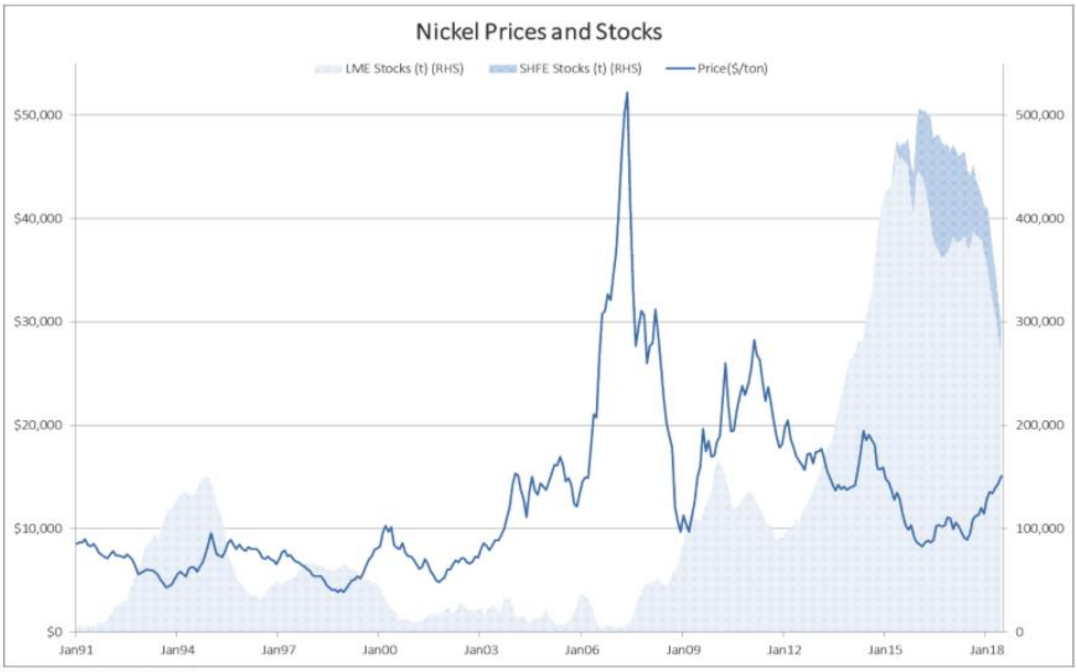
Source: INSG, 2016

Figure 1.6: Production of Primary Nickel

Prices and Stocks

The price of nickel has shown considerable volatility over the last forty years. The chart below shows the historic LME price for nickel in nominal values from 1991 to 2018H1. In the late 1980s there was a peak in the price of nickel. In the first half of the 1990s the economic collapse of the former "Eastern Bloc" countries resulted in a surge of nickel exports that drove nickel prices lower than the cash costs of production resulting in reduced nickel production in the "West". Until 2003 the nickel cash price remained below US$10,000 per tonne. The price breached $14,000 per tonne in 2005 and then escalated dramatically through 2006 before peaking at $52,179 per tonne in May 2007. Nickel prices then declined until the end of 2008, when the average cash price in December hit a low of $9,678. In early 2009, nickel prices began to once again climb and reached $24,103 by the end of 2010. In 2011 the price continued to move up and reached a peak in February, with an average price of $28,247. It has declined since then until the end of 2013 when it stayed below $14,000. The initial reaction to the implementation of the export ban of unprocessed ores in Indonesia in January 2014, nickel price climbed to just below $20,000 in July 2014, but since then it declined almost every month until February 2016 to be traded at around $8,300. After this trough, a year of volatility at around $10,000 followed and from the end of 2017, monthly average prices have consistently surpassed $10,000, showing rising trend and a peak at $15,111 in June 2018.

LME stocks of nickel were relatively stable during the period 2001 to 2005 at around 20,000 tonnes. In 2005 stocks increased somewhat and again declined in 2006. During the period 2007 to 2009 stocks rapidly increased to over 158,000 tonnes at the end of the period. In 2010 and 2011 destocking took place with stocks at the end of December 2011 at 91,000 tonnes. Since the beginning of 2012 to March 2016 a long period of stocking took place, reaching over 470,000 tonnes in June 2015. In the second quarter of 2015, the Shanghai Futures Exchange (SHFE) launched the nickel contract and stocks have been rising there to a level of 73,000 in March 2016. By the end of March 2016, the combined LME and SHFE stocks were over 500,000 tonnes. A period of destocking then started, that became more accentuated in the beginning of 2018. By the end of 2018H1, inventories at LME and SHFE registered warehouses combined were under 300,000 tonnes.



Source: LME and SHFE

Figure 1.7: Nickel Prices and Stocks

(Source: International Nickel Study Group https://insg.org/index.php/about-nickel/production-usage/#:~:text=World%20nickel%20demand%20increased%20from,rate%20of%203.8%25%20since%202000.,Retrieved:2020)

The mining industry is one of the priority areas of the Philippine Government in its aim to wisely utilize existing natural resources in economic development. The proof of the Philippine Government's aspiration to explore, develop ,and utilize the country's mineral resources is reflected in the enactment of Republic Act No.7942 (Philippine Mining Act of 1995), the promulgation of its revised implementing Rules and Regulations (DENR) Administrative Order No.96-40), the issuance of Executive Order No.270 (National Policy Agenda on Revitalizing Mining in the Philippines), and the issuance of the Memorandum Circular No.67, which directs the Operationalization of the Mineral Action Plan for Resources Development.

The Government, both national and local (regional included), will benefit from the project through taxes, fees, and duties, both direct and indirect including labor and employment . Since the products of the mine will be exported, the foreign revenue earnings of the country will also gain from this proposed undertaking. The proposed amendment to the Project, in including the mining of Nickel reserves, will further complement the present positive contributions of the project to the Philippine economy.

The Proponent will infuse an additional investment in direct and indirect capital for the entire project duration. This includes the 400 million pesos per annum investment into the Nickel Mining Project. This will have significant impact in local and national economy. The key beneficiaries will include the local workforce and businesses allied to the mining operations. It will also impact significantly on the government's revenue collection through the direct and indirect taxes paid by RCMC.

Education and development of new enterprises in the host communities will create employment and new skills. Taxes from contractors would also significantly contribute to the direct earnings of the local governments that are not only the main employers but are also 97% reliant on the national budget allocation. The operation of the Nickel Mining Project is in line with the mandate of the Philippine Government to promote the mining industry and at the same time augment foreign revenue earnings. It will also provide a significant boost to local economies by creating opportunities for local employment.

The mining capacity in the country is severely underutilized. Of its 30 million hectares, 9 million hectares are identified to have high potential for mineral deposit. The Philippine country profile of the U.S. State Department claims that the Philippines has an estimated $840 billions of untapped mineral wealth. According to The Resource Information Unit (Register of Pacific mining 2000), the Philippines is 2nd to

Indonesia in the Asia Pacific Region in terms of mining potential. However, as of September 23, 2004, only 473,373 hectares have been covered with existing mining rights.

Its excise tax, business tax and income tax are estimated to reach about Php378.14 Million, Php189.07 Million and Php3.74 Billion respectively. These taxes shall be appropriately shared by the national (60%) and local (40%) governments, which will translate to better delivery of basic services by the various national and local government agencies.

Market Study

As the Philippines fail to satisfy China's nickel ore demand, refined metal prices will be pushed up by more than 15 per cent. The Southeast Asian nation would not be able to supply enough ore once China exhausts stockpiles built up before last year's export ban by Indonesia, previously the biggest producer. China's output of nickel pig iron, a lower-grade substitute for the refined metal used to make stainless steel, may fall by about 30 per cent when the country becomes solely dependent on Philippine supply.

NPI producers would be completely reliant on Philippine ore after stockpiles of Indonesia ore run out, and Chinese stainless steel producers will now have to source nickel elsewhere. The tightening supply may drive prices to $16,000 a metric ton on the London Metal Exchange. Nickel for delivery in three months on the LME rose 2.8 percent to $13,790 a ton. The metal slumped 34 percent since May 2014, when it hit the highest in more than two years. While the Philippines raised output after Indonesia's export ban started in January 2014, Chinese imports still fell 33 percent last year to the lowest since 2010. Inbound shipments in the first three months of the year are also at the least in five years.

Any time between the third and fourth quarter, we'll see the stockpiles being fully depleted. This event will serve as a strong catalyst for price recovery. China's inventories of laterite ore, the type shipped from Indonesia, fell to equivalent of about 120,000 tons of pure nickel at the end of March from about 194,000 tons at the start of 2014. Current stockpiles of nickel ore, refined nickel and ferro-nickel can cover three months of the country's stainless steel production. While the Philippines in 2015 can export close to last year's record 43 million tons to China, the raw material will only be enough to make as much as 350,000 tons of NPI, down from about 485,000 before the Indonesia ban. The forecast for Chinese NPI output this year is at 360,000 tons

Prices may also find support from growing demand. China's stainless steel production, which accounts for 85 percent of the nation's nickel consumption, will expand in the second half of the year after contracting in the first quarter, resulting in its nickel demand expanding 3 percent in 2015. Banks see prices averaging $17,500 a ton next year.

Indonesia's ore exports to China tumbled to 10.6 million tons in 2014 from 41.1 million tons the previous year. The Philippines replaced Indonesia as the world's largest producer of nickel ore last year and accounted for 98 percent of China's imports in March. The metal's global deficit will deepen to 70,000 tons in 2016 from 33,000 tons this year. Stockpiles monitored by the LME have gained 61 percent in the last 12 months to a record 444,756 tons.

(Source : Biggest Nickel Producer Can't Mine Enough to Satisfy China
http://www.bloomberg.com/news/articles/2015-04-30/world-s-top-nickel-producer-can-t-mine-enough-to-satisfy-china)

Demand and Prices of the Ore/Mineral

While the nickel industry has recovered from the depths seen during the global downturn, a number of uncertainties continue to surround its future years. Global nickel demand is still heavily dependent on China, so whether the Chinese macroeconomic conditions experience a gradual slowdown or an abrupt one will have a great impact on the price of nickel prices and the general nickel market.

Below are three price forecast trends for nickel from World Bank, International Monetary Fund (IMF) and Economist Intelligence Unit (EIU).

3. Project Alternatives

In terms of mining area, the proposed project has already obtained an MPSA and therefore no option for the proponent to relocate. Mining projects are site specific, as mineral extraction only be undertaken in areas where economic ore deposits occur. Unlike other natural resources, there is no opportunity to consider other alternative sites in mineral development and utilization project the only alternative is not having the project.

RCMC has assessed a number of alternatives in coming to the proposed extraction of Nickel.

The technological alternatives considered include the following:

- Constructability and operational aspects for mining:
  - ✓ Physical and mechanical characteristics of the nickel deposits;
  - ✓ Grade of the ore deposits;
  - ✓ Capital and operating cost; and
  - ✓ Mining rate or annual productivity.
- Environmental Aspects:
  - ✓ Likelihood of significant impacts to the environmental values of the MPSA area; and
  - ✓ Influence of environmental fluctuation such as earthquake/rain- induced landslides, volcanic eruptions, liquefaction, ground shaking, ground rupture, storm surge, tsunami, and flooding and extreme climatologic conditions.
- Community and social aspects:
  - ✓ Existing land use;
  - ✓ Availability of land for purchase or lease;
  - ✓ Opportunity for local, regional and national benefits;
  - ✓ Impact on local communities; and
  - ✓ Impact on cultural heritage.

Facility Siting

The proposed Nickel Mining project can utilize existing haul roads as access to the project area. While new mine pits and stock piles would be developed that will require additional haul roads, this will be minimal in terms of works and capitalization. Due to the terrain in the project area, it would be beneficial and safer to locate the other support facilities outside the project are as shown in the proposed layout.

Mining Method

Considering the lateritic nature of the Nickel deposit, no other mining method would prove to optimize return of investment and the incorporation of Progressive Mining Rehabilitation to minimize adverse effects on the surrounding environment than Shallow Surface Mining technique. Factors contributing to the implementation of Surface mining method are:

- Deposit is shallow
- Enables bulk mining which suits the low Fe grade nickel ore
- 100 percent of the resource would be recovered
- Staff is very familiar and experienced in the proven method and technologies required to develop a surface mine.
- Mine pits will be located where the economical lateritic deposits are and therefore, there is no viable alternative.

Availability of Resources

In terms of Ore deposits, the exploration activities would show that there is sufficient amount of mineral deposit which makes the project economically viable.

Mineralization

The known and verified mineral occurrences in Davao Oriental are nickel, iron, chromite, copper, gold, magnesite, magnetite and coal. The northern portion of Davao Oriental has copper and gold prospects, which are spatially related to the volcanic – plutonic rocks of the Mount Diwata Range. The central to southern portion, specifically the Pujada Peninsula, is prominent for nickel, chromite and magnesite, with minor copper and gold prospects. Examples are the 5M gold prospect in the municipality of Boston and the Mabalante copper – gold prospect in Mati city.

The nickel, chromite and magnesite are common in areas underlain by ultramafic rock peridotite and its serpentinized equivalent. These areas include Banaybanay and more commonly in Governor Generoso and portion of Mati city in Pujada Peninsula. The prominent Sawidan iron prospect in barangay Tagbinonga, Mati city is a contact metasomatic / skarn iron prospect. It formed along the contact of diorite and calcareous sedimentary rock, specifically sandstone.

No-Project Option

In the 'No-Project Option', there will be no investment that will be infused in the municipality. The project area will remain as covered forest areas. Traditional extractive mining activities by small-scale miners in the area will continue their activities which is detrimental to the protection of the environment since most of them do not have the necessary permits. Included in these extractive activities are timber cutting. Communities around the area also thrive on procuring wood requirements for other uses.

a. Banaybanay nickel laterite

The Banaybanay nickel laterite is composed of two confirmed limonite-saprolite areas, namely the Causwagan nickel laterite in the southern portion of Parcel II, and the Puntalinao nickel laterite in Parcel III. The limonite-saprolite was formed from the intense chemical weathering of the ultramafic / ophiolitic rock peridotite, which produced a distinct vertical zonation in the weathered portion of the peridotite. This vertical profile is termed the "laterite profile".

The nickel laterite profile was deduced from the test pits and core logging in Puntalinao area and the limonite-saprolite horizons shown along the pit wall in Causwagan open pit. The upper horizon is limonite zone, composed of ferruginous, commonly hematite-rich, soil. The lower horizon is termed rocky saprolite, composed of weathered peridotite, which locally contains nickel sulphide, specifically garnierite. The nickel laterite ore is composed of the limonite soil horizon in the upper section of the nickel laterite profile, and the saprolite and saprolitic weathered host rock peridotite in the lower section. The nickel laterite profile for the Banaybanay nickel laterite project is referred to as limonite-saprolite.

a.1 Causwagan nickel laterite

The limonite-saprolite zone in the Causwagan open pit measures approximately 300m wide by 600m long. The *in-situ* limonite soil (**Photo 1**), however, extends approximately 200m further along the mine haul road towards the west – southwest. The limonite-saprolite in the open pit and its potential extension coincides with the upper slope to ridge crest area of the northeast – southwest hill, at elevations between 100m and 300m asl. The north wall of the open pit showed at least 5.0m thick limonite-saprolite horizon, characterized by blocky to well-developed fracture pattern. Common fracture-fills are black to dark reddish limonite and localized nickel sulphide garnierite **(Photo 2)**.

Photo 1. Limonite soil at Causwagan open pit.

Photo 2. Fracture-fill nickel sulphide garnierite in saprolite in Causwagan open pit.

The assay results for the test pit samples in Causwagan-Mahayag showed maximum limonite-saprolite thickness of 12 meters for the test pit grid pattern measuring 1.5 kilometers along the northwest-southeast by 2.5 kilometers along the northeast-southwest.

a.2 Puntalinao nickel laterite

Limonite-saprolite was validated by test pit sampling in the northeast block of Parcel III in barangay Puntalinao, continuing to the western portion of Parcel II in barangay Pintatagan. It occurs on the middle slope to ridge crest portion of an elongated ridge, at elevations between 400m and 900m asl **(Photo 3)**. The confirmed limonite-saprolite measures approximately 1.2 kilometers wide by 3.0 kilometers long oriented along the northeast-southwest, and still open to the north-northeast. Using cut-off grade of 0.5% Ni and 0.8% Ni for the limonite and saprolite, respectively, the maximum thickness, and still open at depth, for the combined limonite-saprolite measured+indicated resource was 12 meters, at average grade of 1.12% Ni. The average measured+indicated thickness of the limonite-saprolite is 8.10 meters.

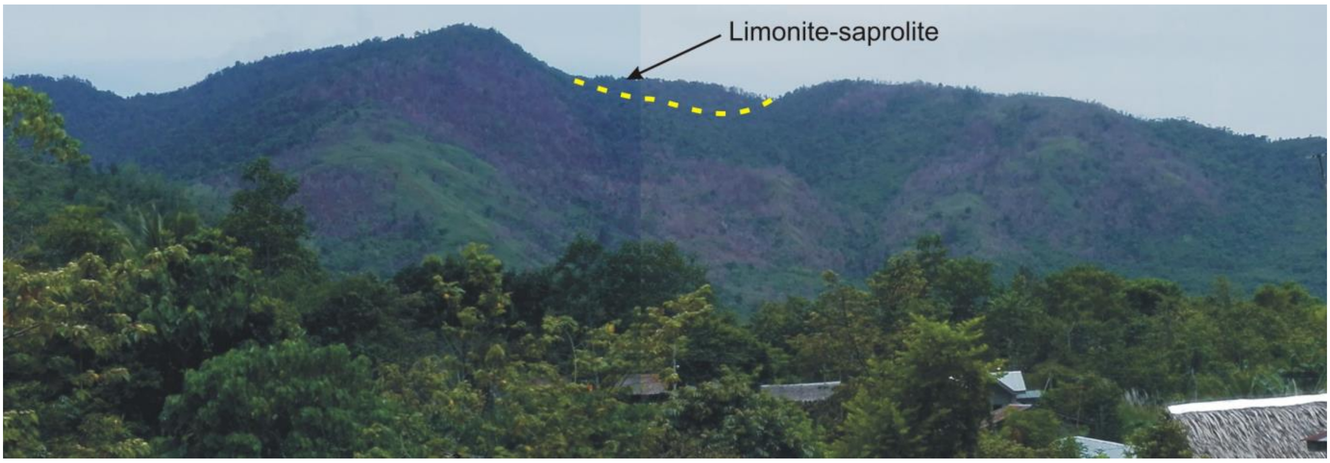


Photo 3. Puntalinao ridge showing the limonite-saprolite at the upper slope to ridge crest portion, which is still open to the northeast (left of photo). View is to the southwest.

b. Inferred nickel laterite resource

The Puntalinao-Pintatagan and Causwagan-Mahayag nickel laterites both follow a northeast-southwest orientation, generally parallel to the configuration of the upper ridge to ridge crest portions. The limonite-saprolite, as delineated by reconnaissance and semi-detailed geological mapping and extensive test pit programs in both the Causwagan-Mahayag and Puntalinao-Pintatagan nickel laterites imply an inferred resource of approximately 26,129,250 metric tonnes at average grade of 1.51% Ni (**Table 1.3**).

c. Resource Estimate

The nickel laterite resource estimate was based on the result of extensive test pit programs in both the Puntalinao and Causwagan nickel laterite areas. The tonnage and grade estimates for the Puntalinao limonite-saprolite has utilized the assays of 1,220 samples from 199 test pits. The tonnage and grade estimates for Causwagan has utilized 680 samples from 79 test pits.

Table 1.3. Detail of the inferred nickel laterite resource estimates for the Puntalinao and Causwagan nickel laterites.

Nickel Laterite	Tonnage	% Ni
Puntalinao	3,854,813	1.49
Causwagan	22,274,438	1.51
Total	26,129,251	1.51

The measured and indicated nickel laterite resource estimate has considered 25-meter and halfway to surrounding test pit to the north, south, west and east directions, area of influence, respectively. The cut-off grade was set to be 0.5% Ni and 1.0% Ni for the limonite and saprolite zones, respectively. The specific gravity is 1.40, representing the in-situ laterite horizons. The total measured+indicated+inferred limonite-saprolite resource estimate for the combined Puntalinao-Pintatagan and Causwagan-Mahayag nickel laterite areas is 68,344,194 wet metric tonnes at average grade of 1.45% Ni **(Table 1.4)**.

Table 1.4. Summary of resource estimate for the combined Puntalinao-Pintatagan and Causwagan-Mahayag limonite-saprolite.

Limonite-saprolite	Measured	% Ni	Indicated	% Ni	Inferred	% Ni	Total	% Ni
Puntalinao	3,576,300	1.10	5,445,081	1.13	3,854,813	1.49	12,876,194	1.23

Limonite-saprolite	Measured	% Ni	Indicated	% Ni	Inferred	% Ni	Total	% Ni
Causwagan	2,303,000	1.45	30,890,563	1.49	22,274,438	1.51	55,468,000	1.50
TOTAL	5,879,300	1.24	36,335,644	1.44	26,129,251	1.51	68,344,194	1.45

d. Estimated Mine Life

The projected monthly mine production is 800,000 MT of nickel ores, hence this schedule:

Table 1.5: Projected Monthly Mine Production

Year	Production (MT)
1	9,600,000
2	9,600,000
3	9,600,000
4	9,600,000
5	9,600,000
6	9,600,000
7	9,600,000
8	1,144,000
Total	**68,344,000**

Geohazard Considerations

Another consideration for site selection, mining methodology and the mine development plan is its susceptibility to geologic and hydrological hazards summarized as follows:

Table 1.6: Summary of Hazard Susceptibility

Description of Hazard	Level of Vulnerability
Susceptibility to Erosion	MPSA area is susceptible to splash, sheet, rill, gully and channel erosion
Susceptibility to Sedimentation	Rivers are susceptible
Susceptible to liquefaction	Unlikely in the MPSA Area / Possible along creeks / Highly susceptible in coastal plains or swampy araes
Susceptible to earthquake-triggered landslides	High to extreme susceptibility in steep slopes
Susceptibility to Ground Rupture (Seismic)	Unlikely in the site
Susceptible to tsunami	Shoreline area Susceptible to locally generated tsunami
Proximity to fault structures	22Km away from the nearest structure (PFZ 2)
Susceptible to Flooding	Moderate to high flood susceptibility based on MGB 1:10,000 map; facilities are within low flood susceptibility area
Susceptibility to Mass Movement /Land slide	MPSA area – high susceptibility (MGB, 1:10k hazard map; Project NOAH)

Description of Hazard	Level of Vulnerability
Susceptible to Volcanic Hazard	Low Susceptibility (Hazard includes ashfall)

With the different mining methods presented in the table below, Surface Mining is the most suitable form since it will generate optimum return on investment. Progressive Mining-Rehabilitation will be incorporated to minimize the adverse effects on the environment.

Table 1.7: Options for Mining Methods

Alternatives	Opportunities	Issues
Surface Mining	Deposit is shallow	Surface disturbance is larger as compared to underground mining projects (which is not suitable for the project) but any environmental disturbance could be addressed by the Environmental Protection and Enhancement Program.
	Enables bulk mining which suits the grade of nickel ore for extraction	
	100 percent of the resource would be recovered	
	Staff very familiar and experienced in the proven method and technologies required to develop a surface mine.	
Underground Mining	Less surface disturbance	Not applicable for shallow deposit
		Selective for high grade deposit only
		Lower resource recovery therefore leaving much of the mineral resource on the ground
		Economically less attractive due to high cost of development and operational cost
		Possible negative perception from the community since they are not familiar with underground mining

4. Project Components

a) *Identification of Major Components*

a.1 Mine Pits and Mine Facilities

Significant nickel laterite mineralization was delineated inside Parcels II and III of MPSA 263-2008-XI-Amended-IB. The planned mine operation will be divided into two smaller mine areas, namely the Causwagan block and Puntalinao block, with a combined 44 tenement blocks (**Figure 1.8**).

The Causwagan block is located at the southeastern portion of the Parcel II. The mine pit design measures 700m to 800m wide and as much as 1.5km long. Portion of the low relief topography at elevations between 100 and 200m asl will have a pit stockpile, silt pond and waste dump areas.

The Puntalinao block is inside the central portion of Parcel II and at the northeastern half of Parcel III. The mine pit design measures approximately 500m wide and 1.5km long. It is surrounded by characteristic high relief terrain. Ore stockpile area is separate, to be established at the port loading facility itself in Puntalinao Port 1 area.

In year 1 of the mining operations, it will focus on the first 100 hectares, as projected, of Mining Area 1 creating a 50 hectares mined out area. Year 2 of the mining operations still includes Mining Area 1 which is projected to disturb an additional of 25 hectares and another 25 hectares from Mining Area 2 resulting to a total of 50 hectares mined out area with an estimate rehabilitation area of 50 hectares in the latter part of year 1 and progressively to continue rehabilitation activities at this sequence. In the 3rd year of the mining operations, the projected disturbed area would be at 200 hectares, this may attribute to 150 hectares mined out area. Thus, the 100 hectares will be the company's rehabilitation commitment in the course of its three (3) years operation. Should there be any variance in terms of mined out and rehabilitated hectarage still to be continued as a commitment by the proponent. With the context of DAO No. 2018-19 as here followed, the company do not expect any effect in the mining operations when the progressive rehabilitation sequenced is observed. Development of mine pit from year 1 to 3 are shown in **Figure 1.20a, Figure 1.20b, Figure 1.20c,** respectively.

Table 1.8: Projected Mine Plan of the Mining Areas

Year	Location	Disturbed area (has.)	Mined Our Area (has.)	Rehab Areas (has.)
Year 1	Area 1	100	50	
Year 2	Area 1	25	50	50
	Area 2	25		
Year 3	Area 1	25	25	50
	Area 2	25	25	
TOTAL		**200**	**150**	**100**

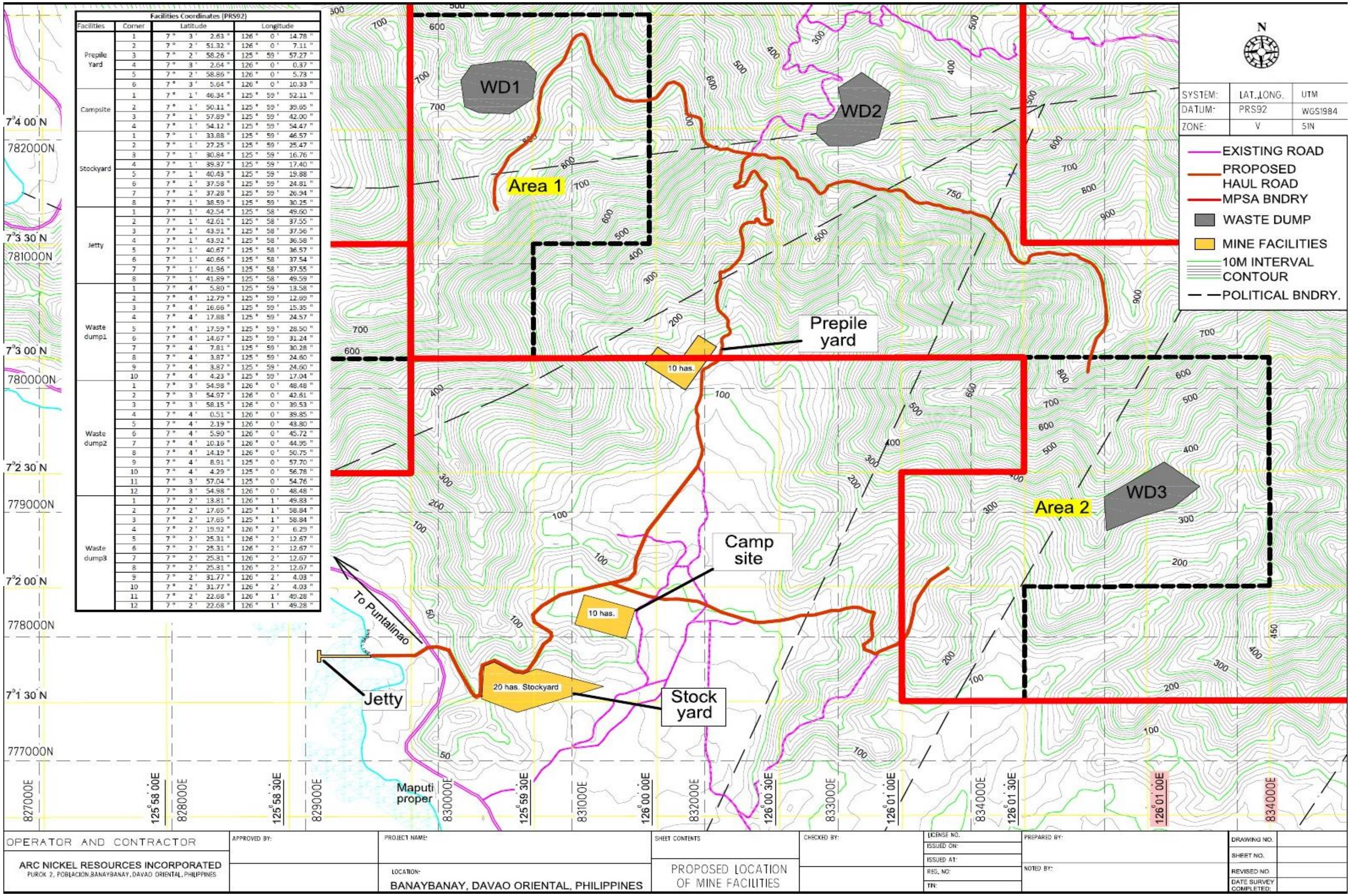
The stockyards location was selected based on the available plain area away from the community which has more than 20 hectares and proximate to the jetty's location with existing haul roads from the pre-pile stockyard area. Projected to have a low capital investment cost whereas no development needed involving heavy equipment. The stockyard has a total number of 12 stockpiles with a total tonnage capacity of 1,276,418.57 and a ten (10) meter road. Stockpiles will have an eight (8) meter height pile with 30° slope and a matting material laid under the stockyard facility. (See **Figure 1.10)**

Pre-pile yard is a ten (10) hectare area that is almost the same as the stockyard area. It has a five (5) meter pile height with a tonnage capacity of 93,500.00, where recently mined nickel ore is hailed and stockpiled at 25 truckload per pile while awaiting for the assay results and its ore classifications before transferring to the stockyard area.

There are three (3) proposed waste dumps inside the MPSA. Waste dump no. 1 and no. 3 are located inside mining area 1 and mining area 2. Location of waste dump no. 2 is distanced from the two (2) mining areas which is considered as alternative waste dump. Each waste dumps has an approximate area of 20 hectares with a total capacity of 1,893,920 cu.m. These waste dumps were selected as they are proximate to the mining areas. The design of the waste dumps as indicated in the attached plan **(Figure 1.12)** will be typically located on the most favorable terrain to minimize environmental impacts. The dumps will start at its lowest elevation, supported by rock boulders around its toe line to be sloped at 35 degrees and to be compacted by backhoe's bucket. The toe line around the dump will have to be trenched in 2.5 width and 2.5 m depth to accommodate large sizes of rock boulders to control possible movements of materials. As the first stage of dumps it will also serve as the foundation while it is continually compacted as the dumps progresses in upward direction following the slope and the drainage system. Downward proximate to the dumps toe line run off system will be addressed properly by providing drainages. All dumps surface area's run off from top to bottom will be managed by drainage in each dump toe line which is 2% inclined from the crest line to prevent run off over flow across the dumps crest resulting to slope erosions and eventual damages.

The proposed jetty port in the area (as shown in the mine facilities map provided) will be developed and will be covered by an independent ECC application which is currently on process of securing relevant documents for the application. This structure has a very vital role in completing the mining operations, specifically, in transporting and shipping process of nickel ore.

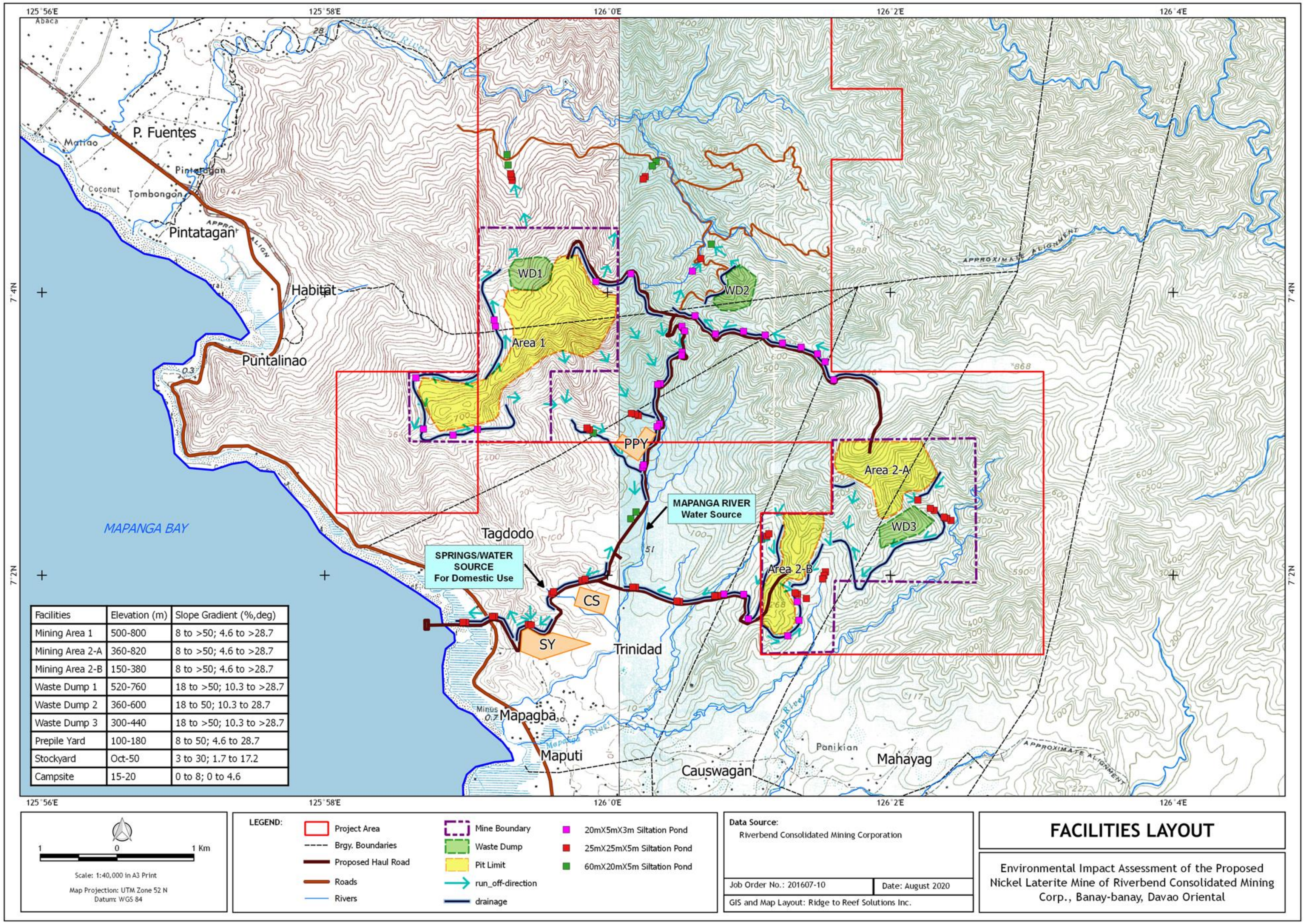
The proposed mining project will be a direct shipping operations and no mineral processing will occur.



Facilities Coordinates (PRS92)

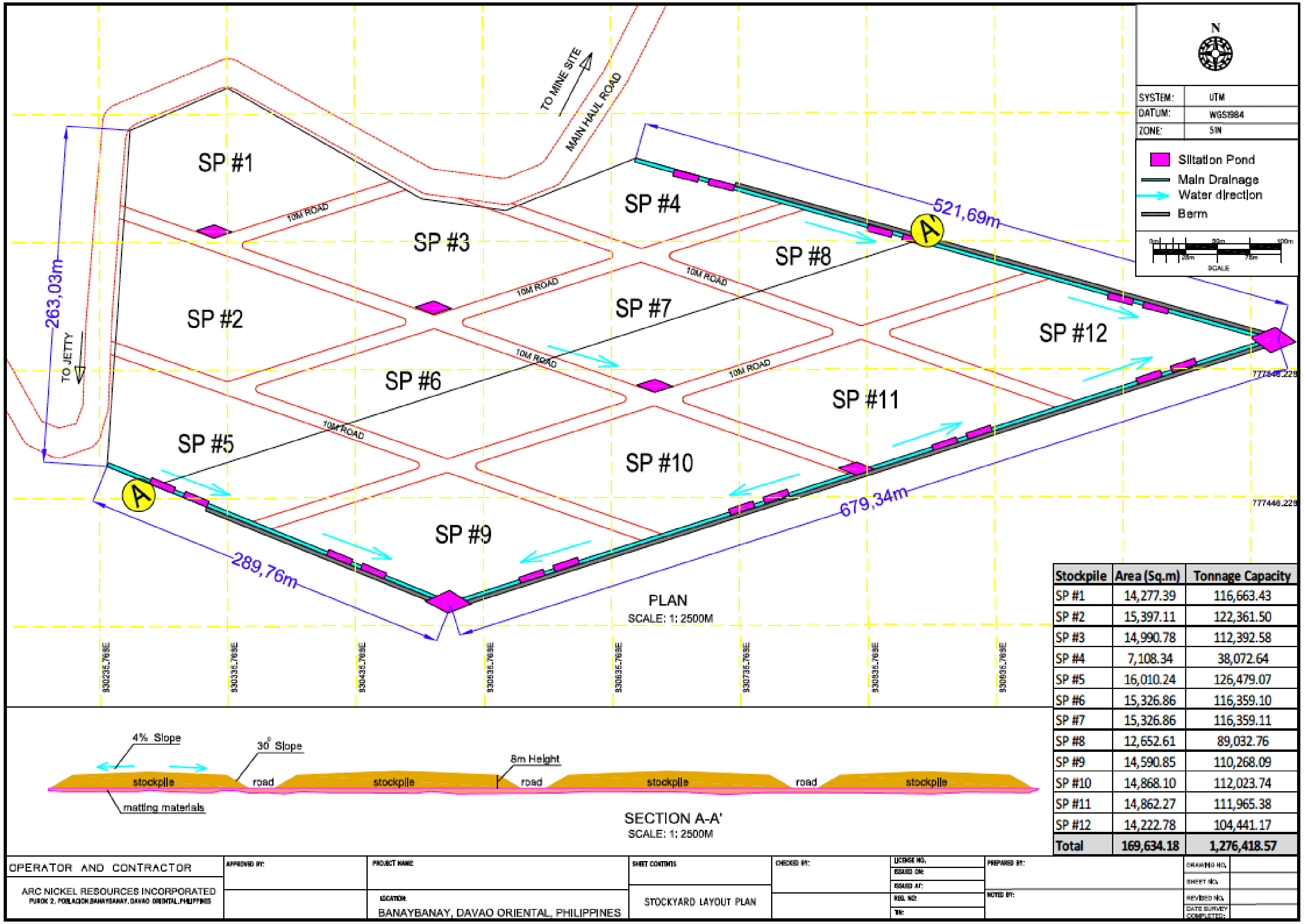
Facilities	Corner	Latitude			Longitude		
Prepile Yard	1	7 °	3 '	2.63 "	126 °	0 '	14.78 "
	2	7 °	2 '	51.32 "	126 °	0 '	7.11 "
	3	7 °	2 '	58.26 "	125 °	59 '	57.27 "
	4	7 °	3 '	2.64 "	126 °	0 '	0.37 "
	5	7 °	2 '	58.86 "	126 °	0 '	5.73 "
	6	7 °	3 '	5.64 "	126 °	0 '	10.33 "
Campsite	1	7 °	1 '	46.34 "	125 °	59 '	52.11 "
	2	7 °	1 '	50.11 "	125 °	59 '	39.65 "
	3	7 °	1 '	57.89 "	125 °	59 '	42.00 "
	4	7 °	1 '	54.12 "	125 °	59 '	54.47 "
Stockyard	1	7 °	1 '	33.88 "	125 °	59 '	46.57 "
	2	7 °	1 '	27.25 "	125 °	59 '	25.47 "
	3	7 °	1 '	30.84 "	125 °	59 '	16.76 "
	4	7 °	1 '	39.37 "	125 °	59 '	17.40 "
	5	7 °	1 '	40.43 "	125 °	59 '	19.88 "
	6	7 °	1 '	37.58 "	125 °	59 '	24.81 "
	7	7 °	1 '	37.28 "	125 °	59 '	26.94 "
	8	7 °	1 '	38.59 "	125 °	59 '	30.25 "
Jetty	1	7 °	1 '	42.54 "	125 °	58 '	49.60 "
	2	7 °	1 '	42.61 "	125 °	58 '	37.55 "
	3	7 °	1 '	43.91 "	125 °	58 '	37.56 "
	4	7 °	1 '	43.92 "	125 °	58 '	36.58 "
	5	7 °	1 '	40.67 "	125 °	58 '	36.57 "
	6	7 °	1 '	40.66 "	125 °	58 '	37.54 "
	7	7 °	1 '	41.96 "	125 °	58 '	37.55 "
	8	7 °	1 '	41.89 "	125 °	58 '	49.59 "
Waste dump1	1	7 °	4 '	5.80 "	125 °	59 '	13.58 "
	2	7 °	4 '	12.79 "	125 °	59 '	12.69 "
	3	7 °	4 '	16.66 "	125 °	59 '	15.35 "
	4	7 °	4 '	17.88 "	125 °	59 '	24.57 "
	5	7 °	4 '	17.59 "	125 °	59 '	28.50 "
	6	7 °	4 '	14.67 "	125 °	59 '	31.24 "
	7	7 °	4 '	7.81 "	125 °	59 '	30.28 "
	8	7 °	4 '	3.87 "	125 °	59 '	24.60 "
	9	7 °	4 '	3.87 "	125 °	59 '	24.60 "
	10	7 °	4 '	4.23 "	125 °	59 '	17.04 "
Waste dump2	1	7 °	3 '	54.98 "	126 °	0 '	48.48 "
	2	7 °	3 '	54.97 "	126 °	0 '	42.61 "
	3	7 °	3 '	58.15 "	126 °	0 '	39.53 "
	4	7 °	4 '	0.51 "	126 °	0 '	39.85 "
	5	7 °	4 '	2.19 "	126 °	0 '	43.80 "
	6	7 °	4 '	5.90 "	126 °	0 '	45.72 "
	7	7 °	4 '	10.16 "	126 °	0 '	44.95 "
	8	7 °	4 '	14.19 "	126 °	0 '	50.75 "
	9	7 °	4 '	8.91 "	125 °	0 '	57.70 "
	10	7 °	4 '	4.29 "	125 °	0 '	56.78 "
	11	7 °	3 '	57.04 "	125 °	0 '	54.76 "
	12	7 °	3 '	54.98 "	126 °	0 '	48.48 "
Waste dump3	1	7 °	2 '	13.81 "	126 °	1 '	49.83 "
	2	7 °	2 '	17.65 "	125 °	1 '	58.84 "
	3	7 °	2 '	17.65 "	125 °	1 '	58.84 "
	4	7 °	2 '	19.92 "	126 °	2 '	6.29 "
	5	7 °	2 '	25.31 "	126 °	2 '	12.67 "
	6	7 °	2 '	25.31 "	126 °	2 '	12.67 "
	7	7 °	2 '	25.31 "	126 °	2 '	12.67 "
	8	7 °	2 '	25.31 "	126 °	2 '	12.67 "
	9	7 °	2 '	31.77 "	126 °	2 '	4.03 "
	10	7 °	2 '	31.77 "	126 °	2 '	4.03 "
	11	7 °	2 '	22.68 "	126 °	1 '	49.28 "
	12	7 °	2 '	22.68 "	126 °	1 '	49.28 "

Figure 1.8 : Map Showing General Layout of Facilities *(Source: RCMC)*



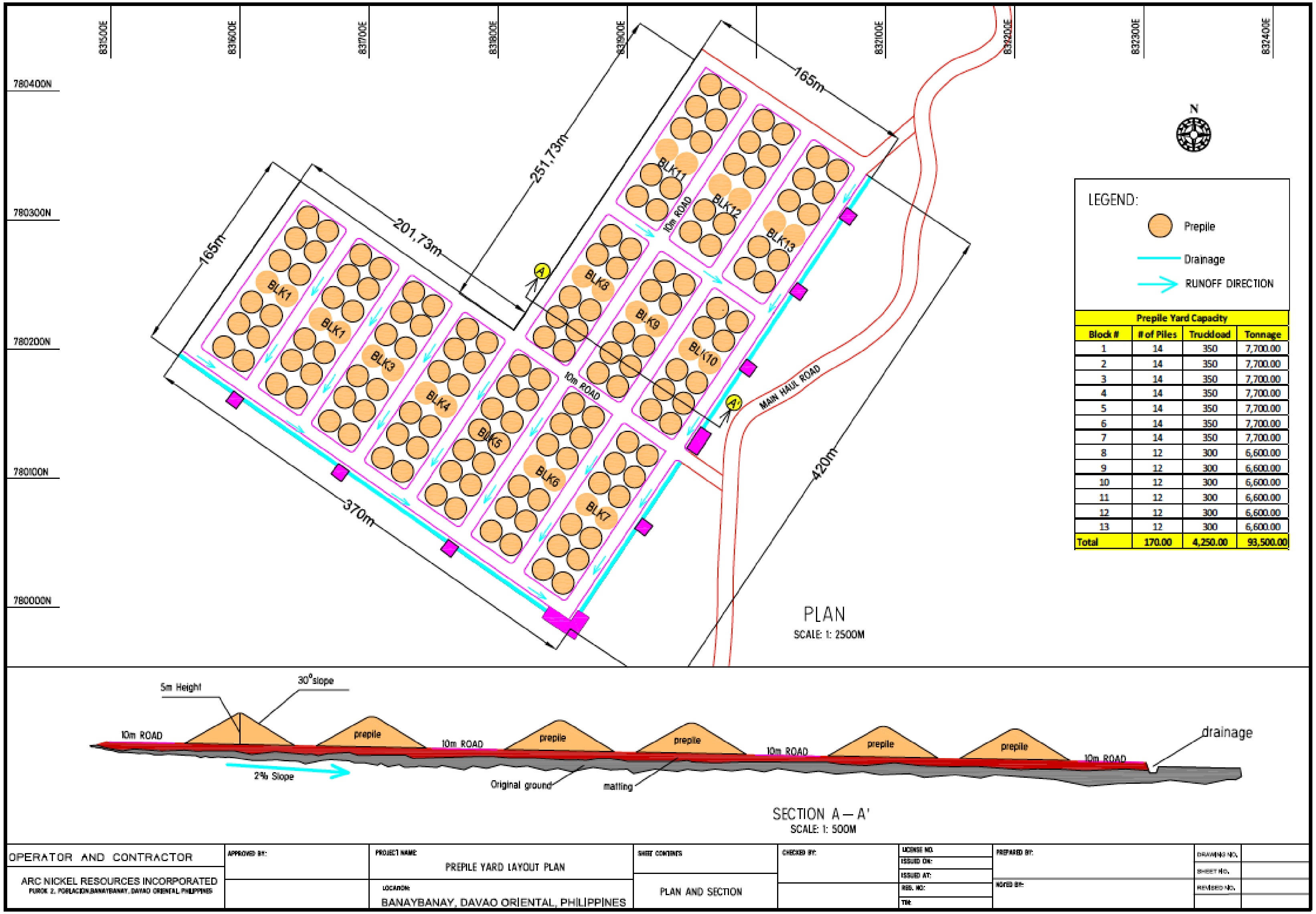
Facilities	Elevation (m)	Slope Gradient (%,deg)
Mining Area 1	500-800	8 to >50; 4.6 to >28.7
Mining Area 2-A	360-820	8 to >50; 4.6 to >28.7
Mining Area 2-B	150-380	8 to >50; 4.6 to >28.7
Waste Dump 1	520-760	18 to >50; 10.3 to >28.7
Waste Dump 2	360-600	18 to 50; 10.3 to 28.7
Waste Dump 3	300-440	18 to >50; 10.3 to >28.7
Prepile Yard	100-180	8 to 50; 4.6 to 28.7
Stockyard	Oct-50	3 to 30; 1.7 to 17.2
Campsite	15-20	0 to 8; 0 to 4.6

Figure 1.9. Map of the Project Area showing the Elevation of each Project Components on NAMRIA Map



Stockpile	Area (Sq.m)	Tonnage Capacity
SP #1	14,277.39	116,663.43
SP #2	15,397.11	122,361.50
SP #3	14,990.78	112,392.58
SP #4	7,108.34	38,072.64
SP #5	16,010.24	126,479.07
SP #6	15,326.86	116,359.10
SP #7	15,326.86	116,359.11
SP #8	12,652.61	89,032.76
SP #9	14,590.85	110,268.09
SP #10	14,868.10	112,023.74
SP #11	14,862.27	111,965.38
SP #12	14,222.78	104,441.17
Total	169,634.18	1,276,418.57

Figure 1.10. Layout of Stockyard Layout Plan *(Source: RCMC)*



Prepile Yard Capacity			
Block #	# of Piles	Truckload	Tonnage
1	14	350	7,700.00
2	14	350	7,700.00
3	14	350	7,700.00
4	14	350	7,700.00
5	14	350	7,700.00
6	14	350	7,700.00
7	14	350	7,700.00
8	12	300	6,600.00
9	12	300	6,600.00
10	12	300	6,600.00
11	12	300	6,600.00
12	12	300	6,600.00
13	12	300	6,600.00
Total	170.00	4,250.00	93,500.00

Figure 1.11. Pre-pile Yard Layout Plan *(Source: RCMC)*

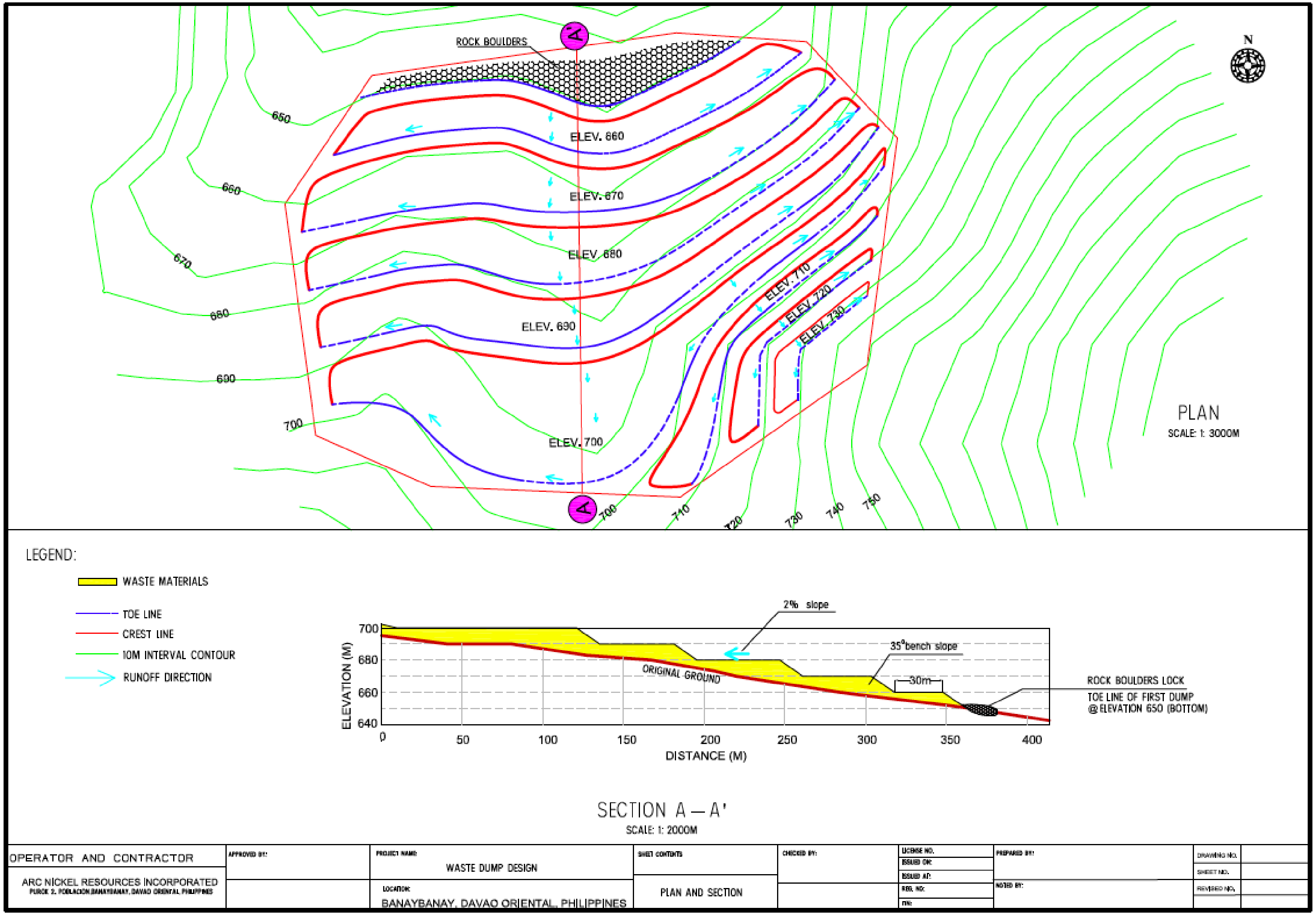


Figure 1.12. Waste Dump Layout Plan *(Source: RCMC)*

b) Identification and description of support facilities and infrastructure requirements

A central office building for the administration, key operation group services and technical support departments will be built in a 13-hectare are in Barangay Maputi. The technical key operations groups, who will be directly involved in the mine pit operation will include the offices for Mine Geology and Grade Control, Mine Engineering, Electrical, Civil Works, IT and Communication, Community Relations and Environmental departments and Core house.

The Camp Site, a separate warehouses and buildings, will be constructed in the same areas for the heavy equipment and motorpool, including the trucking contractors quarters, materials procurement and storage facility, power generation facility, medical clinic and assay laboratory.

A first-aid clinic will be established on-site and strategic office and building complexes. The Mine clinic will have medical personnel and equipment capable of handling and treating patient with serious injuries. An ambulance will be available for immediate transport to the nearest city hospital in Tagum City.

The electricity requirement of the mine pit operation and the support facilities will be supplied by the Davao Oriental Electric Cooperative, Inc. (Doreco), with main office in Mati City. A stand-by back-up 250 kVA, 125kVA, and 75kVA generator sets will be provided.

Water requirement for domestic use in the mine support facilities, offices and water refilling stations will be sourced from the spring water located to the west and upstream of the proposed Campsite. The water requirement for dust suppression, irrigation and nursery maintenance, and environmental emergency will be obtained from Mapanga River and from siltation ponds **(Figure 1.17).**

Table 1-9: Annual Water Consumption Per Source

Sources	Capacity Flow (cu.m/day)	Usage	Water Volume Needed (cu.m/day)	Total volume per day	Annual Consumption (cu.m/day)
Spring waters	192.0	Water refilling station	15.0	100.0	23,400
		Offices	20.0		
		Domestic use	65.0		
Rivers/streams	114,630.92	Dust suppression	190.0	204.0	47,736
		Nursery maintenance	9.0		
		Environmental Emergency	5.0		

c) Identification and description of pollution control devices and waste management system

Solid waste management system of the proponent shall be adopted from the Republic Act 9003 also known as the Ecological Waste Management Act of 2000 that applied resource recovery methodology in which generated solid wastes are segregated according to its category to promote the 3 R's (Reduce, Reuse and Recycling) of solid waste management. Facilities such as compost pit and material recovery facility (MRF) shall be constructed and implemented for proper storage and final disposal of segregated collected wastes. Provision of color-coded garbage bin and compartmentalized garbage stand with label indicating the classification of each wastes, as temporary storage for segregated wastes, to offices and other working places. Temporary storage shall be equipped with cover to prevent the propagation or attraction of vectors and the creation of nuisances. Collected solid wastes shall be weighed to monitor the volume of generated solid waste per classification of biodegradable wastes, recycled wastes, residual wastes, and hazardous wastes.

Biodegradable wastes shall be disposed to the compost pit. The decomposed wastes will enrich soil nutrients, hence this shall be used in the nursery for potting of seedlings. Recyclable wastes shall be stored temporarily in MFR. Residual wastes shall be disposed to the Local Government Unit Sanitary

Landfill scheduled to be collected weekly. Classified special or hazardous wastes shall be treated before disposal thus it shall be stored in the hazardous waste facility for proper disposal.

Generated hazardous waste shall be properly organized in the storage facility such that hazardous wastes with different characteristic shall be kept separately. Proper handling of hazardous wastes generated from the maintenance of vehicles and equipment including assay laboratory chemical wastes and container shall be handled, stored and disposed of properly to prevent hazard and contamination. A separate storage for waste oil and other hazardous waste shall be provided. Provisions of hazardous waste storage facility will be impermeability of flooring, proper ventilation of the storage facility, provision of oil and water separator and emergency devices. The design of the septic vault for infectious wastes will be impermeability of flooring, fully concrete with plastered walls, floor and cover, and provision of detachable cover for access of disposing infectious wastes. Hazardous wastes shall be disposed through a DENR accredited transporter and treatment storage and disposal facility.

Wastewater at the mine pits will constitute the rain water runoff and silted ponded water. This will be managed by developing appropriate drain channels to the designated settling ponds. These series of settling ponds are designed so that on the last stage of the process, where water quality analysis is taken to ensure that it is already within the permissible limits and effluent quality as stipulated in DAO 2016-18, are suitable for discharge to natural environment. Discharging to natural environment is carried out only when it is at critical level (to overflow), especially when there is a weather condition threat. But other than that, these waters are reserved and utilized for dust suppression activities and environmental activities such as in nurseries and rehabilitation areas. The same water will also be used as reserved for environmental emergencies such as fire, clean up, and housekeeping.

As presented in **Figure 1.17,** there are 3 types of siltation ponds based on their capacity.

Mine drainage mitigation and maintenance will be confined in, and immediately close to the mine pits. Development of channel drains will restrict the flow of runoff and storm water from the disturbed mine pit – stockpile area to an area with adequate space and appropriate elevation to be utilized as settling pond or sump, and which will prevent the outflow of silt-saturated water. Further reduction of the drainage grade allows the formation of low to gentle slope, where water runoff is reduced.

Management of sewerage and drainage mine system will also look into the installation of surface stability lining, specifically on very erodible soils; mini dams and periodic desiltation program on water confining structures and natural basins.

Erosion of topsoil will be minimized by restricting the ground slopes to more stable slope gradient, not exceeding 10%. Earthwork lining (rip-rap) will be installed on weak slopes, specifically to ground slope composed of relatively soft material. All affected ground slopes at the mine pit area will be rehabilitated and replanted. The accumulation of sediment-bearing surface water to creek and river channels will be mitigated by draining it to settling pond on-site. Water quality monitoring on creeks and river channels will be part of the monitoring study during the mine operation.

Smoke and dust generation will be minimized by strict monitoring on the road worthiness of vehicles, specifically hauling dump trucks, and establishing regular water sprinkler system at the mine pit and along the hauling road. Air quality monitoring device recommended by the Environmental Management Bureau (EMB) will be utilized.

As practiced, water conservation activities and/or programs will be in placed to ensure that resources are conserved and utilized efficiently such as: signages are posted in strategic areas to conserved usage of water; regular inspection of water pipes to ensure no leakage; controlled and monitored water tanks refilling; collection and suction of water from silt ponds to be utilized in dust suppression activities.

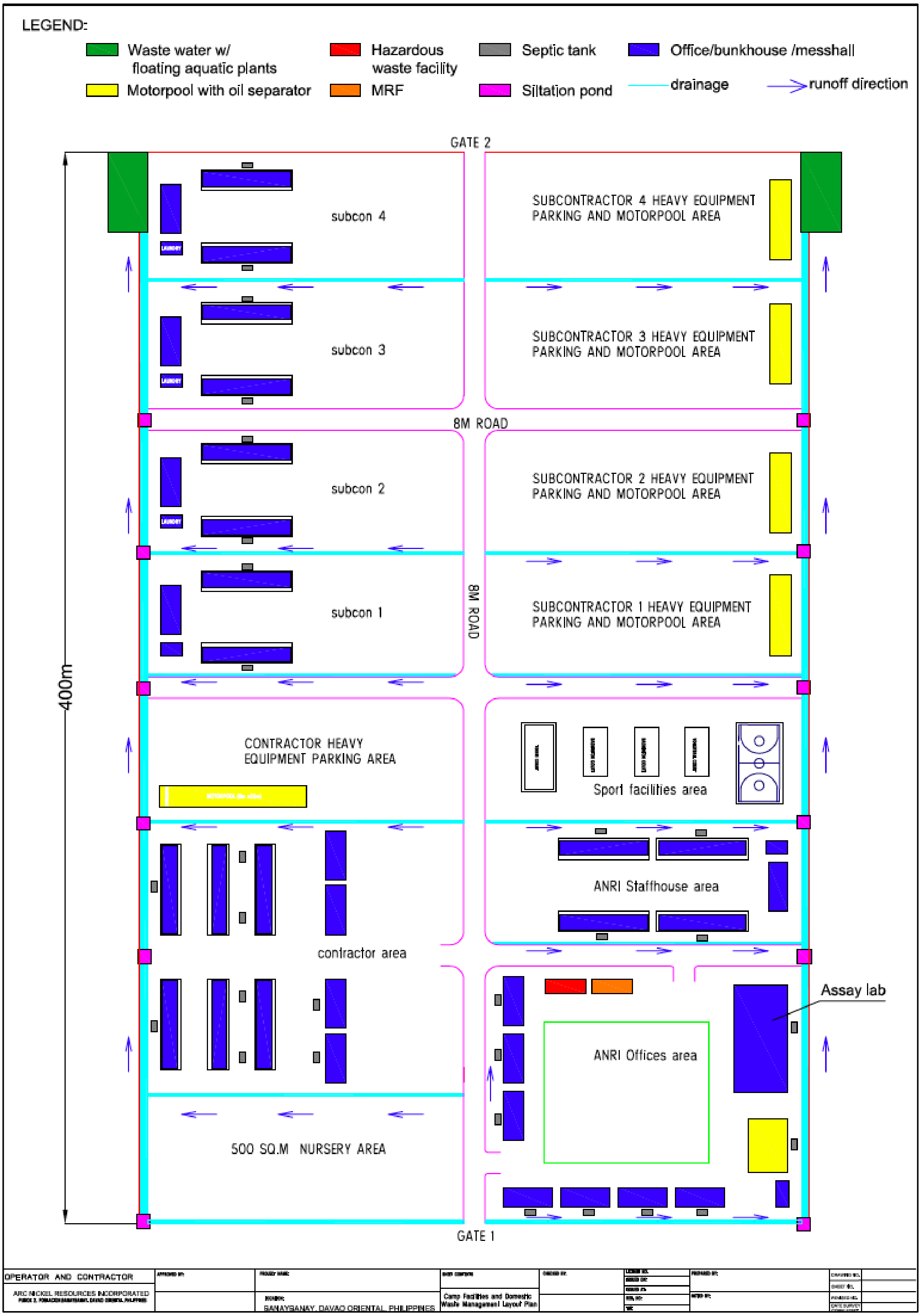


Figure 1.13. Design Layout of Campsite Facilities and Waste Management
(Source: RCMC)

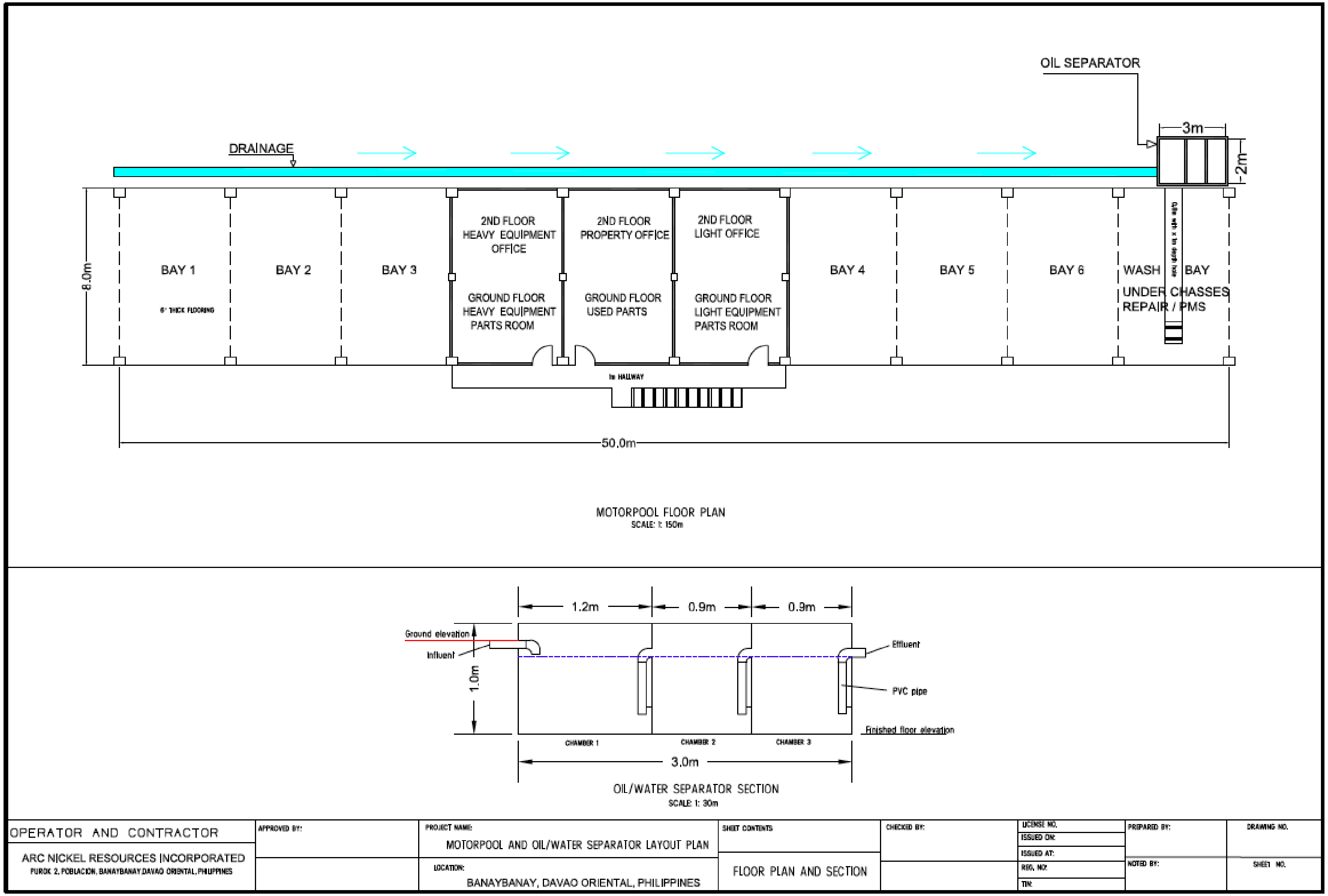


Figure 1.14. Motorpool and Oil & Water Separator Layout Plan *(Source: RCMC)*

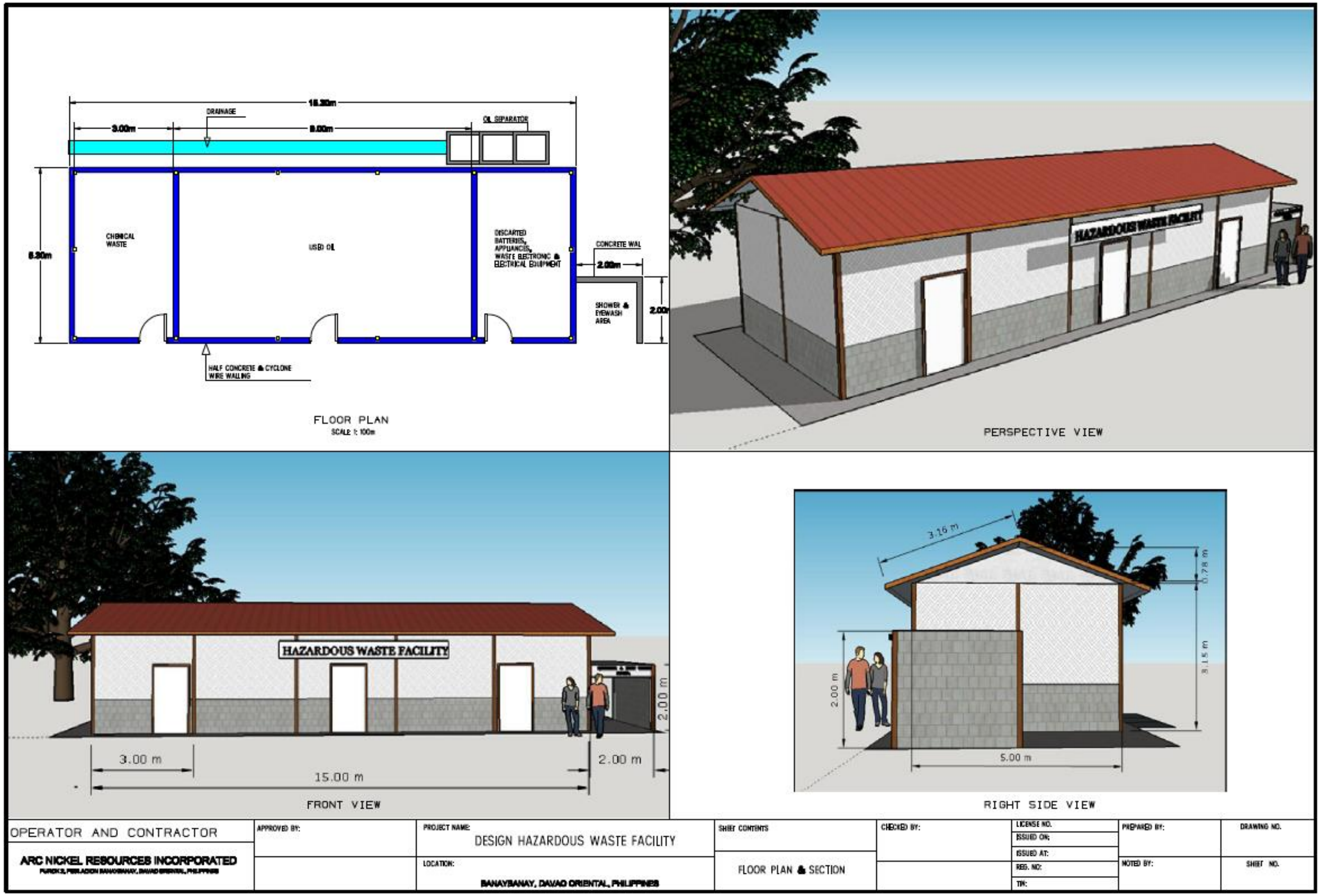
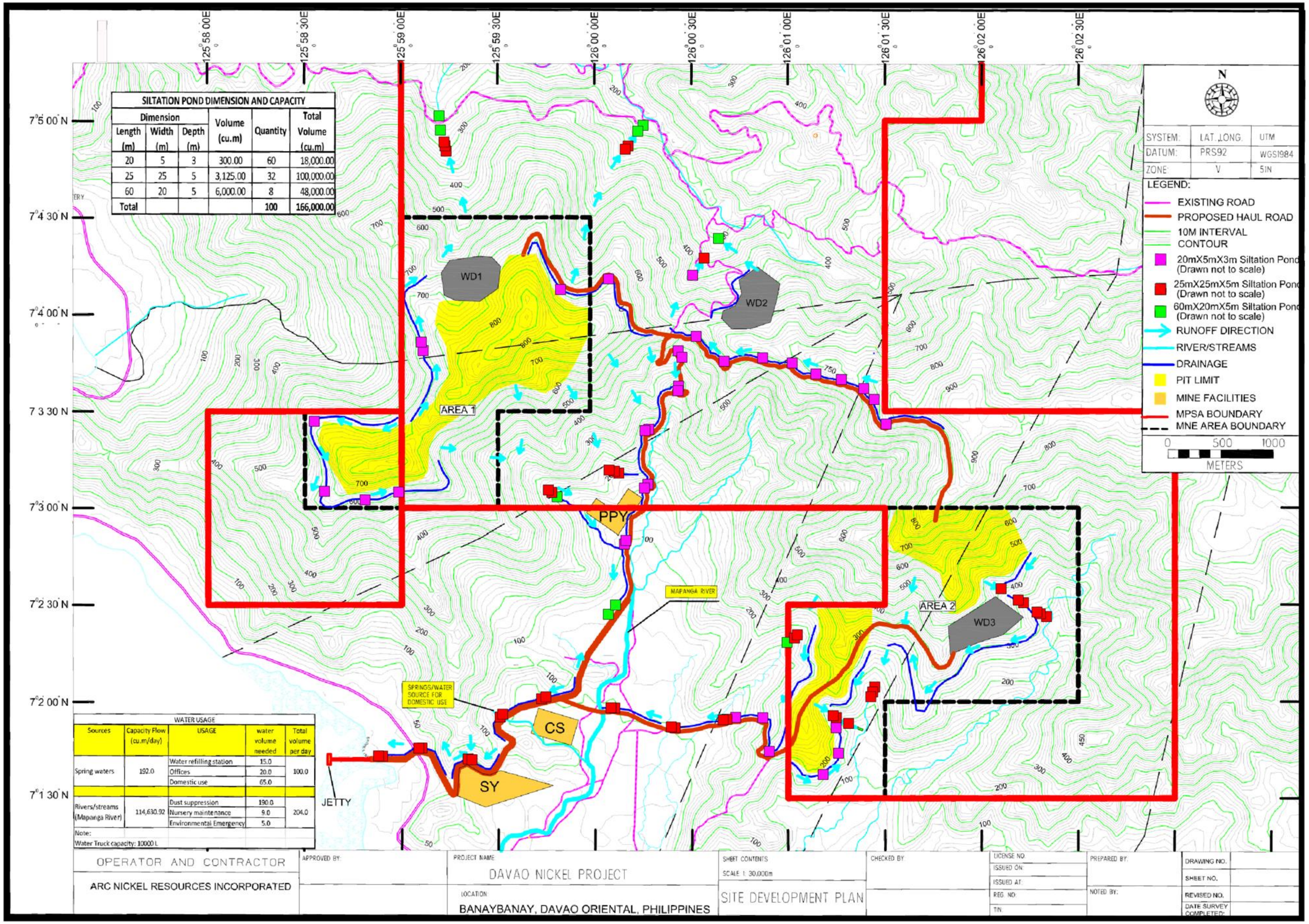


Figure 1.15. Hazardous Waste Facility Design *(Source: RCMC)*

Figure 1.16. Material Recovery Facility (MRF) Design *(Source: RCMC)*



SILTATION POND DIMENSION AND CAPACITY					
Dimension			Volume (cu.m)	Quantity	Total Volume (cu.m)
Length (m)	Width (m)	Depth (m)			
20	5	3	300.00	60	18,000.00
25	25	5	3,125.00	32	100,000.00
60	20	5	6,000.00	8	48,000.00
Total				100	166,000.00

WATER USAGE				
Sources	Capacity Flow (cu.m/day)	USAGE	water volume needed	Total volume per day
Spring waters	192.0	Water refilling station	15.0	100.0
		Offices	20.0	
		Domestic use	65.0	
Rivers/streams (Mapanga River)	114,630.92	Dust suppression	190.0	204.0
		Nursery maintenance	9.0	
		Environmental Emergency	5.0	
Note:				
Water Truck capacity: 10000 L				

Figure 1.17. Site Development Plan showing the Location of Water Sources and Siltation Ponds *(Source: RCMC)*

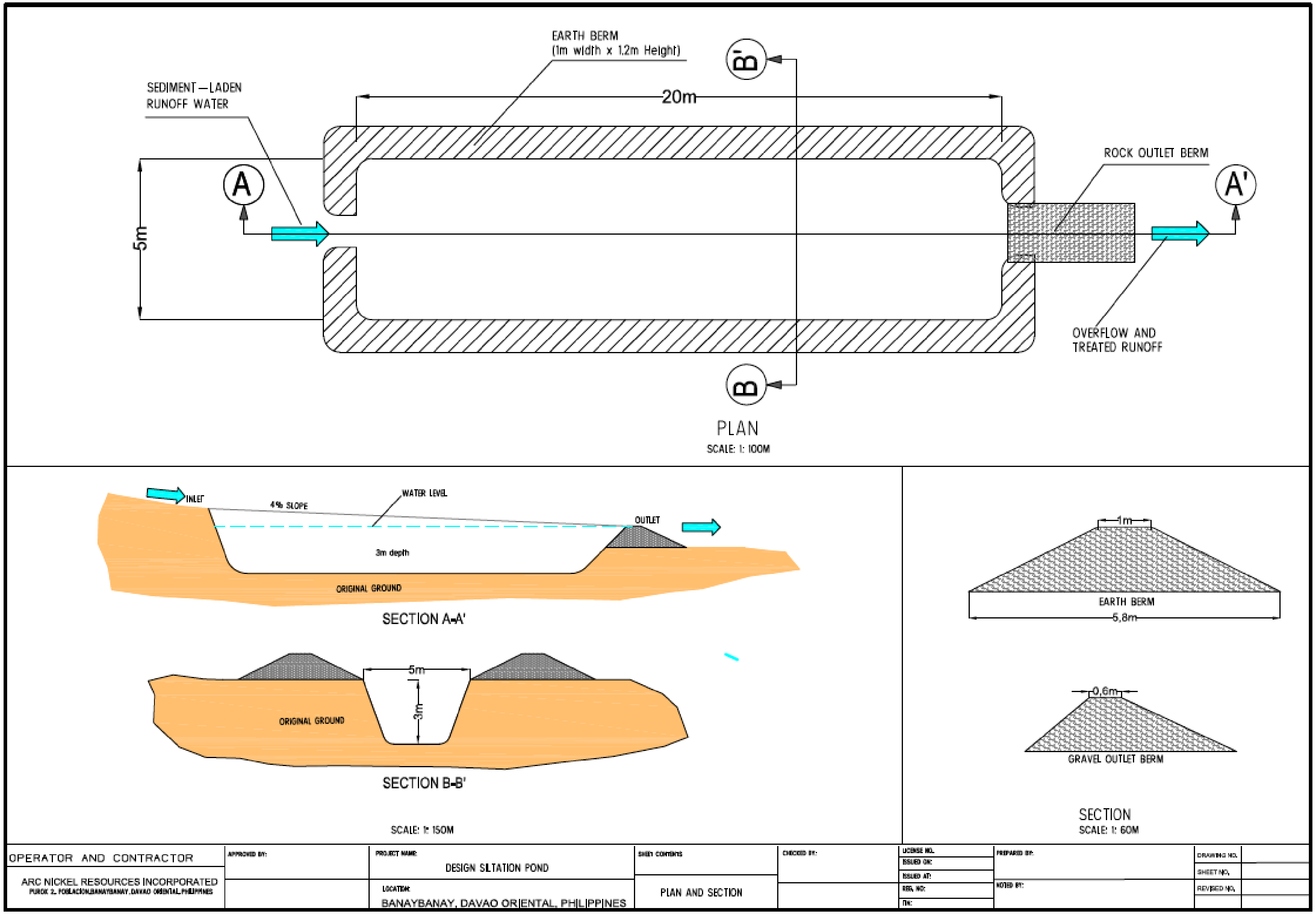


Figure 1.17a: Design Layout of Siltation Ponds

5. Process / Technology

a) Method/Technology for:

- Ore/mineral processing

There will be no ore processing to be done. The Nickel laterite extraction will be direct shipping operation (DSO) and will not require mineral processing. The primary work flow of the mining operations after survey and exploration will be: clearing, grubbing and construction of access roads and haul roads; bench forming; ore extraction and loading; pre-pile stockpiling for ore classification; ore hauling going to port stockpiling; barging; ship siding; and loading to the mother vessel for shipping. On-pit or pre-pile stockpiling will categorize the Nickel laterite ore into low, medium and high grades Nickel. The commonly high grade saprolite Nickel ore will have oversized fragments that need aggregation and re-sizing prior to stockpiling. The different categories on Nickel laterite ore will be reclassified, blended and dried to achieve the desired Nickel grade and moisture content for shipment.

A simple free digging contour load and haul mining is planned for the two pits in Causwagan and Puntalinao blocks. The main stages of pit mining and grade control are:

a.1 Pit preparation – Clearing and grubbing

Clearing and grubbing is the removal of all vegetation on the delineated area for mining development. The equipment involve is backhoe to load and handle scraped shrubs and bulldozer to clear off vegetation. To minimize damages to the environment the area being cleared and grubbed of its vegetation, the team is guided by exploration-survey to ensure the exact lateral extent of the projected pit limit. Materials being cleared from this process like timbers are properly accounted for the DENR inventory and documentation. Top soils are hauled and readily stockpiled to be used for mine rehabilitations.

Mining haul roads and access roads shall be developed into the mining areas. These roads shall be constructed with appropriate road base to allow safe and efficient flow of traffic. Traffic signages will also be placed in certain areas as guide.

A total of 34 tree species that can be potentially affected by the mining operations. This is based on the 2019 assessment conducted within the proposed mining area.

Table 1-10: Potentially Affected Tree Species

Family	**Species**	**Local Name**
Anacardiaceae	*Mangifera indica*	Manga
Anacardiaceae	*Bucchanania sp*	Manga-manga
Annonaceae	*Haplostichanthus lanceolata*	Banga
Arecaceae	*Cocos nucifera*	Lubi
Burseraceae	*Garuga floribunda decne*	bugo
Burseraceae	*Canarium ovatum*	Pili-pili
Calophyllaceae	*Calophyllum blancoi*	Bitanghol/Yelohan
Celastraceae	*Euonymus javanicus*	Tabaan
Clusiaceae	*Garcinia rubra*	Batwan
Dipterocarpaceae	*Dipterocarpus grandiflorus*	Apitong
Dipterocarpaceae	*Shorea sp.*	Lawaan
Dipterocarpaceae	*Shorea astylosa*	Yakal
Phyllanthaceae	*Cleistanthus pilosus*	Malatabako
Fabaceae	*Cynometra inaequifolia*	Dila- Dila
Fabaceae	*Falcataria moluccana*	Falcata
Fabaceae	*Pterocarpus indicus*	Narra
Fagaceae	*Castanopsis sp*	Indang-Indang
Fagaceae	*Lithocarpus llanosi*	Ulayan
Lamiaceae	*Gmelina arborea*	Gmelina

Family	Species	Local Name
Meliaceae	*Swietenia macrophylla*	Mahogany
Meliaceae	*Sandoricum koetjape*	Santol
Moraceae	*Artocarpus heterophyllus*	Langka
Moraceae	*Artocarpus odoratissimus*	Marang
Myrtaceae	*Syzygium cumini*	Lumboy-lumboy
Myrtaceae	*Xanthostemon verdugonianus*	Magkuno
Myrtaceae	*Syzyguim brevistylum*	Sagimsim
Pentaphylacaceae	*Eurya sp.*	Tag-lemonsito
Podocarpaceae	*Podocarpus philippinensis*	Malakauayan
Rubiaceae	*Nauclea orientalis*	Bangkal
Rubiaceae	*Greeniopsis sp*	Hambabalod
Rutaceae	*Melicope sp*	Ansohan/Tulusan
Sapotaceae	*Palaquium luzoniense*	Nato
Urticaceae	*Urtica sp*	Alingatong
Myrtaceae	*Syzygium sp.*	Itoman

a.2 Bench Forming

Bench forming is done on the cleared area (cleared of vegetation) with the guide of survey team to lay out each designed mine pit benches following the ground surface contour marked by the survey stakes with its elevation indicating each bench elevation. The distance between the laid out lines is determined by the ground slope to make up a next bench at a height of 3.0 meters and so forth forming benches from top to down up to the pit limit. Following the laid out survey stakes is the bulldozer which slices and cut the ground surface eventually forming benches at different levels, e.i;B-358 ;B-355; B-352.

On-contour benching and road development will outline a maximum bench height of 3 meters and bench widths of 15 meters and 20 meters for production bench and road, respectively. The saprolite zone, because of having more competent material, will have a maximum bench height of 5 meters.

a.3 Stripping

This is done by backhoes digging and loading the overburden materials on different benches to expose the nickel ore. The 22 tonners rear dump trucks are used to haul all dug materials to each designated dumping area. While the stripping of the overburden is carried out, top soil is separately hauled and stockpiled for rehabilitation use. Majority of the waste are delivered into the designated waste dump areas. Stripped out materials are usually consist of the limonitic materials which is overlain the nickel ore. Limonitic materials sometimes has a commercial market value and could be blended during shipment, therefore it has to be stockpiled for future use.

a.4 Ore extraction and grade control

Before ore extraction is carried out, all benches should have been sampled along its faces proceeding in the limonite zone, progressing at lower benches in the saprolite zone. In the limonitic zone face, sampling interval is for every 5.0 meters and 3.0 meters interval for the saprolite zone. Nickel ore classifications (grade control) will be indicated by different color coding tagged in the ribbons placed across the benches. These would serve as guide to the engineers and production supervisors where to assign backhoes in ore extraction which entails skilled operators to visually recognizes the ore classifications. Grade control sampling will be done at slope face and on benches prior to free digging and patterned grade control sampling in dump boxes prior to hauling and on stockpile prior to barging. A total of between 25 and 30 grade control samples will be collected from slope face, on benches, in dump boxes and stockpiles for every truck load. Nickel ores segregation right from the ore extraction/mining to optimize ore grade recovery
.
The mining system involves hydraulic excavators in backhoe mode loading rear dump trucks. The ore benches will then be progressively mined by excavating the overlying bench to allow the progression of the mining to the lower benches until the pit bottom is reached.

a.5 Ore hauling

Ore hauling will use 20-tonne and 25-tonne dump trucks appropriate for transport in both dry and wet conditions from the unsheeted bench ramp road through unpaved road to port loading facility.

Road for ore hauling dump trucks is maintained. The road distance from pit / stockpile area in Causwagan block to the common port loading facility at Purok Mapanga is approximately 6km through mainly unpaved road.

At the Puntalinao area, the existing foot trail will be developed to a suitable 4 km road for ore hauling dump trucks from pit / stockpile area in Puntalinao block to Puntalinao Port 1 area.

a.6 Stockpiling and blending

Pre-pile stockpiling and secondary stockpiling areas will be established. The pre-pile yard will be for differentiating the laterite ore on the basis of slope face and on-bench Nickel grades. The secondary stockpile area at the port loading facility will categorize the laterite ore on the basis of bulk patterned grade control sampling, specifically the determination of moisture content.

a.7 Barging and shipping

Barging corresponds to loading the laterite ore, either by direct loading from dump trucks to barges. Each barge carries a maximum of 5,000 tonnes.

The shipping stage pertains to the loading of the laterite ore from barge to offshore mother vessel. The mother vessel is equipped with 32 tonnes capacity hydraulic excavators. The mother vessel will have maximum capacity of 50,000 wet metric tonnes.

Sample preparation facility and assay laboratory will be constructed near the port loading facility in Purok Mapanga, Barangay Maputi. All mine and grade control samples will be processed, which involves crushing, drying and sieving of soil and rock samples. Assaying of nickel laterite ore will utilize the XRF analysis in the determination of Ni, Fe and Co in unit percentages.

Bulk density determination will be done using bulk test pit samples collected from different laterite zones. Each bulk sample, representing distinct zone in the Nickel laterite profile, will weigh at least 5 kilograms to be suitable to paraffin wax method.

b) Description of the pollution control devices and waste management system

The detailed discussion of the pollution control system is presented in Section 4.c.

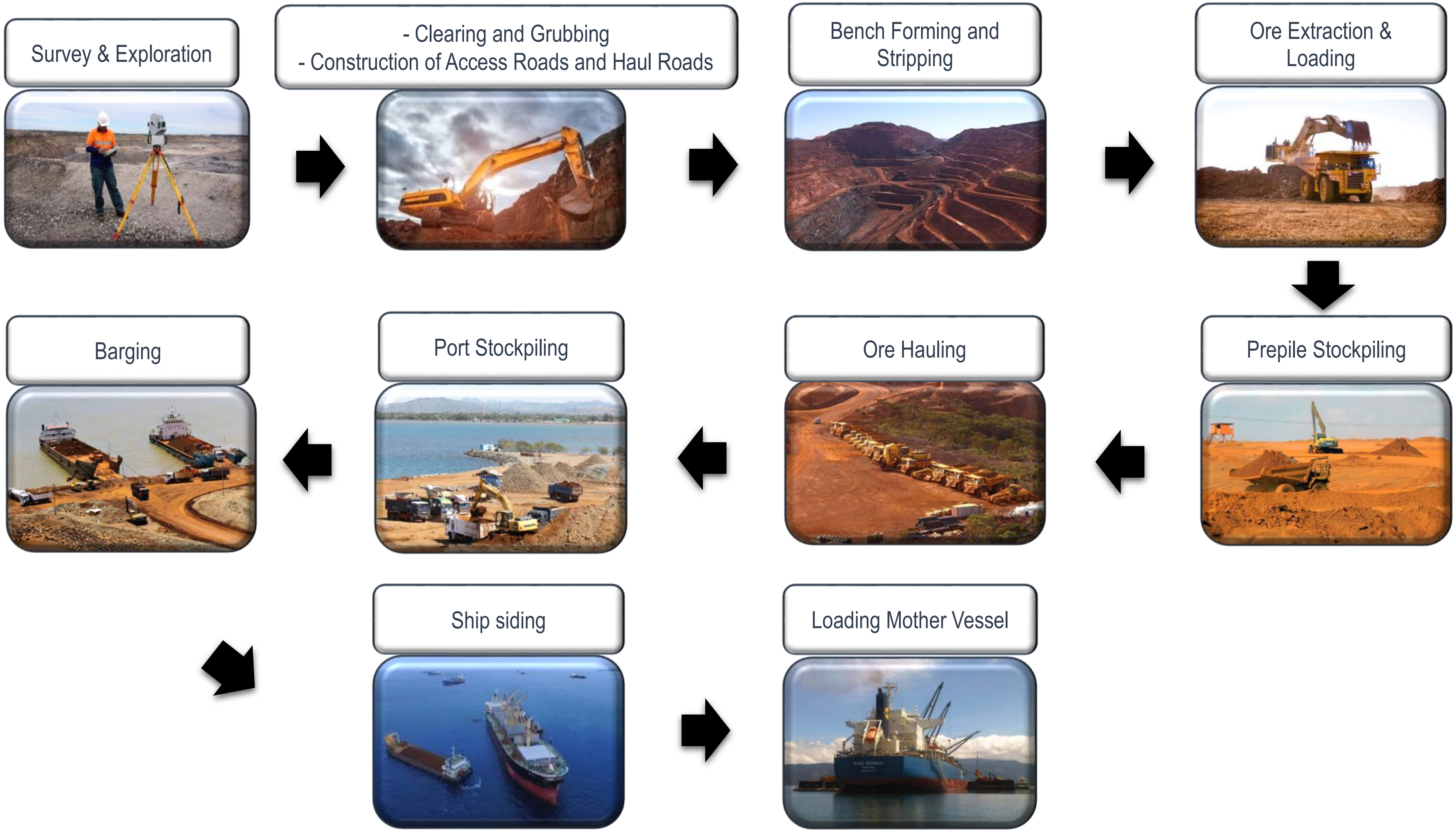


Figure 1.18: Mining Operations Work Flow

6. Project Size

a) Total Amount of Ore/Mineral Reserves in the project area based on exploration data, total Amount of Ore/Mineral Reserves to be extracted, rate of extraction and timetable

Based on the calculated mineral resource of 68,344,000 MT and at an average annual production capacity of 9,600,000 MT, the life of the mine is approximately 8 years. However, there is a great possibility of blocking additional mineral resources within the existing mineral claim as soon as infill exploration drilling progresses.

- *Projected Material Balance for the Mined and Stockpiled Nickel Ore for 3 Vessels Loading: Mining to Shipment Material Balance*

The run off mines during the first (1st) stage of operations where stripping of the waste/overburden is carried out. Wastes like the top soil is separately stockpiled in different waste dump for progressive rehabilitation as the mining progresses.

Table 1.11: Grubbing and Stripping of Overburden

Wastes	Volume
25% top soil	41,250.00 WMT
75% over burden	123,750.00 WMT
Total Waste	**165,000.00 WMT**

Ore production comes in after establishing or exposing the identified benched in the pit area. Ore is mined and hauled in their respective ore classifications in the stockpile yards which has a capacity of 1000 stockpile, each weighing 625 WMT (25 truckloads at 25WMT per truck pile).

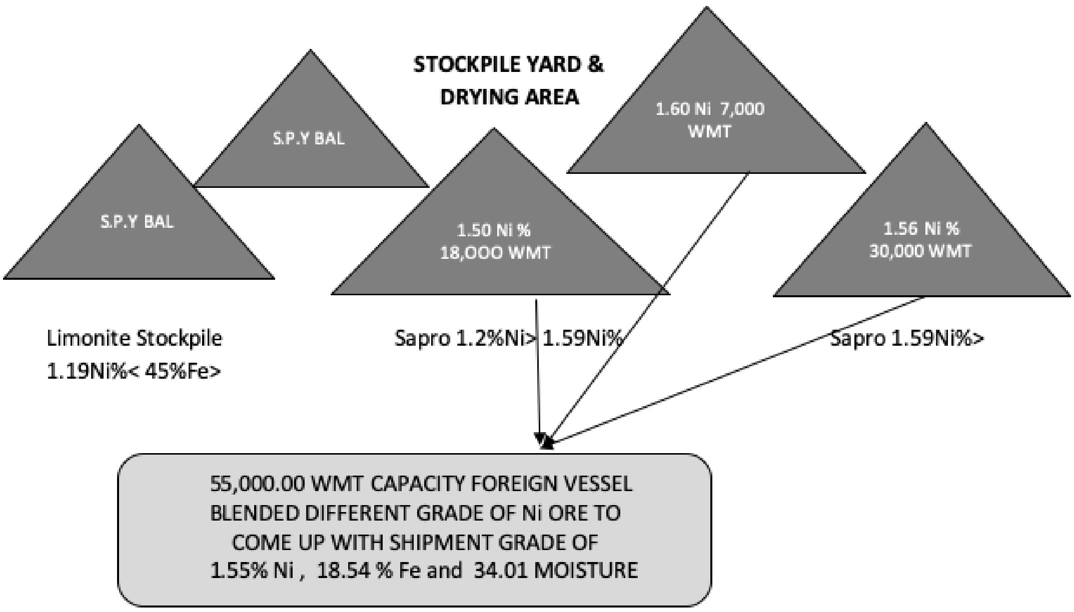


Figure 1.19. Stockpiled Yard and Drying Area

Table 1.12: Mining Pit Ore Extraction

% Grade	Volume
10% limonite	33,000.00 WMT
50% Sapro 1.20>1.59%Ni	165,000.00 WMT
40% Sapro> 1.59% Ni	132,000.00 WMT
Total Nickel Ore	**330,000.00 WMT**

Table 1.13: 1st Vessel Shipment of Nickel Ore Blended Materials

CU. M.	WMT	Ni%	Fe%	H2O
20,000.00	30,000.00	1.56	18.80	33.60
12,000.00	18,000.00	1.50	19.26	34.32
4,667.00	7,000.50	1.60	15.56	35.00
36,667.00	**55,000.50**	**1.55**	**18.54**	**34.01**

Table 1.14: 2nd Vessel Shipment of Nickel Ore Blended Materials

CU. M.	WMT	Ni%	Fe%	H2O
20,000.00	30,000.00	1.56	18.80	33.60
12,000.00	18,000.00	1.50	19.26	34.32
4,667.00	7,000.50	1.60	15.56	35.00
36,667.00	**55,000.50**	**1.55**	**18.54**	**34.01**

Table 1.15: 3rd Vessel Shipment of Nickel Ore Blended Materials

CU. M.	WMT	Ni%	Fe%	H2O
3,250.00	4,875.00	1.30	25.00	34.00
5,500.00	8,250.00	1.45	21.00	31.00
16,000.00	24,000.00	1.75	14.00	34.00
12,000.00	18,000.00	1.60	16.00	36.00
36,750.00	**55,125.00**	**1.53**	**19.00**	**33.75**

The three (3) shipments will have a total of 165,126.00 WMT with 55,000 WMT capacity each. With a volume of 330,000 WMT nickel ore extracted, the material balance left in the stockpile, theoretically for 3 vessel shipment, would be 164,874.00 WMT.

Ore Classification is their %grade of nickel and its iron content. Different ore classification is yet to be established after the mining production reaches to its target tonnage and its nickel %grade mining recovery. For a nickel mine that has not yet started its ore production, material balance is not accurate in terms of quality as its presented grade is randomly taken from the drill holes not in real stockpiles. However, the indicated diagram of stockpiles is the usual movement of nickel ore being mined, hauled, and stockpiled to the stockpile yard and purposely also as drying area to mining moisture content down to 30%, as required. With this circumstances, the annual material balance was shifted to the early stage of mining operations. Normally, this example of production started with stripping of waste/overburden and will took about 3 to 4 months to accomplish depending on the weather.

b) Total Project Area in square meters or hectares

The total MPSA are is 6,363.3368 hectares with 1,072.20 hectares considered for partial declaration. Mining area 1 and Mining area 2 has a total area to 500 hectares each.

The summary of the estimated Ore Reserve is detailed in Table 1.3 on page 15 above.

7. Development Plan, Description of Project Phases

Pre-Construction Phase

The pre-construction phase will involve the following activities:

- Exploration and Site Assessment
- Securing of necessary permits and clearances
- Land acquisition and/or land lease for support facilities (including finalization of other necessary lease agreements)
- Focused Group Discussions among stakeholders

Construction and Operational Process

The construction and operational phase include the development of mine pits and trenches, construction of support facilities such as additional access roads, bunk houses, erosion control structures, drainage canals, settling ponds, stockyards and slope stabilization measures.

Development of Mine Pits

Overburden materials will be removed to expose nickel laterite ores. Once the surface has been stripped, excavated and extracted the Nickel deposits will follow using bulldozers as rippers or backhoes with rock breaker.

The progress of mining operation is indicated, herein, with the benches elevation mined out down to designed elevation (see **Figures 1.20a, 1.20b, and 1.20c)**. It could be noted that the development of Mining Area 1 starts at B-860 down to B-701, this would attribute to the alteration of the original ground elevation to this particular mine pit only. Same with the succeeding development of each Mining Area 1 and Mining Area 2 scheduled during year 2 and year 3. The table shows the projected top elevation to be started overburden stripping and will end at the bottom as shown in the difference in elevation column. The height of the benches are three (3) meters and final pit slope is 45 degrees. The final mined out pit area is provided with proper drainage until it undergo rehabilitation works. (*Presently 3-D maps for the purpose of geomorphological presentation is not available as it requires a mining engineering software.)*

Table 1-16: Development of Mine Pit

Year	Bench/Elevation	Location	Difference in Elevation	Benches
Year 1	860-701	Area 1	159	53
Year 2	800-752	Area 1	48	16
	842-701	Area 2	141	47
Year 3	770-731	Area 1	39	13
	350-252	Area 2	99	33

Mine Yards and Waste Dumps

RCMC will construct mine yards to accommodate ore piling, segregation and drying operation. Portion will be allotted for overburden materials for backfilling, road construction or for mined-out area rehabilitation.

Mine yards and waste dumps shall be provided with adequate drainage canals and silt control ponds/sumps.

Construction of Support Facilities

RCMC constructed support facilities, including the maintenance of the access road from mine site to main road, construction of other mine facilities such as workers camp, assay laboratory, stockpile yards, mine utilities (water supply, power supply, motor pool, etc), other pollution control facilities (i.e, settling ponds, fascines, mini-rock dams, drainage, canals and sumps), and nursery.

Road construction and maintenance

Mine haul roads were develop into the mining areas initially on natural topographic surface. These road have be constructed with the appropriate road base to allow safe and efficient traffic management and provided with drainage canals and sumps. The Proponent also implements appropriate mechanism for grade control and ensure that the ore transport is within the parameters set by the MGB and other regulatory agencies.

Abandonment and Rehabilitation Phase

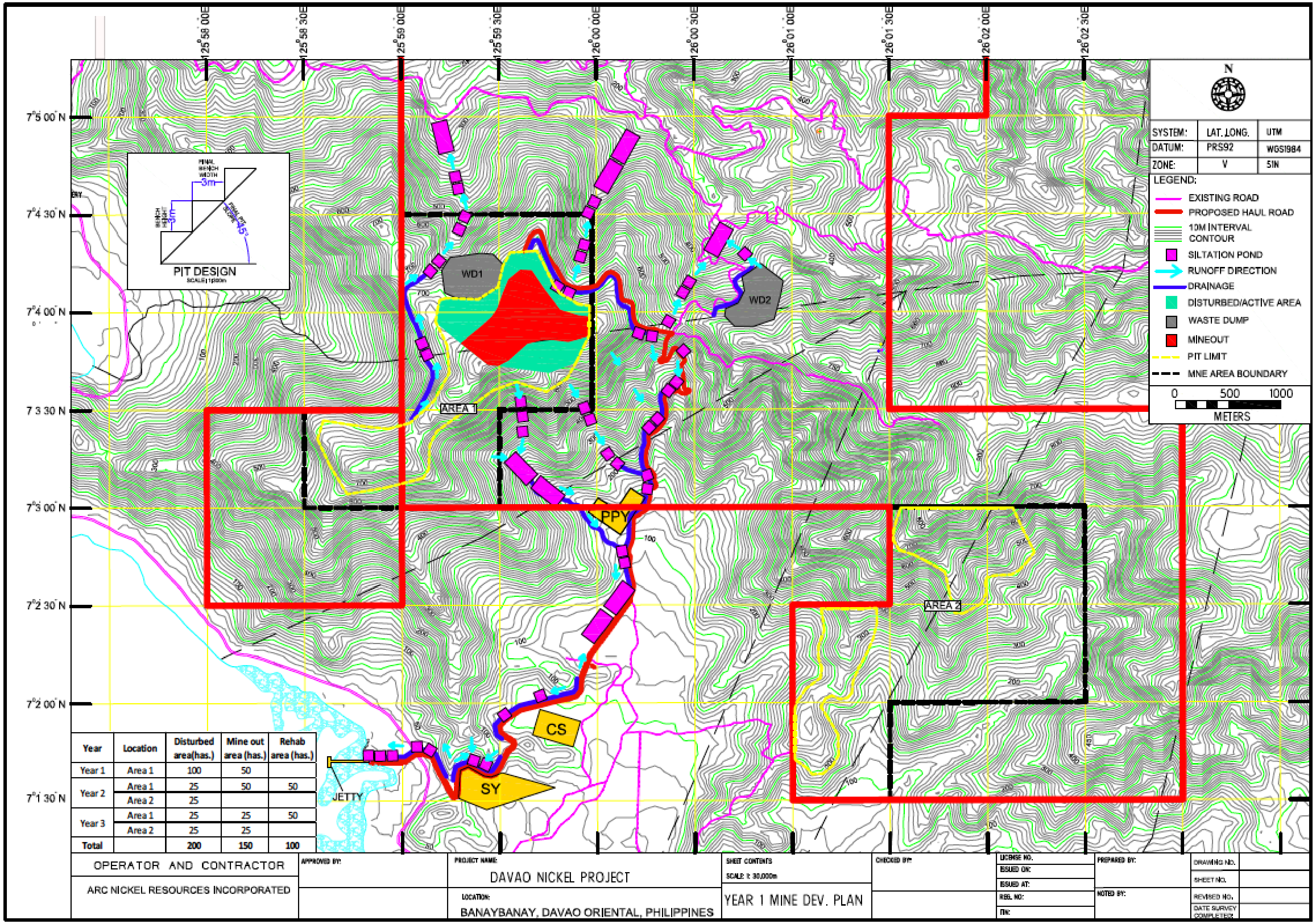
Progressive rehabilitation strategy will be implemented, integrating mitigation and management of adverse impacts to the mining operation cycle, instead of undertaking a large scale rehabilitation work at the conclusion of mining operation. Whenever feasible, backfilling of the mind-out voids will be undertaken. The details of the work program for a given area depends on the local bench configurations and ultimate landform design. Small steep benches will be left exposed ,while mined areas and shallow trenches will be backfilled and graded to long-term stable slopes. Adits, trenches and open pit that were abandoned are included in the progressive rehabilitation and abandonment plan.

The progressive rehabilitation scheme will minimize the extent of disturbance and the time of exposure of disturbed areas. This will be complemented by mulching of disturbed areas and covering of dried ore in the stockyard area. Below are the details of the progressive rehabilitation scheme to be implemented:

1. Planning
   - 1.1 Set up and build appropriate plant nursery right at the 1st stance of the mobilization as equipment needed is already available.
   - 1.2 Collect and condition endemic plant species during clearing & grubbing
   - 1.3 Preparation of fast growing trees which could be planted 5 months period.
   - 1.4 Soil testing will be needed to test acidity and type of tree plants is suitable, including fertilizers.
   - 1.5 Keep close coordination with the local CENRO office for assistance to produce more species of seedlings suitable for the area.

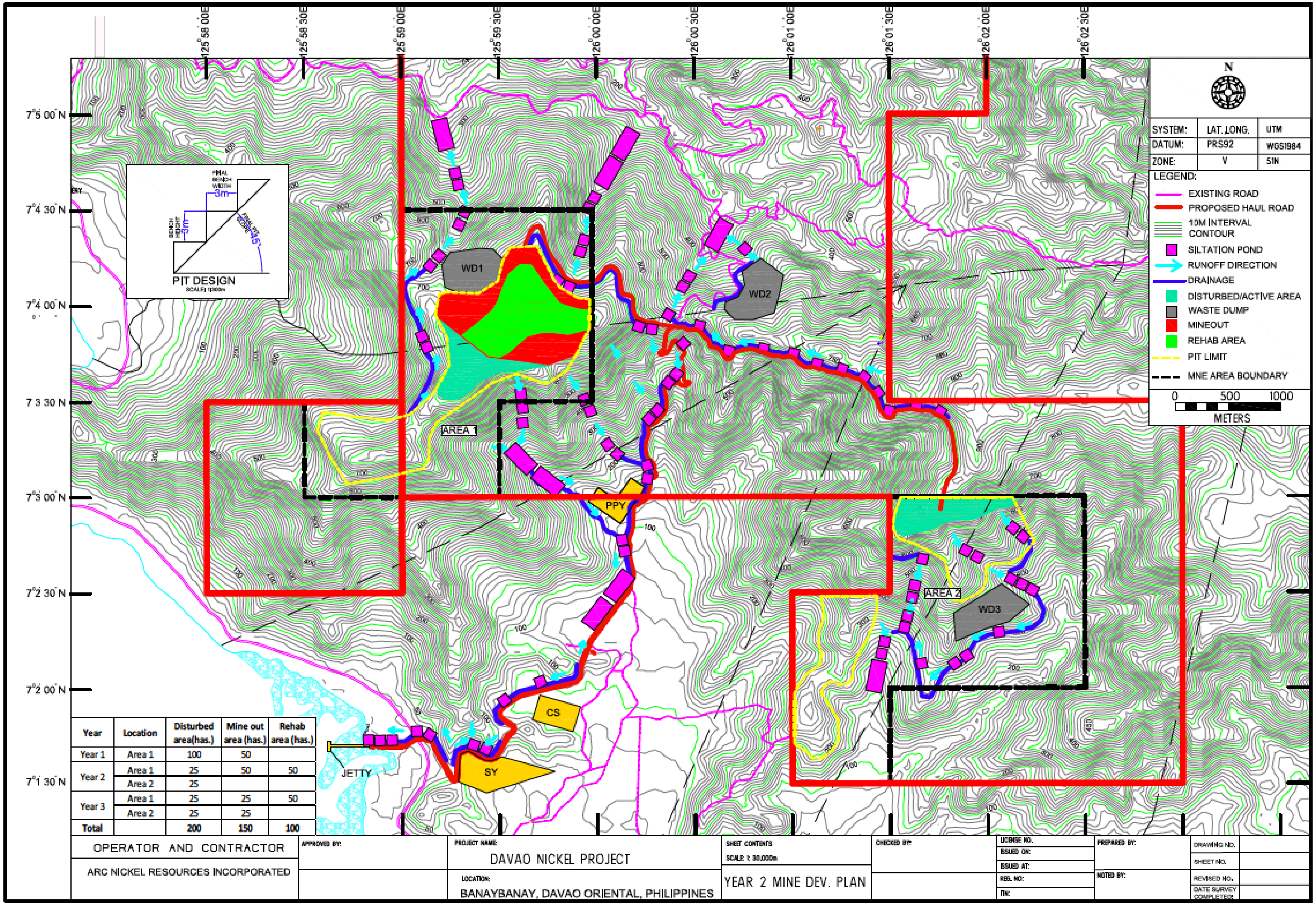
2. Implementations
   - 2.1 Fast track the progress of the targeted mined out area for immediate ground preparation even if after 5-6 months operations to initially commence at 10 has.
   - 2.2 Reshape the area as ground preparation in progress making a ground slope less than 40 degrees.
   - 2.3 Design proper drainages system to avoid the creation of ripples across the slope that will cause erosion.
   - 2.4 Drainage should be at the toe line of the slope and not at the crest line where water will pool in during heavy rains.
   - 2.5 Backfill the area by overburden mixed with top soil .
   - 2.6 Coco net is always installed in unstable ground slope to avoid or minimize erosions.

Prior to the actual abandonment and rehabilitation phase, a detail abandonment and rehabilitation plan shall be develop based on the detailed biological, geological and engineering assessment. The company forester will lead the terrestrial and fresh water biological assessment to the update the plan. The company mining engineer and geologist will take stock and update the geological and engineering requirement for abandonment and rehabilitation. The RCMC management shall ensure that the plans are adequately backed by personnel and financial support.



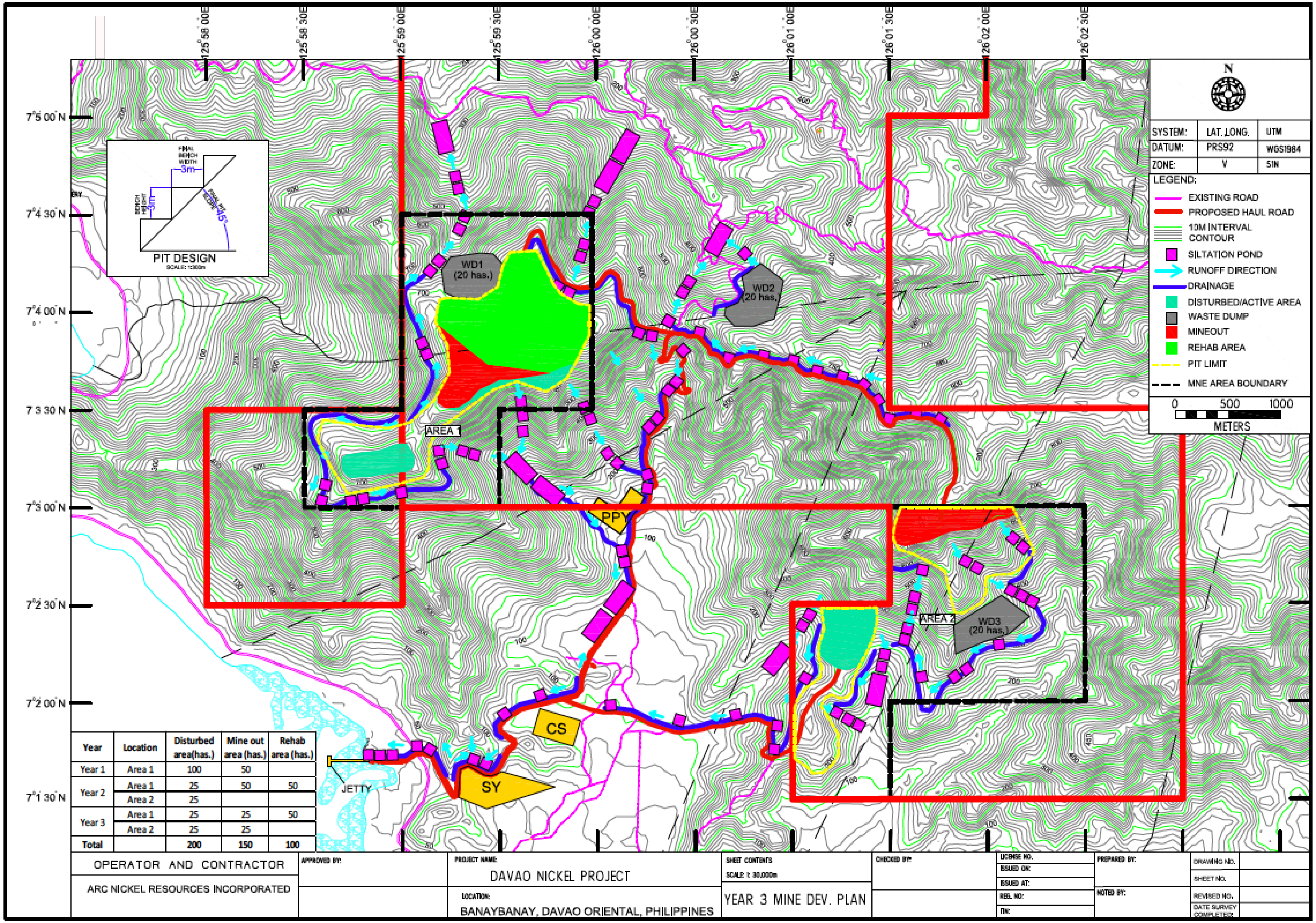
Year	Location	Disturbed area(has.)	Mine out area (has.)	Rehab area (has.)
Year 1	Area 1	100	50	
Year 2	Area 1	25	50	50
	Area 2	25		
Year 3	Area 1	25	25	50
	Area 2	25	25	
Total		200	150	100

Figure 1.20a. Mine Development Plan Year 1



Year	Location	Disturbed area(has.)	Mine out area (has.)	Rehab area (has.)
Year 1	Area 1	100	50	
Year 2	Area 1	25	50	50
	Area 2	25		
Year 3	Area 1	25	25	50
	Area 2	25	25	
Total		200	150	100

Figure 1.20b. Mine Development Plan Year 2



Year	Location	Disturbed area(has.)	Mine out area (has.)	Rehab area (has.)
Year 1	Area 1	100	50	
Year 2	Area 1	25	50	50
	Area 2	25		
Year 3	Area 1	25	25	50
	Area 2	25	25	
Total		200	150	100

Figure 1.20c. Mine Development Plan Year 3

8. Manpower

The free digging, direct shipping ore Nickel laterite operation will require approximately 1,000 employees, including the contractors, on the basis of a 100,000-tonne-per-day (tpd) mine production. The total manpower requirement will consists of the Mine Operation, Administration and General Support groups and Contractors. Please refer to **Table 1.16** for the summary.

Table 1.17: Summary of Manpower Requirement

Table 1.17a: Manpower during Construction

DIVISION GROUP	DEPARTMENTS	No. OF PERSONNEL
Roads Construction	1.0 Mine Engineering	18
Environmental Works	2.0 MSHED	9
Administration	3.0 Human Resources	6
	3.1 Security	100
Accounting Finance	4.0 Warehousing and Logistics	18
General Support Group	5.0 Constructions	100

Table 1.17b: Manpower during Operation

DIVISION GROUP	DEPARTMENTS	No. OF PERSONNEL
Mining Operations	1. Mine Engineering	12 w/ Manager
	2. Production	22 w/ Manager
	3. Mine Quality Control	12 w/ Manager
	4. MSHED-Mine Safety Health and Environment	8 w/ Manager
	4.1 Environmental and Forestry (MEPEO)	3
	4.2 Medical Clinic	4 w/ Medical Doctor
	5. Mine Quality Assurance	9 w/ Manager
	6. Mine Port and Shipment	9 w/ Manager
Administration	7. Mine Admin/ HR	22 w/ Manager
	7.1 Corporate Social Responsibility	3
Accounting and Finance	8. Purchasing / Warehousing	7 w/ Manager
General Support Group	9. Mine Technical Services	9 w/ Manager
	10. Exploration	3
Security Agency	11. Security Coordinator	4
	Personnel	100

9. Project Cost

The proposed Nickel Mining project is estimated to have an investment of One Billion Eight Hundred Million Pesos (Php1,800,000,000.00) which will cover the construction of buildings, and structures, purchase of office and laboratory equipment, working capital, and miscellaneous expenses.

2.0 Baseline Environmental Conditions, Impact Assessment, and Mitigation

2.1 LAND

2.1.1 Land use and Classification

Based on the 2010 Land Use Map from the NAMRIA, the major land use or vegetative cover of the area includes open forest, shrubs/grasslands and perennial crops. The area is designated as Alienable and Disposable Land.

2.1.1.1 Impact in terms of compatibility with existing land use

The proponent will secure proper clearances prior to the development of the project to address land compatibility.

2.1.1.2 Impact on compatibility with classification as an Environmentally Critical Area (ECA)

There are identified environmentally critical areas near the project site. **Table 2.1** summarizes the list of ECA categories as declared by Proclamation No. 2146 in relevance to the project site.

Table 2.2-1: List of ECA Categories

List of ECA Categories (as declared by Proclamation No. 2146)	Remarks
1. All areas declared by law as national parks, watershed reserves, wildlife preserves, sanctuaries	The project area is not within a declared NIPAS Protected Areas. Please see **Figure 2.1-1.**
2. Areas set aside as aesthetic potential tourist spots	There are no identified potential tourist spots within the boundaries of the project site. Please see **Figure 2.1-2.**
3. Areas which constitute the habitat of any endangered or threatened species of indigenous Philippine wildlife (flora and fauna)	There are no protected KBAs present within the boundaries of the project site. Therefore the area is not inhabited by endangered species. Please see **Figure 2.1-3.**
4. Areas of unique historic, archaeological or scientific interest	As shown in **Figure 2.1-5**, there are ni identified historical centers/zones in the proposed project site.
5. Areas which are traditionally occupied by cultural communities or tribes	The Mamanua Tribe (Mansaka-Mandaya Tribe) are the local IPs present in the neighboring barangays in the project site. The proponent is undergoing the process of securing the FPIC with the tribe. A memorandun of agreement has been forged between the tribal representatives and the proponent and is attached as Annex 10. The proponent will comply with the conditions set forth in the MOA during the course of project's development and operations. The Approved CADT Map of the Province of Davao Oriental is presented as **Figure 2.1-4**.
6. Areas frequently visited and/or hard-hit by natural calamities: 6.1 Geologic hazard areas	 The project site and its vicinity is situated in a seismically active region. There are also nearby earthquake generators that pose seismic hazards (**Figure 2.14**). Based on the active faults map of PHIVOLCS, the project site is about 13 km to the west of the Mati Segment of Philippine Fault Zone (PFZ)

List of ECA Categories (as declared by Proclamation No. 2146)	Remarks
	Within the MPSA, the areas susceptible to liquefaction are the river and creeks and their associated floodplains and terrace deposits where silty and sandy layers abound **(Figure 2.17).** The swampy areas and rice fields along the coasts are susceptible to liquefaction. The reclaimed areas in Puntalinao are also highly susceptible to liquefaction. Based on the earthquake-induced landslide susceptibility map from PHIVOLCS **(Figure 2.19)**, the project site has low to high susceptibility to earthquake-induced landslide. Causwagan block is mostly classified as having low susceptibility while Puntalinao block has medium to high susceptibility. The landslide hazard map of the Banaybanay produced by DOST - Project NOAH classifies most of the MPSA area as high susceptibility to landslides **(Figure 2.24)**
6.2 Flood-prone areas	The southern part of the MPSA area is drained by at least four well-defined streams. Debris flows and stream bank erosion are the major flood related hazard identified within the MPSA area. The flat to gently sloping areas of barangays Maputi and Causwagan are within low to moderately susceptible zone. This is outside of the MPSA area but there are proposed facilities such as the motorpool and materials storage area. The access roads also traverse these areas. According to the residents in the built-up areas near Maputi and Mapagba rivers, flood depth reaches up to waist level or around 1 m when river flood coincide with high tide. The Mines and Geosciences Bureau published a flood susceptibility map in 1:10,000 scale, which classifies flooding from low to very high (**Figure 2.29).**
6.3 Areas frequently visited or hard-hit by typhoons	The coastal areas in Barangays Causwagan and Puntalinao are susceptible to tsunami that could come from Celebes Sea or Davao Gulf based on the tsunami hazard map produced by PHIVOLCS **(Figure 2.22).**
6.4 Areas prone to volcanic activities / earthquakes	There is no nearby active volcano close to the project site. The nearest active volcano is Mt. Leonard Kniassef in Maco, Compostela Valley **(Figure 2.28).** Mt. Matutum is another active volcano located in South Cotabato, which is about 128 km to the southwest of the project site.
7. Areas with critical slope	The MPSA area is situated in this hilly to mountainous terrain with elevation varying from 40 to 900 m **(Figure 2.5).** Slopes within the project site ranges from steep (30-50%) to very steep (>50%), with some undulating (8-18%) to

List of ECA Categories (as declared by Proclamation No. 2146)	Remarks
	moderately steep (18-30%) areas in narrow valleys **(Figure 2.6)**
8. Areas classified as prime agricultural Lands	Based on the **(Figure 2.1-6)** proposed mining site is not covered by the existing agricultural production areas map of Davao Region.
9.Recharged areas of aquifers	Based on **Figure 2.1-7,** the project site is adjacent to the watershed.
10. Water bodies (all natural water bodies (e.g. rivers, lake, bay) that have been classified or not)	Water bodies within and near the project area are not declared as protected.
11. Mangrove areas (as mapped or identified by DENR)	The proposed mining site is inland; therefore, this will pose no impacts on Mangroves and coral reefs.
12. Coral reefs (as mapped or identified by DENR or DA-BFAR)	

Based on the situations summarized above, the project is subjected to criteria's that concern cultural/social and geologic hazard areas.

To harmonize the existence of the project and the IP community, the proponent has undergone the Free, Prior and Informed Consent (FPIC process) that eventually forged a Memorandum of Agreement (MOA) with the IP group/s. The proponent will follow abide by the stipulations of the MOA to ensure the safety and general well-being of the IP community.

Consequently, the corresponding geohazard assessment findings shall be taken into account in the planning, day to day operations and the eventual rehabilitation of mining areas.

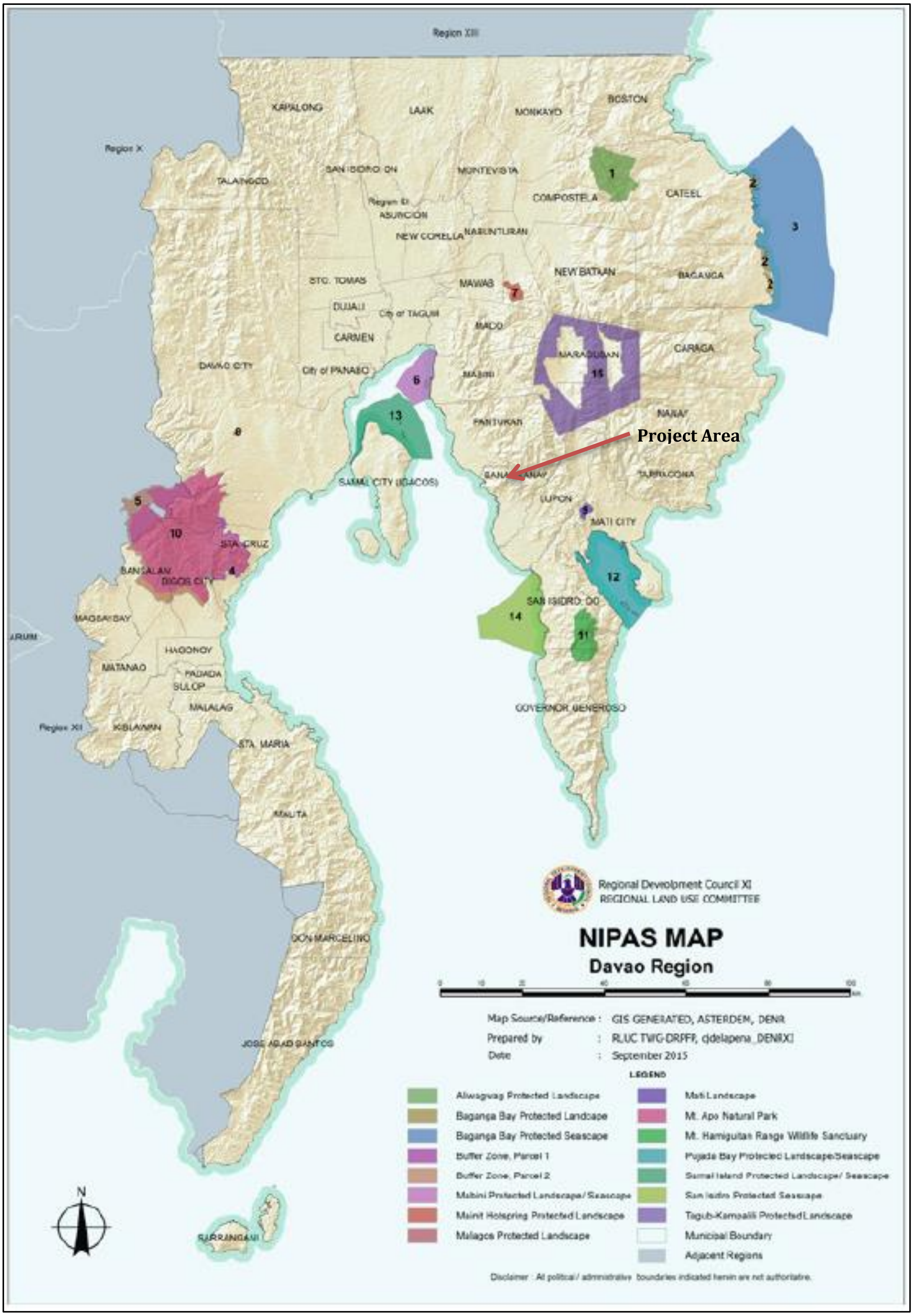


Figure 2.1-1: NIPAS Map of Davao Region
(Source: DRPFP 2015-2045, September 2015: ASTERDEM, DENR, GIS Generated)

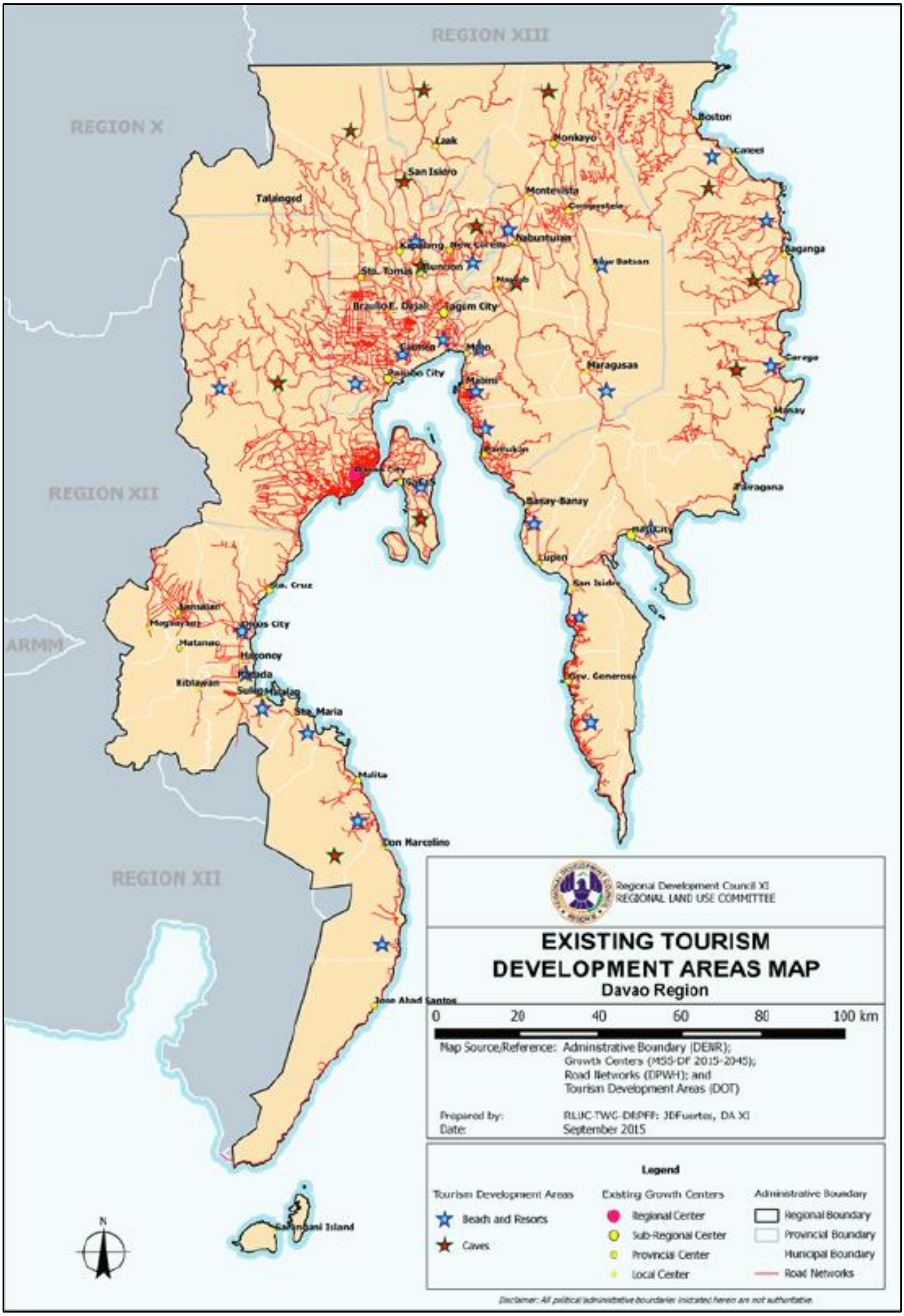


Figure 2.1-2: Existing Tourism Development Areas Map of Davao Region (Source: DRPFP 2015-2045, September 2015: Administrative Boundary by DENR, MSS-DF 2015-2045, DPWH, and DOT)

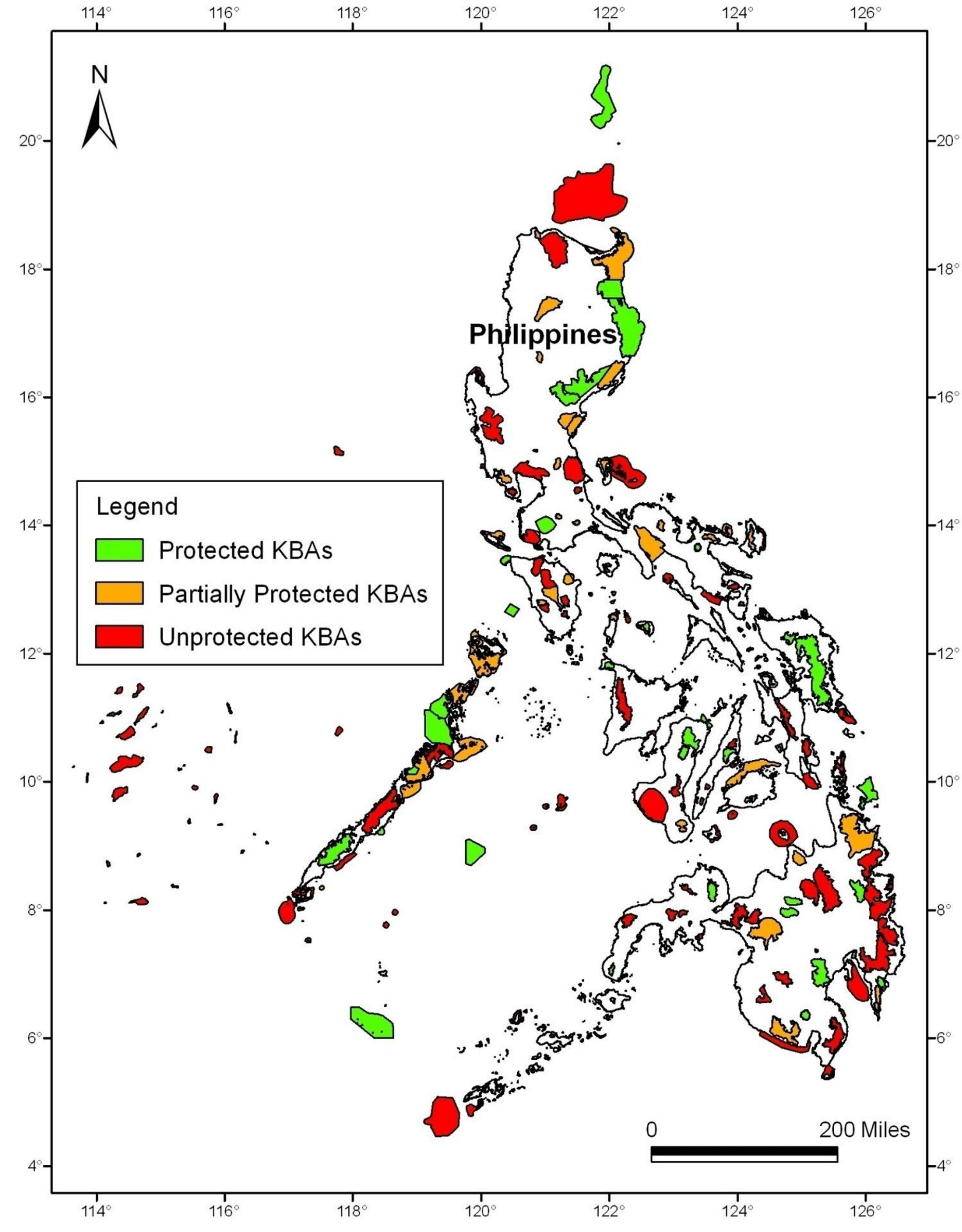


Figure 2.1-3: Philippine KBA's Protection Map 2006 to 2009
(Source: Ambal RGR, et.al. 2012)

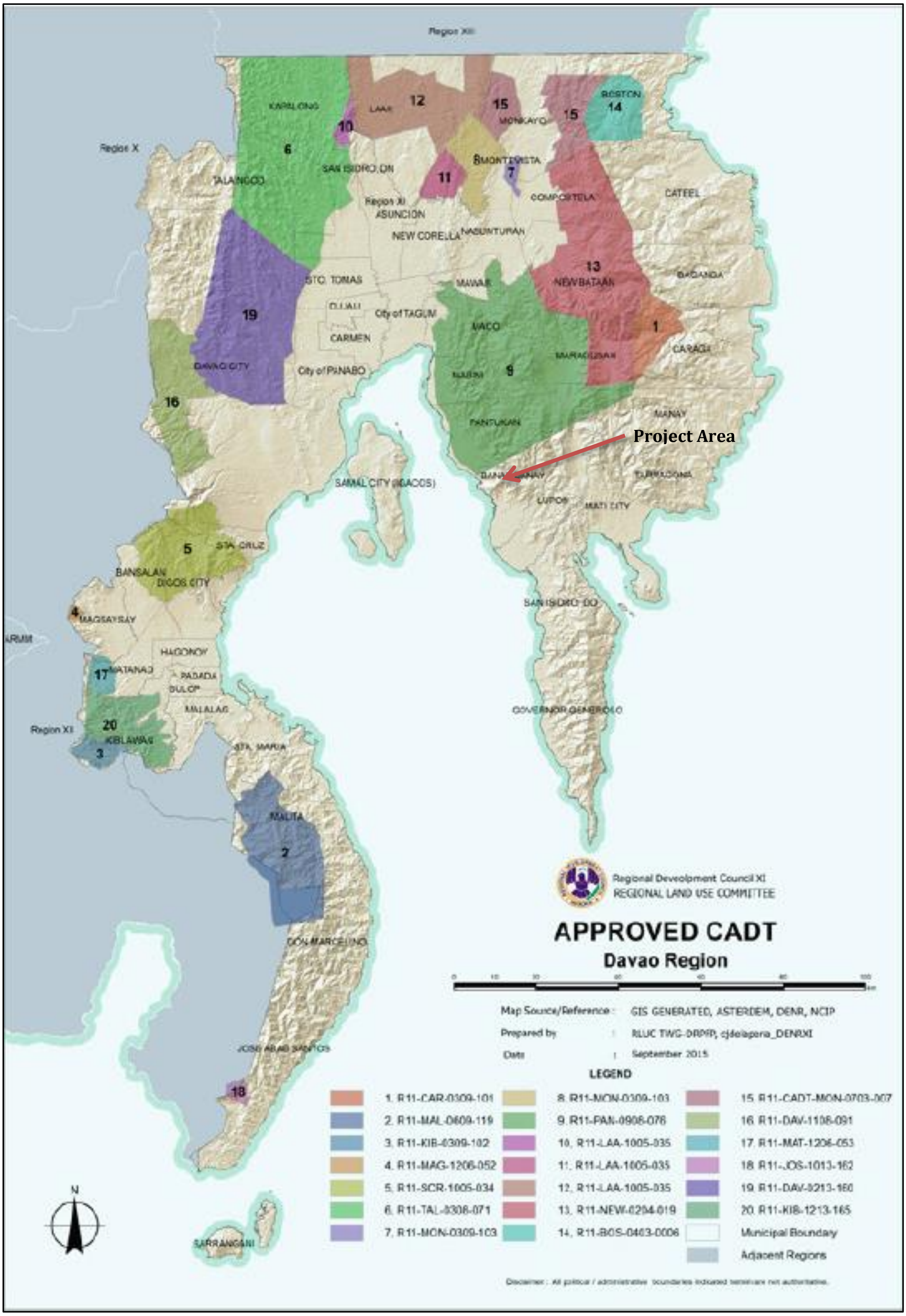


Figure 2.1-4: Approved CADT Map of Davao Region
(Source: DRPFP 2015-2045, September 2015: DENR, NCIP, ASTERDEM, GIS Generated)

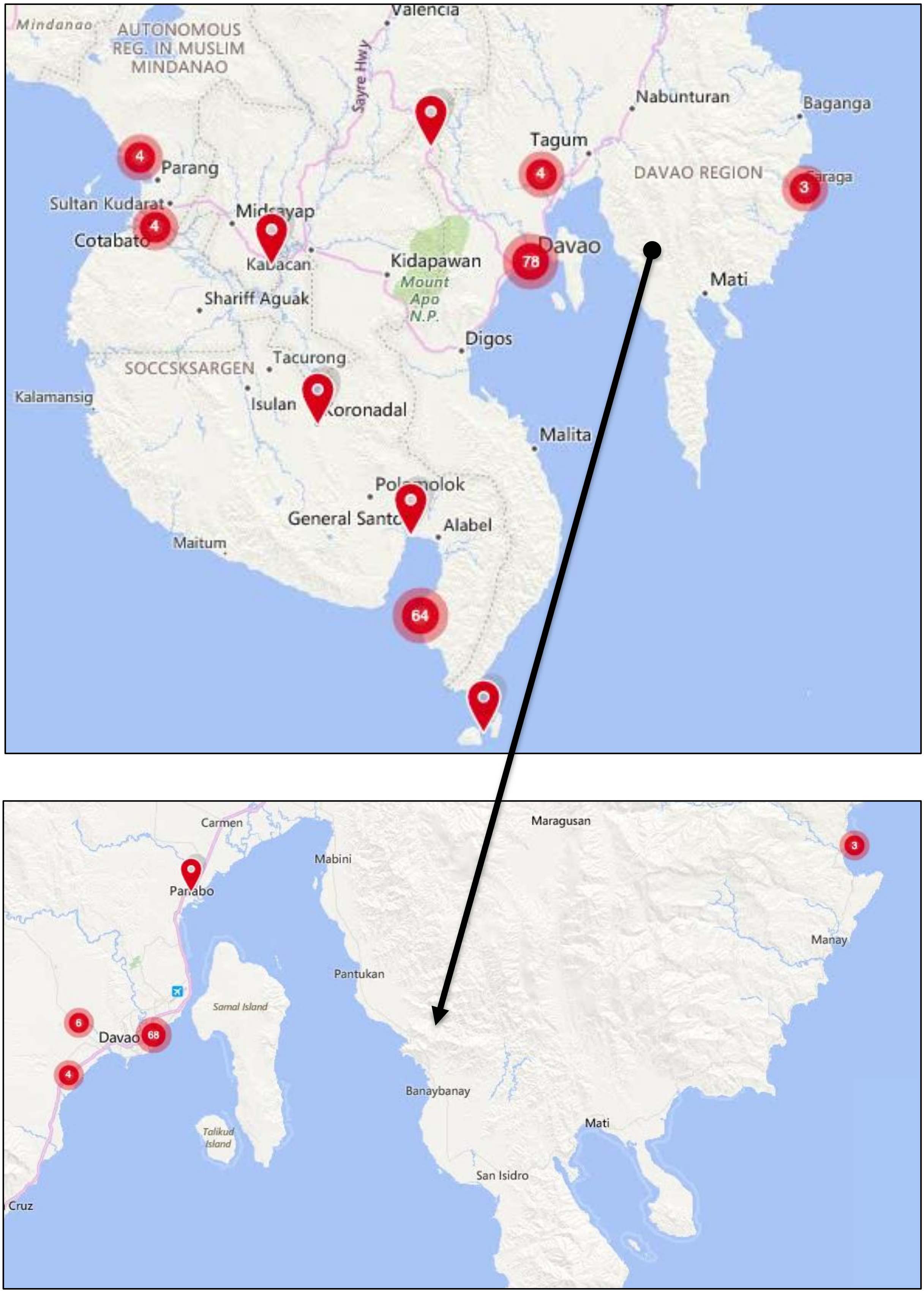


Figure 2.1-5: Identified Historical Centers/Zones in the Philippines
(Source: https://www.philippineheritagemap.org/map, Retrieved: October 2019)

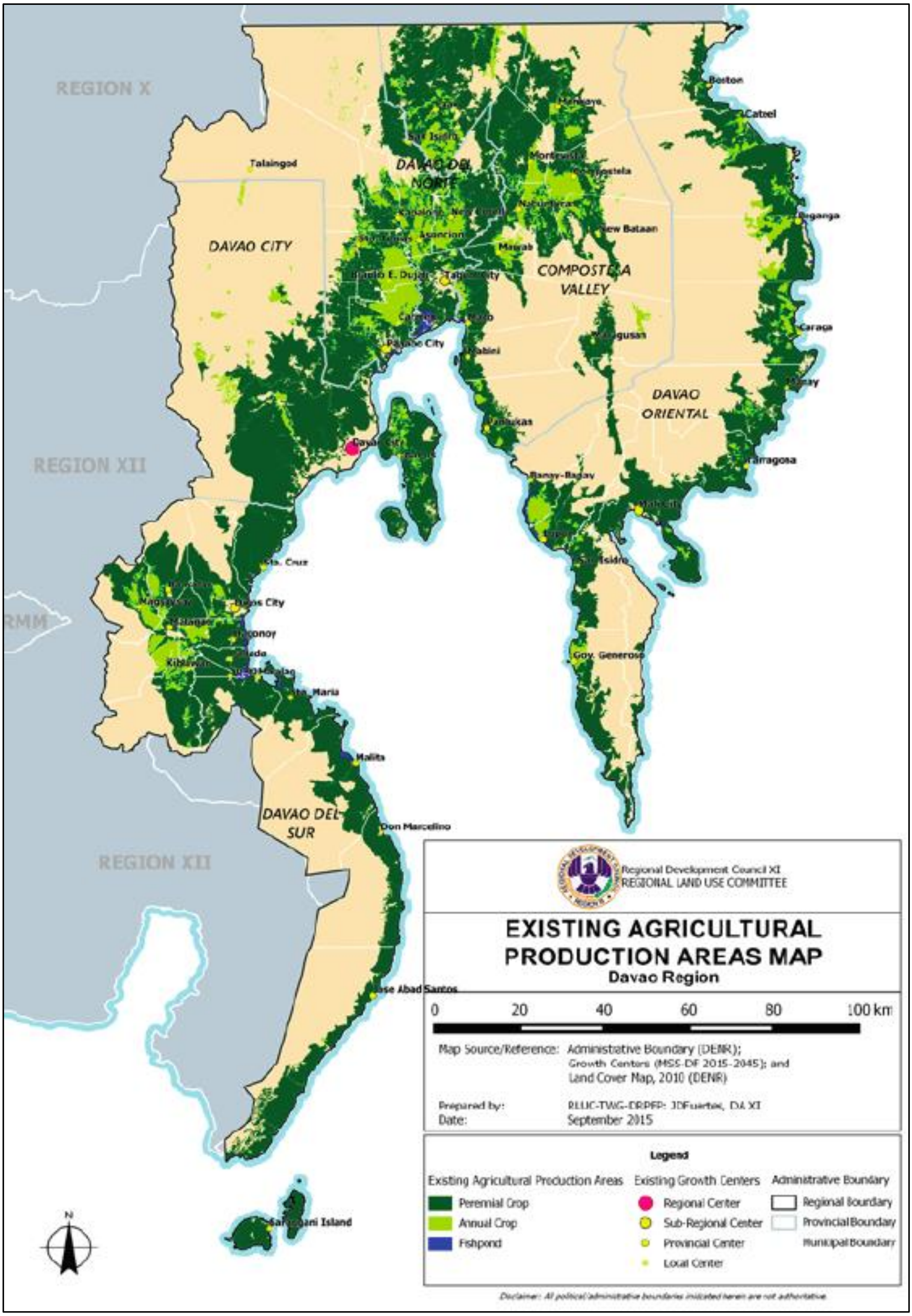


Figure 2.1-6: Existing Agricultural Prodcution Areas Map in Davao Region (Source: DRPFP 2015-2045, September 2015: Administrative Boundary by DENR, MSS-DF 2015-2045 and Land Cover Map, 2010 by DENR)

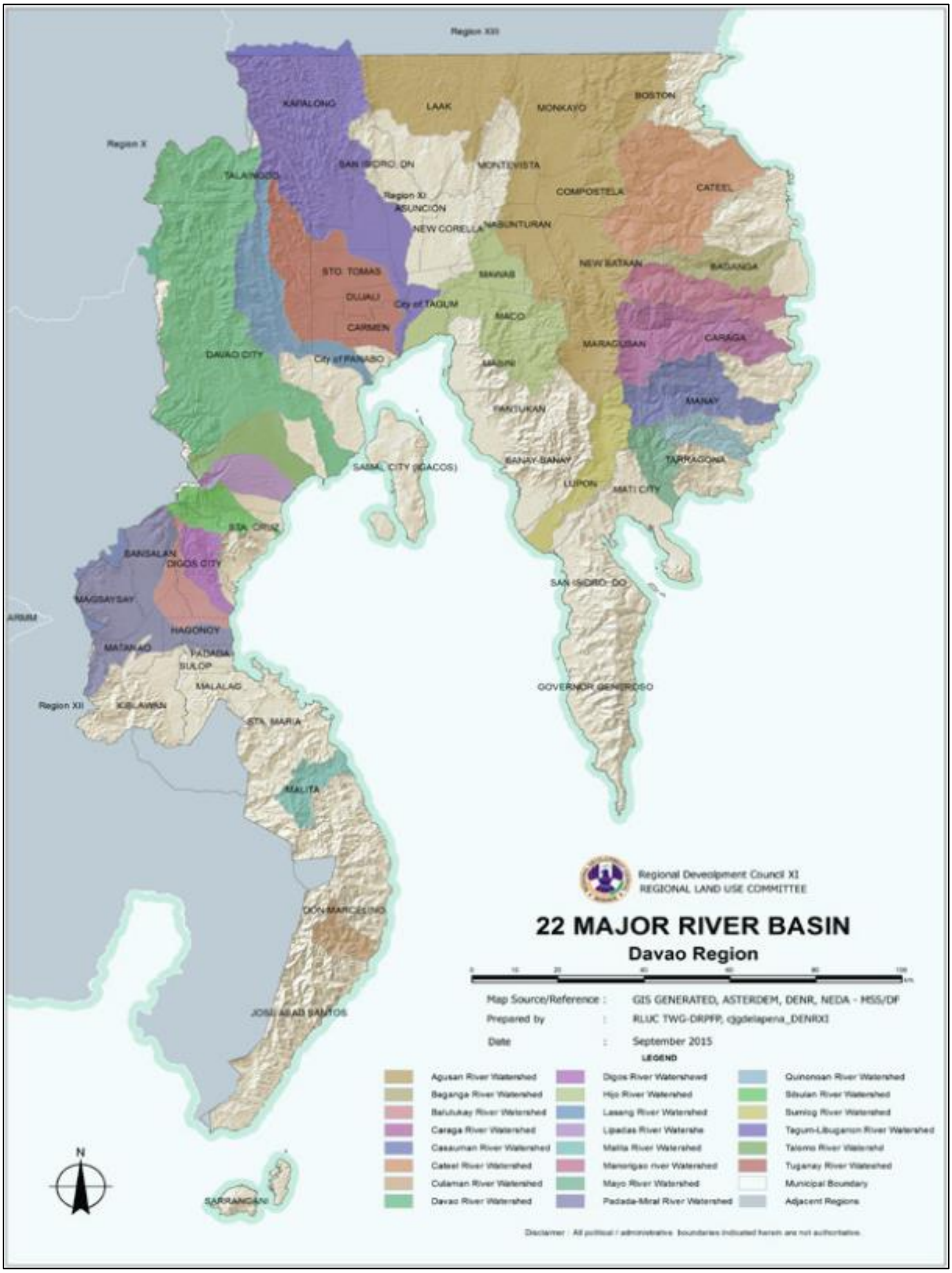


Figure 2.1-7: 22 Major River Basins in Davao Region
(Source: DRPFP 2015-2045, September 2015: NEDA-MSS/DF, ASTERDEM, GIS Generated)

2.1.1.3 Impact in existing land tenure issue/s

The proponent is undergoing the process of securing the Free, Prior and Informed Consent with the Mandaya tribe in the community. After series of community consultative assemblies, consensus building and decision meeting, an NCIP endorsement will be issued to the proponent. A Memorandum of Agreement (MOA) was forged between the tribal representatives and the proponent.

The proponent shall continue to comply with the conditions set forth in the MOA during the course of the project's development and operations. Being a partner in community development, the proponent has been supporting the programs of the Indigenous Peoples group/s.

The stipulations of the aforementioned MOA will be enforced for the duration of the project to give what is due to the Mandaya tribe in the host communities.

2.1.1.4 Impairment of visual aesthetics

Davao Oriental covers the southern part of the Pacific Cordillera in eastern Mindanao. It is generally mountainous with sharp ridges and spurs surrounded by low hills. The MPSA area is situated in this hilly to mountainous terrain with elevation varying from 40 to 900 m. Secondary forests mostly cover the central part of the MPSA area, but there are spurs which are dominantly grassland. The surrounding low hills are converted into croplands planted with mangoes and other crops. Landslides abound particularly in the grassy slopes. The existing mining site of Golden Summit Mining in Barangay Maputi and Causwagan is very prominent amidst the greeneries. It is situated adjacent to Causwagan Block and encroaches to the western part of the MPSA area. The mining site in Causwagan Block is located between 200 to 300 m elevation. It is visible in the national road and open areas particularly in Barangay Maputi, Causwagan, Piso and other communities to the southwest. The proposed mine site in Puntalinao Block is located in the ridge, between 700 to 800 m elevation. It is visible along the national road and coastal barangays including Maputi, Puntalinao, Pintatagan and other communities in Pantukan, Compostela Valley (**Figure 2.1-8 and Figure 2.1-9**).

Figure 2.1-8. View of the existing mine site of Golden Summit from the national road. The eastern part (right side) of the mine site is within the MPSA area of Riverbend. The mountainous terrain in the background is also part of the MPSA area.

Figure 2.1-9. The ridge in this photo is the proposed mining site in Puntalinao Block.

Clearing of vegetation, road construction and open cut mining in the mining blocks will have a visual impact to the community and travelers passing along the major roads. The mine site will be very visible since it is located in an elevated area and there is a significant contrast in the color of the laterite and vegetation. A visual impact assessment was conducted to determine the areas where the proposed mining sites maybe visible. The analysis was carried out using the Viewshed Tool in QGIS. The input used was the SRTM-DEM. Hypothetical viewpoints were created in the area with high Nickel concentration to represent the location of the open cut. Each view point has its corresponding area where it will be visible given its position in the topography. The result of the viewshed analysis for each point is combined to form the Area Visibility Map. This map shows the composite area where the hypothetical open cuts will be visible assuming that all open cuts are active at the same time. Based on this map, there are mining areas, which will be visible in the communities and along the major roads (**Figure 2.1-10**). This implies that when the all the mining areas are cleared at the same time, the visual impact covers a large area. Thus, it is necessary for the mining activity to operate in stages and immediately rehabilitate the mined out areas to lessen the visual impact. Vegetation buffer, consisting of suitable fast growing trees, could also be maintained around the mine sites to shield the view.

2.1.1.5 Devaluation of land value as a result of improper solid waste management and other related impacts

To minimize devaluation of the land due to improper solid waste management, measures such as proper housekeeping, waste minimization and segregation, and proper machine maintenance will be employed. Proper housekeeping is basically keeping a clean, orderly construction site. It will involve implementation of rules and regulations within the Project site that will reduce, if not eliminate, the possibility of accidental spills, improve the response time if there is a spill, and reduce safety hazards as well. Related to this, waste minimization and segregation practices to prevent soil contamination. Waste recycling and timely waste collection and disposal are just a few of the numerous techniques that can be used in the Project site. This will be done in coordination with the LGU. Likewise, proper machine maintenance of equipment involves regular maintenance check-up, timely fuel and oil change, and proper machine handling to minimize the risk of soil contamination. A designated machine shed and fuel/oil depot with oil collectors and proper floor protection further minimizes soil contamination. As much as possible, major maintenance works for equipments will be done outside the project area. Each worker shall also be given instructions on the proper storage, use and disposal of supplies used.

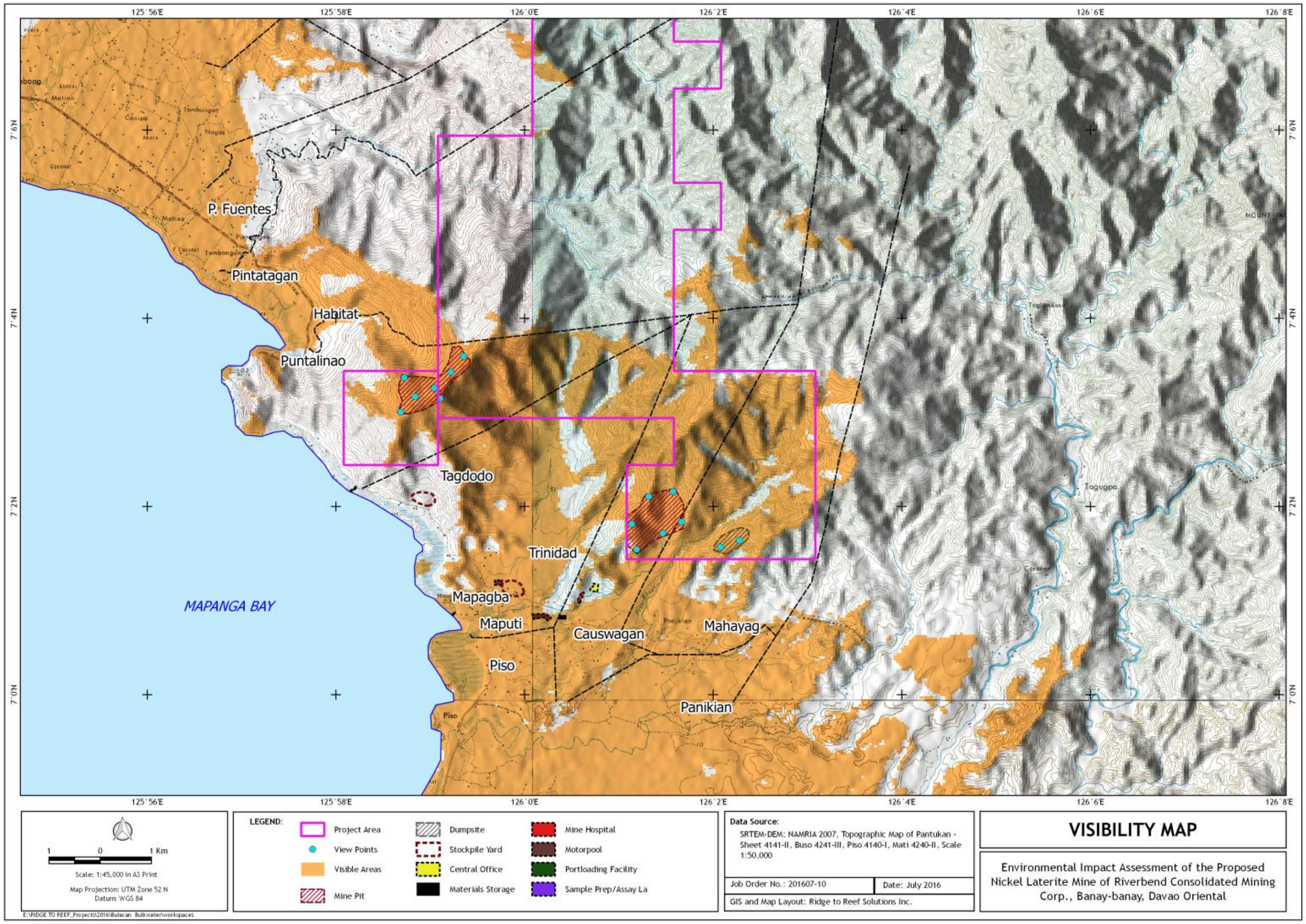


Figure 2.1-10. Visibility map of the proposed mining sites. This shows the areas where the proposed mining sites are potentially visible. (Source: NAMRIA, 2007)

2.1.2 Geology/ Geomorphology

Methodology, Nature and Source of Information

Literature review was conducted to acquire data from relevant government agencies particularly the Mines and Geosciences Bureau (MGB). This includes geologic reports and maps covering the project site.

Field investigation was done in order to verify the existing data and assess the geological hazards that may affect the project site. Outcrops were examined where available and additional data on subsurface lithology were acquired through the previous studies and reports.

Satellite imagery was used to aid in the identification, analysis and interpretation of hazards. All data, observations and results of the investigation were integrated in this report.

Primary data were obtained from actual fieldwork conducted in September 17-19, 2016. Secondary information was taken from existing literature and maps, Mines and Geosciences Bureau (MGB), Philippine Volcanology and Seismology Institute (PHIVOLCS), Philippine Atmospheric, Geophysical, Astronomical, and Seismological Administration (PAGASA), and previous works in the area.

Regional Setting

A. Baseline Condition of Geomorphology

Davao Oriental is located in southern part of the southern Pacific Cordillera in Eastern Mindanao, bordered by Compostela Valley to the west, Agusan del Sur and Surigao del Sur to the north, the Davao Gulf to the southwest, and the Philippine Sea to the east and southeast. The southern portion of the province consists of the Pujada and Guanguan Peninsula. Davao Oriental is a rugged mountainous region with patches of alluvial plains at the mouth of rivers.

The project site is situated in Banaybanay which is located at the boundary of Davao Oriental and Compostela Valley on the western side of the province. Like most of the province, it is characterized by mountainous terrain with rounded ridges, flanked by steep to very steep gradients. This transition to low hills and plains toward alluvial plains of major rivers (**Figure 2.1-11**). Slopes within the project site ranges from steep (30-50%) to very steep (>50%), with some undulating (8-18%) to moderately steep (18-30%) areas in narrow valleys (**Figure 2.1-12**). The highest elevation is around 880 m located at the Puntalinao Block while lowest elevation within the project site is located at the southern boundary along the floodplain of Piso River at 80 m (**Figure 2.1-13**). The elevation and gradient in the proposed location of facilities are listed in **Table 2.1-2**.

Table 2.1-2. Topographic characteristics of the facilities.

Facilities	Elevation (m)	Slope Gradient (%,°)
Mining Area 1	500 - 880	8 to >50; 4.6 to >28.7
Mining Area 2-A	360 - 820	8 to >50; 4.6 to >28.7
Mining Area 2-B	150 - 380	8 to >50; 4.6 to >28.7
Waste Dump 1	520 - 760	18 to >50; 10.3 to >28.7
Waste Dump 2	360 - 600	18 to 50; 10.3 to 28.7
Waste Dump 3	300 - 440	18 to >50; 10.3 to >28.7
Pre-pile Yard	100 - 180	8 to 50; 4.6 to 28.7
Stockyard	10 - 50	3 to 30; 1.7 to 17.2
Campsite	15 - 20	0 to 8; 0 to 4.6

The project site is drained by dendro-rectangular streams which empties into Mapagba Bay. The major rivers draining the project site are the west draining Pintatagan River, southwest draining Piso, Maputi

(Mapanga) and Mapagba River. These V-shaped streams have narrow channels with steep banks and steep longitudinal gradients, particularly in the mountainous sections.

B. Change in Surface Landform/ Geomorphology/ Topography/ Terrain/ Slope

Surface mining permanently changes the topography, terrain and slope of the mining sites and related facilities. However, the mountainous geomorphological unit remains the same. Construction of new haul roads and rehabilitation of existing access roads and construction of benches in mining pits and siltation ponds will require excavation, leading to formation of steep slopes. Steepening of slopes usually promotes instabilities that often lead to slope failures when they are not provided with appropriate support. Construction of stockyard, pre-pile yard and campsite will require levelling of slopes. Flat slopes are prone to water ponding and often affected by flood when located in low-lying areas. Construction of siltation ponds will introduce depressions in the topography. Construction of waste dumps in steep slopes can block the natural waterways. Construction of drainage canals will introduce new drainage lines and change the natural flow paths. Runoff will be diverted towards the location of siltation ponds. During operation stripping, bench forming, and ore extraction activities will also lower the elevation up to the designed mining limit. Stockpiling of materials in the waste dump will create mounds with relatively steep sides. During operation, the benches in the active mining areas will have vertical slope, with slope height of 3 m, separated by 3 m wide berm. The final pit slope is 45°. This slope angle is much steeper than the existing slope along the ridge which varies from 5 to 17°, although the slopes across the ridge are also very steep, greater than 29°.

The slopes that will be steepened during construction of roads, waste dumps and siltation ponds must be provided with slope stability measures to prevent or minimize slope failure. This is discussed farther in the geohazard section of this report. The design of the pit slope must be supported by a slope stability study to determine if it is stable throughout the active mining period. During rehabilitation, the topography of the mined-out areas must be restored to a stable slope angle close to its natural form. As mentioned in the project description, the target slope design for mined-out areas is 40°. This must be supported by a slope stability study to ensure that it is stable for the long-term. Relatively flat areas such as in the waste dumps, pre-pile yard, stockpile yard and campsite must have sufficient gradient that will direct runoff towards drainage lines to avoid water ponding. If possible, diversion canals will also be directed towards the original natural waterways.

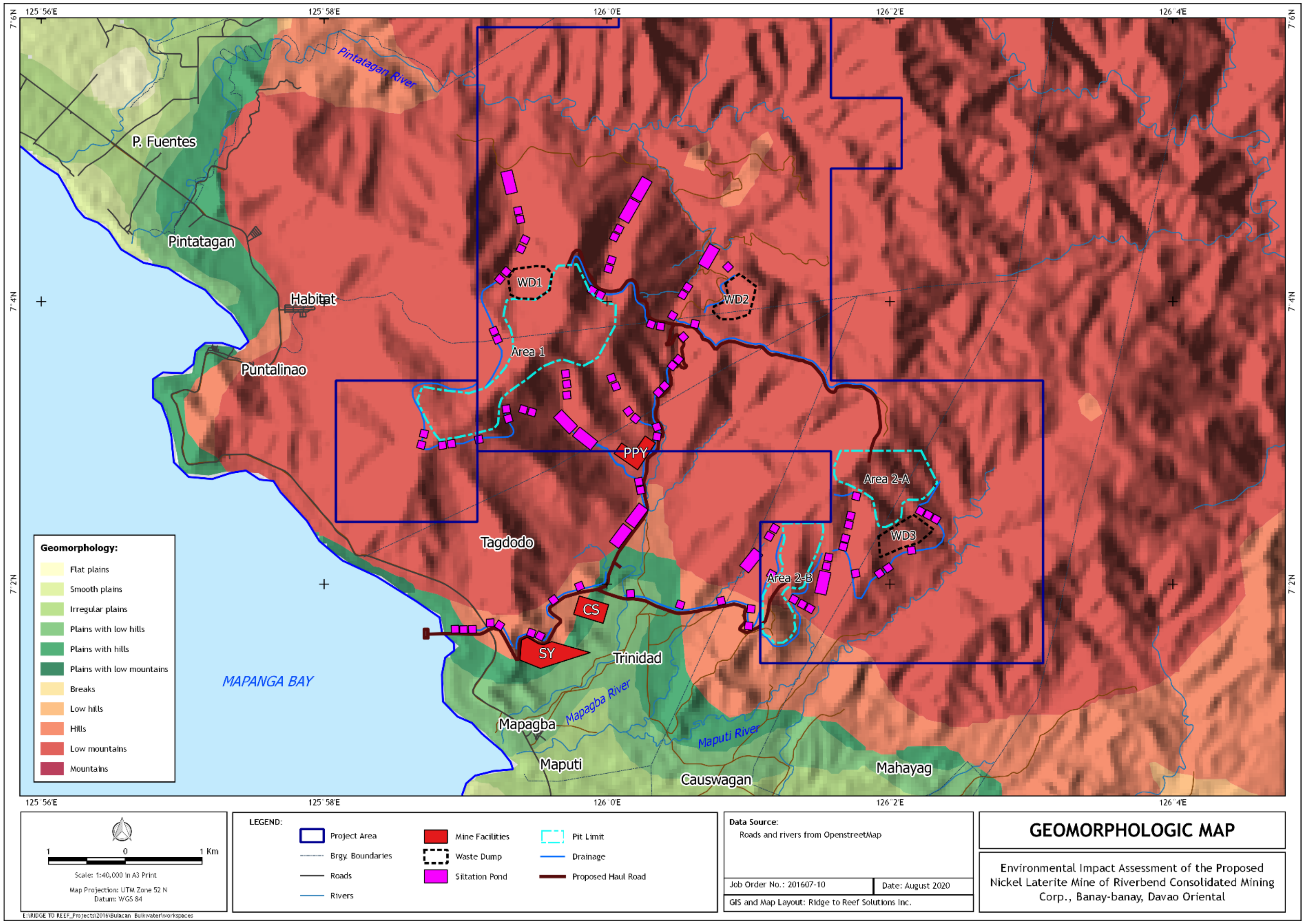


Figure 2.1-11. Geomorphologic map of the project site generated using SRTM-DEM.

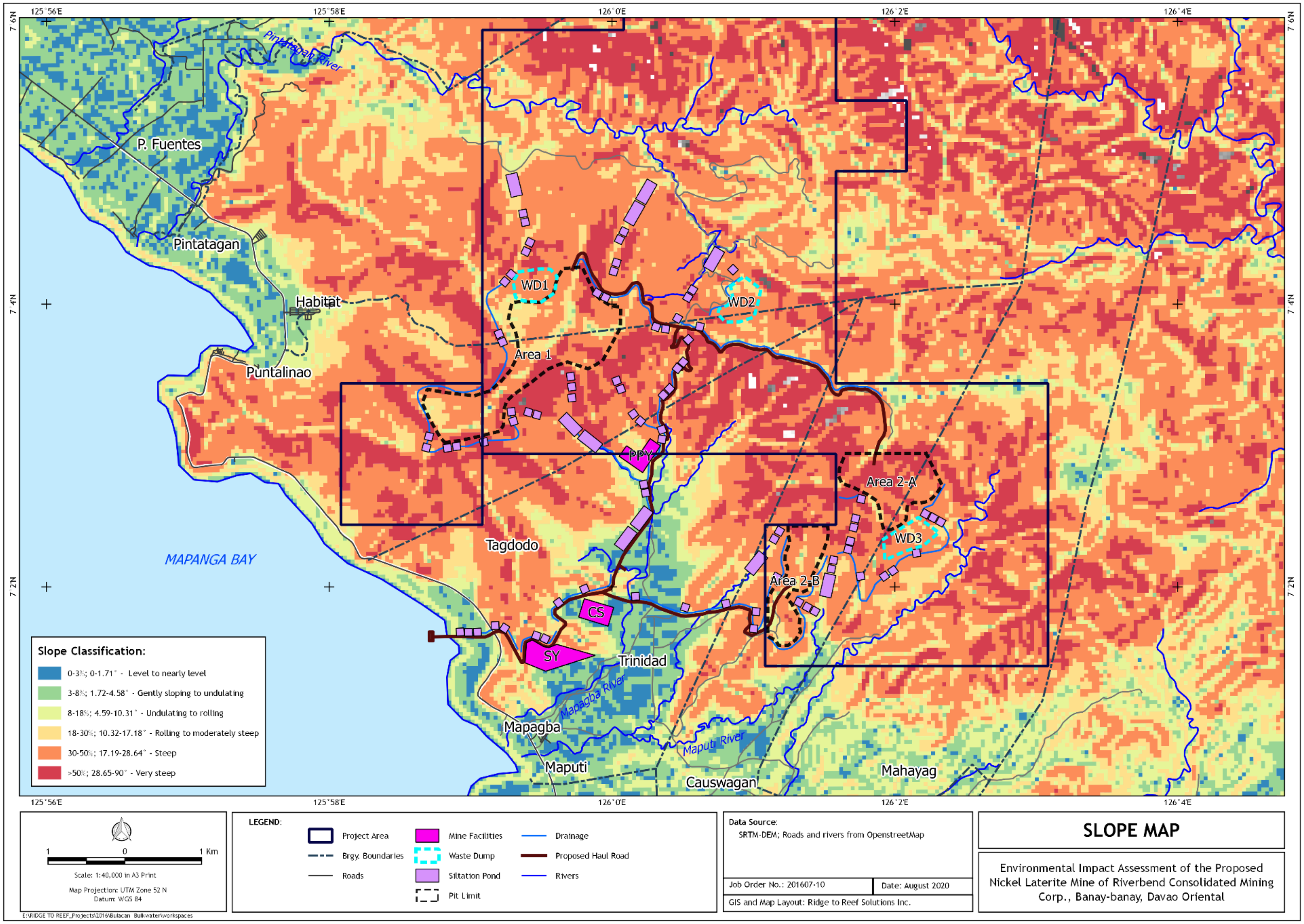


Figure 2.1-12. Topographic Map of the Project Site. (Source: NAMRIA, 2007)

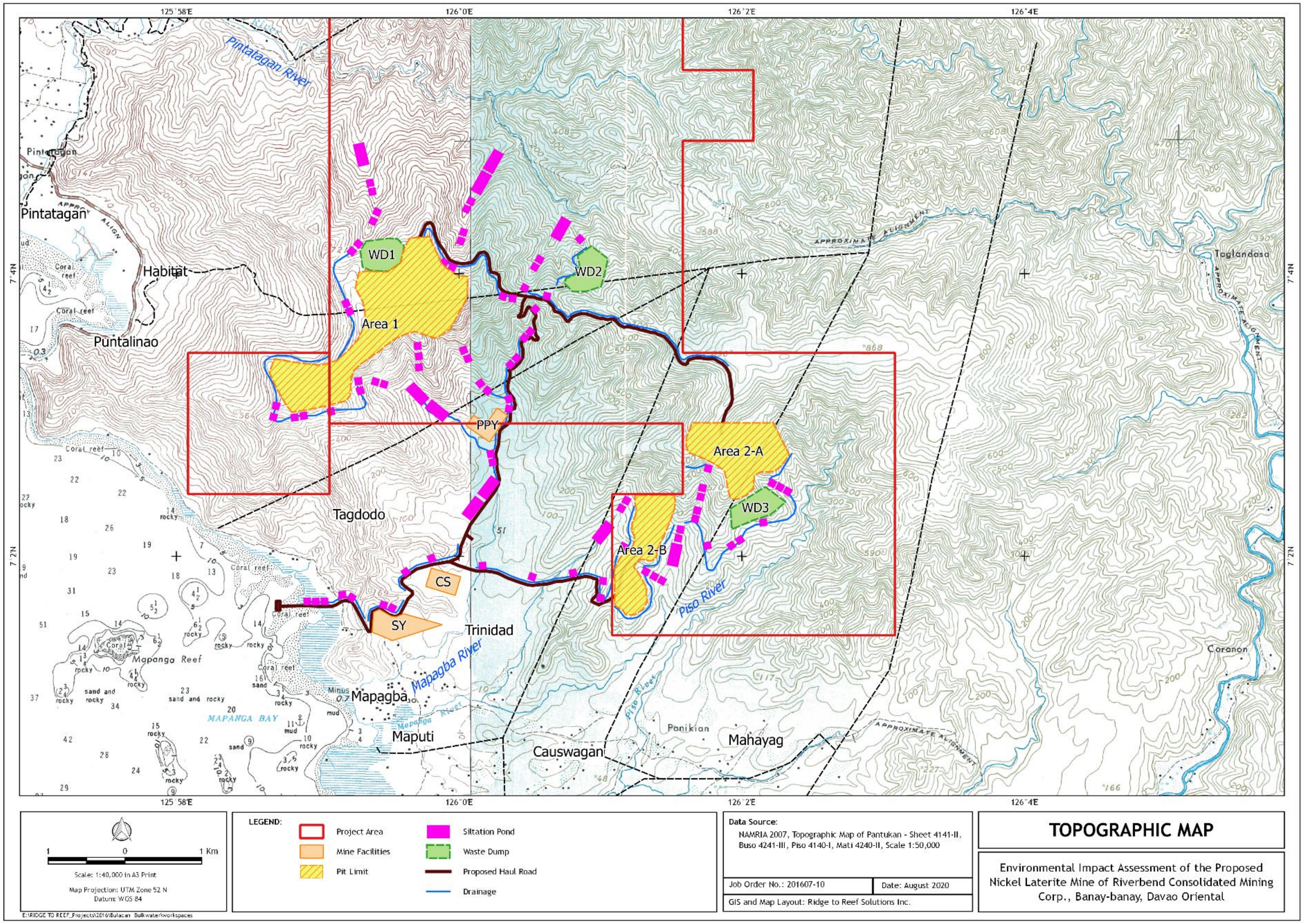


Figure 2.1-13. Topographic Map of the Project Site (NAMRIA, 2007).

C. Baseline Condition of Geology

1. Geology and Stratigraphy

Based on the stratigraphic grouping in the Lexicon of Philippine Stratigraphy by Peña (2008) the project site is within the Pujada Block (**Figure 2.1-14**, **and Figure 2.1-15**). Stratigraphic descriptions by Peña (2008) are as follows:

The oldest rocks in the Pujada Block is the Cretaceous Pujada Ophiolite, a west dipping ophiolite which includes the Magpapangi Greenschist, Ansuwang Amphibolite, Surop Peridotite, Nagas Peridotite, Matalao Gabbro, Lumao Diabase, Kalunasan Basalt and Iba Formation. Its lithology is composed of Amphibolite, dunite, peridotite, gabbro, volcanic and sedimentary rocks.

Widespread in the project site is the Surop Peridotite. A layered and folded ultramafic body approximately 30 km in length and 5 km in width. The Surop Peridotite consists mainly of harzburgite, dunite and lherzolite with varying degrees of serpentinization. In places where the Surop is thrusted against the Kalunasan Basalt, the thrust zone is characterized by the development of amphibolite and greenschists at the sole of the peridotite.

Cretaceous volcanics and sedimentary units of the Barcelona Formation composed of the basalts and clastics are present to the west of the project site.

Unconformable over the Kalunan Basalt of the Pujada Ophiolite is the Eocene Basiaw Limestone which occurs as thin lenticular bodies defining a narrow belt found either in massive outcrops or more commonly as scattered blocks along the creeks and ridge tops. These rocks are generally recrystalllized, marbleized or schistose and is t is generally barren of fossils or organic remains.

Overlying the Iba Formation is the Eocene Sanghay Formation composed of well-bedded graywackes and mudstones with a thickness of approximately 500 m. This formation is associated with pillow basalts and pelagic sediments of the Iba Formation and the graywackes overlie the late Cretaceous pelagic sedimentary rocks that are thought to represent the ophiolite’s sedimentary carapace.

Unconformable over the Pujada Ophiolite is the Late Pliocene – Early Pleistocene Sigaboy Formation composed of thick beds of conglomerate, sandstone, mudstone found along the western coast of Pujada Peninsula. The thick bedded conglomerates of Sigaboy are highly resistant to erosion, forming well developed cuestas. The conglomerates are poorly sorted and contain boulders of peridotite, serpentinite, gabbro, diabase, basalt, amphibolite, greenschist, marble and limestone. Towards the top, sandstones and mudstones become more common and the conglomerates become finer grained and contain more clasts of basalts, hyaloclastites, dacite, scoria, pumice and tuff in a tuffaceous matrix.

Unconformable over the Sanghay Formation is the Late Pleistocene Maco Limestone that is an unconsolidated coral breccia which dips gently to the west towards Davao Gulf. It has a limited areal extent and is not observed to rest on the Sigaboy Formation at Pujada Peninsula. The youngest rocks are the Quaternary surface deposits which area are mainly composed of sandy loam and sandy gravel that are exposed in gullies and gentle slopes.

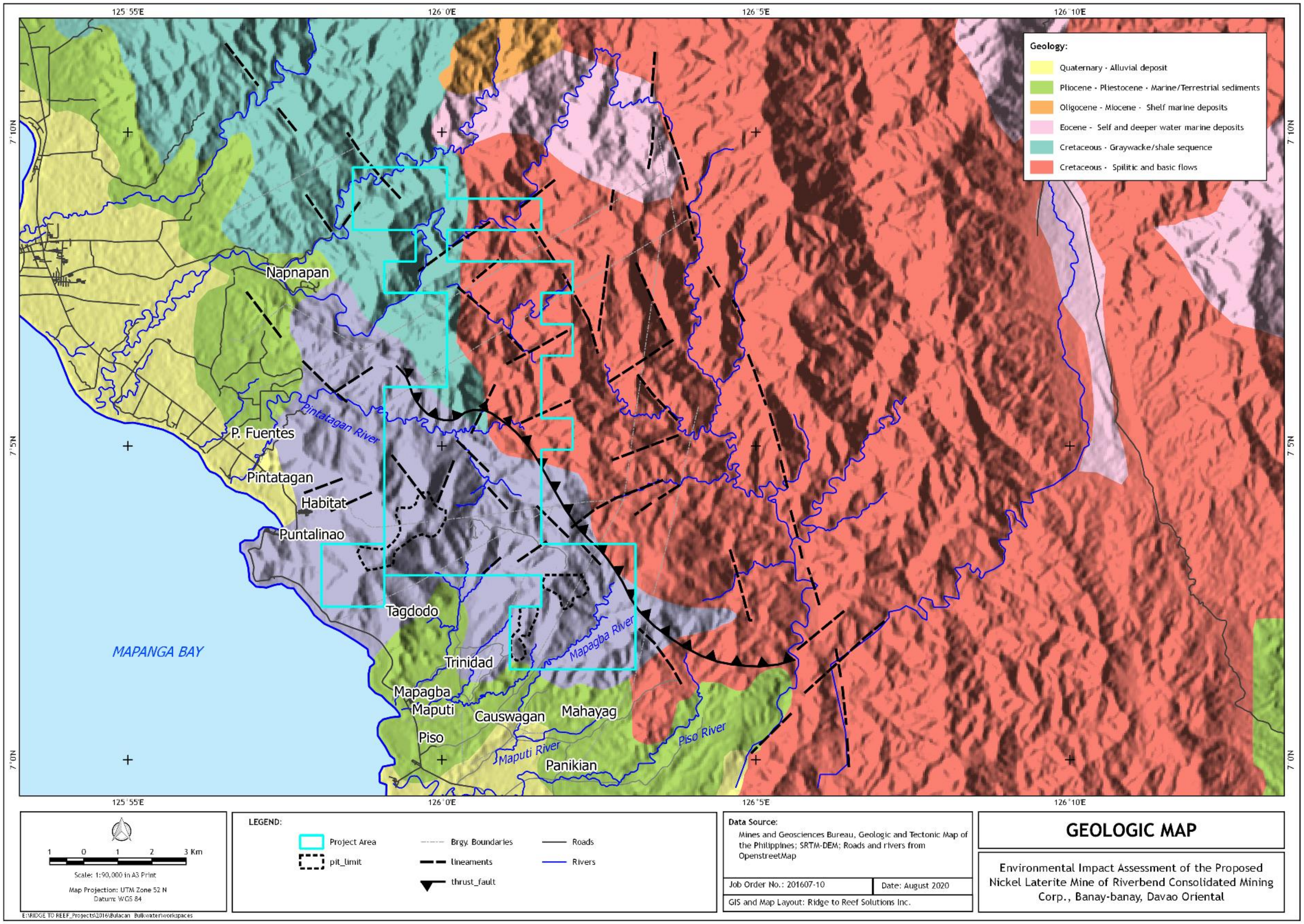


Figure 2.1-14. Regional geologic map of the project site and vicinity (modified from MGB, 2010)

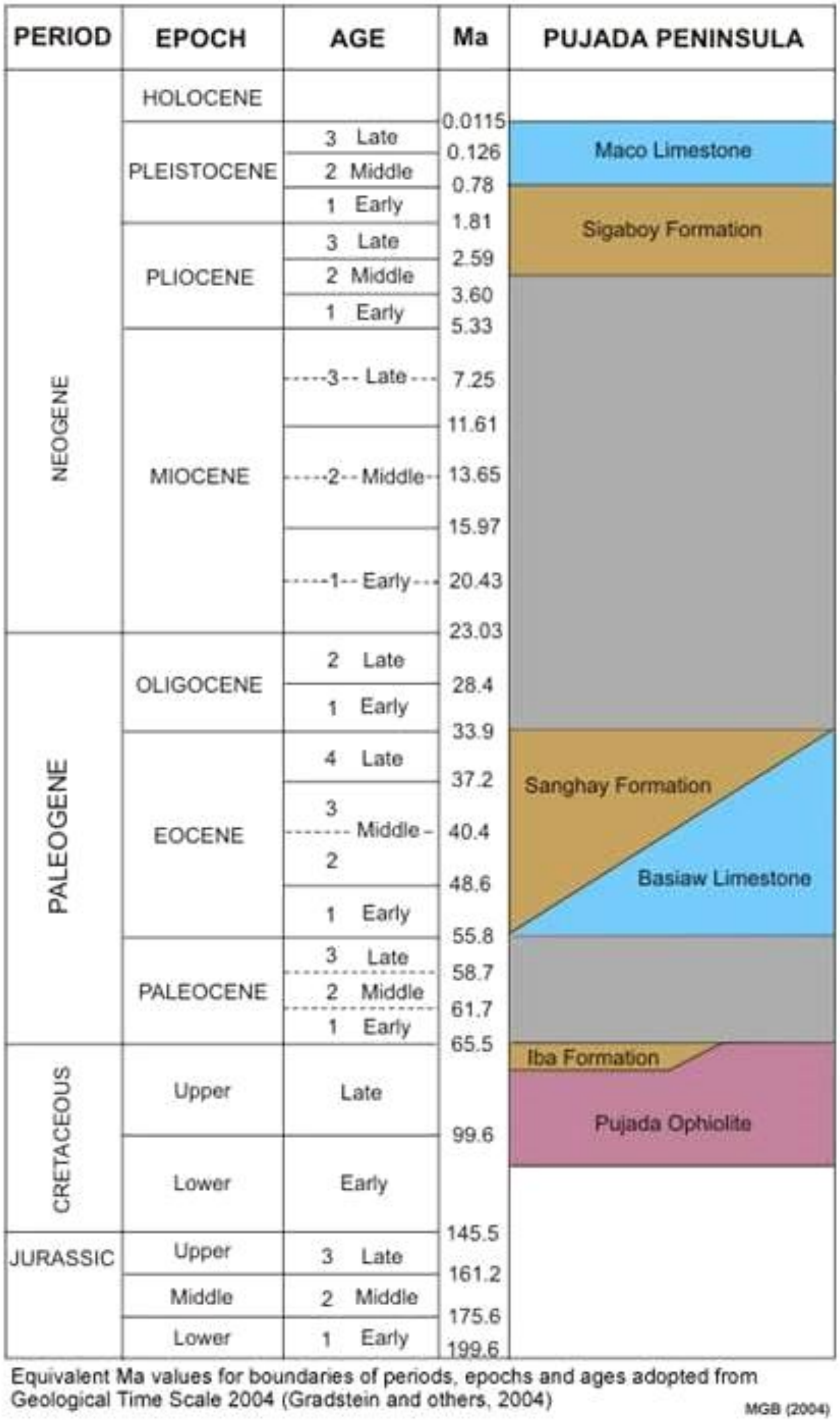


Figure 2.1-15. Stratigraphic column of Pujada Peninsula (MGB, 2004).

a.) Site Geology

The lithology within the project site as observed during the fieldwork consists of ultramafic rocks, laterite, calcareous sandstone, coralline limestone and Quaternary alluvium.

The dominant rocks in the project site are ultramafics belonging to the Surop Peridotite composed mostly of harzburgite, dunite, and serpentinite (**Figure 2.1-16 and 2.1-17**). These were observed to be highly fractured and cut by shear zones. Nickel, iron and chromite mineralization are present in these rocks which are the bedrock of laterite deposits.

Reddish brown to maroon laterite which is the result of the weathering of ultramafic rocks are found along ridges with gentle to moderate slopes. Laterite comprises part of Causwagan Block previously mined by Golden Summit Mining with an approximate area of 4.4 hectares (**Figure 2.1-18**).

Calcareous Sandstone and Coralline Limestone are present in lower slopes (**Figure 2.1-19**) while Quatenary alluvium were encountered along gentle slopes and within the flood plains of rivers and gullies (**Figure 2.1-20**).

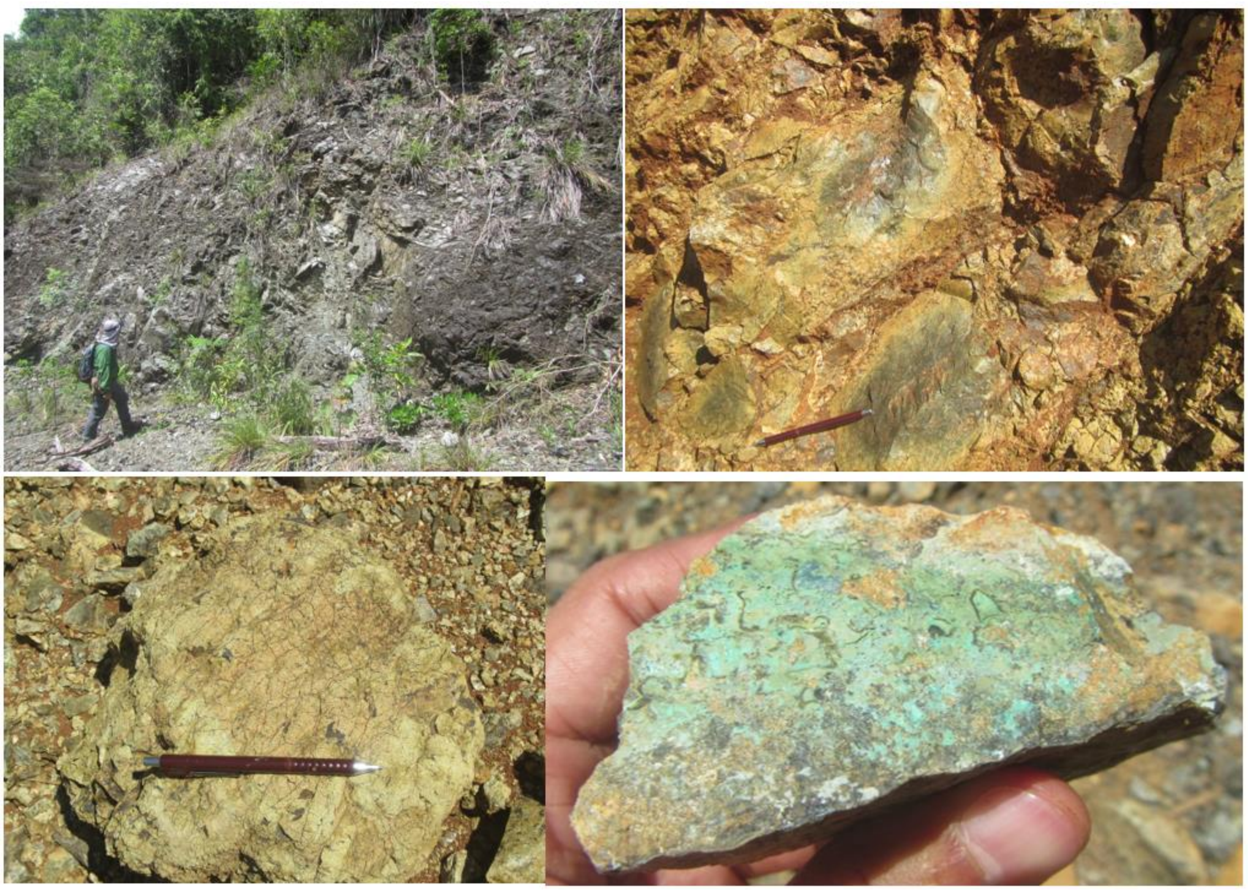


Figure 2.1-16. Ultramafic rocks of the Surop Peridotite within the Project Site. Clockwise from top: highly fractured peridotite; development of red clayey laterite in between fractures in saprolite zone; greenish Ni-bearing garnierite mineral; serpentinite alteration along fractures.

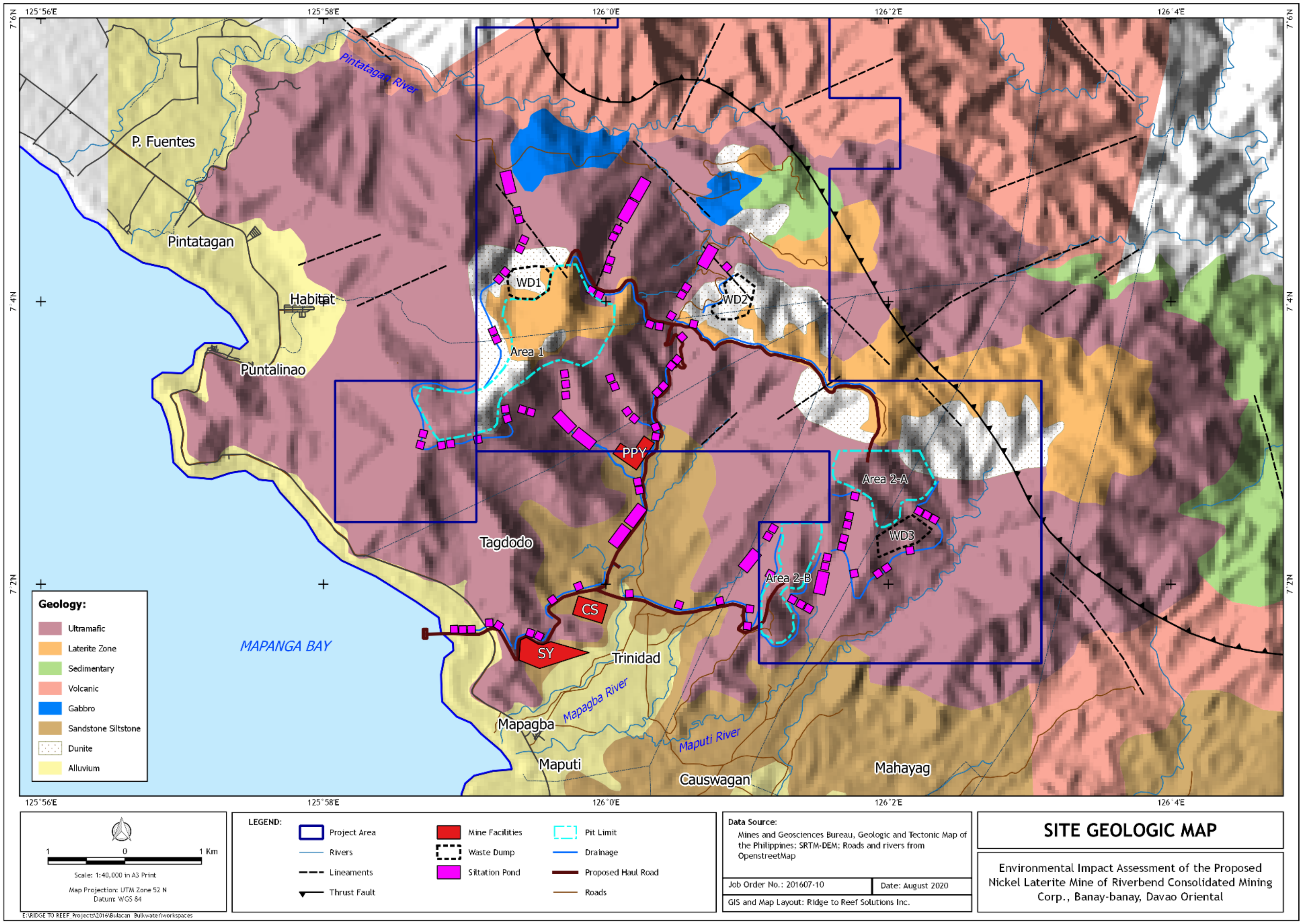


Figure 2.1-17. Geologic Map of the Project Site (modified from RCMC, 2020; MGB, 2010)

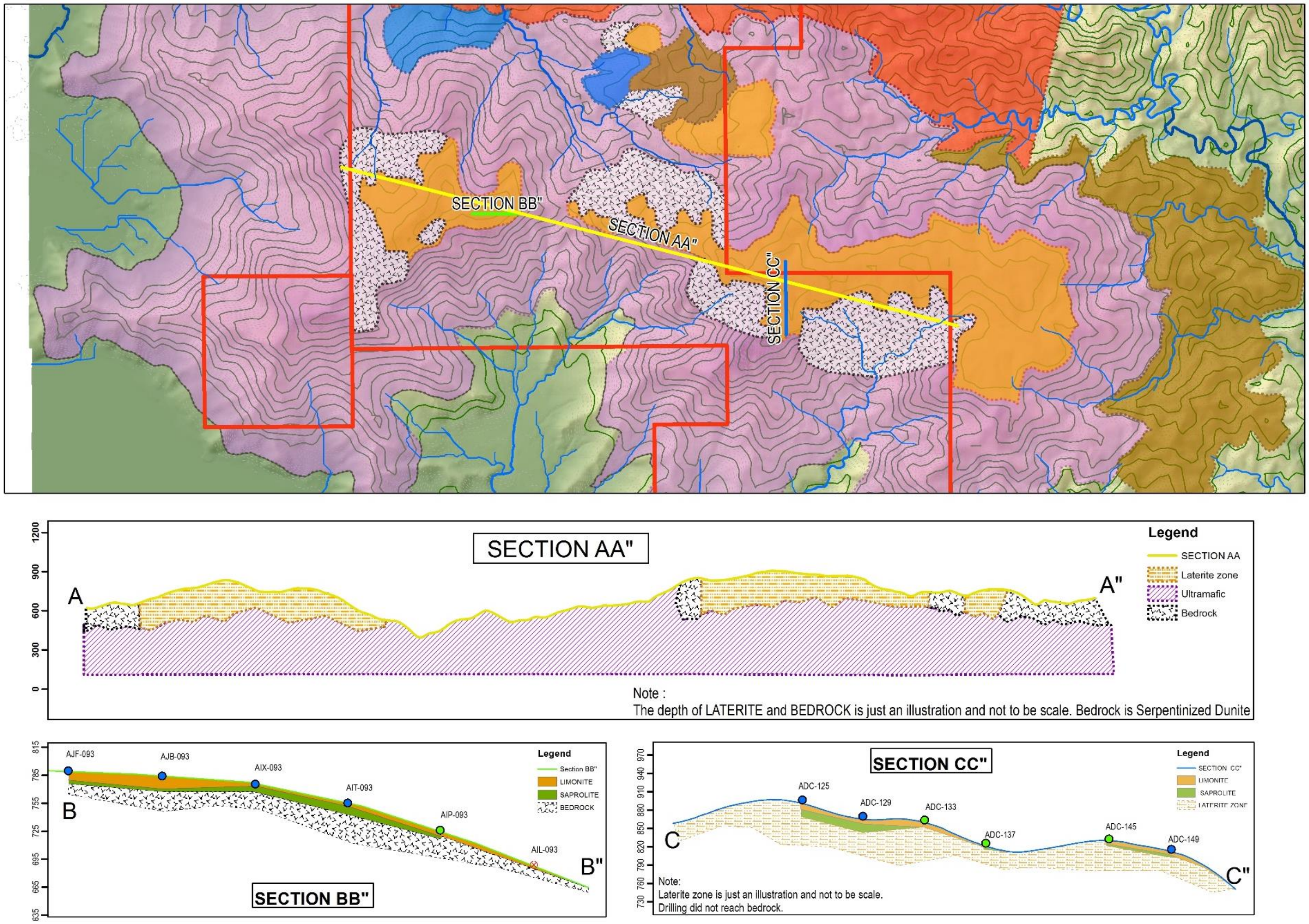


Figure 2.1-17-1. Cross Section along the Proposed Mining Areas (RCMC, 2020)

Figure 2.1-18. (Top) Weathering of peridotite into a saprolite zone overlain by laterite soil. (Bottom) Stockpile of laterite from the previous mining operation.

Figure 2.1-19. (Left) Calcareous Sandstone. (Right) Coralline Limestone outcrop.

Figure 2.1-20. Quaternary Alluvium along the flood plain in Barangay Maputi.

b.) Engineering Geologic Properties

Rock Mass Characteristics

The MPSA area, particularly in the Puntalinao and Causwagan blocks, is underlain by peridotite commonly identified as harzburgite. This rock is dark grey in color when fresh and with light brown coating in weathered parts. Exposures along roadcuts show highly fractured outcrops with moderate to highly weathered zones. Along ridges, the bedrock is overlain by maroon to dark reddish-brown Ni-laterite soil with 5 to 7 m thickness. In steep slopes the reddish-brown soil mantle is only about 0.5 to 2 m thick.

The intact rock strength of the harzburgite, estimated by counting hammer blows to create fracture, varies from medium strong (25 – 50 MPa) for the highly weathered zones and strong to very strong (50 – 250 MPa) for the slightly to moderately weathered portions.

The Geological Strength Index (GSI) developed by Hoek and Brown (1997) and Marinos and Hoek (2000) was used to characterize the geotechnical properties of the bedrock. The inputs are Intact Rock Strength estimated in the field using hammer, degree of weathering and fracturing of outcrops. Based on this classification, the GSI values for highly weathered zones varies from 25 to 30 which means that the rock is disturbed to very blocky with very poor to poor surface conditions. Rocks with slight to moderate weathering have GSI values ranging from 35 to 40. They are very blocky with fair surface conditions. The derived rock mass parameters using the Hoek-Brown Criterion are shown in **Table 2.1-3**. The shear strength parameters (friction angle and cohesion) shown in this table is applicable for the rock mass and not to the individual discontinuity surface.

Table 2.1-3. Rock mass parameters.

Geotechnical Unit	Intact Rock Strength (MPa)	GSI Values	Hoek-Brown Rock Mass Parameters				Mohr-Coulomb Fit (rock mass)	
			Tensile Strength (MPa)	Unconfined Compressive Strength (MPa)	Global Strength (MPa)	Deformation Modulus (MPa)	Friction Angle (°)	Cohesion (MPa)
Highly Weathered Zone	25 - 50	25	-0.002	0.109	2.512	911.9	38.27	0.157
		30	-0.003	0.175	3.045	1216.04	41.2	0.184
Slight to Moderately Weathered Zone	50 - 250	35	-0.012	0.775	10.367	2741.03	51.36	0.316
		40	-0.018	1.172	12.21	3655.22	53.66	0.366

The high friction angle values of the rock mass can be correlated to the existing topography. In general, the slight to moderately weathered rocks can maintain steeper slopes. However natural processes such as basal erosion in streams and anthropogenic activities like road construction can make the slopes steeper. When the slopes are steeper than the friction angle of the rock mass instabilities occur and may lead to slope failures.

c.) Structures

Peridotites are commonly sheared as a result of thrusting when they were emplaced over younger lithologic units. Their boundaries are thrust faults and wide shear zones are common across the units resulting to highly fractured rock mass. Younger tectonic events also contribute to the fracturing of these rocks.

Lineaments were delineated in the project area using the SRTM-DSM with 30 m resolution. The analysis reveals the presence of several linear features with length varying from about 0.4 to 3 km. The orientations and corresponding dominant length are shown in **Table 2.1-4**. **Figure 2.1-21** is a rose diagram plot of the lineaments.

Table 2.1-4. Lineament Orientation

Orientation	Length, km
NW-SE	0.9 to 2
NNW-SSE	0.9 to 1.5 and 2 to 2.5
NE-SW	0.9 to 2.5
N-S	0.9 to 1.5 and 2 to 2.5

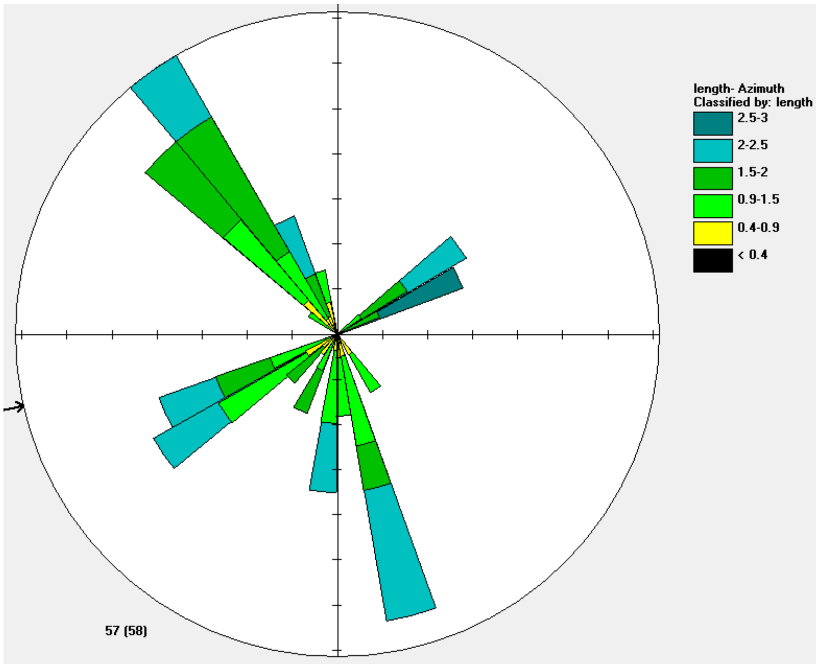


Figure 2.1-21. Rose diagram of the lineaments.

Some lineaments are shorter, but they are aligned in a particular direction signifying a possible continuous structure. The NW-SE lineaments traverses the MPSA area while the long NNW-SSE features are located mostly 4 to 6 km to the northeast of the MPSA boundary.

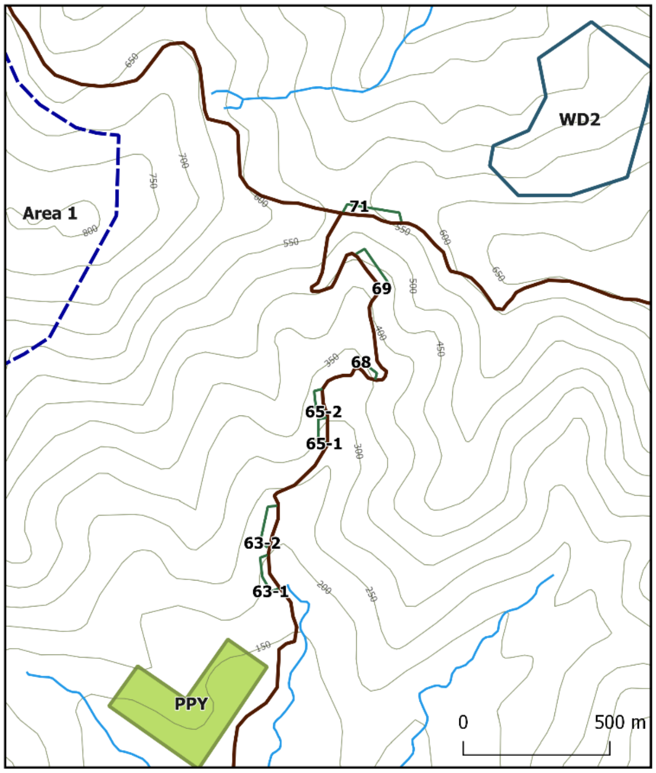


Figure 2.1-22. Location of rock slopes along the access road.

Geologic mapping conducted along roadcuts reveal the highly fractured nature of the peridotites (**Figure 2.1-22**). The orientations of joint sets and faults, collectively referred as discontinuities, were measured and plotted in the lower hemisphere equal-area plot and rose diagram (**Figure 2.1-23 left and middle**). The data shows that the dominant trend of the discontinuities within the lower portion of the MPSA area and adjacent southern part is NW-SE, followed by N-S and NE-SW oriented structures. The orientation grouping is clearly shown in the density contour of the poles of the structures shown in **Figure 2.1-23 right**. These patterns correspond also to the trends of the lineaments, signifying that the lineaments are most probably controlled by geologic structures.

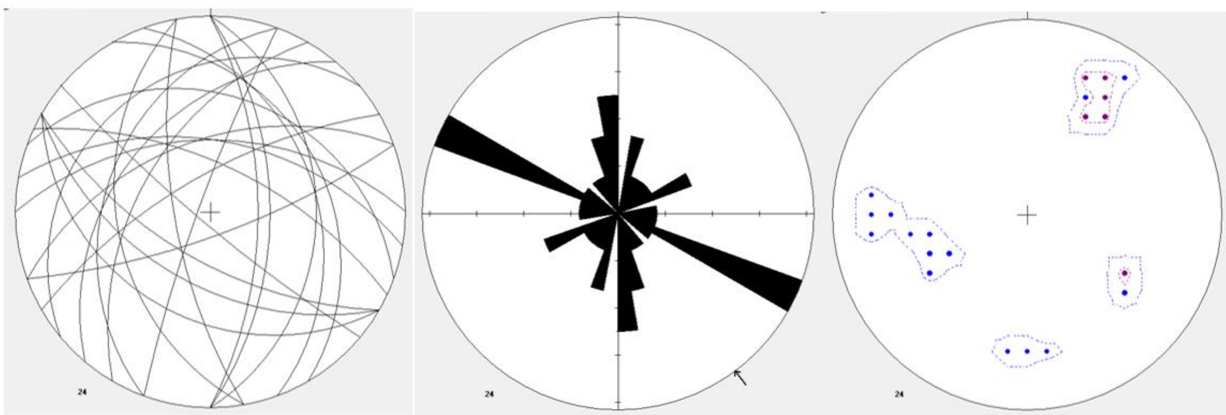


Figure 2.1-23. Left) Lower hemisphere equal-area plot of 24 geologic structures representing joint sets, faults and shear zones; Middle) Rose diagram; Right) Contour density plot of poles.

The characteristics of the discontinuities were described based on the International Society of Rock Mechanics (ISRM, 1981) suggested methods and Bieniawski's Rock Mass Rating (RMR) System (1993).These include measurements of spacing, persistence, separation or aperture and description of wall roughness, wall weathering, intact rock strength and groundwater condition along joint surfaces. **Table 2.1-5** shows the characteristics of the discontinuities. The spacing varies from 5 to 60 cm but mostly are within 5 to 10 cm. Shear zones have very close spacing usually around 5 cm. The persistence ranges from 1.5 to 7 m but mostly within 5 m. The presence of thick vegetation and orientation obscures the persistence. The separation between discontinuity walls are mostly 1 to 5 mm. Surface roughness is generally slightly curved to curved in large-scale but planar in the small-scale. This is equivalent to Joint Roughness Coefficient (JRC) of 4 to 8. The infills include mostly zeolite and Fe-oxide in joints and coarse gouge in faults and shear zones. There are no seepages observed during the survey, but the discontinuities are generally damp. They are potential location of seepage during periods of continuous precipitation. Wall weathering is characterized by general discoloration in relatively tight discontinuities. The percentage of decomposed rock is less than 10%. Discontinuities with larger separation have partially decomposed walls usually reaching 20 to 40%.

Due to the presence of several intersecting discontinuities, the rock block shape is rhombohedral characterized by obliquely intersecting sets. The rock block dimension is small to medium with maximum width ranging from 0.06 to 0.2 m. The intersecting discontinuities form unstable blocks that are prone to rockslide and rock fall.

Geotechnical parameters were derived based on the condition of the rock mass and the discontinuities. The shear strength parameters of the different discontinuities were estimated based on the Barton-Bandis criterion (1990). The result is shown in **Table 2.1-6**. Higher shear strength values are found in rocks with stronger joint wall compressive strength (JCS). The rock mass is classified based on Rock Mass Rating (RMR) System (1993). Most of the slopes have fair to poor rock mass class.

Table 2.1-5. Characteristics of discontinuities based on ISRM suggested methods (1981).

Slope ID	Type	Dip	Dipdirn	Spacing cm	Persis-tence, m	Roughness Large-scale	Roughness Small-scale	JRC	Infill	Sepa-ration, mm	Seepage	Wall weathering
63-1	JS1	80	160	20	1.5	straight	planar	6-8'	zeolite	0.5	damp	gen discoloration
	JS2	60	340	60	2	sl curved	planar	6-8'	zeolite	0.5	damp	gen discoloration
	JS3	85	220	10	1.5	sl curved	planar	6-8'	zeolite	5	damp	partial decomp
63-2	Fault1	70	25	10	5	curved	planar	4-6'	coarse gouge	5	damp	partial decomp
	Fault2	40	20	5	5	curved	planar	4-6'	coarse gouge	1	damp	gen discoloration
	Fault3	65	90	10	5	curved	planar	4-6'	coarse gouge	5	damp	partial decomp
	JS4	50	310	60	2	sl curved	planar	6-8'	zeolite	0.5	damp	gen discoloration
	JS5	40	60	10	1.5	sl curved	planar	6-8'	zeolite	5	damp	partial decomp
65-1	Fault4	45	90	5	5	curved	planar	4-6'	coarse gouge	1	damp	gen discoloration
	JS6	30	320	5	5	curved	planar	4-6'	coarse gouge	1	damp	gen discoloration
65-2	JS7	60	300	5	5	curved	planar	4-6'	zeolite	1	damp	gen discoloration
	JS8	45	290	10	1.5	sl curved	planar	6-8'	zeolite	5	damp	partial decomp
	JS9	60	10	5	7	sl curved	planar	6-8'	Fe oxide	1	damp	gen discoloration
	JS10	45	210	10	5	sl curved	planar	6-8'	Fe oxide	1	damp	gen discoloration
68	Fault5	75	260	5	5	curved	planar	4-6'	coarse gouge	1	damp	gen discoloration
	JS11	70	210	5	5	curved	planar	4-6'	coarse gouge	1	damp	gen discoloration
	JS12	60	360	5	5	curved	planar	4-6'	coarse gouge	1	damp	gen discoloration
69	JS13	75	330	10	1.5	sl curved	planar	6-8'	zeolite	5	damp	partial decomp
	JS14	70	90	10	1.5	sl curved	planar	6-8'	zeolite	5	damp	partial decomp
	JS15	60	210	10	1.5	sl curved	planar	6-8'	zeolite	5	damp	partial decomp
71	JS16	60	210	10	1.5	sl curved	planar	4-6'	zeolite	5	damp	partial decomp
	JS17	45	70	10	1.5	sl curved	planar	4-6'	zeolite	5	damp	partial decomp
	JS18	50	260	10	1.5	sl curved	planar	4-6'	zeolite	5	damp	partial decomp
	JS19	85	290	10	1.5	sl curved	planar	4-6'	zeolite	5	damp	partial decomp

Table 2.1-6. Geotechnical parameters derived from the discontinuity characteristics.

Slope ID	Type	Dip	Dipdir	JCS, MPa	Cohesion, MPa	Friction angle (°)	Rock Mass Class
63-1	JS1	80	160	75	0.052	45.22	fair to good
	JS2	60	340	75	0.052	45.22	
	JS3	85	220	37.5	0.047	43.18	
63-2	Fault1	70	25	37.5	0.028	40.54	poor to fair
	Fault2	40	20	75	0.03	42.01	
	Fault3	65	90	37.5	0.028	40.54	
	JS4	50	310	75	0.052	45.22	
	JS5	40	60	37.5	0.028	40.54	
65-1	Fault4	45	90	75	0.03	42.01	poor
	JS6	30	320	75	0.03	42.01	
65-2	JS7	60	300	75	0.03	42.01	fair
	JS8	45	290	37.5	0.028	40.54	
	JS9	60	10	75	0.052	45.22	
	JS10	45	210	75	0.052	45.22	
68	Fault5	75	260	75	0.03	42.01	fair
	JS11	70	210	75	0.03	42.01	
	JS12	60	360	75	0.03	42.01	
69	JS13	75	330	37.5	0.047	43.18	fair
	JS14	70	90	37.5	0.047	43.18	
	JS15	60	210	37.5	0.047	43.18	
71	JS16	60	210	37.5	0.028	40.54	fair
	JS17	45	70	37.5	0.028	40.54	
	JS18	50	260	37.5	0.028	40.54	
	JS19	85	290	37.5	0.028	40.54	

D. Change in Subsurface Geology/ Underground Condition

Nickel, iron and other associated minerals are concentrated in the upper surface of the topography. Thus, extraction of these minerals will focus on the surface up to around 7 to 10 m depth. Removal of the weathered horizon, as mining progresses, will make the fresh or slightly weathered bedrock expose to the different agents of weathering. Water can easily flow into the open fractures, accelerating weathering along discontinuity surfaces. Although this is a slow process, this will affect the geotechnical characteristics of the rock mass such that poor rock mass quality can change into very poor classification. The overburden and topsoil in the waste dumps will induce additional load into the slope that will increase the lithostatic pressure in the underlying rocks. This can cause slope failure either at the basal part of the slope or throughout the whole slope including the waste dump.

The overburden and topsoil must be returned immediately in the mined-out area to restore the natural cover of the bedrock. It must be properly compacted with compaction level similar to that of the undisturbed soil in the area. The clayey soil will slow down water infiltration reaching the bedrock. Detailed geotechnical assessment must be conducted to determine if the load impose by the overburden and topsoil in the waste dump can be safely supported by the underlying rocks. During rehabilitation the load in the waste dump will be lessened if not completely removed.

E. *Baseline Condition of Geological Hazards*

The hazards entirely or partly caused by the processes that take place in the subsurface of the earth are discussed in this section. These include earthquake or seismic-related, mass movements and volcanic hazards.

1. Seismic Hazard

The project site and its vicinity are situated in a seismically active region. Historical and instrumentally recorded earthquakes occurred in the past (Bautista and Oike, 2000; SEASEE, 1985). There are also nearby earthquake generators that pose seismic hazards. The historical seismicity and active faults are shown in **Figure 2.1-24**.

a.) Ground Shaking

Ground vibrations caused by the passage of seismic waves from an earthquake source to the ground surface usually result to damages of buildings and other infrastructures. Seismic magnitude, epicentral distance and the site response or the modifying effects of subsoil conditions generally influence the intensity of ground shaking. Usually, the shallower the focus of the earthquake and the closer the site from the epicentral area, the stronger is the felt intensity. The extent of damage to buildings and other similar structures also depends on other factors such as age, type and quality of materials used, quality of design, mode of construction and the natural period/frequency or resonance of the structure. Most casualties during earthquakes are from collapse of buildings and structures caused by strong ground shaking.

The intensity of ground shaking is usually expressed in relation to the value of g, the gravitational constant equivalent to 9.80 m/sec^2. Thus, a value of 0.5g means a ground acceleration of 4.9 m/sec^2.

Regional Peak Ground Acceleration Values

A collaborative USGS-PHIVOLCS study (Thenhaus, et al., 1994) estimated peak ground acceleration (PGA) values of 0.29g for bedrock, 0.68g for hard-soil, 0.56g for medium-soil and 0.70g for soft-soil ground conditions in Banaybanay and vicinity (**Figure 2.1-25**). The above PGA values have a 10% probability of exceedance within a period of 50 years. These PGA values were calculated from potential worst-case earthquake magnitudes that could be produced by surrounding earthquake generators.

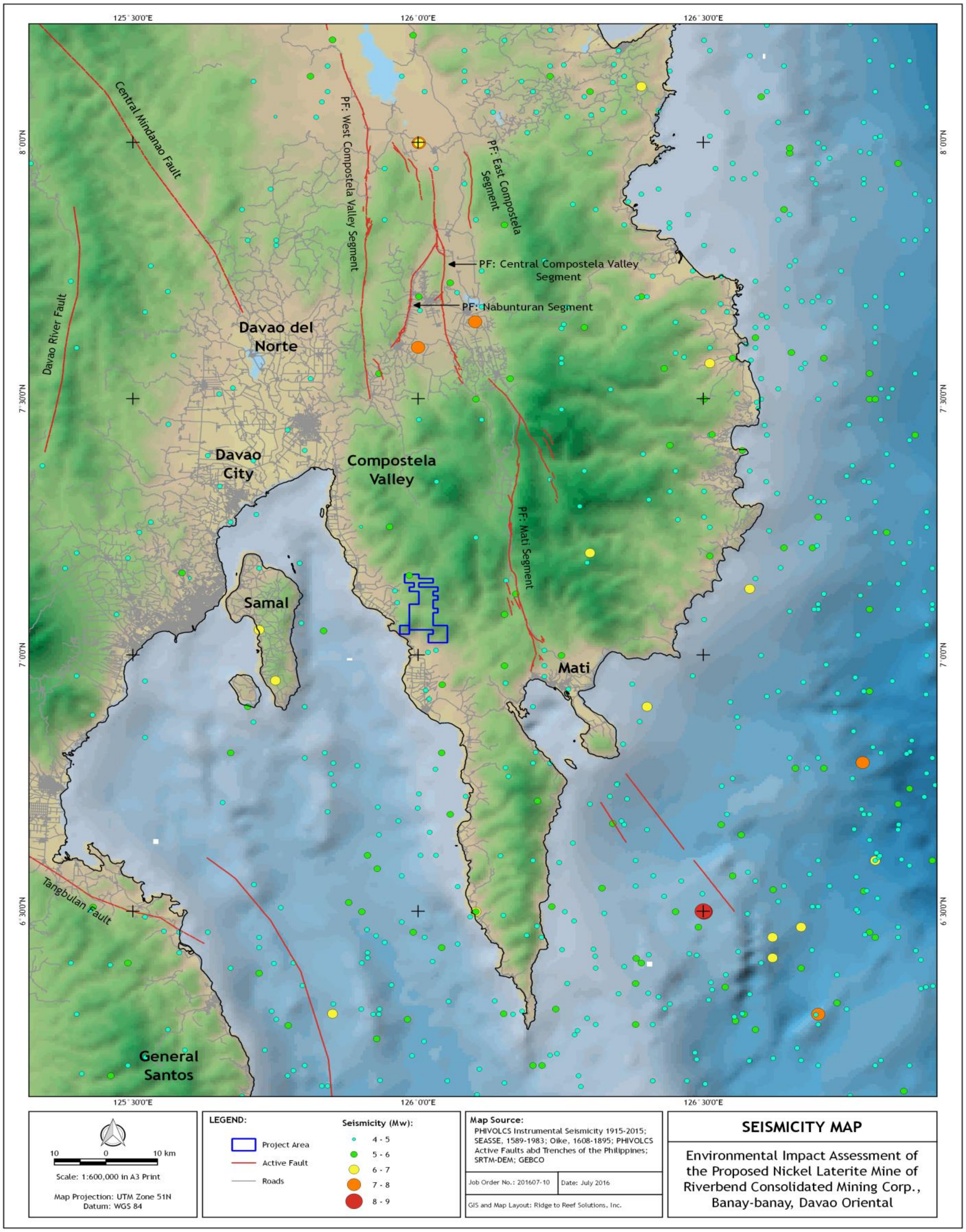
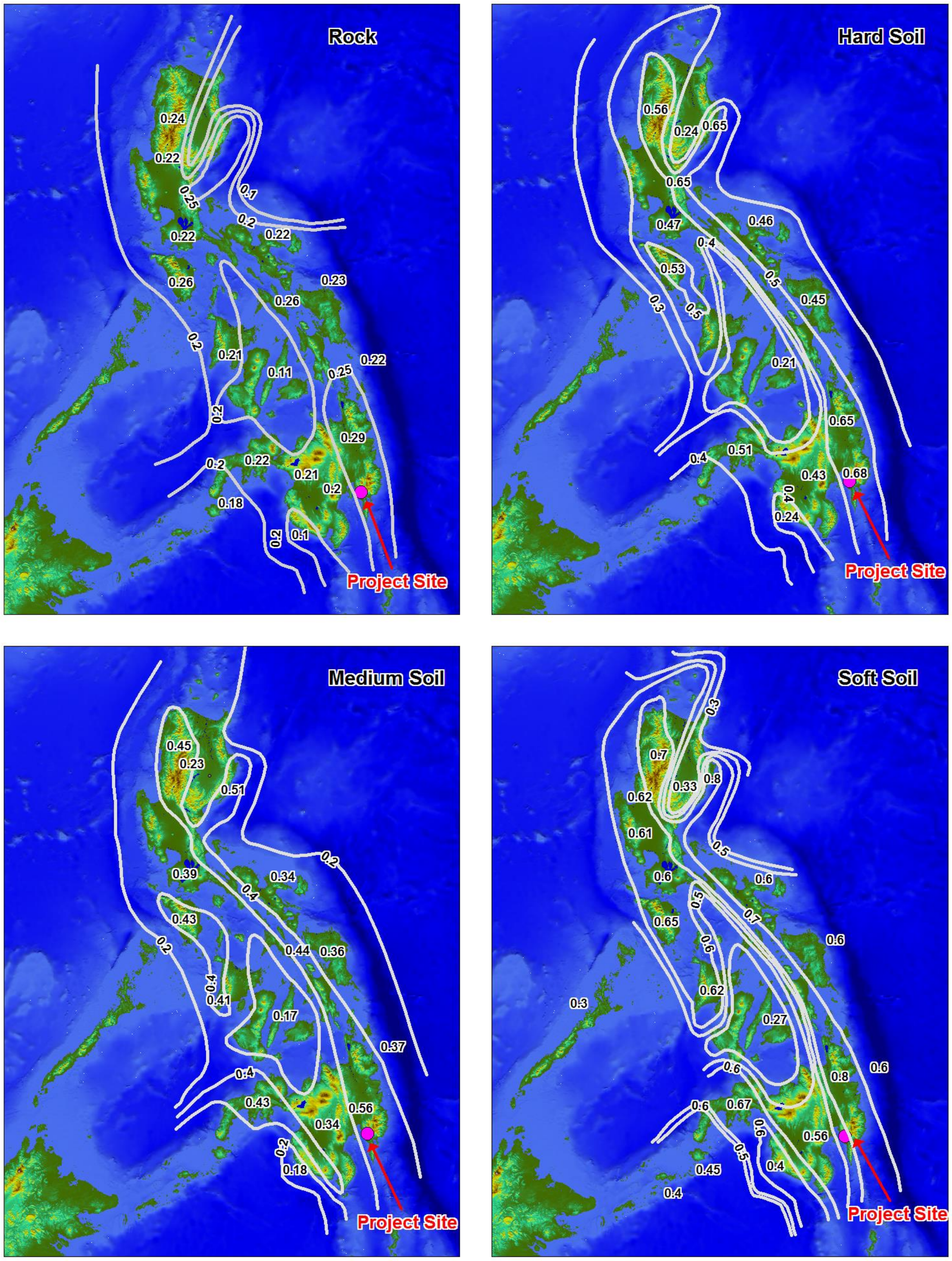


Figure 2.1-24. Seismicity Map in the region (Sources of earthquake data: PHIVOLCS, 2015; SEASSE, 1985; Bautista and Oike, 2000; PHIVOLCS Active Faults and Trenches of the Philippines, 2015).



90% Probability of not being exceeded in 50 years **Source: Thenhaus and others, 1994**

Figure 2.1-25. Regional PGA values (Thenhaus et.al., 1994).

Site Specific Peak Ground Acceleration Values

By using the Deterministic Seismic Hazard Analysis Approach and the Fukushima-Tanaka Attenuation Relationship Equation (Fukushima-Tanaka, 1990), site-specific PGA values that are applicable to the site were calculated.

The ground shaking hazard for the project site can be calculated using the Fukushima-Tanaka attenuation relationship: $\log_{10} A = 0.41M - \log_{10} (R + 0.032 \cdot 10^{0.41M}) - 0.0034R + 1.30$ where A is the mean peak ground acceleration from horizontal components at each site, R is the shortest distance between the site and the fault rupture and M is the surface-wave Magnitude (Ms). Fukushima and Tanaka (1990) in their studies in Japan statistically came up with multiplication factors of 0.60 for bedrock, 1.07 for hard soil, 0.87 for medium soil and 1.39 for soft soil ground conditions.

Utilizing the fault parameters present in the region (**Figure 2.1-24**) and the Fukushima-Tanaka attenuation relationship equation, gives the PGA values for the different sub-surface condition (**Table 2.1-7**) applicable in the study area.

Table 2.1-7. Earthquake generators and the peak ground acceleration values that could be generated.

Fault	Computed Earthquake Magnitude (Ms)	Distance to Site (aerial kilometers)	g	Bedrock	Hard Soil	Medium Soil	Soft Soil	MMI
PFZ Mati Segment	7.1	13	0.383073	0.229844	0.409888	0.333274	0.532472	VIII-IX
PFZ Mati Segment Offshore	8.3	45	0.287194	0.172317	0.307298	0.249859	0.3992	VII-IX
PFZ West Compostela Segment	7.8	50	0.215892	0.129535	0.231004	0.187826	0.300089	VII-VIII
PFZ Caraga River Segment	6.8	34	0.178336	0.107002	0.19082	0.155152	0.247887	VII-VIII
PFZ Central Compostela Segment	7.1	53	0.138394	0.083036	0.148081	0.120403	0.192367	VI-VIII
Central Mindanao Fault	7.6	74	0.128538	0.077123	0.137536	0.111828	0.178668	VI-VII
Davao River Fault	7.1	80	0.08351	0.050106	0.089355	0.072653	0.116078	VI-VII
Tangbulan Fault	7	77	0.081923	0.049154	0.087658	0.071273	0.113873	VI-VII
Philippine Trench	8.3	139	0.078783	0.04727	0.084298	0.068541	0.109508	VI-VII
PFZ East Compostela Segment	6.5	86	0.047587	0.028552	0.050918	0.041401	0.066146	V-VI
Earthquake	**Magnitude (Ms)**							
2010 January 15	5.3	8.2	0.219102	0.131461	0.234439	0.190619	0.304552	VII-VIII
1924 April 15	8.3	84	0.161589	0.096953	0.1729	0.140582	0.224609	VII-VIII
1891 June 24	7.2	57	0.13608	0.081648	0.145606	0.11839	0.189152	VI-VIII
1893 June 21	7.3	63	0.129346	0.077608	0.1384	0.112531	0.179791	VI-VII
1991 November 21	6.2	32	0.127815	0.076689	0.136762	0.111199	0.177663	VI-VII
2013 October 14	4	5.7	0.119642	0.071785	0.128017	0.104089	0.166303	VI-VII
1939 February 4	6	34	0.103982	0.062389	0.11126	0.090464	0.144535	VI-VII

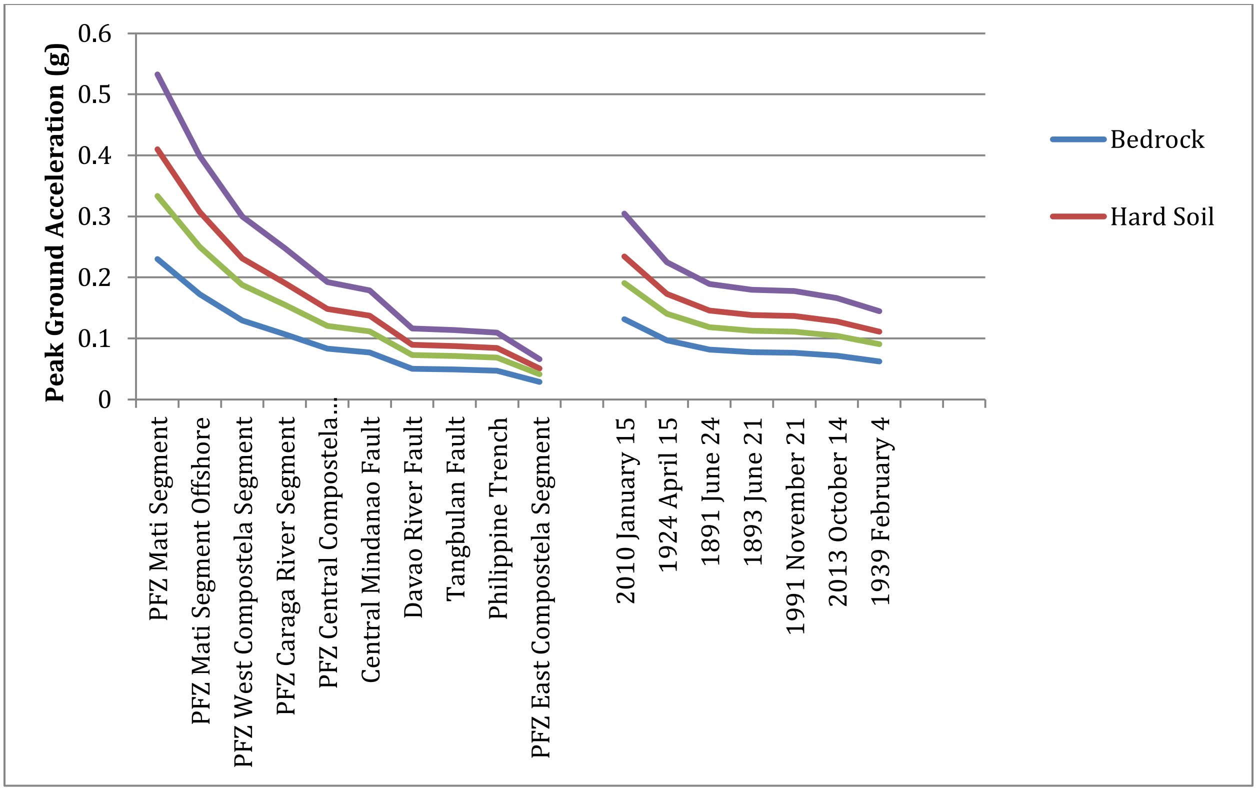


Figure 2.1-26. Comparison of PGA values of the different earthquake generators near the study area.

The above peak ground acceleration values clearly show that the potentially destructive to very destructive earthquake generators that could affect the project site are those generated from the nearby active faults (**Figure 2.1-26**). The fault with the highest PGA values is the Mati Segment of the Philippine Fault Zone (PFZ), which is located 13 km to the east of the project site. An offshore extension of this fault was the focus of the Magnitude 8.3 earthquake in 1924. Mati Fault and its offshore extension yielded the worst-case potential earthquake scenario peak ground acceleration (PGA) values of 0.172-0.230g for bedrock, 0.307-0.410g for hard soil, 0.250-0.333g for medium soil and 0.399-0.532g for soft soil ground conditions. The second group of faults which has high influence in terms of PGA values includes the Central and West Compostela Valley segments as well as the Caraga River segment of PFZ. The PGA values are 0.083-0.107, 0.148-0.231, 0.120-0.188, and 0.192-0.300 for bedrock, hard soil, medium soil and soft soil, respectively. Earthquakes generated by Philippine Trench, Tangbulan Fault, Central Mindanao Fault and Davao River Fault may have less impact to the project site.

For comparison of the fault-derived PGA values to the previous ground shaking experienced in the project area, PGA values were also derived from selected historical earthquakes with epicenters close to the project site (**Table 2.1-7** and **Figure 2.1-26**). The earthquakes present within 100 km radius have magnitudes ranging from Ms 1 to 8.3 although only those with magnitude 4 and above are presented in the seismicity map. The strongest significant earthquake is the Ms 8.3 Earthquake, which occurred offshore about 85 km southeast from the project site on April 15, 1924. Two earthquakes associated with the Compostela Valley Segments of PFZ occurred in June 24, 1891 and June 21, 1893 with magnitudes of 7.2 and 7.3, respectively. A magnitude 5.3 earthquake occurred on January 15, 2010, with epicenter located about 5.3 km northwest of the project site. Based on calculation, the resulting intensity is around VII (MMI) at the site. The PGA values generated by these selected historical earthquakes are comparable to the values of the second group of faults mentioned above.

The regionally estimated PGA values are consistently higher than the above site-specific PGA values. For safety purposes, the higher PGA values should be considered in the design of the structures to be built.

The typical earthquake intensities that could be felt near the epicenters of earthquakes using the Modified Mercalli Intensity (MMI) scale are shown in **Table 2.1-8**(USGS). The possible range of intensity (MMI) associated with the different PGA values are also shown in **Table 2.1-7**. based on the formula of Trifunac and Brady (1975). Table **2.1-9** shows the comparison of the PHIVOLCS Earthquake Intensity Scale (PEIS) and MMI. In the project site the expected earthquake intensities from the nearest fault range from MMI VII to IX or equivalent to PEIS VII to VIII which could be described as destructive to very destructive.

Table 2.1-8. Typical intensities corresponding to earthquake magnitude (USGS).

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

Table 2.1-9. Comparison of PEIS, MMI and JMAI (PHIVOLCS).

Intensity Scale	Description	MMI	JMAI
I	**Scarcely Perceptible** - Perceptible to people under favorable circumstances. Delicately balanced objects are disturbed slightly. Still Water in containers oscillates slowly.	I	0
II	**Slightly Felt** - Felt by many individuals at rest indoors. Hanging objects swing slightly. Still Water in containers oscillates noticeably.	II	1
III	**Weak**- Felt generally by many people indoors especially in upper floors or 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.	III	2
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.	IV	2 - 3
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 or leaves and twigs of trees are noticeable.	V	3
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.	VI	4
VII	**Destructive** - Most people are frightened and run outdoors. People find it difficult to stand in upper floors. Heavy objects and furniture may 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 are shaken strongly. (Liquefaction is a process by which loose saturated sand lose strength during an earthquake and behave like liquid.	VII	4
VIII	**Very Destructive** - People panicky. People find it difficult to stand even outdoors.	VIII,	5 - 6

Intensity Scale	Description	MMI	JMAI
	Many well-built buildings are considerably damaged. Concrete dikes and foundation of bridge 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 structure 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 rapture may be observed. Trees are violently shaken. Water splash or stop over dikes or banks of rivers.	IX	
IX	**Devastating** - People are forcibly thrown to ground. 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 sand boils 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 or stops over dikes and banks.	X, XI	7
X	**Completely Devastating** - Practically all man-made structures are destroyed. Massive landslides and liquefaction, large-scale subsidence and uplifting of landforms and many ground fissures are observed. Changes in river courses and destructive seiches in large lakes occur. Many trees are toppled, broken and uprooted.	XII	7
Source: PHIVOLCS web site, http://www.phivolcs.dost.gov.ph/Earthquake/Scale/peis.html MMI: Modified Mercalli Intensity; JMAI: Japan Metrological Agency Intensity			

b.) Ground Rupture

Ground rupture is a visible breaking and displacement of the Earth's surface along the trace of the fault, which may be in the order of several meters in the case of major earthquakes. It is a major risk for large engineering structures built on top of active faults.

Based on the active faults map of PHIVOLCS, the project site is about 13 km to the west of the Mati Segment of Philippine Fault Zone (PFZ) (**Figure 2.1-24**). This fault is trending in a north-south manner. It has an extent of about 56 km. Since this fault is of considerable distance, the site is unlikely susceptible to ground rupture.

c.) Liquefaction and Differential Settlement

The typical soil that is susceptible to liquefaction is loose sand located near the surface and with shallow groundwater table. During an earthquake, ground shaking causes loosely consolidated sand deposits to contract resulting to increase in pore water pressure and reduced grain to grain effective stress (Seed, 1970). This causes loss of soil bearing capacity and makes the soil behave like fluid. In the process, there is an upward flow of water to the ground surface where it emerges in the form of mud spouts or sand boils. Liquefaction is usually accompanied by differential settlement and lateral spreading because of lateral movement of the liquefied soil away from the vertically loaded area. Smaller ground settlement can also occur after the earthquake as pore water pressures dissipate and the soil consolidates (Orense, 2003). The occurrence of sand boils can also lead to localized differential settlement.

Areas where liquefaction is likely to occur include riverbeds, old or abandoned riverbeds and meanders, swamps and back swamps (Youd and Perkins, 1978). Alluvial plains, pyroclastic plains and coastal plains with shallow groundwater and with silty to sandy soils are also possible sites for liquefaction.

Within the MPSA, the areas susceptible to liquefaction are the river and creeks and their associated floodplains and terrace deposits where silty and sandy layers abound. However, this is very limited since most of the streams are cobble to boulder dominated. The floodplains and swampy areas along the coasts are susceptible to liquefaction. These include the built-up areas in Barangays Maputi and Puntalinao. The facilities that are in these areas are the stockyard, jetty and access/haul roads.

2. Mass Movement Hazard

a.) Ground Subsidence and Collapse

Vertical ground movements could be classified into subsidence and collapse. Subsidence is the slow lowering of the land surface due to the presence of collapsible and/or expansive soils and over extraction of groundwater or petroleum. Collapse is the relatively fast opening of the land surface and movement of surface materials into cavities below (Orense, 2003). Sinkholes in karstic limestone are the common example of collapse. Underground mine workings could also collapse when they are not properly supported.

The lithology in the project site is mainly composed of ultramafics such as harzburgite and dunite. There are no extensive soluble rocks such as limestone found in the area. These types of rocks are not prone to dissolution and collapse. However, adits, used in the exploration works, can be present.

b.) Settlement

Ground settlement occurs when structures are built on clayey water-saturated sediments. The weight of the structures compresses the clayey soil, removing the water and resulting to compaction and eventually the surface subsides (Orense, 2003). Larger settlements occur in cohesive clayey soils as compared to granular soils. The factors determining the amount of settlement are the clay mineralogy, diagenetic changes, pre-consolidation history, structural load and foundation shape.

In the MPSA area, clayey soil layers with considerable thickness are confined in the broad ridges as lateritic soils that will be mined for their nickel content. These soils have thickness of up to 7 m. Colluvial soils found at the lower to basal part of the slopes are also typically clayey and are potentially prone to ground settlement. The coastal plains, particularly the swampy areas are also prone to settlement.

c.) Landslides

Landslides may be caused by one or a combination of several factors, such as steep slopes, the properties of the slope material, heavy rainfall, ground shaking, and river or wave erosion; however, there is usually one identifiable trigger or event that is responsible for initiating the landslide. Rain-induced landslides are usually triggered by extreme rainfall events that may or may not be associated with typhoons, and commonly occur in hilly to mountainous areas with steep slopes and poor drainage. Strong earthquake also triggers landslide.

The MPSA area is generally characterized by steep to mountainous terrain. The topographic relief is moderate to high. Based on the 1:10,000 Landslide Susceptibility Map of MGB (**Figure 2.1-27 and Table 2.1-10),** the MPSA area, which includes the proposed mine sites, waste dumps and siltation ponds are in high susceptibility zone. Most of the existing access roads, proposed haul roads and proposed drainage canals also traverse the high susceptibility zone. The proposed pre-pile yard is within the moderate to high susceptibility area while the proposed campsite and stockyard are situated in flat to slightly undulating terrain with low landslide susceptibility.

Table 2.1-10. Landslide susceptibility classification of MGB.

Susceptibility	Description
Low	Areas with low to moderate slope, slight to moderate weathering, and good to very good rock mass strength. Ground is stable, with no identified landslide scars, either old, recent or active.
Moderate	Areas with moderate to steep slope, moderate weathering, and fair rock mass strength. Soil creep and other indications for possible landslide occurrence are present.
High	Areas with steep to very steep slope, intense weathering, presence of usually non-cohesive

Susceptibility	Description
	soil, and poor to very poor rock mass strength. Inactive landslides evident and tension cracks are present.
Very High	Areas with steep to very steep slope, intense weathering, presence of usually non-cohesive soil, and poor to very poor rock mass strength. Active landslides evident and tension cracks, bulges, terracettes, and seepage are present. Human initiated effects maybe an aggravating factor.

Numerous landslides where identified in the 2004, 2009, 2010 and 2013 Digital Globe and 2014 and 2015 CNES-Astrium satellite imageries obtained through Google Earth (**Figure 2.1-28**). The landslides are present both within and outside of the MPSA areas. This confirms the high susceptibility classification of the project area to landslides. Most of the landslides observed in the satellite images were triggered by heavy rainfall, one of which was due to Typhoon Pablo on December 4, 2012. They occurred in both forested and deforested slopes. The landslide observed during the fieldwork occurred in grass/shrub covered steep slopes (**Figure 2.1-29**) and were triggered by heavy rainfall in October 2015. The landslides in vegetated areas are mostly along gullies and appear to be debris flows. Along the access roads the landslides are associated with the instabilities caused by steep slope cut. The main channels of the creeks are also choked with debris coming from these landslides. Some of the large debris flows have cut the access road (**Figure 2.1-30**).

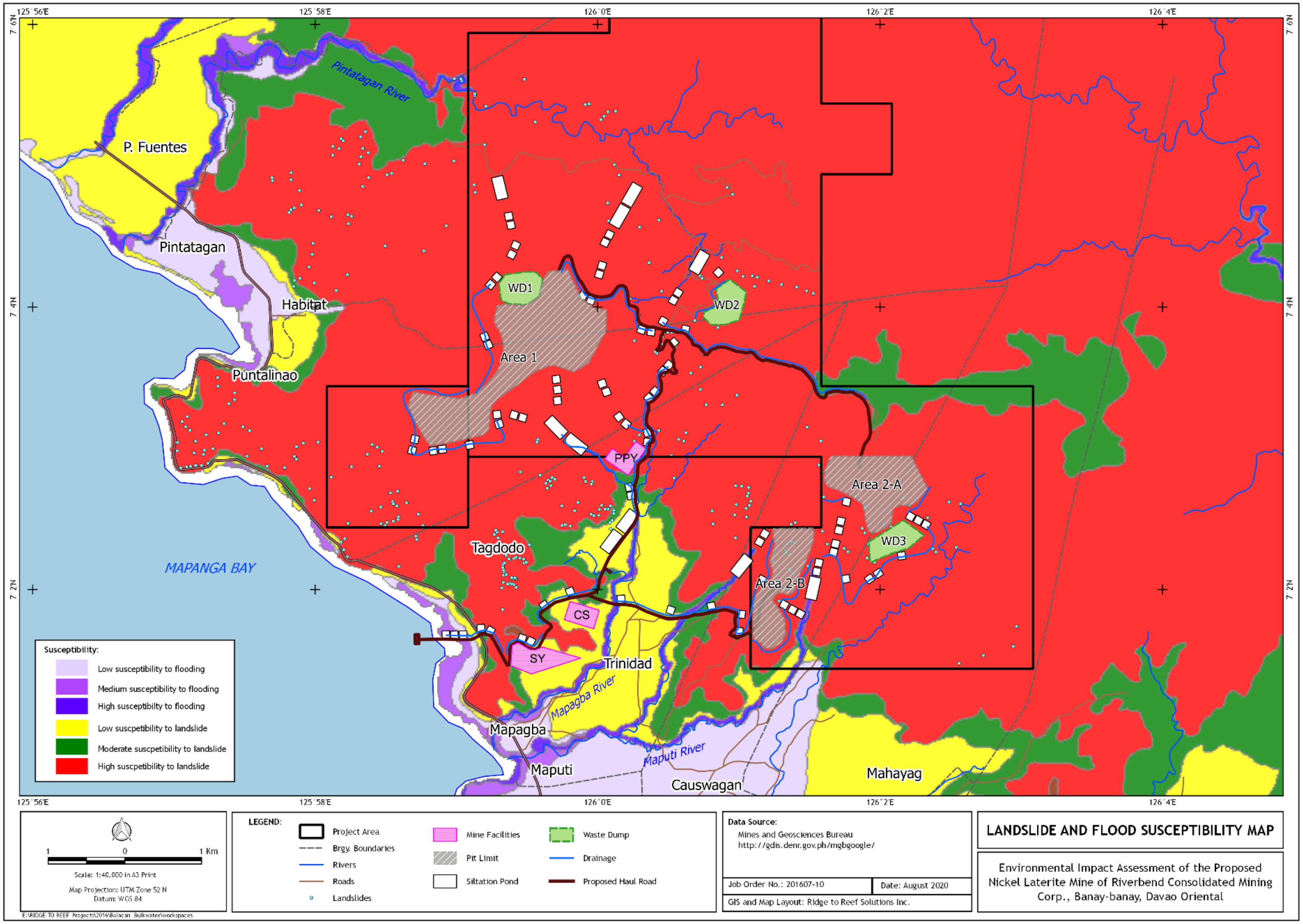


Figure 2.1-27. Landslide and Flood Susceptibility Map of the Project Site (Modified from MGB, 2015).

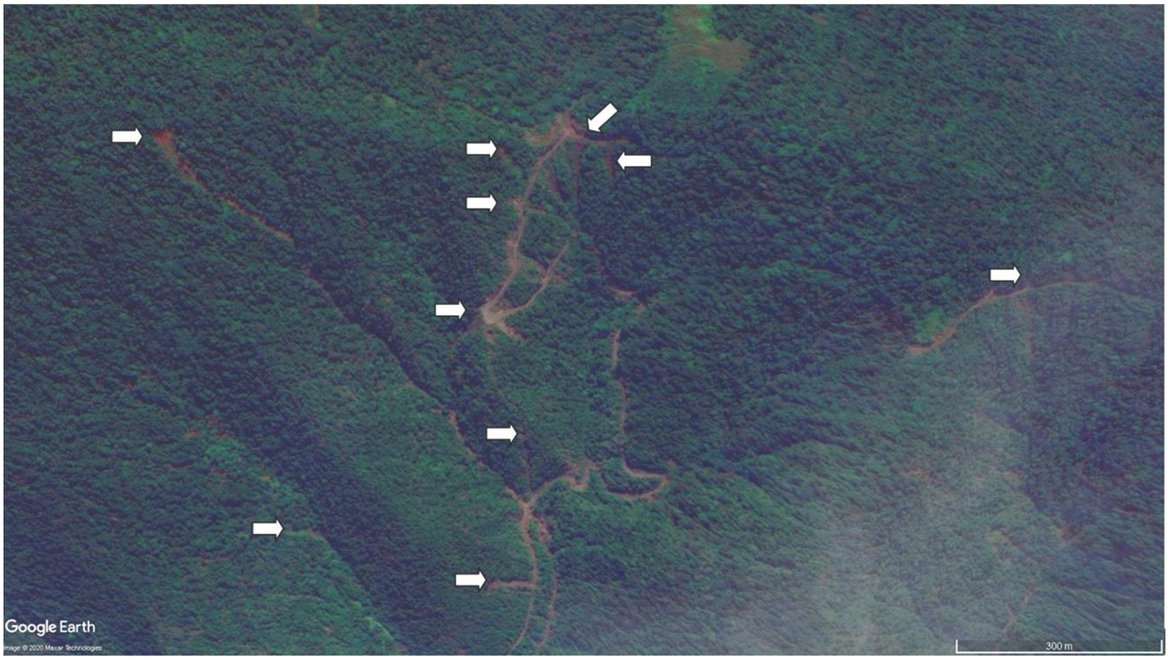


Figure 2.1-28. Landslides within the MPSA area along the access road and vicinity captured in the July 14, 2017 Maxar Technologies satellite image (accessed through Google Earth). The long scars are debris flows (pointed by white arrows).

Figure 2.1-29. Photo of landslides (light brown bare areas) present in deforested slopes. These were triggered by heavy rainfall last October 2015. This area is in Brgy. Maputi, to the south and outside of the MPSA area.

Figure 2.1-30. Photos of slopes and landslides along the access road within the MPSA area. Clockwise from top: highly fractured rocks prone to rockfall along the road; scar of debris flow track; dominantly large boulders debris flow deposit in one of the stream crossing; and landslide originating from the ridge.

Slope Stability Assessment

Rock Slopes

Preliminary assessments for potential slope failures were conducted in exposures along the existing roads going to the mine site (**Figure 2.1-31**). The Slope Mass Rating (SMR) System of Romana (1993) and the Slope Stability Probability Classification (SSPC) of Hack et al. (2002) were used to assess instabilities of rock slopes. The inputs are the rock mass and structure characteristics, discontinuity orientations describe in the previous sections, slope height and slope orientation. Failure of rock slopes is controlled by two factors: the first is related to the orientation of discontinuities and the slope and governed by the shear strength of the discontinuities. Discontinuity planes that are oriented parallel to and at a lesser angle than the slope cut are highly prone to planar slide. The discontinuity plane becomes the sliding plane. Slopes with two intersecting discontinuities in which the line of intersection is oriented parallel to and at a lesser angle than the slope cut are highly susceptible to wedge slide. Discontinuity sets that are steeply dipping in the direction opposite of the slope cut are prone to toppling failure. This are referred as orientation-dependent stability and is considered both in SMR and SSPC systems. Slopes cut by different discontinuity sets that are closely spaced are also susceptible to slope failure. Intact rock strength, block size, shear strength along discontinuities and slope height influence the development of failure planes not related to a single discontinuity set. This is referred as orientation-independent stability in SSPC.

In the SMR system adjustment factors for the discontinuity and slope orientation relationship and for the effect of method of excavation were added to the basic RMR rating. Stability and suggested slope support were derived from the SMR classes. The SSPC provides the stable slope height (Hmax) for orientation-independent stability and probability of slope failure.

The results of the assessment are shown in **Table 2.1-11**. Based on SMR there are at least one discontinuity set that makes the slope unstable either for sliding or toppling failure. Most of the slopes are classified as partially stable to unstable and there are two slopes that are completely unstable. The probability of these slopes to be stable are 45% and below based on SSPC. The stable slope height for the slopes located in the foothills (Slopes 63-1 and 63-2) ranges from 15 to 20 m. The current slope heights are only 3 to 5 m. For the slope cuts at higher elevation and steeper slopes (Slopes 65-1, 65-2, 68, 69 and 71) the stable slope height ranges only from 3.5 to 4.2 m. The probability of these slopes to be stable is 20% and below based on SSPC if there is no slope support constructed.

Given the highly fractured nature and fair to poor classification of the rock mass in the slopes assessed, it is expected that the rock mass in the MPSA area underlain by harzburgite and other ultramafic rocks, such as in the waste dump areas, haul roads and mine pits have similar fair to poor rock mass characteristics. Thus, rock slope instabilities are expected. The orientation and angle of the slope are important factors affecting the stability of the rock masses particularly for orientation-dependent stability. Slope height and surcharge load contributed by stockpiles will also affect slope stability of the rock mass.

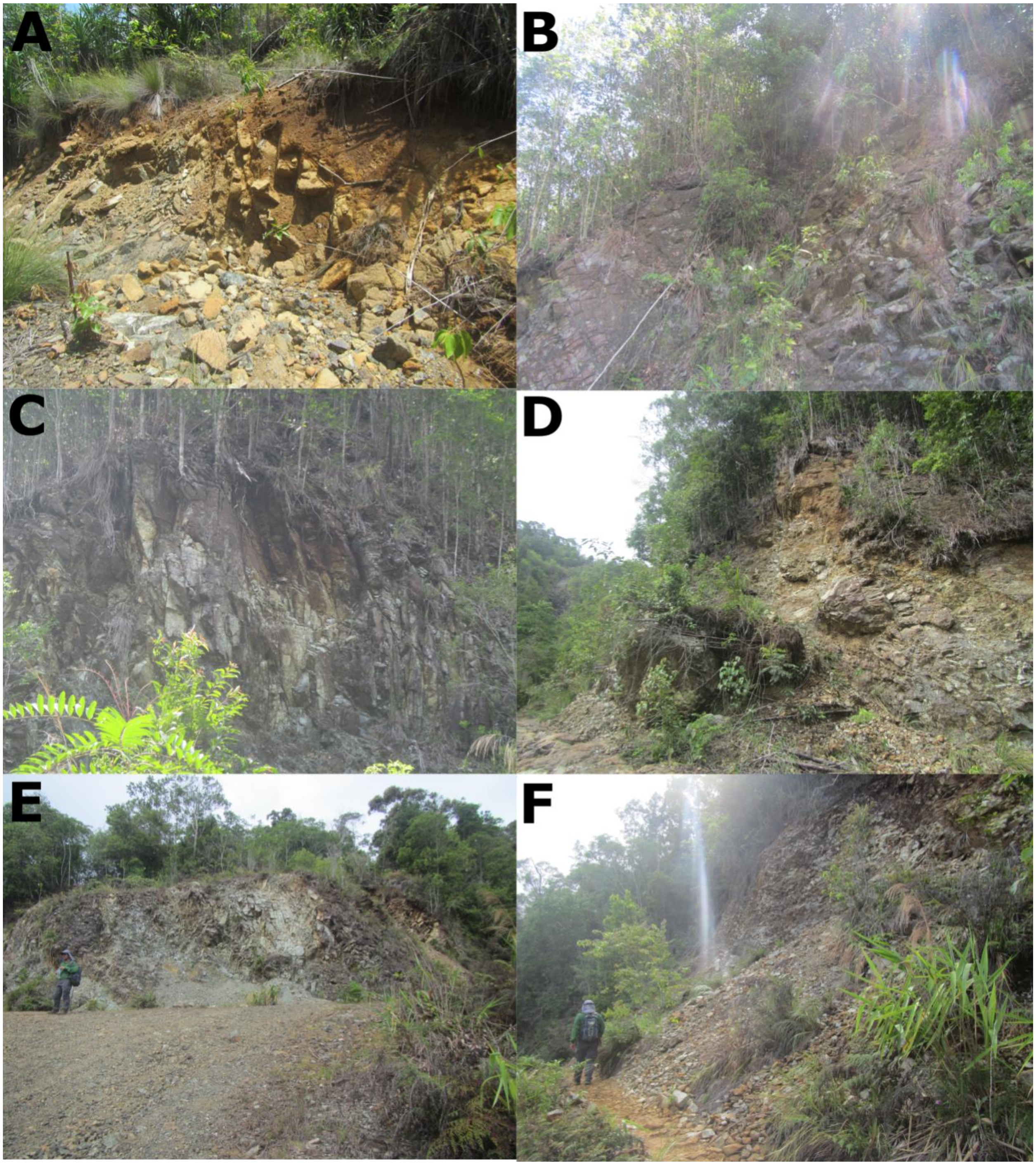


Figure 2.1-31. Photos of some of the slopes along the access road assessed for slope stability. A) Slope 63-1, B) Slope 65-2, C) Slope 69, D) Slope 68, E and F) Slope 71

Table 2.1-11. Results of the stability assessment in selected rock slopes.

Slope ID	Slope Dip °	Slope Dirn ° azi	Slope Height m	Dip °	Dip Dirn ° azi	Type	RMR	SMR System (Romana)			SSPC System (Hack)			
								SMR Score/Class	Failure Type	Support	Orientation independent		Orientation dependent	
											Hmax m	Stability	Failure	Stability
63-1	60	70	3	80	160	JS1	good	61/stable	some blocks	occasional	20	100%	toppling	10%
				60	340	JS2	good	63/stable	some blocks	occasional				
				85	220	JS3	fair rock	41/partially stable	some joints or many wedges	systematic				
63-2	60	70	5	70	25	Fault1	fair rock	44/partially stable	some joints or many wedges	systematic	15	100%	sliding	60%
				40	20	Fault2	poor	32/unstable	planar or big wedges	important / corrective				
				65	90	Fault3	fair rock	49/partially stable	some joints or many wedges	systematic				
				50	310	JS4	good	58/stable	some blocks	occasional				
				40	60	JS5	fair rock	15/partially stable	some joints or many wedges	systematic				
65-1	60	90	7	45	90	Fault4	poor	21/completely unstable	big planar or soil-like	re-excavation	3.5	10%	sliding	5%
				30	320	JS6	poor	33/unstable	planar or big wedges	important / corrective				
65-2	60	70	6	60	300	JS7	fair	38/unstable	planar or big wedges	important / corrective	4	15%	sliding	45%
				45	290	JS8	fair	33/unstable	planar or big wedges	important / corrective				
				60	10	JS9	fair	38/unstable	planar or big wedges	important / corrective				
				45	210	JS10	fair	41/partially stable	some joints or many wedges	systematic				
68	65	225	7	75	260	Fault5	fair	38/unstable	planar or big wedges	important / corrective	3.3	10%	sliding	45%
				70	210	JS11	fair	38/unstable	planar or big wedges	important / corrective				
				60	360	JS12	fair	34/unstable	planar or big wedges	important / corrective				
69	70	110	7	75	330	JS13	fair	49/partially stable	some joints or many wedges	systematic	3.6	10%	toppling	40%
				70	90	JS14	fair	35/unstable	planar or big wedges	important / corrective				
				60	210	JS15	fair	44/partially stable	some joints or many wedges	systematic				
71	65	210	6	60	210	JS16	fair	3/completely unstable	big planar or soil-like	re-excavation	4.2	20%	sliding	95%

Slope ID	Slope Dip °	Slope Dirn ° azi	Slope Height m	Dip °	Dip Dirn ° azi	Type	RMR	SMR System (Romana)			SSPC System (Hack)			
								SMR Score/Class	Failure Type	Support	Orientation independent		Orientation dependent	
											Hmax m	Stability	Failure	Stability
				45	70	JS17	fair	44/partially stable	some joints or many wedges	systematic				
				50	260	JS18	fair	44/partially stable	some joints or many wedges	systematic				
				85	290	JS19	fair	49/partially stable	some joints or many wedges	systematic				

Earthquake-induced Landslides

Intense ground shaking can trigger landslides by loosening the cohesion that bonds the slope materials together, thereby making it easier for gravity to effect failure. Hilly and mountainous areas, escarpments, and steep riverbanks, sea cliffs, and other steep slopes are prone to landslides. A landslide may be a rock fall, topple and slide or lateral spread.

According to Keefer (1984), the minimum earthquake magnitude that could trigger small rockfall is Ms 4.0. Landslides involving large volume of materials require higher magnitude to be generated. Keefer (1993) designed a flow chart to determine the susceptibility of slopes to earthquake-induced landslides based on rock mass characteristics and slope angles (**Figure 2.1-32**). It was derived from well-documented worldwide data. Based on this diagram, the susceptibility of steep to very steep rock slopes to earthquake-induced landslides is high to extremely high. The mining areas, waste dumps and siltation ponds are in extremely high to high susceptibility zones. This is also particularly significant in cut slopes traversed by existing roads and proposed haul roads where the slope gradient is very steep to almost vertical and the rocks are highly fractured (**Figure 2.1-31**). The proposed locations of the pre-pile yard, stockyard, camp site and jetty have low susceptibility to this hazard.

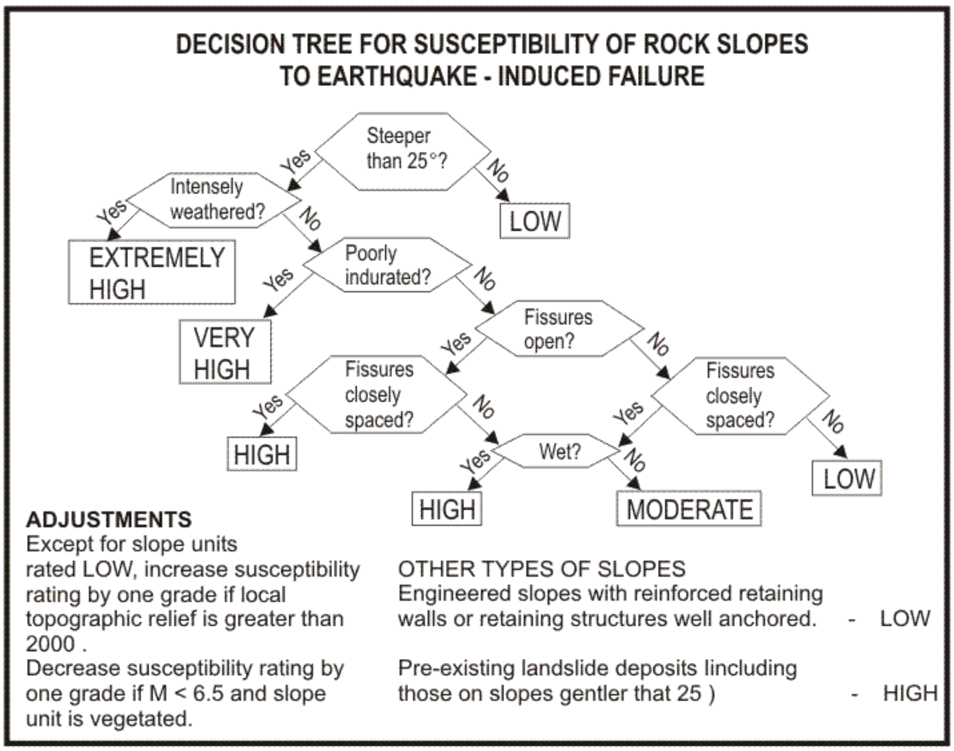


Figure 2.1-32. Flow chart for determining the susceptibility of rock slopes to earthquake-induced landslides (Keefer, 1993). The slopes in the proposed mining areas, waste dumps, siltation ponds and haul roads have high to extremely high susceptibility.

Soil Slopes

In rolling to mountainous slopes, landslides involving the upper soil layer commonly occur as a result of prolonged and/or intense rainfall. This kind of landslide involves translational movement along planar surface which is usually the contact between the rock and soil layers. Thus, the failure is generally shallow, reaching only about 1 to 3 m. When the material is saturated or when its velocity increases during transport, the initial translational sliding failure can propagate into flow, transforming the debris slide to debris flows. Due to high mobility of debris flows, they can travel long distances depending on the volume of materials involved and the degree of saturation. Previous studies have identified that the source area of debris flows is morphologically controlled (Dietrich et al., 1986; Guzzetti and Cardinali, 1992). They generally occur in concave planiform areas referred as hollows covered with thin colluvium. Storm runoff converge in these areas leading to local groundwater concentrations above perched groundwater tables and therefore enhances potential failure (Melelli and Taramelli, 2004).

Identification of the possible shallow debris slides and debris flow source areas was carried out in GIS environment using the 30 x 30 m grid derived from IFSAR-DSM. The Stability Index Mapping (SINMAP) model developed by Tarboton (1997) was used to generate the susceptible zones in terms of shallow translational landslides that consist mostly of soil. It is based on the infinite slope stability model and steady-state hydrology model. The data required to implement the model include soil and climate properties that can be highly variable. The model accepts ranges of values to represent this uncertainty. The geotechnical parameters used in the model include friction angle, cohesion factor (ratio of combined root and soil cohesion over soil thickness and density), and the ratio of transmissivity to effective recharge (T/R) of soils. T/R is related to the length of slope needed to attain saturation. The values of these parameters were derived from literature. The soil type was based on the soil map produced by the Bureau of Soils and Water Management (BSWM). There are four types of soil used in the model, namely Camasan sandy clay loam, San Manuel silty clay loam, Malalag loam and undifferentiated mountain soil. The mountain soil covers the MPSA area while the silty clay loam is found in the plains where the stockyard and campsite are located. Based on the soil sample collected within the MPSA area, the undifferentiated mountain soil was identified as clay. The range of geotechnical parameters for these different soils is shown in **Table 2.1-12.**

Table 2.1-12. Geotechnical parameters of soils.

Soil	Friction Angle, °	Cohesion factor	Soil Density, kg/m^3	T/R, m
Camasan sandy clay loam	26 - 34	0.2 – 0.5	1,835	500 - 1000
San Manuel silty clay loam	21 - 29	0.3 – 0.6	1,746	500 - 1000
Malalag loam	28 - 36	0 – 0.8	2,114	500 - 1000
Mountain Soil (clay)	18 - 26	0.2 – 0.5	1,697	500 - 1000

The output is a stability index map showing the factor of safety at each grid location. Stability indices are not interpreted as numerically precise but in terms of relative hazard. The susceptibility class was derived based on the following factor of safety values: 0 to 1.0 – very high; 1.0 to 1.1 high; 1.1 to 1.25 – moderate; 1.25 to 1.5 – low; and above 1.5 – unlikely. The possible distance that can be reached by the landslide once the slope fails (runout) was modeled using the avalanche runout model in TAUDEM. The landslide type is assumed as debris flows, which can reach long distances depending on the saturation of the material. The basic input for the model is the landslide initiation point and the angle of reach, which was derived from typical values for debris flows (Prochaska et al, 2008). The runout and accumulation zone of debris flows are represented by the diagonal hatched area in the map.

Figure 2.1-33 shows the shallow landslide susceptibility distribution in the study area. Based on the model the soils in steep slopes within the MPSA area have high to very high susceptibility to shallow translational landslides. Broad ridges with gentle slopes are unlikely susceptible or have low susceptibility. However active landslides in steep slopes can progress retrogressively to these gentle slopes along ridges and spurs. The runout zone represents the track and accumulation zone of the landslide deposit. Landslides coming from high elevation and steep slopes can reach distances from 2 to 3 km according to the model. As shown in the map it will reach the plains and nearby streams, even those outside of the MPSA boundary. Depending on the volume and amount of saturation, such materials can travel farther downstream as debris flows in conjunction with flashfloods.

Areas with loose rock and soils are the most susceptible to earthquake-induced landslides. The areas susceptible to rain-induced shallow landslides are also highly prone to earthquake-induced landslides. Based on the earthquake-induced landslide susceptibility map from PHIVOLCS (**Figure 2.1-34**), the project site has low to high susceptibility to earthquake-induced landslide. In low susceptibility areas, landslide is possible if the earthquake intensity is PEIS VIII (MMI IX) or the PGA value is 0.3g. In high susceptibility areas, PEIS VII (MMI VIII) earthquakes or those with PGA value of 0.07 could trigger landslides. These values are within the range of PGA values that could be generated by the first group of faults mentioned in the ground shaking section above. The proposed haul road located in gentle slopes and pre-pile yard have low to moderate susceptibility. The stockpile yard and campsite have moderate susceptibility.

The susceptibility of the different project components and facilities to the types of slope failure are summarized in **Table 2.1-13**.

Table 2.1-13. Susceptibility to slope failure of areas that will be affected by the project.

<table>
<tr><th rowspan="2">Components</th><th rowspan="2">Shallow landslide</th><th colspan="2">Rock slope</th></tr>
<tr><th>Rock mass stability</th><th>Earthquake-induced slide</th></tr>
<tr><td>Mining area 1</td><td>Very high; low to moderate along ridge</td><td rowspan="5">Fair to poor rock mass; partially stable to unstable depending on slope orientations, prone to planar slide, wedge slide and toppling</td><td>Extremely high to high (Keefer)</td></tr>
<tr><td>Mining area 2</td><td>Very high; low to moderate along ridge</td><td>Extremely high to high (Keefer)</td></tr>
<tr><td>Waste dumps</td><td>Very high</td><td>Extremely high to high (Keefer)</td></tr>
<tr><td>Haul road in mountainous terrain</td><td>Very high</td><td>Extremely high to high (Keefer)</td></tr>
<tr><td>Siltation ponds in mountainous terrain</td><td>Very high</td><td>Extremely high to high (Keefer)</td></tr>
<tr><td>Haul road in gentle slopes</td><td>low to unlikely in flat areas but with segments in runout zone</td><td>Stable; most likely with thick alluvial cover</td><td>Low to moderate (Phivolcs)</td></tr>
<tr><td>Pre-pile yard</td><td>Moderate to high; within runout zone</td><td>Stable; most likely with thick alluvial/colluvial cover</td><td>Low to moderate (Phivolcs)</td></tr>
<tr><td>Stockpile yard</td><td>Unlikely but adjacent to very high hazard zone; western part within runout zone</td><td>Stable; most likely with thick alluvial cover</td><td>Moderate (Phivolcs)</td></tr>
<tr><td>Campsite</td><td>Unlikely; western part within runout zone</td><td>Stable; most likely with thick alluvial cover</td><td>Moderate (Phivolcs)</td></tr>
<tr><td>Siltation ponds in flat terrain</td><td>Unlikely; some adjacent to high hazard zone and within runout zone</td><td>Stable; most likely with thick alluvial cover</td><td>Low to moderate (Phivolcs)</td></tr>
</table>

The above table shows that the rock and soil slopes are currently highly prone to rain-induced and earthquake-induced landslides even without mining activities. The trigger to slope failure can be heavy rainfall, strong ground shaking due to earthquake, additional load due to stockpiles, steepening of slopes or combination of these. These landslides can occur as debris flows when the materials are saturated. Debris flows can travel long distances especially when they originate from high elevation with steep slopes.

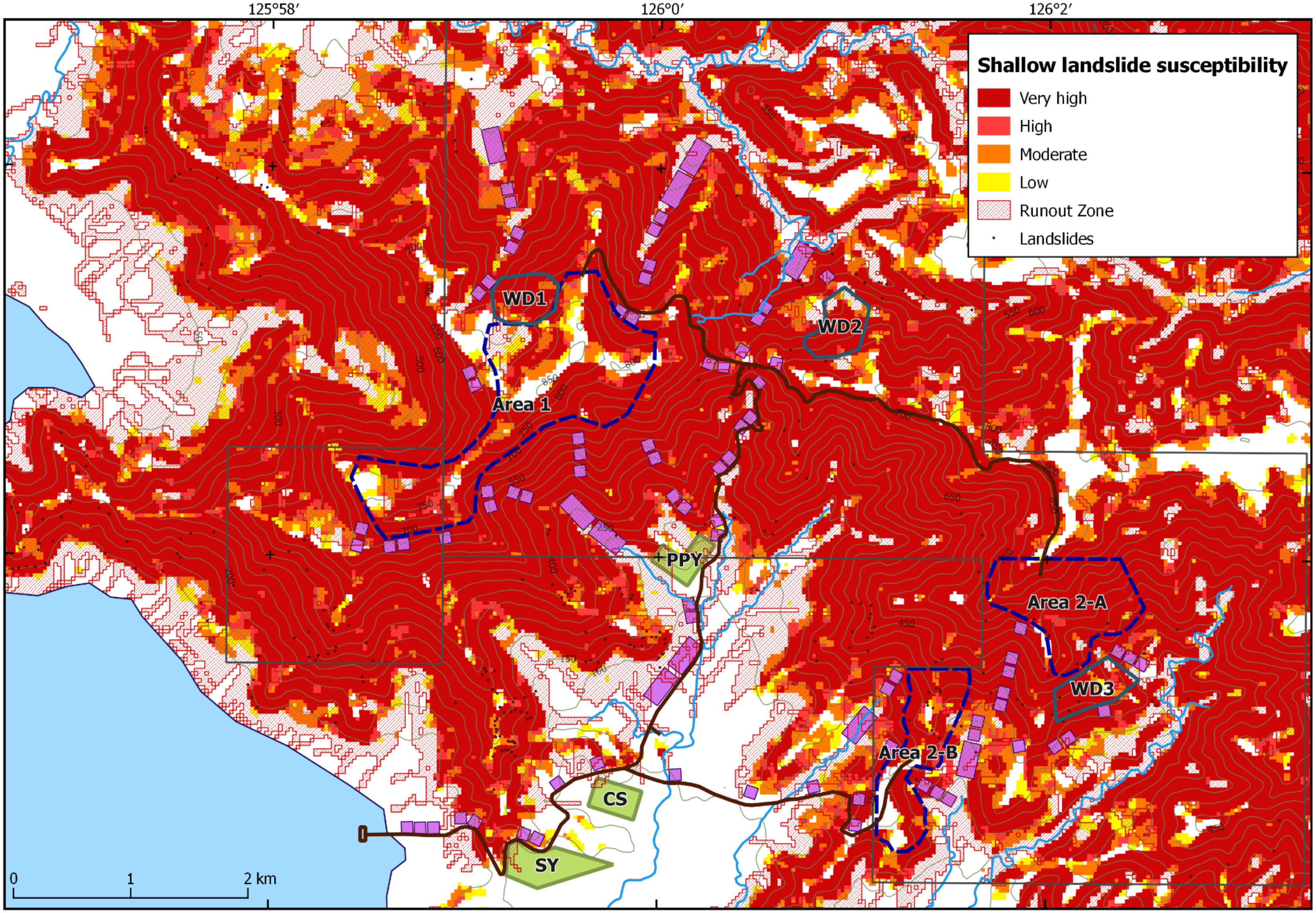


Figure 2.1-33. Shallow landslide susceptibility map generated using SINMAP software.

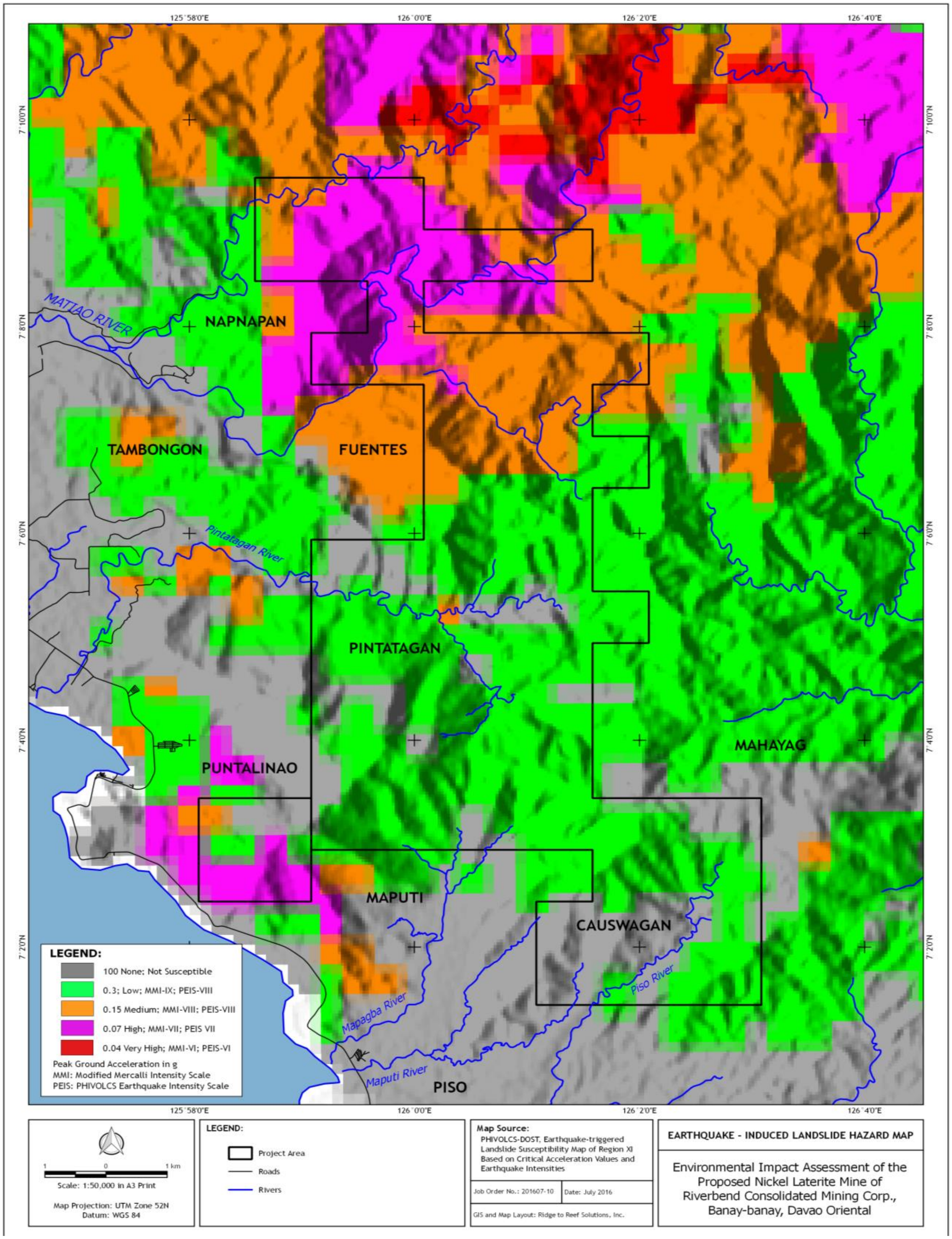


Figure 2.1-34. Earthquake-induced Landslide Susceptibility Map of the Project Site. (Modified from PHIVOLCS, 2015)

3. Volcanic Hazard

There is no nearby active volcano close to the project site. The nearest active volcano is Mt. Leonard Kniassef in Maco, Compostela Valley (**Figure 2.1-35**). It is about 37 km north-northeast of the site. According to the volcano database of PHIVOLCS this is a stratovolcano composed of andesitic to dacitic rocks. Lake Leonard is a caldera lake found on the crater of this volcano. There are thermal areas with hot springs on its slopes. The age of the youngest deposit is 1,800 before present based on Carbon 14 dating. A monitoring expedition conducted in 1995 did not record any volcanic activity.

Mt. Matutum is another active volcano located in South Cotabato, which is about 128 km to the southwest of the project site. According to the volcano database of PHIVOLCS this is a stratovolcano composed of andesitic rocks. Its latest eruption was on March 7, 1911.

If ever these volcanoes will erupt in the future, the volcanic hazard that could affect the site is the fall of volcanic ejecta or tephra. This could include ash and gravel-size fragments, called lapilli. Lapilli are deposited near the flank of the volcano while ash could travel for very long distance when picked up by the prevailing wind current. The amount of tephra that could affect the site is dependent on the amount of ejected materials and the prevailing wind condition. Ashfall can cause significant damage to buildings, transportation, water, wastewater, power supply, communications equipment, agriculture and human health.

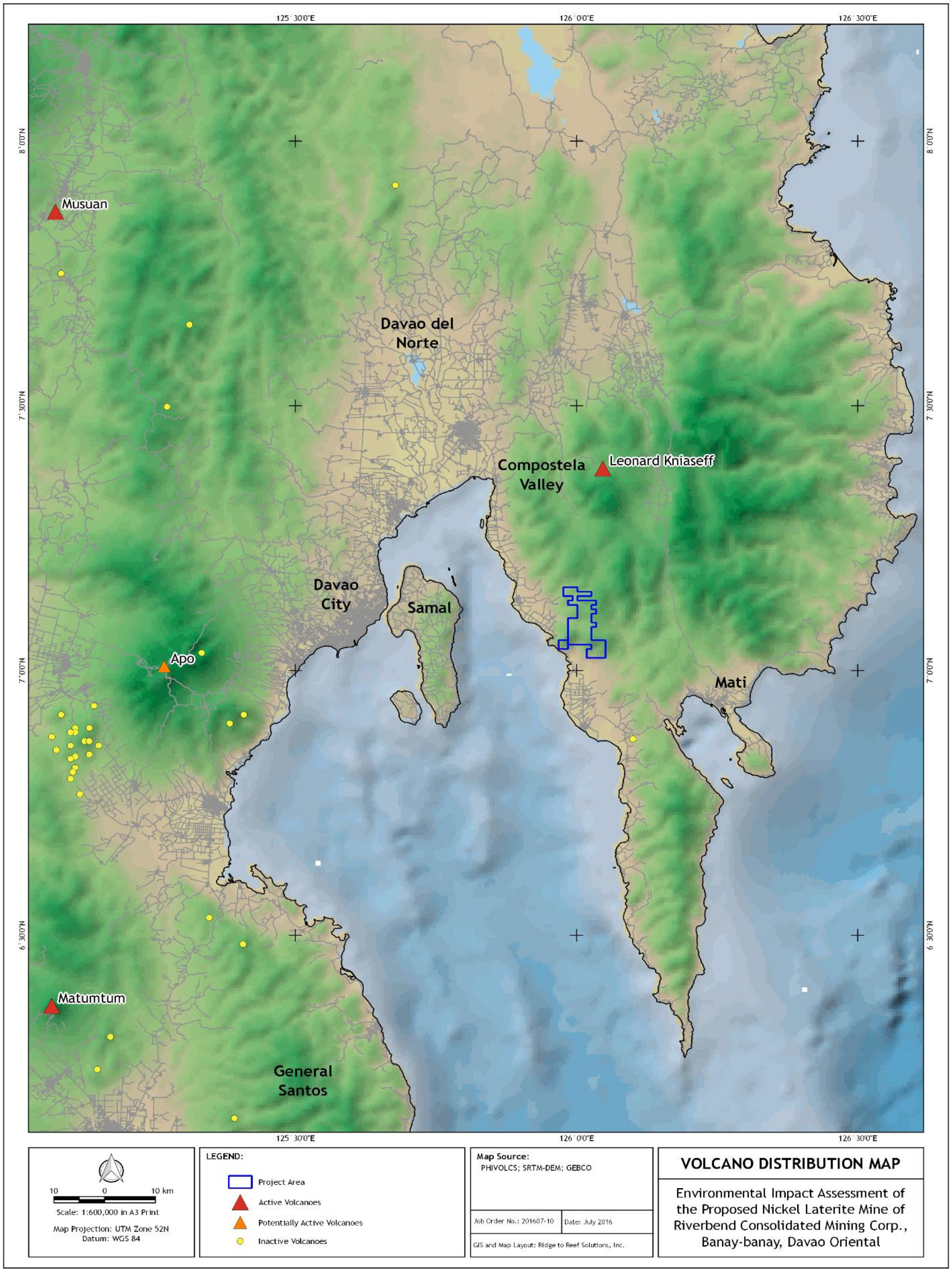


Figure 2.1-35. Volcano Distribution Map in the region. (Modified from PHILVOLCS, 2015).

4. Occurrence of Disasters

The incident of natural disasters in Mindanao is increasing in recent years. It is not usually affected by typhoons but there were at least two occurrences that resulted to disasters within the past ten years. It is expected that the flood magnitude, frequency and consequently sediment yield of the rivers will increase due to the projected increase in rainfall during the wet season because of climate change (DOST-PAGASA, 2011). Eastern Mindanao is also transected by active faults and close to the Philippine Trench where at least one earthquake with magnitude above 8 was recorded in the past. The least of disasters that occurred in the region where the project site is situated is listed in **Table 2.1-13-1**.

Heavy rainfall due to northeast monsoon and tail end of the cold front is already common in the eastern seaboard and caused disasters. This is usually the cause of the almost annual flooding experienced in Davao Oriental including the town of Banaybanay.

Table 2.1-13-1. List of disasters that affected the region.

Date	Geologic and Hydro-meteorologic Hazards	Cause	Extent	Impact
January 26, 2019	Flashflood, River Flood, Landslides	Heavy rainfall due to Tail End of Cold Front starting on January 19	Regional, mostly eastern part of Davao Oriental facing Philippine Sea	Four houses totally damaged, 1 dead, 2 missing, 2 injured in Manay, Davao Oriental; blocked roads due to landslides in Mati, Tarragona and Caraga
March 18, 2019	Flashflood, River Flood, Landslides	Heavy rainfall due to Troprical Depression Chedeng	Regional, eastern and southern part of Davao Oriental	Evacuation of about 920 families in Mati City, San Isidro, Cateel;
September 8, 2018	Ground shaking and landslides	Magnitude 6.4 Earthquake with epicenter in Manay, Davao Oriental; 57 km east of Banaybanay	Regional mostly in municipalities of Tarragona, Manay and Mati City	Damaged buildings, houses and roads; rockfalls along highways; Intensity VI in Banaybanay;
June to July, 2016	Flooding coincident with high tide	Frequent heavy rainfall	Local, Banaybanay and adjacent municipalities facing Davao Gulf	Waist to chest deep floods (1 to 1.5 m depth) affected fishponds and farms adjacent to Maputi River in Brgy. Maputi and Kalangawan River in Brgy. Causwagan, Banaybanay
October 3, 2015	Flashflood	Heavy rainfall	Local, Banaybanay and adjacent municipalities facing Davao Gulf	Waist deep flood in Mapagba River lasting for almost 12 hours; affected Purok 8 of Sitio Trinidad and Sitio Mapagba; two houses destroyed due to riverbank erosion
January 17, 2014	Flashflood, River Flood, Landslides	Heavy rainfall due to Typhoon Agaton from Jan 17 to 20	Regional, mostly eastern part of Davao Oriental facing Philippine Sea	10 fatalities, 25 injured and 1 missing in Davao Oriental mostly due to landslides; 10 families from 1 barangay in Banaybanay were evacuated
February 18, 2013	Flashflood, River Flood, Landslides	Heavy rainfall due to Tropical Depression Crising from February 18 to 21	Regional, eastern and southern Mindanao	Flooding in low-lying areas along rivers in Banaybanay
December 4, 2012	Flashflood, River Flood, Landslides (debris flows), Storm Surge	Typhoon Pablo	Regional, mostly eastern part of Davao Oriental facing Philippine Sea and and upland municipalities of Davao de Oro	537 fatalities, 2271 injured and 51 missing in Davao Oriental; mostly in Baganga, Boston, Cateel; 651 fatalities in Davao de Oro mostly from New Bataan; 42 families affected in Banaybanay by flood and landslides
July 4, 2012	Flashflood, River Flood, Landslides	Heavy rainfall	Local, Banaybanay and adjacent municipalities facing Davao Gulf	Evacuation of about 144 families from different barangays of Banaybanay
December 16, 2011	Flashflood, River Flood, Landslides	Heavy rainfall due to Typhoon Sendong from Dec 14 to 17	Regional, northern and eastern Mindanao	Flashfloods and localized flooding; Debris flows in Bukidnon and Cagayan de Oro
October 10, 2011	Flood	Heavy rainfall due to Tropical Storm Ramon from Oct 9 to 12	Regional, eastern Mindanao	
March 19, 2002	Flashflood, River Flood, Landslides	Heavy rainfall due to Tropical Depression Caloy Crising from March 19 to 25	Regional, eastern Mindanao	Around 35 fatalities in Surigao del Sur
May 9, 2001	Flashflood, River Flood, Landslides	Heavy rainfall due to Typhoon Crising from May 9 to 14	Regional, eastern Mindanao	
January 1, 2001	Ground shaking and landslides	Magnitude 7.2 Earthquake; epicenter 91 km southeast of Banaybanay	Regional, eastern Mindanao	Intensity VI in Banaybanay
2000	Flashflood	Heavy rainfall	Local, Banaybanay and adjacent municipalities facing Davao Gulf	Waist deep flood occurred in Brgy. Causwagan
November 21, 1991	Ground shaking and landslides	Magnitude 6.2 Earthquake; epicenter 32 km west of Banaybanay	Regional, eastern Mindanao	Intensity VII in Banaybanay
September	Flashflood, River	Typhoon Nitang	Regional, eastern portion of	Around 1000 fatalities in Surigao del Norte; 119,000 families

Date	Geologic and Hydro-meteorologic Hazards	Cause	Extent	Impact
1, 1984	Flood, Landslides, Storm Surge		Mindanao, Visayas; landfall in Surigao del Norte - Dinagat area	affected
January 10, 1970	Ground shaking and landslides	Magnitude 6.2 Earthquake; epicenter 48 km east-southeast of Banaybanay	Regional, eastern Mindanao	Intensity VI in Banaybanay
June 16, 1941	Ground shaking and landslides	Magnitude 6.5 Earthquake; epicenter 34 km east-northeast of Banaybanay	Regional, eastern Mindanao	Intensity VII in Banaybanay
February 4, 1939	Ground shaking and landslides	Magnitude 6 Earthquake; epicenter 34 km east-northeast of Banaybanay	Regional, eastern Mindanao	Intensity VII in Banaybanay
November 16, 1927	Ground shaking and landslides	Magnitude 6.9 Earthquake; epicenter 65 km south of Banaybanay	Regional, eastern Mindanao	Intensity VI in Banaybanay
April 14, 1924	Ground shaking and landslides	Magnitude 8.3 Earthquake; epicenter 84 km southeast of Banaybanay	Regional, eastern Mindanao	Intensity VII in Banaybanay
February 7, 1918	Ground shaking and landslides	Magnitude 7.5 Earthquake; epicenter 84 km southeast of Banaybanay	Regional, eastern Mindanao	Intensity VII in Banaybanay

F. Inducement of Geologic Hazards

1. Seismic Hazard

a.) Ground Shaking

Mine development and construction of facilities will result to the introduction of new elements at risk to strong ground shaking. The design of mining pit, waste dumps, siltation ponds, buildings, haul roads and access roads must incorporate the computed PGA values. Slope stability assessment must include pseudo-static analysis to determine the effect of ground shaking and incorporate it in slope support. Design and construction of buildings in the camp site must strictly follow the building/structural code.

b.) Liquefaction, Differential Settlement and Lateral Spread

The stockyard, jetty and segments of access/haul roads are close to the streams and underlain by alluvial and beach deposits. During construction and operation phase, hauling of laterite from stockyard to jetty could cause localized liquefaction in the sediments beneath the road due to dynamic loading (vibration). This could cause differential settlement that would create cracks on the surface or pavement. Differential settlement in these areas due to liquefaction may result to the flow of sediments towards existing waterways. Geotechnical study must be conducted to know the potential to liquefaction of the different sand layers, their extent and to determine the possible mitigating measures. Artificial fill must be sufficiently compacted prior to construction of structures. Roads must be properly compacted during construction. Slopes in liquefiable areas must be supported to prevent lateral spread.

2. Mass Movement Hazard

a.) Ground Subsidence

Adits used in mineral exploration phase can induce ground collapse or subsidence when left unsupported once the exploration phase is finished. As mentioned in the project description the proponent will include the rehabilitation of abandoned adits. It must be completely backfilled to minimize collapse of surface materials. The ground above the adits must be monitored for signs of subsidence like occurrence of circular tension cracks. If present, runoff coming upslope must be diverted away from this area by constructing cutoff drains and channel it to nearby natural drainage.

b.) Settlement

Construction of facilities such as the stockyard, waste dumps, pre-pile yard, campsite, siltation ponds, jetty and access/haul roads on top of thick clayey soil will lead to compaction and settlement. Differential ground movement can destroy the gradient, affect drainage lines and can promote water ponding. Geotechnical study must be conducted to know the compressibility of the clay layers and determine the possible amount of settlement. Artificial fills must be sufficiently compacted. The appropriate type of foundation as determined by the geotechnical study must be implemented.

c.) Landslides

Mine development and construction will induce slope failures. The rehabilitation of access roads and construction of new haul roads, waste dumps, siltation ponds and mining itself will create new slope cuts which will steepen the slopes in the mountainous terrain. The topsoil and overburden stockpiles in the waste dumps will create surcharge load in the already unstable slopes. Based on the site development plan, there are siltation ponds located in steep slopes and gullies. The main purpose of siltation pond is to collect sediments and water to allow the sediments to settle. The additional weight of sediments and water in siltation ponds will also add load to the slope. Based on the topographic map and ocular inspection, the relatively gentle slopes are located along ridges. Gentle slopes with enough space for siltation ponds maybe limited to none along gullies. Construction of siltation ponds in gullies will also block the flow of water. The location of waste dumps can also block gullies. During heavy rainfall ephemeral streams usually form and can erode the siltation ponds and waste dumps causing breaching and generation of debris flows and flashfloods that can travel long distances downslope. Construction of drainage lines will remove the clayey soil. In areas with shallow bedrock this can promote rapid seepage going to the rock fractures. This will increase hydrostatic pressure in the slope and can lead to slope failure. Clearing of vegetation at the onset of the operation will reduce the total soil cohesion due to the removal of cohesion contributed by plant roots. Construction of benches, removal of soil and overburden, and extraction of ore during operation will all steepen the slope. The benches are usually vertical to maximize the volume of material that will be extracted. Transport of ore from the mine site to the pre-pile yard, stockyard and jetty will contribute dynamic load to the slopes due to passage of trucks carrying the ore. Steepening of slopes decrease in cohesion, addition of static and dynamic loads and increase in hydrostatic pressure will decrease the factor of safety and aggravate instability and will lead to slope failure.

The proponent will undertake progressive rehabilitation of mined out areas after five to six months of operation and will initially commenced in 10 hectares area. Reshaping of the mined-out area to a stable slope angle will restore slope stability. Backfilling of overburden and topsoil following its original stratification will reduce infiltration into unfavorably oriented rock fractures. Construction of efficient drainage system will divert away from unstable slopes surface runoff and channel it to natural drainage. Installation of coco nets and planting of fast-growing native vegetation will minimize erosion. Plant roots will again contribute to soil cohesion.

Impact Mitigation

Detailed and site-specific geotechnical study must be conducted by a competent geotechnical engineer in all critical areas such as in the proposed mine pit, waste dumps, siltation ponds and haul roads with slope height of 3 m and above. This must include detailed mapping of slopes and slope stability assessment using kinematic analysis, limit equilibrium and finite element methods. Geotechnical drilling is necessary to gather site-specific geotechnical parameters of soils. This study will serve as the basis for determining the stable slope design and the appropriate slope support and protection measures for soil and rock slopes. To illustrate, the suggested slope support based on the SMR classes of Romana (1993) is shown in **Figure 2.1-36.** For the slopes classified as unstable, the slope support that must be installed include reinforced shotcrete in combination with anchors or concrete ribs or retaining wall. For completely unstable slopes it is necessary to re-scale and decrease the slope angle. In partially stable slopes nets and systematic bolting must be installed. The base of the waste dumps and fill portions of haul roads will most probably require retaining structures or toe buttress. Large boulders are suitable as buttress while small boulders can be used to build gabion walls.

Obviously slope support is not applicable in active mining areas. However, a lower effective slope angle (as determined in the detailed slope stability study) must be maintained for the entire pit to decrease the probability of large slope failure. The 3 m wide berms are probably not sufficient to catch the materials coming from the slopes of 3 to 5 m high benches in case of slope failure.

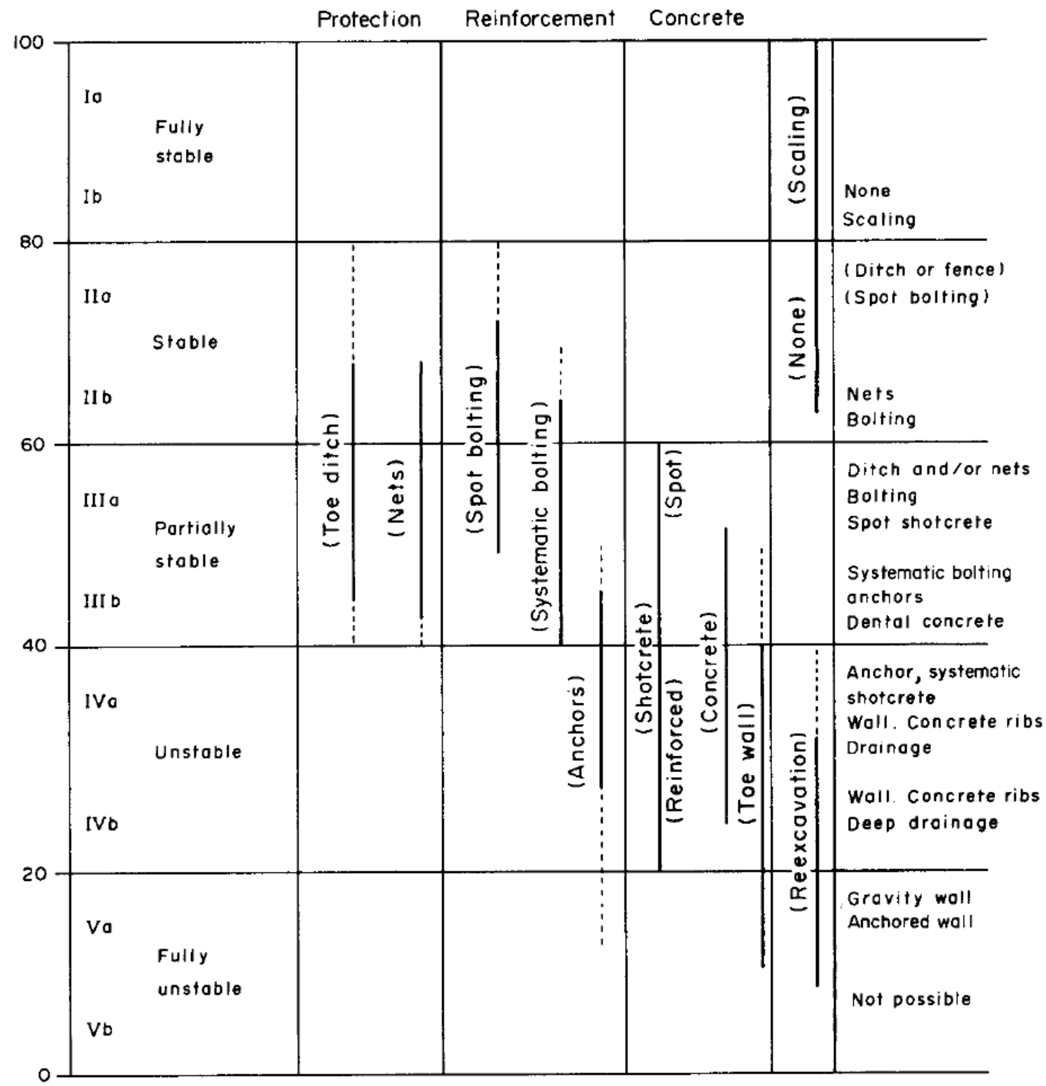


Figure 2.1-36. Recommended slope support and protection based on SMR (Romana, 1993).

All slopes must be provided with enough drainage to catch runoff and divert it away from unstable areas. This include slope ditches that will catch runoff originating from upper slopes and channel it to cascades (down-slope or stepped channels) and catch pits and eventually to the main or natural drainage system. The ditches must be lined with concrete to avoid infiltration. Regular maintenance of the slope drainage system must be conducted to facilitate smooth flow of water down slope particularly after heavy rainfall. Vegetation growth near drainage lines must be constantly monitored. Large trees with wide root system must not be planted close to the drainage system because the roots will damage the concrete lining.

The impact of debris flows will be minimized by installing debris flow control structures along its track particularly in upper slopes. The bulk of the materials carried by debris flows will be prevented from reaching the foot slopes by constructing series of check dams upstream along the possible debris flow track instead of siltation ponds as indicated in the site development plan. These dams will collect the large debris and allow the passage of finer sediments and water. The siltation ponds located in stable areas downstream will collect the finer sediments and water. The dams can be built using gabions, reinforced concrete or timber in smaller channels. Maintenance is needed after each debris flow event to make sure that there is enough space for future debris flow deposits. Formation of landslide dam in narrow channels with steep banks must also be monitored and a warning system must be developed to alert residents downstream. Sudden breaching of landslide dams will cause extensive debris flows depending on the accumulated volume of debris.

3. Volcanic Hazards

In the event of a volcanic eruption of nearby active volcanoes, ashfall can affect the project site and accumulate on roofs of buildings, roads and drainage systems. Ashfall will reduce visibility and will make the roads slippery when wet and dusty when dry. Thick ash accumulation must be immediately removed to prevent overloading and collapse of lightweight roof structures. It must be removed from roads immediately to prevent accidents. It must be flushed out from the water tanks, pipes, drainage systems and other water conveyances since it will clog these structures. It must be collected and stored in waste dump areas.

Potential impacts and options for prevention or mitigation or enhancement

The impact of the project to geology, geomorphology and geologic hazards and the corresponding mitigating measures are summarized in **Table 2.1-14, 2.1-15 and 2.1-16.**

Table 2.1-14. Impact on Geomorphology

ACTIVITY	IMPACT	MITIGATING MEASURES
PRE-CONSTRUCTION PHASE		
Existing land condition due to previous Ni laterite mining and exploration	Land degradation as a result of landslides and erosion within the MPSA area due to unmaintained roads	Prioritize the rehabilitation of existing roads, landslide areas and drainage canals
	Erosion of laterite stockpiles in Causwagan Block	Cover stockpiles with plastic sheeting; construct perimeter sediment barriers; Divert upstream drainage away from the stockpiles; install drainage canals and settling pond;
CONSTRUCTION PHASE		
Rehabilitation of access roads Construction of haul roads, waste dumps, siltation ponds, drainage lines	Steepening of slopes which will promote instabilities; Creation of level areas in waste dumps, stockyard, pre-pile yard, campsite which are prone to water ponding; Natural flow paths will be changed with the construction of new drainage lines Siltation ponds will introduce depressions in topography	Provide slope stability measures to prevent or minimize slope failure Flat areas will have sufficient gradient to direct runoff towards drainage lines Natural flow paths will be restored during rehabilitation; diversion canals will be redirected towards original natural waterways
OPERATION PHASE		
Survey and exploration		
Clearing and grubbing of vegetation	Exposure of surface to heavy rainfall will lead to erosion	Limit disturbance and removal of vegetation within the identified mining area scheduled for operation
Construction of benches in mining area	Steepening of slopes which will promote instabilities;	Design gradient of active mining pit is 10% on the average but can increase to 12 up to 15% depending on the deposit; gradient must not exceed the natural slope along the ridge (8 to 30%)
Removal of topsoil and overburden		
Ore extraction and loading		
Stockpiling in pre-pile yard and waste dumps	Stockpiles will create mounds in the landscape which could be destabilized by heavy rainfall and earthquake;	Limit the stockpiles to a stable height and gradient; stockpiles which will not be used immediately must be protected from rainfall by covering with plastic sheeting or stabilized using coco net and vegetation
Ore hauling to and stockpiling in stockyard		
Ore hauling to barges		
Shipping and loading to mother vessel		
REHABILITATION PHASE		
Reshaping of mined-out	Will lessen slope gradient; Will remove the temporary mounds in the stock yards, waste dumps;	Rebuild slope to a stable angle similar to the natural slope before mining Backfilling of siltation ponds Natural flow paths will be restored during rehabilitation; diversion canals will be redirected towards original natural
Backfilling of overburden and topsoil		

		waterways;
Construction of efficient drainage system lined with concrete	Will divert runoff away from unstable slopes and will reduce infiltration;	Ensure that the drainage canals are wide enough to accommodate the size of sediment and debris present;
Installation of coco nets Planting of fast-growing native vegetation	Will protect soil from erosion; will increase total cohesion due to root cohesion	Trees must not be planted close to drainage canals so that roots will not destroy the concrete lining

Table 2.1-15. Impact on Subsurface Geology/ Underground Conditions

ACTIVITY	IMPACT	MITIGATING MEASURES
OPERATION PHASE		
Construction of benches in mining area Removal of topsoil and overburden Ore extraction and loading	Fresh to slightly weathered bedrock will be exposed to different agents of weathering; water will infiltrate the fractures and accelerate weathering; will degrade the rock mass quality Overburden and topsoil in waste dumps will increase lithostatic pressure in underlying rocks	Implement progressive rehabilitation immediately in mined-out areas to restore natural cover; Removal of overburden and topsoil from waste dump during rehabilitation will decrease the lithostatic pressure
REHABILITATION PHASE		
Backfilling of overburden and topsoil	Clayey soil will limit water infiltration to fractures and fresh rock;	Topsoil and overburden will be compacted similar to compaction level before mining;

Table 2.1-16. Impact on Geologic Hazards

ACTIVITY	IMPACT	MITIGATING MEASURES
PRE-CONSTRUCTION PHASE		
Existing land condition due to previous Ni laterite mining and exploration	Land degradation as a result of landslides and erosion within the MPSA area due to unmaintained roads	Prioritize the rehabilitation of existing roads, landslide areas and drainage canals
	Erosion of laterite stockpiles in Causwagan Block	Cover stockpiles with plastic sheeting; construct perimeter sediment barriers; Divert upstream drainage away from the stockpiles; install drainage canals and settling pond;
CONSTRUCTION PHASE		
Rehabilitation of access roads Construction of haul roads, waste dumps, siltation ponds, drainage lines	*Ground Shaking* Introduction of new elements at risk *Liquefaction, differential settlement, lateral spread* Vibrations can contribute to dynamic load and cause liquefaction in highly susceptible soils *Landslides* Steepening of slopes along roads; addition of load in slopes where cut materials will be stored;	Incorporate the computed PGA values in the design of mining facilities; include pseudo-static analysis in slope stability assessment. The building/structural code in design of buildings and other structures will be followed. Conduct geotechnical study to determine liquefiable layers and appropriate mitigation Conduct detailed slope stability study; install appropriate slope support and protection such as rockbolts, anchors, shotcrete, cribwalls and retaining walls; cut

	Steepening of slopes in gullies to accommodate siltation ponds; blockage of flow or reduction in cross sectional area of channel along gullies; addition of load due to accumulated water and sediments; breaching will cause debris flow and flashfloods; Location of waste dumps will block gullies and the natural drainage Removal of clayey soil will promote seepage to rock fractures leading to rapid saturation of slopes	materials will be used as fills to widen the road; backfilled slopes will be protected by retaining structures; drainage systems will be built; maximum weight of stockpiles must be incorporated in the design; rock buttress will be used as foundation and support in waste dumps; its stability will be verified by geotechnical study Large capacity siltation ponds will be constructed in stable areas at the footslopes; series of check dams will be constructed in gullies to catch large sediments and debris and allow passage of finer materials and water; Natural waterways will remain open; dumping of overburden and wastes must be limited in the stable slopes; cut-off drain will be installed on the slope immediately above the waste dumps to divert runoff to natural drainage areas. Drainage canals with the appropriate size and lined with concrete will be constructed.
OPERATION PHASE		
Survey and exploration	*Ground Subsidence* Adits used in mineral exploration will induced ground collapse when left unsupported *Landslides* None	Adits will be completely backfilled to minimize collapse of surface materials; monitor occurrence of circular tension cracks above adits; divert drainage away from this area; Monitoring and mapping of unstable slopes indicated by presence of tension cracks, bulges, seepages etc.
Clearing and grubbing of vegetation	*Landslides* Reduction of total cohesion due to removal of cohesion contributed by plant roots;	Limit disturbance and removal of vegetation within the identified mining area scheduled for operation
Construction of benches in mining area	*Landslides* Steepening of slopes will promote instabilities	Construct temporary diversion ditches to divert runoff away from unstable benches; monitor development of tension cracks, bulges, seepages etc.; provide slope support if needed
Removal of topsoil and overburden	*Landslides* Steepening of slopes will promote instabilities	Construct temporary diversion ditches to divert runoff away from unstable benches; monitor development of tension cracks, bulges, seepages etc.; provide slope support if needed
Ore extraction and loading	*Landslides* Steepening of slopes will promote instabilities	Construct temporary diversion ditches to divert runoff away from unstable benches; monitor development of tension cracks, bulges, seepages etc.; provide slope support if needed
Stockpiling in pre-pile yard and waste dumps	*Landslides* Dynamic load in slopes due to passage of	Monitor development of tension cracks,

	trucks carrying the ore Creation of mounds that can be susceptible to slope failure	bulges, seepages along haul and access roads; divert drainage away from tension cracks and unstable slopes; provide slope support if needed Limit the stockpiles to a stable height and gradient;
Ore hauling to and stockpiling in stockyard	*Liquefaction, differential settlement, lateral spread*	
Ore hauling to barges	Hauling of materials will create dynamic load that can generate liquefaction in highly susceptible areas *Settlement* Stockpiles will transfer heavy loads to clayey soil and induce ground settlement; hauling will also induce settlement in roads on top of clayey soils *Landslides* Dynamic load in slopes due to passage of trucks carrying the ore Creation of mounds that can be susceptible to slope failure	Roads will be adequately compacted; embankments in liquefiable areas wiill be supported to prevent lateral spread Geotechnical study will be conducted to determine the compressibility of clayey soils and the appropriate foundation treatment to avoid settlement; artificial fills must be sufficiently compacted Monitor development of tension cracks, bulges, seepages along haul and access roads; divert drainage away from tension cracks and unstable slopes; provide slope support if needed Limit the stockpiles to a stable height and gradient;
Shipping and loading to mother vessel		
(Event that can occur anytime)	*Volcanic Eruption* Ashfall can affect project site and cause low visibility, slippery/dusty roads, clogged drainages, heavy load on roof	Immediately remove accumulated ash from roof, roads and drainages; store in secured dump areas
REHABILITATION PHASE		
Reshaping of mined-out area to a stable slope angle	*Landslides* Positive impact; will restore slope stability	Slope design will be based on the detailed slope stability study; install appropriate slope support and protection if needed
Backfilling of overburden and topsoil	*Landslides* Addition of load but lesser impact if stable slope angle is attained; presence of clayey soil will decrease infiltration to rock fractures	Ensure that a stable slope angle is attained considering the load due to overburden and topsoil
Construction of efficient drainage system lined with concrete	*Landslides* Positive impact; will restore slope stability; will divert runoff away from unstable slopes and will reduce infiltration	Ensure that the drainage canals are wide enough to accommodate the common size of sediment and debris present; trees will not be planted close to drainage so that roots will not destroy the concrete lining
Installation of coco nets	*Landslides* Positive impact; will protect soil from erosion and help plants to recover	Ensure that the drainage canals are wide enough to accommodate the common size of sediment and debris present; trees will not be planted close to drainage so that roots will not destroy the concrete lining
Planting of fast-growing native vegetation	*Landslides* Positive impact; will protect soil from erosion; will increase total cohesion due to root cohesion	Trees will not be planted close to drainage canals so that roots will not destroy the concrete lining
Decommissioning of siltation ponds	Will remove external load due to water and accumulated sediments	Backfilling of siltation ponds once the mined-out area is completely rehabilitated;

2.1.3 Pedology

A. Baseline Condition of Pedology

This section describes the properties and characteristics of the soils within the study area located inside the Mineral Permit Sharing Agreement (MPSA) of Riverbend Consolidated Mining Corporation (RCMC). The report is focused on the baseline condition of the soils, identification of major soil type, soil capabilities and its suitability criteria to support the proposed mining. The anticipated impacts as a result of the proposed nickel laterite mining project to the soil chemical properties, including the mitigation of the mining impacts are also discussed.

The specific objectives of this study are the following:

- To understand the physical and chemical characteristics of the soils in the area;
- Assess the suitability of the physical and chemical characteristics of soils to the development of the nickel laterite mining project;
- Identify the potential impacts of the nickel laterite mining project to the existing pedologic conditions of the area; and
- Provide appropriate mitigation measures to address the identified potential impacts to the soil

1. Background

Drastic use and poor management of soil resources not only for agriculture but also for mining can lead to soil degradation, a process that lowers the capacity of soils to produce goods or services. The soil deterioration process has tremendous consequences considering the important functions of soils for plant production, buffering, transformation, filtering, geogenic, cultural heritage and infrastructure. Detailed understanding of the characteristics and fertility status of the soils are important in the planning suitable soil management strategies needed for sustainable and suitable land management, particularly in areas that will be used for mining operations. Such knowledge can be obtained through quantitative appraisal of the soil properties, including the assessment of soil fertility status prior to the start of the nickel laterite mining development and operation. Together, these reasons justify the need to include the soil or pedological component in the environmental impact assessment as the properties and characteristics of the soils will determine how the present land use will have a significant impact on soil quality and, in turn, determine its suitability in terms of the development and operation of the proposed nickel laterite mining project.

This baseline assessment will help determine the suitable control or mitigation measures that will address soil concerns during the construction and operations phase of the project. Key findings of this study, its impact including the mitigation of such impacts are presented in the succeeding sections.

2. Materials and Methods

These subsections present the fieldwork, laboratory analysis, and gathering of supplementary or secondary data from published technical report, methods of soil analysis and relevant peer-accepted standards and guidelines by which to interpret and compare the results.

a.) Field Methods

A total of 9 soil samples from various locations were collected during the field survey conducted on September 2016 (**Fig. 2.1-37**). **Table 2.1-17** summarizes the location where the soil samples were collected at the nickel laterite mining site.

Soil samples were collected from the surface soil (**Figs. 2.1-38 and 2.1-39**). Approximately 1 kg of soil samples was collected per sample site and packed in plastic cellophane which was sealed airtight and labelled accordingly before being sent to the FAST Laboratories for chemical analyses.

b.) Laboratory Methods

Soil samples were submitted for chemical analyses to FAST Laboratories in Cagayan de Oro, City. Briefly, the analytical methods for each analyte and the purpose of the analyses are presented in **Table 2.1-18.**

Table 2.1-17. Soil sampling location, elevation, slope type, soil description and parent material

Sample No.	Longitude (N)	Latitude (E)	Elevation (m)	Slope Classification	Description	Soil depth (cm)	Parent material
MPT-01	126° 0' 40"	7° 3' 45"	579	>50%; Very Steep	Reddish brown, silty clay	7	Ultramafic rock, Harzburgite
MPT-02	126° 0' 23"	7° 3' 51"	578	30-50%; Steep	Brown, silty clay	4-6	Ultramafic rock, Harzburgite
CWG-03	126° 1' 6"	7° 1' 41"	242	18-30%; Rolling to Moderately Steep	Reddish brown, clay with soft black kernels	5-7	Ultramafic rock, dunite
CWG-04	126° 1' 17"	7° 0' 43"	37	3-8%; Gently Sloping to Undulating	Brown, fine sand to silt	0.5- 1	Alluvial deposit
CWG-05	126° 1' 1"	7° 0' 56"	63	0-3%; Level to Nearly Level	Dark brown, silty clay	1-3 m	Clastic sedimentary rock
MPT-06	126° 0' 17"	7° 1' 2"	15	8-18%; Undulating to rolling	Dark brown, silty clay	1-2	Alluvial deposit
PTG-07	125° 57' 11"	7° 4' 57"	25	3-8%; Gently Sloping to Undulating	Brown, silty clay	1-2	Alluvial deposit
PTG-08	125° 57' 58"	7° 3' 58"	58	8-18%; Undulating to rolling	Brown, silt with pebbles	0.5-1	Alluvial deposit
PTG-09	125° 58' 42"	7° 3' 22"	630	30-50%; Steep	Reddish brown, clay	4-6	Ultramafic rock
MPT-10	125° 58' 55"	7° 1' 59"	25	8-18%; Undulating to rolling	Very dark grey, clay loam	1-2	Colluvial deposit

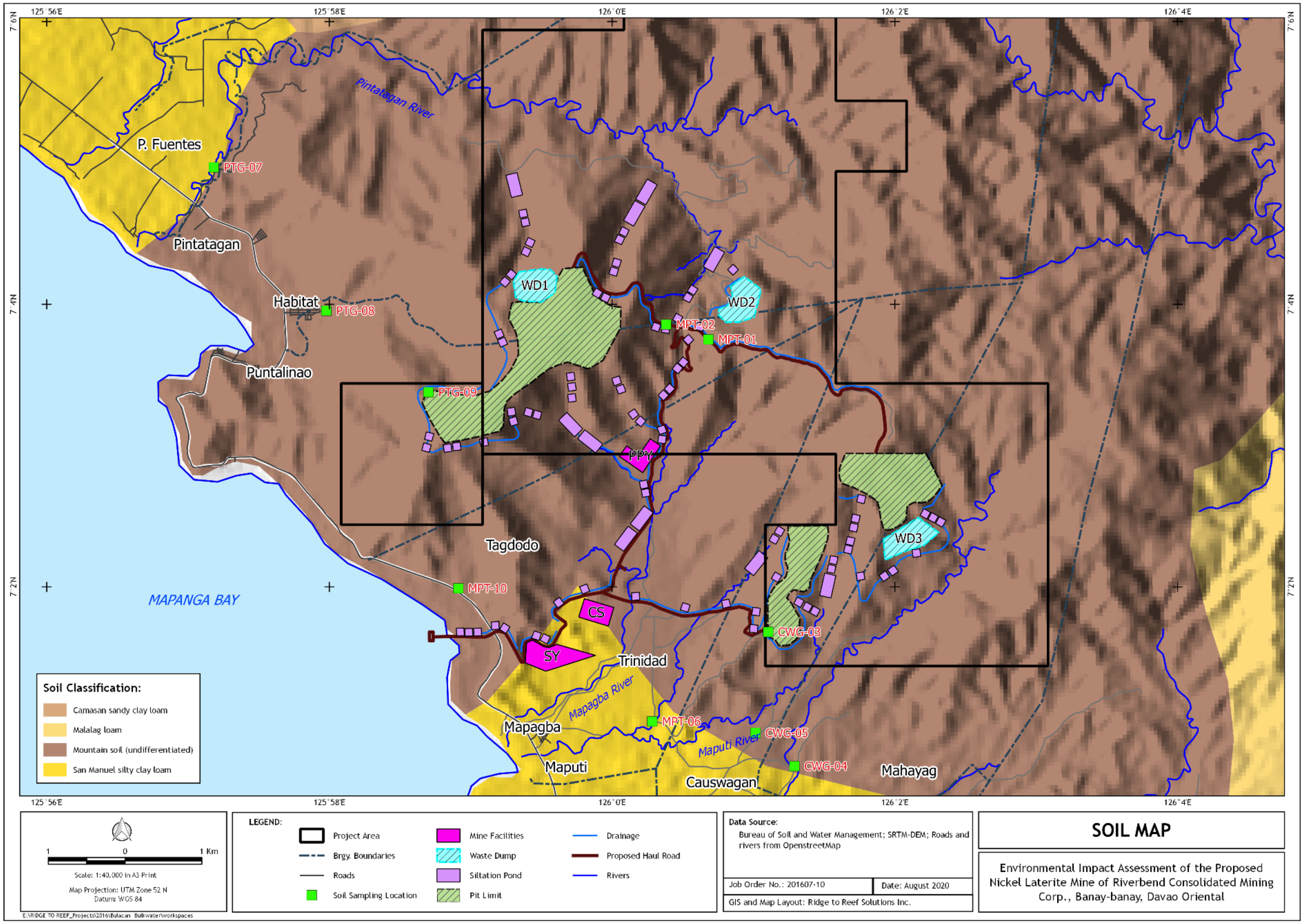


Figure 2.1-37. Soil sampling stations and BSWM soil map (NAMRIA geoportal, accessed on July 2020).

Figure 2.1-38. Photos of the area where the surface soil samples were collected.

Figure 2.1-39. Photo of the area where the surface soil samples were collected.

Table 2.1-18. Chemical soil parameters, analytical methods and purpose of the analysis

Chemical properties	Method	Purpose
pH (water)	Electrometry	Potential nutrient supply, alkalinity or acidity of the soils
Nitrogen	Kjeldahl	Potential N supply
Organic matter (OM)	Walkley-Black	Nutrient availability, influences soil pH, cation and anion exchange capacity, soil stability and permeability, structure of the soil, and other relationships with other physical, chemical and biological properties
Total phosphorus	Modified Troug	Potential P supply
Potassium	Extraction-Flame AAS	Nutrient supply
Metals: Pb, Cu, Fe, Mg, Cd, Cr	Extraction-Flame AAS	Availability when correlated with plant response, identification of toxicities and antagonistic effect
Metals: Hg, As	Cold Vapor AAS Silverdiethyldithiocarbamate	

c.) Supplementary Information

The soils were classified using the Soil Map of the Philippines (Manila Observatory, 2012**).** The land capability classifications were made following the guidelines for arability and land capability categories from the USDA Land Capability Classification System and Food and Agriculture Organization (FAO). Land capability was also determined based on the soils' physicochemical characteristics, slope and landform association and the current land use.

d.) Criteria /Standard for Comparison

The following international standards as reference values were used in the study to determine the geochemistry of the soils.

Global Average Shale Values

In the absence of the site-specific standard for heavy metal concentrations in the soil, the Average Shale Value (ASV) is used as reference to elucidate the relative enrichment of known heavy metals concentration, which may have practical implications directly to the health of the workers or cause environmental distress when liberated. The ASV is based on the works of Turekian and Wedepohl (1961) by establishing the distribution of major elements from some major units of the earth's crust. ASV is used as proxies for typical baseline concentrations of heavy metals in the soil due to the lack of standard values in the local setting. The use of this ASV proxy for measuring the enrichment of heavy metals in the soils has been accepted locally such as on the Philippine coastal and inland sediment sources (Li, 2009).

Geo-accumulation index

To assess the enrichment levels of the different heavy metals in soils, the geo-accumulation index (I_{geo}) was calculated from the ASV and the obtained concentrations from the laboratory analysis. The I_{geo} is a quantitative measure of the enrichment level of heavy metals and it allows for rating the soil quality from un-enriched to extremely enriched based on the ratings described by Müller (1981). The original Müller ratings have attributes from unpolluted to extremely polluted, but these attributes were modified in the present study to exclude the confusion that the present environmental concentrations are of anthropogenic in origin.

The I_{geo} is calculated using the formula:

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

where, Cn = measured concentrations
Bn = baseline concentration (shale)

e.) Assumptions and Limitations

It should be noted that the relative enrichment of heavy metals in the soils was determined using the geo-accumulation indices through the use of the ASV because local values for these parameters are not currently available. Land capability was assessed following the standard soil fertility values from the BSWM of the Philippines. Other physicochemical parameters were also assessed within the study area on a one-time sampling only. Seasonal variations in soil characteristics and soil quality were not considered in this report.

3. Soil Types and Land Capability

The major soil types in the study areas identified based from the soil map of the Philippines **(Fig. 2.1.40)** are ACRISOLS and CAMBISOLS or NITISOLS (WRB Classification). ACRISOLS (or ULTISOL in the USDA classification system) are soils that form on old landscapes that have an undulating topography and in a humid tropical climate. Because of the old nature of the soil (highly weathered soils), Acrisols soils are acidic, low amounts of OM, N and available P (**Table 2.1-19**) have low levels of plant nutrients (e.g. Ca, Mg, K, and Na) due to extensive leaching, have toxic levels of aluminum, and have high erodibility, which are problematic for agriculture. On the other hand, CAMBISOLS or NITOSOLS (INCEPTISOLS in the USDA classification system) are young soils, which are characterized by the absence of a layer of accumulated clay, very low amount of OM and N, soluble salts, or iron and aluminum oxides. Because of the young nature of the soil, they have a high content of weatherable minerals coupled with the good soil physical condition; this soil can be exploited for agriculture subject to the limitations of terrain and climate. As observed in the field, CAMBISOLS exhibited minimal soil horizon development, whereas for the ACRISOLS, they have a differentiated soil horizon, indicating the old nature of the soil.

Based on the physical characteristics, nutrient levels and soil types, land capability for the proposed project area and its vicinity is classified as CLASS IV and VI (**Table 2.1-20**). This class is characterized by moderate to severe limitations that require intensive management practices to ensure productive cultivation. In general, the use of these soils should be limited to forestland.

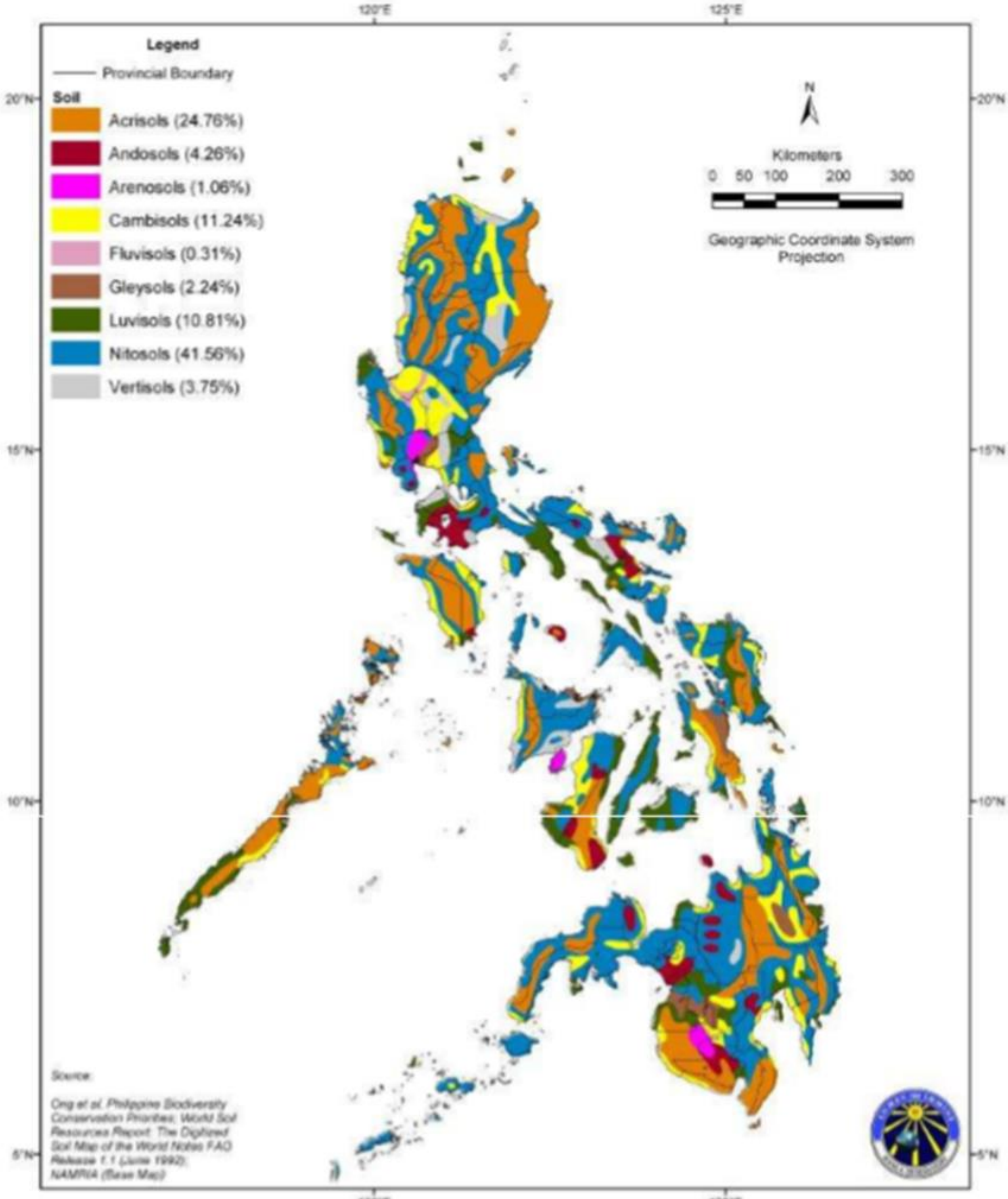


Figure 2.1-40. Soil map of the Philippines showing the soil type of the study area (Manila Observatory, 2012).

Table 2.1-20. USDA Department of Agriculture (USDA) Land Capability Classification

Classes	Descriptions
I	Few limitations that restrict their use
II	Few limitations that reduce the choice of plants or require moderate conservation practices
III	Severe limitations that reduce the choice of plants or require special conservation practices, or both
IV	Very severe limitations that restrict the choice of plants, require special management, or both
V	Little or no erosion hazards but have other limitation, impracticable to remove, that limit their use largely to pasture or range, woodland, or wildlife food and cover
VI	Severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife food and cover
VII	Very severe limitations that make it unsuited to cultivation and that restrict their use largely to grazing, woodland or wildlife
VIII	Limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, or water supply, or to aesthetic purposes

4. Soil Texture

Soil texture is the single most important soil physical property as it provides information on the water flow potential, water holding capacity, fertility potential, and suitability for many land uses and for identifying the soil's capability of supporting plant life. The textural analysis is also fundamental in determining the soil type and the behavior of other properties that are largely dependent on grain size, including hydraulic and reactive properties. Soil is favorable for plant growth if the soil has moderate amount of clay as these can carry essential nutrients including calcium, magnesium, potassium and sodium, which exchange in cation for in the soil matrix because of the charged nature of the clay minerals.

In this study, a visual-manual procedure based on ASTM D2488 was used to determine soil texture of the studied soils. Result of the feel method is presented in Table 5. In this method, grittiness indicates the presence of sand, stickiness the presence of clay, and silkiness the presence of silt. Samples CWG-03 and PTG-09 were classified as clay, MPT-01, MPT-02, CWG-05, CWG-06, PTG-07, and PTG-08 as silty clay, MPT-10 as clay loam and CWG as fine sand (**Table 2.1-21).**

All, except one, soil samples have a high clay fraction and is derived from the weathering of ultramafic rocks. These clay soils which becomes hard when the soil is dry and very plastic and sticky when the soil is wet.

Table 2.1-21. Soil color and texture by 'feel method'

Sample name	Depth (cm)	Soil color	Soil texture (Feel method)	Parent material
MPT-01	7	Reddish brown	Silty clay	Ultramafic rock, Harzburgite
MPT-02	4-6	Brown	Silty clay	Ultramafic rock, Harzburgite
CWG-03	5-7	Reddish brown	Clay	Ultramafic rock, Dunite
CWG-04	0.5- 1	Brown	Fine sand	Alluvial deposit
CWG-05	1-3 m	Dark brown	Silty clay	Clastic sedimentary rock
MPT-06	1-2	Dark brown	Silty clay	Alluvial deposit
PTG-07	1-2	Brown	Silty clay	Alluvial deposit
PTG-08	0.5-1	Brown	Silty clay	Alluvial deposit
PTG-09	4-6	Reddish brown	Clay	Ultramafic rock
MPT-10	1-2	Very dark grey	Clay loam	Colluvial deposit

Feel Method

Soil texture refers to the proportion of sand, silt, and clay in a soil. Texture influences almost every aspect of soil use, both in agricultural and engineering applications, and even how natural ecosystems function. Accurately determining soil texture in a lab requires time and money; therefore, it is often necessary to estimate soil texture in the field by feel, which can be very accurate if done correctly (Ritchey, 2015).

Hand analysis is a simple and effective means to rapidly assess and classify a soil's physical condition. Correctly executed, the procedure allows for rapid and frequent assessment of soil characteristics with little or no equipment. Although qualitative, the texture by feel flowchart by S.J. Thien (1979) can be an accurate way for a scientist or interested individual to analyze the relative proportions of sand, silt, and clay **(Figure 2.1-41).**

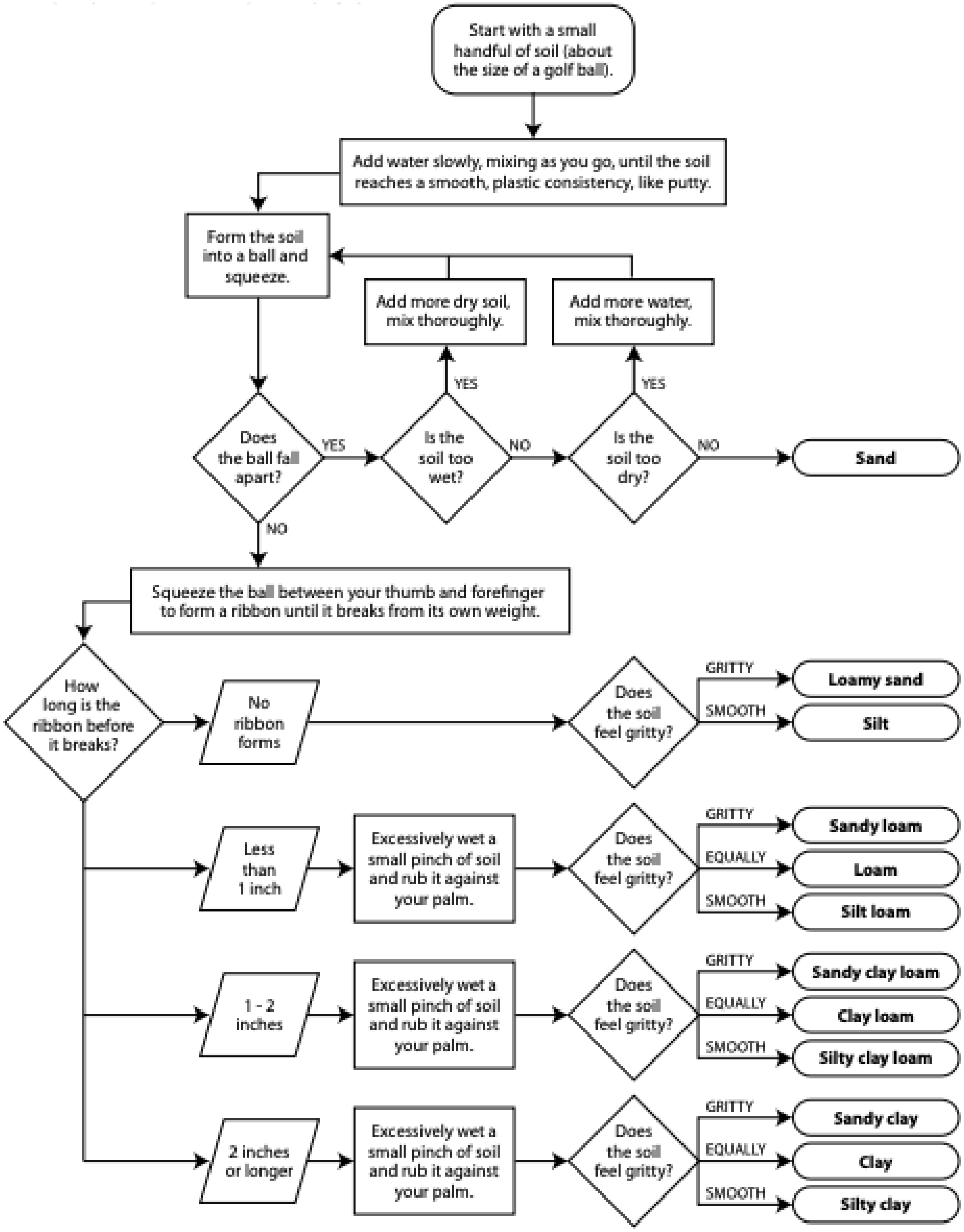


Figure 2.1-41: Flowchart to Determine Soil Texture By Feel

5. Fertility Status and Soil Chemistry

Matching selected soil properties with published threshold or favorable values/ condition for crop growth or crop production allows one to recognize potential fertility constraints to the production of agricultural crops. The comparison provides a basis for planning suitable soil management strategies for crop production in problem soils such as those in the study site. Comparison with the BSWM criteria for Soil Fertility Rating showed distinctive fertility constraints as summarized in Table **2.1-17**.

All samples except CWG-04 have a high clay fraction, which becomes hard when the soil is dry and very plastic and sticky when the soil is wet. When very plastic and sticky, the soil becomes troublesome for farming due to resistance and compression, particularly if animal driven plough is used.

Results of the laboratory analyses are presented in Table **2.1-17**. OM is a widely used measure of organic quantity and quality in soils and is a crude measure of the fertility status. It affects both the physical, chemical and biological properties of soils and is widely used as an indicator of soil productivity and sustainability. OM is responsible for the formation of soil aggregates that improves soil structure resulting to good soil aeration, soil permeability and increased the water infiltration capacity, thus preventing soil erosion. In highly weathered soils such as the ACRISOLS in this study, about 90% of the soil capacity to retain nutrient originates from OM. Hence, soil OM management will be a key factor in the productivity of these soils.

OM is adequate (i.e., favorable for crop growth) in CWG-05 and MPT-10, whereas MPT-02, CWG-03, CWG-04, PTG-07, and PTG-09 are deficient (i.e., unfavorable for plant growth) in OM, suggesting that OM management is necessary in the later soils when used for agriculture. There is a close correlation between the total N and OM which can explained by the fact that more than 95% of N is bound in OM (Scheffer and Schachtschabel, 1992). The rate of decomposition or mineralization of OM is greatly controlled by the C/N ratio. Low C/N value suggests high degree of decomposition or a low content of organic nitrogen from vegetation, while high C/N value is indicative of slow decomposition.
Tropical soils are generally P deficient and, in many cases, P is the limiting nutrient in agriculture (Sanchez and Logan, 1992). Available P as used in the discussion refers to the P readily available to plant. As P levels are extremely low in all samples, it appears to be the most limiting nutrient in these soils. The low P availability in the soil can be ascribed to the low P content in the parent material (typical for soils developed from volcanic parent materials).

Potassium is an essential plant nutrient that can be rooted from soil and is required in large amounts for proper growth of plants. Only MPT-01, PTG-07, and MPT-10 have adequate amounts of Potassium. This is because K is supplied by primary minerals like feldspars that are abundant in volcanic rocks. Both the iron and manganese are adequate in all soils which are typical of soils derived from ultramafic rocks.
The presence of heavy metals in soil are prominent especially in mining areas. The most common types of heavy metals that can be detected in soils are manganese (Mn), iron (Fe) and copper (Cu) while heavy metals such as chromium (Cr), cadmium (Cd), arsenic (As), lead (Pb), and mercury (Hg) are regarded as the main threat since they are very harmful to living things. Although heavy metals are naturally present in the soil, geologic and anthropogenic disturbances may contribute to its increasing concentrations in the environment that may lead to harmful effects.
Dutch Target and Intervention Values (200) was used in this study to determine the accepted concentrations of these parameters in the soil. Dutch standards are environment pollutant reference values used to determine the concentration of pollutant present in the soil. These standards are representative of the level of contamination in which a serious case of soil contamination is deemed to exist.

The results of the soil sampling were compared to the Dutch Target Values **(Table 2.1-17)**. Readings for pH are within the accepted value of 6.5-9.5, soil pH were slightly basic for sites CWG-04, CAG-06, PTG-07, and PTG-09. While the other sites are considered slightly acidic especially site CWG-05 with a reading of 6.1. Arsenic (As), cadmium (Cd), lead (Pb) and iron (Fe) in all sampling sites are within the values set forth by the Dutch environmental standards. While in chromium (Cr), all sampling sites have exceeded the standard values of a much higher concentration. This implies that the soil samples gathered in the sampling areas were contaminated with chromium due to mining activities and other anthropogenic activities. But concentrations of chromium may vary considerably according to the natural composition of rocks. Mercury on sites MPT-01, MPT-02, CWG-05, CAG-06, PTG-07, PTG-08, PTG-09 and MPT-10 have exceeded the 0.3 mg/kg limit of mercury in soil. This implies that certain concentration of mercury is present in the soil. Mercury is naturally occurring in the environment in small amounts but increase in concentration can affect humans and other life forms. On the other hand, concentration of copper on sites

MPT-01, MPT-02, MPT-03, CWG-05, CAG-06, PTG-07, PTG-08, and PTG-09 have exceeded the allowable values in Dutch soil standards. Certain concentrations of copper in soil maybe beneficial to it but higher concentration can be toxic. Manganese on sites MPT-01, MPT-02, CWG-03, CWG-05, CAG-06, PTG-09 and MPT-10 have surpassed the allowable value of 1,800 mg/kg concentration. It is an essential plant mineral nutrient in soil but can be toxic in higher concentrations.

Table 2.1-19. Fertility properties of soil samples

Parameter	Unit	MPT -01	MPT -02	CWG -03	CWG -04	CWG-05	CAG -06	PTG-07	PTG-08	PTG -09	MPT-10	Dutch Standards for Soil	Soil fertility rating guidelines* Adequate[2]	Moderate[1]	Deficient[3]
pH		6.5	6.8	6.8	7.6	6.1	7.2	7.4	6.5	7.4	6.7	≥6.5 or ≤9.5	5.5-7.0		
Nitrogen	%	0.12	0.09	0.06	0.13	0.16	0.07	0.11	0.12	0.04	0.53	-	**	**	**
OM	%	2.73	1.11	0.33	0.61	3.88	0.50	1.15	2.26	0.57	8.99	-	>3	2-3	<2
C:N ratio		23	12	6	5	24	7	10	19	14	17	-			
Phosphorus	%	0.74	<0.4	<0.4	1.25	0.40	0.91	26	<0.4	<0.4	6.43	-	>10	6-10	<6
Arsenic	mg/kg	<0.05	<0.05	0.11	<0.05	<0.05	0.05	0.09	<0.05	<0.05	<0.05	29			
Mercury	mg/kg	0.22	0.20	<0.02	<0.02	0.44	0.19	0.08	0.23	0.11	0.21	0.3			
Lead	mg/kg	9.07	5.30	4.54	1.84	7.32	5.16	4.62	6.29	5.3	6.04	85	**	**	**
Potassium	mg/kg	83.6	28.8	13.9	22.7	246	50.6	1262	52.9	24.7	302	-	>75	50-75	<50
Copper	mg/kg	59.8	51.1	47.9	16.6	43.9	39.7	74	37.2	90.7	30.2	36	>0.2	**	<0.2
Iron	mg/kg	18.2	8.92	17.7	0.70	5.06	9.26	5.10	7.56	3.59	2.18	200	>4.5	2.5-4.5	<2.5
Manganese	mg/kg	4256	4452	4248	1040	5704	3023	1599	1736	5606	2097	1,800	>1.0	**	<1.0
Cadmium	mg/kg	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	0.8	**	**	**
Chromium	mg/kg	2232	3393	2846	260	2866	882	369	800	3276	576	100	**	**	**

*Source-Bureau of Soils and Water Management; [1]Moderately unfavorable, [2]Favourable, [3]Unfavorable; ND

6. Erosion Condition at the Site

Excessive rainfall causes increase in surface run-off that could transform into overland flow and result to soil erosion. In general slopes with adequate forest cover are less prone to erosion. However anthropogenic factors such as improper land use, forest fires, logging, mining, road construction and overgrazing can accelerate erosion. The types of erosion observed in the project area include splash, sheet, rill, gully and channel erosions.

Erosion is actively occurring in the nickel laterite stockpiles present in the mining site previously operated by Golden Summit Mining. Part of this mine pit is found within the proposed mining site in Causwagan block (Area 2-B). Well defined rills and gullies are present in the stockpiles and within the stockyard (**Figure 2.1-42**). No erosion control measures were observed during the field inspection. Other stockpiles that are being eroded are also present in other areas outside of the MPSA area. Erosion was also observed along access roads. There are no effective drainage canals along the roads. As a result, surface runoff is concentrated along the roads, creating rills and gullies. Eroded sediments from landslides and road cuts are directly transported to the streams, particularly in areas with steep slopes. Riverbank erosion is also active along the streams. In Sitio Trinidad of Brgy. Maputi, Mapagba River carried two houses in October 2015 due to scouring. Erosion is still active, and the access road and several houses are at still risk (**Figure 2.1-43**). The trails and slopes within the MPSA area, particularly in Puntalinao Block, are also eroded due to logging. Logs manually drag along the trails scrape the soil and promotes erosion (**Figure 2.1-44** and **Figure 2.1-45**).

Figure 2.1-42. Photos showing active erosion in the project area and vicinity. Clockwise from top: Laterite stockpile at the mine site in Causwagan block affected by rill erosion, no erosion control measures are present; eroded access road to Causwagan mine site, no drainage canals;

stockpiles in one of the stockyard of Golden Summit Mining outside of the MPSA area; rill and gully erosion are present in these stockyards.

Figure 2.1-43. Riverbank erosion in Sitio Trinidad (Purok 8) in Brgy. Maputi. Two houses were carried by flood in October 2015 due to scouring. The flood depth along the road is around ankle deep but in the channel, flood depth is about 5 m.

Figure 2.1-44. Photos of denuded slopes in the vicinity of the MPSA area (near Puntalinao Block). Upper photos show logout slopes in kaingin areas. Bottom photo shows wide, deeply eroded trail due to log dragging and overland flow.

Figure 2.1-45. Photo of a log cut from the remaining forest at the upper slopes and manually dragged along the trail.

7. Universal Soil Loss Equation

Soil is a basic resource that is essential to our survival but is often ignored. Soil erosion is a result of the interaction of several process which is mostly driven by water in the Philippines and other areas in the humid tropics. The interactive processes causing erosion by water include detachment and transport by falling rain or flowing water and is influenced by the parameters such as: cover, soil physical and chemical properties, raindrop energy, flow velocities and hydraulic properties, cover management, slope, slope length, and conservation practices. Soil erosion is often classified based on descriptive parameters such as magnitude, source, location, and shape (e.g. sheet, rill, gully, mass movement, construction and mining erosion This section is limited to sheet and rill erosion which is the removal of the thin top layer of top soil by raindrops, overland flow, or by shallow, channelized rill flows (David, 1988).

Although soil erosion is a natural process, it can also be aggravated by anthropogenic activities such as mining. The soil loss for the project area was modeled using a Geographic Information System (GIS) software in order to provide an estimate of the baseline pre-mining existing soil loss in the area and its corresponding soil vulnerability as well as projected values and changes during the conduct of mine operations. It is also essential in guiding management to determine the necessary mitigation and rehabilitation measures to reduce the minimize the impact of the project to the soil during operations and return it to its baseline conditions after abandonment. The coverage of the model are sub watersheds adjacent to mine facilities and operation. The model is based and is limited to available data from the proponent, pertinent government agencies, published reports, and scientific papers.

The Universal Soil Loss Equation was used due to its relative simplicity and robustness (Desmet and Govers, 1996). The principal soil loss equation is as follows:

$$A = R * K * LS * C * P$$

where, A is the annual soil loss (ton/ha)
R is the rainfall erosivity factor
K is the soil erodibility factor
LS is slope length and steepness factors,
C is cover and management, and
P is support practice factor

The rainfall erosivity R factor represents the effect of rainfall on soil erosion (Benavidez et al., 2018). The equation by El-Swaify et al. (1987) was used for this study as it can be used to calculate R factor in the absence of detailed hydrometeorological information and was used by Adornado et al. (2009) in their erosion vulnerability study for Quezon Province. In this equation, rainfall erosivity in tons per hectare per year (t/ha/yr) is given by $R = 38.5 + 0.35P$, where P is the mean annual precipitation in millimeters (mm). The annual precipitation values for PAGASA weather stations in Mindanao (**Table 2.1-22**) was used to derive the annual precipitation for the project area using the Thiessen Polygon Method in QGIS. A P value of 1759.1 mm was obtained for the project area and the subsequent R is 654.185 t/ha/yr.

Table 2.1-22. List of PAGASA Stations used to estimate the annual rainfall in the project area.

PAGASA Station	Annual Precipitation (mm)
Butuan City	2057.8
Davao City	1759.1
Dipolog	2352.9
General Santos	959.9
Hinantuan	4464.9
Lumbia Airport	1703.3
Surigao del Norte	3651.8
Zamboanga	1266.5

The K factor represents the influence of different soil properties on the slope's susceptibility to erosion (Renard, et al., 1997). A higher K factor value means a higher susceptibility of soil to erosion. Values used by David (1988) was used in this study and is shown in **Table 2.1-23**.

Table 2.1-23. K factor values derived from David (1988).

Soil Classification	Soil Type	K Factor
San Manuel silty clay loam	Silty Clay Loam	0.3
Malalag loam	Loam	0.27
Mountain soil (undifferentiated)	Undifferentiated	0.3
Camasan sandy clay loam	Sandy Clay Loam	0.24
San Manuel silty clay loam	Silty Clay Loam	0.3

The LS Factor represents the effect of the slope's length and steepness on sheet, rill and inter-rill erosion by water (Wischmeier and Smith, 1978). For this study LS Factor was processed in QGIS using an SRTM Digital Elevation Model with 30-m resolution. The methodology by Desmet and Govers (1996) was used to derive the LS factor for the project area.

The cover and management factor C is the ratio of soil loss from a field with a particular cover and mangaement to that of a continouos barren field (Wischmeier and Smith, 1978). It is often derived using reported values for land cover types from previous studies. For this study, the 2015 land cover data was obtained from the National Mapping and Resource Information Authority as baseline and corresponding C factor values was obtained from David (1988) as shown in **Table 2.1-24**. Areas operation defined in the subsequent mine development plans for given years were assigned a C factor value of 1.0000 which is that of bare soil. For rehabilitation areas, a C factor value of 0.3 was assigned as it is expected to have the land cover characteristics similar to grassland for the next 5 years.

Table 2.1-24. C factor values derived from David (1988).

Land Cover	C Factor
Annual Crop	0.2

Land Cover	C Factor
Built-up	0.2
Closed Forest	0.001
Fishpond	0.0001
Grassland	0.3
Mangrove Forest	0.001
Open Forest	0.003
Perennial Crop	0.2
Shrubs	0.15
Wooded Grassland	0.15

The support practice factor P is defined as the ratio of soil loss under a specific soil conservation practice to that of a field with upslope and downslope tillage (Renard, et al., 1997). The lower the P facto, the more effective the conservation practice is in mitigating soil erosion (Benavidez et al., 2018). Since there were no defined and extensive soil conservation measures observed in the study area, a P factor of 1 is assigned similar to the approach in Adornado et al. (2009).

The generated annual soil loss (t/ha/yr) is the used to determine soil vulnerability by categorizing in into six (6) classes similar to what was used in Adornado et al. (2009). : 0-5 t/ha/yr = None to slight; 5-15 t/ha/yr = Moderate; 15-50 t/ha/yr = High; 50-150 t/ha/yr = Very high; 150-300 t/ha/yr = Severe; >300 t/ha/yr = Very severe.

Results of the USLE model shows that in the baseline pre-mining conditions, half (52%) of the total area of the delineated sub-watersheds adjacent to the project area is classified as having a high to very severe soil vulnerability. This is mainly due to the high precipitation, steep slopes, soil erodibility, and vegetation cover dominated by grasslands and shrubs. The estimated baseline pre-mining total volume of erosion is 409,288 tons for the entire 3,740-hectare watershed with average annual volume of soil erosion per hectare of 109 t/ha.

To determine the impact of the project on soil erosion, the mine development plans for years 1 to 3, provided by the proponent was a used to generate soil erosion values for these yeas. Based on the results of the model (**Table 2.1-25**), the % area classified as very severe increased from a pre-mining baseline value of 8% to 13% in year 1; 15% in year 2; and 16% in year 3. The total volume of annual soil erosion also increased from a pre-mining baseline value of 409,288 tons to 664,362 tons in year 1; 753,880 in year 2; and 774,215 tons in year 3. The increase in average annual volume of soil erosion per hectare of is 109 t/ha/yr as baseline, 178 t/ha/yr in year 1; 202 t/ha/yr in year 2; and 207 t/ha/yr in year 3 (**Table 2.1-26**).

Table 2.1-25. Soil Vulnerability classes.

Soil Vulnerability		Baseline		Year 1		Year 2		Year 3	
Classes	**Soil Loss (t/ha/yr)**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**
None to slight	0-5	920	25	801	21	756	20	747	20
Moderate	5-15	873	23	825	22	798	21	786	21
High	15-50	210	6	189	5	190	5	187	5
Very high	50-150	386	10	389	10	391	10	385	10
Severe	150-300	1,054	28	1,053	28	1,053	28	1,040	28
Very severe	>300	297	8	483	13	553	15	594	16
Total		3,740	100	3,740	100	3,740	100	3,740	100

Table 2.1-26. Estimated volume of soil erosion

Area of Watershed (ha)	3,740	
Modeled Time Period	**Total Annual Volume (t)**	**Ave. Annual Volume per hectare (t/ha/yr)**
Pre-Mining Baseline	409,288	109
Year 1 Mine Development	664,362	178
Year 2 Mine Development	753,880	202
Year 3 Mine Development	774,215	207

Soil erosion values from this study are comparable to results with values in other areas published in David (1988) such as the Pantabangan watershed with 108 t/ha/yr and high soil erosion rates in the Old kaingin areas in Benguet with values ranging from 308-414 t/ha/yr.

Not all eroded soil particles will be delivered to the waterways of a watershed. Some will be deposited for good or temporarily at various depositional locations within the watershed. Thus, at a watershed, the sedimentary yield or outflow at any point across the stream and for a given period may differ significantly from the soil loss due to erosion. Sediment yields from watersheds with primary forests are low, averaging <0.5 t/ha/yr. As the watershed cover is disturbed and reduced, sediment yields increase and fluctuate considerably. In the Bugsuanga Watershed, over half of the watershed consists of overgrazed grasslands, pastures, and open areas the Ave. Mean Annual Sediment Discharge is 233.3 t/ha/yr (David, 1988).

The results of the study reflect the likely impacts of the project on soil erosion rates due to its significant disturbance on the watershed landscape. The USLE model was also ran assuming that rehabilitation plans particularly the Soil Management Plan (SMP) will be strictly followed. A period of 15-20 years was considered as the minimum amount of time for the rehabilitated areas to develop into second growth forests with patches of shrubs and plantation crops of 5 years or more with a corresponding C factor value of 0.006. The result of this model shows that area with very severe soil vulnerability will go down to 10%; the total volume of annual soil erosion will go down to 498,524 t/yr and average annual volume of soil erosion per hectare to 133 t/ha/yr (**Table 2.1-27** and **Table 2.1-28**).

Table 2.1-27. Soil Vulnerability classes prior to, during and post mining assuming that the SMP is strictly followed.

Soil Vulnerability		Pre-Mining		Year 3		15-20 Years Post Mining	
Classes	**Soil Loss (t/ha/yr)**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**
None to slight	0-5	920	25	747	20	785	21
Moderate	5-15	873	23	786	21	1,004	27
High	15-50	210	6	187	5	194	5
Very high	50-150	386	10	385	10	377	10
Severe	150-300	1,054	28	1,040	28	1,010	27
Very severe	>300	297	8	594	16	370	10
Total		3,740	100	3,740	100	3,740	100

Table 2.1-28. Estimated volume of soil erosion prior to, during and post mining assuming that the SMP is strictly followed.

Area of Watershed (ha)	3,740	
Modeled Time Period	**Total Annual Volume (t)**	**Ave. Annual Volume per hectare (t/ha/yr)**
Pre-Mining Baseline	409,288	109

Area of Watershed (ha)	3,740	
Modeled Time Period	**Total Annual Volume (t)**	**Ave. Annual Volume per hectare (t/ha/yr)**
Year 1 Mine Development	664,362	178
Year 2 Mine Development	753,880	202
Year 3 Mine Development	774,215	207
15-20 Years Post Mining	498,524	133

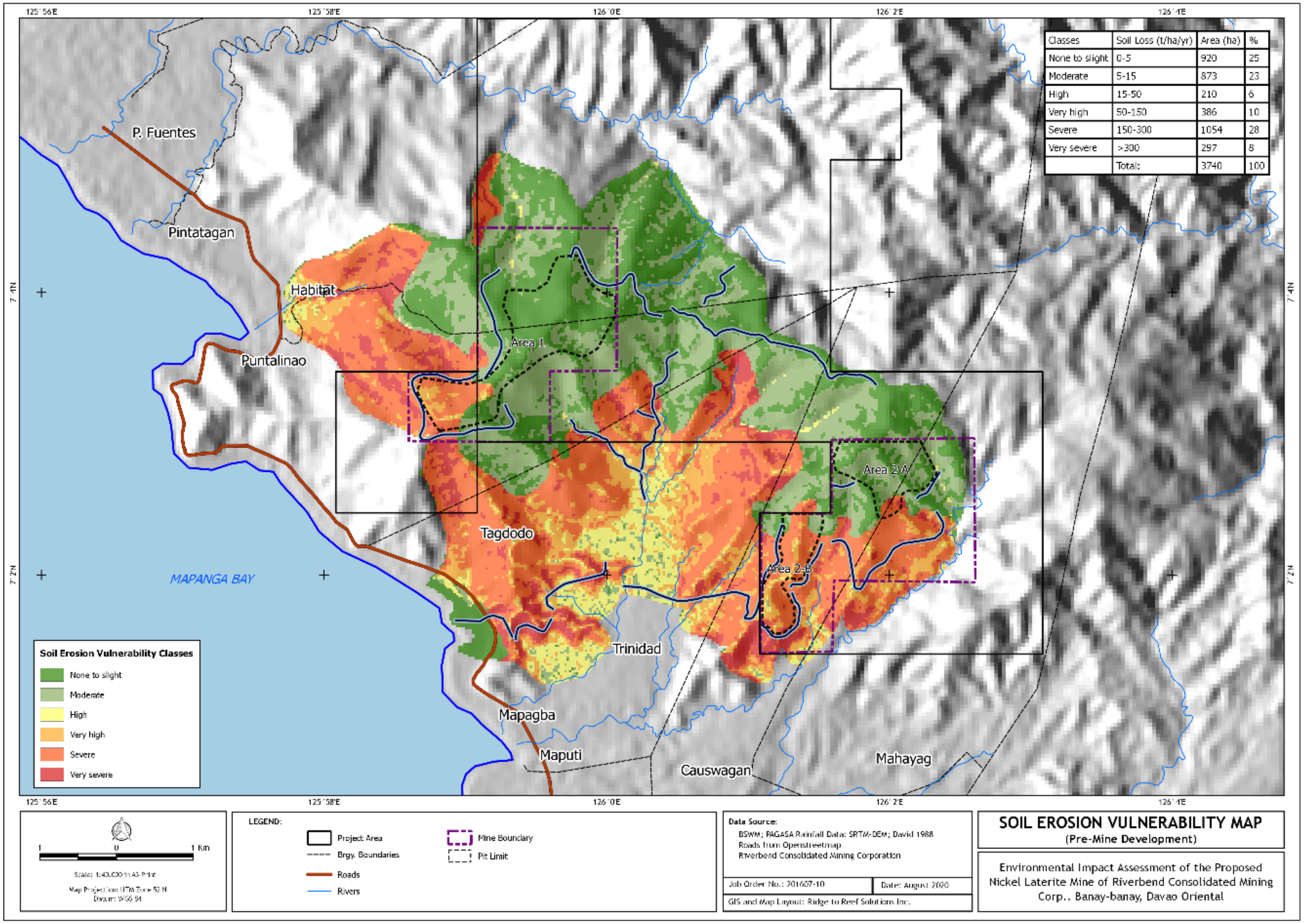


Figure 2.1-46. Baseline Pre-Mine Development Soil Vulnerability Map.

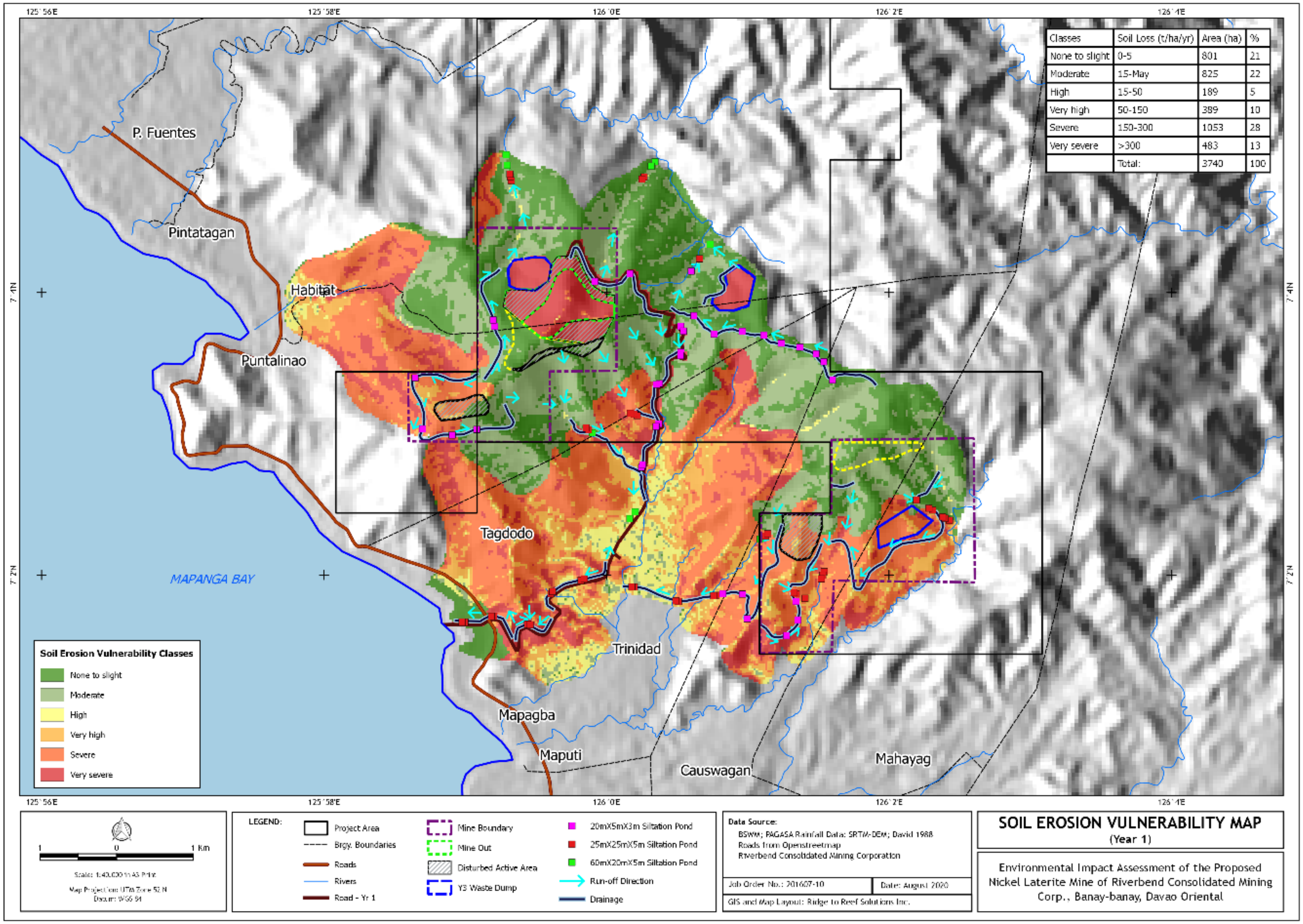


Figure 2.1-47. Soil Vulnerability Map for Year 1 of Mine Development.

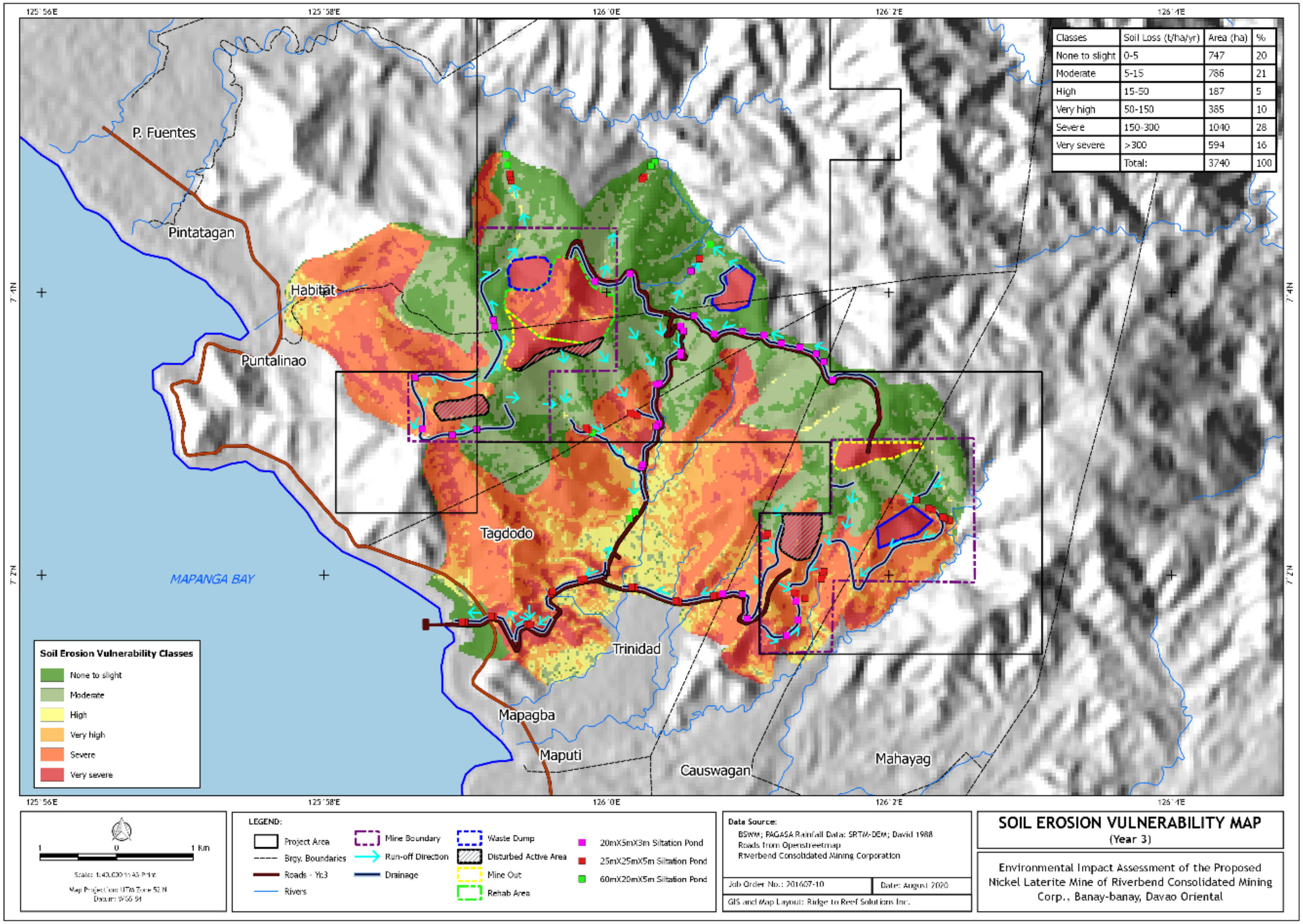


Figure 2.1-48. Soil Vulnerability Map for Year 3 of Mine Development.

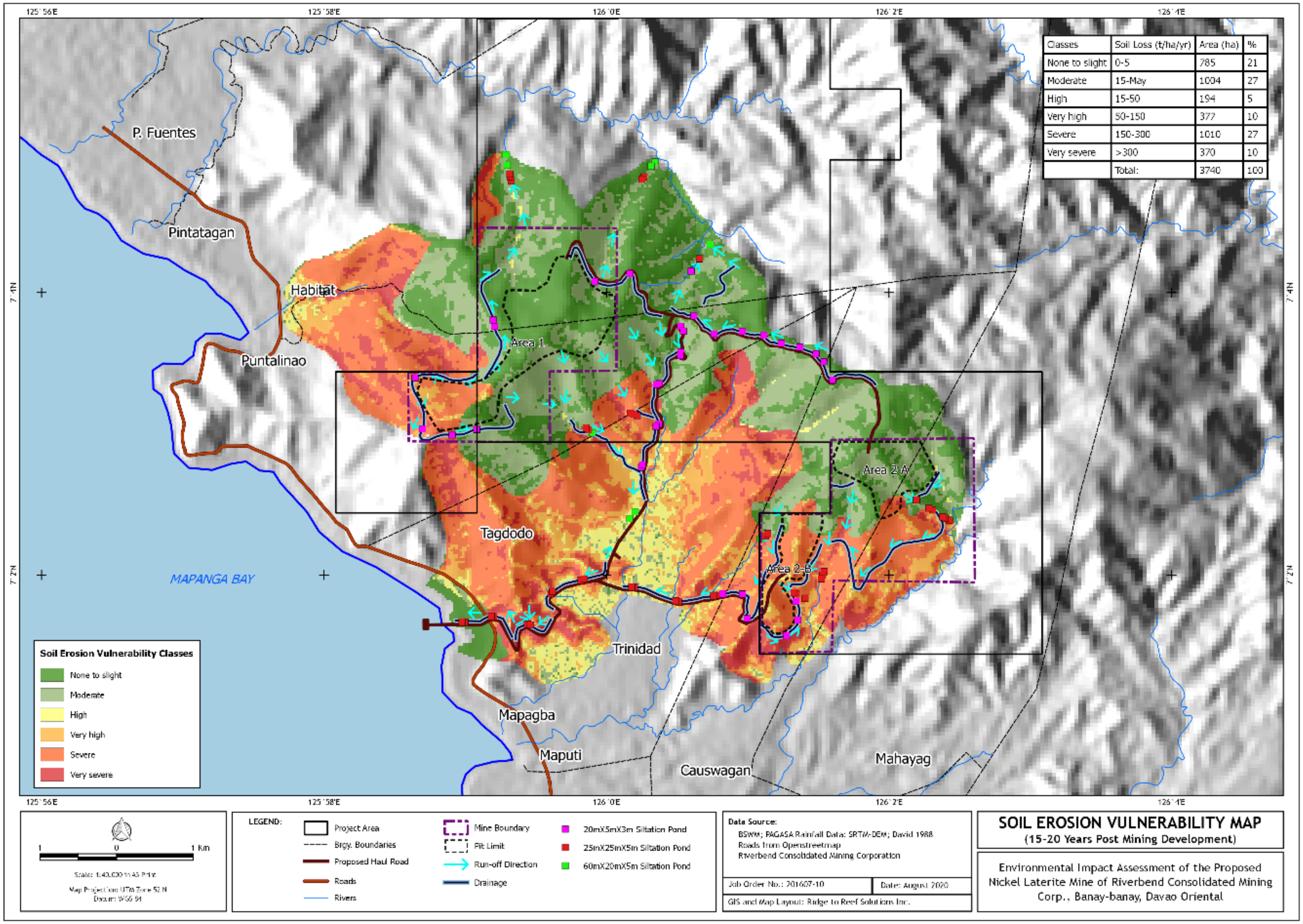


Figure 2.1-49. Soil Vulnerability Map 15-20 Years Post Mining

B. Soil Erosion/ Loss of Topsoil/ Overburden

1. Impacts

Surface mining of involve significant disturbance of the landscape including disruption of natural drainage patterns, exposure of soils to erosion, and entrainment and transport of eroded sediments to valuable aquatic environments downstream of the mine site. Removal of vegetation will expose the soil to rainfall, promoting splash, sheet, rill and even gully erosion. The rate of erosion and sedimentation can increase rapidly with increasing levels of land disturbance. The construction of roads, waste dumps, siltation ponds and drainage lines will disturb the slopes and promote erosion and sedimentation in nearby streams. Activities during the operation such as clearing and grubbing, bench forming, stripping and ore extraction will all contribute to loosening of soil and exposing it rainfall and promote erosion and increase sedimentation. Hauling of ores and wastes to stockpile yards and to the jetty will also promote wind transport of very fine sediments in the form of dusts lifted from the roads. Stockpiling of ore, topsoil and overburden in waste dumps, pre-pile yard and stockpile yard will create slopes that are sources of sediments that will be eroded during heavy rainfall.

2. Soil Management Plan (SMP)

The importance of SMP is to provide guidance and direction to the proposed project for the management and use of surface soil recovered during the construction and development of the project. This is prepared to preserve surface soil quality during salvaging and storing of soil materials in stockpiles. The systematic implementation of SMP will lead to an effective re-use of surface soil for future use in the project.

A detailed SMP must be formulated prior to the project development and must be strictly implemented during construction and operation. Such plan will address soil surface excavation and stockpiling of earth materials but would not be of use for the development of the project. SMP will address surface soil stripping methods, storage, erosion prevention, and may include soil amelioration should there be a need to use it in the future for rehabilitation of the destroyed vegetation. Best management practices that can be incorporated in the SMP are as follows:

a.) Vegetation stabilization

There are a number of technologies to control soil erosion, improve productivity, and reduce the risk to farmers by sustaining agricultural production. Among the several technologies is the use of vegetative soil and moisture conservations measures, including planting of native tree species (e.g., *Albizialeb beck, Pterocymbium tinctorium, Artocarpus blancoi, Barringtonia racemosa, and Glochidion album*), which has proven to improve the biodiversity and site quality. Also, *Vetiveria zizanoides, locally known as* vetiver grass in the form of a dense, permanent hedge that are cheap, replicable, sustainable and has been effective in controlling soil erosion (e.g., Navarrete et al., 2000). Vetiver hedge, unlike soil banks, can be safely breached to provide access for equipment. The special feature of soil conservation with vegetative hedges is that it filters runoff and retains soils (World Bank Technical Paper, 1995). This vegetative system is sustainable and meets the needs of the present without compromising the needs of future generation.

When soil is covered with vegetation, including those plants mentioned above, but not limited to, roots of plants and trees interlock to bind soil particles. Planting of trees, shrubs, grasses and ground covers provide long-term stabilization of soil, which does not allow soil particles to be carried away by wind or water and it does not allow free flow of water over the soil that prevent soil erosion by water action. Grass should be planted for temporary stabilization in barren and inactive areas near the project sites. It is appropriate for site-stabilization both during and after the construction or in cleared areas, where earthwork activities have ceased.

b.) Construction road stabilization

Access roads and other on-site vehicle transportation routes to the project sites should be stabilized immediately after widening and should be frequently maintained to prevent erosion. Areas, which are graded for construction vehicle transport, are susceptible to erosion. Exposed soil surface is continually disturbed, leaving no opportunity for vegetative stabilization. Such areas also tend to collect and transport surface run-off. During rainy season, some areas, particularly those areas that are heavy clay can generate significant quantities of sediment that may be unloaded to nearby streams as facilitated by the high rainfall in the area. Efficient road stabilization not only reduces on-site soil erosion, it also significantly speeds upon site work, avoids instances of immobilized equipment and delivery vehicles and generally improves working conditions during adverse weather condition particularly in the monsoon known locally as *Amihan* that blows from the northwest, causing high rainfall. Along access road should also be planted with vetiver that can stabilize the soil.

c.) Slope drain

A slope drain is a temporary pipe or lined channel to drain the top of a slope to a stable discharge point at the bottom of a slope minimizing soil erosion. It is typically used in combination with an earth bank or diversion channel at the top of the slope. A slope drain is effective because it prevents run-off from flowing directly down a slope by confining all the run-off into a channel or enclosed pipe. However, larger areas would require a rock-lined channel. And if clogging happens in slope drains, water will force around the pipe and may result to slope erosion.

d.) Diversion channel

Temporary diversion channels are suggested to divert off-site run-off around construction areas, divert run-off from stabilized areas around disturbed area, and direct run-off into sediment traps or basins. Diversion channels should be installed when the site is initially graded and remain in place until permanent structures are installed. Diversion channels are appropriate for diverting any upslope run-off around disturbed areas of the project site in order to prevent soil erosion and sediment accumulation into waterways, increase the potential of infiltration and divert sediment-laden run-off into trapping devices.

e.) Minimize degradation of soil fertility

Fertile soil support vegetation. Therefore, loss of fertility results in a loss of vegetation, and this expose the land to erosion. A detailed SMP should therefore be developed and implemented prior to construction that will address surface soil stripping methods, proper storage, and may include soil amelioration should there be a need to use it in the future for seedbed and vegetation. The use of vermicompost as soil enhancer for the surface soils is being promoted recently (Asio et al., 2009). Like any organic fertilizer and adequate amount of vermicompost is expected to improve the fertility status of degraded soils especially those low in humus content.

The following practices must be incorporated in the SMP:

1) Strip surface soil from areas that will be disturbed by excavation, roadways or compaction by heavy equipment.
2) Strategically select stockpile locations that are away from steep slopes, natural waterways and traffic routes. As it is economical, stockpiles of surface soil must be near to areas where they will be used.
3) Use sediment barriers (silt screen, silt fence, berms, bunds or dikes) where necessary to retain sediments.
4) Protect topsoil stockpiles by temporary seeding of annual crops as soon as possible.
5) For stockpiles that will not be used immediately, they must be stabilized with permanent vegetation, particularly the use of vetiver grass or coco coir mats, which are known to control or reduce soil erosion.

6) Erosion and sedimentation control structures must be constructed before spreading the surface soil, particularly in berms, waterways and sediment catchment basins.
7) Before spreading the surface soil, loosen the subgrade by scrapping the soil to a depth of at least 10 cm to ensure bonding of the surface and subsurface soils.
8) Ensure that surface soils are replaced in the same order that they were removed. Keep the surface soil separate from overburden, and store layers separately to ensure that materials are restored in the same order that it was removed.

The environmental section of the RCMC will be responsible for the overall management of the SMP to ensure the sustainable use of the soil resources within the project area. The environmental sections of the company will also regularly review and update periodically the SMP throughout the phase of the project construction in response to the changes in technology (if applicable), research and to address changes to management strategies.

3. Impact Mitigation

Surface soils from areas that will be disturbed by excavation, roadways or compaction by heavy equipment must be stripped and stored in designated areas. Topsoil and overburden must be kept and stored in separate areas to ensure that materials will not mix and restored in the same order during rehabilitation.

It is important to minimize erosion and control sediments as near to the source as possible. In this way lesser amount of sediment load is placed on downstream sediment controls (Sloat and Redden, 2005). The active mining pit will have a slope gradient of 10% (5.7°) at the average but can increase to 12 to 15% (6.8 to 8.5°) depending on the nature of the deposit. The slope gradient must not exceed the natural slope along the ridge which varies from 8 to 30% (4.6 to 17.2°). Proper water management in active mining areas and other disturbed areas such as along access roads, waste dumps, pre-pile yard, stockpile yard and campsite is critical in erosion and sediment control. Drainage in active mining area will be built close to the mine pits to restrict runoff and stormwater coming from disturbed slopes and stockpile areas. These waters will be channeled to settling ponds or sumps located in areas with adequate space and appropriate elevation to allow sediments to settle. The drainage will have a gentle slope to decrease the flow or water. Surface lining will be installed in settling ponds to prevent leakage or outflow of silt-saturated water. The settling ponds will be constantly monitored and desilted periodically or after heavy rainfall events. Contour bunds must be installed at the side of berms to reduce overland flow and direct sediments to drainage canals. Silt fence will also be installed at the perimeter of the mining pit. In mining areas where overland flow can come from upslope, cut-off drains and diversion canals must be installed to divert the surface runoff away from active mining pits.

Outside of the active mining area, such as along access roads, waste dumps and in steep slopes surrounding the pre-pile yard and stockpile yard, sediment-laden water will be directed to settling ponds by concrete-lined drainage canals. Sediment traps will be installed along ditches to help in slowing runoff velocities and allow suspended sediments to settle. In steep waterways or gullies coming from disturbed slopes, series of check dams will be installed to catch coarse sediments. Active gullying will be controlled by installing diversion canals at gully head to prevent surface-runoff from entering the gully. The various portions of the gully channel and branch gullies will be stabilized by installing brush fills; earth plugs; and brushwood or loose-stone check dams. At a stable point in the lowest section of the main gully channel, such as a rock outcrop, a gabion check dam or cement masonry check dam will be constructed. Regular monitoring and maintenance of these structures will be conducted.

As indicated in the site development plan, series of settling ponds will be constructed at appropriate elevations with gentle and stable slopes to serve as the final interceptors of sediment-laden waters coming from the mining areas. For Area 1 these will be located downstream of the pre-pile yard and at the foot of the mountainous terrain near the tributaries of Pintatagan River. For Area 2, these will be located at the foot of the hilly terrain near the tributaries of Maputi River. Porous baffles must be built in settling ponds to force the water to spread across the entire pond and reduce turbulence to enhance settling.

Stockpiles in the pre-pile yard and stockyard must be covered with plastic sheeting if it will not be hauled immediately or during times of heavy rainfall. Temporary perimeter sediment barriers such as silt fence or berms must be installed to protect the stockpiles from stormwater. Ring bunds will be installed at appropriate locations in the waste dumps, pre-pile yard and stockyard to reduce overland flow and direct sediments to drainage canals. Topsoil and overburden stockpiles that will not be used immediately must be stabilized with permanent vegetation together with coco coir mats. Annual crops will be planted to protect the topsoil. Dust generation will be minimized by regular watering of mine pit and hauling/access roads using truck-mounted water sprinkler system.

During rehabilitation of mined out areas, the slope will be restored to a stable slope angle similar to the existing gradient before mining. Erosion and sediment control structures such as berms, drainage canals and settling ponds must be functional before the overburden and topsoil are spread on the mined-out area. The subgrade must be loosened by scrapping to a depth of at least 10 cm to ensure bonding of soils with the underlying layer. The soils must be replaced in the same order when they were removed so that the natural stratification will be restored. Temporary sediment barriers must be installed at the perimeter of the rehabilitation site. Contour bunds must be installed at different elevations to minimize runoff and surface erosion. Geomembrane such as the locally available coco-net will be used to initially cover bare slopes and promote the growth of vegetation during the rehabilitation phase of the mined-out areas. A grass commonly used to prevent soil erosion is vetiver (*Vetiveria zizanoides*). Vetiver roots can extend as deep as 3 meters into the ground. However, the suitability of this plant in ultramafic-derived soils and its adaptability in the local setting must be studied. Fast growing native species of trees, shrubs and grasses available in the area must be preferred. Vegetative hedges must be planted along the bunds to filter runoff and retain soils. In slope fills such as sides of access roads and waste dumps, ripraps will be installed on the top of retaining structures to prevent erosion.

Potential impacts and options for prevention or mitigation or enhancement

The impact of the project to pedology and the corresponding mitigating measures are summarized in **Table 2.1-29.**

Table 2.1-29. Impact on Pedology

ACTIVITY	IMPACT	MITIGATING MEASURES
PRE-CONSTRUCTION PHASE		
Mineral exploration activities;	Soil disturbance due to excavations in test pits, trenches, adits and in drilling areas; Localized soil contamination from rig oil spills; Generation of solid wastes;	All excavated areas will be backfilled immediately after completion of exploration works Drilling operational guidelines will be strictly implemented; Proper housekeeping and solid waste management will be strictly observed;
Existing land condition due to previous Ni laterite mining and exploration	Land degradation as a result of landslides and erosion within the MPSA area due to unmaintained roads	Prioritize the rehabilitation of existing roads, landslide areas and drainage canals
	Erosion of laterite stockpiles in Causwagan Block	Immediate action will be done: cover stockpiles with plastic sheeting; construct perimeter sediment barriers; Divert upstream drainage away from the stockpiles; install drainage canals and settling pond; transfer stockpiles to stockyard when ready
CONSTRUCTION PHASE		
Rehabilitation of access roads Construction of haul roads, waste dumps, siltation ponds, drainage lines	Landscape disturbance will expose the soil and rocks to erosion; will disrupt natural drainage; will contribute to entrainment and transport of sediments Fuel and oil spills from heavy equipment may occur in work areas which will contaminate the soil; contamination can also occur thru worker's improper sanitation activities and indiscriminate garbage disposal	Concrete-lined drainage canals will be installed to channel sediment-laden water to settling ponds; Sediment traps will be installed along ditches to help in slowing runoff velocities and allow suspended sediments to settle; In steep waterways or gullies coming from disturbed slopes, series of check dams will be installed to catch coarse sediments; Active gullies will be stabilized; Environmental best practices in construction management will be enforced in all work sites including proper management practices for handling fuels and soils; enforcement of solid waste management plan; provision of temporary toilet facilities and proper housekeeping
OPERATION PHASE		
Survey and exploration		
Clearing and grubbing of vegetation Construction of benches in mining area Removal of topsoil and overburden Ore extraction and loading	Landscape disturbance will expose the soil and rocks to erosion; will disrupt natural drainage; will contribute to entrainment and transport of sediments	Topsoil and overburden will be stored separately; Design gradient of active mining pit is 10% on the average but can increase to 12 up to 15% depending on the deposit; gradient must not exceed the natural slope along the ridge (8 to 30%)

		Drainage in active mining area will be built close to the mine pits to restrict runoff and stormwater coming from disturbed slopes and stockpile areas; Waters will be channeled to settling ponds or sumps located in areas with adequate space and appropriate elevation to allow sediments to settle; Surface lining will be installed in settling ponds to prevent leakage or outflow of silt-saturated water; Settling ponds will be constantly monitored and desilted periodically or after heavy rainfall events; Contour bunds will be installed at the side of berms to reduce overland flow and direct sediments to drainage canals; Silt fence will be installed at the perimeter of the mining pit; In mining areas where overland flow can come from upslope, cut-off drains and diversion canals will be installed to divert the surface runoff away from active mining pits; Series of settling ponds will be constructed at appropriate elevations with gentle and stable slopes to serve as the final interceptors of sediment-laden waters coming from the mining areas; Regular monitoring and maintenance of these structures will be conducted; Progressive rehabilitation will be done as soon as possible in mined-out areas;
Stockpiling in pre-pile yard and waste dumps	Stockpiling of ore, topsoil and overburden in waste dumps, pre-pile yard and stockpile yard will create slopes that are sources of sediments that will be eroded during heavy rainfall	Stockpiles will be covered with tarpaulin if it will not be hauled immediately or during times of heavy rainfall. Temporary perimeter sediment barriers such as silt fence or berms will be installed. Ring bunds will be installed at appropriate locations in the waste dumps, pre-pile yard and stockyard to reduce overland flow and direct sediments to drainage canals. Topsoil and overburden stockpiles that will not be used immediately will be stabilized with permanent vegetation together with coco coir mats;
Ore hauling to and stockpiling in stockyard	Hauling of ores and wastes will promote wind transport of very fine sediments	Regular watering of mine pit and hauling/access roads using truck-mounted

Ore hauling to barges		water sprinkler system will be conducted;
Shipping and loading to mother vessel	Wind transport of very fine sediments	An appropriate moisture content will be maintained;
Daily operation in mine offices and facilities	Domestic solid wastes maybe indiscriminately disposed in adjacent areas	A solid waste management plan will be strictly enforced;
REHABILITATION PHASE		
Reshaping of mined-out Backfilling of overburden and topsoil	Will lessen slope gradient; Will remove the temporary mounds in the stock yards, waste dumps;	Rebuild slope to a stable angle similar to the natural slope before mining. Ensure that berms, drainage canals, settling ponds are functional before spreading the soil and overburden; Install temporary sediment barrier at the perimeter of rehabilitation site; Scrape subgrade to ensure bonding with soil; Replace soil in the same order when it was removed to restore natural stratification; Contour bunds must be installed at different elevations; plant vegetative hedges along these bunds Natural flow paths will be restored during rehabilitation; diversion canals will be redirected towards original natural waterways;
Construction of efficient drainage system lined with concrete	Will divert runoff away from unstable slopes and will reduce infiltration;	Ensure that the drainage canals are wide enough to accommodate the common size of sediment and debris present;
Installation of coco nets Planting of fast-growing native vegetation	Will protect soil from erosion;	Fence the newly planted area to minimize plant disturbance by animals and humans
Decommissioning of siltation ponds	Will remove external load due to water and accumulated sediments	Backfilling of siltation ponds once the mined-out area is completely rehabilitated; planting of native trees in abandoned siltation ponds

2.1.4 Terrestrial Ecology

General Description of the Sampling Stations

There were two seasons of sampling which includes the 1st season which is considered as the dry season and it was conducted in year 2016. Meanwhile, the second season is considered as the wet season and it was conducted in year 2019. Three sampling area was established within different barangays namely, Barangay Puntalinao, Barangay Maputi and Barangay Causwagan. Blocks of Barangay Puntalinao and Maputi were the planned mine pit whereas, blocks of Barangay Causwagan was the planned dumpsite of this project.

The topography of the area is characterized by moderately sloping to rugged terrain with elevation ranging from 100 to 633 meters above sea level. The major drainage systems in the area are Mapanga River to the west and Piso and Maputi River to the south. The area is underlain by Cretaceous to Paleogene assemblage of ultramafic and mafic rocks that is thrusted against Cretaceous rocks. The rea is also composed of moderate to highly fractured serpentinized peridotite. Below is a map showing the visual representation of the three sampling areas.

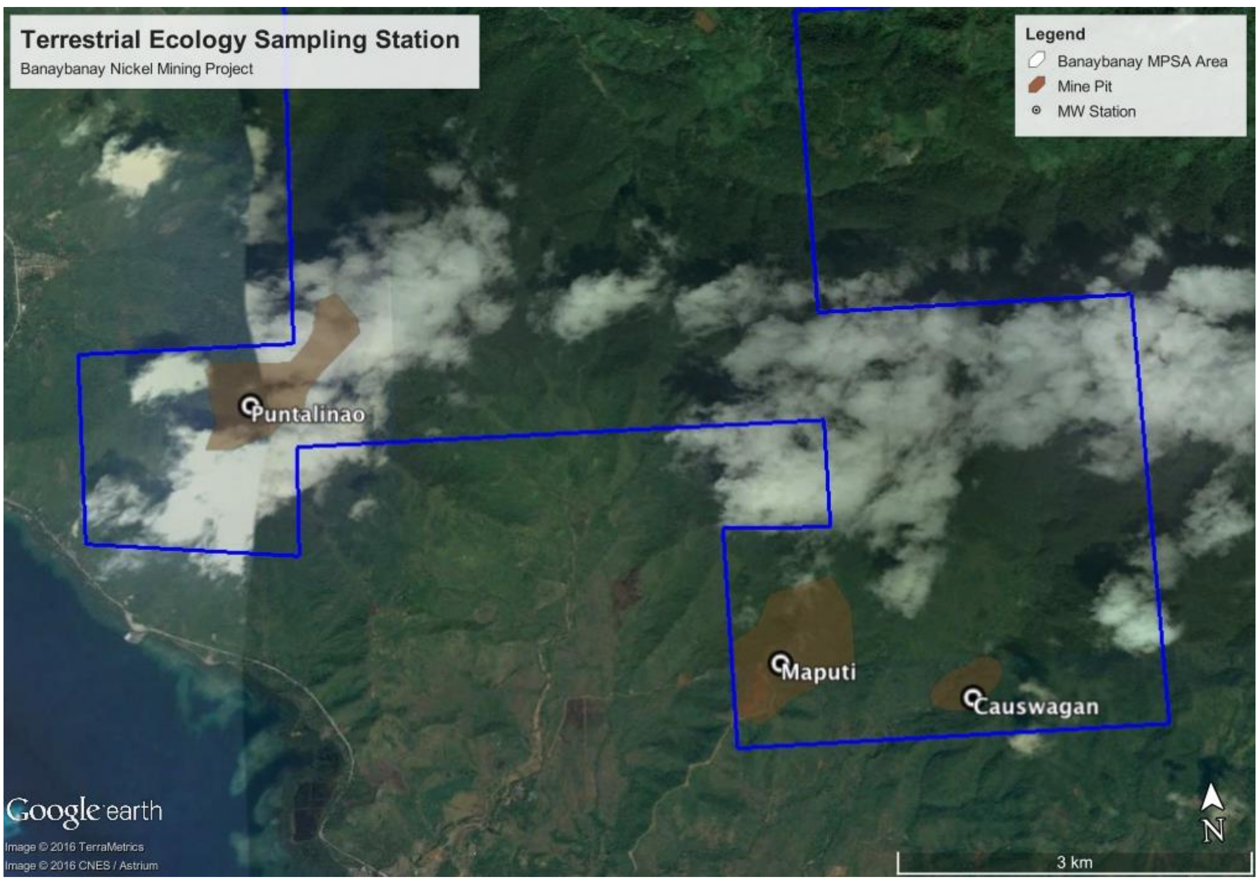


Figure 2.1-50: First Season (Dry Season) Sampling Map for Terrestrial Ecology both for Flora and Fauna *(Source: Google Earth)*

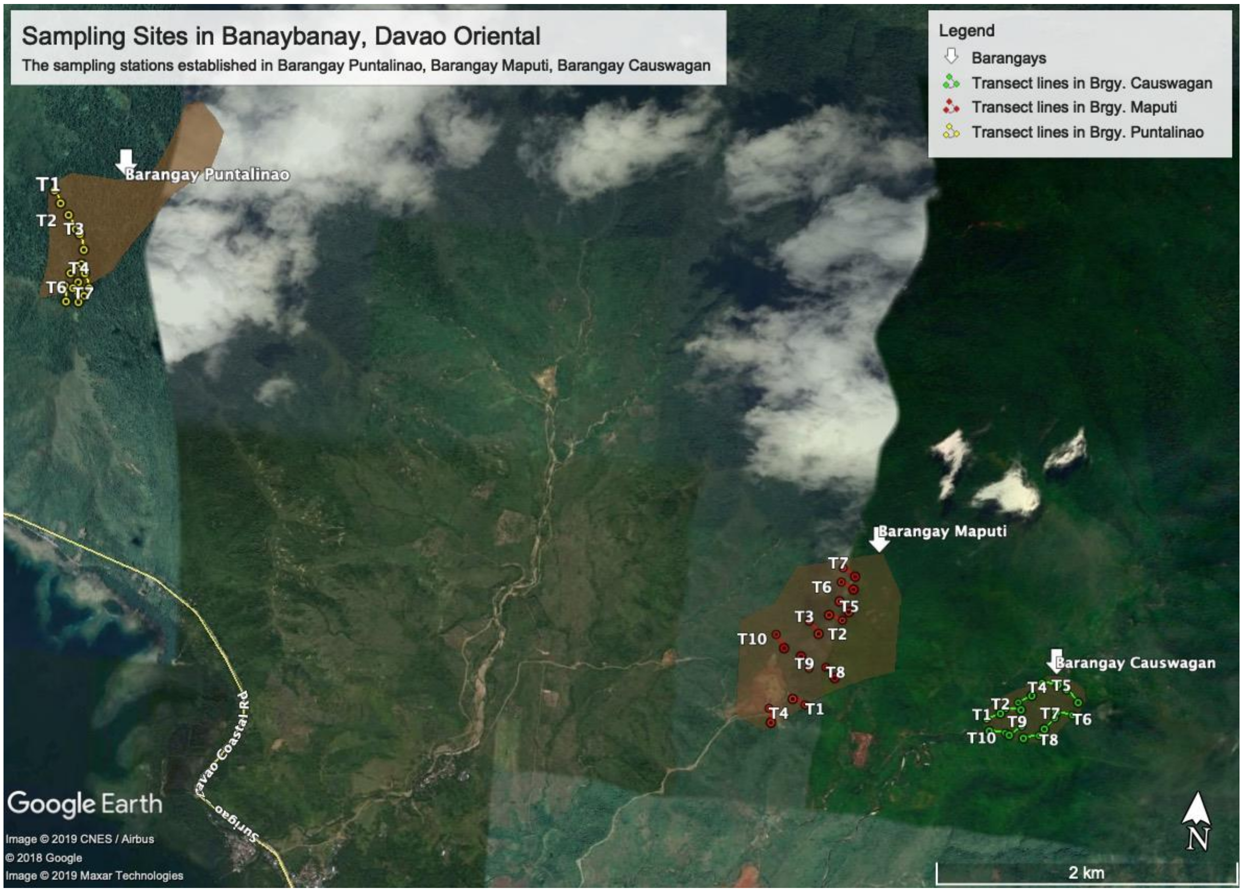


Figure 2.1-51: Second Season (Wet Season) Sampling Map for Terrestrial Ecology showing the transect lines both for Flora and Fauna *(Source: Google Earth)*

2.1.4.1 Terrestrial Ecology: 1st Season Sampling (Dry Season) 2016

2.1.4.1.1 Materials and Methods

Floral Survey

Floral Survey was conducted using a line transect method. The method was conducted by walking through a line across the sampling station. All tree species intercepted by the transect line measuring > 5 m in height and > 10 cm diameter-at- breast- height were identified and recorded.

Faunal Sampling

Avifauna

Avifaunal survey was conducted through mist netting, transect count and incidental survey. Transect count was conducted by walking a 1 kilometer transect line for 2 hours within the sampling station. Birds were identified according to their local names, acoustic calls and visual representations with the aid of a field guide (Tañedo, 2015). Birds were released right after photo documentations.

Volant Mammals

Sampling for volant mammals was conducted using mist nets. Ten mist nets measuring 4 m x 12 m at 36 mm mesh size were installed near fruiting Ficus trees, in ridge tops and probable flyways. Age and sex of bats were determined, including external measurements such as total length (TL), tail vent length (TV), ear length (EL), forearm length (FA), and hind foot length (HF). Bats were identified using the Key to Philippine Bats (Ingle and Heaney, 1992). After documentation, bats were revitalized with sugar solution and released back into the wild.

Non-Volant Mammals

Non-Volant mammals were sampled using live traps. Traps were set up at about 6:00 in the evening and were checked every four hours until morning. Peanut butter and dried fish were used as bait to attract small non-volant mammals roaming at night and during the day. Traps were positioned along possible runways, near burrow entrances, under root tangles, on top of fallen logs and other probable faunal corridor. Mammals that were trapped in the cage were subjected to basic morphometric measurements and were released thereafter.

Herpetofauna

Frogs were sampled using cruising methods or opportunistic sampling. Streams and creeks were search for frogs. All captured individuals were subjected to morphometric measurement. Frogs and other herpetofauna species were identified based on “The amphibians and reptiles of Mindanao Island, southern Philippines, II: the herpetofauna of Northeast Mindanao and Adjacent Islands” (Brown et. Al 2012).

Table 2.1-30. Geographical Location of the three sampling stations.

Barangay	Latitude	Longtitude
Punta Linao	7° 01.859’	125° 59.207'
Maputi	7° 01.015’	126° 00.38’
Causwagan	7° 01.225	126° 01.195'

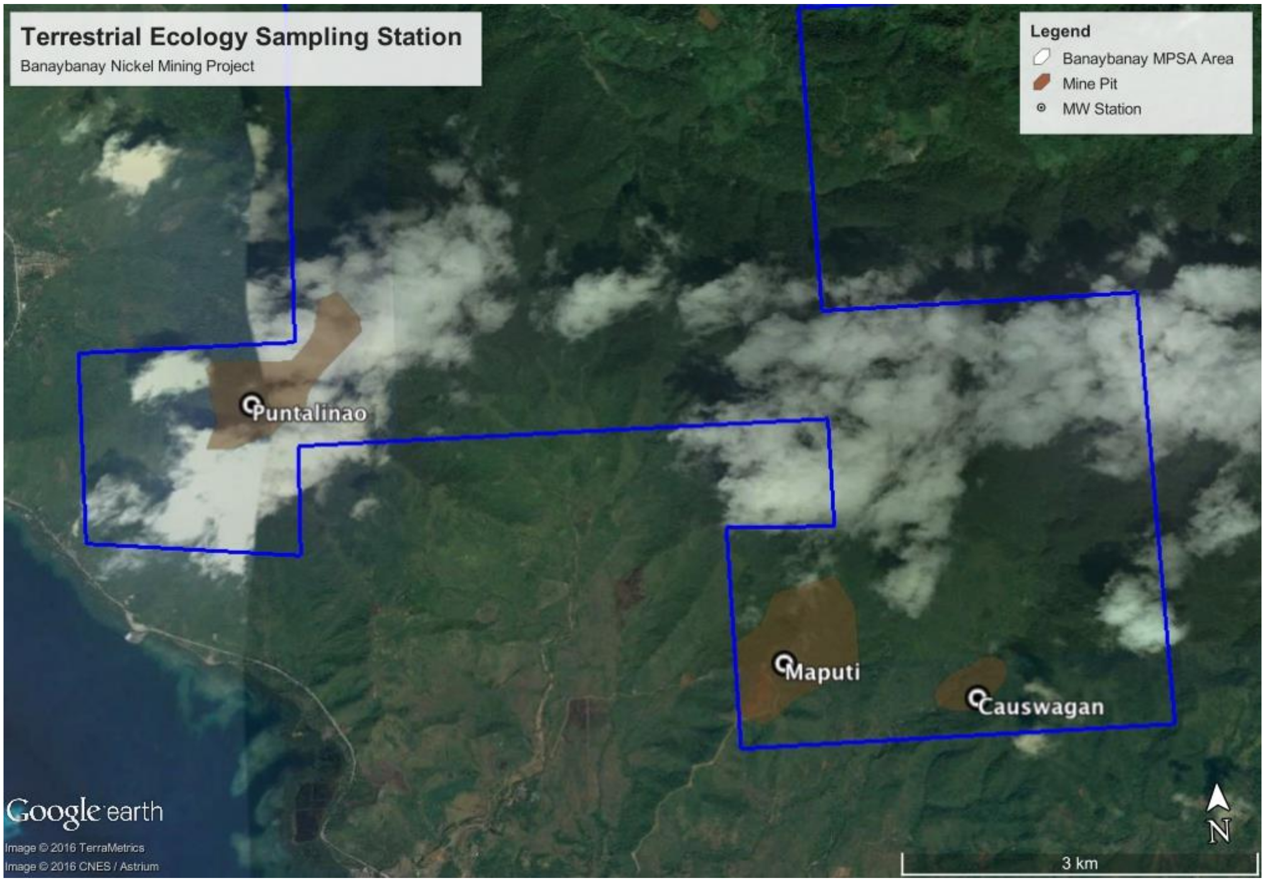


Figure 2.1-52. Map showing the location of the three sampling stations.

2.1.4.1.2 Result and Discussion

2.1.4.1.2.1 Description of Sampling Stations

Station 1 (Barangay Punta Linao)

Station 1 is situated within barangay Punta Linao. The sampling station is located approximately 2 kilometer from the barangay hall. The area is an open forest dominated by shrubs and evergreen trees species. Slash and burn farming is also observed within the sampling area.

Figure 2.1-53. Visual representation of the area.

Station 2 (Barangay Maputi)

Station 2 was established within barangay Maputi. The sampling station is located 2 kilometer away from the laterite stockpiles at Barangay Maputi. The area is a mosaic of evergreen tree species and coconut plantation. Below is the visual representation of the sampling station.

Figrue 2.1-54. Visual representation of the sampling area.

Station 3 (Barangay Causwagan)

Station 3 is situated within Barangay Causwagan. The sampling area was established near the laterite stockpile at Barangay Causwagan and approximately 2 kilometers away from the barangay hall. Below is the visual representation of the sampling area.

Figure 2.1-55. Visual representation of the sampling area

2.1.4.1.2.2 Terrestrial Flora

Species Listing

Below are representative species of trees that were recorded within the three sampling stations.

Conservation status

The table below shows the conservation status of tree species listed within the three sampling stations. There were about 26 species of trees recorded within the three sampling stations with about 366 tree individuals. The table shows that only 2 species of trees were considered vulnerable according to IUCN while only one recorded species is considered critically endangered while others are not listed and was categorized as least concern. Based from DAO 2007-01, only one is categorized as endangered and one vulnerable while other species are not listed.

Table 2.1-31. Conservation Status of trees recorded within the sampling stations.

SPECIES	IUCN CONSERVATION STATUS	DAO 2007-01 CONSERVATION STATUS
Antidesma ilocanum Mer	Not Listed	Not Listed
Artocarpus blancoi	Vulnerable	Not Listed
Artocarpus heterophyllus	Not Listed	Not Listed
Artocarpus odoratissimus Blanco	Not Listed	Not Listed
Canarium asperum	Least concern	Not Listed
Cleistanthus pilosus	Not Listed	Not Listed
Cocos nucifera	Not Listed	Not Listed
Ficus benjamina	Least Concern	Not Listed

SPECIES	IUCN CONSERVATION STATUS	DAO 2007-01 CONSERVATION STATUS
Ficus nota	Least Concern	Not Listed
Gmelina arborea	Not Listed	Not Listed
Leea aculeata Blume	Not Listed	Not Listed
Leucaena leucocephala	Least Concern	Not Listed
Litsea glutinosa	Least Concern	Not Listed
Macaranga tanarius	Not Listed	Not Listed
Mangifera indica	Not Listed	Not Listed
Melanolepis multiglandulosa	Not Listed	Not Listed
Paraserianthes falcataria	Not Listed	Not Listed
Premna odorata	Not Listed	Not Listed
Semecarpus philippinensis	Not Listed	Not Listed
Shorea contorta	Critically endangered	Endangered
Switenia macrophylla	Least Concern	Not Listed
Syzygium brevistylum	Not Listed	Not Listed
Syzygium cumini	Not Listed	Not Listed
Voacanga megacarpa	Not Listed	Not Listed
Xanthostemon verdugonianus	Vulnerable	Vulnerable

Presence

The table below shows the presence of trees species within the three sampling stations. Based from the table below, there are eleven different tree species present in station 1 while twelve species of trees in station 2 and eleven species was also recorded within station 3.

Table 2.1-32. Presence of tree species within each sampling area

SPECIES	Station 1	Station 2	Station 3
Antidesma ilocanum Mer	x	x	x
Artocarpus blancoi	x	x	x
Artocarpus heterophyllus			x
Artocarpus odoratissimus Blanco	x		
Canarium asperum		x	
Cleistanthus pilosus		x	x
Cocos nucifera			x
Ficus benjamina	x		
Ficus nota			x
Gmelina arborea			x
Leea aculeata Blume		x	
Leucaena leucocephala			x
Litsea glutinosa	x		
Macaranga tanarius	x		x
Mangifera indica	x	x	x

SPECIES	Station 1	Station 2	Station 3
Melanolepis multiglandulosa		x	
Paraserianthes falcataria	x		
Premna odorata		x	
Semecarpus philippinensis		x	
Shorea contorta	x	x	
Switenia macrophylla	x		
Syzygium brevistylum	x	x	x
Syzygium cumini		x	
Voacanga megacarpa	x		x
Xanthostemon verdugonianus			x

Dominance

Station 1

Dominant families within station 1 are presented on the figure below. Based from the figure below, family Moraceae (35) and Leguminosae (25) are the most dominant family within station 1 followed by family Anacardiaceae (10), Dipterocarpaceae (12), and Euphorbiaceae (8). Family Apocynaceae has four individuals while Lauraceae (2) and Meliacceae (6) have two and six individuals respectively.

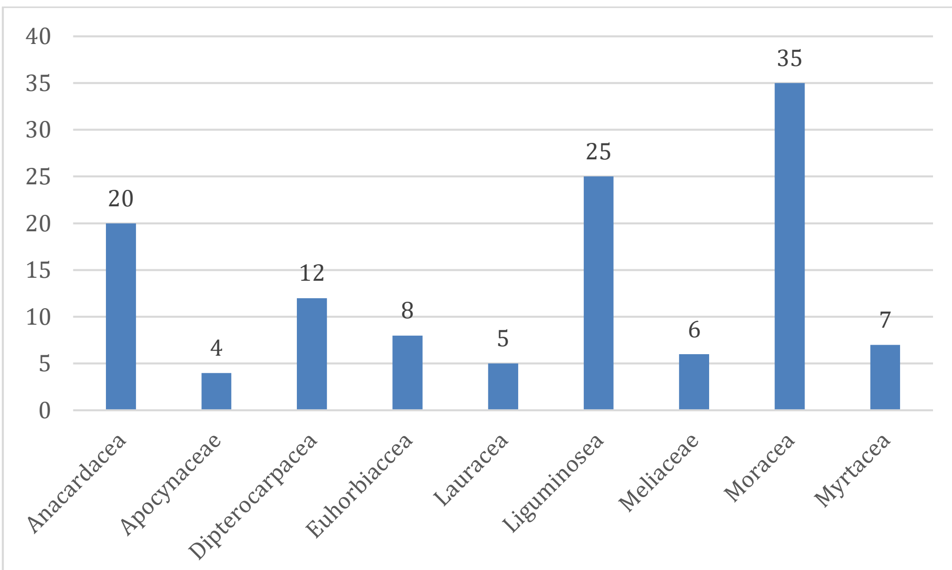


Figure 2.1-56. Dominant family within Station 1

Station 2

For station two, Family Euphorbiaceae (37) is the most abundant followed by Moraceae (22), Leguminosae (20) and Myrtaceae (12). Family Anacardiaceae (8), Apocynaceae (8) and Verbenaceae (8) have the same number of recorded individuals while Arecaceae (3) and Phyllanthaceae (3) has the least number of individuals.

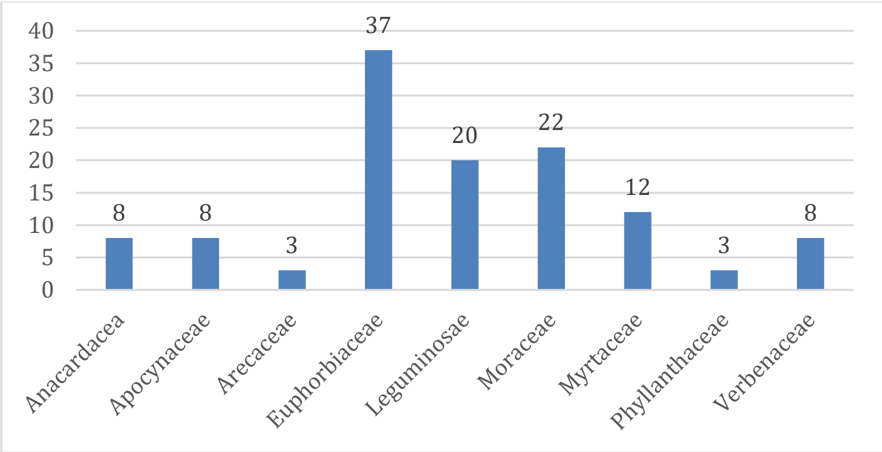


Figure 2.1-57. Dominant Family within station 2.

Station 3

Family Phyllanthaceae (25), Euphorbiaceae (20), Burseraceae (16) Vitaceae (13), Myrtaceae (19) and Anacardiaceae (9) are the most dominant families within station three. Family Euphorbiaceae (7), and Verbenaceae (7) have the same number of individuals. While family Dipterocarpaceae and Moraceae have four and three individuals respectively.

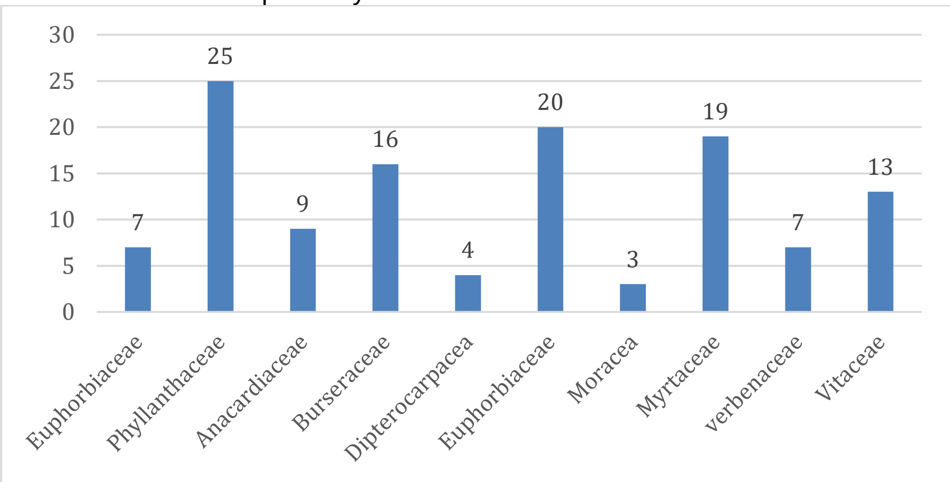


Figure 2.1-58. Dominant Family within station 3

Abundance

Station 1

Percent abundance of tree species for station 1 is presented on the figure below. Among the thirteen tree species recorded within satation 1, *Paraserianthes falcataria (20.49%)* and *Mangifera indica (16.39%)* has the highest number of percent abundance followed by *Artocarpus odoratissimus blanco (12.30%), Shorea contorta (9.84%), Artocapus blancoi (9.84%), Ficus benjamina(6.56%),Macaranga tanarius(6.56%) and Syzygium brevistylum (5.74%).*

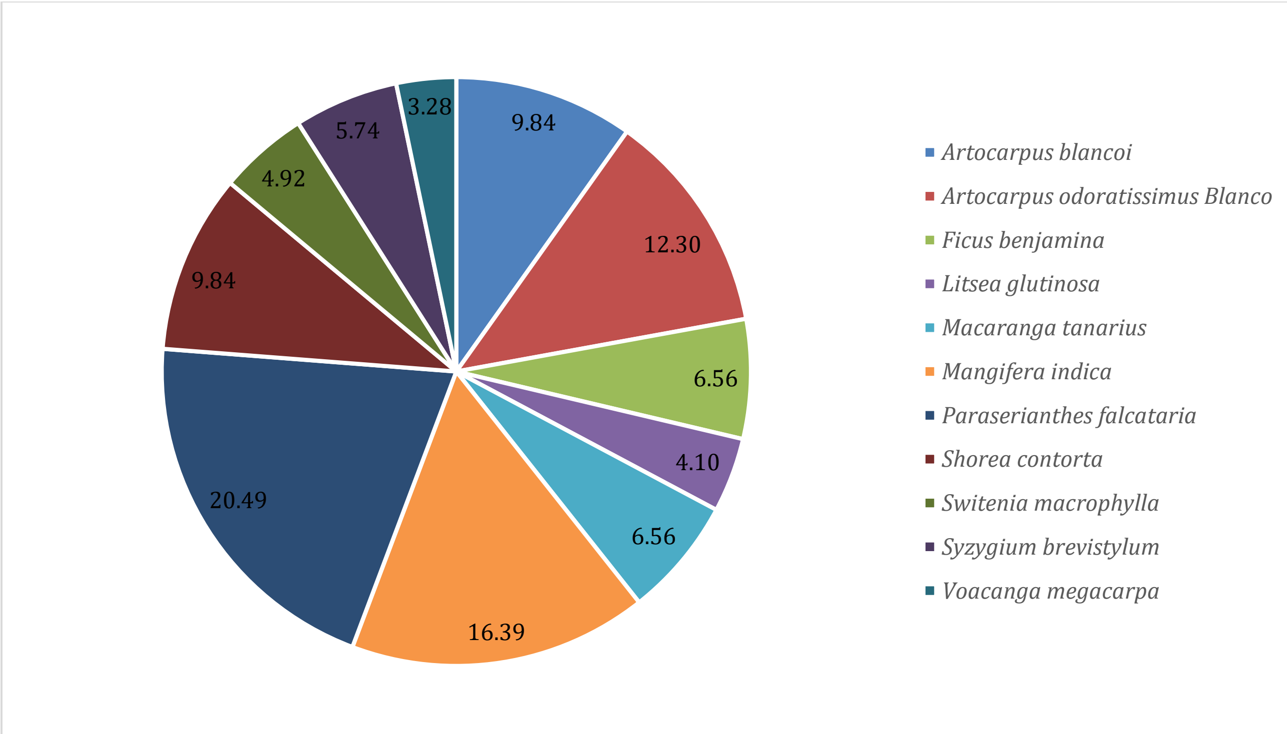


Figure 2.1-59. Percent dominant of tree species for station 1

Station 2

For station 2, *Macaranga tanarius (19.83%), Leucaena leucocephala (16.53%), Ficus nota (14.74%) and Antidesma ilucanum Mer (10.74%)* has the highest percent abundance followed by *Vocanga megacarpa (6.61%), mangifera indinca (6.61%) , gmelina arborea* (6.61%) and *Syzygium brevistylum (5.79%).*

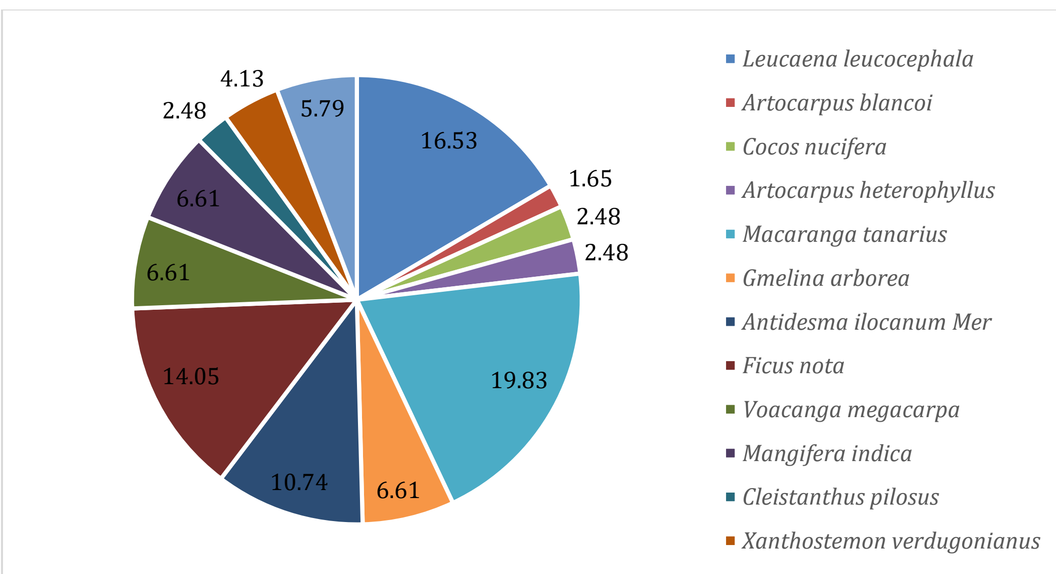


Figure 2.1-60. Percent dominant of trees for station 2.

Station 3

For station 3, *Cleistanthus pilosus (201.33%), Leea aculeate Blume (10.57%), canariumasperum (13.01) and Antidesma ilucanum Mer (16. 26%)* has the highest percent dominance followed by *Syzygium cumini* (9.76%), *Melanolepis multiglandilosa* (5.69%) and *Premna odorata* (5.69%).

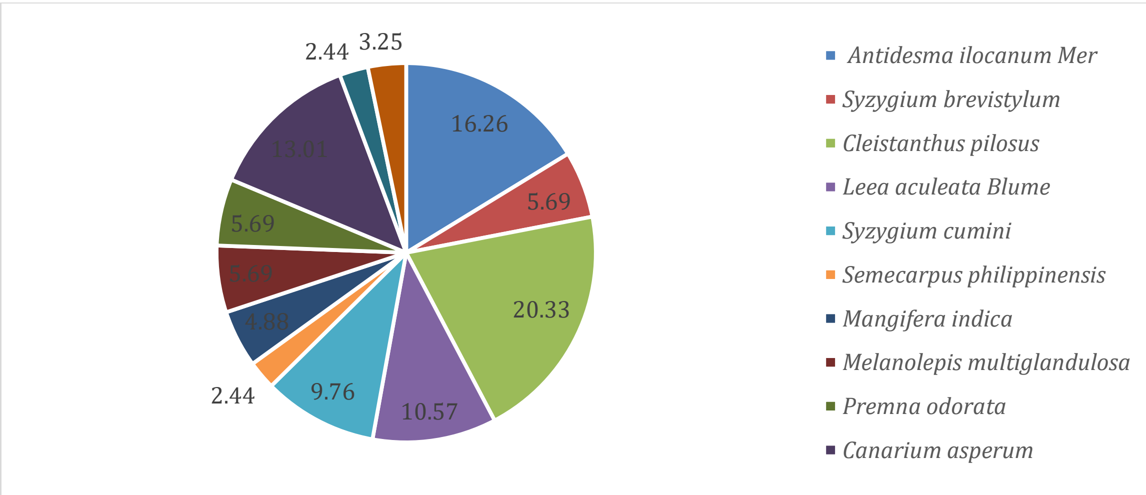


Figure 2.1-61. Percent dominance of trees for station 3

2.1.4.1.2.3 Terrestrial Fauna

Avifauna

Birds play an important role in maintaining the balance of the ecosystem. They are effective pollinators and at the same time instrument for seed dispersal which is a vital process in maintaining the biodiversity of flora where all fauna is dependent to. Sudden change in the bird's abundance might even indicate the severity of habitat destruction or habitat loss in the forests where they commonly strive.

Species Listing

Many bird species were identified in-situ. After identification, they are then released immediately in the wild. Below are representative species of birds recorded within the three sampling stations.

Photo 2.1-1. *Otus mirus*

Photo 2.1-2. *Chalcophaps indica*

Photo 2.1-3. ***Motacilla cinerea***

Photo 2.1-4. ***Nectarinia jugularis***

Photo 2.1-5. ***Lanius validirostris***

Photo 2.1-6. ***Megalurus palustris***

Photo 2.1-7. ***Rhipidura cyaniceps***

Photo 2.1-8. ***Pycnonotus goiavier***

Photo 2.1-9. *Hypsipetes philippinus*

Presence

Upon listing all the bird species captured, a total of 26 species was noted. Some species are present in some areas but absent in the other sites. Except for few species, which were found in all sampling sites. These are *Geopelia striata*, *Pycnonotus goiavier* and *Rhipidura cyaniceps.* The table below shows the presence of different bird species recorded within the three sampling stations.

Table 2.1-33. Presence of Bird species within the three sampling stations.

Species	Common Name	Station 1	Station 2	Station 3
Alcedo atthis	Common Kingfisher	x		
Chalcophaps indica	Lesser Coucal		x	x
Centropus bengalensis	Common Emerald Dove	x		x
Cinnyris jugularis	Olive Backed Sunbird		x	x
Coracina striata	Bar Billed Cuckoo Shrike	x		
Corvus macrorhynchos	Large billed crow			x
Geopelia striata	Zebra Dove	x	x	x
Halcyon smyrnensis	White Throated Kingfisher			x
Hypsipetes philippinus	Philippine Bulbul	x		x
Lanius cristatus	Brown Shrike		x	x
Lanius schach	Long Tailed Shrike		x	x
Lanius validirostris	Mountain shrike	x		
Lonchura atricapilla	Chesnutt Munia			x
Megalurus palustris	Striated Grass Bird			x
Merops philippinus	Blue Tailed Bee Eater	x		
Motacilla cinerea	Gray Wagtail			x
Motacilla flava	Yellow Wagtail		x	
Nectarinia jugularis	Olive-Backed Sunbird	x		
Otus mirus	Mindanao Scopes Owl		x	
Pachycephala philippinensis	Yellow bellied whistler			x
Phylloscopus borealis	Artic Barbler			x
Pycnonotus goiavier	Yellow Vented Bulbul	x	x	x
Rhipidura cyaniceps	Blue Headed Fantail	x	x	x
Saxicola caprata	Pied Bush Chat		x	x

Species	Common Name	Station 1	Station 2	Station 3
Spilornis cheela	Crested Serpent Eagle	x		
Streptopelia chinensis	Spotted Dove		x	

Conservation Status

From the 26 bird species identified, three (3) of them were not listed in the IUCN. These are *Cinnyris jugularis, Hypsipetes philippinus and Streptopelia chinensis.* While the remaining 23 species are labeled as "Least Concern". The following table shows the conservation status of each bird species recorded within the sampling stations base on the IUCN Red List.

Table 11-34. Conservation Status of Birds recorded within the three sampling stations.

Species	Common Name	IUCN Conservation status
Alcedo atthis	Common Kingfisher	Least Concern
Centropus bengalensis	Lesser Coucal	Least Concern
Chalcophaps indica	Common Emerald Dove	Least Concern
Cinnyris jugularis	Olive Backed Sunbird	Not Listed
Coracina striata	Bar Billed Cuckoo Shrike	Least Concern
Corvus macrorhynchos	Large billed crow	Least Concern
Geopelia striata	Zebra Dove	Least Concern
Halcyon smyrnensis	White Throated Kingfisher	Least Concern
Hypsipetes philippinus	Philippine Bulbul	Not Listed
Lanius cristatus	Brown Shrike	Least Concern
Lanius schach	Long Tailed Shrike	Least Concern
Lanius validirostris	Mountain shrike	Least Concern
Lonchura atricapilla	Chesnutt Munia	Least Concern
Megalurus palustris	Striated Grass Bird	Least Concern
Merops philippinus	Blue Tailed Bee Eater	Least Concern
Motacilla cinerea	Gray Wagtail	Least Concern
Motacilla flava	Yellow Wagtail	Least Concern
Nectarinia jugularis	Olive-Backed Sunbird	Least Concern
Otus mirus	Mindanao Scopes Owl	Least Concern
Pachycephala philippinensis	Yellow bellied whistler	Least Concern
Phylloscopus borealis	Artic Barbler	Least Concern
Pycnonotus goiavier	Yellow Vented Bulbul	Least Concern
Rhipidura cyaniceps	Blue Headed Fantail	Least Concern
Saxicola caprata	Pied Bush Chat	Least Concern
Spilornis cheela	Crested Serpent Eagle	Least Concern
Streptopelia chinensis	Spotted Dove	Not Listed

Abundance

Station 1

Percent abundance of birds that was recorded within station 1 is presented on the figure below. The figure shows that Philippine bulbul (*Hypsipetes philippinus*) has the highest (34.2%) percent abundance followed by *Pycnonotus goiaver* (17.8%) and *Centropus bengalensis* (). Other bird species aare composed of *Lanius validirostris* (11.0%), *Nectarina jugularis* (6.8%), *Alcedo atthis* (5.5%), *Merops philippinus* (5.5%) and *Rhipidura cyaniceps* (4.1%).

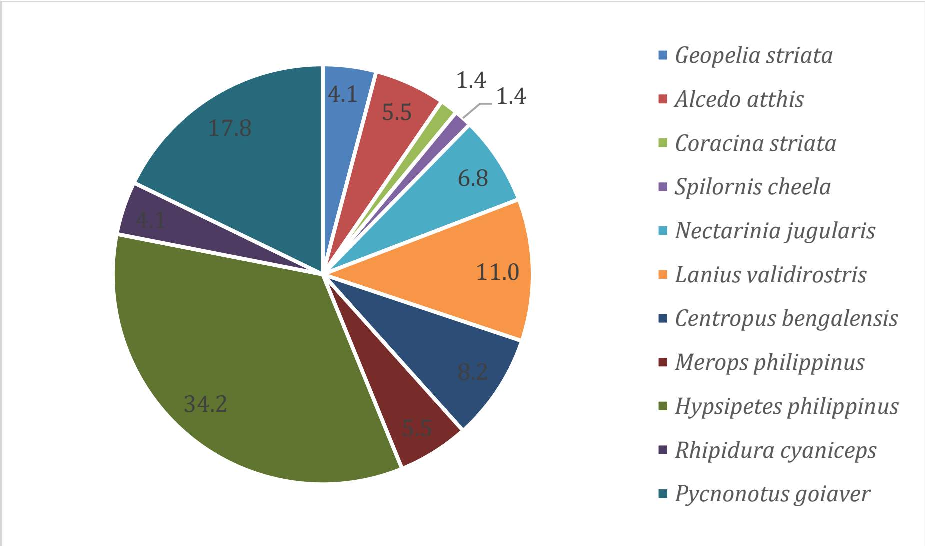


Figure 2.1-62. Percent abundance of birds within station 1.

Station 2

For station 2, *Cinnyris jugularis (21.21%), Lanius cristatus (18.18%)* and *Geopelia striata* (15.15%) are bird species which has the highest number of abundance. While Pycnonotus goiaver (), motacilla flava() and Lanius schach () have the same number in terms of percent abundance. Other recorded bird species includes Chalcophaps indica ()

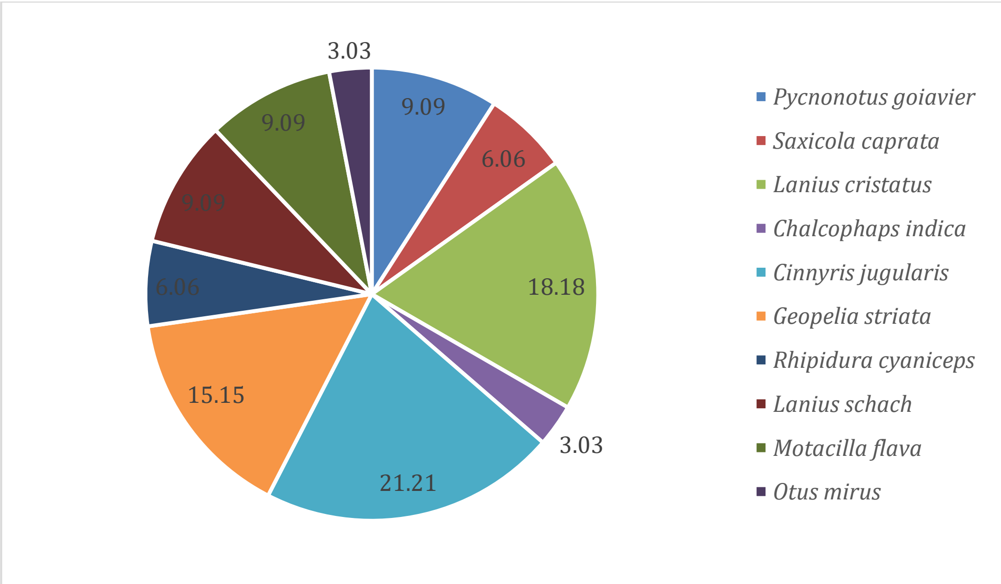


Figure 2.1-63. Percent dominance of birds recorded within station 2

Station 3

Percent dominance for station 3 is presented on the figure below. The figure shows that *Pycnonotus goiavier* (14.13%) has the highest number of percent dominance followed by *Hypsipetes philippinus* (10.87%), *Cinnyris jugularis* (9. 78%), *Lanius cristatus* (8.70%), *Lonchura atricapilla* (7.61%), *Geopelia striata* (5.43%) and *Streptopelia chinensis* (6.52%). Other bird species that was recorded within the sampling station includes *Chalcophaps indica* (3.26%), *Corvus macrorhynchos* (2.17%) and others.

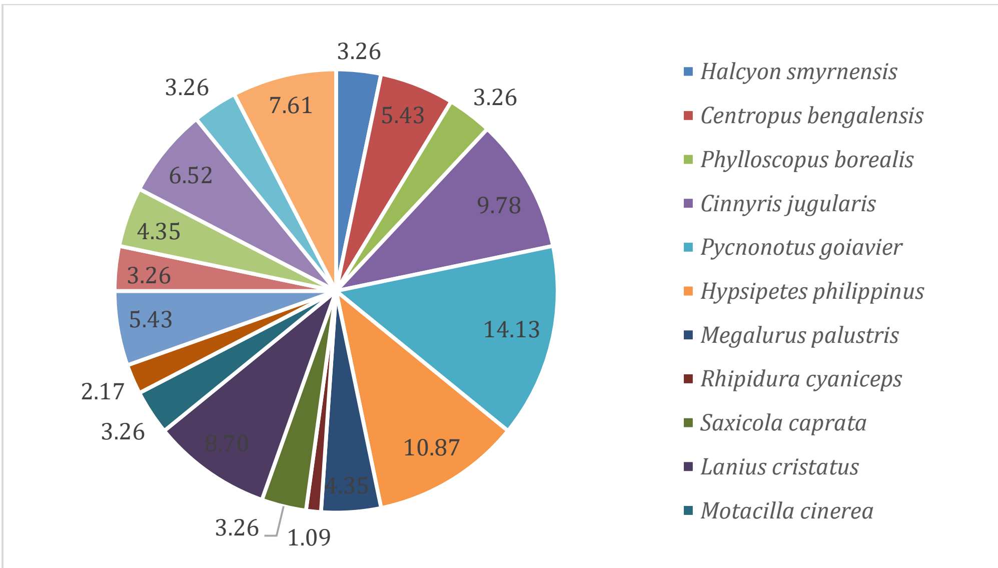


Figure 2.1-64. Percent dominance of birds recorded within station 3

Diversity Indices

In the study of 2016 Station 3 which is situated in Barangay Causwagan has the highest number of species among all the assessed stations. It has a dominance of 7.56% and evenness of 15.11%. Stations 1 and 2 has a dominance of 18.22% and 13.5%, respectively. Both stations has a criterion of "low" diversity indices, while station 3 has a "moderate" diversity indices.

Table 2.1-35. Species Diversity of Avifauna (2016)

Stations	Abundance	Species	H-diversity	Dominance	Evenness	Criterion
S1	73	11	2.00	18.22%	18.18%	Low
S2	33	10	2.13	13.5%	21.3%	Low
S3	92	18	2.72	7.56%	15.11%	Moderate

Volant mammals

Like birds, bats also act as seed pollinator in a specific ecosystem. Bats can have a variety of diet. From small insects to big fruits, many are included in their menu. They usually haunt for smaller flying insects during night time, thus, aside from being a pollinator and seed disperser, they also effectively controls and regulate the rapid increase on the population of insects and pests.

Species listing

Below are plates showing visual representation of different species of bats recorded within the three sampling stations.

Photo 2.1-10. *Cynopterus brachyotis* (Lesser Short Nose Fruit Bat)

Photo 2.1-11. *Ptenochirus jagori* (Greater Musky Fruit Bat)

Presence

All species of bats are present within each sampling station. Both two bats noted in all sampling sites are fruit bats which indicates the presence of fruit trees around the areas. These bats do not only consume fruits as parts of their diet but also transports its seeds which ensures the survival of many floral species. Due to this important function, they are also regarded as “Keystone Species” and massive reduction on their population may lead to drastic change in the ecosystem. The table below shows the presence of different bats species in the sampling area.

Table 2.1-36. Presence of bats within the three sampling stations

SPECIES	COMMON NAME	Station 1	Station 2	Station 3
Cynopterus brachyotis	Lesser Short Nose Fruit Bat	x	x	x
Ptenochirus jagori	Greater Musky Fruit Bat	x	x	x

Conservation status

Conservation status of different species of bats is presented on the table below. All species of bats that was recorded within the sampling stations were listed under least concern.

Table 2.1-37. Conservation status of bats within the three sampling stations

SPECIES	COMMON NAME	IUCN CONSERVATION STATUS
Cynopterus brachyotis	Lesser Short Nose Fruit Bat	Least Concern
Ptenochirus jagori	Greater Musky Fruit Bat	Least Concern

Abundance

Station 1

Two species of bats was noted in Station 1. As shown in the figure below, the highest percentage abundance was accounted for by *Cynopterus brachyotis* with 58.33. While the other species *Ptenochirus jagori* made up the remaining 41.67%.

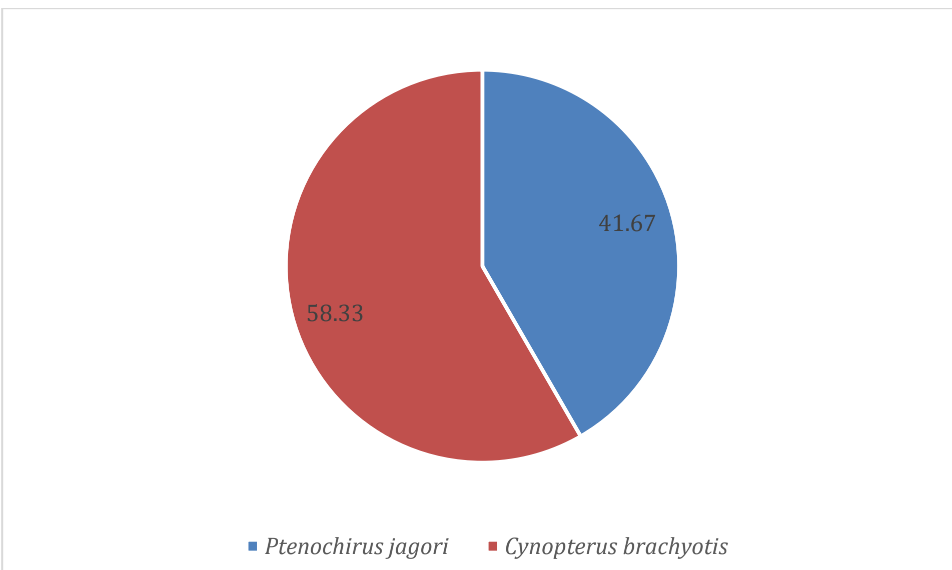


Figure 2.1-65. Percent abundance of bats species within station 1

Station 2

Like station 2, *Cynopterus brachyotis* was found to have the highest percent abundance of 62.50% followed by and *Ptenuchirus jagori* (37.50%).

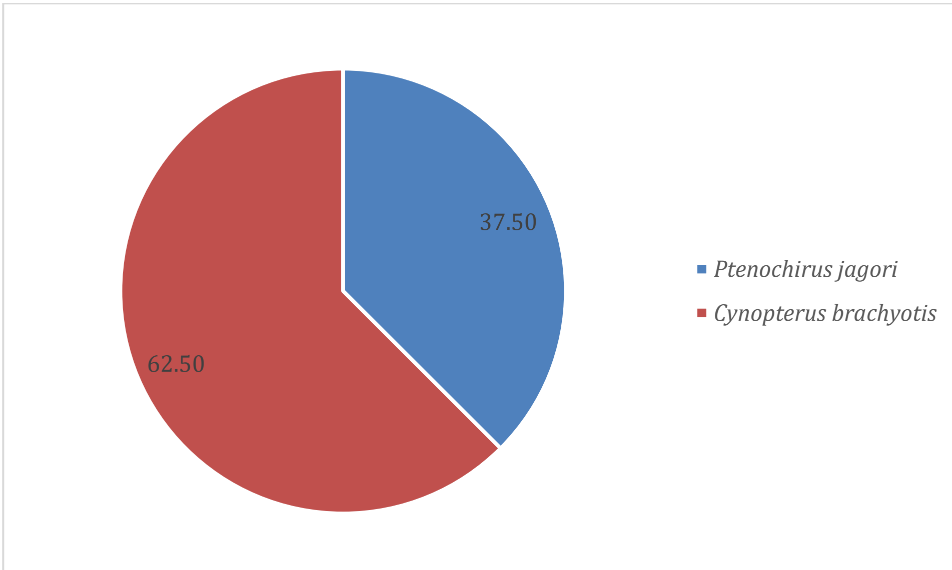


Figure 2.1-66. Percent abundance of bats species within station 1

Station 3

Cynopterus brachyotis (60%) is still has the highest percentage abundance for station 3 seconded be Ptenochirus jagori (40%).

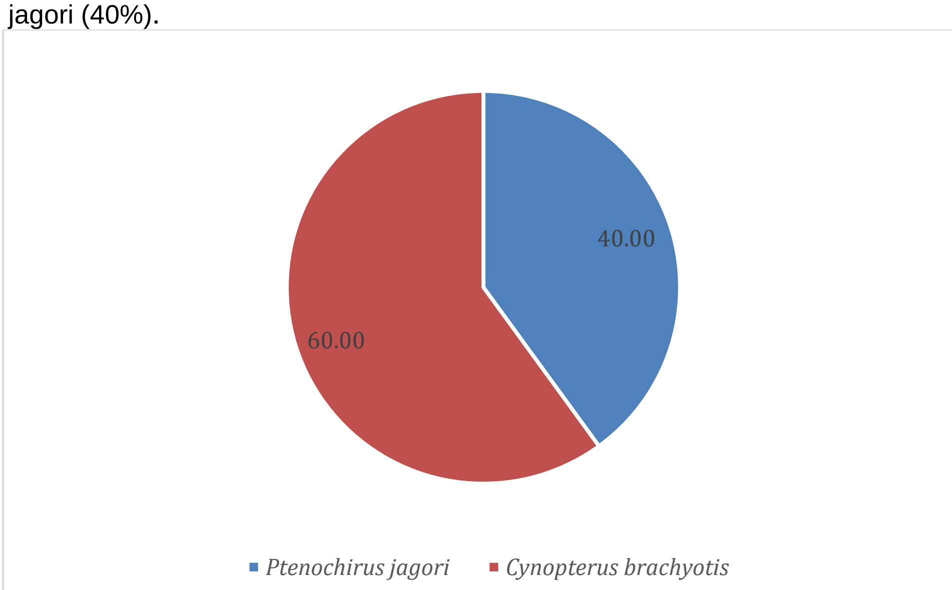


Figure 2.1-67. Percent abundance of bats species within station 3.

Tabel 2.1-38. Potential impacts and options for prevention or mitigation or enhancement

Potential Hazards/Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
Vegetation Removal and loss of Habitat in the construction of offices, support facilities and actual mining activity					
The naturally grown trees within Punta Linao, Maputi and Causwagan has already been removed brought by the slash and burn farming method of locals. Moreover, a forest fire happened in Punta Linao and Maputi which has further removed the vegetation in the area. Even though with this man-made activities, regenerating vegetation were observed.		x	x		• Inventory of potential affected trees shall be conducted. Proper ratio of tree replacement should be done. • A tree nursery shall be setup to be a nurturing facility for trees and other plants that will be earthballed. • Species observed in the site shall be used the priority for tree planting. Exotic species such as *Gmelina* shall be discouraged
Threat to existence and/or loss of important local species					
There were about 26 species of trees recorded within the three sampling stations with about 366 tree individuals. There are 2 species of trees were considered vulnerable according to IUCN while only one recorded species is considered critically endangered while others are not listed and was categorized as least concern. Based from DAO 2007-01, only one is categorized as endangered and one vulnerable while other species are not listed. No fauna species that were observed with high conservation importance observed in all sampling areas		x	x		• Biodiversity Management Plan shall be in placed to give priority in the conservation of tree species with high conservation importance. • Tree species that are considered endangered shall be prioritized in the greening program of the company • The company shall initiate an Information, Education and Communication Drive to intensify the awareness of the employees and also the stakeholders about the importance of Biodiversity
Hindrance to Wildlife Access					

Potential Hazards/Impacts	Phases				Options for Prevention or Mitigation or Enhancement
	Preconstruction	Construction	Operation	Closure	
There were no Bird and Bat highways within the area. Moreover, the area is not a migration path of birds.		x	x		• The company shall initiate an Information, Education and Communication Drive to intensify the awareness of the employees and also the stakeholders about the importance of Biodiversity • The company shall make its own regulation in that taking animals especially the ones that has high conservation importance shall be banned

2.1.4.2 Terrestrial Ecology: 2nd Season Sampling (Wet Season) 2019

2.1.4.2.1 Methodology

Terrestrial Fauna

Terrestrial fauna is defined as animals that are living on land and are using the land for the most part of their lives. Terrestrial fauna can be further divided into vertebrates (birds, mammals including bats, reptiles and amphibians) and invertebrates (arachnids, crustaceans, insects, mollusk and worms). Terrestrial fauna also helps in maintaining the general health of ecosystem since most invertebrates act like pollinators that allow the dispersion of plant seeds, fruits and fungi spores.

AviFauna

The avifaunal survey was conducted through Transect walk method and mist netting method.

Transect Walk Method

Five transects were set in the study area, at an established trail was measured at 25 meters apart along the trail and mark as stations. Walking through the transect line at a pace of one kilometer per hour.

From 0500H until 1000H, which is also the peak hour of bird activity, all birds seen observed by sight using a pair of binoculars and long-range still camera along the trails are recorded. Identification by listening to bird calls/acoustic calls was also done.

Mist-Netting Method

Mist nets with a dimension of 10m x 2.5 m with fine mesh were laid on suitable sites selected which are adjacent to the transects lines. The nets were set hanging from tree branches and anchored to the ground below. The captured bird species were retrieved at specific time to avoid excessive stress and prevent death to the entangled individuals. Birds were identified according to their local names, acoustic calls and visual representations with the aid of a field guide (Tañedo, 2015 & Kennedy et al, 2000). Birds were released right after photo documentation.

Photo 2.1-12. Mist-netting Method During the Sampling Period

Volant Mammals

Establishment of survey locations were done and followed by ocular visitation upon arrival in the area. Fruit and insectivorous bats were sampled by mist netting through high and ground. At least one high net was set randomly in each transect line, composed usually of two to five nets. High nets were opened starting 1700 H and closed at 0600H. Ground nets were evenly distributed along the transect line. Dimensions of high and ground nets are 12 x 2 m.

Captured bats were carefully removed from the nets and placed in a cotton cloth bag to minimize stress. Standard morphometrics were taken and identified using the “Key to the bats of the Philippine Islands” by Ingle and Heaney 1992.

Photo 2.1-13. Mist-netting Method for Volant Mammals

Photo 2.1-14. Unloosing the bats captured during the mist-netting method

Non-Volant Mammals

Non-volant mammals such as rodents were sampled using live traps. Traps were set up at around 1800H and were checked every four hours until morning. Peanut butter and dried fish were used as bait to attract small non-volant mammals roaming at night and during the day. Traps were positioned along possible runways, near burrow entrances, under root tangles, on top of fallen logs and other probable faunal corridor.

Mammals that are trapped in the cage are subjected to basic morphometric measurements and are released thereafter. Standard morphometrics (total length, tail length, hind foot, ear, and weight) were taken from the captured samples. Specimens were identified up to the species level based on the measurements on the "Illustration Guide of the Non-flying Mammals of Mindanao Island, Philippines" by Heaney et al. (1999) and "A Synopsis of the Mammalian Fauna in the Philippines by Heaney et al. (1998). There were also species that were identified in the area through Key Informant Interviews (KII). Local residents, especially farmers, hunters and enthusiasts were interviewed to check if they have recently observed these species.

Photo 2.1-15. Setting Up of Cage Traps for non-volant mammals during nighttime.

Hepterofauna

Herpetofauna, comprising of reptiles and amphibians, were sampled using cruising methods or opportunistic sampling. Bodies of water such as streams and creeks were searched for frogs. Snakes were searched in possible areas such as burrows and thick vegetation covers. Searches were done within 10-m parallel distance from the transect line. Visuals and acoustic calls of species were used to identify the species. Samples were hand-captured whenever possible.

All captured individuals were subjected to morphometric measurement. Frogs and other herpetofauna species were identified based on Amphibians and Reptiles of Luzon Island (Philippines), VII: Herpetofauna of Ilocos Norte Province, Northern Cordillera Mountain Ranged (Brown et. al 2012). Amphibians and Reptiles of Luzon Island, V: The Herpetofauna of Angat Dam Watershed, Bulacan Province, Luzon Island, Philippines (Mcleod et. al 2012).

Terrestrial Flora

Floral Survey was conducted using a line transect method. A 100m line was laid across the established stations. The method was conducted by walking through the line. All tree species intercepted by the transect line measuring > 5 m in height and > 10 cm diameter-at-breast-height were identified and recorded.

Photo 2.1-16. Setting up transect line for floral survey

2.1.4.2.2 Results and Discussion

2.1.4.2.2.1 Sampling Site Description

Site 1 – Barangay Punta-linao

Site 1 is located in Barangay Punta-linao, with coordinates of N 7°3´21" E 125°58´52". It is a secondary dipterocarp forest surrounded by 80 degrees sloping ridges. There is a stream 1 km away from the established transect line. Site 1 is dominated by ferns species, dipterocarp tree species is relatively in patches, *Syziguim brevistylum* with the 60 ft (H) and 30 cm (DBH) is the highest and have largest DBH in the transect line.

Photo 2.1-17 Visual Representation of the Sampling Area in Barangay Puntalinao, Banaybanay, Davao Oriental

Site 2 – Barangay Maputi

Site 2 is located in Barangay Maputi, with coordinates of N 7°3´23" E 126°0´20". It is a secondary dipterocarp forest. This site is dominated by fern species, dipterocarp; tree species are dominated by *Eurya sp.*. A 5m-wide logging road was also observed in the area. There is a stream five meters away from the established transect line.

Photo 2.1-18. Visual Representation of the Sampling Area in Barangay Maputi, Banaybanay, Davao Oriental

Site 3 – Barangay Causwagan

Site 3 is located in Barangay Causwagan, with coordinates of N 7°1´25” E 126°1´28". It is a secondary agro-dipterocarp forest dominated by dipterocarp trees and agricultural trees like Mangoes, Falcata, Marang, Langka and Coconut tree, a river was observed 300 meters away transect line, 5 m wide road is present and currently use for logging in the area.

Photo 2.1-19. Visual Representation of the Sampling Area in Barangay Causwagan, Banaybanay, Davao Oriental

The sampling stations were located in Barangay Puntalinao, Barangay Maputi and Barangay Causwagan. There were eight (8) transect-walk established in Baranagay Puntalinao and ten (10) for both Barangay Maputi and Barangay Causwagan. The access of the researchers in the area was limited by the barangay officials for safety purposes.

2.1.4.2.2.2 Terrestrial Flora

Species Richness

A total of thirty-four (34) species were observed during the 2019 monitoring across all sampling sites. (Site 1, Site 2 and Site 3). These species belong to 21 different families. The families with the richest species recorded in the area are Myrtaceae with four (4) species and Dipterocarpaceae and Fabaceae with three (3) species each.

The table below shows the different flora species that were observed in the 2019 monitoring.

Table 2.1-39. Flora Species Observed in the 2019 Study

Family	Species	Local Name
Anacardiaceae	*Mangifera indica*	Manga
Anacardiaceae	*Bucchanania sp*	Manga-manga
Annonaceae	*Haplostichanthus lanceolata*	Banga
Arecaceae	*Cocos nucifera*	Lubi

Family	Species	Local Name
Burseraceae	Garuga floribunda decne	bugo
Burseraceae	Canarium ovatum	Pili-pili
Calophyllaceae	*Calophyllum blancoi*	Bitanghol/Yelohan
Celastraceae	*Euonymus javanicus*	Tabaan
Clusiaceae	*Garcinia rubra*	Batwan
Dipterocarpaceae	*Dipterocarpus grandiflorus*	Apitong
Dipterocarpaceae	*Shorea sp.*	Lawaan
Dipterocarpaceae	*Shorea astylosa*	Yakal
Phyllanthaceae	*Cleistanthus pilosus*	Malatabako
Fabaceae	*Cynometra inaequifolia*	Dila- Dila
Fabaceae	*Falcataria moluccana*	Falcata
Fabaceae	*Pterocarpus indicus*	Narra
Fagaceae	*Castanopsis sp*	Indang-Indang
Fagaceae	*Lithocarpus llanosi*	Ulayan
Lamiaceae	*Gmelina arborea*	Gmelina
Meliaceae	*Swietenia macrophylla*	Mahogany
Meliaceae	*Sandoricum koetjape*	Santol
Moraceae	*Artocarpus heterophyllus*	Langka
Moraceae	*Artocarpus odoratissimus*	Marang
Myrtaceae	*Syzygium cumini*	Lumboy-lumboy
Myrtaceae	*Xanthostemon verdugonianus*	Magkuno
Myrtaceae	*Syzyguim brevistylum*	Sagimsim
Pentaphylacaceae	*Eurya sp.*	Tag-lemonsito
Podocarpaceae	*Podocarpus philippinensis*	Malakauayan
Rubiaceae	*Nauclea orientalis*	Bangkal
Rubiaceae	*Greeniopsis sp*	Hambabalod
Rutaceae	*Melicope sp*	Ansohan/Tulusan
Sapotaceae	*Palaquium luzoniense*	Nato
Urticaceae	*Urtica sp*	Alingatong
Myrtaceae	*Syzygium sp.*	Itoman

Presence

Among the 34 species that were observed in the 2019 monitoring, there were only two (2) species that were found across all sampling sites. These species are Syzygium cumini and Syzyguim brevistylum. There were also eight (8) species that were found in just two (2) sites, while the other 24 species are only present in one (1) site.

The table below shows the presence of the flora species observed across the three (3) sampling sites.

Table 2.1-40. Presence of Flora Species

Family	Species	Site 1	Site 2	Site 3
Anacardiaceae	*Mangifera indica*			/
Anacardiaceae	*Bucchanania sp*		/	
Annonaceae	*Haplostichanthus lanceolata*	/	/	
Arecaceae	*Cocos nucifera*			/
Burseraceae	*Garuga floribunda decne*	/		
Burseraceae	*Canarium ovatum*		/	/
Calophyllaceae	*Calophyllum blancoi*	/		/
Celastraceae	*Euonymus javanicus*	/		
Clusiaceae	*Garcinia rubra*		/	/
Dipterocarpaceae	*Dipterocarpus grandiflorus*	/		
Dipterocarpaceae	*Shorea sp.*		/	
Dipterocarpaceae	*Shorea astylosa*	/	/	
Phyllanthaceae	*Cleistanthus pilosus*			/
Fabaceae	*Cynometra inaequifolia*	/		
Fabaceae	*Falcataria moluccana*			/
Fabaceae	*Pterocarpus indicus*			/
Fagaceae	*Castanopsis sp*			/
Fagaceae	*Lithocarpus llanosi*	/	/	
Lamiaceae	*Gmelina arborea*			/
Meliaceae	*Swietenia macrophylla*			/
Meliaceae	*Sandoricum koetjape*			/
Moraceae	*Artocarpus heterophyllus*			/
Moraceae	*Artocarpus odoratissimus*			/
Myrtaceae	*Syzygium cumini*	/	/	/
Myrtaceae	*Xanthostemon verdugonianus*		/	
Myrtaceae	*Syzyguim brevistylum*	/	/	/
Pentaphylacaceae	*Eurya sp.*		/	
Podocarpaceae	*Podocarpus philippinensis*	/		
Rubiaceae	*Nauclea orientalis*			/
Rubiaceae	*Greeniopsis sp*	/		/
Rutaceae	*Melicope sp*	/		
Sapotaceae	*Palaquium luzoniense*	/	/	
Urticaceae	*Urtica sp*			/
Myrtaceae	*Syzygium sp.*	/		

Abundance

A total of 355 individual flora belonging to 34 species were observed across the three (3) sampling sites. The species with the highest counts are Syzyguim brevistylum, Mangifera indica, Falcataria moluccana with 64, 40 and 38 individuals, respectively. Furthermore, Mangifera indica is also the most abundant species in Site 3, while the latter two (2) which were only found in Site 3, were the second and third most abundant species on site, respectively.

Station 1 (Barangay Puntalinao)

There were a total of 82 individuals that were observed in Site 1 belonging to 15 species. The most abundant species is Euonymus javanicus with an abundance of 25.61% of the species found (21 individuals, followed by Lithocarpus llanosi which is 17.07% abundant (14 individuals), and Syzyguim brevistylum with 13.41% abundance (11 individuals). Each of the other species found in the site are less than 10% in abundance.

The figure below shows the relative abundance of Flora species in Site 1

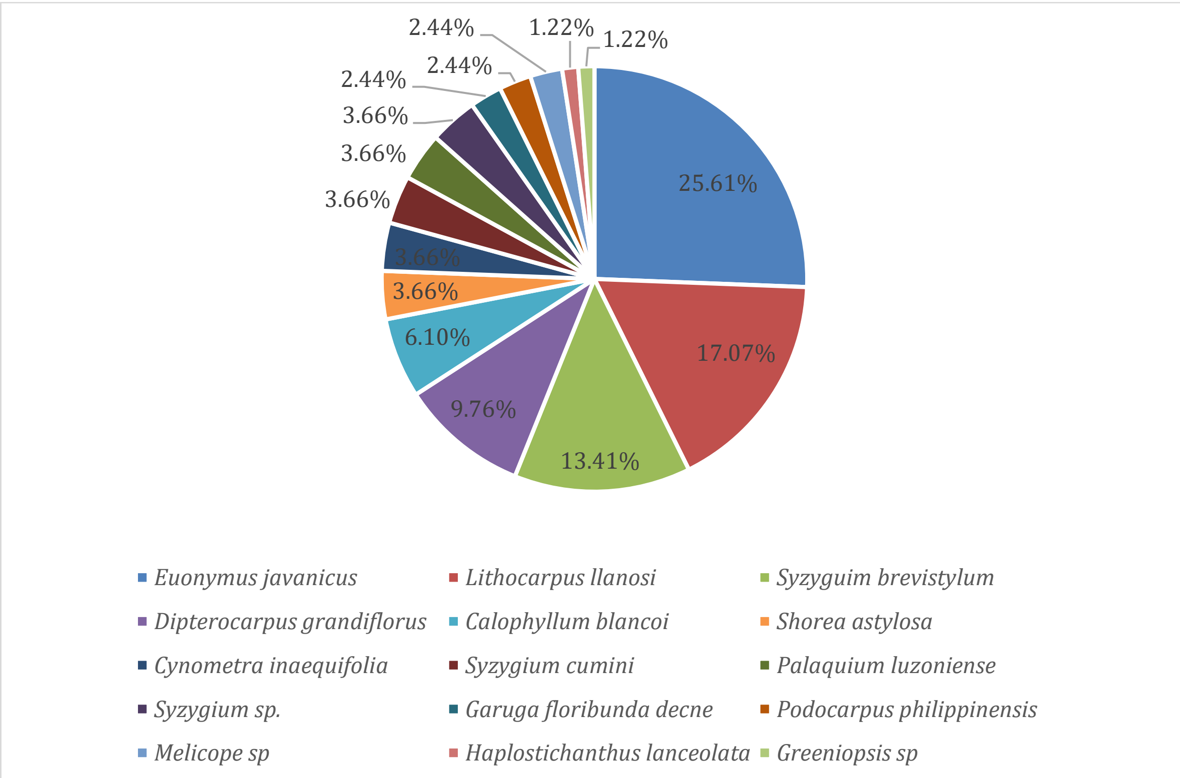


Figure 2.1-68. Site 1 Relative Abundance

Station 2 (Barangay Maputi)

There were a total of 61 individuals belonging to 12 species that were observed in Site 2. Among these species, Xanthostemon verdugonianus has the highest abundance of 32.79% (20individuals), followed by Syzygium cumini with 29.51% abundance (18 individuals). Each of the other species that were identified in the site are less than 10% in abundance.

The figure below shows the relative abundance of the species observed in Site 2.

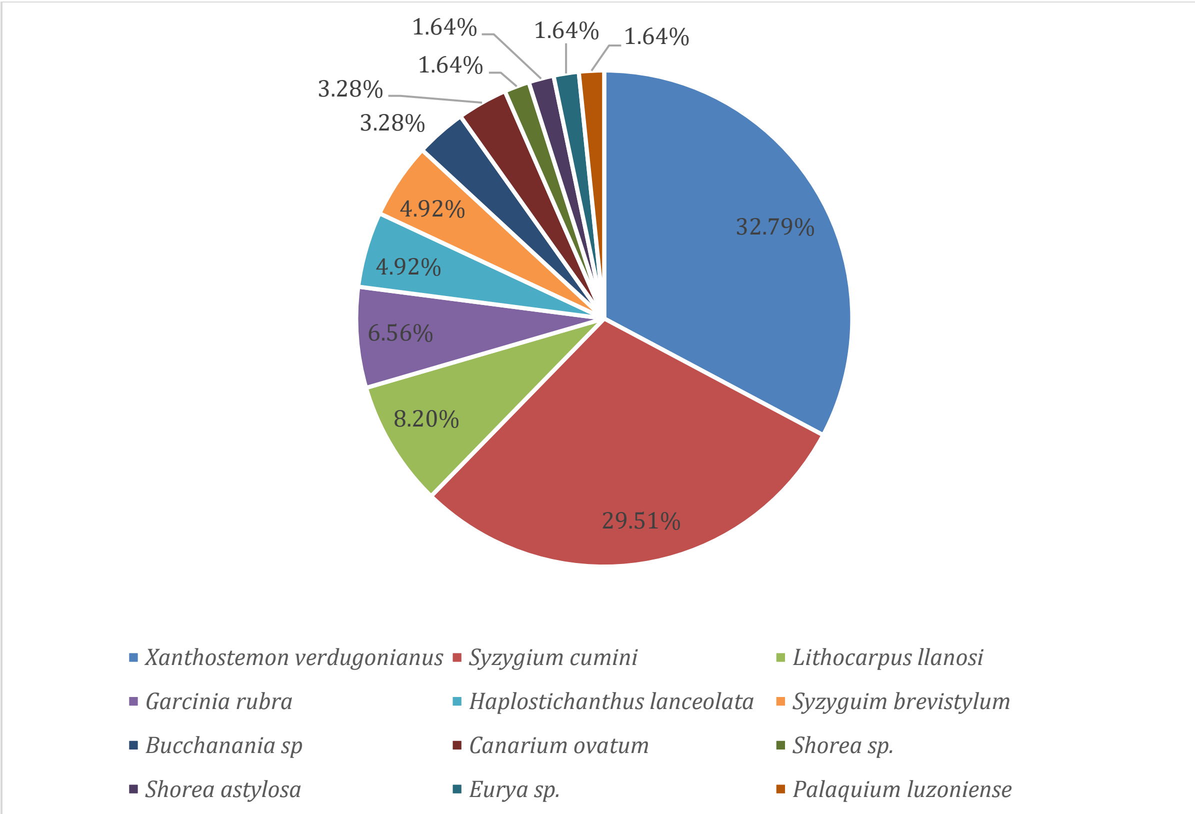


Figure 2.1-69. Site 2 Relative Abundance

Station 3 (Barangay Causwagan)

Site 3 has the highest number of individual species that were observed at 212 belonging to 19 species. Among these species, Syzyguim brevistylum has the highest relative abundance at 23.58% (50 individuals), followed by Mangifera indica, Falcataria moluccana, Swietenia macrophylla, with relative abundance of 18.87%, 17.92%, and 10.38%, respectively. Each of the other species that were identified in the site are less than 10% in abundance.

The figure below shows the relative abundance of the species observed in Site 3.

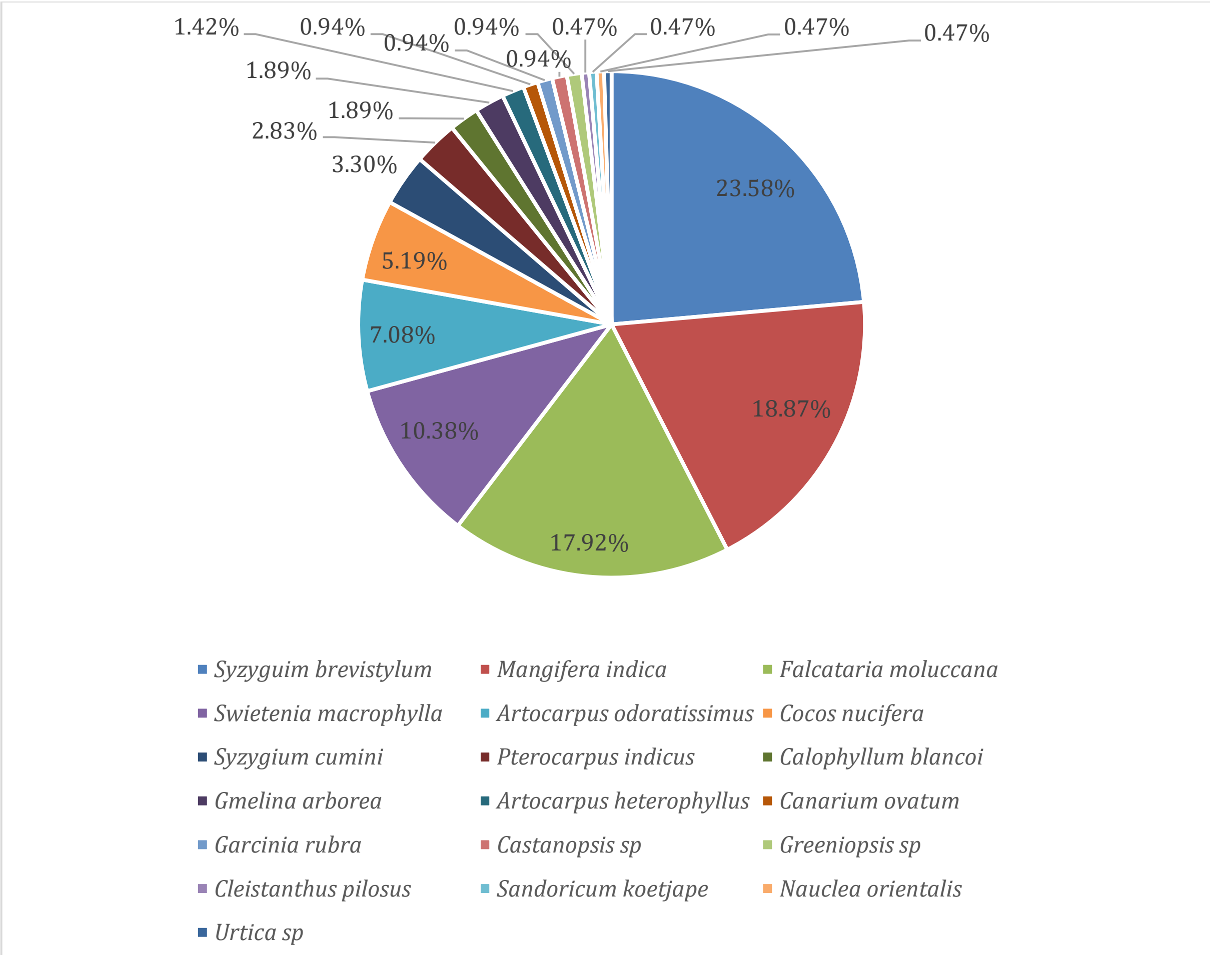


Figure 2.1-70. Site 3 Relative Abundance

Conservation Status of Flora (DAO 2017-11)

The International Union for Conservation of Nature (IUCN) lists and identifies the threatened species as a group of 3 categories: Vulnerable, Endangered and critically endangered species. The aim of the system is to provide a framework for the broadest classification of species in relation to their corresponding extinction risk.

In the Philippines the Department of Environment and Natural Resources (DENR) issued a list of threatened species of plants in the country. The species of plants listed are monitored by the DENR. The categories fall under critically endangered, endangered, vulnerable and other threatened species. The list is based on scientific and internationally accepted criteria.

Table 2.1-41. Conservation Status using IUCN Red List and DAO 2017-11

Species	IUCN	DAO 2017-11
Mangifera indica	Data Deficient	Data Deficient
Bucchanania sp	NA	Not listed
Haplostichanthus lanceolata	Not listed	Not listed
Cocos nucifera	Not listed	Not listed
Garuga floribunda decne	Not listed	Not listed
Canarium ovatum	Vulnerable	Other Threatened Species (OTS)

Species	IUCN	DAO 2017-11
Calophyllum blancoi	Not listed	Not listed
Euonymus javanicus	Least Concern	Not listed
Garcinia rubra	Not listed	Not listed
Dipterocarpus grandiflorus	Endangered	Vulnerable
Shorea sp.	NA	N/A
Shorea astylosa	Critically Endangered	Critically Endangered
Cleistanthus pilosus	Not listed	Not listed
Cynometra inaequifolia	Vulnerable	Vulnerable
Falcataria moluccana	Not listed	Not listed
Pterocarpus indicus	Endangered	Vulnerable
Castanopsis sp	NA	N/A
Lithocarpus llanosi	not listed	Endangered
Gmelina arborea	Least Concern	Not listed
Swietenia macrophylla	Vulnerable	Not listed
Sandoricum koetjape	Least Concern	Not listed
Artocarpus heterophyllus	not listed	Not listed
Artocarpus odoratissimus	Near Threatened	Not listed
Syzygium cumini	Least Concern	Not listed
Xanthostemon verdugonianus	Vulnerable	Endangered
Syzyguim brevistylum	Least Concern	Not listed
Eurya sp.	NA	Not listed
Podocarpus philippinensis	Not listed	Not listed
Nauclea orientalis	Least Concern	Not listed
Greeniopsis sp	NA	N/A
Melicope sp	NA	Not listed
Palaquium luzoniense	Vulnerable	Vulnerable
Urtica sp	NA	Not listed
Syzygium sp.	NA	N/A

The table below summarizes the conservation status of the flora species that were observed in the 2019 monitoring based on the IUCN Red List and the DAO 2017-11 Species list. Among the 34 species that were observed, 16 were listed in the IUCN Red List. Those species listed are categorized as follows: Least Concern – 6, Vulnerable – 5, Endangered – 2, and Critically Endangered – 1, Data Deficient – 1, and Near Threatened – 1.

There were 8 among the species that were observed that were also listed in the DAO 2017-11. These species are listed as follows: Vulnerable – 4, Endangered – 4, Critically Endangered – 1, and Other Threatened Species – 1

Table 2.1-42. Summary of Conservation Status of Flora Species

Conservation Status	2019
IUCN	
Not listed	10
NA	8
Least Concern	6

Conservation Status	2019
Vulnerable	5
Endangered	2
Critically Endangered	1
Data Deficient	1
Near Threatened	1
DAO 2017-11	
Not listed	22
N/A	4
Vulnerable	4
Endangered	2
Critically Endangered	1
Other Threatened Species (OTS)	1

Monitoring Comparison for Terrestrial Flora

Diversity Indices

The diversity indices for 2016 study, all of the stations have a criterion of low diversity of species in the area. The highest H-diversity present is found in station 2 which has 2.31. In addition, it has dominance of 11.82% and 17.77% of evenness. The least H-diversity is station 1 which has 2.25, however it has the highest evenness of 20.45% and dominance of 12.04%.

Table 2.1-43. Diversity Indices of Flora Species in 2016 Study

Stations	Abundance	Species	H-diversity	Dominance	Evenness	Criterion
S1	122	11	2.25	12.04%	20.45%	Low
S2	121	13	2.31	11.82%	17.77%	Low
S3	123	12	2.28	14.79%	19%	Low

In addition, the diversity indices for 2019 study has a criterion of very low to low diversity of species. The station with very low diversity is station 2 with 1.89 H-diversity, 21.37% dominance and 15.75% evenness. The highest H-diversity is present in station 1 with 2.30 and followed by station 3 with 2.24. However, station 1 has 13.47% and 15.33% of dominance and evenness, respectively. And, for station 3 it has 14.51% dominance and 11.79% evenness.

Table 2.1-44. Diversity Indices of Flora Species in 2019 Study

Stations	Abundance	Species	H-diversity	Dominance	Evenness	Criterion
S1	82	15	2.30	13.47%	15.33%	Low
S2	61	12	1.89	21.37%	15.75%	Very Low
S3	212	19	2.24	14.51%	11.79%	Low

Based on diversity indices of 2016 and 2019 study, station 3 has decrease number of species, abundance and H-diversity from 2016 study to 2019 study. However, for station 1 it has decrease the abundance and number of species, yet the H-diversity increases of 0.05 from 2016 to 2019 study. Station 2 has an additional of one species present in 2019 study however, it decreases the number of individuals which resulted to lower H-diversity of 1.89. In addition, the criterion of station 2 became very low diversity of species in year 2019 study.

Cluster Analysis

The percent of similarity for flora species in stations 3 and 2 is 25.41%. Meanwhile, station 1 has 23.86% of similarity of flora species. It can be inferred that there are areas of station 3 and station 1 has the same flora species present. However, for station 1 there are lesser similarity of flora species present.

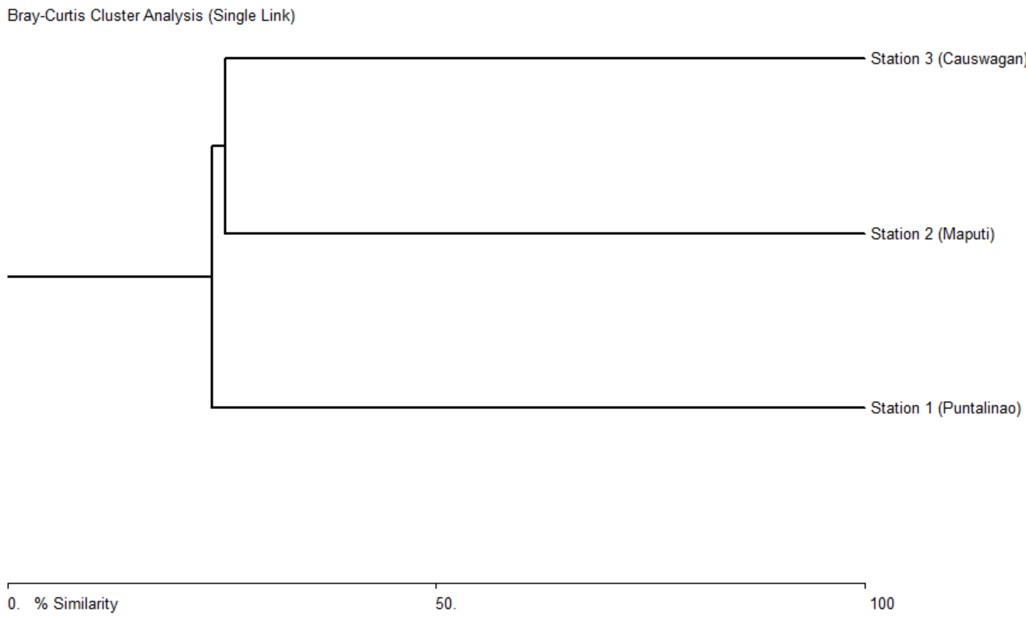


Figure 2.1-71. Cluster Analysis of Flora Species in 2016 Study

In the 2019 study, it can be inferred that there are lesser percentage of similarity present compared to the 2016 study. For station 1 and station 2 similarity of flora species, it has 19.58% while for station 3 it has 12.92% of similarity to station 2 and 1.

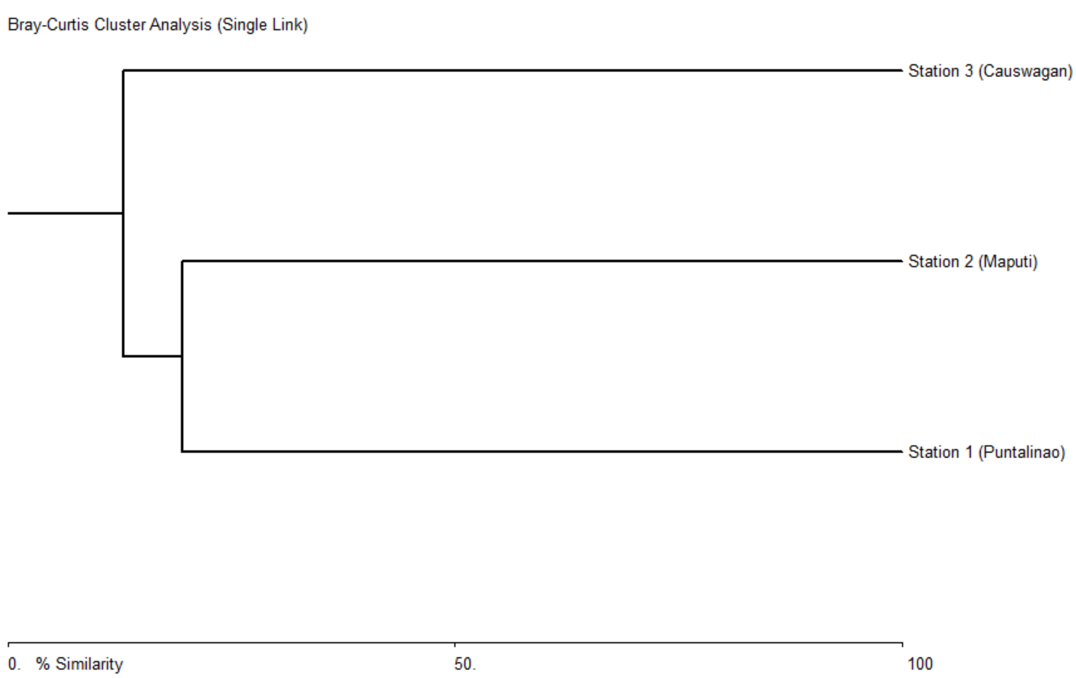


Figure 2.1-72. Cluster Analysis of Flora Species in 2019 Study

Species Richness

In the 2016 baseline study, there were a total of 25 species belonging to 14 families that were observed . Among these, the family with the richest species is Moraceae with five (5) species, followed by Myrtaceae with three (3) species. On the other hand, 34 species belonging to 21 different species were observed in the 2019 monitoring. The families with the richest species recorded in the area are Myrtaceae with four (4) species and Dipterocarpaceae and Fabaceae with three (3) species each.

There were also ten (10) species that were observed in both the 2016 baseline study and the recent monitoring. The species are Mangifera indica, Cocos nucifera, Cleistanthus pilosus, Gmelina arborea, Swietenia macrophylla, Artocarpus heterophyllus, Artocarpus odoratissimus, Syzygium cumini, Xanthostemon verdugonianus, and Syzyguim brevistylum.

The table below shows all of the species observed in the 2019 monitoring in comparison with the 2016 baseline study.

Table 2.1-45. Species Richness between 2016 and 2019 Study

Family	Species	Local Name	2016	2019
Anacardiaceae	*Mangifera indica*	Manga	/	/
Anacardiaceae	*Bucchanania sp*	Manga-manga		/
Annonaceae	*Haplostichanthus lanceolata*	Banga		/
Arecaceae	*Cocos nucifera*	Lubi	/	/
Burseraceae	*Garuga floribunda decne*	bugo		/
Burseraceae	*Canarium ovatum*	Pili-pili		/
Calophyllaceae	*Calophyllum blancoi*	Bitanghol/Yelohan		/
Celastraceae	*Euonymus javanicus*	Tabaan		/
Clusiaceae	*Garcinia rubra*	Batwan		/
Dipterocarpaceae	*Dipterocarpus grandiflorus*	Apitong		/
Dipterocarpaceae	*Shorea sp.*	Lawaan		/
Dipterocarpaceae	*Shorea astylosa*	Yakal		/
Phyllanthaceae	*Cleistanthus pilosus*	Malatabako	/	/
Fabaceae	*Cynometra inaequifolia*	Dila- Dila		/
Fabaceae	*Falcataria moluccana*	Falcata		/
Fabaceae	*Pterocarpus indicus*	Narra		/
Fagaceae	*Castanopsis sp*	Indang-Indang		/
Fagaceae	*Lithocarpus llanosi*	Ulayan		/
Lamiaceae	*Gmelina arborea*	Gmelina	/	/
Meliaceae	*Swietenia macrophylla*	Mahogany	/	/
Meliaceae	*Sandoricum koetjape*	Santol		/
Moraceae	*Artocarpus heterophyllus*	Langka	/	/
Moraceae	*Artocarpus odoratissimus*	Marang	/	/
Myrtaceae	*Syzygium cumini*	Lumboy-lumboy	/	/
Myrtaceae	*Xanthostemon verdugonianus*	Magkuno	/	/
Myrtaceae	*Syzyguim brevistylum*	Sagimsim	/	/
Pentaphylacaceae	*Eurya sp.*	Tag-lemonsito		/
Podocarpaceae	*Podocarpus philippinensis*	Malakauayan		/
Rubiaceae	*Nauclea orientalis*	Bangkal		/

Family	Species	Local Name	2016	2019
Rubiaceae	*Greeniopsis sp*	Hambabalod		/
Rutaceae	*Melicope sp*	Ansohan/Tulusan		/
Sapotaceae	*Palaquium luzoniense*	Nato		/
Urticaceae	*Urtica sp*	Alingatong		/
Myrtaceae	*Syzygium sp.*	Itoman		/
Anacardiaceae	*Semecarpus philippinensis*	Kaming	/	
Apocynaceae	*Voacanga megacarpa*	Bayag Usa	/	
Burseraceae	*Canarium asperum*	-	/	
Dipterocarpaceae	*Shorea contorta*	White Lauan	/	
Euphorbiaceae	*Macaranga tanarius*	Binunga	/	
Euphorbiaceae	*Melanolepis multiglandulosa*	Pakalkal	/	
Fabaceae	*Leucaena leucocephala*	Ipil ipil	/	
Fabaceae	*Paraserianthes falcataria*	-	/	
Lamiaceae	*Premna odorata*	Alagaw	/	
Lauraceae	*Litsea glutinosa*	Puso-puso	/	
Moraceae	*Artocarpus blancoi*	Antipolo	/	
Moraceae	*Ficus benjamina*	Balete	/	
Moraceae	*Ficus nota*	Tibig	/	
Phyllanthaceae	*Antidesma ilocanum Mer*	Buol	/	
Vitaceae	*Leea aculeata blume*	Mali-mali	/	

Presence

Among the 25 species that were observed during the 2016 baseline study, only four (4) species were present across all three sites. These species were Antidesma ilocanum Mer, Artocarpus blancoi , Mangifera indica, and Syzyguim brevistylum. Four (4) others were found in at two (2) sites, while the other 17 species were found only in one site.

The table below shows the presence of species across the sampling sites in both the 2016 and 2019 study.

Table 2.1-46. Presence of Flora Species between 2016 and 2019 across sampling sites

Species	2016			2019		
	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
Antidesma ilocanum Mer	/	/	/			
Artocarpus blancoi	/	/	/			
Artocarpus heterophyllus			/			/
Artocarpus odoratissimus	/					/
Bucchanania sp					/	
Calophyllum blancoi				/		/
Canarium asperum		/				
Canarium ovatum					/	/
Castanopsis sp						/
Cleistanthus pilosus		/	/			/
Cocos nucifera			/			/

Species	2016			2019		
	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
Cynometra inaequifolia				/		
Dipterocarpus grandiflorus				/		
Euonymus javanicus				/		
Eurya sp.					/	
Falcataria moluccana						/
Ficus benjamina	/					
Ficus nota			/			
Garcinia rubra					/	/
Garuga floribunda decne				/		
Gmelina arborea			/			/
Greeniopsis sp				/		/
Haplostichanthus lanceolata				/	/	
Leea aculeata blume		/				
Leucaena leucocephala			/			
Lithocarpus llanosi				/	/	
Litsea glutinosa	/					
Macaranga tanarius	/		/			
Mangifera indica	/	/	/			/
Melanolepis multiglandulosa		/				
Melicope sp				/		
Nauclea orientalis						/
Palaquium luzoniense				/	/	
Paraserianthes falcataria	/					
Podocarpus philippinensis				/		
Premna odorata		/				
Pterocarpus indicus						/
Sandoricum koetjape						/
Semecarpus philippinensis		/				
Shorea astylosa				/	/	
Shorea contorta	/	/				
Shorea sp.					/	
Swietenia macrophylla	/					/
Syzygium cumini		/		/	/	/
Syzygium sp.				/		
Syzyguim brevistylum	/	/	/	/	/	/
Urtica sp						/
Voacanga megacarpa	/		/			
Xanthostemon verdugonianus			/		/	

Relative Abundance

Site 1

There were a total of 12 species that were observed in Site 1 during the 2016 baseline study. Among these 12 species, 11 were actually counted during the sampling period. The most abundant flora species on site during the study was Paraserianthes falcataria with 20.49% relative abundance, followed by Mangifera indica with 16.39%, and Artocarpus odoratissimus with 12.30% abundance. Each of the other nine (9) species have less than 10% abundance.

The table below compares the abundance of species between the 2016 and 2019 study in Site 1.

Table 2.1-47. Relative Abundance of Species in Site 1 between 2016 and 2019

Species	2016	2019
Antidesma ilocanum Mer		
Artocarpus blancoi	9.84%	
Artocarpus odoratissimus	12.30%	
Calophyllum blancoi		6.10%
Cynometra inaequifolia		3.66%
Dipterocarpus grandiflorus		9.76%
Euonymus javanicus		25.61%
Ficus benjamina	6.56%	
Garuga floribunda decne		2.44%
Greeniopsis sp		1.22%
Haplostichanthus lanceolata		1.22%
Lithocarpus llanosi		17.07%
Litsea glutinosa	4.10%	
Macaranga tanarius	6.56%	
Mangifera indica	16.39%	
Melicope sp		2.44%
Palaquium luzoniense		3.66%
Paraserianthes falcataria	20.49%	
Podocarpus philippinensis		2.44%
Shorea astylosa		3.66%
Shorea contorta	9.84%	
Swietenia macrophylla	4.90%	
Syzygium cumini		3.66%
Syzygium sp.		3.66%
Syzyguim brevistylum	5.74%	13.41%
Voacanga megacarpa	3.28%	

Site 2

There were a total of 12 species that were observed in Site 2 during the 2016 baseline study. Among these 12 species, the most abundant flora species was Cleistanthus pilosus with 20.33% relative abundance, followed by Antidesma ilocanum Mer, Canarium asperum and Leea aculeata blume with a relative abundance of 16.26%, 13.01%, and 10.57%, respectively. Each of the other species are less than 10% in abundance.

The table below compares the abundance of species between the 2016 and 2019 study in Site 2.

Table 2.1-48. Relative Abundance of Species in Site 2 between 2016 and 2019

Species	*2016*	2019.00%
Antidesma ilocanum Mer	*16.26%*	
Artocarpus blancoi	*2.44%*	
Bucchanania sp		3.28%
Canarium asperum	*13.01%*	
Canarium ovatum		3.28%
Cleistanthus pilosus	*20.33%*	
Eurya sp.		1.64%
Garcinia rubra		6.56%
Haplostichanthus lanceolata		4.92%
Leea aculeata blume	*10.57%*	
Lithocarpus llanosi		8.20%
Mangifera indica	*4.88%*	
Melanolepis multiglandulosa	*5.69%*	
Palaquium luzoniense		1.64%
Premna odorata	*5.69%*	
Semecarpus philippinensis	*2.44%*	
Shorea astylosa		1.64%
Shorea contorta	*3.25%*	
Shorea sp.		1.64%
Syzygium cumini	*9.76%*	29.51%
Syzyguim brevistylum	*5.69%*	4.92%
Xanthostemon verdugonianus		32.79%

Site 3

There were 13 species that were observed in Site 3 during the baseline study in 2016. Among these species, the species with the highest relative abundance is Macaranga tanarius with 19.83%, followed by Leucaena leucocephala, Ficus nota, and Antidesma ilocanum Mer with a relative abundance of 16.53%, 14.05%, and 10.74%, respectively. Each of the other 9 species have an abundance of less than 10 percent.

The table below compares the abundance of species between the 2016 and 2019 study in Site 3.

Table 2.1-49. Relative Abundance of Species in Site 3 between 2016 and 2019

Species	2016	2019
Antidesma ilocanum Mer	10.74%	
Artocarpus blancoi	1.65%	
Artocarpus heterophyllus	2.48%	1.42%
Artocarpus odoratissimus		7.08%

Species	2016	2019
Calophyllum blancoi		1.89%
Canarium ovatum		0.94%
Castanopsis sp		0.94%
Cleistanthus pilosus	2.48%	0.47%
Cocos nucifera	2.48%	5.19%
Falcataria moluccana		17.92%
Ficus nota	14.05%	
Garcinia rubra		0.94%
Gmelina arborea	6.61%	1.89%
Greeniopsis sp		0.94%
Leucaena leucocephala	16.53%	
Macaranga tanarius	19.83%	
Mangifera indica	6.61%	18.87%
Nauclea orientalis		0.47%
Pterocarpus indicus		2.83%
Sandoricum koetjape		0.47%
Swietenia macrophylla		10.38%
Syzygium cumini		3.30%
Syzyguim brevistylum	5.79%	23.58%
Urtica sp		0.47%
Voacanga megacarpa	6.61%	
Xanthostemon verdugonianus	4.13%	

Conservation Status

Among the 25 species that were observed in the 2016 baseline study, only 14 were listed in the IUCN Red list. These 14 species were listed as follows: Critically Endangered – 1, Data Deficient – 1, Least Concern – 8, Near Threatened – 1, and Vulnerable – 3. On the other hand, there were 16 species observed in the 2019 monitoring that appears on the same list and were categorized as follows: Critically Endangered – 1, Data Deficient – 1, Endangered – 2, Least Concern – 6, Near Threatened – 1, and Vulnerable – 5.

In the DAO 2017-11, there were also two (2) species listed among the species identified in the 2016 baseline study. The species were categorized as follows: Endangered – 1, Vulnerable – 1. However, eight (8) of the species that were observed in the 2019 monitoring. The species were categorized as follows: Critically Endangered – 1, Endangered – 2, Other Threatened Species (OTS) – 1, and Vulnerable – 4.

The table below summarizes the conservation status of all the flora species that were observed in both the 2016 baseline study and the 2019 monitoring:

Table 2.1-50. Summary of Conservation Status of Flora Species between 2016 and 2019

Conservation Status	2016	2019
IUCN		
Critically Endangered	1	1
Data Deficient	1	1

Conservation Status	2016	2019
Endangered	0	2
Least Concern	8	6
NA	0	8
Near Threatened	1	1
Not listed	11	10
Vulnerable	3	5
DAO 2017-11		
Critically Endangered	0	1
Endangered	1	2
N/A	0	4
Not listed	23	22
Other Threatened Species (OTS)	0	1
Vulnerable	1	4

Economic Importance

The following are the economic importance of the species observed in the area:

Table 2.1-51. Economic Importance of Species

Scientific Name	Economic Importance
Mangifera indica	food, wood and medicine
Bucchanania sp	Medicine
Haplostichanthus lanceolata	wood
Cocos nucifera	food, wood and medicine
Garuga floribunda decne	Food, wood and medicine
Canarium ovatum	food, wood and medicine
Calophyllum blancoi	medicine
Euonymus javanicus	food, wood and medicine
Garcinia rubra	food
Dipterocarpus grandiflorus	wood
Shorea sp.	wood
Shorea astylosa	wood
Cleistantus pilosus	wood
Cynometra inaequifolia	wood
Falcataria moluccana	wood and medicine
Pterocarpus indicus	food, wood and medicine
Castanopsis sp	wood
Lithocarpus llanosi	wood
Gmelina arborea	food, wood and medicine
Swietenia macrophylla	wood and medicine
Sandoricum koetjape	wood
Artocarpus heterophyllus	wood, food and medicine
Artocarpus odoratissimus	food, wood and medicine
Syzygium sp.	wood and medicine
Syzygium cumini	food, wood and medicine
Xanthostemon verdugonianus	wood
Syzyguim brevistylum	food, wood and medicine
Eurya sp.	wood and medicine
Podocarpus philippinensis	wood
Nauclea orientalis	food, wood and medicine

Scientific Name	Economic Importance
Greeniopsis sp	ornamental
Melicope sp	medicine
Palaquium luzoniense	wood
Urtica sp	medicine

2.1.4.2.2.3 Terrestrial Fauna

Avifauna

There are about 600 bird species, or 6% of the world's avifauna, which are found in the Philippines. Since the country has a wide range of habitats such as tropical forests, mangrove areas, peat swamp forests and montane forests it supports a huge diversity of birds that results to high endemism.

In this assessment a total of 36 species of birds were identified in all the sampling stations. It was observed that all avian species present in the area are categorized as "least concern" in reference to the IUCN Red List which means that the observed species are very common species and their population is stable. There were 11 species that were identified to be endemic in the Philippines: *Phapitreron brevirostris, Bolbopsittacus Lunolatus, Centropus viridis, Harpactes ardens, Hypsipetes philippinus, Poliolophus urostictus, Sitta oenochlamys, Macronus striaticeps, Pachycephala philippinensis, Dicaeum australe, Dicaeum pygmaeum.* There were also two (2) Migratory species: *Merops philippinus* and *Lanius cristatus.* All other species that were observed in the area are Resident species.

The most abundant species identified in the area was the Philippine bulbul (*Hypsipetes philippinus*) with 291 individuals. This species is very adaptable to human habitation and could they could exist in those types of disturbed habitat.
Species Richness

In the 2019 study, there were thirty-six (36) species observed in all three (3) sampling sites (Barangay Puntalinao, Barangay Maputi, Barangay Causwagan) which were classified under twenty-two (22) families. The families with with the highest species richness observed in the sites are Family Columbidae, Pycnonotidae, and Musicapidae.

There were 11 species that were common between the both the 2016 and 2019 studys namely: *Geopelia striata, Chalcopaps indica, Merops philippinus, Hypsipetes philippinus, Pycnonotus goiavier, Corvus macrorhynchos, Pachycephala philippinensis, Lanius cristatus, Sarcops calvus, Cinnyris jugularis, Lonchura atricapilla.* On the other hand, there were 25 species of birds that were observed in the 2019 study which were not observed in the baseline.

Table 2.1-52. Composition and Comparison of Species Present in the 1st Season (2016) and 2nd Season (2019) Assessment

Family	Scientific Names	Common Names	2016	2019
Accipitridae	*Haliastur indus*	Brahminy Kite		/
	Spilornis cheela	Crested Serpent-eagle	/	
Columbidae	*Phapitreron brevirostris*	Short-billed Brown Dove		/
	Geopelia striata	Zebra Dove	/	/
	Spilopelia chinensis	Spotted Dove		/
	Streptopelia chinensis	Eastern Spotted Dove	/	
	Chalcopaps indica	Grey-capped Emerald Dove	/	/

Family	Scientific Names	Common Names	2016	2019
	Macropygia tenuirostris	Philippine Cuckoo Dove		/
Psittacidae	*Bolbopsittacus Lunolatus*	Guaiabero		/
Cuculidae	*Centropus viridis*	Philippine Coucal		/
	Centropus bengalensis	Lesser Coucal	/	
Trogonodae	*Harpactes ardens*	Philippine Trogon		/
Apodidae	*Collocalia esculenta*	Glossy Swiftlet		/
	Collocalia vanikorensis	Island Swiftlet		/
Alcidinidae	*Todiramphus chloris*	Collared Kingfisher		/
	Alcedo atthis	Common Kingfisher	/	
	Halcyon smyrnensis	White Throated Kingfisher	/	
Meropidae	*Merops philippinus*	Blue-tailed Bee-eater	/	/
Megalaimidae	*Psilopogon haemacephalus*	Coppersmith Barbet		/
Phylloscopidae	*Phylloscopus borealis*	Arctic Warbler	/	
Pycnonotidae	*Hypsipetes philippinus*	Philippine Bulbul	/	/
	Pycnonotus goiavier	Yellow-vented Bulbul	/	/
	Poliolophus urostictus	Yellow-wattled Bulbul		/
Corvidae	*Corvus macrorhynchos*	Large-billed Crow	/	/
Campephagidae	*Coracina striata*	Bar-bellied Cuckoshrike	/	
Paridae	*Pardaliparus elegans*	Elegant Tit		/
Sittidae	*Sitta oenochlamys*	Sulphur-billed Nuthatch		/
Timaliidae	*Macronus striaticeps*	Brown Tit-babbler		/
Sylvidae	*Cincloramphus timoriensis*	Tawny Grassbird		/
Motacillidae	*Motacilla cinerea*	Gray Wagtail	/	
	Motacilla flava	Western Yellow Wagtail	/	
Musicapidae	*Rhipidura javanica*	Pied Fantail		/
	Cyornis rufigastra	Mangrove Blue-flycatcher		/
	Pachycephala philippinensis	Yellow-bellied Whistler	/	/
	Culicicapa helianthea	Citrine Canary Flycatcher		/
	Saxicola caprata	Pied Bushcat	/	
Laniidae	*Lanius cristatus*	Brown Shrike	/	/
	Lanius schach	Long-tailed Shrike	/	
	Lanius validirostris	Mountain Shrike	/	
Locustellidae	*Megalurus palustris*	Striated Grass Bird	/	
Sturnidae	*Aplonis panayensis*	Asian Glossy Starling		/

Family	Scientific Names	Common Names	2016	2019
	Sarcops calvus	Coleto	/	/
Strigidae	*Otus mirus*	Mindanao Highland Scops-owl	/	
Nectariniidae	*Cinnyris jugularis*	Olive-backed Sunbird	/	/
	Anthreptes malacensis	Brown-throated Sunbird		/
Dicaeidae	*Dicaeum australe*	Red-kelled Flowerpecker		/
	Dicaeum pygmaeum	Pygmy Flowerpecker		/
Estrildidae	*Lonchura punctulata*	Scaly-breasted Munia		/
	Lonchura atricapilla	Chestnut Munia	/	/
Rhipiduridae	*Rhipidura cyaniceps*	Blue-headed Fantail	/	
Zosteropidae	*Zosterops montanus*	Mountain white-eye		/

The following are some of the birds observed in all three (3) sampling sites in the 2019 monitoring:

Photo 2.1-20. *Haliastur indus* (Brahminy Kite)

Photo 2.1-21. *Phapitreron brevirostris* (Short-billed Brown-Dove)

Photo 2.1-22. *Geopelia striata* (Zebra Dove)

Photo 2.1-23. *Spilopelia chinensis* (Spotted Dove)

Photo 2.1-24. *Chalcopaps indica* (Grey-capped Emerald Dove)

Photo 2.1-25. *Macropygia tenuirostris* (Philippine Cuckoo Dove)

Photo 2.1-26. *Bolbopsittacus Lunolatus* (Guaiabero)

Photo 2.1-27. *Centropus viridis* (Philippine Coucal)

Photo 2.1-28. *Harpactes ardens* (Philippine Trogon)

Photo 2.1-29. *Collocalia esculenta* (Glossy Swiftlet)

Photo 2.1-30. *Collocalia vanikorensis* (Island Swiftlet)

Photo 2.1-31. *Collocalia troglodytes* (Pygmy Swiftlet)

Photo 2.1-32. *Halcyon gularis*
(Collared Kingfisher)

Photo 2.1-33. *Merops philippinus*
(Blue-tailed Bee-eater)

Photo 2.1-34. *Psilopogon haemacephalus*
(Coppersmith Barbet)

Photo 2.1-35. *Hypsipetes philippinus*
(Philippine Bulbul)

Photo 2.1-36. *Pycnonotus goiavier*
(Yellow-vented Bulbul)

Photo 2.1-37. *Poliolophus urostictus*
(Yellow-wattled Bulbul)

Photo 2.1-38. *Corvus macrorhynchos* (Large-billed Crow)

Photo 2.1-39. *Parrus elegans* (Elegant Tit)

Photo 2.1-40. *Sitta oenochlamys* (Sulphur Bellied Nuthatch)

Photo 2.1-41. *Macronus striaticeps* (Brown Tit Babbler)

Photo 2.1-42. Cincloramphus timoriensis (Tawny Grassbird)

Photo 2.1-43. *Rhipidura javanica* (Pied Fantail)

Photo 2.1-44. *Cyornis rufigastra* (Mangrove Blue Flycatcher)

Photo 2.1-45. *Lanius cristatus* (Brown Shrike)

Photo 2.1-46. *Aplonis panayensis* (Asian Glossy Starling)

Photo 2.1-47. *Cinnyris jugularis* (Olive-backed Sunbird)

Photo 2.1-48. *Anthreptes malacensis* (Brown-throated Sunbird)

Photo 2.1-49. *Dicaeum austral* (Red-kelled Flowerpecker)

Photo 2.1-50. ***Dicaeum pygmaeum***
(Pygmy Flowerpecker)

Photo 2.1-51. ***Lonchura punctulate***
(Scaly-breasted Munia)

Photo 2.1-52. ***Lonchura atricapilla***
(Chestnut Munia)

Photo 2.1-53. ***Zosterops montanus***
(Mountain white-eye)

Presence

The table below shows the presence of bird species in the different sampling sites.

The species common in all sites are *Phapitreron brevirostris, Hypsipetes philippinus, Macronus striaticeps, Dicaeum australe, and Anthreptes malacensis.*

Table 2.1-53. Presence of AviFauna Species in 2nd Season Sampling (2019)

Scientific Names	Common Names	Puntalinao	Maputi	Causwagan
Haliastur indus	Brahminy Kite		x	
Phapitreron brevirostris	Short-billed Brown Dove	x	x	x
Geopelia striata	Zebra Dove			x
Spilopelia chinensis	Spotted Dove			x
Chalcopaps indica	Grey-capped Emerald Dove	x	x	x
Macropygia tenuirostris	Philippine Cuckoo Dove			x
Bolbopsittacus Lunolatus	Guaiabero	x		x
Centropus viridis	Philippine Coucal	x	x	
Harpactes ardens	Philippine Trogon	x		
Collocalia esculenta	Glossy Swiftlet			x
Collocalia vanikorensis	Island Swiftlet		x	x
Todiramphus chloris	Collared Kingfisher		x	
Merops philippinus	Blue-tailed Bee-eater		x	x
Psilopogon haemacephalus	Coppersmith Barbet			x
Hypsipetes philippinus	Philippine Bulbul	x	x	x
Pycnonotus goiavier	Yellow-vented Bulbul			x
Poliolophus urostictus	Yellow-wattled Bulbul	x	x	
Corvus macrorhynchos	Large-billed Crow			x
Pardaliparus elegans	Elegant Tit	x		
Sitta oenochlamys	Sulphur-billed Nuthatch	x		
Macronus striaticeps	Brown Tit-babbler	x	x	x
Cincloramphus timoriensis	Tawny Grassbird			x
Rhipidura javanica	Pied Fantail			x
Cyornis rufigastra	Mangrove Blue-flycatcher		x	
Pachycephala philippinensis	Yellow-bellied Whistler	x	x	
Culicicapa helianthea	Citrine Canary Flycatcher	x	x	
Lanius cristatus	Brown Shrike		x	x
Sarcops calvus	Coleto		x	
Aplonis panayensis	Asian Glossy Starling	x		x
Cinnyris jugularis	Olive-backed Sunbird		x	x
Anthreptes malacensis	Brown-throated Sunbird	x	x	x
Dicaeum australe	Red-kelled Flowerpecker	x	x	x

Scientific Names	Common Names	Puntalinao	Maputi	Causwagan
Dicaeum pygmaeum	Pygmy Flowerpecker			x
Lonchura punctulata	Scaly-breasted Munia		x	x
Lonchura atricapilla	Chestnut Munia			x
Zosterops montanus	Mountain white-eye	x		

Relative Abundance

Site 1 – Puntalinao

There were sixteen (16) species were observed and identified in the 2019 monitoring in Barangay Puntalinao. These species were classified under 13 families namely, Columbidae, Psittacidae, Cuculidae, Dicaeidae, Trogonidae, Pycnonotidae, Paridae, Sittidae, Timaliidae, Musicapidae, Sturnidae, Nectariniidae and Zosteropidae. The species with the highest relative abundance is *Hypsipetes philippinus* which is 40.09% among all species, followed by *Aplonis panayensis* and *Zozterops montanus* with 15.42% and 10.57% relative values, respectively.

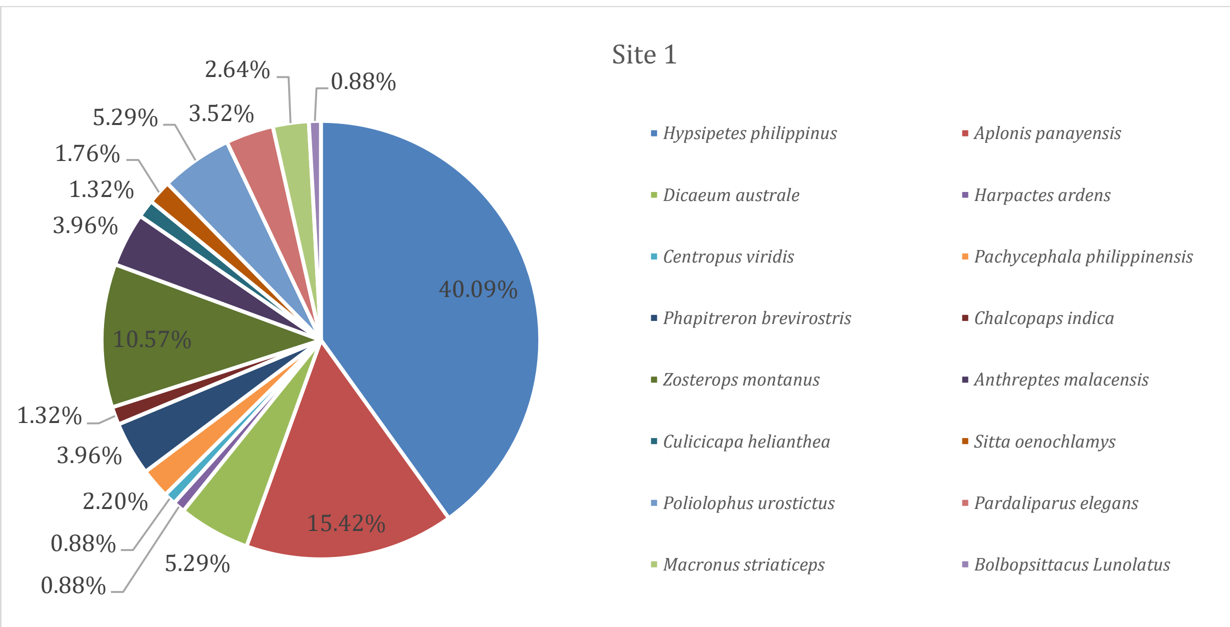


Figure 2.1-73. Site 1 Species Abundance in 2nd Season Sampling

The chart below **(Figure 2.1-69)** compares the abundance of species that were observed in the 2016 baseline study and the 2019 monitoring. *Hypsipetes philippinus* is the only species that was commonly observed between the two (2) studies. The other ten (10) species found on 2016 study that were not present on the latest study are *Alcedo atthis, Centropus bengalensis, Coracina striata, Geopelia striata, Lanius validirostris, Merops philippinus, Nectarina jugularis, Pycnonotus goiaver, Rhipidura cyaniceps,* and *Spilornis cheela.*

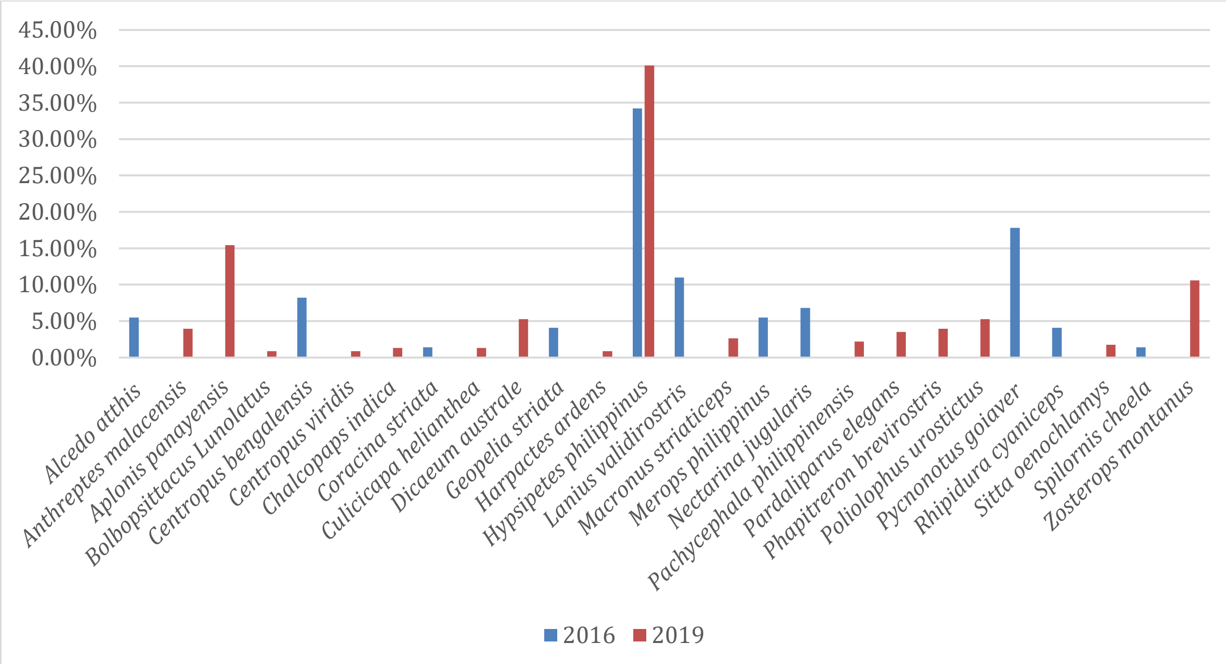


Figure 2.1-69. Site 1 – 1st Season (2016) and 2nd Season (2019) Sampling Species Abundance Comparison

Site 2 – Maputi

In Barangay Maputi, there were nineteen (19) species identified which are classified under 14 families, namely, Accipitridae, Alcidinidae, Apodidae, Columbidae, Cuculidae, Dicaeidae, Estrildidae, Laniidae, Meropidae, Musicapidae, Nectariniidae, Pycnonotidae, Sturnidae, and Timaliidae.

The species with the highest relative abundance is *Hypsipetes philippnus* with 49.78%, followed by *Dicaeum australe* and *Cinnyris jugularis* with the values of 16.01% and 8.23%, respectively.

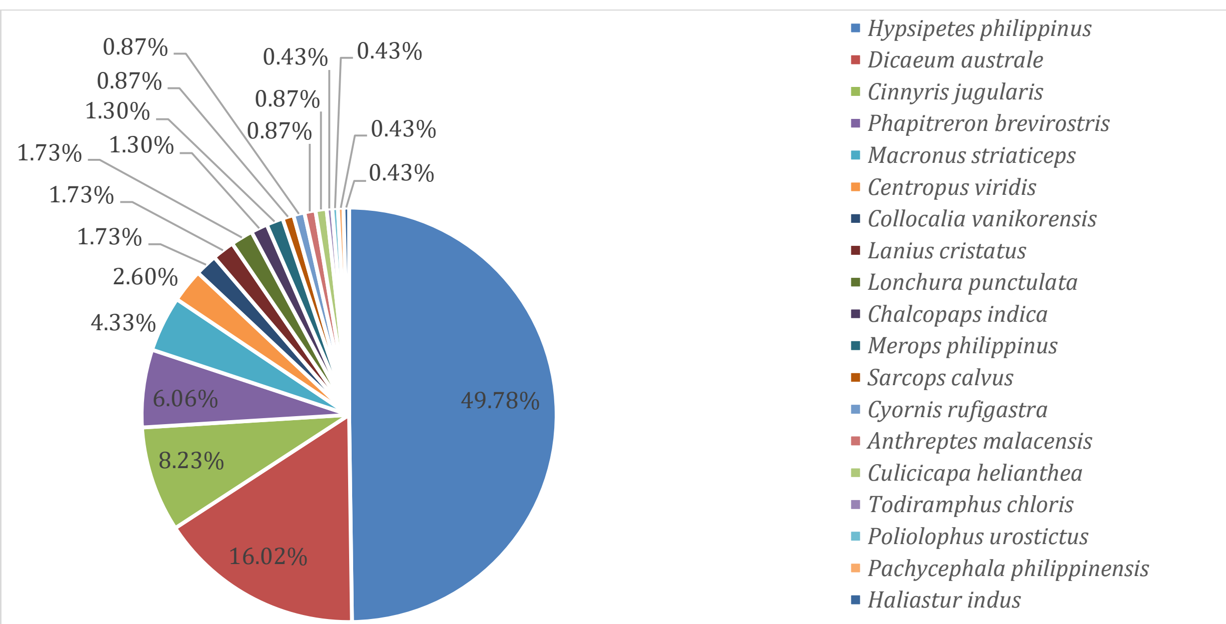


Figure 2.1-74. Site 2 Species Abundance in 2nd Season Sampling

The chart below compares the abundance of species that were observed in the 2016 baseline study and the 2019 monitoring. Based on the baseline report (2016), station 2 was dominated with *Cinnyris jugularis* with the highest relative abundance of 21.21%. Then followed by *Lanius cristatus* and *Geopelia striata* which had 18.18% and 15.15% relative values, respectively. There are three species that were commonly observed in 2019, namely, *Chalcophaps indica* (3.03%), *Cinnyris jugularis* (21.21%) and *Lanius cristatus* (18.18%); however, the *relative* abundance values were decreasing.

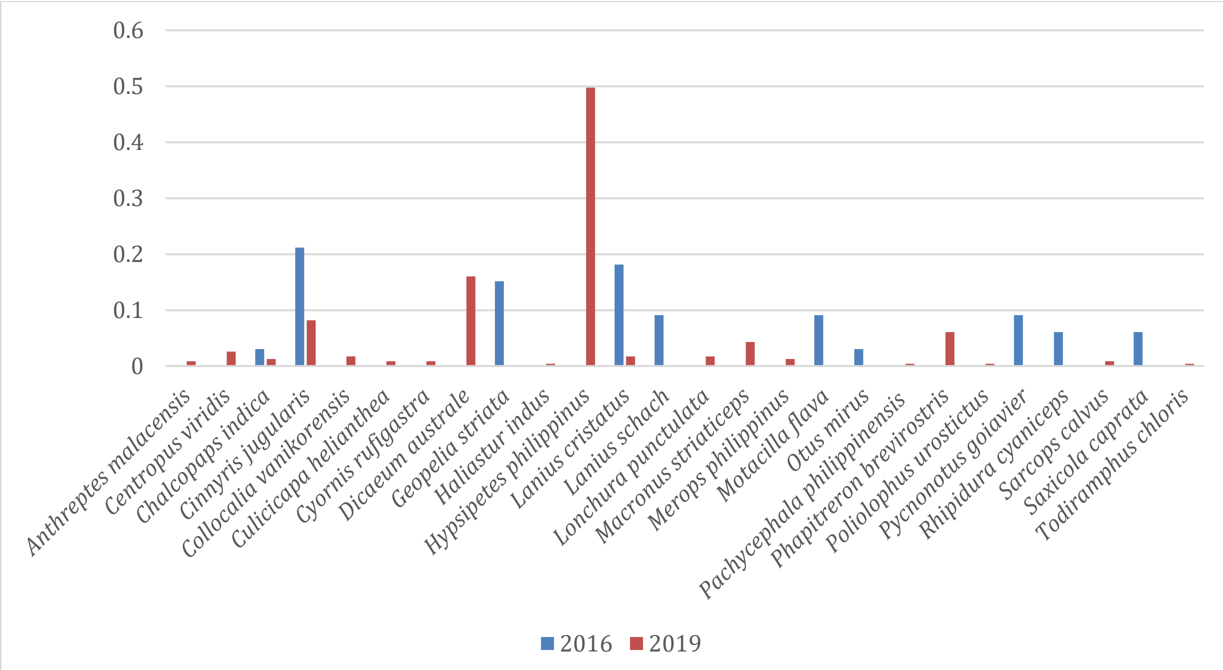


Figure 2.1-75. Site 2 – 1st Season (2016) and 2nd Season (2019) Sampling Species Abundance Comparison

Site 3 – Causwagan

There were 24 species observed in Barangay Causwagan. These species were classified under fifteen (15) families: Apodidae, Columbidae, Corvidae, Dicaeidae, Estrildidae, Laniidae, Megalaimidae, Meropidae, Musicapidae, Nectariniidae, Psittacidae, Pycnonotidae, Sturnidae, Sylvidae, Timaliidae. Species with the highest relative abundance is *Hypsipetes philippinus* with 22.97%. It is followed by *Pycnonotus goiavier* with 22.16%. Both species belong to the family Pycnonotidae.

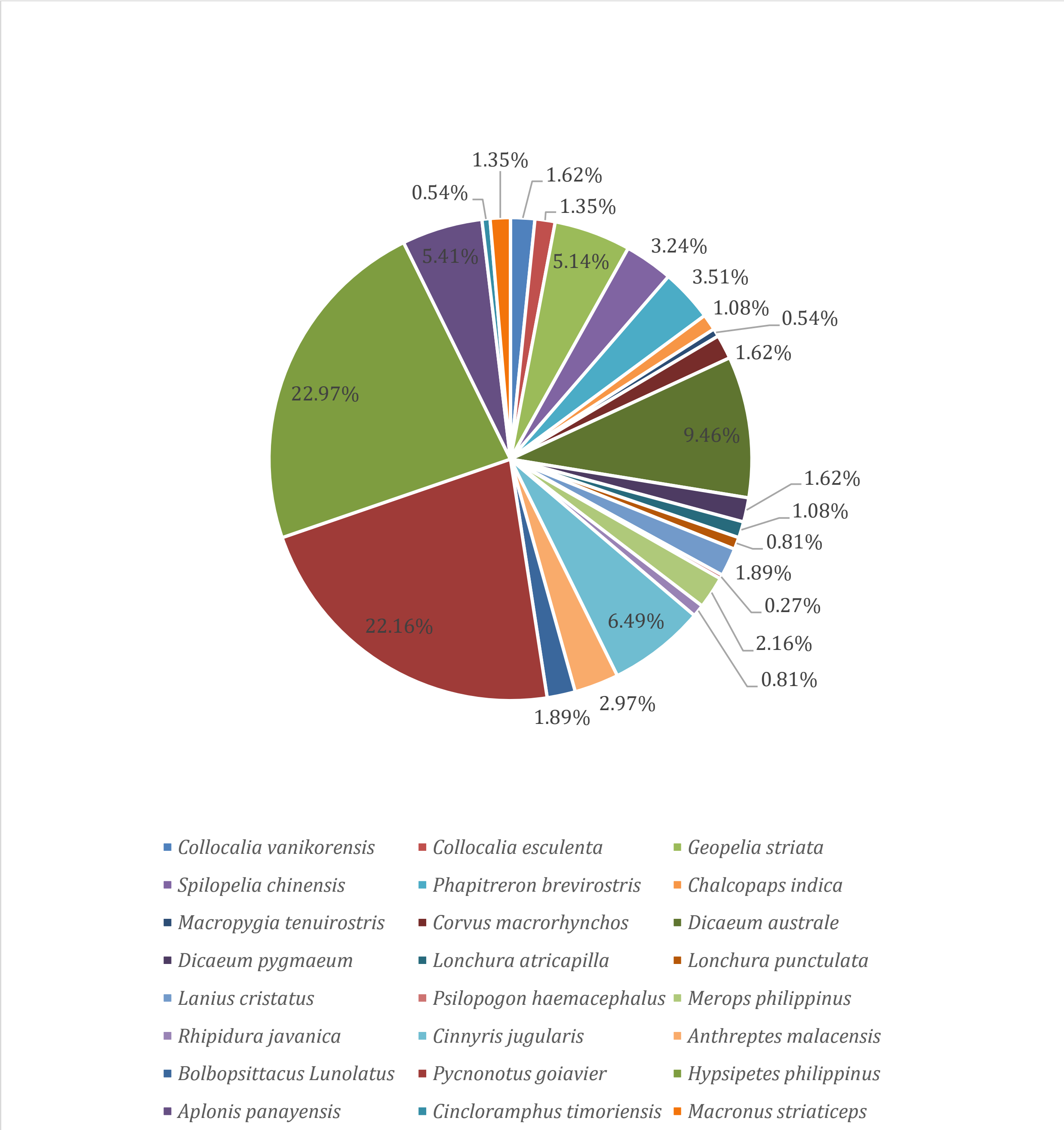


Figure 2.1-76. Site 3 Species Abundance in 2nd Season Sampling

The chart below compares the abundance of species that were observed in the 2016 baseline study and the 2019 monitoring. Based on the baseline study (2016), in site 3 (Barangay Causwagan) *Pycnonotus goiavier* and *Hypsipetes philippinus* had the highest relative abundance among all species observed, with relative abundance of 14.13% and 10.87%, respectively. As observed in the 2019 study, the abundance of these species has increased.

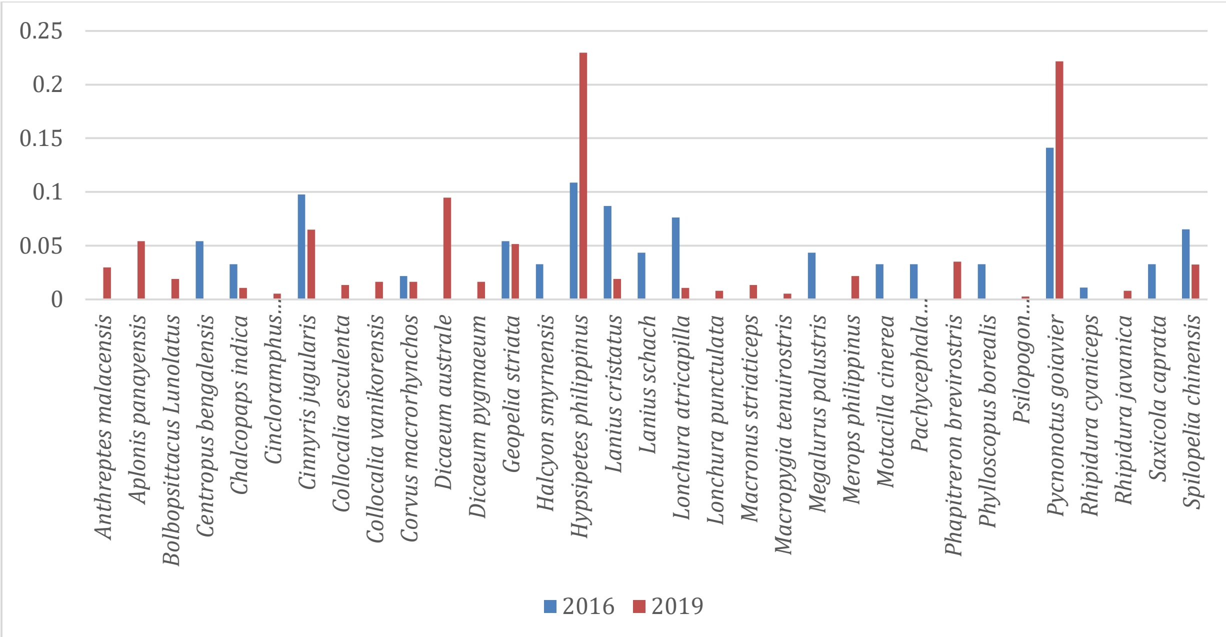


Figure 2.1-77. Site 3 – 1st Season (2016) and 2nd Season (2019) Sampling Species Abundance Comparison

Species Diversity (Diversity Indices)

In addition to the latest report (2019), the abundance of species indicates the wide distribution across the globe. Station 3 which is situated in Barangay Causwagan has the highest number of species among all the assessed stations. It has a dominance of 12.9% and evenness of 9.96%. Stations 1 and 2 has a dominance of 20.77% and 28.81%, respectively. Its quantitative values of diversity were classified to "low" and "very low" indices.

Table 2.1-54. Species Diversity of Avifauna

Stations	Abundance	Species	H-diversity	Dominance	Evenness	Criterion
S1	227	16	2.07	20.77	12.94	Low
S2	231	19	1.83	28.81	9.63	Very Low
S3	366	25	2.49	12.9	9.96	Low

Based on diversity indices in 2016 and 2019 study, the abundance and number of species increases in year 2019. The H-diversity of station 2 and 3 has decreases which resulted to criterion of low to very low and moderate to low for stations 2 and 3, respectively. However, the H-diversity of station 1 has increases 0.07 from 2016 to 2019 study which belongs to the criterion of low diversity.

Cluster Analysis

Bray-Curtis Cluster analysis is an analysis which measures the similarity of group of subjects. For 2016 study, stations 1, 2 and 3 has 44.8% similarity of each other.

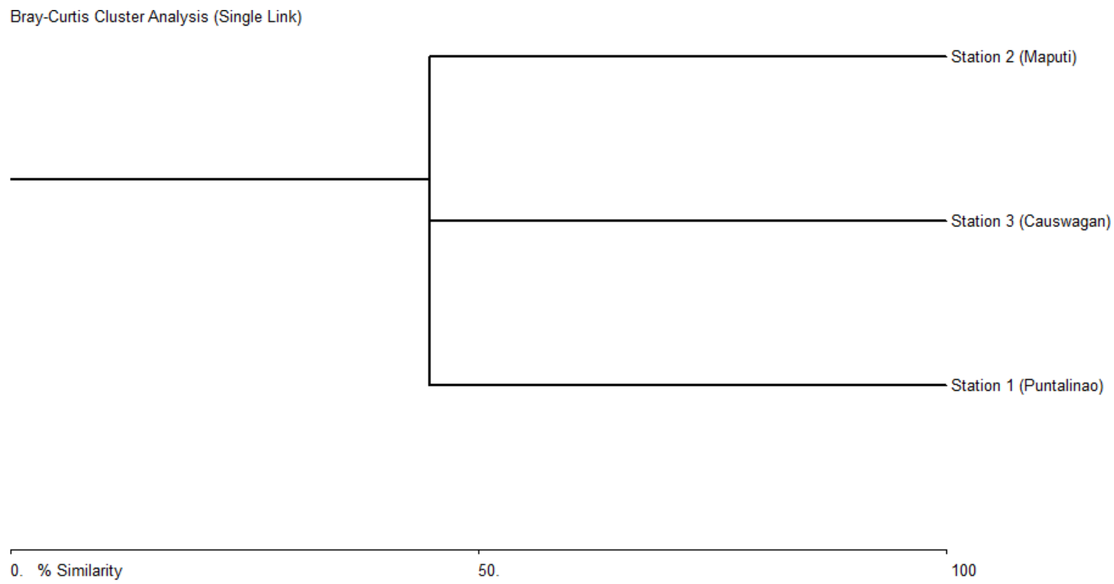


Figure 2.1-78. Cluster Analysis of Avifauna in 2016 study

Meanwhile, in the 2019 study stations 2 and 3 has 59.02% of similarity avifauna species present. Whereas, station 1 has 56.83% of similarity of avifauna species present to stations 2 and 3.

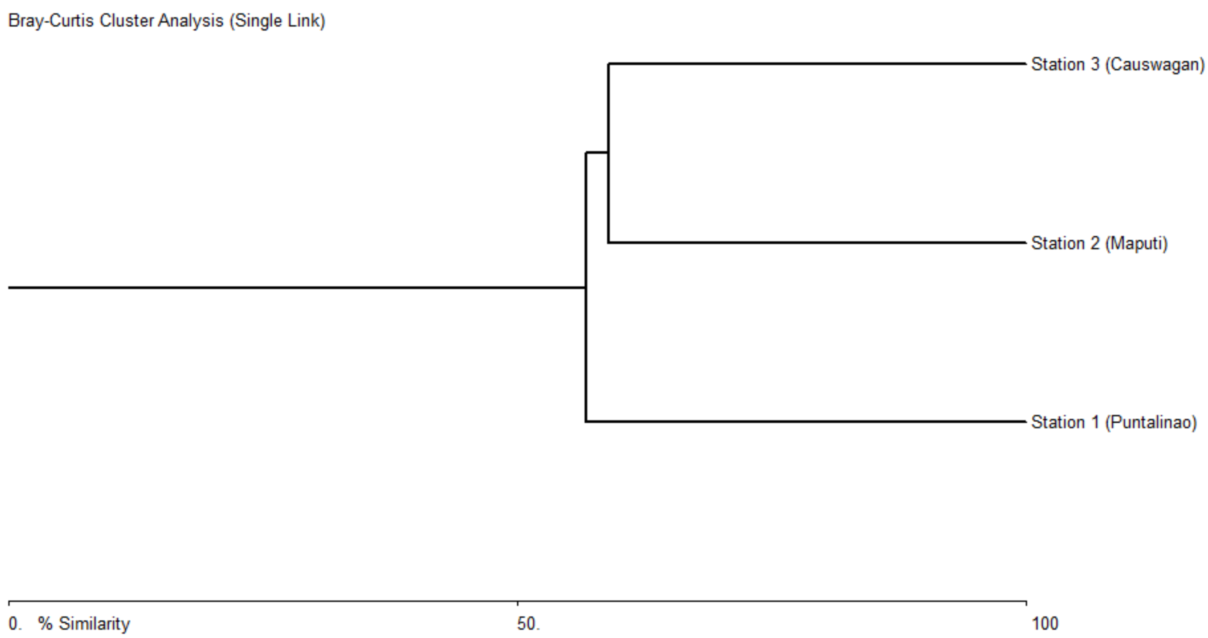


Figure 2.1-79. Cluster Analysis of Avifauna in 2019 Study

Distribution

Among the thirty-six (36) species found in three sampling stations, there are twenty-three 23 species considered as residents, eleven (11) species are endemic and two (2) species are migratory. The Migratory species are *Merops philippinus* and *Lanius cristatus.*

Table 2.1-55. Distribution of AviFauna Species

Family	Scientific Names	Common Names	Distribution
Accipitridae	*Haliastur indus*	Brahminy Kite	Resident
Columbidae	*Phapitreron brevirostris*	Short-billed Brown Dove	Endemic
Columbidae	*Geopelia striata*	Zebra Dove	Resident
Columbidae	*Spilopelia chinensis*	Spotted Dove	Resident
Columbidae	*Chalcopaps indica*	Grey-capped Emerald Dove	Resident
Columbidae	*Macropygia tenuirostris*	Philippine Cuckoo Dove	Resident
Psittacidae	*Bolbopsittacus Lunolatus*	Guaiabero	Endemic
Cuculidae	*Centropus viridis*	Philippine Coucal	Endemic
Trogonodae	*Harpactes ardens*	Philippine Trogon	Endemic
Apodidae	*Collocalia esculenta*	Glossy Swiftlet	Resident
Apodidae	*Collocalia vanikorensis*	Island Swiftlet	Resident
Alcidinidae	*Todiramphus chloris*	Collared Kingfisher	Resident
Meropidae	*Merops philippinus*	Blue-tailed Bee-eater	Migratory
Megalaimidae	*Psilopogon haemacephalus*	Coppersmith Barbet	Resident
Pycnonotidae	*Hypsipetes philippinus*	Philippine Bulbul	Endemic
Pycnonotidae	*Pycnonotus goiavier*	Yellow-vented Bulbul	Resident
Pycnonotidae	*Poliolophus urostictus*	Yellow-wattled Bulbul	Endemic
Corvidae	*Corvus macrorhynchos*	Large-billed Crow	Resident
Paridae	*Pardaliparus elegans*	Elegant Tit	Resident
Sittidae	*Sitta oenochlamys*	Sulphur-billed Nuthatch	Endemic
Timaliidae	*Macronus striaticeps*	Brown Tit-babbler	Endemic
Sylvidae	*Cincloramphus timoriensis*	Tawny Grassbird	Resident
Musicapidae	*Rhipidura javanica*	Pied Fantail	Resident
Musicapidae	*Cyornis rufigastra*	Mangrove Blue-flycatcher	Resident
Musicapidae	*Pachycephala philippinensis*	Yellow-bellied Whistler	Endemic
Musicapidae	*Culicicapa helianthea*	Citrine Canary Flycatcher	Resident
Laniidae	*Lanius cristatus*	Brown Shrike	Migratory
Sturnidae	*Sarcops calvus*	Coleto	Resident
Sturnidae	*Aplonis panayensis*	Asian Glossy Starling	Resident
Nectariniidae	*Cinnyris jugularis*	Olive-backed Sunbird	Resident
Nectariniidae	*Anthreptes malacensis*	Brown-throated Sunbird	Resident
Dicaeidae	*Dicaeum australe*	Red-kelled Flowerpecker	Endemic
Dicaeidae	*Dicaeum pygmaeum*	Pygmy Flowerpecker	Endemic

Family	Scientific Names	Common Names	Distribution
Estrildidae	*Lonchura punctulata*	Scaly-breasted Munia	Resident
Estrildidae	*Lonchura atricapilla*	Chestnut Munia	Resident
Zosteropidae	*Zosterops montanus*	Mountain white-eye	Resident

Figure below compares Distribution of species observed in the 2016 baseline study and the 2019 monitoring.

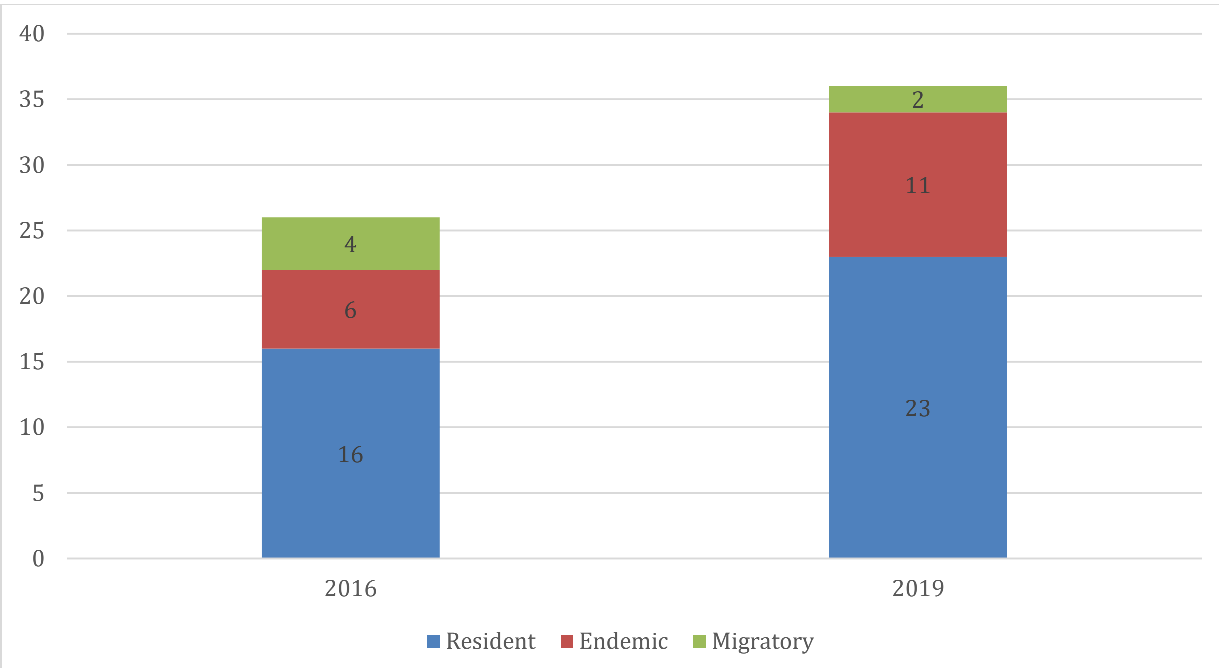


Figure 2.1-80. Dry (2016) and Wet Season Sampling (2019) Comparison of Avifauna Distribution

Conservation Status

The list of categories and criteria of IUCN are intended to be an easily and widely understood system for classifying species at high risk of global extinction. The general aim of the system is to provide an explicit, objective framework for the classification of the broadest range of species according to their extinction risk. However, while the Red List may focus attention on those taxa at the highest risk, it is not the sole means of setting priorities for conservation measures for their protection. Below are definition of conservation status and or criteria.

Table 2.1-56. Definition of Conservation Status and/or Categories

Conservation Status / Categories	International Union for the Conservation of Nature (IUCN)
EXTINCT (EX)	A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon’s life cycle and life form.

Conservation Status / Categories	International Union for the Conservation of Nature (IUCN)
EXTINCT IN THE WILD (EW)	A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
CRITICALLY ENDANGERED (CR)	A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered (see Section V), and it is therefore considered to be facing an extremely high risk of extinction in the wild.
ENDANGERED (EN)	A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered (see Section V), and it is therefore considered to be facing a very high risk of extinction in the wild
VULNERABLE (VU)	A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable (see Section V), and it is therefore considered to be facing a high risk of extinction in the wild.
NEAR THREATENED (NT)	A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.
LEAST CONCERN (LC)	A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category
DATA DEFICIENT (DD)	A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.
NOT EVALUATED (NE)	A taxon is Not Evaluated when it has not yet been evaluated against the criteria.

The table below shows the conservation status of the different bird species identified and recorded within the area. All of the 36 bird species are listed under "Least Concern" category indicating that ~~.~~ the~~Bird~~ species that were observed were common and populations are widespread.

Table 2.1-57. Conservation Status of the Species Present in the Wet Season Sampling

Family	Scientific Names	Common Names	IUCN Status
Accipitridae	*Haliastur indus*	Brahminy Kite	Least Concern

Family	Scientific Names	Common Names	IUCN Status
Columbidae	*Phapitreron brevirostris*	Short-billed Brown Dove	Least Concern
Columbidae	*Geopelia striata*	Zebra Dove	Least Concern
Columbidae	*Spilopelia chinensis*	Spotted Dove	Least Concern
Columbidae	*Chalcopaps indica*	Grey-capped Emerald Dove	Least Concern
Columbidae	*Macropygia tenuirostris*	Philippine Cuckoo Dove	Least Concern
Psittacidae	*Bolbopsittacus Lunolatus*	Guaiabero	Least Concern
Cuculidae	*Centropus viridis*	Philippine Coucal	Least Concern
Trogonodae	*Harpactes ardens*	Philippine Trogon	Least Concern
Apodidae	*Collocalia esculenta*	Glossy Swiftlet	Least Concern
Apodidae	*Collocalia vanikorensis*	Island Swiftlet	Least Concern
Alcidinidae	*Todiramphus chloris*	Collared Kingfisher	Least Concern
Meropidae	*Merops philippinus*	Blue-tailed Bee-eater	Least Concern
Megalaimidae	*Psilopogon haemacephalus*	Coppersmith Barbet	Least Concern
Pycnonotidae	*Hypsipetes philippinus*	Philippine Bulbul	Least Concern
Pycnonotidae	*Pycnonotus goiavier*	Yellow-vented Bulbul	Least Concern
Pycnonotidae	*Poliolophus urostictus*	Yellow-wattled Bulbul	Least Concern
Corvidae	*Corvus macrorhynchos*	Large-billed Crow	Least Concern
Paridae	*Pardaliparus elegans*	Elegant Tit	Least Concern
Sittidae	*Sitta oenochlamys*	Sulphur-billed Nuthatch	Least Concern
Timaliidae	*Macronus striaticeps*	Brown Tit-babbler	Least Concern
Sylvidae	*Cincloramphus timoriensis*	Tawny Grassbird	Least Concern
Musicapidae	*Rhipidura javanica*	Pied Fantail	Least Concern
Musicapidae	*Cyornis rufigastra*	Mangrove Blue-flycatcher	Least Concern
Musicapidae	*Pachycephala philippinensis*	Yellow-bellied Whistler	Least Concern
Musicapidae	*Culicicapa helianthea*	Citrine Canary Flycatcher	Least Concern
Laniidae	*Lanius cristatus*	Brown Shrike	Least Concern
Sturnidae	*Sarcops calvus*	Coleto	Least Concern
Sturnidae	*Aplonis panayensis*	Asian Glossy Starling	Least Concern
Nectariniidae	*Cinnyris jugularis*	Olive-backed Sunbird	Least Concern
Nectariniidae	*Anthreptes malacensis*	Brown-throated Sunbird	Least Concern
Dicaeidae	*Dicaeum australe*	Red-kelled Flowerpecker	Least Concern
Dicaeidae	*Dicaeum pygmaeum*	Pygmy Flowerpecker	Least Concern
Estrildidae	*Lonchura punctulata*	Scaly-breasted Munia	Least Concern
Estrildidae	*Lonchura atricapilla*	Chestnut Munia	Least Concern
Zosteropidae	*Zosterops montanus*	Mountain white-eye	Least Concern

The figure below visualizes the conservation status based on IUCN Red List between the two studies, 2016 and 2019. There were only two species fall under as “not listed” last 2016, namely, *Cinnyris jugularis* and *Hypsipetes philippinus.*

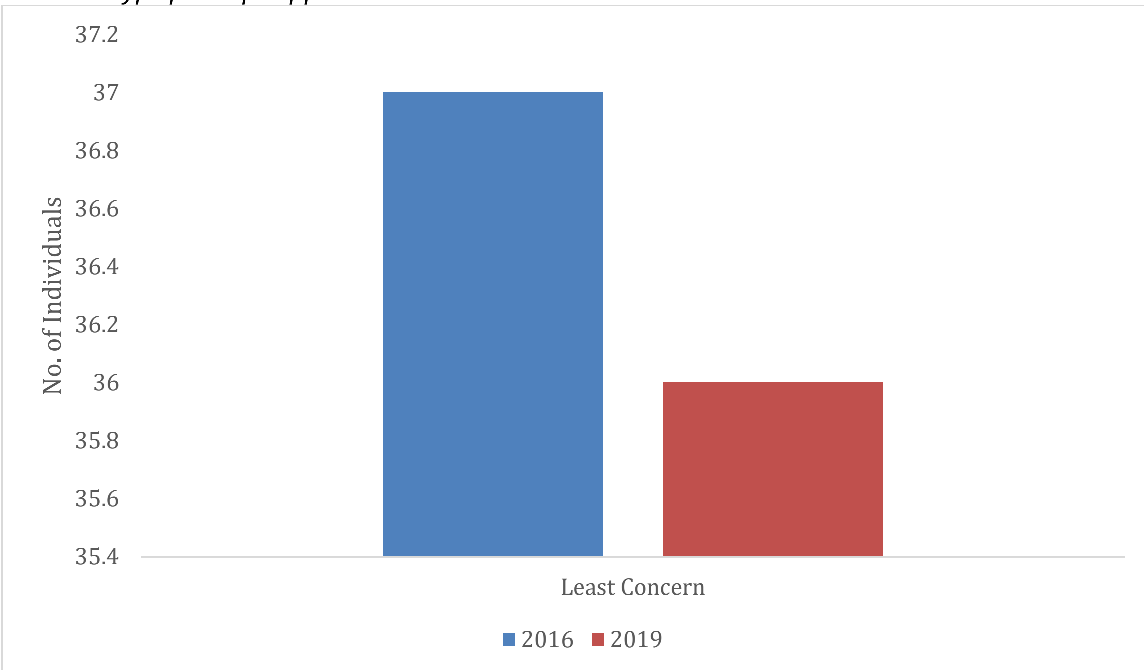


Figure 2.1-81. Conservation Status of Avifauna Species Identified in the Dry (2016) and Wet (2019) Season Sampling

Volant Mammals

Species Composition

There were two (2) species belonging to two (2) families that were observed in the 2019 study. These species are *Cynopterus brachyotis* and *Hipposideros obscurus.*

Cynopterus brachyotis is also a common species observed in the 2016 baseline study and the 2019 monitoring. The chart below compares the species observed in both the 2016 and the 2019 Study.

Table 2.1-58. Species Richness in Dry Season Sampling (2016) and Wet Season Sampling (2019) Assessment

Scientific Name	Common Name	2016	2019
Cynopterus brachyotis	Lesser Short Nose Fruit Bat	/	/
Ptenochirus jagori	Greater Musky Fruit Bat	/	
Hipposideros obscurus	Philippine forest roundleaf bat		/

The following are representative of the bat species observed:

Photo 2.1-54. *Hipposideros obscurus* (Lesser Short Nose Fruit Bat)

Photo 2.1-55. *Cynopterus brachyotis* (Philippine Forest Roundleaf Bat)

Presence

The table below shows the presence of volant mammals in the three sampling sites. Cynopterus brachyotis is present in all sampling sites while Hipposideros obscurus was only present in station 1.

Table 2.1-59. Presence of Volant Mammals in 2019 study

Species	SITE 1 (Puntalinao)	SITE 2 (Maputi)	SITE 3 (Causwagan)
Cynopterus brachyotis	x	x	x
Hipposideros obscurus	x		

The table below compares the presence of the bat species observed in both 2016 and 2019 study.

Table 2.1-60. Presence of Volant Mammal Species in both 2016 and 2019 Studies

Scientific Name	Common Name	2016			2019		
		Station 1	Station 2	Station 3	Station 1	Station 2	Station 3
Cynopterus brachyotis	Lesser Dog-faced fruit bat	/	/	/	/	/	/
Hipposideros obscurus	Philippine forest roundleaf bat				/		
Ptenochirus jagori	Greater musky fruit bat	/	/	/			

Diversity Indices

The diversity indices for 2016 study, all of the stations have a criterion of none diversity of species in the area. This is due to number of species present which is 2 species throughout the three sampling stations. The H-diversity is at 0.67-0.68, dominance is on 51.39% to 53.13% and the computed evenness is at 33%-34%.

Table 2.1-61. Diversity Indices of Volant Mammals in 2016 Study

Stations	Abundance	Species	H-diversity	Dominance	Evenness	Criterion
S1	12	2	0.68	51.39%	34%	None
S2	8	2	0.66	53.13%	33%	None
S3	10	2	0.67	52%	33.5%	None

In addition, the 2019 study has none diversity of species since it has only 1 to 2 species of volant mammals recorded in three sampling stations. Due to this the H-diversity ranges from 0 – 0.56. For stations 2 and 3, it has 100% dominance since it has only one species of volant mammals present and 0% evenness. However, for stations 1 there are 2 recorded species which has dominance of 62.5% and evenness of 28%.

Table 2.1-62. Diversity Indices of Volant Mammals in 2019 Study

Stations	Abundance	Species	H-diversity	Dominance	Evenness	Criterion
S1	4	2	0.56	62.5%	28%	None
S2	6	1	0	100%	0%	None
S3	19	1	0	100%	0%	None

Based on the diversity indices found in studies 2016 and 2019, there is a decrease of species number in stations 2 and 3 from 2016 to 2019 which resulted to decrease in H-diversity. The abundance of species in stations 1 and 2 increases. However, the criterion of 2016 and 2019 study still in none diversity of species.

Cluster Analysis

The percent of similarity for volant mammals in stations 1 and 2 is 80%. Meanwhile, station 3 has 55.56% of similarity of volant mammals. It can be inferred that station 1 and station 2 has almost the same of volant mammals present. However, station 3 has some species of volant mammals which can only be found in station 3.

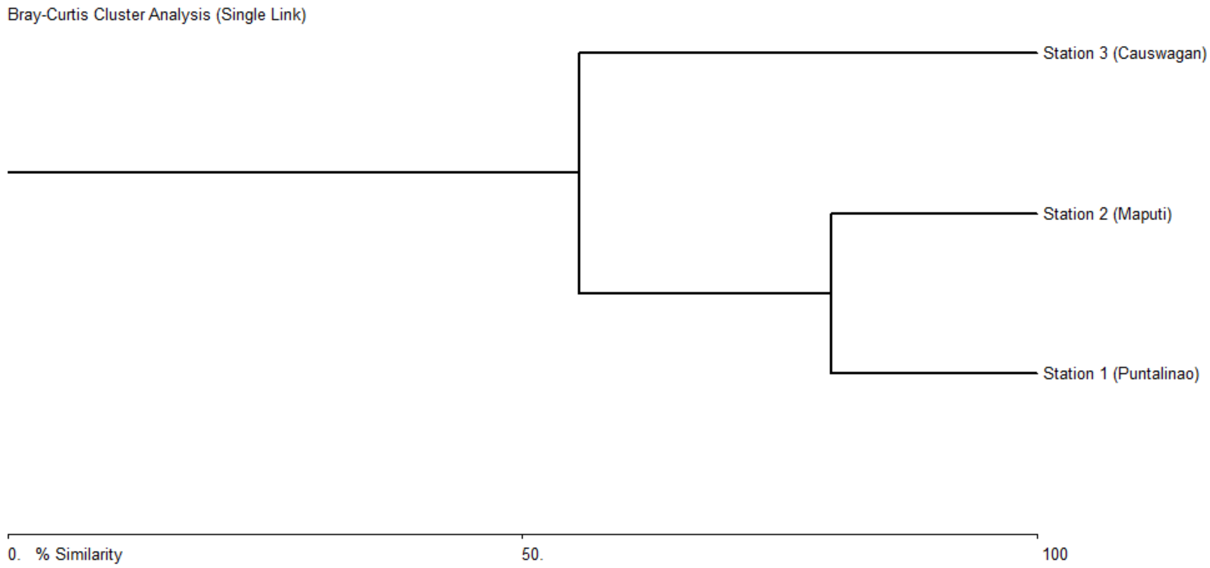


Figure 11. Cluster Analysis of Volant Mammals in 2016 Study

For 2019 study, station 1 and 2 is still has higher percentage of similarity compared to station 3. Station 1 and 2 has 60% of similarity of volant mammals present in the area. Whereas, for station 3 it has 48% of similarity to stations 1 and 2.

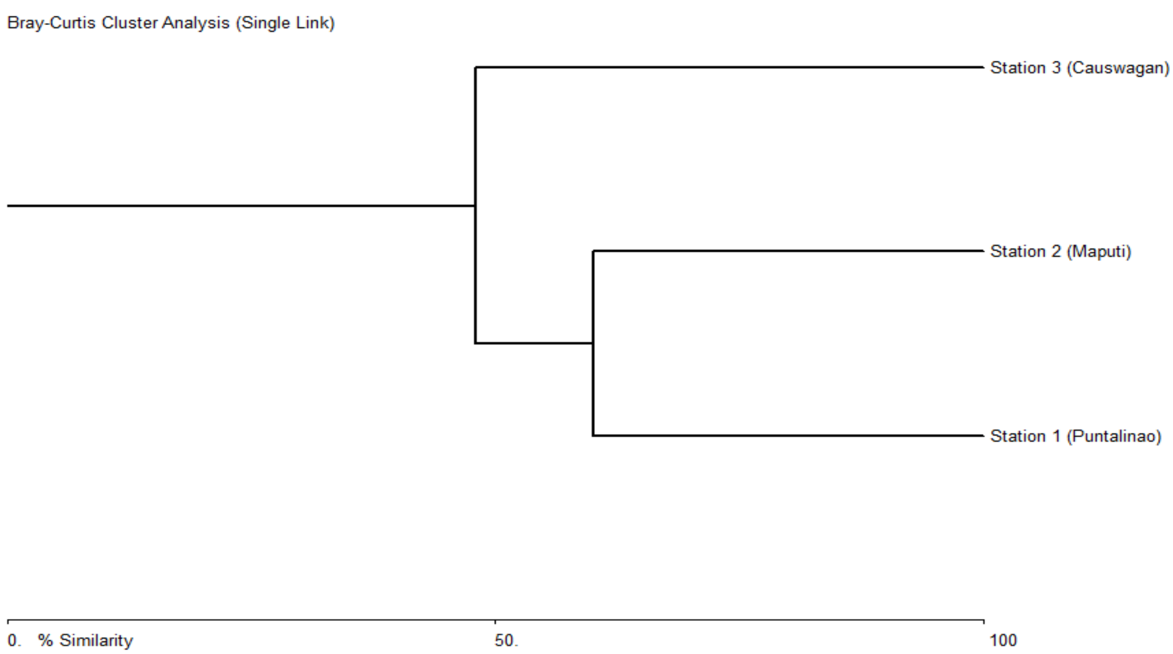


Figure 12. Cluster Analysis of Volant Mammals in 2019 Study

Distribution

The table below shows the Distribution Status of the two volant mammal species observed in the 2019 monitoring.

Table 2.1-63. Distribution of Volant Mammals in 2019 Study

Species	Common Name	Distribution
Cynopterus brachyotis	Lesser Short Nose Fruit Bat	Resident
Hipposideros obscurus	Phil. Forest roundleaf bat	Endemic

Conservation Status

The table below shows the Conservation status of the species observed in the 2019 study based on the IUCN Red List. Both the species observed are listed under the "Least Concern" category. This means that their population is stable and unlikely to decline.

Table 2.1-64. Conservation of Volant Mammals in 2019 Study

Species	Common Name	Conservation Status
Cynopterus brachyotis	Lesser Short Nose Fruit Bat	Least Concern
Hipposideros obscurus	Phil. Forest roundleaf bat	Least Concern

Abundance

There were a total of 20 individual bats that were captured during the sampling activity. There were 19 individuals of *Cynopterus brachyotis* with three (3), six (6) and ten (10) individuals captured in Site1, Site 2 and Site 3, respectively. There was also a single (1) bat captured belonging to the species *Hipposideros obscurus* in Site 1.

In comparison to the baseline data, assessed last 2016, *Cynopterus brachyotis* had the highest value of abundance among all stations (Barangay Puntalinao, Baranagay Maputi and Barangay Causwagan). Then, followed by *Ptenochirus jagori* that rages 37-41% of abundance value.

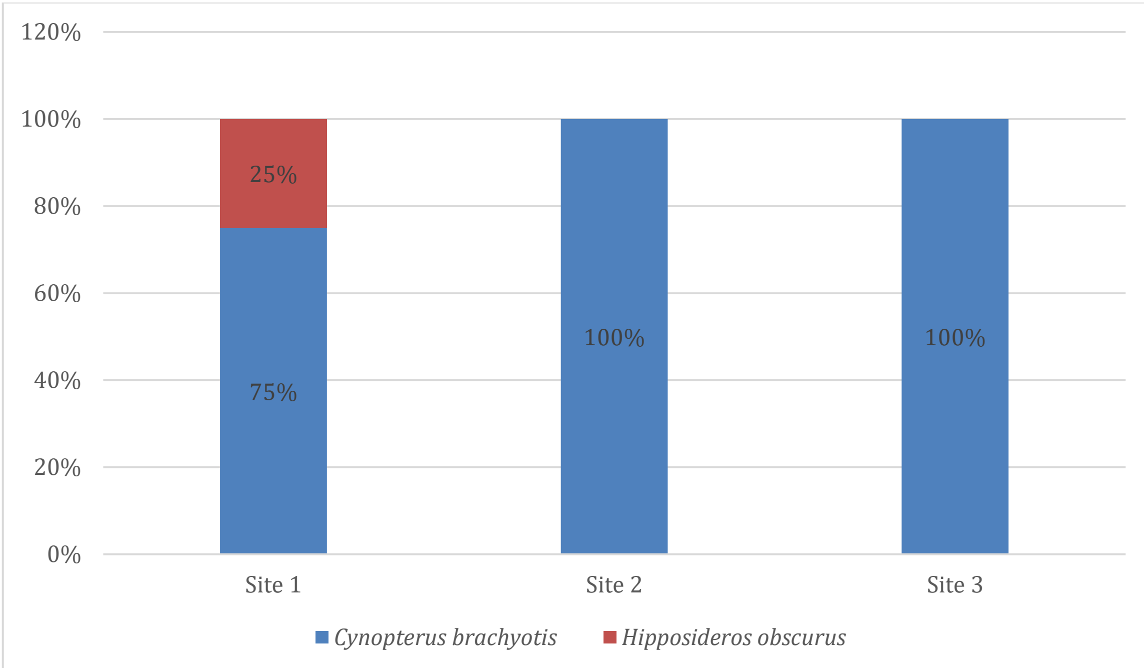


Figure 2.1-82. Volant Mammals Abundance in Wet Season (2019) Sampling

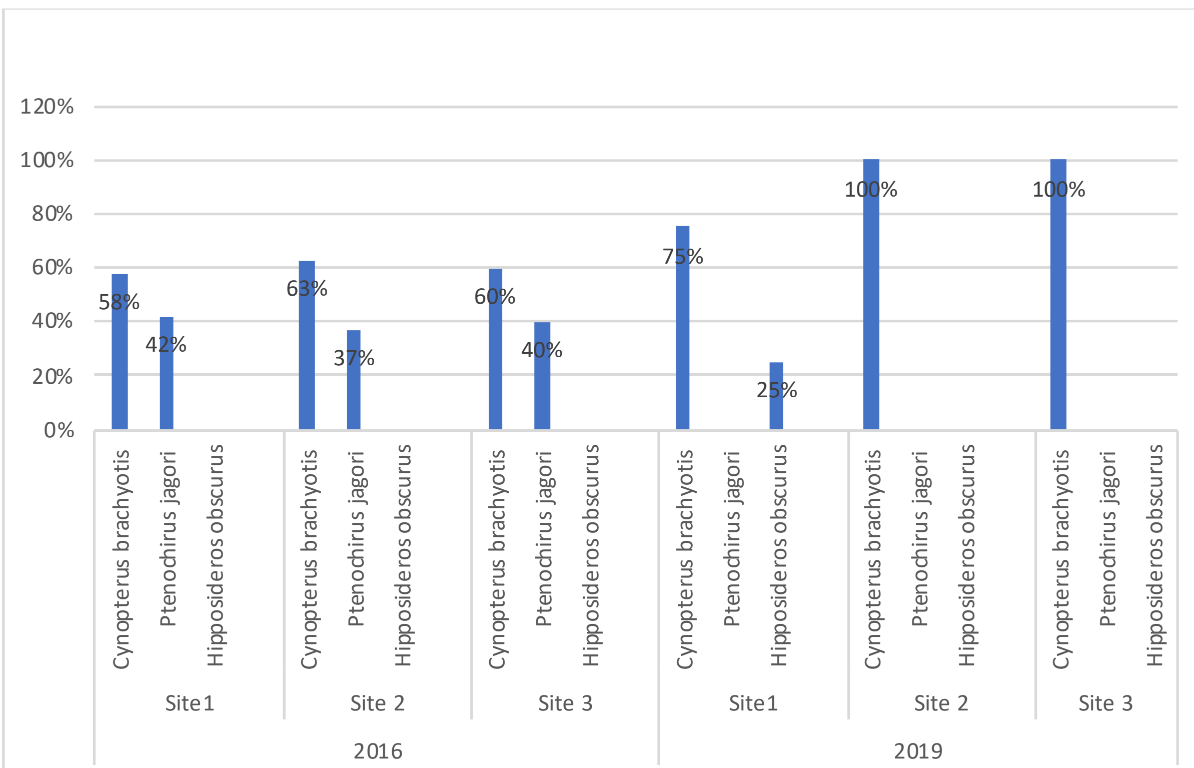


Figure 2.1-83. Volant Mammals Relative Abundance Comparison for Dry Season Sampling (2016) and in Wet Season Sampling (2019)

Non-volant Mammals

Species Listing

Non-volant mammals are land-based mammals that are not able to take flight. The non-volant mammals that were observed in the in three sampling sites were Sus philippensis, Macaca fascicularis philippensis, Tarisus syrichta and Rusa mariana. Among the four (4) species, only Rusa mariana was actually observed during sampling, while the other three were identified through Key Informant Interviews.

Table 2.1-65. Non-Volant Mammal Species Observed in the 2019 Study

Family	Species	Common Name
Suidae	*Sus philippensis**	Philippine Warty Pig
Cercopithecidae	*Macaca fascicularis philippensis**	Philippine Long Tailed Macaque
Tarsiidae	*Tarisus syrichta**	Philippine Tarsier
Cervidae	*Rusa mariana*	Philippine Brown Deer

**Key Informant Interview*

Distribution

All of the four (4) observed species are endemic in the Philippines.

Table 2.1-66. Distribution of Non-Volant Mammal Species observed in the 2019 Study

Species	Common Name	Distribution
*Sus philippensis**	Philippine Warty Pig	Philippine Endemic
*Macaca fascicularis philippensis**	Philippine Long Tailed Macaque	Philippine Endemic
*Tarisus syrichta**	Philippine Tarsier	Philippine Endemic
Rusa mariana	Philippine Brown Deer	Philippine Endemic

**Key Informant Interview*

Presence

Sus philippensis and Macaca fascicularis were observed in all three (3) sites through either actual observation or Key Informant Intervies (KII). The other two species, Tarsius syrichta and Rusa mariana were both not observed in Site 3 and Site 1, respectively.

Table 2.1-67. Presence of Non-Volant Mammals across the sampling sites in the 2019 Study

Species	SITE 1 (Puntalinao)	SITE 2 (Maputi)	SITE 3 (Causwagan)
*Sus philippensis**	x	x	x
*Macaca fascicularis philippensis **	x	x	x
*Tarsius syrichta **	x	x	
Rusa mariana		x	x

**Key Informant Interview*

Conservation Status

Among the four (4) species that were observed in the area, two are listed as “Vulnerable” in the IUCN Red List while the other two (2), the Philippine long-tailed macaque and the Philippine tarsier, are listed as “Near Threatened”. Moreover, in the DENR list of Threatened Species, both Sus philippensis and Rusa mariana are listed as “Vulnerable” while Macaca fascicularis philippensis and Tarsius syrichta are listed under the “Other Threatened Species” category.

Table 2.1-68. Conservation Status of Non-Volant Mammals Observed in the 2019 Study

Species	Common Name	IUCN Red List	DAO 2004 – 15 and CITES as of 2017
*Sus philippensis**	Philippine Warty Pig	Vulnerable	Vulnerable
*Macaca fascicularis philippensis**	Philippine Long Tailed Macaque	Near Threatened	Other Threatened Species
*Tarsius syrichta**	Philippine Tarsier	Near Threatened	Other Threatened Species
Rusa mariana	Philippine Brown Deer	Vulnerable	Vulnerable

**Key Informant Interview*

Herpetofauna

Herpetofauna is a collective term used for reptiles and amphibians of a particular region. Even these different taxa were evolutionary distinct, monitoring for both species are of the same method making monitoring easier and efficient.

Amphibians

Species Richness

There were six (6) species, belonging to four (4) families, of amphibians found across the three (3) sampling sites. The table below shows the species that were observed across all the sampling sites.

Table 2.1-69. Amphibian Species Observed in the 2019 Study

Family	Species Name	Common Name
Rhacophoridae	*Philautus surdus*	Common Forest Tree Rrog
	Polypedates leucomystax	Common Tree Frog
Raniidae	*Pulchrana grandocula*	Big Eyed Frog
	Staurois guttatus	Black-spotted Rock Frog
Dicroglossidae	*Limnonecetes magnus*	Mindanao Fanged Frog
Ceratobatrachidae	*Platymantis* sp.	

Presence

There were two species of Philautus that were found in Site 1, and there are no other species that were found in the site. In Site 3, only Limnonectes magnus was observed. This species is also common between Site 2 and Site 3. Three other species aside from Limnonectes magnus were observed in Site 2.

The table below shows the species of amphibians found in each site.

Table 2.1-70. Presence of Amphibians in in the Sampling Sites

Family	Species	Station 1 (Puntalinao)	Station 2 (Maputi)	Station 3 (Causwagan)
Rhacophoridae	*Philautus surdus*	x		
Ceratobatrachidae	*Platymantis sp.*	x		
Raniidae	*Pulchrana grandocula*		x	
Dicroglossidae	*Limnonectes magnus*		x	x
Rhacophoridae	*Polypedates leucomystax*		x	

Family	Species	Station 1 (Puntalinao)	Station 2 (Maputi)	Station 3 (Causwagan)
Raniidae	*Staurois natator*		x	

Species Distribution

A total of six (6) species of amphibians found and identified in all sampling stations. The table below shows the species list of amphibians in three sampling sites, six (6) species were recorder, with two species that is endemic to the Mindanao islands, Pulchrana grandocula and Limnonectes magnus , and one species that is endemic to the Philippines, Philautus surdus, Only one species the Limnonectes magnus is categorized as Near threatened by IUCN, and the rest are in Least Concern status.

Table 2.1-71. Distribution of Amphibians observed in the 2019 Study

Species Name	Common Name	Ecological Status
Philautus surdus	Common Forest Tree Frog	Endemic
Polypedates leucomystax	Common Tree Frog	Resident
Pulchrana grandocula	Big Eyed Frog	Mindanao Endemic
Staurois guttatus	Black-spotted Rock Frog	Resident
Limnonectes magnus	Mindanao Fanged Frog	Mindanao Endemic
Platymantis sp.		N/A

Abundance

In figure 5 shows the abundance of six species in the respected sites, P. surdus has the highest individuals (3) , and all the five species have only one individual as representative. Site 3 has only one (1) species observed.

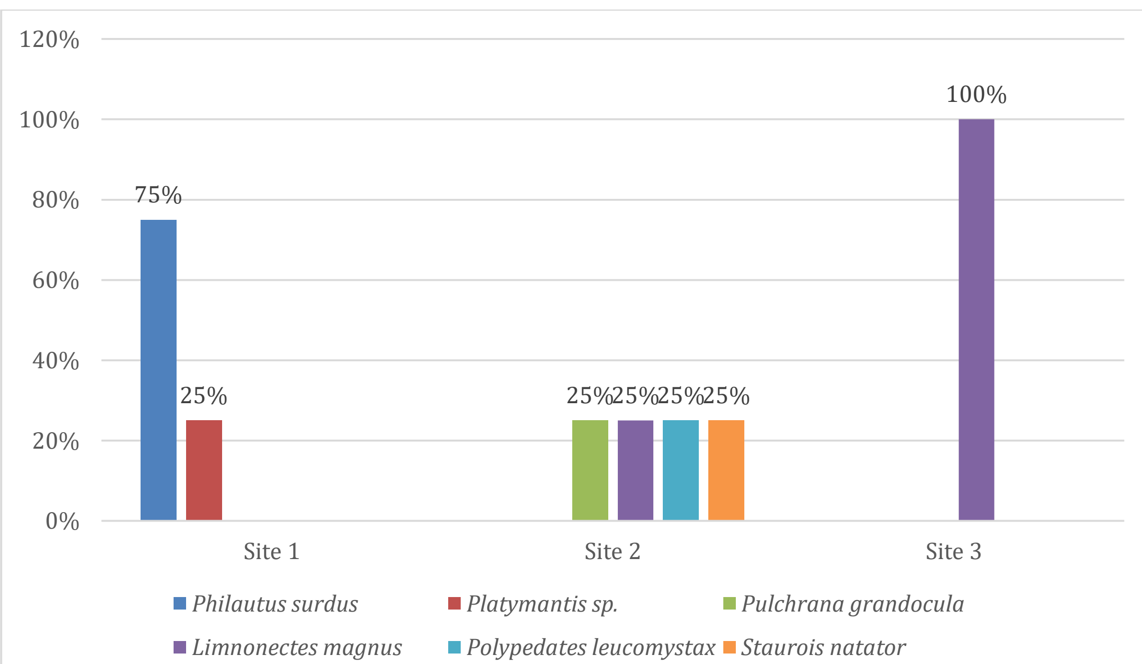


Figure 2.1-84. Abundance of amphibians

Conservation Status

Among the six (6) observed species of amphibians across the three sampling sites, one (1) was listed as "Near Threatened" in the IUCN Red list, while four (4) others were listed as "Least Concern". Also, there is one (1) other species that was not identified. On the other hand, only Limnonectes magnus was listed on the DENR List of Threatened species as "Vulnerable".

Table 2.1-72. Conservation Status of Amphibians observed in the 2019 Study

Species Name	Common Name	IUCN Red List	DAO 2004 – 15 and CITES as of 2017
Philautus surdus	Common Forest Tree Frog	Least Concern	Not Listed
Polypedates leucomystax	Common Tree Frog	Least Concern	Not Listed
Pulchrana grandocula	Big Eyed Frog	Least Concern	Not Listed
Staurois guttatus	Black-spotted Rock Frog	Least Concern	Not Listed
Limnonectes magnus	Mindanao Fanged Frog	Near Threatened	Vulnerable
Platymantis sp.		N/A	N/A

Reptiles

Species Richness

Seven (7) species of reptiles were observed across the sampling sites, with four (4) actually observed during the sampling activities. The other three (3) species were identified through Key Informant Interviews involving the locals, farmers, and enthusiasts encountered in the area.

Table 2.1-73. Reptile Species observed in the 2019 Study

Family	Species	Common Name
Scincidae	*Sphenomorphus veriegatus*	Blackspotted *sphenomorphus*
	Eutropis multicarinata	Philippine Mabuya
Agamidae	*Draco volans*	Common gliding lizard
Colubridae	*Ahaetulla prasina*	Asian Vine Snake
Varanidae	Varanus salvator*	Water monitor Lizard
Pythonidae	*Python reticulatus* *	Reticulated Phyton
Elapidae	*Ophiophagus hannah**	King Cobra

**Key Informant Interview*

Presence

The table below shows the presence of reptiles across the three sampling sites. Site 1 has the highest number of reptile species observed with seven (7) , while Site 2 and Site 3 has four (4) species each.

Table 2.1-74. Presence of Reptile Species in each Sampling Site in the 2019 Study

Species	SITE 1 (Puntalinao)	SITE 2 (Maputi)	SITE 3 (Causwagan)
Sphenomorphus veriegatus	x	x	x
Draco volans	x	x	
Ahaetulla prasina	x		
Eutropis multicarinata	x		x
*Varanus salvator**	x	x	

Species	SITE 1 (Puntalinao)	SITE 2 (Maputi)	SITE 3 (Causwagan)
*Python reticulatus**	x		x
*Ophiophagus hannah**	x	x	x

**Key Informant Interview*

Species Distribution

Among the seven (7) observed species of reptiles, five (5) were resident species while the other two (2) are endemic in the Philippines.

Table 2.1-75. Distribution of Reptile Species observed in the 2019 Study

Species	Common Name	Distribution
Sphenomorphus veriegatus	Blackspotted sphenomorphus	Endemic
Draco volans	Common gliding lizard	Resident
Ahaetulla prasina	Asian Vine Snake	Resident
Eutropis multicarinata borealis	Philippine Mabuya	Endemic
Varanus salvator*	Water monitor Lizard	Resident
Python reticulatus*	Reticulated Phyton	Resident
Ophiophagus hannah*	King Cobra	Resident

**Key Informant Interview*

Abundance

The figure below shows the relative abundance of the reptile species that were observed in each sampling site. There were eight (8) individuals that were observed in Site 1. The most abundant species in Site 1 is Sphenomorphus veriegatus with 37.5%, followed by Draco volans and Eutropis multicarinata with 25% each, and lastly, Ahaetulla prasina with 12.5% abundance. In site 2, there were only two (2) species that were observed comprising of three (3) individuals with Sphenomorphus veriegatus being the more abundant with 66.67%, followed by Draco Volans with 33.33% abundance. In Site 3, there were only two species observed with a total of 4 individuals. Both species in the area have a relative abundance of 50%.

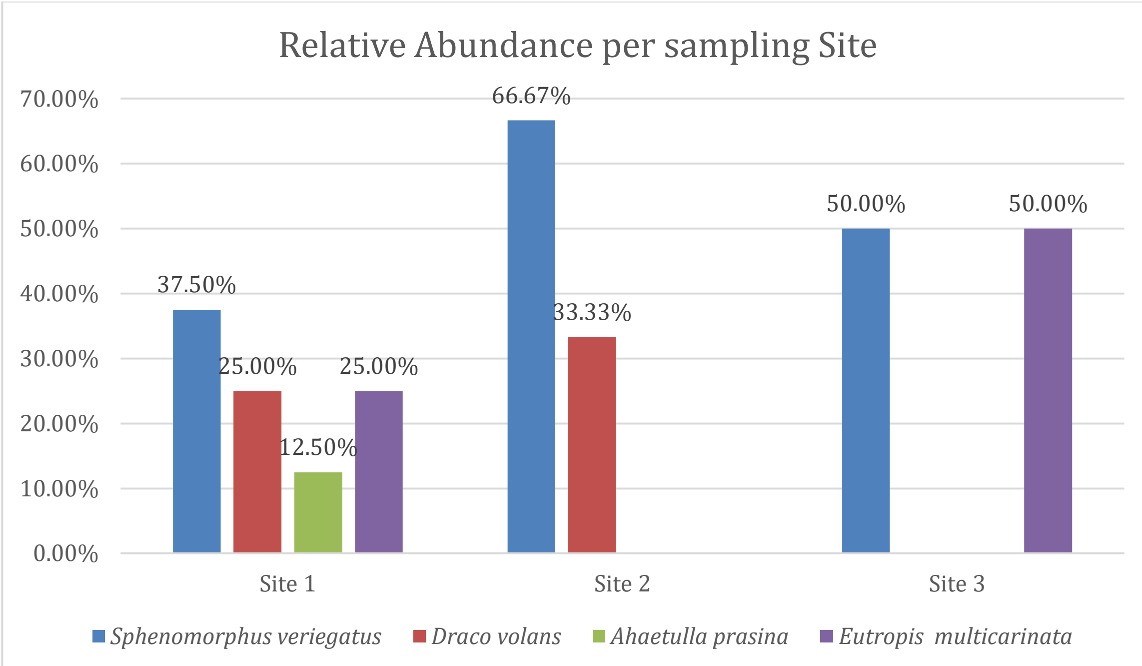


Figure 2.1-85. Relative Abundance per Sampling Site

Conservation Status

All of the seven (7) species observed in the area are listed under the "Least Concern" category of the IUCN Red List.

Table 2.1-76. Conservation Status of the Reptiles observed in the 2019 Study

Species	Common Name	Conservation Status
Sphenomorphus veriegatus	Blackspotted sphenomorphus	Least Concern
Draco volans	Common gliding lizard	Least Concern
Ahaetulla prasina	Asian Vine Snake	Least Concern
Eutropis multicarinata	Philippine Mabuya	Least concern
*Varanus salvator**	Water monitor Lizard	Least Concern
*Phyton reticulatus**	Reticulated Phyton	Least Concern
*Ophiophagus hannah**	King Cobra	Least Concern

**Key Informant Interview*

Discussion on the General Relationship of Trophic Structure

Three sampling area was established within different barangays namely, Barangay Puntalinao, Barangay Maputi and Barangay Causwagan. Blocks of Barangay Puntalinao and Maputi were the planned mine pit whereas, blocks of Barangay Causwagan was the planned dumpsite of this project. The topography of the area is characterized by moderately sloping to rugged terrain with elevation ranging from 100 to 633meters above sea level. The area is underlain by Cretaceous to Paleogene assemblage of ultramafic and mafic rocks that is thrusted against Cretaceous rocks. The area is also composed of moderate to highly fractured serpentinized peridotite.

The trophic levels are determined by feeding relationships, with basal level of primary producers or detritus and upper levels based on consumption of these basal levels. Organisms on the trophic level is called primary consumers which later consume by the second consumer and until up on the theoretical trophic level. Primary consumers consist of herbivores and detritivores, while the third trophic level and those above include predators and parasites. Energy and matter move up trophic chains, and some compounds, including various toxins, may bioaccumulate at upper trophic levels. The concept of trophic level has generated a sizeable literature yielding useful ecological models, such as trophic cascades, and debates about top-down versus bottom-up regulation of herbivores (Dyer, 2012).

Terrestrial ecosystem decimation of green plants by grazers is an infrequent occurrence. Plant-animal interaction is a good indicator of this phenomenon. The main type of such interactions is to have sufficient energy that allows the individual to maximize its survival and reproductive fitness. In order to have that energy, the primary source of this energy is the plant. Green plants are responsible for converting radiant energy into usable chemical energy in a form of glucose. However, the primary producers are not only limited to green plants but also to cyanobacteria and lichens. The major factor that would affect the distribution, abundance and diversity of green plant communities on the surface of the planet is mainly governed by location, amount of solar radiation reaching the earth's surface, local and regional topography, and type of soils (Tadesse, 2017).

The trophic levels for consumers include herbivores, predators, parasites, and parasitoids that ecologically interact in various ways. Consumers form aggregated trophic levels from what they feed. One of the most pervasive forces of interaction is the predator-prey interaction in which it determines the species composition, abundances, distributions and behavior of organisms in the terrestrial biological communities. The primary consumers include the herbivores in which they are found to have closest direct dependence and interactions with green plants. The secondary consumers include omnivore species which follows different interactions such as predations and parasitism (Tadesse, 2017).

Impact Assessment

Habitat fragmentation causes disturbance in the existing ecological conditions of the ecosystem. This form of fragmentation occurs by pollution that causes habitats to be destroyed because it changes the quality of air, water, and land while becoming into an area contaminated with toxins. However, there are methods or possible options for prevention or mitigation in this kind of fragmentation. The table below shows the possible impact for the proposed project and the possible option for prevention, mitigation and/ or enhancement to preserve the existing ecological conditions of the ecosystem.

Table 2.1-77. Potential Impacts and Mitigation

Potential Impacts	Option for Prevention, Mitigation and/or Enhancement
Physical disturbance to the terrestrial ecosystem due to construction and operational phase	• Regular monitoring of terrestrial flora and fauna
Loss of habitat among aquatic flora and fauna	• A thorough study shall be further conducted for the importance of fish passage that will be constructed
Noise disturbance to existing fauna	• Installation of noise mitigating facilities
Cutting of affected trees within the area	• Planting of seedlings equal to the number of trees been cut
Clearing of vegetation for the establishment of various facilities resulting to an increase potential of run-offs and soil erosion	• Employing applicable soil erosion control measures during the construction stage
Intensified soil erosion	• Develop erosion control mechanism
Soil erosion and loose soil quality	• Installation of barriers and soil erosion control project
Sedimentation/Siltation of public water ways due to unconfined stockpiles of soil during operation of heavy equipment	• Cover the open stockpiles during rain to prevent soil erosion near the streams
During the construction phase, vegetation removal in certain areas may be required. This will result to intensification of run-off and soil erosion which	• Proper Land Management should be implemented during the construction phase. Erosion control measures such

affects the turbidity of the water which deteriorates the water quality. This latter alters the photosynthetic activity of phytoplankton and benthic flora, disrupting the natural physiological processes of aquatic organisms.	canals should be installed and as much as possible, the removal of vegetation should be minimized. • Monitoring of the water quality on the fixed sampling station should be conducted in order to measure the environmental impact.
There will be a possibility of species alteration on composition, abundance and density due to the possible pollution on water bodies caused by construction activities.	• Proper waste management should be strictly observed. • Monitoring of the freshwater ecology

2.2 WATER

2.2.1 Hydrology / Hydrogeology

2.2.1.1 Change in drainage morphology

There are five (5) river systems that traverse the mine site particularly the area where high grade of ore deposits was identified (**Figure 2.2-1**). Mining operations is expected to be intensive in this area. Delineation of the watershed areas is necessary for the hydrologic studies. The analysis includes estimation of dependable flows, floods, and soil erosion and sediment yields. Establishing the baseline hydrologic data will enable the company to plan appropriate mitigation once exceeded on alarming levels.

As shown in **Figure 2.2-2**, the watersheds covered by the project include the Piso-Catangawan, Mapagba/Mapanga, Maputi, Pintataganan, Punta Linao and the Puntalinao Proper. Although the latter have no definite or single river system, it is included because part of the area is covered by the proposed mine pits. All the watersheds drain towards Davao Gulf.

Using a Geographic Information System (GIS), the watershed divides were delineated and the corresponding areas were calculated as presented in **Table 2.2-1**.

Table 2.2-1: Watersheds covering the Mining Area

Name of Watershed	Drainage Area (km^2)
Piso-Catangawan	21.56
Mapagba/Mapanga	15.00
Maputi	10.00
Pintatagan	37.17
Punta Linao	10.56
Punta Linao Proper	6.76

Watershed Characteristics

Presented in the following discussions are the characteristics of the watersheds in terms of land use/vegetative cover, topography/slope and soils. These parameters are among the basic inputs in generating the soil erosion susceptibility map as well as the estimation of sediment yields.

Land Use/Vegetative Cover

Based on the 2010 Land Use Map from the NAMRIA, the major land use or vegetative cover of the area includes open forest, shrubs/grasslands and perennial crops (**Figure 2.2-3**). The area distribution for each watershed is summarized in **Table 2.2-2**. Mangrove is observed along the coastal area particularly at the drainage outlet of Maputi and Piso Rivers as shown in **Photo 2.2-1**.

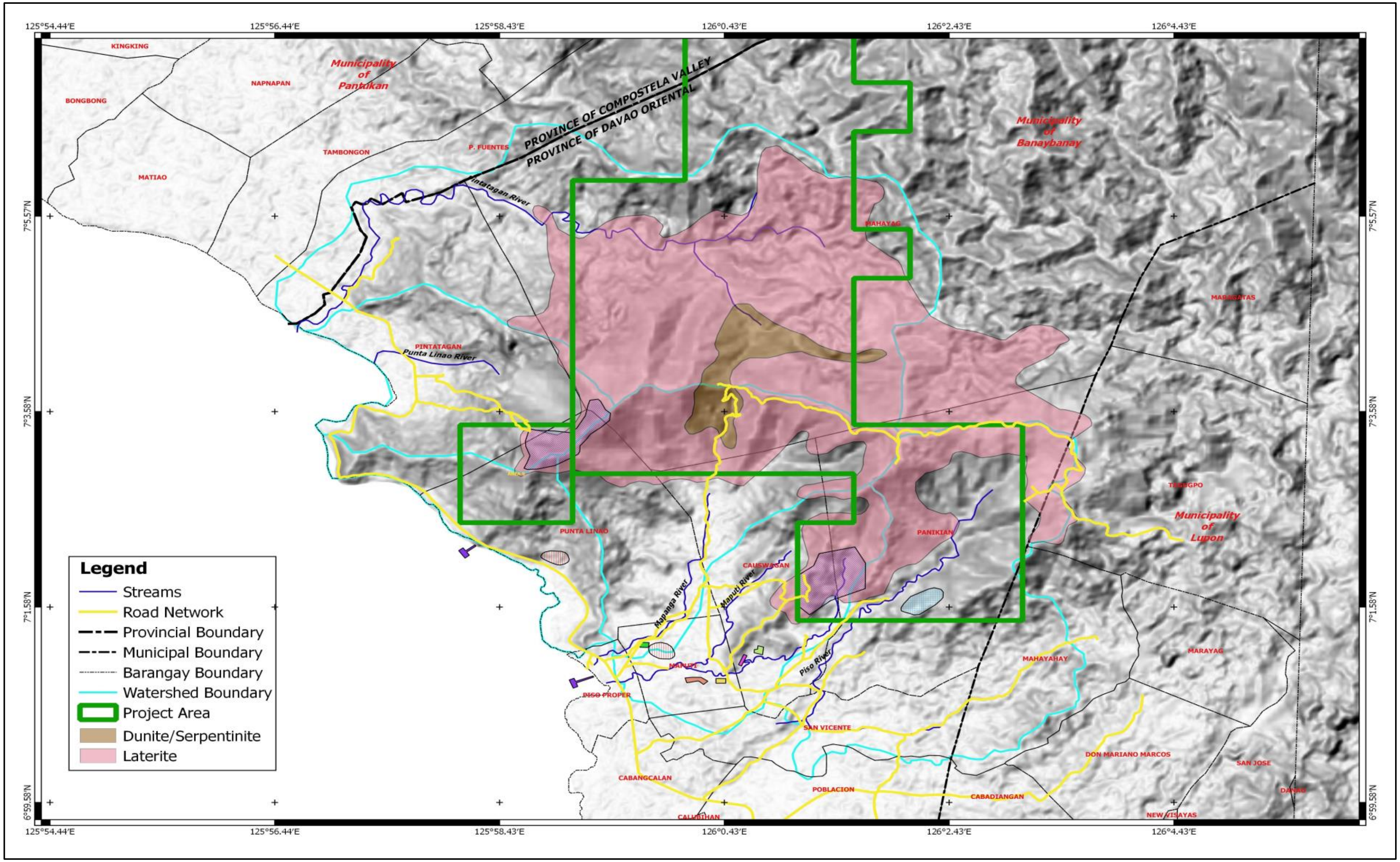


Figure 2.2-1: Location of Ore Deposits in the MPSA

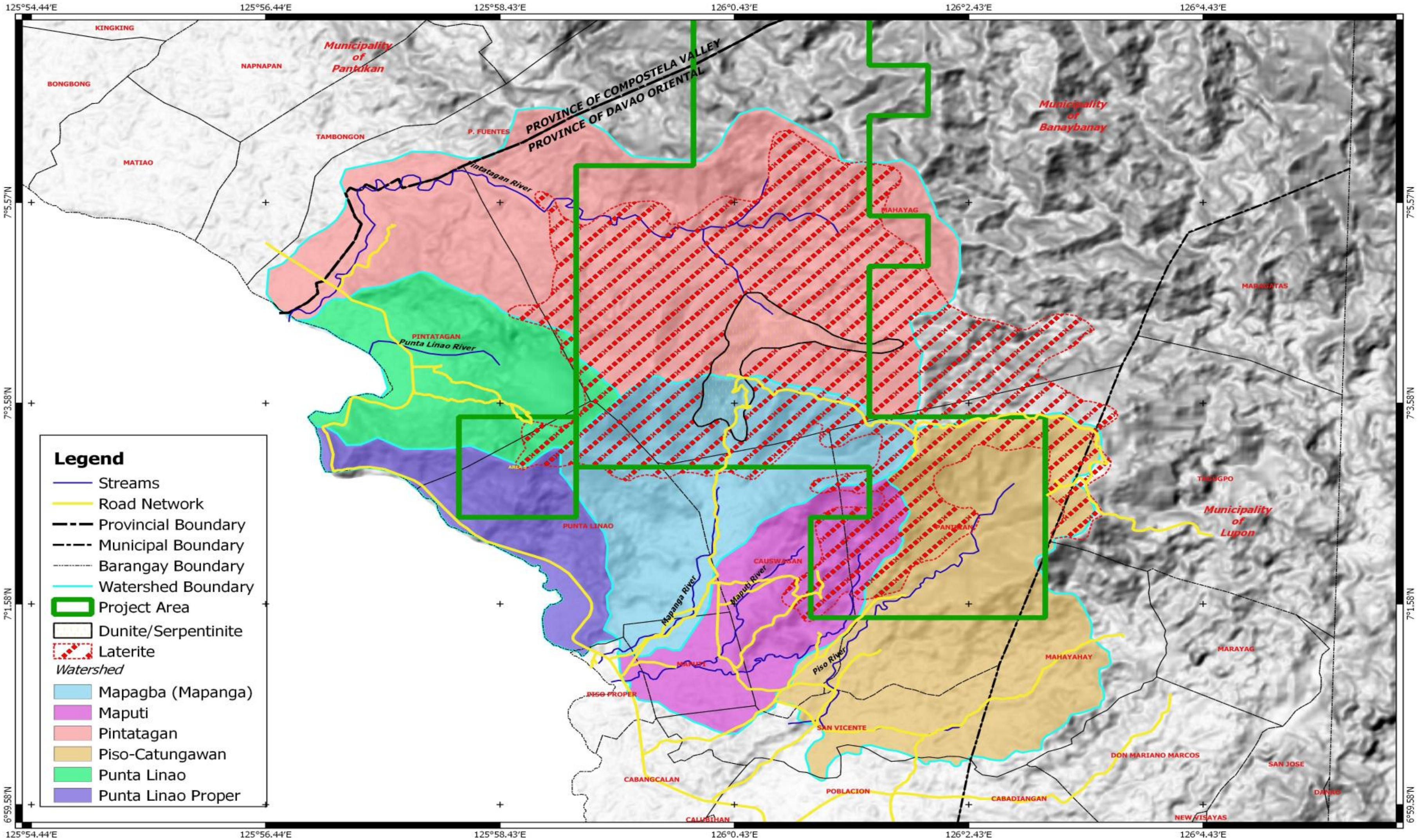


Figure 2.2-2: Watersheds draining the MPSA/Ore deposit Area (Source: NAMRIA, 2010)

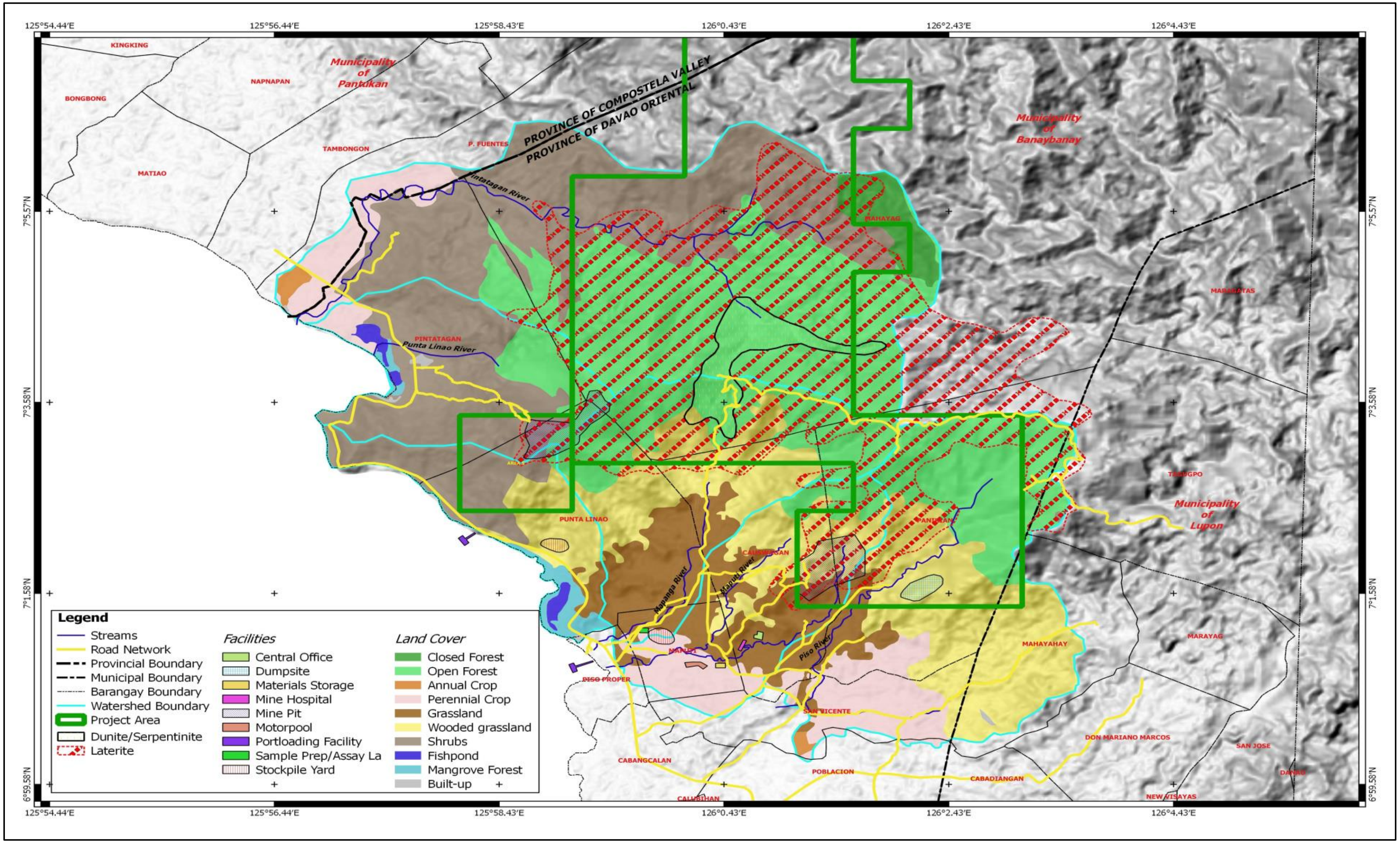


Figure 2.2-3: Land Use/Vegetative Cover of Watersheds in the MPSA (Source: NAMRIA, 2010)

Table 2.2-2: Land Use/Vegetative Cover of Watersheds in the MPSA

Piso-Catangawan Watershed

Description	Area (ha)	Area (%)
Annual Crop	11.24	0.52
Built-up	2.70	0.13
Grassland	177.03	8.21
Open Forest	658.72	30.55
Perennial Crop	359.00	16.65
Shrubs	2.58	0.12
Wooded grassland	944.69	43.82
Total	**2,155.96**	**100.00**

Mapagba/Mapanga Watershed

Description	Area (ha)	Area (%)
Grassland	378.42	24.80
Mangrove Forest	0.43	0.03
Open Forest	600.97	39.38
Perennial Crop	9.99	0.65
Wooded grassland	536.27	35.20
Total	**1,526.08**	**100.06**

Maputi Watershed

Description	Area (ha)	Area (%)
Grassland	363.99	36.39
Open Forest	97.35	9.73
Perennial Crop	214.83	21.48
Wooded grassland	324.03	32.40
Total	**1,000.20**	**100.00**

Pintatagan Watershed

Description	Area (ha)	Area (%)
Annual Crop	23.47	0.63
Perennial Crop	256.51	6.90
Open Forest	1,657.59	44.60
Closed Forest	176.60	4.75
Shrubs	1,601.53	43.09
Built-up	0.94	0.03
Total	**3,716.64**	**100.00**

Punta Linao Watershed

Description	Area (ha)	Area (%)
Perennial Crop	47.94	4.54
Annual Crop	0.83	0.08
Open Forest	194.28	18.40
Shrubs	766.30	72.59
Mangrove Forest	13.89	1.32
Fishpond	24.03	2.28
Built-up	8.38	0.79
Total	**1,055.65**	**100.00**

Punta Linao (Proper) Watershed

Description	Area (ha)	Area (%)
Annual Crop	0.04	0.01
Built-up	1.83	0.27
Fishpond	17.14	2.54
Grassland	35.03	5.18
Mangrove Forest	74.01	10.95
Open Forest	7.23	1.07
Shrubs	328.26	48.56
Wooded grassland	212.42	31.42
Total	**675.96**	**100.00**

Topography/Slope
The topography of the mining area is considered mountainous and rugged terrain where majority of the area have slope of greater than 30%. Pintatagan watershed have the biggest area under this slope category covering almost 70 %. On the contrary, Maputi watershed is considered the least where in about 77% of its watershed area have slope of less than 8 %. Presented in Table **2.2-3** and **Figure 2.2-4** are the area distribution by slope category.

Table 2.2-3: Slope of the Watersheds in the MPSA

Piso-Catangawan Watershed

Description	Area	
	ha	%
0-3 (Level to nearly level)	153.76	7.13
3-8 (Gently sloping to undulating)	596.62	27.67
8-18 (Undulating to rolling)	233.74	10.84
18-30 (Rolling to moderately steep)	448.32	20.79
30-50 (Steep)	723.52	33.56
Total Piso	**2,155.96**	**100.00**

Mapagba/Mapanga Watershed

Description	Area	
	ha	%
0-3 (Level to nearly level)	297.26	19.48
3-8 (Gently sloping to undulating)	231.09	15.14
8-18 (Undulating to rolling)	59.40	3.89
18-30 (Rolling to moderately steep)	58.10	3.81
30-50 (Steep)	870.37	57.03
50 > (Very Steep)	9.86	0.65
Total	**1,526.08**	**100.00**

Maputi Watershed

Description	Area	
	ha	%
0-3 (Level to nearly level)	307.65	30.76
3-8 (Gently sloping to undulating)	477.07	47.70
18-30 (Rolling to moderately steep)	169.13	16.91
30-50 (Steep)	46.35	4.63
Total	**1,000.20**	**100.00**

Pintatagan Watershed

Description	Area	
	ha	%
0-3 (Level to nearly level)	20.87	0.56
8-18 (Undulating to rolling)	792.14	21.31
18-30 (Rolling to moderately steep)	305.86	8.23
30-50 (Steep)	2,578.03	69.36
50 > (Very Steep)	19.74	0.53
Total	**3,716.64**	**100.00**

Punta Linao Watershed

Description	Area	
	ha	%
8-18 (Undulating to rolling)	236.17	22.37
18-30 (Rolling to moderately steep)	268.26	25.41
30-50 (Steep)	141.55	13.41
50 > (Very Steep)	409.67	38.81
Total Punta Linao	**1,055.65**	**100.00**

Punta Linao (Proper) Watershed

Description	Area	
	ha	%
0-3 (Level to nearly level)	82.17	12.16
8-18 (Undulating to rolling)	152.98	22.63
18-30 (Rolling to moderately steep)	68.80	10.18
30-50 (Steep)	117.76	17.42
50 > (Very Steep)	254.25	37.61
Total Punta Linao Proper	**675.96**	**100.00**

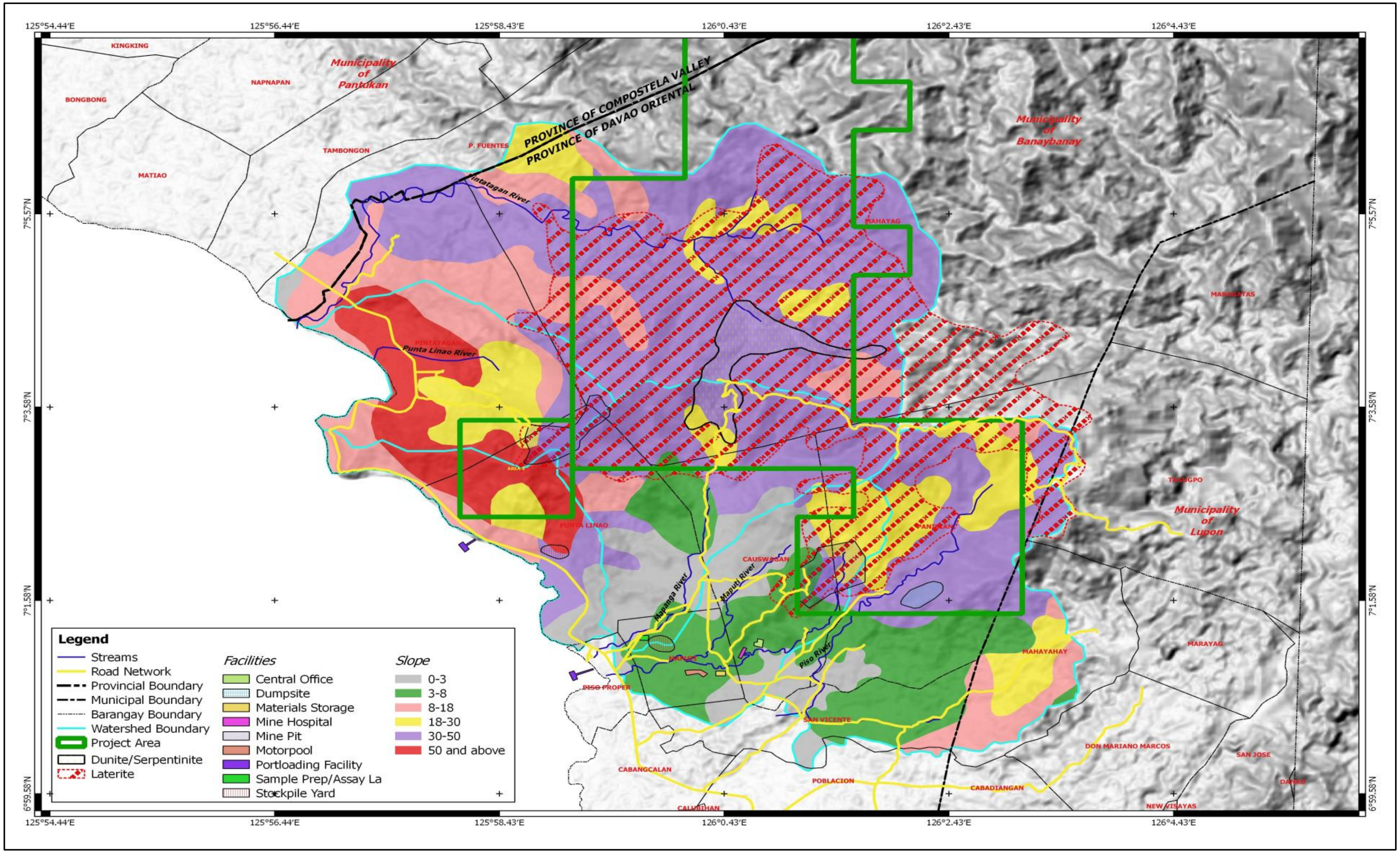


Figure 2.2-4: Slope Map of the Watersheds in the MPSA (Source: Bureau of Soils and Water Management)

Soil Type

Based on the soils classification map from the Bureau of Soils and Water Management (BSWM), majority of the area particularly the mountainous part of the watersheds, are still unclassified. Only in the flatter areas where agriculture is being practiced are classified either under San Manuel silty clay loam and Malalag loam. Presented in **Table 2.2-4** and mapped in **Figure 2.2-5** are the coverage for each type of soil within the watersheds.

Table 2.2-4: Soil Classification of the Watersheds in the MPSA

Piso-Catangawan Watershed

Description	Area	
	ha	%
Mountain soil (undifferentiated)	1,956.13	90.7
Malalag loam	22.69	1.1
San Manuel silty clay loam	177.14	8.2
Total Piso	**2,155.96**	100.0

Mapagba/Mapanga Watershed

Description	Area	
	ha	%
Mountain soil (undifferentiated)	1,465.26	96.0
San Manuel silty clay loam	60.82	4.0
Total Mapanga	**1,526.08**	**100.0**

Maputi Watershed

Description	Area	
	ha	%
Mountain soil (undifferentiated)	751.28	75.1
San Manuel silty clay loam	248.92	24.9
Total Maputi	**1,000.20**	100.0

Pintatagan Watershed

Description	Area	
	ha	%
Mountain soil (undifferentiated)	3,716.64	100.0
Total Pintatagan	**3,716.64**	100.0

Punta Linao Watershed

Description	Area	
	ha	%
Mountain soil (undifferentiated)	1,055.65	100.0
Total Punta Linao	**1,055.65**	100.0

Punta Linao (Proper) Watershed

Description	Area	
	ha	%
Mountain soil (undifferentiated)	518.88	76.8
San Manuel silty clay loam	157.08	23.2
Total Punta Linao Proper	**675.96**	100.0

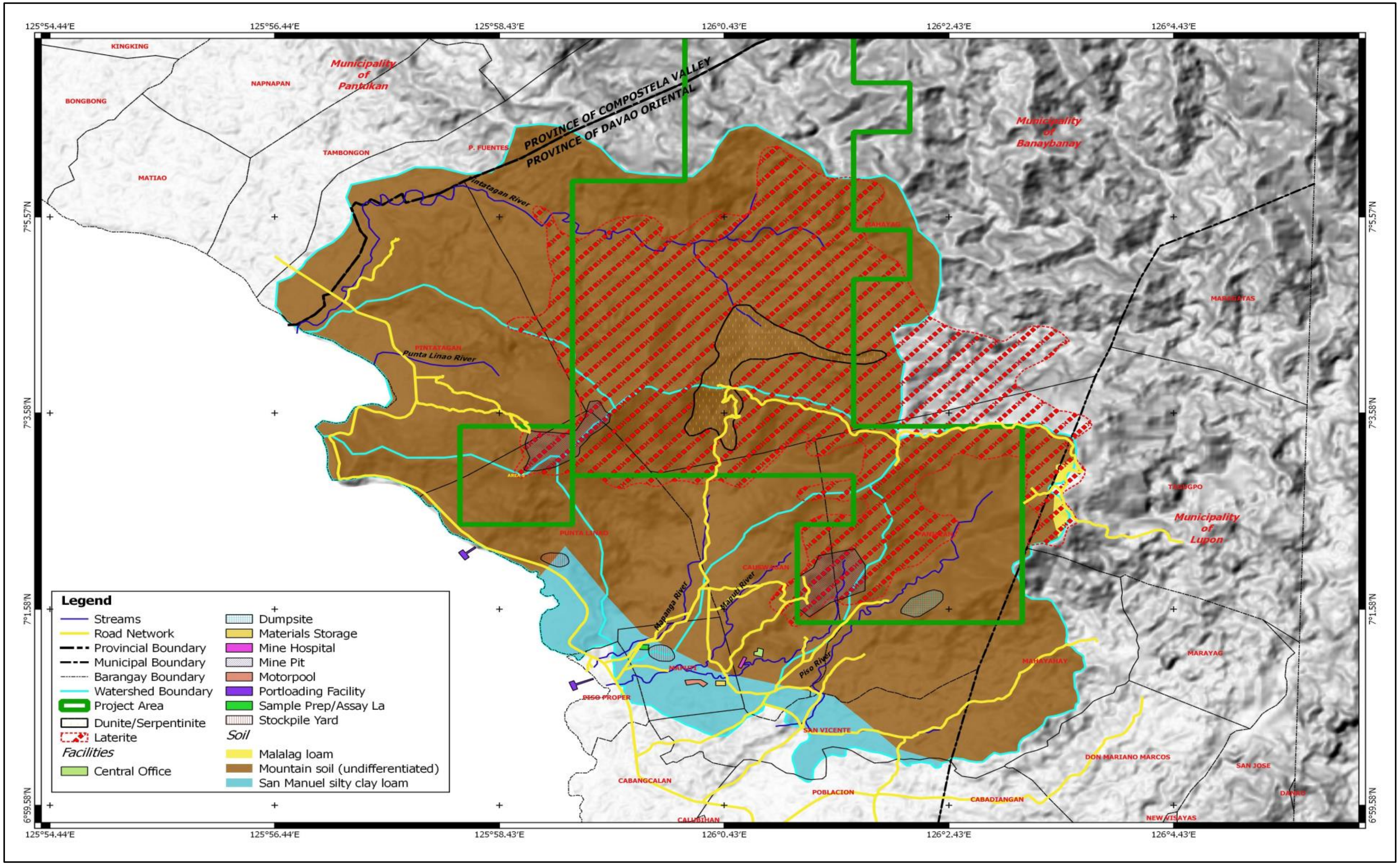


Figure 2.2-5: Soil Map of the Watersheds in the MPSA (Source: Bureau of Soils and Water Management)

Watershed Management Plan

Major features of a watershed management approach are targeting priority problems, promoting a high level of stakeholder involvement, developing integrated solutions that make use of the expertise and authority of multiple agencies and organizations, and measuring success through monitoring and other data gathering (SF Bay RWQCB, 2004).

Below are the planned approach:

- Identify the declared watershed that proximate to the MPSA area.
- Determine how mining operations would directly or indirectly affect the watershed to avoid issues or to address rightly;
- Determine the population of the stakeholders benefited by the water resources coming from the watershed;
- Delineate barangays that are within it the watershed to know if conflicts or disputes over land and water resources among the locals;
- Coordinate with the LGU in the event that the watershed has to be evaluated of its present environmental conditions such as erosions, degradation and sedimentations affecting their water sources;
- Coordinate with PENRO and CENRO to present or introduce environmental works enhancing the implementation of the National Greening Program such as:
    - site assessment;
    - site soil preparations;
    - species selection and spacing;
    - nursery establishment and seedling production;
    - maintenance and protection.

The watershed planning process should be implemented in a dynamic and adaptive manner to ensure that implementation of the plan can proceed even though some of the information in the watershed plan is imperfect and might need to be modified or improved upon over time as better information becomes available.

2.2.1.2 Reduction in stream volumetric flow

Mean Monthly Discharges

There are no available records of river discharges in the area that could be directly used in the hydrologic analysis particularly the determination of water availability or dependable flows and flood frequency for the mine site.

The nearest stream gauging stations to the project site are in the Lipadas River located in Toril, Davao City with a drainage area of 149 km^2 and Lasang River in Paquibato, Davao City with a drainage area of 344 km^2. The drainage areas of these rivers are much bigger as compared to the rivers in the mine area. Large rivers behave differently with small rivers, and as such, the streamflow data of the two (2) gaging stations could not be used to estimate the discharge data for ungauged rivers at the mine area. Empirical method has to be resorted to generate the required information.

Flow Measurements

In order to have an idea of the flow in the five (5) rivers, flow measurements were conducted on pre-determined measuring sites of each river using a current meter (**Figure 2.2-6**).

Flow measurement was undertaken by wading using a Valeport Model BFM001S-N3077 current meter with a digital velocity meter reader, which is highly reliable for average and turbulent flow and even for low flows. Current metering is generally an acceptable method of taking the velocity of water flowing in a river channel

An improvised tagline made of pre-calibrated vinyl rope at one (1) meter interval was laid across the river to serve as a guide in the placement of the current meter. Direct reading of flow velocities, in meters/sec, were obtained from the current meter set at 20 seconds observation-duration per sampling point. A calibrated wadding rod is used to obtain the water depth. Relevant information was recorded using a standard field data sheet.

In principle, flow velocity measurement is carried out following the 3-point method, in which the flow velocity is measured in three (3) different water depths from the surface (0.2, 0.6 & 0.8 of the water depth). However, if the water depth is insufficient for the 3-point method, a 2-point method (0.2 & 0.8 of the water depth) is adopted. For water depth of less than 0.7 meter, a one-point method (measured at 0.6 of the water depths from the surface) is adopted.

Prior to the conduct of discharge measurements, a reconnaissance survey was made for the selection of measuring sites within the stretch or segment of each river. The purpose is to determine the approach and method of measurements to be made and most appropriate location where flow is more or less concentrated on a single river section and not affected by disturbance of other hydrologic and hydraulic factors to attain high accuracy of measurements.

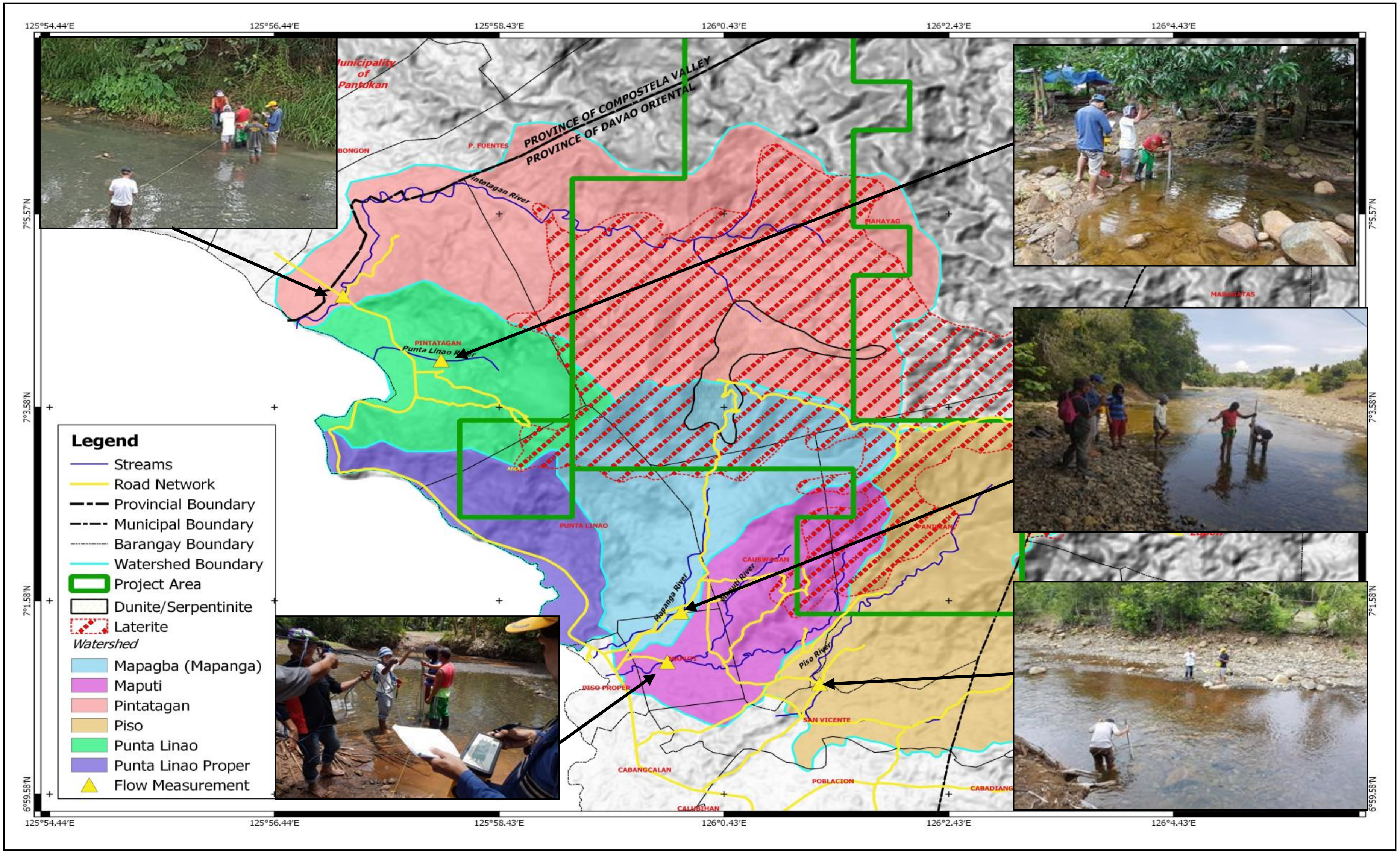


Figure 2.2-6: Location Map of Flow Measurements

Calculation of Discharge

The mean velocity in the sampling vertical is derived by computing the average of the point velocities at depths of 0.2, 0.6 and 0.8 using the following formula:

$$Vm = (V0.2 + V0.6 \times 2 + V0.8)/4$$

Where:

Vm = mean velocity of vertical section, m/sec
V02= Velocity at 0.2 of water depth, m/sec
V0.6=Velocity at 0.6 of water depth, m/sec
V0.8= Velocity at 0.8 of water depth, m/sec

In case velocity is measured at 2-points (0.2 & 0.8 of the water depth), the average of the 2-point velocities is considered. On the other hand, where velocity is measured only at 0.6 of the water depths, the observed velocity is directly taken as the average at the sampling vertical.

The area of the section is computed by multiplying the sectional width by the section depth. Discharge through the section is then derived by multiplying the sectional area by the mean velocity in the section. The total discharge is then derived by totaling the discharge in the individual sections. The results of the discharge measurements of fiver (5) rivers are summarized in **Table 2.2-5.**

Table 2.2-5: Results of Flow Measurements on September 29 & 30, 2016

River name	River width (m)	Discharge, m^3/sec
Piso-Catangawan	7.3	0.26
Mapagba	6.8	0.17
Maputi	7.2	0.11
Pintataganan	14.2	0.28
Punta Linao	3.8	0.04

Mean Monthly Flow

As stated earlier, the rivers draining the mine site has no historical stream flow records that could be used as a reference or basis for dependable flow analysis and flood frequency analysis at the project site. Instead, the monthly discharge of the river was estimated using the empirical formula of the form:

$$Q_i = \frac{0.011574\ (DA)\ (R_f)\ (R_c)}{N_{dm}}$$

Where:
- Q_i = discharge in a given day or month
- DA = drainage area of the river of interest, sq. km.
- R_f = rainfall in a given day or month within or near the project area in mm
- R_c = runoff coefficient (20%-40 %.)
- N_{dm} = no. of days in a month

For this study, the rainfall data of Davao City station is used in estimating the monthly discharges (**Table 2.2-6**).

Table 2.2-6: Estimated Monthly Discharges of Rivers/Watersheds in the MPSA

Month	Mean Monthly Discharge, cms				
	Piso-Catangawan River	Mapagba River	Pinagtatagan River	Maputi River	Punta-Linao River
January	0.36	0.17	0.38	0.17	0.11
February	0.21	0.15	0.27	0.13	0.08
March	0.18	0.13	0.27	0.12	0.06
April	0.35	0.15	0.37	0.15	0.09
May	0.5	0.35	0.58	0.35	0.12
June	0.58	0.37	0.63	0.37	0.15
July	0.53	0.36	0.6	0.36	0.15
August	0.56	0.39	0.63	0.39	0.16
September	0.49	0.19	0.49	0.19	0.14
October	0.53	0.2	0.49	0.2	0.14
November	0.4	0.15	0.32	0.15	0.1
December	0.34	0.14	0.28	0.13	0.09
Mean	0.42	0.23	0.44	0.23	0.11

The measured river discharges and estimated long term mean discharges, although not the same amount, appear to be proportionate with the drainage area. The lower values that were measured during the field investigation could rather represent the dry periods during the month of September.

Dependable Flow Analysis by Flow Duration Curve

A flow duration curve (FDC) is a cumulative frequency curve which shows the percent of time that certain discharges were equalled or exceeded. This is derived by organizing a set of stream flow data by order of magnitude and plotting it against the frequency of its occurrence. As stated earlier, the rainfall data of Davao City was used to generate stream flow data of the ungauged rivers at the mine area.

As mentioned earlier, the stream flow data of five rivers located within the mine area were estimated using the empirical formula shown above and the 30-years record of Davao City rainfall station. The generated long-term monthly stream flows for the five rivers are presented in **Tables 2.2-7**, **2.2-8**, **2.2-9**, **2.2-10** & **2.2-11**.

Using the generated long-term monthly flows, the probability of occurrence was calculated for wide range of discharges, results of which is summarized in **Table 2.2-12** and graphed in **Figure 2.2-7**.

Table 2.2-7: Generated mean monthly flow (m^3/sec)
Piso-Catangawan River, Drainage Area=21.6sq. km.

YEAR	JAN	FEB	MAR	APRL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1983	0.14	0.03	0.02	0.04	0.33	0.69	1	0.83	0.51	0.39	0.34	0.54
1984	0.21	0.22	0.26	0.28	0.25	0.57	0.31	0.16	0.43	0.44	0.23	0.21
1985	0.16	0.11	0.12	0.86	0.69	0.13	0.53	1.04	0.6	1.32	0.44	0.31
1986	0.73	0.14	0.13	0.11	0.32	0.81	0.4	0.15	0.67	0.39	0.41	0.02
1987	0.33	0.21	0.02	0.26	0.48	0.69	0.34	0.76	0.25	0.97	0.2	0.38
1988	0.07	0.19	0.57	0.85	0.66	0.51	0.41	0.48	1.04	0.41	0.2	0.23
1989	0.29	0.19	0.31	0.51	0.66	0.92	0.19	0.69	0.27	0.34	0.48	0.25
1990	0.09	0.07	0.08	0.48	0.78	0.32	0.67	0.65	0.66	0.53	0.4	0.18
1991	0.37	0.17	0.02	0.37	0.6	0.57	0.44	0.32	0.11	0.17	0.64	0.03
1992	0.01	0	0.01	0.01	0.31	0.68	0.85	0.24	0.4	0.23	0.54	0.27
1993	0.25	0.21	0.15	0.66	0.28	0.29	0.92	0.39	1.13	0.17	0.22	0.5
1994	0.13	0.14	0.16	0.69	0.73	1.09	0.18	1.23	0.32	0.43	0.18	0.22
1995	0.24	0.33	0.19	0.2	0.52	0.34	0.57	0.76	0.56	0.36	0.41	0.58
1996	0.52	0.2	0.07	0.13	0.4	0.5	0.43	0.34	0.3	0.53	0.67	0.13
1997	0.73	0.28	0.19	0.37	0.53	0.19	0.31	0.15	0.49	1.3	0.1	0.2
1998	0.1	0.04	0.01	0.09	0.68	0.46	0.45	0.3	0.67	0.6	0.51	0.24
1999	0.74	0.24	0.46	0.49	0.68	0.55	0.36	0.5	0.62	0.26	0.31	0.72
2000	0.81	0.55	0.37	0.28	0.29	0.58	0.54	0.82	0.17	0.81	0.6	0.37
2001	0.24	0.14	0.18	0.17	0.21	0.35	0.7	0.49	0.47	0.29	0.58	0.24
2002	0.31	0.29	0.06	0.11	0.33	1.11	0.16	0.66	0.54	0.38	0.61	0.09
2003	0.26	0.32	0.19	0.32	0.45	0.44	0.6	0.46	0.15	0.61	0.45	0.57
2004	0.24	0.3	0.28	0.48	0.7	0.29	0.57	0.05	0.81	0.53	0.27	0.72
2005	0.15	0.03	0.04	0.19	0.47	0.57	0.64	0.53	0.4	0.46	0.21	0.69
2006	0.47	0.26	0.41	0.17	0.61	0.83	0.59	0.54	0.4	0.54	0.32	0.23
2007	0.37	0.21	0.14	0.2	0.66	0.5	0.48	1.02	0.22	0.72	0.28	0.35
2008	0.41	0.29	0.36	0.32	0.52	1.21	0.55	0.18	0.94	0.51	0.93	0.19
2009	0.56	0.32	0.15	0.44	0.57	0.6	0.74	0.56	0.32	0.17	0.41	0.13
2010	0.38	0.03	0.08	0.35	0.18	0.27	0.78	0.9	0.34	0.52	0.26	0.56
2011	0.56	0.26	0.16	0.63	0.55	0.75	0.64	0.84	0.88	0.52	0.35	0.45
2012	0.31	0.37	0.25	0.35	0.48	0.53	0.69	0.68	0.27	0.45	0.38	0.69
2013	1.03	0.38	0.1	0.35	0.4	0.58	0.4	0.59	0.33	1.04	0.58	0.19
Mean	**0.36**	**0.21**	**0.18**	**0.35**	**0.5**	**0.58**	**0.53**	**0.56**	**0.49**	**0.53**	**0.4**	**0.34**

Table 2.2-8: Generated mean monthly flow (m^3/sec)
Mapagba River, Drainage Area= 15.3 sq. km.

YEAR	JAN	FEB	MAR	APRL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1983	0.11	0.2	0.02	0.03	0.22	0.49	0.77	0.65	0.38	0.27	0.24	0.37
1984	0.17	0.21	0.3	0.19	0.17	0.4	0.24	0.13	0.33	0.3	0.16	0.14
1985	0.12	0.08	0.15	0.58	0.47	0.09	0.41	0.81	0.45	0.91	0.3	0.21
1986	0.58	0.18	0.15	0.08	0.22	0.58	0.31	0.12	0.51	0.27	0.29	0.02
1987	0.26	0	0.03	0.18	0.33	0.49	0.27	0.59	0.19	0.67	0.14	0.26
1988	0.05	0.22	0.67	0.58	0.44	0.36	0.31	0.37	0.79	0.29	0.14	0.16
1989	0.23	0.15	0.36	0.34	0.45	0.65	0.15	0.54	0.2	0.24	0.34	0.17
1990	0.07	0.35	0.1	0.33	0.53	0.22	0.52	0.51	0.5	0.36	0.28	0.12
1991	0.29	0.21	0.03	0.25	0.41	0.4	0.34	0.25	0.09	0.12	0.45	0.02
1992	0.01	0.3	0.01	0.01	0.21	0.49	0.66	0.18	0.31	0.16	0.38	0.18
1993	0.2	0.05	0.18	0.44	0.19	0.2	0.71	0.3	0.86	0.12	0.15	0.34
1994	0.1	0.26	0.19	0.46	0.49	0.78	0.14	0.96	0.25	0.3	0.12	0.15
1995	0.19	0.58	0.23	0.14	0.35	0.24	0.44	0.59	0.43	0.25	0.29	0.39
1996	0.41	0.14	0.08	0.09	0.27	0.35	0.34	0.26	0.23	0.37	0.47	0.09
1997	0.58	0.31	0.23	0.25	0.36	0.13	0.24	0.11	0.37	0.9	0.07	0.14
1998	0.08	0.33	0.01	0.06	0.46	0.33	0.35	0.24	0.51	0.41	0.36	0.16
1999	0.58	0.32	0.55	0.33	0.46	0.39	0.28	0.39	0.47	0.18	0.22	0.49
2000	0.64	0.03	0.44	0.19	0.2	0.41	0.42	0.64	0.13	0.56	0.42	0.25
2001	0.19	0.27	0.22	0.12	0.14	0.25	0.54	0.38	0.35	0.2	0.41	0.16
2002	0.24	0.22	0.07	0.08	0.23	0.79	0.12	0.51	0.41	0.26	0.43	0.06
2003	0.21	0.31	0.23	0.22	0.3	0.31	0.46	0.36	0.12	0.42	0.31	0.38
2004	0.19	0.33	0.33	0.33	0.47	0.21	0.44	0.04	0.62	0.36	0.19	0.49
2005	0.12	0.03	0.04	0.13	0.32	0.4	0.49	0.42	0.3	0.32	0.14	0.47
2006	0.37	0.28	0.49	0.11	0.41	0.59	0.45	0.42	0.3	0.37	0.23	0.15
2007	0.29	0.39	0.17	0.14	0.45	0.36	0.37	0.8	0.17	0.5	0.19	0.24
2008	0.33	0.4	0.43	0.22	0.35	0.86	0.43	0.14	0.71	0.35	0.65	0.13
2009	0.44	0.22	0.18	0.3	0.39	0.43	0.58	0.44	0.24	0.12	0.29	0.09
2010	0.3	0.03	0.1	0.24	0.12	0.19	0.6	0.7	0.26	0.36	0.18	0.38
2011	0.44	0.28	0.18	0.43	0.37	0.54	0.49	0.65	0.67	0.36	0.25	0.3
2012	0.25	0.39	0.29	0.24	0.33	0.38	0.54	0.53	0.2	0.31	0.27	0.47
2013	0.82	0.4	0.11	0.24	0.27	0.41	0.31	0.46	0.25	0.71	0.4	0.13
Mean	0.29	0.22	0.21	0.24	0.34	0.41	0.41	0.44	0.37	0.36	0.28	0.23

Table 2.2-9: Generated mean monthly flow (m^3/sec)
Maputi River, Drainage Area= 10.0 sq. km.

YEAR	JAN	FEB	MAR	APRL	*MAY*	*JUN*	JUL	AUG	SEP	OCT	NOV	DEC
1983	0.07	0.02	0.01	0.02	0.23	0.44	0.68	0.54	0.2	0.15	0.13	0.21
1984	0.1	0.13	0.18	0.12	0.18	0.37	0.21	0.54	0.17	0.17	0.08	0.08
1985	0.07	0.07	0.09	0.37	0.49	0.08	0.36	0.11	0.23	0.5	0.16	0.12
1986	0.34	0.08	0.09	0.05	0.23	0.52	0.27	0.68	0.26	0.15	0.15	0.01
1987	0.15	0.13	0.01	0.11	0.34	0.45	0.23	0.1	0.1	0.37	0.07	0.15
1988	0.03	0.11	0.39	0.36	0.47	0.33	0.27	0.5	0.4	0.16	0.07	0.09
1989	0.14	0.12	0.21	0.22	0.47	0.59	0.13	0.31	0.1	0.13	0.18	0.1
1990	0.04	0.05	0.06	0.21	0.55	0.2	0.45	0.45	0.26	0.2	0.15	0.07
1991	0.17	0.11	0.01	0.16	0.43	0.37	0.3	0.42	0.04	0.07	0.23	0.01
1992	0.01	0	0	0.01	0.22	0.44	0.57	0.21	0.16	0.09	0.2	0.11
1993	0.11	0.13	0.11	0.28	0.2	0.19	0.62	0.15	0.44	0.06	0.08	0.2
1994	0.06	0.09	0.11	0.29	0.52	0.71	0.12	0.25	0.12	0.16	0.07	0.09
1995	0.11	0.2	0.13	0.09	0.37	0.22	0.39	0.81	0.22	0.14	0.15	0.23
1996	0.24	0.12	0.05	0.06	0.29	0.32	0.29	0.5	0.12	0.2	0.25	0.05
1997	0.34	0.17	0.13	0.16	0.38	0.12	0.21	0.22	0.19	0.49	0.03	0.08
1998	0.05	0.03	0.01	0.04	0.48	0.3	0.3	0.1	0.26	0.23	0.19	0.1
1999	0.34	0.15	0.32	0.21	0.48	0.36	0.24	0.2	0.24	0.1	0.11	0.28
2000	0.37	0.33	0.25	0.12	0.21	0.38	0.37	0.33	0.07	0.31	0.22	0.15
2001	0.11	0.08	0.13	0.07	0.15	0.23	0.48	0.54	0.18	0.11	0.21	0.09
2002	0.14	0.18	0.04	0.05	0.24	0.72	0.11	0.32	0.21	0.14	0.22	0.03
2003	0.12	0.19	0.13	0.14	0.32	0.28	0.41	0.43	0.06	0.23	0.16	0.22
2004	0.11	0.19	0.19	0.21	0.49	0.19	0.39	0.3	0.31	0.2	0.1	0.28
2005	0.07	0.02	0.02	0.08	0.33	0.37	0.43	0.03	0.15	0.17	0.08	0.27
2006	0.22	0.16	0.28	0.07	0.43	0.54	0.4	0.35	0.15	0.2	0.12	0.09
2007	0.17	0.13	0.1	0.09	0.47	0.32	0.32	0.35	0.09	0.27	0.1	0.14
2008	0.19	0.18	0.25	0.14	0.37	0.78	0.37	0.67	0.36	0.19	0.34	0.07
2009	0.26	0.19	0.1	0.19	0.41	0.39	0.5	0.12	0.12	0.07	0.15	0.05
2010	0.17	0.02	0.06	0.15	0.13	0.18	0.53	0.37	0.13	0.2	0.1	0.22
2011	0.26	0.16	0.11	0.27	0.39	0.49	0.43	0.59	0.34	0.2	0.13	0.18
2012	0.15	0.22	0.17	0.15	0.34	0.34	0.47	0.55	0.1	0.17	0.14	0.27
2013	0.48	0.23	0.07	0.15	0.28	0.37	0.27	0.44	0.13	0.39	0.21	0.07
Mean	0.17	0.13	0.12	0.15	0.35	0.37	0.36	0.39	0.19	0.2	0.15	0.13

Table 2.2-10: Generated mean monthly flow (m^3/sec)
Pintatagan River, Drainage Area= 37.2 sq. km.

YEAR	JAN	FEB	MAR	APRL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1983	0.15	0.03	0.03	0.05	0.38	0.75	1.13	0.93	0.51	0.36	0.27	0.45
1984	0.22	0.28	0.38	0.3	0.29	0.62	0.35	0.19	0.43	0.41	0.18	0.17
1985	0.16	0.14	0.19	0.92	0.8	0.14	0.6	1.17	0.6	1.23	0.35	0.26
1986	0.76	0.17	0.19	0.12	0.37	0.89	0.46	0.17	0.67	0.36	0.33	0.02
1987	0.34	0.26	0.03	0.28	0.56	0.76	0.39	0.85	0.25	0.91	0.16	0.32
1988	0.07	0.24	0.85	0.91	0.76	0.56	0.46	0.54	1.04	0.39	0.16	0.19
1989	0.3	0.25	0.46	0.54	0.77	1.01	0.21	0.78	0.27	0.32	0.39	0.21
1990	0.09	0.1	0.12	0.52	0.9	0.35	0.75	0.73	0.66	0.49	0.32	0.15
1991	0.38	0.22	0.03	0.4	0.7	0.63	0.5	0.36	0.11	0.16	0.51	0.03
1992	0.01	0	0.01	0.02	0.36	0.75	0.96	0.26	0.4	0.21	0.43	0.22
1993	0.26	0.27	0.23	0.7	0.33	0.32	1.04	0.43	1.13	0.16	0.17	0.41
1994	0.13	0.18	0.24	0.73	0.84	1.2	0.2	1.38	0.32	0.4	0.14	0.18
1995	0.25	0.43	0.29	0.22	0.6	0.37	0.65	0.85	0.56	0.33	0.33	0.48
1996	0.54	0.25	0.1	0.14	0.47	0.54	0.49	0.38	0.3	0.49	0.54	0.11
1997	0.76	0.36	0.29	0.4	0.61	0.2	0.35	0.16	0.49	1.21	0.08	0.17
1998	0.11	0.06	0.02	0.09	0.79	0.51	0.51	0.34	0.67	0.56	0.41	0.2
1999	0.77	0.31	0.7	0.52	0.79	0.6	0.4	0.57	0.62	0.24	0.25	0.59
2000	0.84	0.7	0.56	0.3	0.34	0.64	0.61	0.93	0.17	0.76	0.48	0.31
2001	0.25	0.18	0.27	0.18	0.24	0.38	0.79	0.55	0.47	0.27	0.46	0.2
2002	0.32	0.37	0.09	0.12	0.39	1.22	0.18	0.74	0.54	0.35	0.49	0.07
2003	0.27	0.41	0.29	0.35	0.52	0.48	0.68	0.52	0.15	0.57	0.36	0.46
2004	0.25	0.39	0.41	0.51	0.81	0.32	0.64	0.06	0.81	0.49	0.21	0.59
2005	0.16	0.04	0.05	0.2	0.54	0.62	0.72	0.6	0.4	0.43	0.16	0.57
2006	0.49	0.33	0.61	0.18	0.71	0.91	0.66	0.61	0.4	0.5	0.26	0.19
2007	0.38	0.27	0.21	0.22	0.77	0.55	0.54	1.15	0.22	0.67	0.22	0.29
2008	0.43	0.37	0.54	0.35	0.6	1.33	0.62	0.21	0.94	0.47	0.75	0.16
2009	0.58	0.4	0.22	0.48	0.67	0.66	0.84	0.63	0.32	0.16	0.33	0.11
2010	0.39	0.04	0.13	0.37	0.21	0.3	0.88	1.01	0.34	0.49	0.21	0.46
2011	0.58	0.33	0.23	0.68	0.63	0.83	0.72	0.94	0.88	0.48	0.28	0.37
2012	0.33	0.47	0.37	0.38	0.56	0.59	0.78	0.76	0.27	0.42	0.3	0.57
2013	1.08	0.49	0.14	0.37	0.46	0.63	0.45	0.67	0.33	0.96	0.46	0.15
Mean	0.38	0.27	0.27	0.37	0.58	0.63	0.6	0.63	0.49	0.49	0.32	0.28

Table 2.2-11: Generated mean monthly flow (m^3/sec)
Punta Linao River, Drainage Area= 10.56 sq. km.

YEAR	JAN	FEB	MAR	APRL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1983	0.04	0.01	0.01	0.01	0.08	0.18	0.27	0.23	0.14	0.1	0.09	0.14
1984	0.06	0.08	0.09	0.07	0.06	0.15	0.09	0.05	0.12	0.12	0.06	0.05
1985	0.05	0.04	0.04	0.21	0.17	0.03	0.14	0.29	0.17	0.36	0.11	0.08
1986	0.22	0.05	0.04	0.03	0.08	0.21	0.11	0.04	0.18	0.1	0.1	0.01
1987	0.1	0.08	0.01	0.07	0.12	0.18	0.09	0.21	0.07	0.26	0.05	0.1
1988	0.02	0.07	0.19	0.21	0.16	0.13	0.11	0.13	0.29	0.11	0.05	0.06
1989	0.09	0.07	0.11	0.13	0.16	0.24	0.05	0.19	0.07	0.09	0.12	0.06
1990	0.03	0.03	0.03	0.12	0.19	0.08	0.18	0.18	0.18	0.14	0.1	0.05
1991	0.11	0.07	0.01	0.09	0.15	0.15	0.12	0.09	0.03	0.05	0.16	0.01
1992	0.01	0.01	0	0.02	0.08	0.18	0.23	0.07	0.11	0.06	0.14	0.07
1993	0.07	0.08	0.05	0.16	0.07	0.07	0.25	0.11	0.31	0.05	0.05	0.13
1994	0.04	0.05	0.06	0.17	0.18	0.28	0.05	0.35	0.09	0.12	0.05	0.06
1995	0.07	0.13	0.07	0.05	0.13	0.09	0.16	0.21	0.16	0.1	0.1	0.15
1996	0.16	0.07	0.02	0.03	0.1	0.13	0.12	0.09	0.08	0.14	0.17	0.03
1997	0.22	0.11	0.07	0.09	0.13	0.05	0.09	0.04	0.14	0.35	0.02	0.05
1998	0.03	0.02	0.01	0.02	0.17	0.12	0.12	0.08	0.18	0.16	0.13	0.06
1999	0.22	0.09	0.16	0.12	0.17	0.14	0.1	0.14	0.17	0.07	0.08	0.19
2000	0.24	0.21	0.13	0.07	0.07	0.15	0.15	0.23	0.05	0.22	0.15	0.1
2001	0.07	0.05	0.06	0.04	0.05	0.09	0.19	0.14	0.13	0.08	0.15	0.06
2002	0.09	0.11	0.02	0.03	0.08	0.29	0.04	0.18	0.15	0.1	0.15	0.02
2003	0.08	0.12	0.07	0.08	0.11	0.11	0.16	0.13	0.04	0.17	0.11	0.15
2004	0.07	0.12	0.09	0.12	0.17	0.08	0.16	0.01	0.22	0.14	0.07	0.19
2005	0.05	0.01	0.01	0.05	0.11	0.15	0.17	0.15	0.11	0.12	0.05	0.18
2006	0.14	0.1	0.14	0.04	0.15	0.21	0.16	0.15	0.11	0.15	0.08	0.06
2007	0.11	0.08	0.05	0.05	0.16	0.13	0.13	0.29	0.06	0.19	0.07	0.09
2008	0.12	0.11	0.12	0.08	0.13	0.31	0.15	0.05	0.26	0.14	0.24	0.05
2009	0.17	0.12	0.05	0.11	0.14	0.16	0.2	0.16	0.09	0.05	0.1	0.03
2010	0.11	0.01	0.03	0.09	0.04	0.07	0.21	0.25	0.09	0.14	0.07	0.14
2011	0.17	0.1	0.05	0.16	0.13	0.19	0.17	0.24	0.24	0.14	0.09	0.12
2012	0.09	0.14	0.08	0.09	0.12	0.14	0.19	0.19	0.07	0.12	0.1	0.18
2013	0.31	0.14	0.03	0.09	0.1	0.15	0.11	0.17	0.09	0.28	0.15	0.05
Mean	0.11	0.08	0.06	0.09	0.12	0.15	0.15	0.16	0.14	0.14	0.1	0.09

Table 2.2-12: Probability of Occurrence

Probability of Occurrence (%)	Discharge, m^3/sec				
	Piso River	Punta Linao River	Mapagba River	Maputi River	Pintatagan River
5	0.90	0.24	0.52	0.50	0.94
10	0.74	0.21	0.46	0.45	0.80
20	0.62	0.17	0.37	0.36	0.66
30	0.54	0.14	0.28	0.28	0.55
40	0.46	0.12	0.22	0.22	0.47
50	0.38	0.11	0.19	0.19	0.39
60	0.32	0.09	0.15	0.15	0.33
70	0.25	0.07	0.12	0.12	0.27
80	0.19	0.05	0.10	0.10	0.20
90	0.13	0.04	0.06	0.06	0.14
100	0.01	0.01	0.01	0.01	0.02

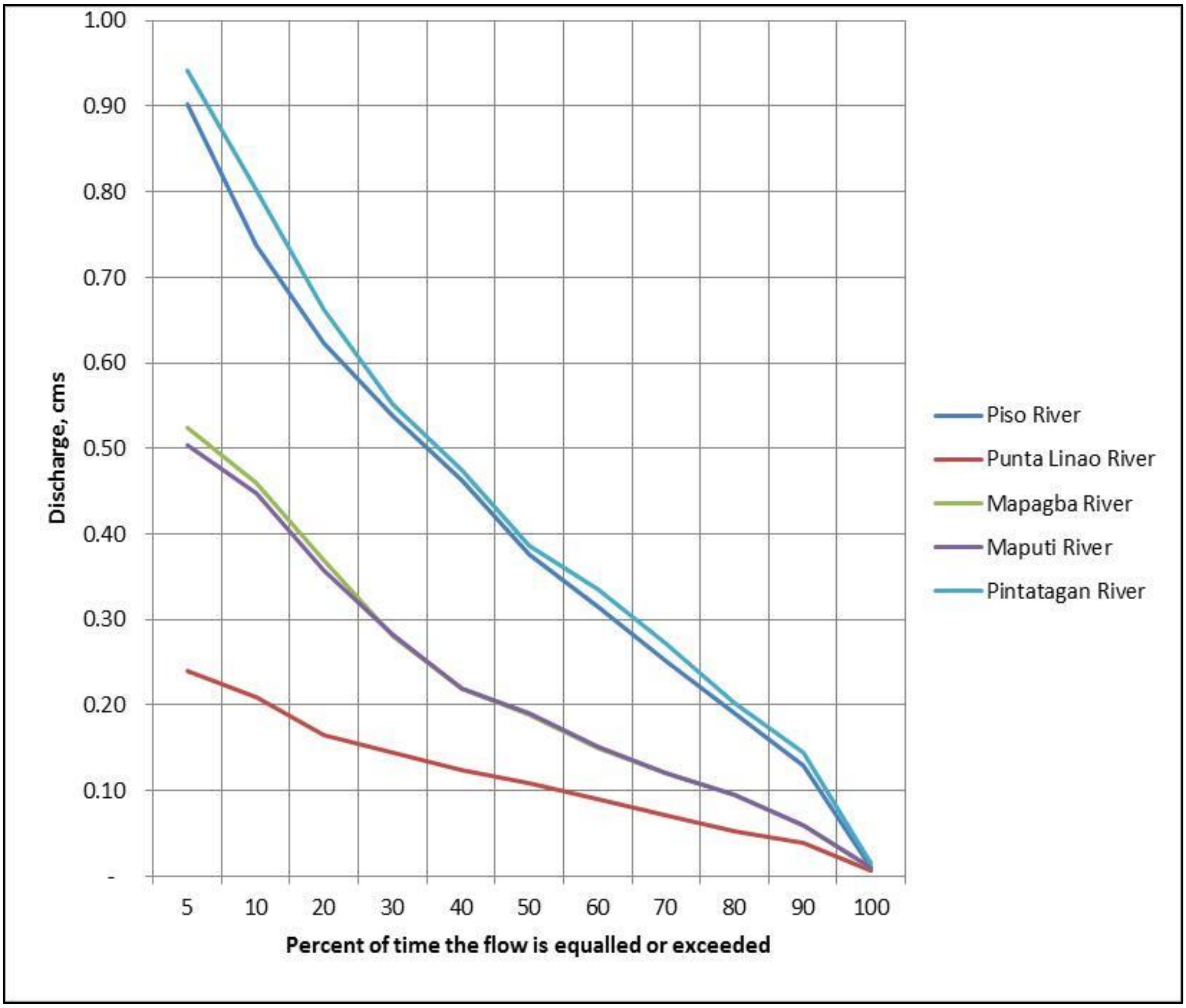


Figure 2.2-7: Flow Duration Curves

The capacity of each river system to deliver specific discharges is normally evaluated using the flow duration curve. It is also used in estimating the environmental flow that should be released downstream if the river is tapped for various purposes like irrigation, domestic, industrial or power generation. When applying for a water permit, the 80 % probability of occurrence is usually used as basis to determine the amount of water to be extracted.

The result of the flow duration analysis of the five rivers indicates rivers draining the mining site are perennial, meaning that there is always water throughout the year. Since most of the residents depends on the river systems for their domestic requirements like washing¸ bathing, navigation, etc. these river systems should be kept on the present quality to have a sustainable beneficial use. Although excessive erosion and siltation are taking place even without mine operation, this situation should be carefully considered in the mine planning in order to minimize the effects of erosion on the river systems. As far as the source of domestic water which is from springs, the headwaters of five rivers should be preserved and should be protected from any human activities that may cause adverse impacts to the spring source.

Photo 2.2-1: Maputi and Piso rivers used for Navigation to the Sea

Photo 2.2-2: Mapagba and Maputi rivers used for irrigation and domestic purposes like washing and bathing

2.2.1.3 Inducement of flooding and water resource competition

Flood Peak and Volume

As mentioned earlier, the rivers that traverse the mine area has no historical records particularly peak flows that will be used for flood analysis. As such, the regional flood analysis will be employed for the study.

All flood peak data of rivers within water resources region no. XI were collected and subjected to point frequency analysis to determine the peak flow values of different return periods utilizing the available historical data on annual flood peaks of the gaged rivers.

The procedure for the Regional Flood Frequency analysis involves the following procedure:

1. Estimation of Mean Annual Flood (MAF)
2. Estimation of Flood peak values with corresponding return periods

The MAF is determined by pooling all the annual flood data series of gaged rivers within water resources region no. XI taking into consideration the homogeneity of data observed, climate type, response to the climatologic and hydrologic inputs and size of the catchment area.

The equation of the MAF will take the form:

$$MAF = 11.5\ A^{0.502}$$

Where:

A = watershed area, km^2

To estimate flood values with corresponding return period, the MAF was multiplied by the factor (**Table 2.2-13)** obtained from the regional flood frequency curves which is a function of the watershed area.

Table 2.2-13: Constant value (k) of different return period of catchment area less or greater than 25 sq. km.

Return period, yr	k (factor)	
	Less than 25 sq. km	Greater than 25 sq. km.
5	1.39	1.39
10	2.13	2.05
26	3.22	3.00
50	3.85	3.55
100	4.95	4.32
200	6.40	5.5

The resulting equation will be:

$$Q_{tr} = q_{tr}MAF$$

Where:

Q_{tr} = flood discharge with the required return period (year)
q_{tr} = factor of the required return period of a watershed area (sq. km.)
MAF = Mean Annual Flood, cubic meters per second (cms)

Table 2.2-14 shows the results of the flood frequency analysis showing various return periods of flood peaks of the five (5) rivers that drains the mine site.

Table 2.2-14: Results of Flood Frequency Analysis

River Name	Drainage Area (sq.km)	Mean Annual Flood (MAF) in cms	Return period, year					
			5	10	25	50	100	200
1. Pintatagan	37.2	78	108	160	234	277	337	429
2.Piso-Catangawan	21.6	59	82	126	190	227	292	378
3. Mapagba	15.3	50	70	107	161	193	248	320
4. Punta- LInao	10.56	42	58	89	135	162	208	269
5. Maputi	10	40	56	85	129	154	198	256

The effects of climate change on the peak flows were incorporated in the resulting peak flows including change in land use (4 percent for climate change and 6 percent for change in land use).

In terms of extreme floods, Pintatagan River, Piso-Catunagwan River and Mapagba River are the most serious area that are most likely be affected. However, the big concentrations of settlement areas in the drainage outlets of Piso-Catungawan and Mapagba rivers put these areas into top most priorities in terms of flood mitigation.

Regulation on the release of storm water at the mining site through the construction of settling ponds could be the most effective measure to control floods at the downstream areas. Regular dredging of silted portions of the river channels will also supports the efforts upstream.

As an input in planning and design of siltation ponds or sedimentation basin a rational method is suggested using the Rainfall Intensity Duration Frequency with 5 -10 up to 30-minute intensity duration (RIDF) of Davao City rainfall station. It is suggested to use the recurrence interval or return period of 5 or 10 years in the design.

Table 2.2-15: Rainfall-Intensity-Duration-Frequency (RIDF) Davao Station

COMPUTED EXTREME VALUES (in millimetres) OF PRECIPITATION										
Return Period	5	10	15	30	60	2	3	6	12	24
Years	mins	mins	mins	mins	mins	hours	hours	hours	hours	hours
2	12.2	21.7	29.6	46.9	67.1	75.5	78.7	83	84.3	95.3
5	14.9	26.9	36.7	59.2	82.9	92.8	96.2	111.3	114.1	129
10	16.8	30.4	41.4	67.3	93.3	104.2	107.7	130.1	133.9	151.2
15	17.8	32.4	44.1	71.9	99.2	110.6	114.3	140.6	145	163.8
20	18.5	33.7	45.9	75.2	103.4	115.1	118.8	148.1	152.8	172.6
25	19.1	34.8	47.4	77.6	106.6	118.6	122.4	153.8	158.8	179.4
50	20.8	38.1	51.8	85.3	116.4	129.3	133.2	171.3	177.3	200.3
100	22.4	41.3	56.2	92.9	126.1	139.9	144	188.8	195.6	221
INTENSITY (in millimetres/hour) OF COMPUTED EXTREME VALUES										
Return Period	5	10	15	30	60	2	3	6	12	24
Years	mins	mins	mins	mins	mins	hours	hours	hours	hours	hours
2	146.4	130.2	118.4	93.8	67.1	37.8	26.2	13.8	7	4
5	178.8	161.4	146.8	118.4	82.9	46.4	32.1	18.3	9.5	5.4
10	201.6	182.4	165.6	134.6	93.3	52.1	35.9	21.7	11.2	6.3
15	213.6	194.4	176.4	143.8	99.2	55.3	38.1	23.4	12.1	6.8
20	222	202.2	183.6	150.4	103.4	57.3	39.6	24.7	12.7	7.2
25	229.2	208.8	189.6	155.2	106.6	59.3	40.8	25.6	13.2	7.5
50	249.6	228.6	207.2	170.6	116.4	64.6	44.4	28.5	14.8	8.3
100	268.8	247.8	224.8	185.8	126.1	70	48	31.5	16.3	9.2

Hydrological Hazards

Hydrological hazards are extreme events associated with water occurrence, movement, and distribution. These are classified into fluvial or those generated by processes on-land and coastal for those occurring at the sea interface. Only the applicable hydrological hazards are presented in this section.

Fluvial Hazard

Flooding

As mentioned in the landslide and erosion sections above, mine development, construction of facilities and mining operation will provide sources of sediments that will eventually arrive to natural waterways when left uncontrolled. These sediments will increase the sediment load of the rivers and the flow will be more erosive. Stream erosion can occur along channels and riverbanks where adjacent farmlands and built-up areas are present. Finer sediments will be transported farther downstream and will eventually reach the coastal area and offshore.

As discussed in the landslide and erosion sections, sediment control structures such as siltation ponds, drainage canals and check dams will be constructed at appropriate locations. Additional sediment and debris control structures must be installed in the upper reach of the streams if the above-mentioned structures are insufficient. These include debris basins, debris deflector and debris rack. Debris dams and basins are structures placed across well-defined channels to form basins which impede the stream flow and provide storage space for deposits of detritus and floating debris. They are suitable at sites that convey heavy debris loads where it is economically impracticable to provide a culvert large enough to convey the surges of debris. They are also used to trap heavy boulders or coarse gravel that would clog culverts, especially on low fills. Debris deflectors are structures placed at the culvert inlet to deflect the major portion of the debris away from the culvert entrance. They are normally "V"-shaped in plan with the apex upstream. Debris racks are structures placed across the stream channel to collect the debris before it reaches the culvert entrance. Debris racks are usually vertical and at right angles to the streamflow, but they may be skewed with the flow or inclined with the vertical. All these structures need regular maintenance after each flood event. Segments of the channels upstream of the road must be graded to decrease the channel gradient. This will decrease the flow velocity and allow deposition of debris. When a enough space is available, the bank of the channel must be widened to accommodate deposition of more debris. Regular removal of accumulated debris must be done to prevent remobilization and provide space for the debris that will be brought by the next flood event. Large boulders must be pushed to the sides of the channel to form rock armor that will help in decreasing bank erosion particularly in outer meander bends. As part of watershed management, non-structural measures must be done to minimize flood magnitude. This will include removal of dead or decayed trees away from unstable slopes, bio-stabilization of hillsides, protection of undisturbed forests from logging and wildfires and installation of fascines in streambanks to promote recolonization of riparian vegetation.

As shown in the list of disasters that affected this region, floods occur regularly in recent years. It is expected that the flood magnitude, frequency and sediment yield of the rivers will also increase due to the projected increase in rainfall during the wet season because of climate change (DOST-PAGASA, 2011). Given the steep topography, abundant supply of sediments and nature of the project, structural measures for flood control may not be enough to address the flooding and landslide issue in the near future. Non-structural disaster mitigation measures must be implemented in line with the LGUs Disaster Risk Reduction and Management (DRRM) plans. One of such measures is to establish an early warning system for landslide and flood. It will consist of weather stations located in the upper watershed area to measure rainfall and other weather data that will be used to issue flashflood and landslide warnings. However, it is necessary first to come up with a rainfall threshold values for landslide and flooding. This will be done by reviewing the rainfall records of past flood and landslide events in the area. A stream gauge will also be setup in the upper reach of Pintatagan, Mapagba and MaputiRivers to provide timely warnings for downstream flooding. A flood warning system must be developed. It will consist of three levels, namely: Level 1 - Alert; Level 2 - Prepare; and Level 3 - Evacuate. Multi-hazard evacuation centers will also be established in safe, accessible areas. Hazard and vulnerability mapping will be conducted to determine priority households/areas for evacuation or relocation. Information dissemination regarding flood hazard and warning system will be conducted to prepare the communities. In addition, signages regarding river flooding and landslides will be put in place in affected areas to increase community awareness.

Soil Erosion Susceptibility and Sediment Yields

Sediment yield could not be directly quantified for the different river systems because there is no sediment load data found in any of the rivers in the area including those in the vicinity of the mining site. Because of this limitation, the use of empirical predictive model is applied.

One method that is already used in some catchment studies in the country is the Soil Erosion Design Curve, developed by Al Khadimi in 1982 from a number of sites around the world. It is a simple model that takes into consideration the current condition of the catchment area in terms of land use/vegetative cover and disturbances that are associated to the land uses, rainfall, topography/slope, soils. The erosion factors, parameters and indices for the model are presented in **Table 2.2-16**.

This method assigns a numerical value to different ranges of catchment characteristics to calculate the Soil Erosion Index of the form:

SEI = SF*RF*ST*CF*DF

Where: SEI = Soil Erosion Index
SF = slope of the catchment
RF = the climate, based on Fournier's p^2/Pa index
ST = soil type, based on USDA classification
CF = cover/vegetation factor
DF = disturbance factor

Once the SEI is calculated using the above formula, the corresponding sediment yield can be determined. In Figure 10.0, the relationship between the Soil Erosion Index and Sediment Yield is presented.

The rainfall index (RF) for the site is estimated using the rainfall data at Davao City station with maximum monthly rainfall of 456.7 mm and the average annual rainfall of 1,803.2 mm. The calculated rainfall distribution ratio is about 115.7 which is equivalent to the maximum SEI of 5.

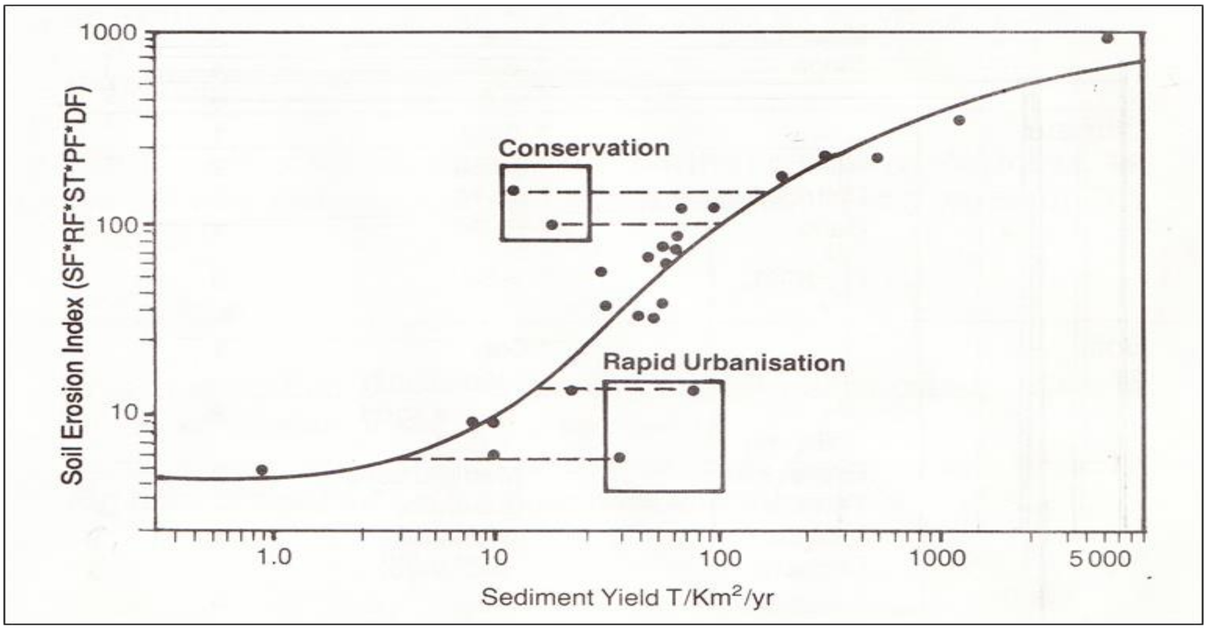


Figure 2.2-8: Soil Erosion Design Curve (Al Khadimi,1982)

Table 2.2-16: Erosion Factors, Parameters and Indices

Soil Erosion Factors and their Parameters		Erosion Index Scales	
		Parameter Class	**Soil Erosion Index**
Climate (RF)	Rainfall Distribution Ratio (p^2/pa), mm	0-30	1
		30-50	2
		50-70	3
		70-90	4
		>90	5
Topography (SF)	Mean Slope, %	0-3	1
		3-8	2
		8-18	3
		18-30	4
		>30	5
Soil (ST)	Soil Type , in median diameter	Clay (d50<0.002)	1
		Coarse Sand (1-0.5)	2
		Medium Sand (0.05-0.002)	3
		Fine Sand (0.25-0.05)	4
		Silt (0.05-0.002)	5
Land Use/Vegetative Cover	Type (PF)	Virgin Forest/Primary Forest	1
		Woodland/Secondary Forest	2
		Pasture/Grasslands/Brushlands	3
		Agricultural/Cultivated	4
		Bare Ground	5
	Frequency of Top Soil Disturbance (DF)	In (100)years	1
		In (30) Years	2
		Grazing	3
		Annual Cultivation	4
		Multiple Annual & Vegetation Clearance	5

Soil Erosion Susceptibility

Using the above parameters, susceptibility on soil erosion can be determined. **Table 2.2-17** presents the soil erosion susceptibility classification showing the soil erosion index and its corresponding description.

Table 2.2-17: Soil Erosion Susceptibility Classification

Soil Erosion Index	Description
1	No apparent Erosion
2	Slight Erosion
3	Moderate Erosion
4	Severe Erosion
5	Very Severe Erosion

[1] **Soil Erosion-Simple Predictive Models, G.Hare, Hydraulics Research Wallingford, UK,January, 1987**

Particular to the watersheds within the mining area (**Figure 2.2-9**), majority or more than 90 % of the watershed areas, is classified under moderate to severe erosion. This means that developmental activities should be properly designed to minimized soil erosion and sedimentation in the downstream areas. Appropriate design and proper locations of erosion control measures like settling ponds, silt traps, etc. should be adopted in the mining operations. In addition, clearing of vegetation should be minimized especially in areas where the slope is steep.

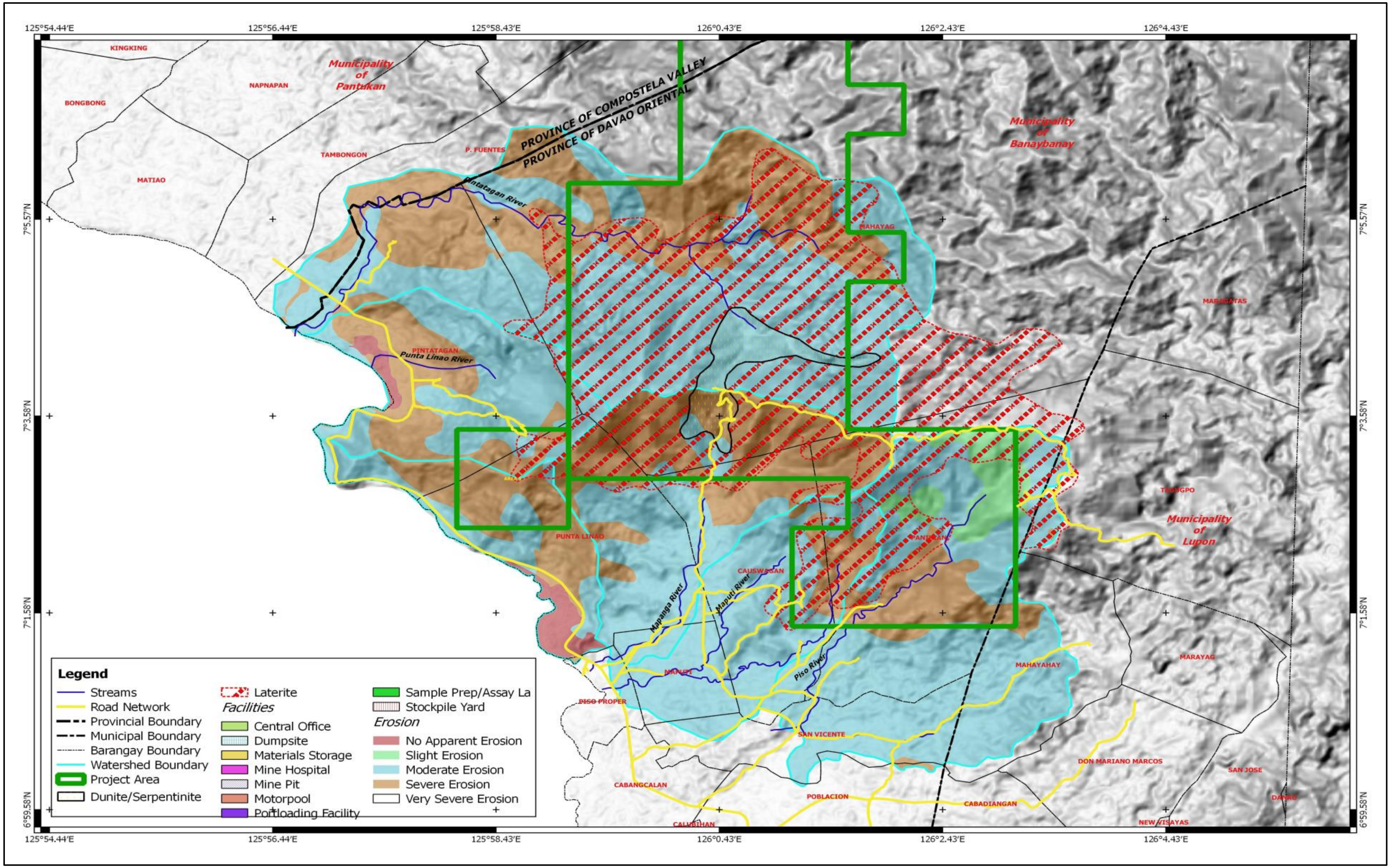


Figure 2.2-9: Soil Erosion Susceptibility Map

Sediment Yield

The product of the above indices gives the Soil Erosion Index and a corresponding value of sediment yield is obtained by interpolating from the graph in **Figure 2.2-8**. The estimated sediment yields for each of the watershed are presented in **Table 2.2-18**.

Table 2.2-18: Estimated Sediment Yield

Watershed	Drainage Area,	Sediment Yield
	km^2	tons/ha/yr
Pintatagan	37.20	21.63
Piso-Catungawan	21.60	8.37
Mapagba	15.30	8.15
Punta Linao	10.56	28.98
Maputi	10.00	6.52
Punta Linao Proper	6.76	25.47

The estimated sediment yields vary from each watershed. Maputi watershed registered the lowest at 6.52 tons/ha/yr to as high as 28.98 tons/ha. /yr. at Punta Linao watershed. Considering that Maputi watershed as well as Piso-Catungawan watershed has a big area of gentle slopes, the rates observed at Punta Linao waterhedshed may be used in the initial designs of settling ponds.

Size Gradation of Bed Loads

On the same location where flow measurements were conducted, bed load sampling was also conducted by grab method for size grading analysis. In addition, one bed load sample was collected along the shoreline at the exit point of Piso River where severe sedimentation is occurring. This will give us information on the uniformity of the sediment being transported by the rivers from the mining site. It could also aid designers in sizing geotextile filter as a measure in controlling sediment load downstream. Presented in **Figure 2.2-10** is the result of the analysis of the bed load samples.

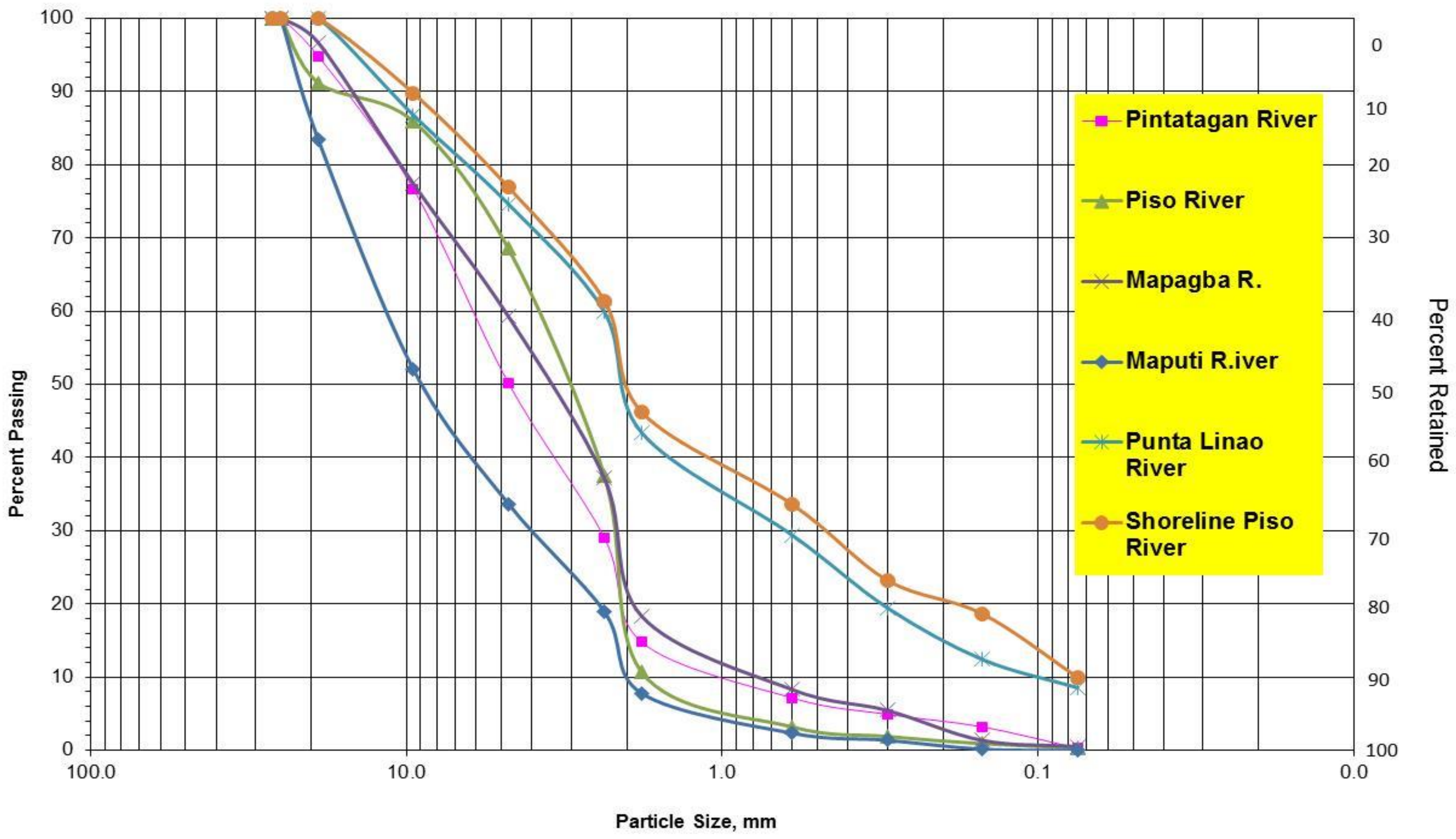


Figure 2.2-10: Size gradation analysis of bed load samples

2.2.1.4 Reduction / Depletion of groundwater flow

The hydrological conditions in the Country were broadly evaluated on a region wide basis by JICA-NWR-DPWH in the Master Plan Study on Water Resources Management in the Republic of the Philippines in 1998. Ground water availability Map was produced similar. From the viewpoint of groundwater development, the area was divided into the following categories:

Table 2.2-19: Groundwater Categories

Category	Description
Shallow & Deep Well Area	It is equivalent to the alluvial plain area that has a groundwater basin consisting of several aquifers and aquicludes. The aquifers consist of sand and gravel layers as well as impervious layers of clay and/or silt. In these areas, shallow and deep groundwater is available.
Deep Well Area	This correspond to diluvium and/or tertiary sediments mainly of the Neogene age which have low groundwater potential as compared to shallow and deep well areas.
Difficult Area	This type of area is the best suited to the development by hand pump deep wells that require small pumping rates corresponds to areas that are difficult in terms of groundwater development. The geology of this type of areas that are difficult in terms of groundwater development. The geology of this type of area is composed mainly of intrusive rocks, metamorphosed rocks and volcanic rocks.

As shown in **Figure 2.2-11**, groundwater in the mine site is considered difficult but on the lower slope towards the coastal areas where settlements are located, it is categorized as shallow and deep well area.

In order to assess the level of ground water condition and utilization in the area, existing wells being used by the communities were surveyed (**Figure 2.2-12**). Please refer to **Table 2.2-20** for the dates when the survey was conducted. The concentrations of ground water utilization were found in Barangays Maputi and Piso Proper. Very rare utilizes ground water wells in the upper barangays towards the mining area apparently because of the difficulty of extraction. Some of the wells in the coastal barangays are not utilized for drinking because of its poor quality and salty tastes. It is possible that saltwater intrusion is already occurring in some areas. Groundwater extraction is obviously unregulated because not a single well has permit from LGUs or proper authorities. Summarized in Table **2.2-25** are the wells and water systems visited.

It is therefore recommended that an in-depth study on the groundwater availability and quality be undertaken in order to guide the communities. Utilization of groundwater resource in the area should also be regulated.

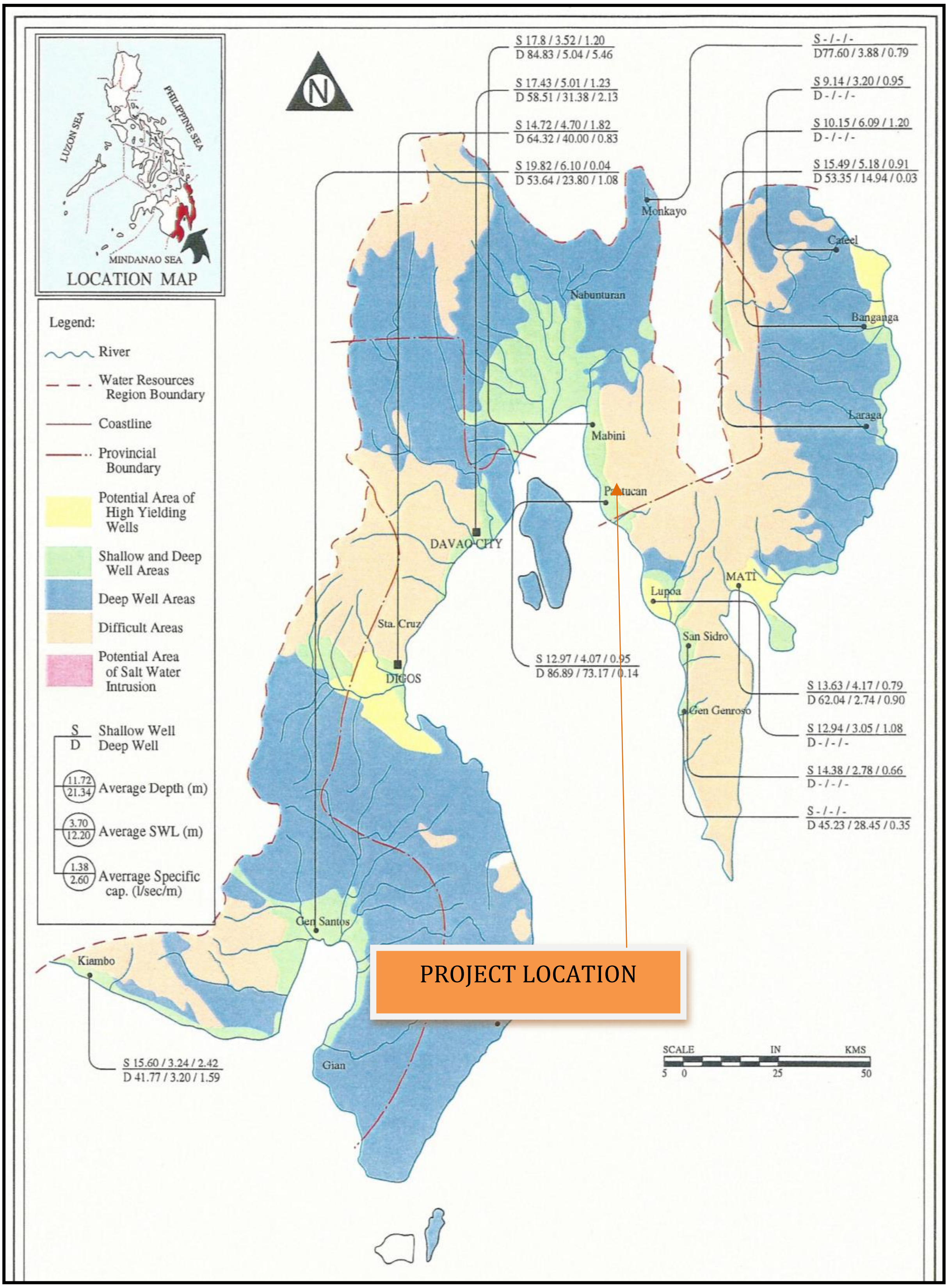


Figure 2.2-11: Groundwater Availability Map of Region XI (Source:

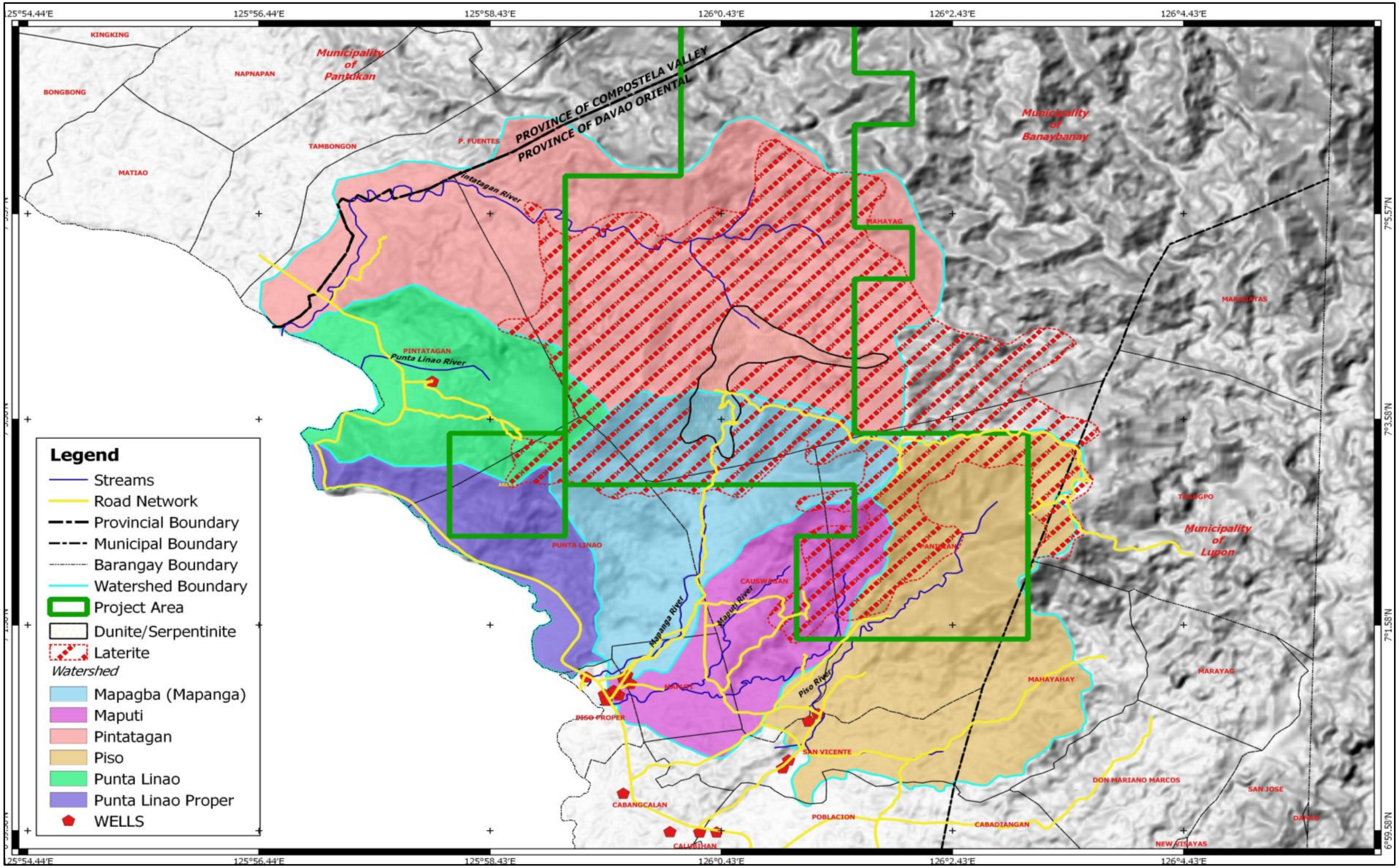


Figure 2.2-12: Location Map of Wells and Springs Surveyed

Table 2.2-20: Ground Water Wells and Springs/Water System

CODE	Date of Survey	Time	Sitio/Barangay	Coordinates		Approx. Depth, m	Type	Status	Pictures
				Long	Lat				
GW-1	29-Sep-16	3.07 PM	Purok Buhangin, Brgy. Causwagan	07° 00' 38.3"	126° 01' 11.2"	18.3	Deepwell	Potable	
GW-2	29-Sep-16	5:08 PM	Brgy Piso	06° 59' 33.7"	126° 00' 14.7"	Freeflowing		Not Potable	
GW-3	30-Sep-16	2:54 PM	Brgy Piso	06° 59' 56.3"	125° 59' 35.1"	121.9	Deepwell	Not Potable/Salty Water	

CODE	Date of Survey	Time	Sitio/Barangay	Coordinates		Approx. Depth, m	Type	Water Quality	Pictures
				Long	Lat				
GW-4	30-Sep-16	3:15 PM	Brgy Piso	06° 59' 33.7"	126° 00' 23.5"	Freeflowing Well		Potable	
GW-5	1-Oct-16	8:31 AM	Purok San Francisco, Brgy. Causwagan	07° 00' 11.1"	126° 00' 57.7"	36.6	Deepwell	Potable	
GW-6	1-Oct-16	8:41 AM	Purok San Francisco, Brgy. Causwagan	07° 00' 15.7"	126° 01' 00.8"	48.8	Deepwell	From Spring Near MPSA serving about 70 households, potable	

CODE	Date of Survey	Time	Sitio/Barangay	Coordinates		Approx. Depth, m	Type	Water Quality	Pictures
				Long	Lat				
GW-7	1-Oct-16	9:14 AM	Purok 5, Brgy. Maputi	07° 00' 56.0"	125° 59' 30.4"	18.3	Deepwell	Potable	
GW-8	1-Oct-16	9:15 AM	Purok 5, Brgy. Maputi	07° 00' 56.2"	125° 59' 30.2"	24,4	Deepwell	Not Potable	
GW-9	1-Oct-16	9:18 AM	Prk. 5, Brgy. Maputi	07° 00' 55.2"	125° 59' 30.6"	18.3	Deepwell	Not Potable	

CODE	Date of Survey	Time	Sitio/Barangay	Coordinates		Approx. Depth, m	Type	Water Quality	Pictures
				Long	Lat				
GW-10	1-Oct-16	9:42 AM	Prk. 7, Brgy, Maput	07^{o} 01' 04.1"	125^{o} 59' 35.6"	12.2	Deepwell	Not Potable	
GW-11	1-Oct-16	9:49 AM	Prk. 7, Brgy, Maputi	07^{o} 00' 54.0"	125^{o} 59' 25.3"	12.2	Deepwell	Not Potable	
GW-12	1-Oct-16	9:55 AM	Prk. 2, Brgy. Maputi	07^{o} 00' 50.5"	125^{o} 59' 26.3"	54.9	Deepwell	Potable	

CODE	Date of Survey	Time	Sitio/Barangay	Coordinates		Approx. Depth, m	Type	Water Quality	Pictures
				Long	Lat				
SW-1	29-Sep-16	3.51 PM	Sitio Kalangawan, Brgy Causwagan	07° 00' 42.7"	126° 01' 16.0"		Spring	From Spring Near MPSA serving about 50 households, potable	
SW-2	30-Sep-16	1:42 PM	Habitat Community, Brgy, Punta Linao	07° 03' 56.4"	125° 57' 56.1"		Spring	Potable	
GW-3	30-Sep-16	2:39 PM	Purok 5, Brgy. Maputi	07° 00' 53.7"	125° 59' 32.7"		Spring	Not Potable	

SYSTEM WATER BALANCE

The relationship between the supply and demand of the mining area can be presented using the system water balance, as expressed in the equation below:

$$S - D = \Delta s$$

Where: S is the system supply
D is the system demand
∆s is the system storage

In this study, the system is referred to as the water resources within the delineated catchments, which covers the mine, as represented by the MPSA, and, the water users identified within the delineated catchments. As previously presented in **Figure 2.2-2** (Watersheds draining the MPSA/ Ore deposit area), hydrologically, there are 6 catchments identified, namely, (1) Piso-Catangawan, (2) Mapagba/ Mapanga, (3) Maputi, (4) Pintatagan, (5) Punta Linao, and, (6) Punta Linao Proper. Although the latter has no definite single river system, it was included as it belongs within the project area bounds. In general, the entire system is bound by the border of the catchments and is 101.05 sq. km in area.

Water Supply/Source

In terms of water studies, the system supply is the identified sources of water within the system bounds. In this case, these are the defined surface water and groundwater sources in the area. The estimated monthly discharges of the rivers in each catchment, defined in the preceding statements, are previously presented in the main report particularly in **Table 2.2-21** (Estimated monthly discharges of Rivers/ Watersheds in the MPSA).

The estimates for the surface water supply is derived from the presented flow duration curve **(Figure 2.2-7).** Discharge values (expressed in m^3/day) of each river at 80% probability of occurrence is used for conservative purposes. The estimated discharges for each river is presented below.

Table 2.2-21: Estimated Discharge of Rivers/ Watersheds in the MPSA

Probability of Occurrence	Piso River	Punta Linao River	Mapagba River	Maputi River	Pintatagan River
5	77,760.00	20,736.00	44,928.00	43,200.00	81,216.00
10	63,936.00	18,144.00	39,744.00	38,880.00	69,120.00
20	53,568.00	14,688.00	31,968.00	31,104.00	57,024.00
30	46,656.00	12,096.00	24,192.00	24,192.00	47,520.00
40	39,744.00	10,368.00	19,008.00	19,008.00	40,608.00
50	32,832.00	9,504.00	16,416.00	16,416.00	33,696.00
60	27,648.00	7,776.00	12,960.00	12,960.00	28,512.00
70	21,600.00	6,048.00	10,368.00	10,368.00	23,328.00
80	16,416.00	4,320.00	8,640.00	8,640.00	17,280.00
90	11,232.00	3,456.00	5,184.00	5,184.00	12,096.00
100	864.00	864.00	864.00	864.00	1,728.00

For the Springs/Groundwater, there are three identified sites; two existing springs and one new /proposed (pls. refer to figure below). The latter is recommended by the company for their domestic usage. As shown in a map below, the Punta Labo sub-catchment, Piso-Catungawan sub-catchment, and in the upper portion of the Mapanga sub-catchment. The latter is a natural spring where the company planned to develop for their domestic water supply. Initial investigation by the company revealed that the estimated flow could yield to about 192 m^3/day.

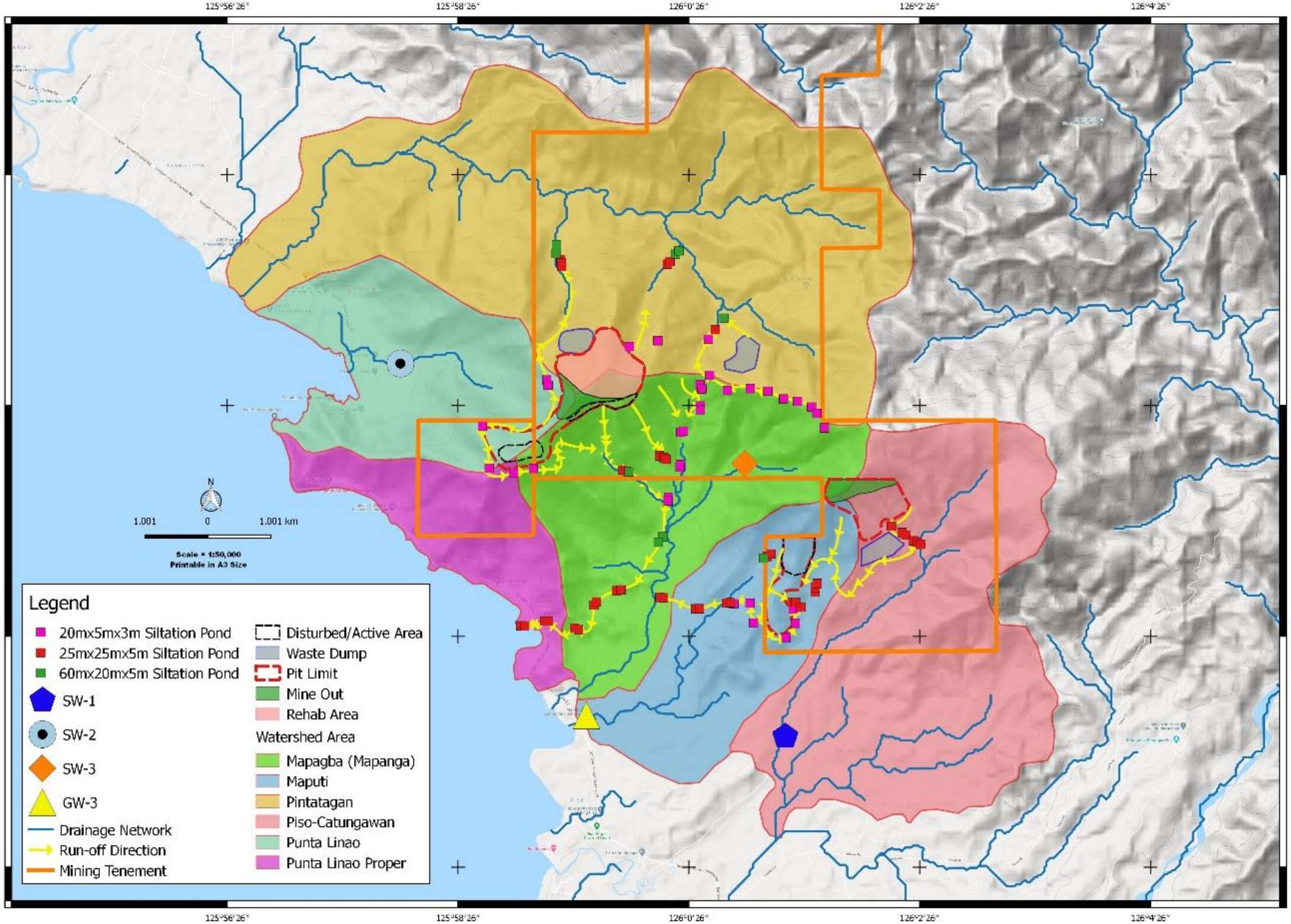


Figure 2.2-13: Identified Groundwater Sites around the MPSA Area

Water Requirements/Demand

The water requirements for the mining operations as well as the intended sources were provided by the company. The intention of the company is to source their domestic water requirements from springs because it is more economical considering the lesser treatment requirements. For their other requirements with lower quality standards, it is planned to be source out from Mapanga and nearby river system. Presented in the succeeding table are the estimated requirements for the mining operations.

Table 2.2-22: Water Requirement of the Proposed Project

Usage	Volume
1. Domestic water supply requirements	Volume, m^3/day
a. Potable use (water refilling)	15.0
b. Domestic use (offices)	20.0
c. Domestic use (others)	65.0
Total	**100.0**
2. Mining operations (environmental)	
a. dust suppression	190.0
b. nursery maintenance	9.0
c. Environmental emergency	5.0
Total	**204.0**

Water Balance

Comparisons of the supply and demand for water by sources are summarized below:

Table 2.2-23: Comparison of the Supply and Demand for Water by Sources

Purpose/Source	Supply, (m^3/day)	Demand (m^3/day)
1. Domestic use (Spring)	193	100
2. Environmental uses	8,640	204

The above results show that the demand of 100 m^3/day can be supplied from the Mapagba Spring with a capacity of about 193 m^3/day. On the other hand, the requirements for environmental uses is only a small percentage (2.4 %) of the dependable flow of Mapagba River. It should be noted that the communities along the river are not withdrawing water for domestic use. It is only used for washing and occasionally bathing which may not be affected.

Sediment Transport Modeling

Field Observation

As part of the input data necessary in setting up a numerical model for Riverbend Consolidated Mining Corporation Project in the municipality of Banaybanay, Davao Oriental, a two-day field reconnaissance survey and coastal oceanographic data gathering were conducted last January 20-21, 2018. Methodologies of the field surveys and data gathered are summarized below:

Tidal Observation

An automatic water level logger was set up at a location Southwest of the RCMC MPSA area from 10:00 AM of January20 to 11:00 AM of January21, 2018 submerged about one and a half meters (1.5 m) below the surface to automatically record the fluctuations in water level every five (5) minutes. Figure below shows the raw data of the tidal pattern, as well as the ambient water temperature, observed and the recorded over a 25-hour observation period. This water level time series were then adjusted into a mean sea level datum as reference and used for comparative analysis and calibration of the tidal water levels predicted during the same period from the results of the hydrodynamic model.

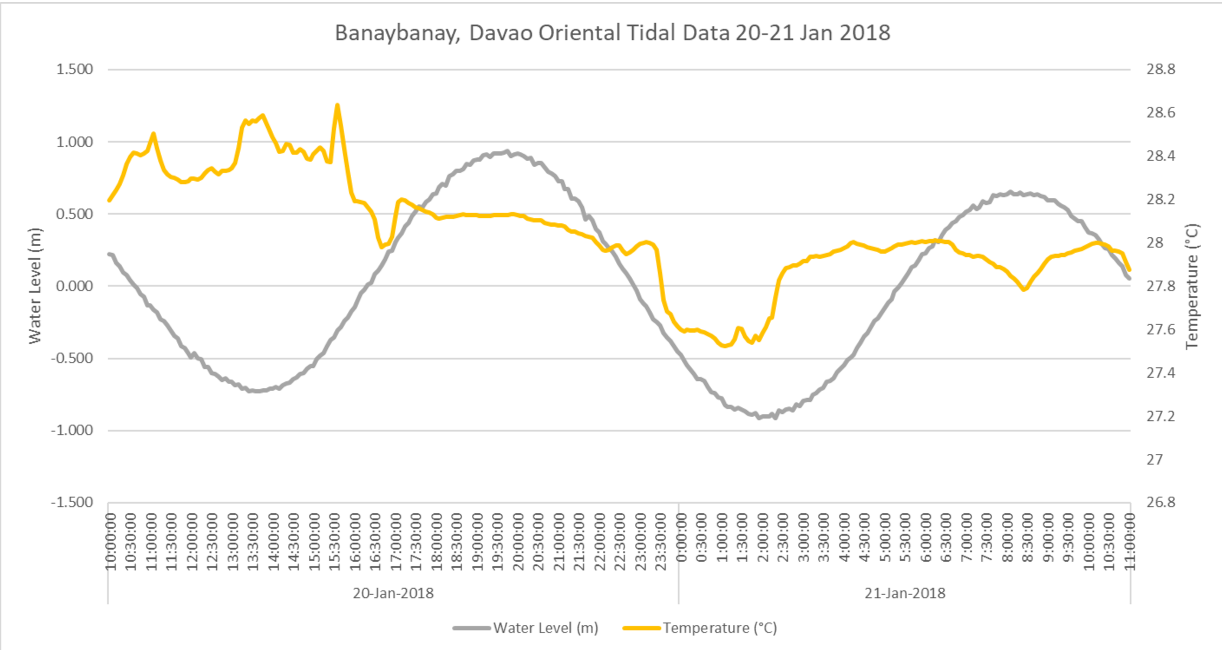


Fig. 2.2-14. Tidal fluctuation and water temperature recorded during the observation period

Tidal water levels of the nearest gauging stations, i.e. Davao City and Mati Pujada Bay were also used to cross reference the observed tide levels in Banaybanay. **Table 2.2-19** summarizes the amplitudes and phases of the major tidal constituents for the said stations. The Form Number (F) or the amplitude ratio, is used to determine the best description of the tide in an area. Based on the values of tidal harmonics, the computed Form Number is about 0.503, which can be interpreted that the area is experiencing mixed primarily semidiurnal tides (i.e., two highs and two lows in a given day).

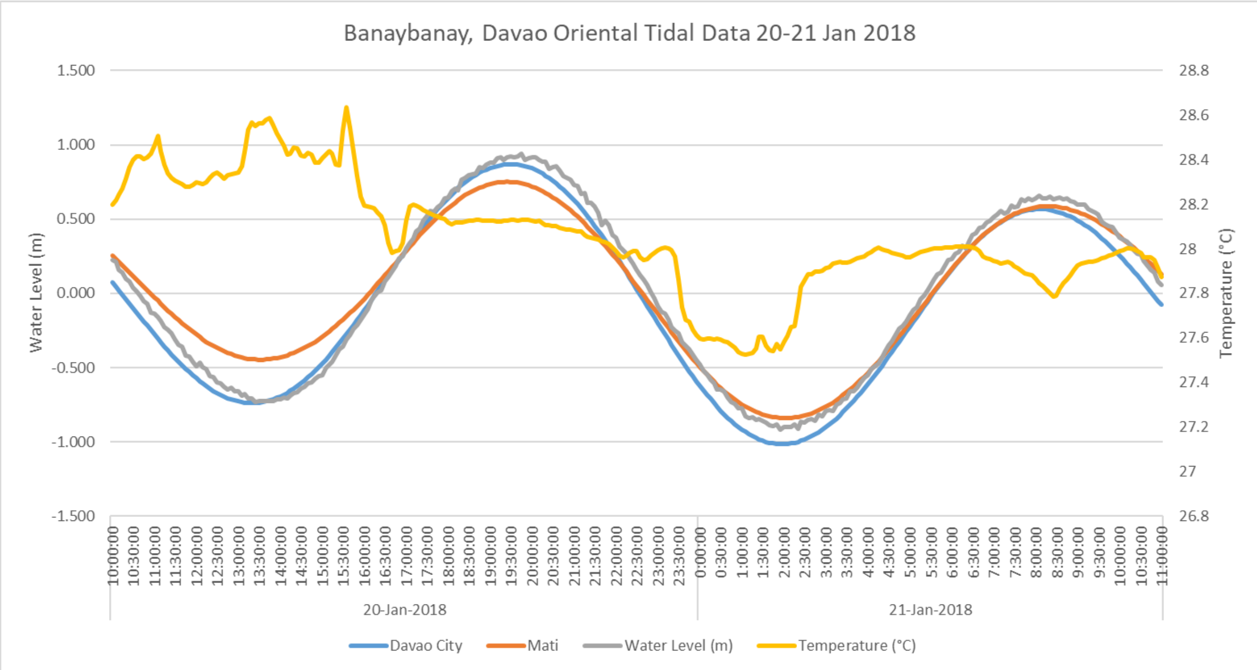


Fig.2.2-15. Tidal levels observed from Banaybanay Davao Oriental showing pattern consistency with simulated tidal models of Davao City and Mati Pujada Bay observation points

Table 2.2-19 Summary of Tidal Constituent for Davao City and Mati Pujada Bay Tidal Stations

Tidal constituent	Davao City		Mati Pujada Bay	
	Amplitude (m)	Phase (deg)	Amplitude (m)	Phase (deg)
Semi-diurnal Species				
M2 (principal lunar)	0.586	283.527	0.550	286.527
S2 (principal solar)	0.295	317.100	0.240	311.600
N2 (elliptical lunar)	0.102	273.182	0.102	265.582
K2 (declination lunar-solar)	0.084	305.143	0.065	311.543
Diurnal Species				
K1 (declination lunar-solar)	0.153	117.171	0.165	86.772
O1 (principal lunar)	0.105	99.656	0.134	70.756
P1 (principal solar)	0.060	106.429	0.055	86.829
Q1 (elliptical solar)	0.022	100.411	0.026	62.811

Wind Pattern, Surface and Sub-surface Water Movement

Wind as one of the principal driving forces influencing most coastal processes, constitutes vital information for physical oceanography and is therefore included in the field observation. A portable digital anemometer was used to measure wind speed and direction. Based on observation, mean wind velocity during the field survey was 1.60 meters per second generally coming from the west direction. It can be noted that the average wind velocity readings were relatively low, that there were not even any wind velocity readings recorded on Station 02.

Table 2.2-24 Summary of wind influence observed from the four stations

Station	Location (UTM) Zone 51Q (Northing; Easting)		Location (DMS)		Wind Direction	Min Speed (m/s)	Max Speed (m/s)	Ave Speed (m/s)
01	825,148	782,344	7° 4.145'N	125° 56.555'E	NW	1.40	1.70	1.50
02	824,657	781,605	7° 3.734'N	125° 56.274'E	N.A.	0.00	0.00	0.00

Station	Location (UTM) Zone 51Q (Northing; Easting)		Location (DMS)		Wind Direction	Min Speed (m/s)	Max Speed (m/s)	Ave Speed (m/s)
03	829,362	776,360	7° 0.849'N	125° 58.848'E	SW	1.50	1.80	1.60
04	829,413	774,487	6° 59.824'N	125° 58.894'E	SW	1.00	1.20	1.10

Measurements of the magnitude of water surface currents were also made during this observation period using a digital flow meter. The directions of the prevailing surface current were determined using the compass function of the GPS. The average surface flow observed was 0.143 m/s generally towards the East.

Table 2.2-25. Summary of water surface flow observed from the three stations

Station	Location (UTM) Zone 51Q (Northing; Easting)		Location (DMS)		Surface Flow Direction	Min Flow Velocity (m/s)	Max Flow Velocity (m/s)	Ave Flow Velocity (m/s)
01	825,148	782,344	7° 4.145'N	125° 56.555'E	NE	0.10	0.20	0.15
02	824,657	781,605	7° 3.734'N	125° 56.274'E	E	0.08	0.06	0.07
03	829,362	776,360	7° 0.849'N	125° 58.848'E	ESE	0.10	0.30	0.20
04	829,413	774,487	6° 59.824'N	125° 58.894'E	NE	0.20	0.10	0.15

Sub-surface currents were observed on four areas (see series of maps below showing drift tracks) near the RCMC's proposed site. A drifter was assembled using a floating styro board, mounted with an air-tight compartment for the GPS receiver at the top and a stainless cross-bladed fin hitched at the bottom of the board with a 1.5-meter-long retractable stainless-steel tail. The drifter board was designed to be driven by sub-surface current with the least influence of wind. As the sub-surface flow strikes the underwater fin of the drifter while left adrift on open waters, the position of the drifter is recorded automatically using the GPS at every three (3) seconds interval. Using the position of the drifter at every specified time interval, the length of the segment traversed by drifter can be computed. The speed of the drift (subsurface) currents were then computed by dividing the distance travelled over the specified time interval. The prevailing direction of subsurface currents is likewise computed using trigonometric functions to determine the angle between two known positions. The trajectory of the drift currents can also be viewed as a map when the recorded coordinates are loaded in a GIS software (see figure below).

Based on drift current observations during that time, the average subsurface current is about 0.224 meters per second generally flowing southwards in the upper survey areas (Stations 01 and 02) and northwards in the lower survey areas (Stations 03 and 04).

Table 2.2-26. Summary of Sub-surface flow trajectories observed from the three stations

Track	Time Stamp		Time Lapsed	Start Position		End Position		Distance	Speed	Dir
	Start	End	(secs)	N	E	N	E	(m)	(m/s)	
01	1/20/18 11:55	1/20/18 12:32	2,219	825,148	782,344	825,179	782,078	272	0.123	S
02	1/20/18 12:40	1/20/18 13:02	1,315	824,657	781,605	825,003	781,105	631	0.480	CCW (SE)
03	1/20/18 14:18	1/20/18 14:43	1,501	829,362	776,360	829,323	776,442	102	0.068	CW (NW)
04	1/20/18 15:06	1/20/18 15:34	1,723	829,413	774,487	829,444	774,830	385	0.223	CW (NNE)

Fig. 2.2-13a

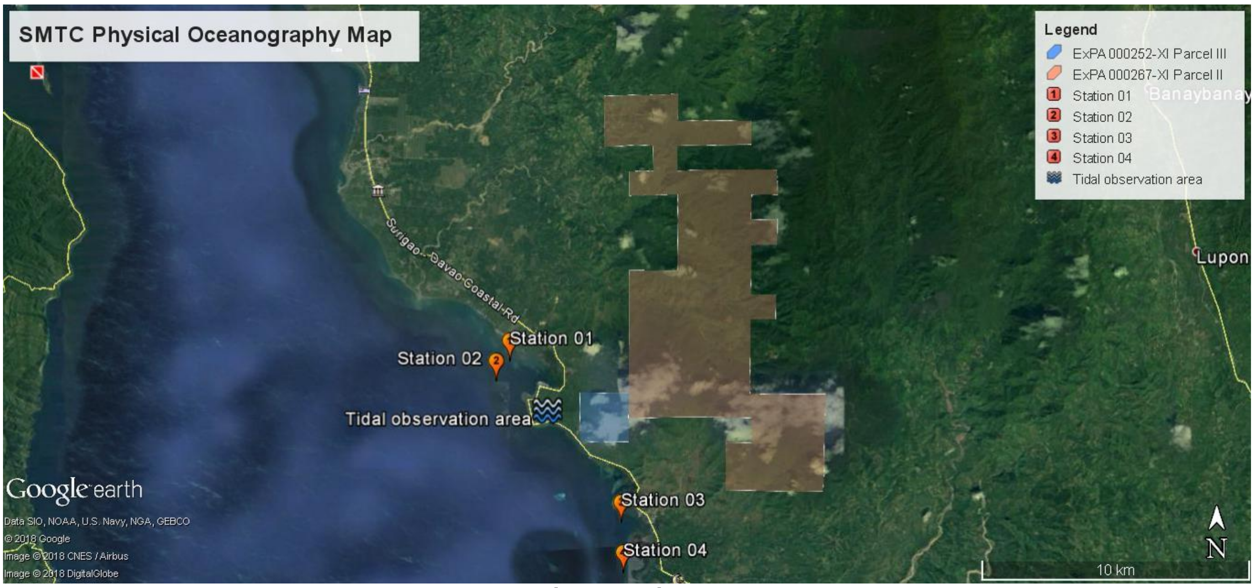


Fig. 2.2-13b

Fig. 2.2-13c

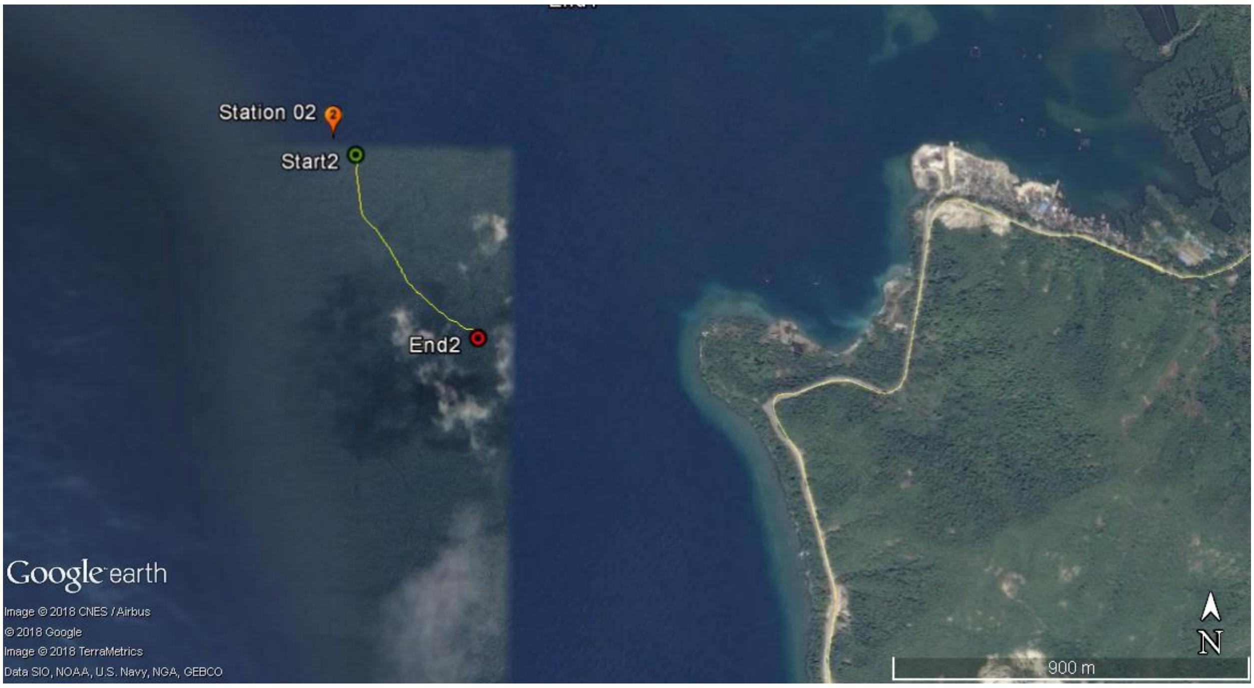


Fig. 2.2-13d

Fig. 2.2-13e

Fig. 2.2-13f

Figures. 2.13-c to f. Sub-surface flow trajectories observed from the four locations using a drifter (the actual trajectories are the yellow lines while start and end points are indicated for better visualization)

Bathymetry

One of the critical inputs of modelling in detail the coastal circulation, thermal stratification, the natural tidal flushing characteristics off the coastal area offshore of the proposed mining project, among others, is the bathymetry (or bottom configuration of the sea bed) and hence, bathymetry survey was conducted to complement the available, but somewhat coarse NAMRIA topographic map.

Bathymetry surveys are usually conducted using echo-sounder mounted on a boat. For this specific survey covering an area of approximately 20km^2, the echo sounder instrument used has a powerful dual-frequency transducer and a built-in, satellite-enhanced worldwide base map and an easy-to-use interface designed to aid navigation and record depth information in open waters.

The bottom depth surveys are be aided by automatic water level loggers (used for correcting the measured depths for tidal fluctuations), echo sounder, and a global positioning system of which water depths at specific coordinates were recorded at regular time interval while traversing thru a boat the coastal area. As the coast is too large to cover but is necessary to include in the setup of the model, the specific portion of the site chosen for the survey is mainly the immediate areas that are outside of the coverage of previous survey works commissioned by the Client. Far offshore that were not covered by the previous and this survey works, the depth data is extracted from the published NAMRIA topographic map covering the whole area. After appropriate post-processing, these three (3) datasets were merged, interpolated at every computational grid cell and then eventually used in the setup of hydrodynamic model for the project area.

The following set of photos show the activities of data gathering taken during the deployment and use of various instruments in conducting the oceanographic surveys in the project's impact area.

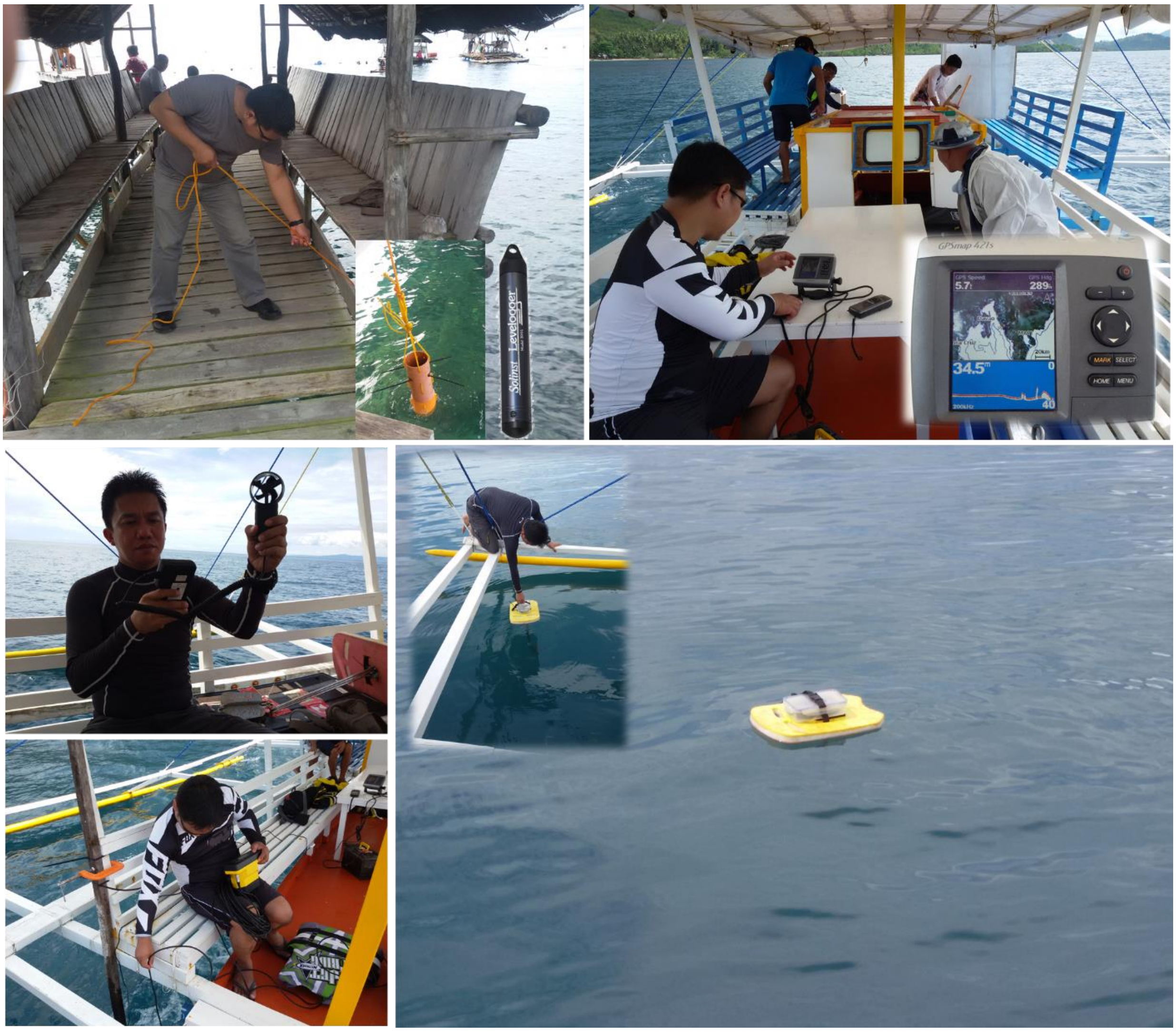


Fig. 2.2-14 Photo documentations of the oceanographic surveys conducted in the area: deployment of an automatic water level logger (upper left); Bathymetric survey using an echo sounder with built-in GPS (upper right); surface current measurement using a digital flow meter and wind velocity measurement (lower left); and sub-surface current (and track) measurement using a drifter and GPS (lower right).

Modelling the Sediment Transport in the Coastal Sea

Background

In this oceanographic assessment study, numerical modelling is employed to assess the potential impact on the water quality from sediment-laden flows on the harbor waters for different wind speed and directions, as well as different tidal conditions (spring and neap tides) downstream of the Proposed Nickel Mining Project located in Barangays Puntalinao, Causwagan, Pintatagan, Maputi, Panikian, and Mahayag Municipality of Banaybanay, Province of Davao Oriental.

The main objective of the modelling was to determine the effect of the project mining area on the flow and water quality of the downstream coastal area of Davao Gulf in Davao Oriental, specifically to determine the area of potential hotspots area as a result of, for example, an accidental spillage of on-site settling ponds, which if left unattended, will eventually ended up into the coastal sea during the operation phase.
The assessment of pollution impacts has been conducted by predicting the dispersion and fate of the pollutant, of which the water quality model was used to simulate pollutant dispersion. The model simulates the dispersion of pollutant by discharging effluent at specified discharge rates and locations.

Because the actual concentration of the sediment-laden flows is not known, the representative sediment load used in this model setup is based on the earlier sediment yield study of the watershed covering the project area. Using the average monthly discharge and estimated sediment yield of the six (6) watershed draining into the coastal area of Banaybanay, the sediment concentrations for use in the model can be derived. To take into account higher-than-normal sediment yield expected during the rainy season, the monthly peak discharge was used instead of the mean monthly watershed discharge in the model simulations. The summary of watershed data used as inputs are tabulated below.

Table 2.2-27: Summary of Watershed Data Used

Name of Watershed	Drainage Area (km2	Peak Monthly Discharge (m3/s)	Sediment Yield (tons/ha/yr)	Sediment Yield (kg/s)
Piso-Catangawan	21.56	0.58	8.37	0.57
Mapagba/Mapanga	15.00	0.39	8.15	0.39
Maputi	10.00	0.39	6.52	0.21
Pintatagan	37.17	0.63	21.63	2.55
Punta Linao	10.56	0.16	28.98	0.97
Punta Linao Proper	6.76	0.16	25.47	0.55

The Deltares' Delft3D models were employed for the assessment. The water quality module simulates transport and simple water quality processes using the flow data from the hydrodynamic module. The sediment plume is followed in two dimensions over time, whereby a dynamic concentration distribution is obtained by calculating the mass of pollutant in the model grid cells.

Basically, the hydrodynamic model setup consists of refined grids, distributed in a way to resolve the high resolution required near the coast of the project area, while providing enough coverage far offshore of Davao Gulf. Grid size ranges from 450 m down to 300 m, covering the whole Davao Gulf. The resolution in the vicinity of the Banaybanay area is enhanced using the small grid size of about 50 m.

The transport of substances is dependent on the results of the hydrodynamic model results and were used as inputs for water quality model to assess the impact of an accidental release of sediments during operational phase of the project.

The models were run for the following simulation periods: January 5 - February 5, 2018. To ensure convergence of the model, a warm up period of 5 days was added to the beginning of the said periods in the hydrodynamic simulations. A specific water quality parameter, total suspended solid (TSS) is used for scenario analysis which is assumed to discharge continuously for 31 days, at the downstream vicinity of the proposed mining area at an assumed sediment yield for the six identified watersheds.

Tidal and wind driven currents will then convey the pollutant and diluting it in the surrounding coastal waters.

Predicted Water Movement Thru Hydrodynamic Modelling Scenarios

To help quantify the effect of coastal circulation and pollutant dispersion on the study area, the hydrodynamic model was used to simulate the effect of the representative tidal events occurred from January 01 to February 05, 2018. The first 5 days of the simulation is used to ensure that the model reaches its steady state thus preventing the effect of numerical oscillations as a result of the initial conditions of the model run. The water quality simulation started from the 5th of January to 5th of February 2018, using the first 5-days of hydrodynamic simulation as the initial condition in the computations. The modelling performed off the coast of the project area was more of a limited analysis, as a comprehensive data set in order to fully model the coastal circulation was not available at the time of preparing this report.

To check the performance of the model, the predicted tidal water levels were then compared to the tidal time series derived from tidal harmonics of the nearest gauging stations in the area: Davao Gulf and Pujada Bay Tidal Stations, as well as from actual measurements taken in the area using an automatic water level logger.

The said comparison of water level time series is shown below, of which it can be deduced that the model (in black line) in some instances under-predicts low tides and over-predicts the high tidal events. Nevertheless, the rise and fall of the tides as well as the timing of the peaks are predicted quite well by the model. The actual measurement using the water level logger recorded a 5-minute interval water level and thus there are ‘noises’ in the record is also shown as a blue line in the figure; due to the short period of measurement the actual data were not able to capture a typical tidal cycle but seems to show in agreement with the water levels predicted both by the model and by the tidal harmonics.

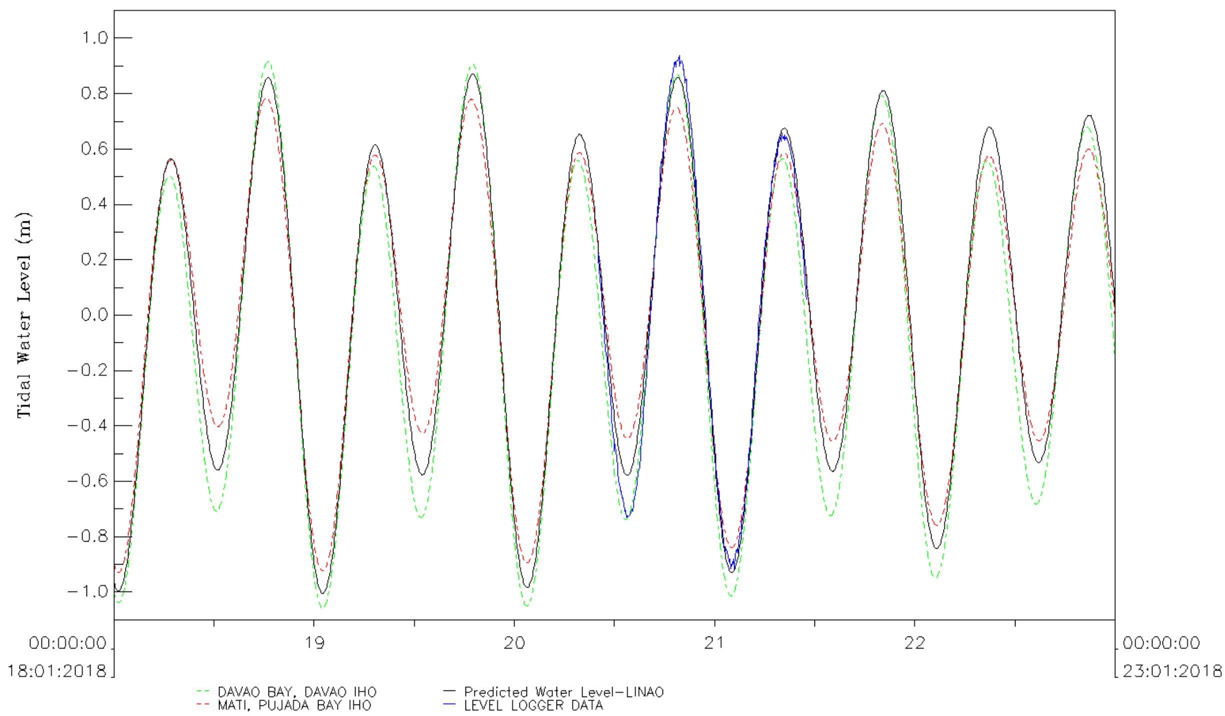


Fig. 2.2-15. Comparison of water levels in the area: Predicted tides at Davao Gulf and Pujada Bay Stations derived from tidal harmonics (dashed green and dashed red lines, respectively), observed water level using a data logger (blue line) and predicted water levels using the model (black line).

While both winds and tidal forces significantly influence current circulation in coastal environments, currents were predominantly governed by tides in the project area. The results of the hydrodynamic simulation demonstrated tidal ebbing and flooding dictating current movement and mass transport within and out of the area. This may have been brought by the complicated topography and coastal configuration of the project site.

The next two figures below show the depth-average current for habagat wind conditions (wind speed of 4 m/s from the southwest) during tidal flooding and ebbing. The right panels show the predicted current speeds as a function of time. The direction axis indicates the direction the current is heading towards.

Using a wind speed of 4 $m \cdot s^{-1}$ blowing from the southwest (the so-called habagat wind), the model runs revealed that from the open sea off Davao Gulf, depth-averaged currents during high tidal event are geared towards the north flowing into the project area and to the innermost portion of the gulf with the residual flow veered southward offshore of Samal Island. The modelled flow magnitudes in the project area is quite moderate, with flow velocities in the range of 0.08 to 0.10 m/s while flow velocity fields in the range of about 0.04 m/s are likewise predicted by the model near the coast of Samal Island with weak formation of circular gyres far offshore.

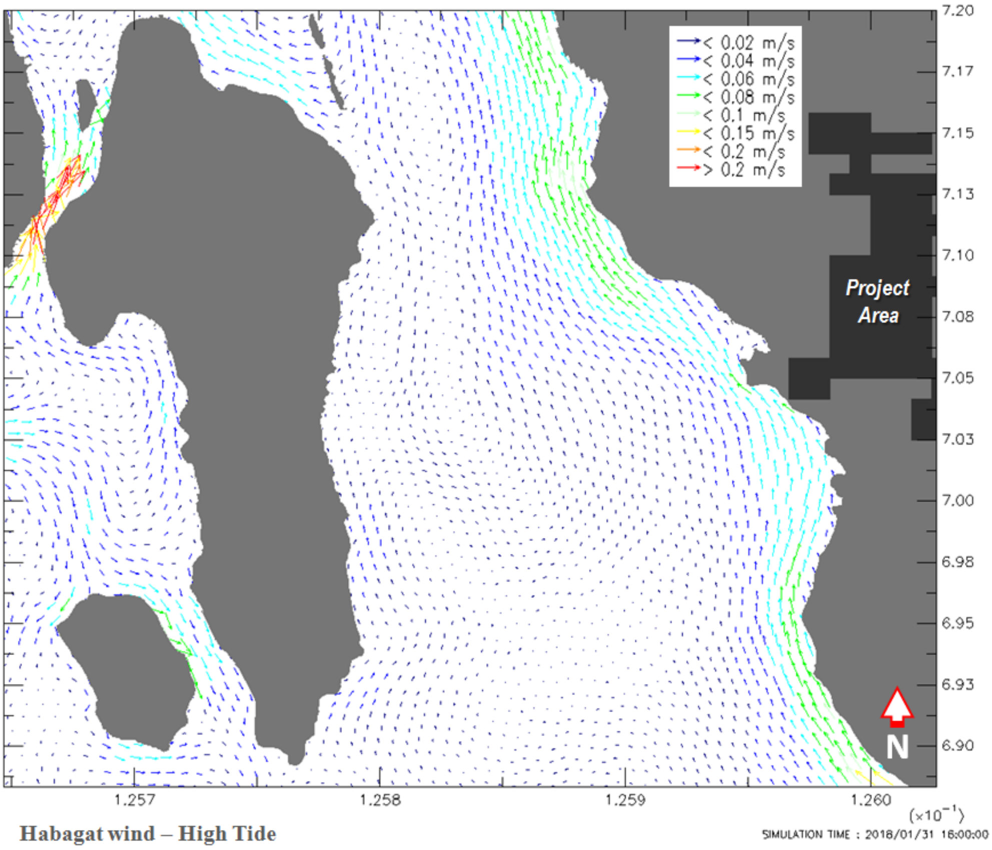


Fig. 2.2-16. Predicted currents in the project area during tidal flooding (habagat wind condition).

During tidal ebbing, the flow velocity field far offshore in between Samal Island and Banaybanay side is directed to flow outwards to the open's sea, with significantly higher flow magnitudes in the range of more than 10 cm/s is predicted to occur at the narrow straits of Talikud and Pakiputan located west of Samal Island. Due to the prevailing habagat wind, the flow direction near the coast of project area remains the same as that of high tidal events, with slightly lower magnitudes of less than 8 cm/s.

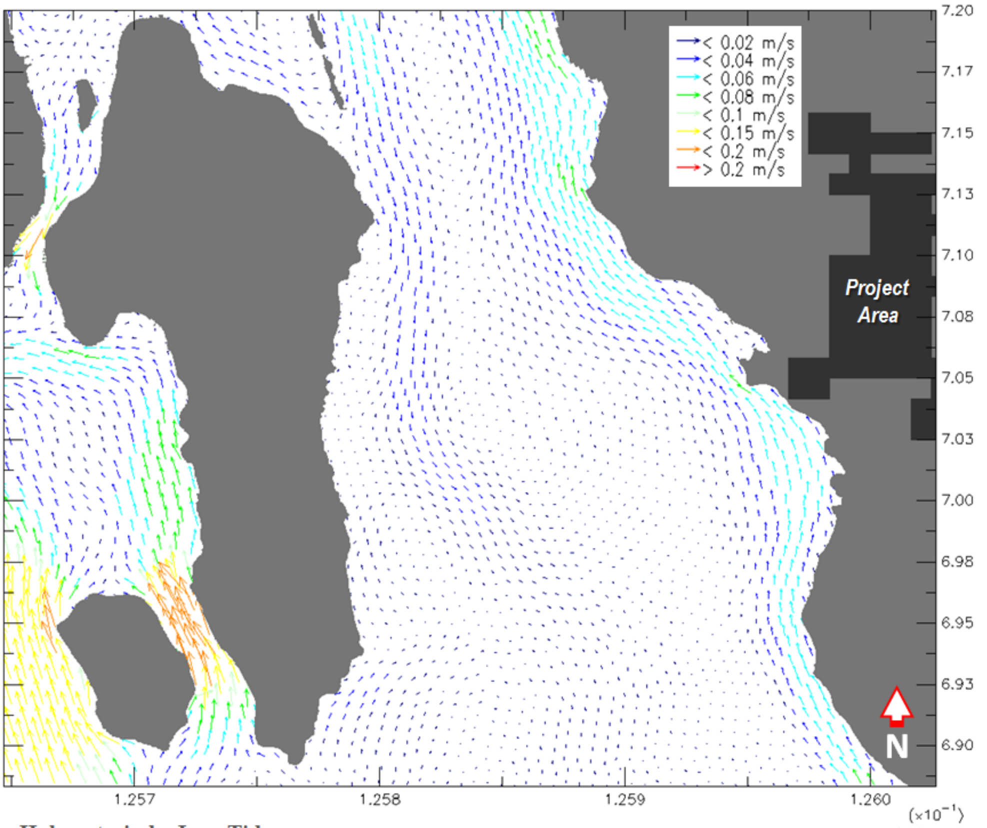


Fig. 2.2-17. Predicted currents in the area during low tidal event (habagat wind condition).

Under amihan wind conditions scenario, with a wind velocity input of 4 $m{\cdot}s^{-1}$ and blowing from the northern direction, the model results revealed a southward flow direction during tidal flooding, with alongshore currents running parallel to the configuration of the coast and into the project area until it flows out of Davao Gulf. During tidal flooding, flow velocity fields are in the range of 4 to 8 cm/s near the coastline. Since the wind field is opposite the incoming tidal waves, the flow is somewhat lower than when the prevailing winds is from the southwest (habagat).

During tidal ebbing, the model predicts similar trend wherein flow rushes out into the project area coming from inner portion of the gulf and into the open sea with some of the out flowing waters traversing southwards exiting Pakiputan Strait. Weak counter-clockwise gyres are also predicted near the coast of the project area and in areas in the middle of the gulf.

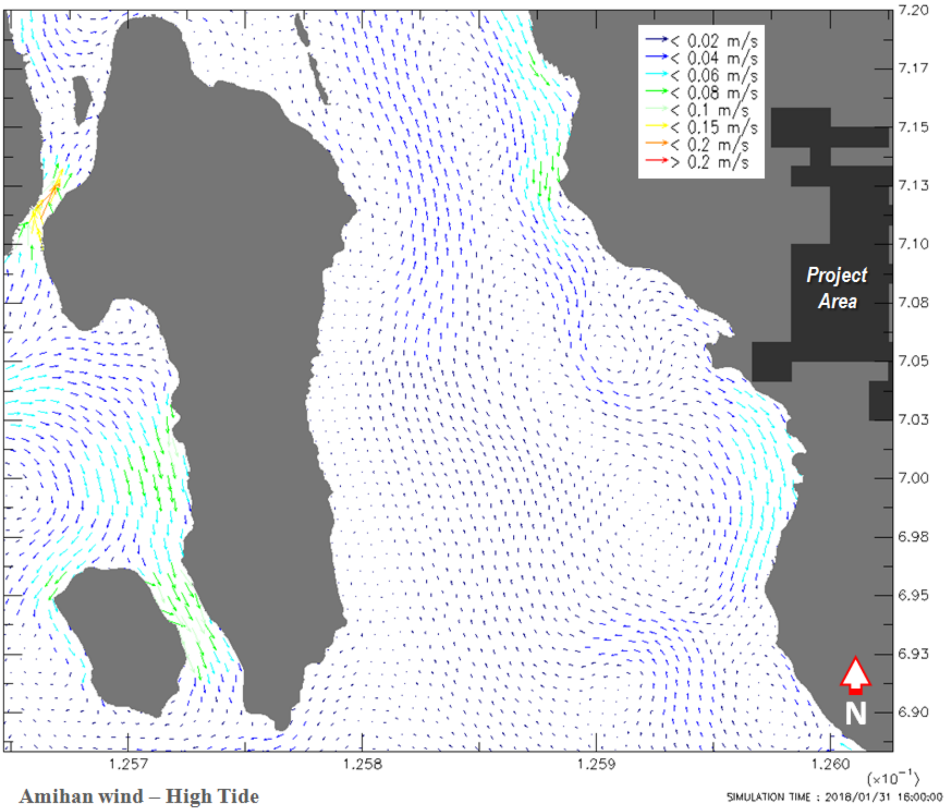


Fig. 2.2-18. Predicted currents in the Project Area during high tidal event for amihan wind condition (wind speed of 4 m/s blowing from the northeast).

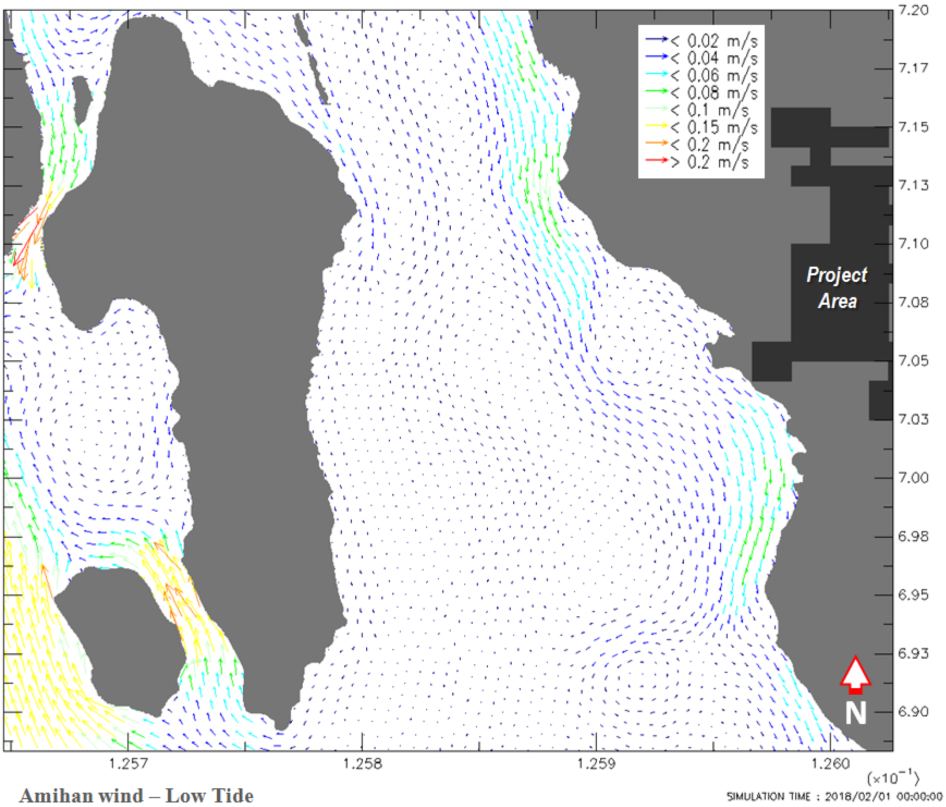


Fig. 2.2-19. Predicted currents in the Project Area during low tidal event for amihan wind condition (wind speed of 4 m/s blowing from the northeast).

From examination of the predicted currents in the project area during these two wind conditions, it follows that wind conditions dictates the direction of current although tidal effects also had a significant influence in steering the currents especially near the coast. During habagat conditions, the currents near the coast exhibit a bias towards the north and northwest, due to the prevailing south westerly winds. The high tidal event induces current speeds reaching a maximum of more than 15 cm/s while the currents during tidal ebbing were generally weaker, reaching a maximum of less than 10 cm/s near the coast. This is somewhat comparable with the drift and surface water current observed during the field surveys.

Far offshore of the project area, the predicted currents are generally weaker due to the natural barrier and 'sheltering' effect of protruding landmass of Mount Manasamuga to the east and Samal Island to the west, except in the area south east of Samal Island where the flow is predicted to be more than 15 cm/s during low tides for both amihan and habagat wind conditions for a wind speed of 4 m/s. For higher wind magnitude, it is expected that high flow velocities would occur, but for pollution dispersal prediction, low magnitude winds are preferred since it offered less mixing and therefore conservative results (higher concentration levels) are expected.

1.1.1 Predicting Sediment Dispersal and Transport thru Water Quality Modelling

This section assesses the suspended sediment transport and simple water quality processes by means of water quality module of Delft3D. In particular, dispersal, dilution and accumulation patterns of particulate matter dispersed as it is transported by the ambient current circulations were investigated. This situation is possible during for example the mining operation or polluted storm water runoff, which eventually ended up at the mouths of rivers and creeks within the immediate vicinity of the project area

The model considers the release of sediments in six outfall locations representing outflow of the river mouths and surface runoff just offshore of the downstream project area to visualize and quantify the dispersion patterns in the area. Scenarios incorporating the effect of south-westerly and north-easterly winds investigate the propagation and dispersal of the pollutant as current is forced by wind, particularly near the surface. The dispersal patterns of the suspended sediment were assessed with the end in view of determining how the project will potentially impact the existing coastal water quality process.

The transport and dilution of continuous release of TSS pollutant in the assumed discharge points within the coastal stretch of the project were simulated for 31 days in the model, to allow buildup of the far field TSS concentrations over many tidal cycles. Results were examined over a spring and neap cycle using tidal data from January-February 2018.

The results of the model runs are shown in the next succeeding figures. Some of the results of the 31-day simulation of TSS incorporating the effects of surface winds, and the rise and fall of tides are presented. Therefore, the snapshots cover most of the interesting patterns that may be expected during flooding and ebbing and also during slack water.

1.1.2 Scenario A – South-westerly (Habagat) Wind Condition

This scenario incorporated the influence of wind on coastal current circulation and pollutant transport and movement in the study area. This was accomplished with the use of a uniform wind forcing (southwesterly wind, ranging from 180 to 225 degrees from the north, with a speed of 4 $m \cdot s^{-1}$), representative of the southwest monsoon conditions.

From the results of the model runs, it appears that for the first few hours of releases of the TSS, the patch is relatively small and the mixing of the pollutant is caused by small-scale turbulence effects only. However, after some time, the TSS plume will have spread sufficiently such that larger-scale eddies and circulations will contribute to the mixing effect.

It can be seen in the figures below that after a few couple of hours, the TSS spreads starts to spread farther from the release point towards the north-western part of the coastal area for a prevailing south-westerly wind field in effect. Very limited plumes near the discharge points drifted southwards even during changes in the direction of the tides as the discharge points are at the concave bend of the coast where exposure to prevailing current and wind drag is most pronounced. Thus, significant amount was transported towards the area of northwest of the project coast, with spreading reaching the inner portion of the gulf further up north but with diluted concentrations of less than 5 mg/L. The model predicts that the spreading of pollutant reaches about 20 km northwest, though the concentration is very minimal at less than 5 mg/L (denoted as light blue in the legend).

The area where most of the pollutant remain is at the concave portion of the bend where weak flow velocities occurred as it is protected by land protrusion that serves as a natural barrier to deflect the otherwise high flow velocities emanating from alongshore currents.

The first four figures represent the dispersion after a few hours of continuous releases in the identified discharge sources. In the series of figures presented below, the legend refers to the resulting level of concentrations, in milligrams per liter, of total suspended sediment parameter.

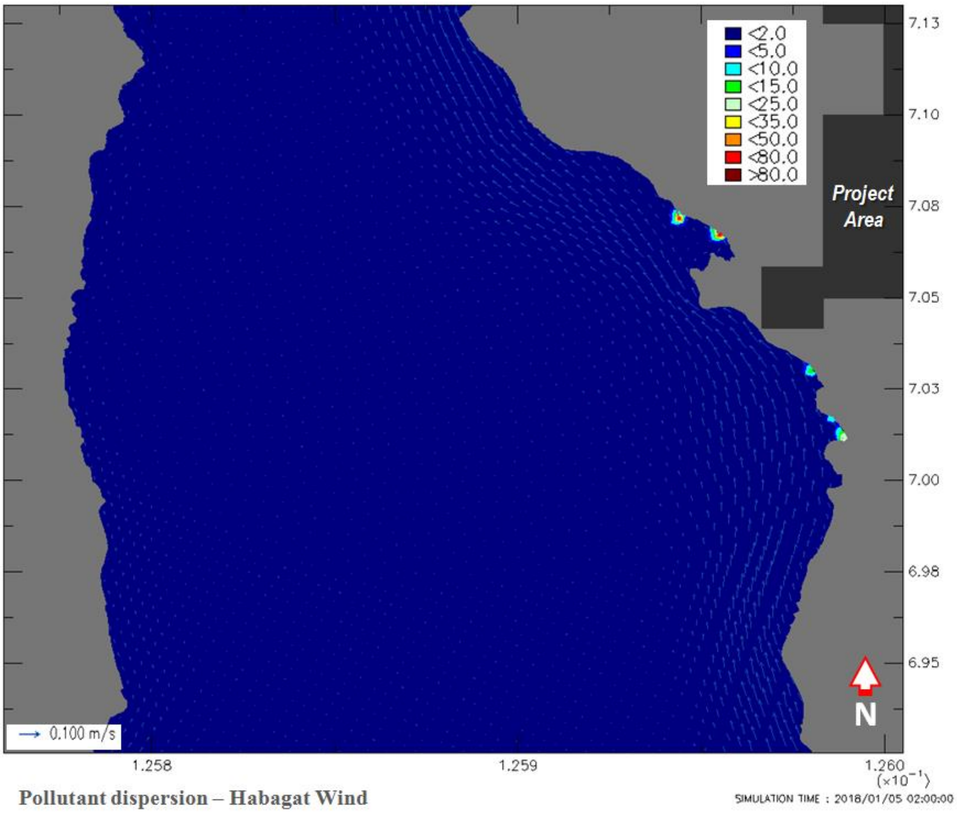


Fig. 2.2-20. Predicted transport of TSS pollutant after 2 hours of continuous releases, under habagat wind condition.

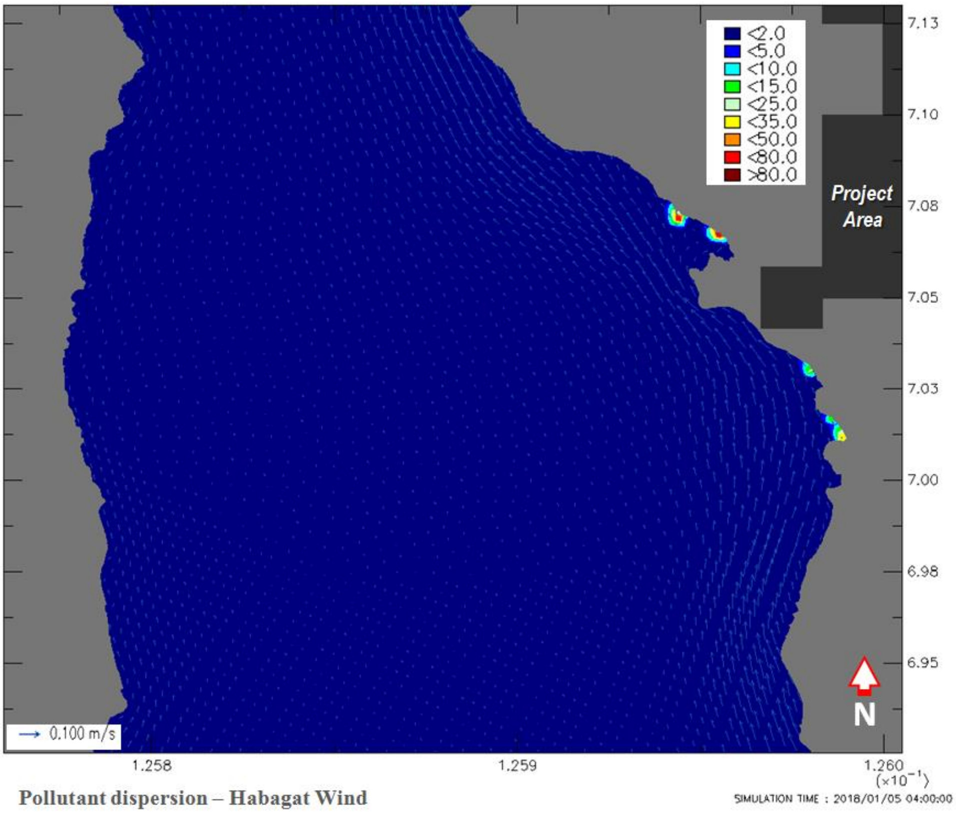


Fig. 2.2-21. Predicted transport of TSS pollutant after 4 hours of continuous release under habagat wind condition.

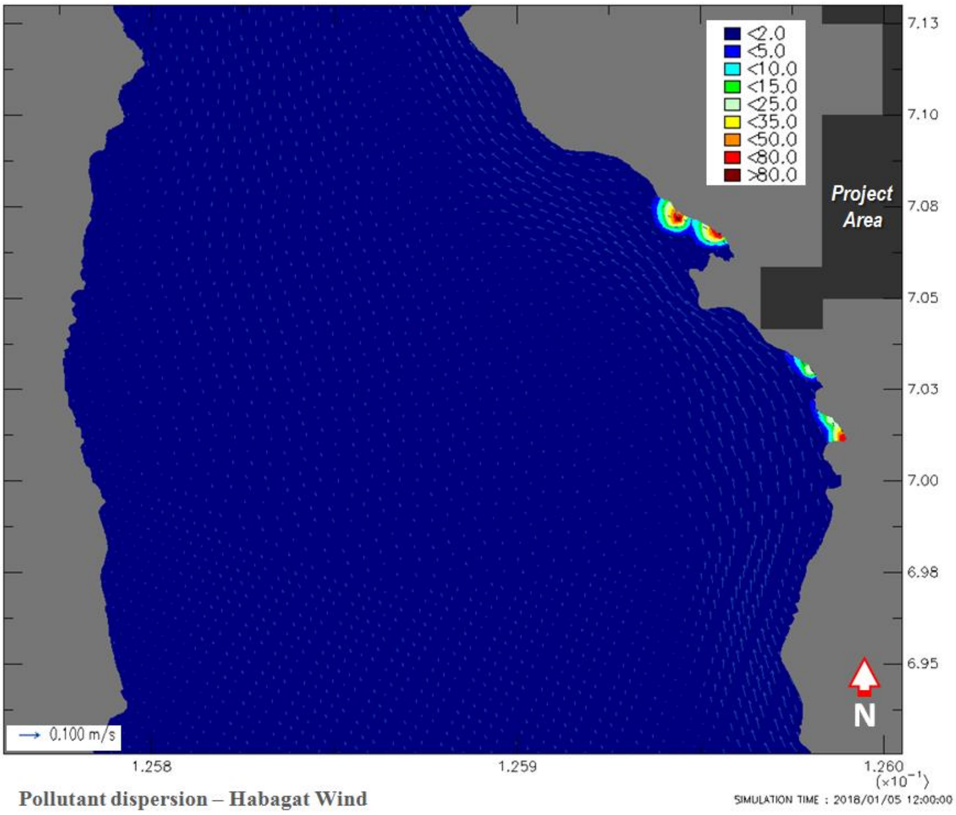


Fig. 2.2-22. Predicted transport of TSS pollutant after 12 hours of continuous releases under habagat wind condition.

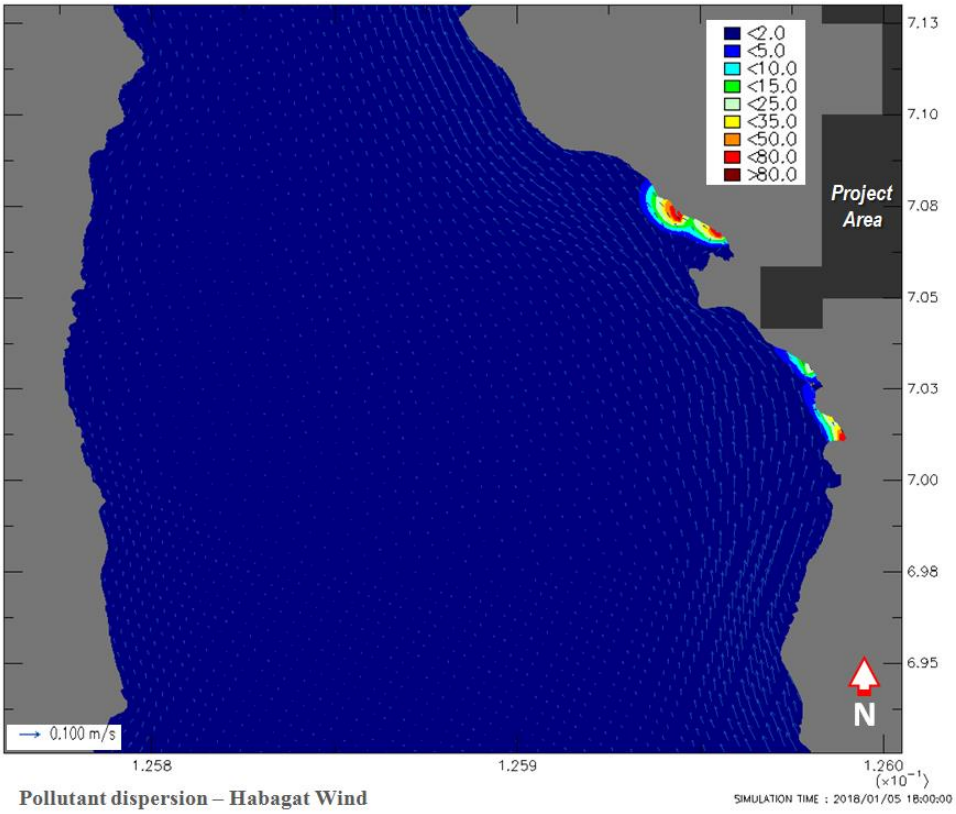


Fig. 2.2-23. Predicted transport of TSS pollutant after 18 hours of continuous release under habagat wind condition.

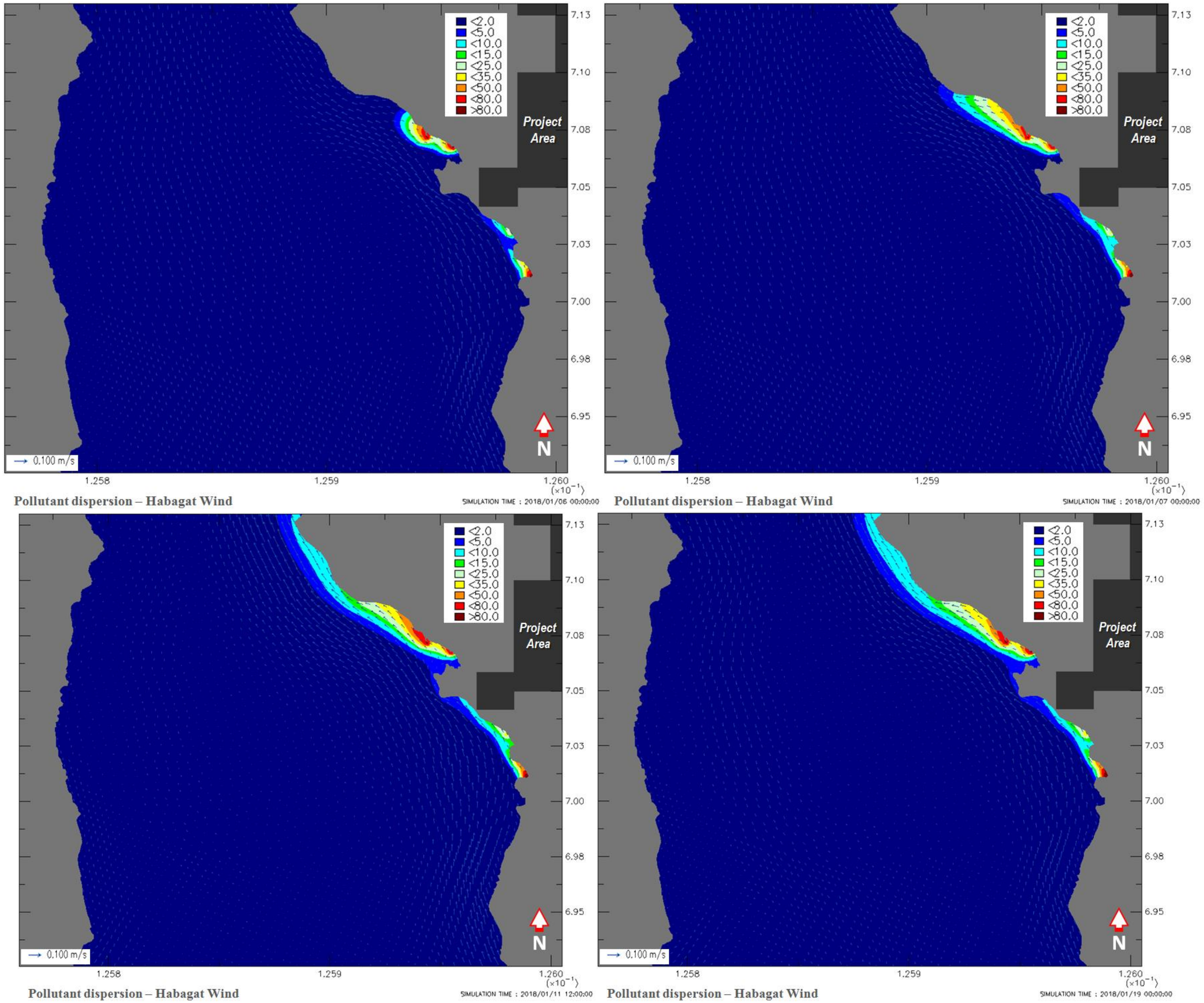


Fig. 2.2-24. Predicted transport of TSS after 1 day (upper left), 2 days after (upper right), 6.5 days after (lower left), and after 14 days (lower right) of continuous releases.

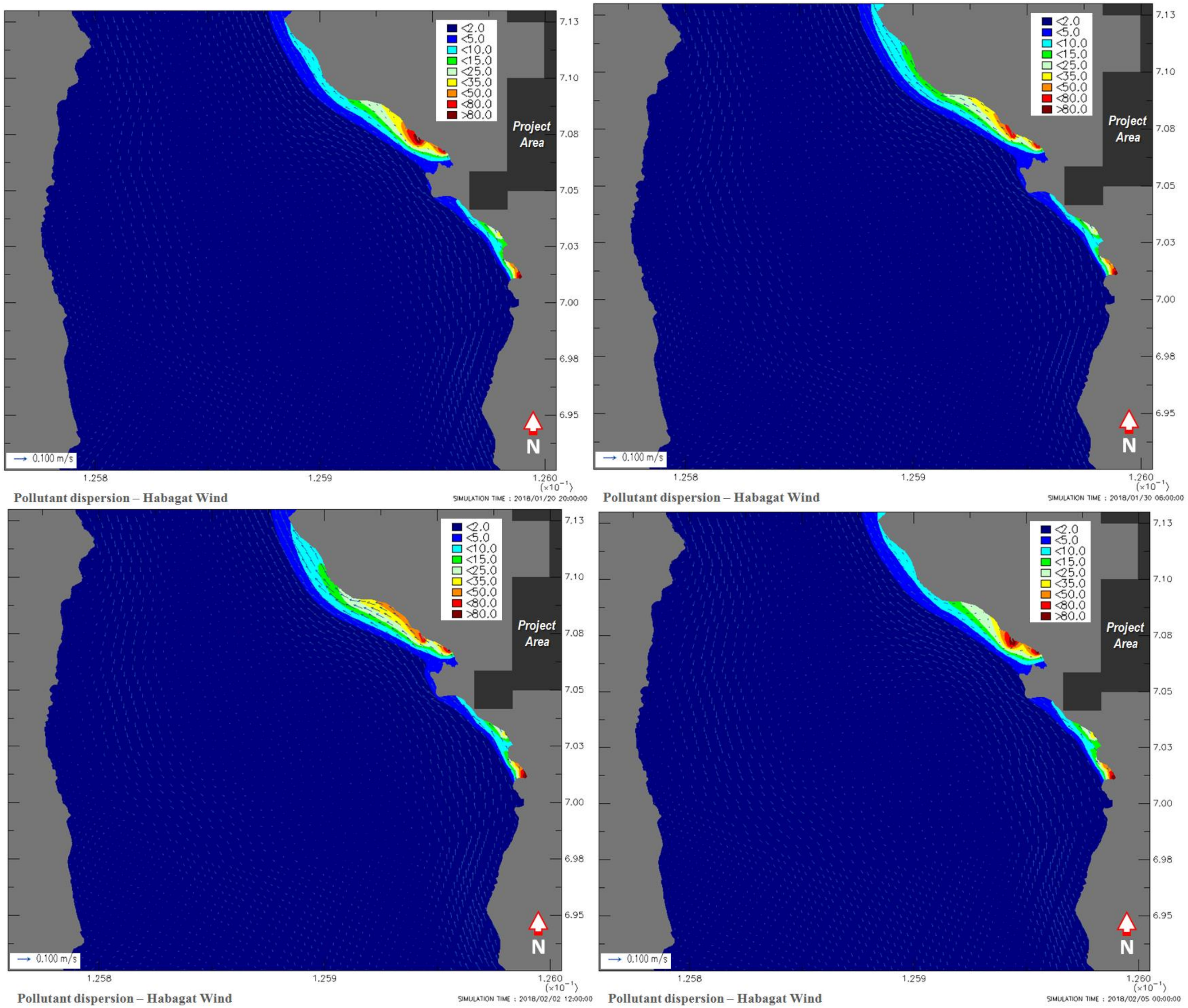


Fig. 2.2-25. Predicted transport of TSS after 15.83 days (upper left), 25.25 days after (upper right), 28.5 days after (lower left), and after 31 days (lower right) of continuous releases.

1.1.3 Scenario B – North-easterly (Amihan) Wind Condition

This scenario incorporated the influence of amihan wind on coastal current circulation and pollutant transport and movement in the study area. A uniform wind forcing (southwesterly wind, ranging from 10 to 45 degrees from the north, with a speed of 4 $m \cdot s^{-1}$), representative of the southwest monsoon conditions is used as one of the model inputs to simulate hydrodynamic and pollutant transport off the coast of the proposed mining area.

Similar to habagat wind scenario results, at the start of the simulation, the TSS pollutant dispersed initially in a radial pattern and after a few hours starts to scatter southwards following the topography of the coast. Because of the prevailing alongshore currents and weak circular eddies formed as the water moves into and out of Davao Gulf due to interaction of tides from the open sea, most of the pollutant are dispersed towards the southern portion. Even during periods of slack tides, almost all of the released pollutant flows toward the southern part which confirm that the flow is mostly wind-driven and that tides has small influence in the prevailing currents in the project area.

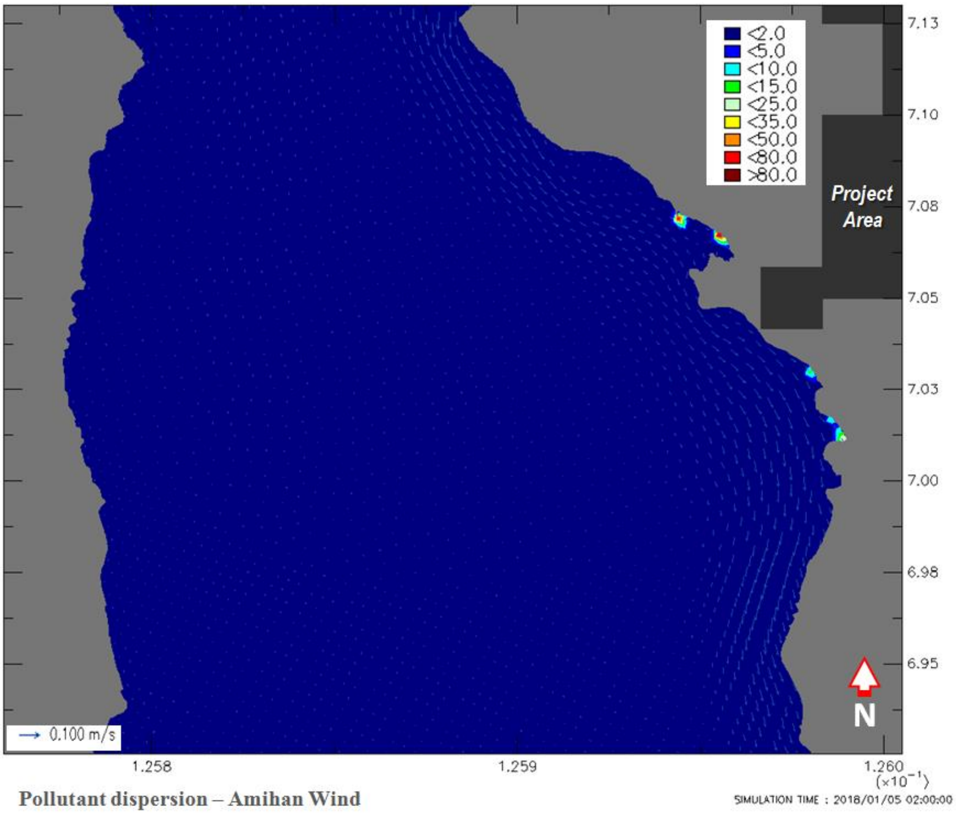


Fig. 2.2-26. Predicted transport of TSS pollutant after 2 hours of continuous releases under amihan wind condition.

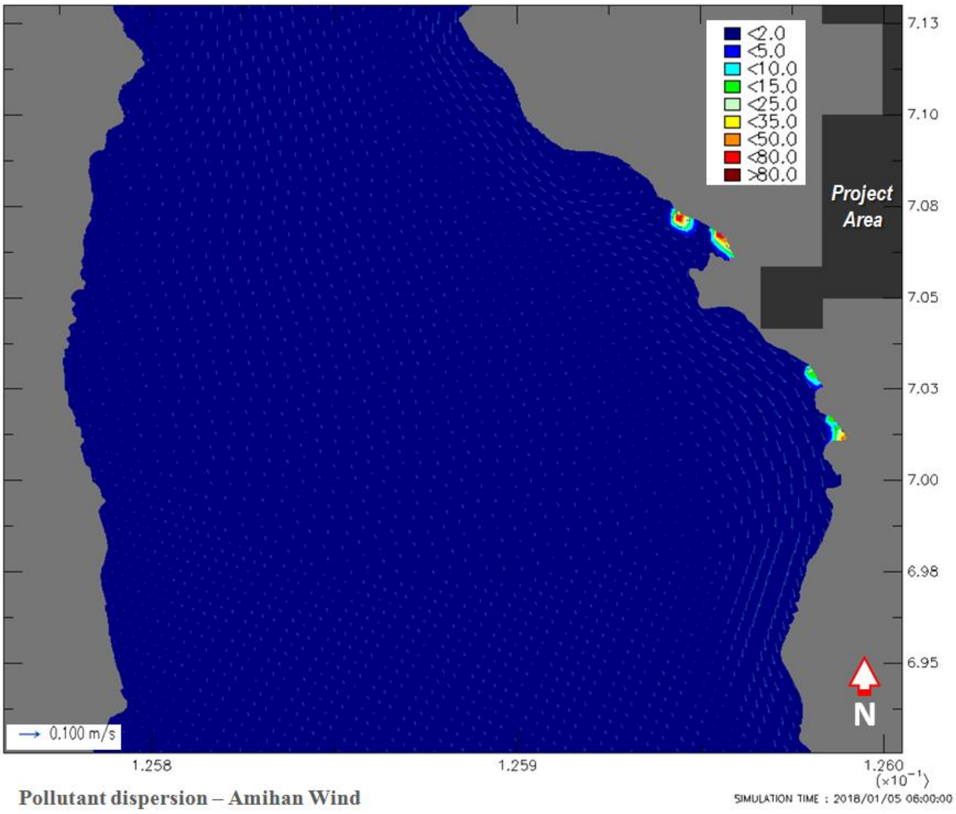


Fig. 2.2-27. Predicted transport of TSS pollutant after 6 hours of continuous releases under amihan wind condition.

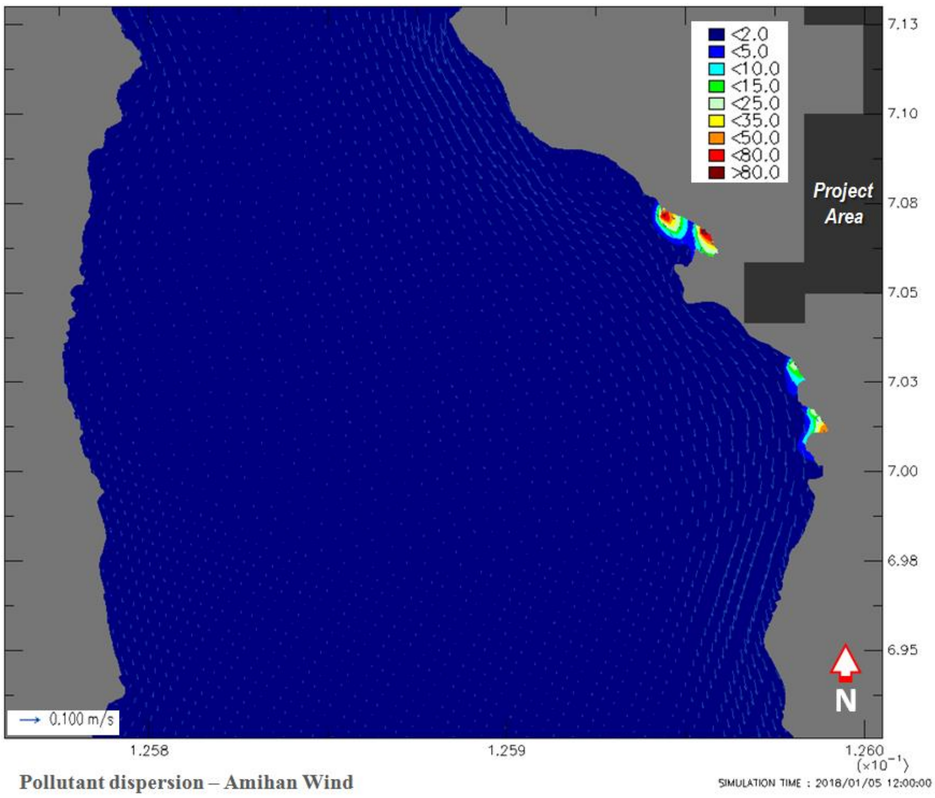


Fig. 2.2-28. Predicted transport of TSS pollutant after 12 hours of continuous releases under amihan wind condition.

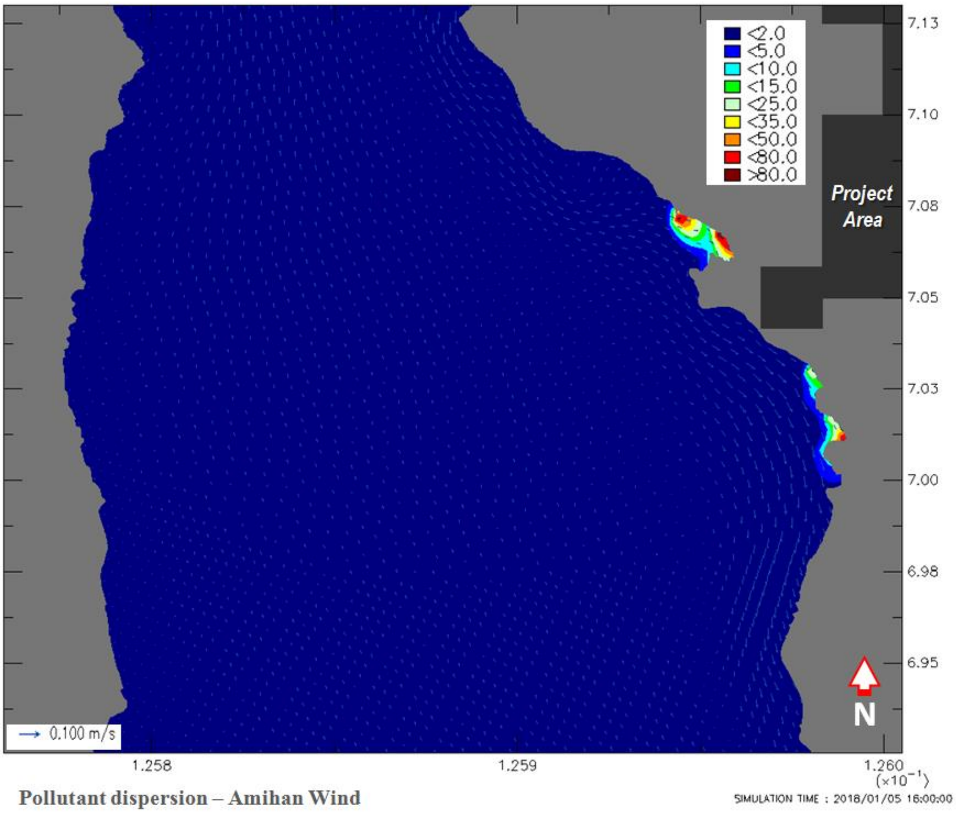


Fig. 2.2-29. Predicted transport of TSS pollutant after 16 hours of continuous releases under amihan wind condition.

The next figure shows a map summary of the dispersion and transport of TSS parameter for some of the time steps in the 31-days simulation.

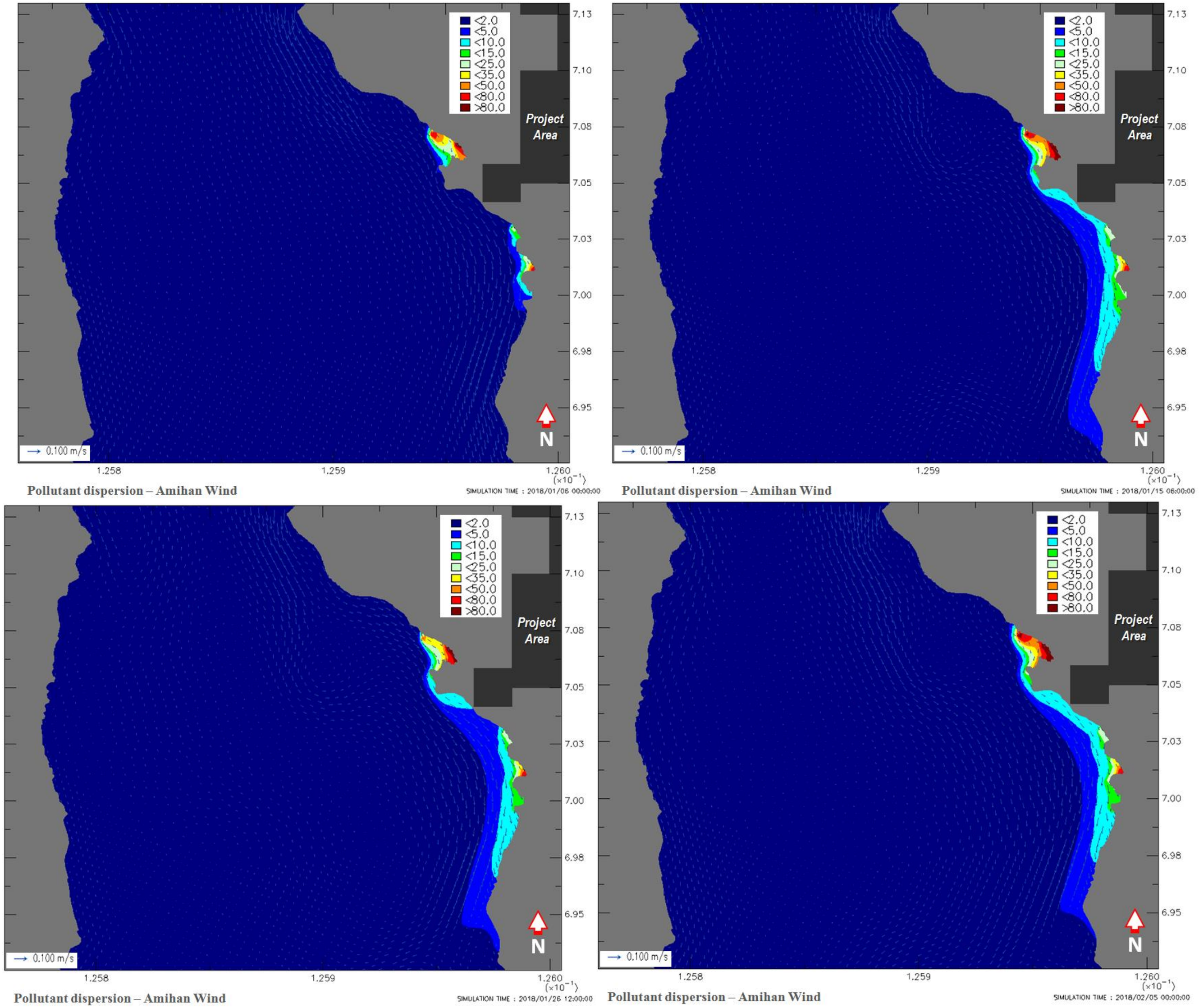


Fig. 2.2-30. Predicted transport of TSS pollutant: after one day (upper left), 10.25 days after (upper right), 21.50 days after (lower left), and after 31 days (lower right) of continuous releases.

1.1.4 Scenario C – Calm Wind Condition

A period of low flow velocities which would correspond to the period of lowest transport and mixing potential is usually when the wind field is relatively calm. Thus, this scenario specifies low wind speed conditions which would allow the TSS plume to sustain its release concentration; this is to determine the likely fate and transport of released pollutant during this type of wind field where a uniform wind forcing speed of less than 1 m/s is used with random wind directions.

The results of the model simulation using calm wind speed are shown in the next succeeding figures. The predicted currents were tidal induced as surface wind-driven turbulence and flow component were obliterated from the model forcing due to low speed specified. The figures provide easy visualization of the pollutant dispersal patterns and trajectories.

Based on the model results, the level of pollutant concentration is inversely proportional to the tide levels. Higher concentrations were predicted during low tides while lower pollutant concentrations were observed during high tides. This is not unusual as the dilution and mixing process is less when the water level becomes shallower. During low tide, the pollutant with a very low concentration (less than 5 mg/L shown in the legend of the figures) veered towards the north-western direction of the adjacent coast with much of the pollutant appeared to remain and concentrate adjacent to the discharge locations and veered towards the southeast during periods of low and slack tides. These are then swept further to the north during transition and high tidal events due to reversal of the current and the influence of the resulting formation of weak circular eddies far off the coast.

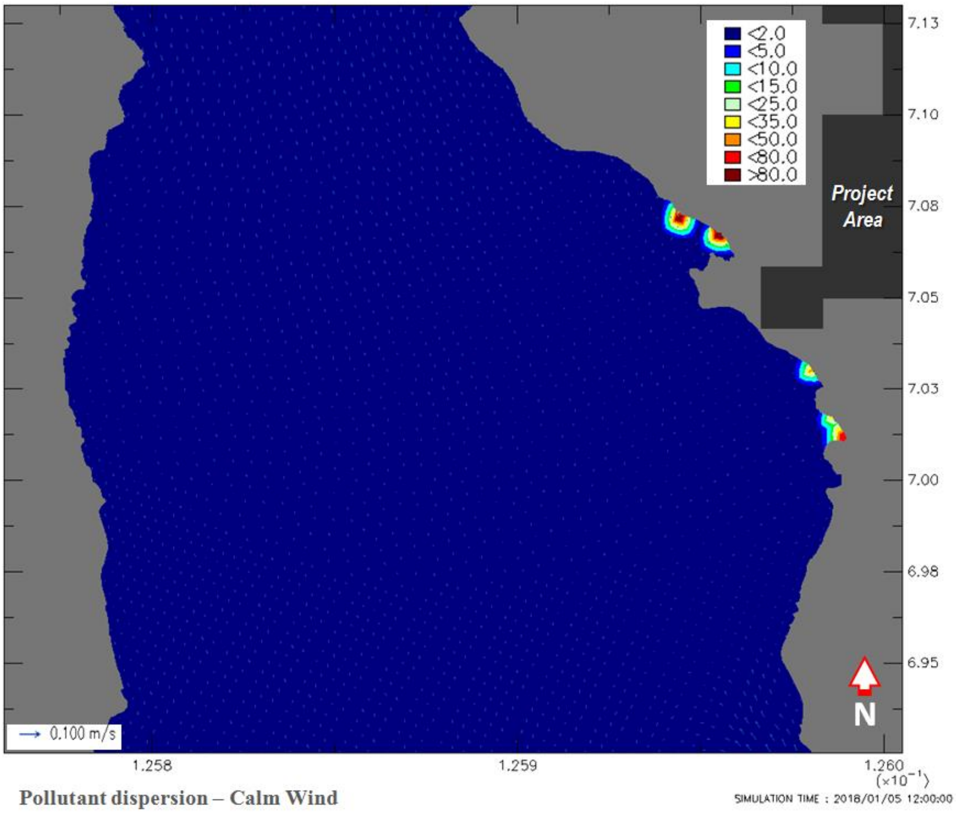


Fig. 2.2-31. Predicted transport of TSS pollutant after 12 hours of continuous pollutant releases under calm wind condition.

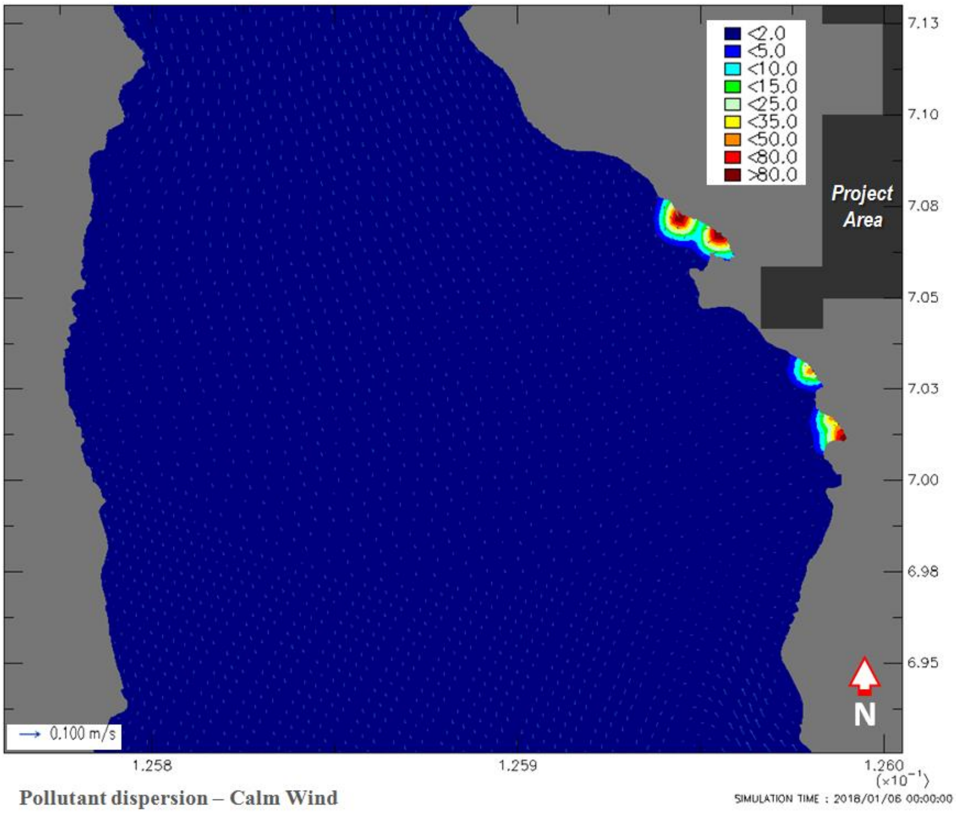


Fig. 2.2-32. Predicted transport of TSS pollutant after 24 hours of continuous pollutant releases under calm wind condition.

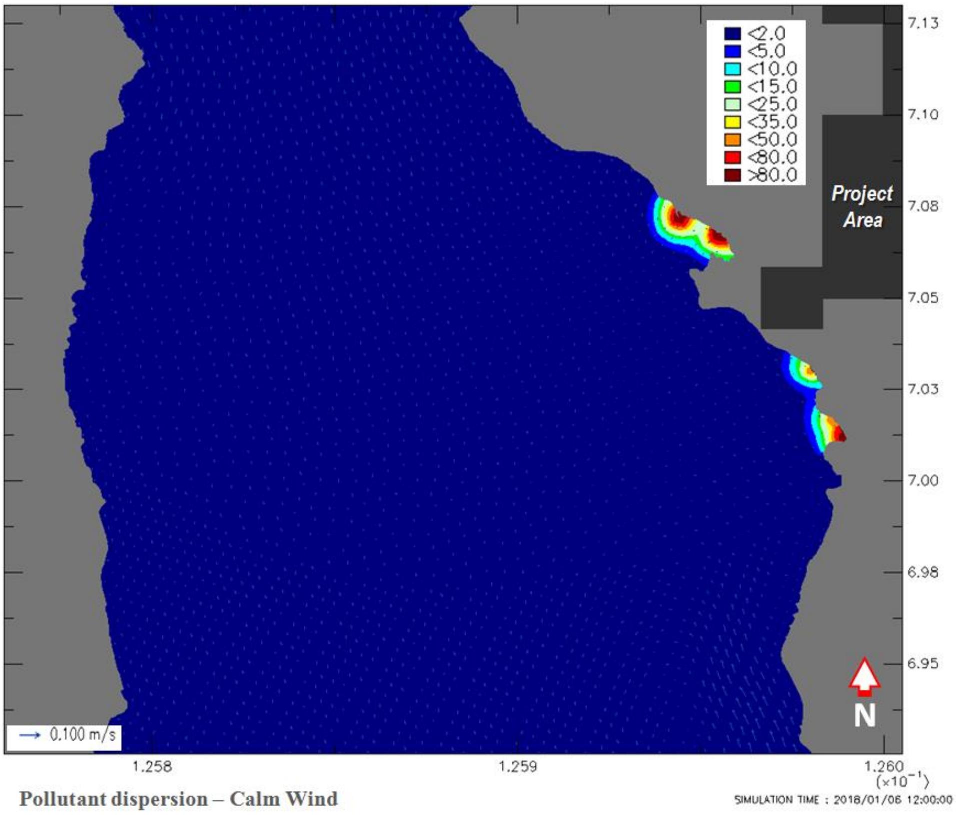


Fig. 2.2-33. Predicted transport of TSS pollutant after 36 hours of continuous pollutant releases under calm wind condition.

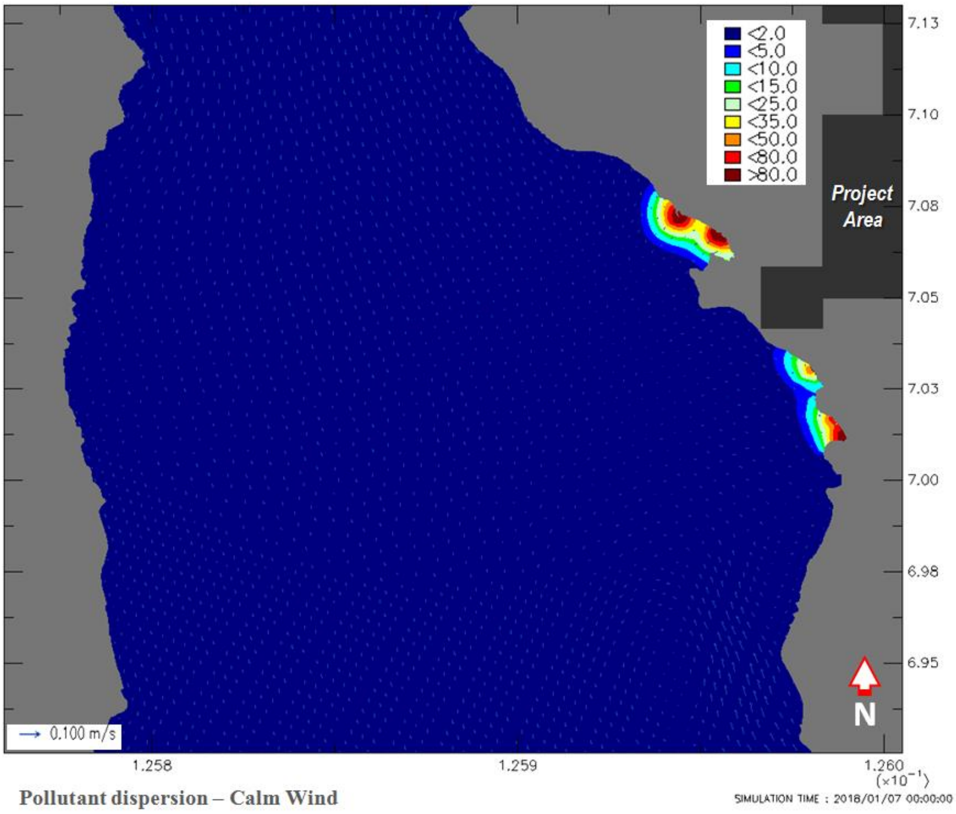


Fig. 2.2-34. Predicted transport of TSS pollutant after 48 hours of continuous releases under calm wind condition.

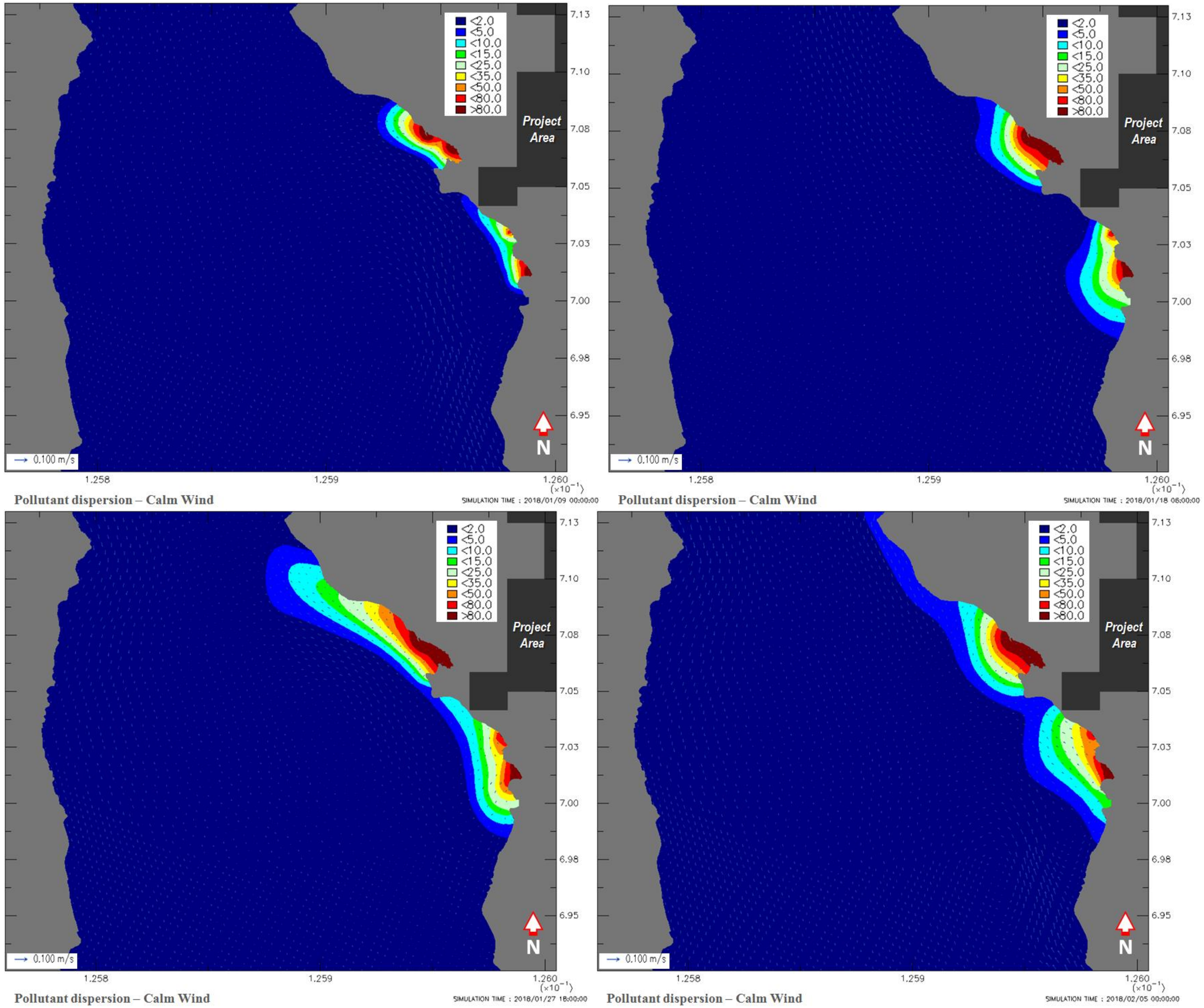


Fig. 2.2-35. Predicted transport of TSS pollutant: after 4 days (upper left), 13.25 days after (upper right), 22.75 days after (lower left), and after 31 days (lower right) of continuous releases.

2.0 Discussions and Conclusions

The numerical modeling study investigated the circulation and transport features of the coastal environments with scenario analysis on the possible impacts of releases of sediments, represented by TSS parameter, in the downstream area of the proposed mining area in Banaybanay, Davao Oriental. The numerical modeling exercise included key components and assumptions, for example, the actual hydrodynamic processes were represented by the model theoretical equations; barotropic and baroclinic pressure gradients were disregarded in the model set-up (river discharges from other river systems within the gulf were neglected due to absence of data, evaporation and direct rainfall were not incorporated); long-term average wind field conditions instead of actual data, etc.

While there is always a degree of uncertainty in the model assumptions, a conservative approach was adopted to ensure that this uncertainty is well incorporated into the variability of the results. For example, extreme scenario simulations thru calm wind condition were undertaken to only consider the effects of tidal oscillations to obliterate the effects of wind-driven turbulence on pollutant transport. Low wind condition results to low mixing of pollutant in the water column which would then predict higher pollutant concentrations.

From the results of the scenario analyses, the model results revealed that pollutant dispersion fluctuates depending on the rise and fall of the tides. As shown in the comparative results of tidal fluctuations and TSS concentrations presented in the figure below, higher pollutant concentration is predicted to be consistent with low tidal level event and vice versa.

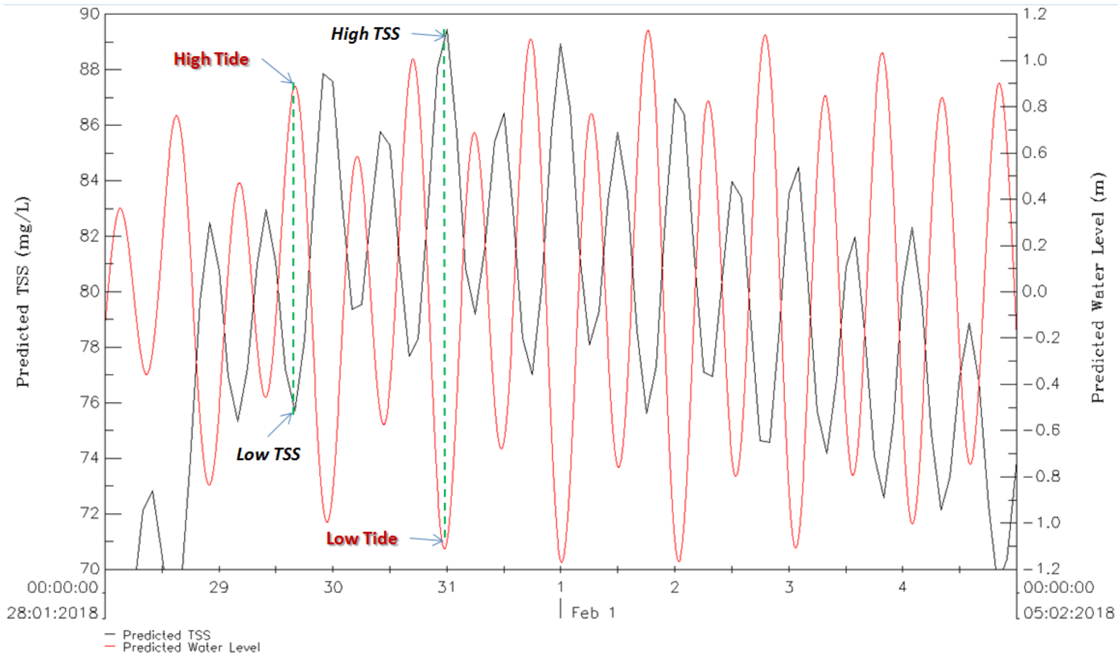


Fig. 2.2-36. Comparison of predicted TSS and water level fluctuations downstream of the project area.

Likewise, the scenario simulations revealed that the sediment released in the immediate vicinity downstream of the project area were not transported far offshore in the direction towards the open sea. The natural concave configuration of the coast of the project area and the sheltering effect of land mass at the eastern side of the gulf appeared to prevent the cross-shore transport of pollutant in the area further offshore, especially during periods of flood and ebb tides where the currents run parallel to the coast.

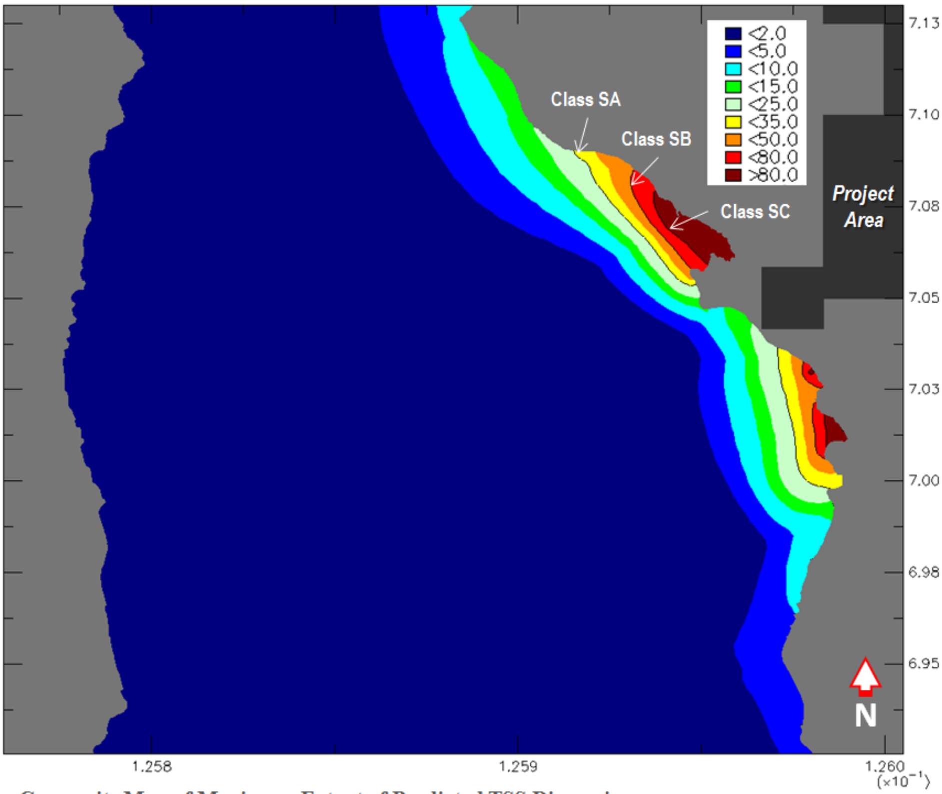
The next figure shows the extent of maximum TSS plumes simulated by the model for the 31-days period, under different wind conditions: amihan, habagat and calm wind fields. The extent of maximum TSS map was derived by taking the maximum predicted values at each computational grid cells for these three scenarios covering the entire 31-day simulation period.

As the predicted sediment yield in the project area is quite significant, the composite map of these simulation runs predict that the maximum TSS concentrations at the vicinity of the identified river mouths exceeded the allowable DENR standards for marine waters, as shown by the contour plots included in the figure. The areal extent of the TSS exceeding the DENR water quality guidelines, however, is predicted to remain at the area within a distance of about 1 km offshore and 3 km along shore. Outside of this area, the model predicts that the estimated sediment yield in the project area that may flow into the coastal sea will meet the Class SC criterion for TSS of less than 35 mg/L.

Table below shows the predicted area exceeding the DENR guidelines for different marine water classifications. As an example, if the area is to be designated as Class SA water, the area of the coast that will be in violation of TSS guideline is about 893.20 hectares. In terms of location, about 65% of the area exceeding the standards is downstream of Pintatagan River system while the remaining 35% is from the Mapanga River system and its tributary rivers.

Table 2.2-28: Predicted Area Exceeding the DENR Guidelines for Marine Classifications

Marine Water Classification	TSS Limit (mg/L)	Area Exceedance (hectares)
Class SA	35	893.2
Class SB	50	558.6
Class SC	80	307.8



Composite Map of Maximum Extent of Predicted TSS Dispersion

Fig. 2.2-37. Composite map of predicted TSS; also shown is the contour delineating the extent of coverage of areas exceeding the DENR water quality guidelines for TSS parameter.

In summary, based from hydrodynamic and water quality modeling studies so far conducted, TSS transported away from the coastal zone may affect certain area based on the DENR water quality threshold in case of accidental spillage of particulate matter or sediment downstream of the project area. Most of the pollutant released are dispersed mainly towards the northwest during habagat and calm wind conditions and southeast during amihan wind fields.

The critical situation is during calm wind condition, with predicted concentrations nearest the point sources of pollutant reaching more than 80 mg/L, but generally is less than said concentration once the spreading reaches a few hundred meters away from these sources. In the area far offshore, the concentration of pollutant is less than 10 mg/L.

As the model results revealed increase in suspended sediment concentrations based on estimated sediment yield of the basin, proper mitigating measures are strongly recommended to ensure the confinement of the suspended material to prevent accidental spillage during the operational phase of the project (or during transport and hauling of mined materials) for maintaining the environmental integrity of the coastal zone. The proposed mitigating measures are not included in the model simulations; therefore, the results could be interpreted as extreme instances wherein the sediment control structures and other mitigating measures that will be put in place failed or become inadequate.

Coastal Hazard

Coastal erosion and aggradation

The construction and operation of jetty and the haul road will have an impact in the depositional areas of sediments along the shoreline. When the general current direction is coming from the southeast, sediment deposition will occur to the south of the jetty. If the season changes and the current come from the northwest, deposition will occur in the northern side of the jetty. There will be depletion of sediments on the opposite side of the depositional area. Erosion can occur if the depleted sediments are not naturally replenished.

The design of the jetty must consider the nearshore hydrodynamics. Its foundation must be strong enough to withstand the impact of waves and currents which can cause erosion. After the mining operation the jetty must be removed to restore the natural coastal hydrodynamics.

Tsunami and storm surge

Construction of jetty and haul roads in the coastal area will contribute to the elements at risk to tsunami and storm surge. Destruction of the jetty and road embankment will contribute to sedimentation in the nearshore and offshore areas.

The design of the jetty must consider the coastal hydrodynamics and effects of sea level rise to reduce its vulnerability. Its foundation must be strong enough to withstand the impact of these strong waves. After the mining operation the jetty must be removed to lessen the elements at risk to these hazards. The site must be rehabilitated by promoting recovery of coastal ecosystem.

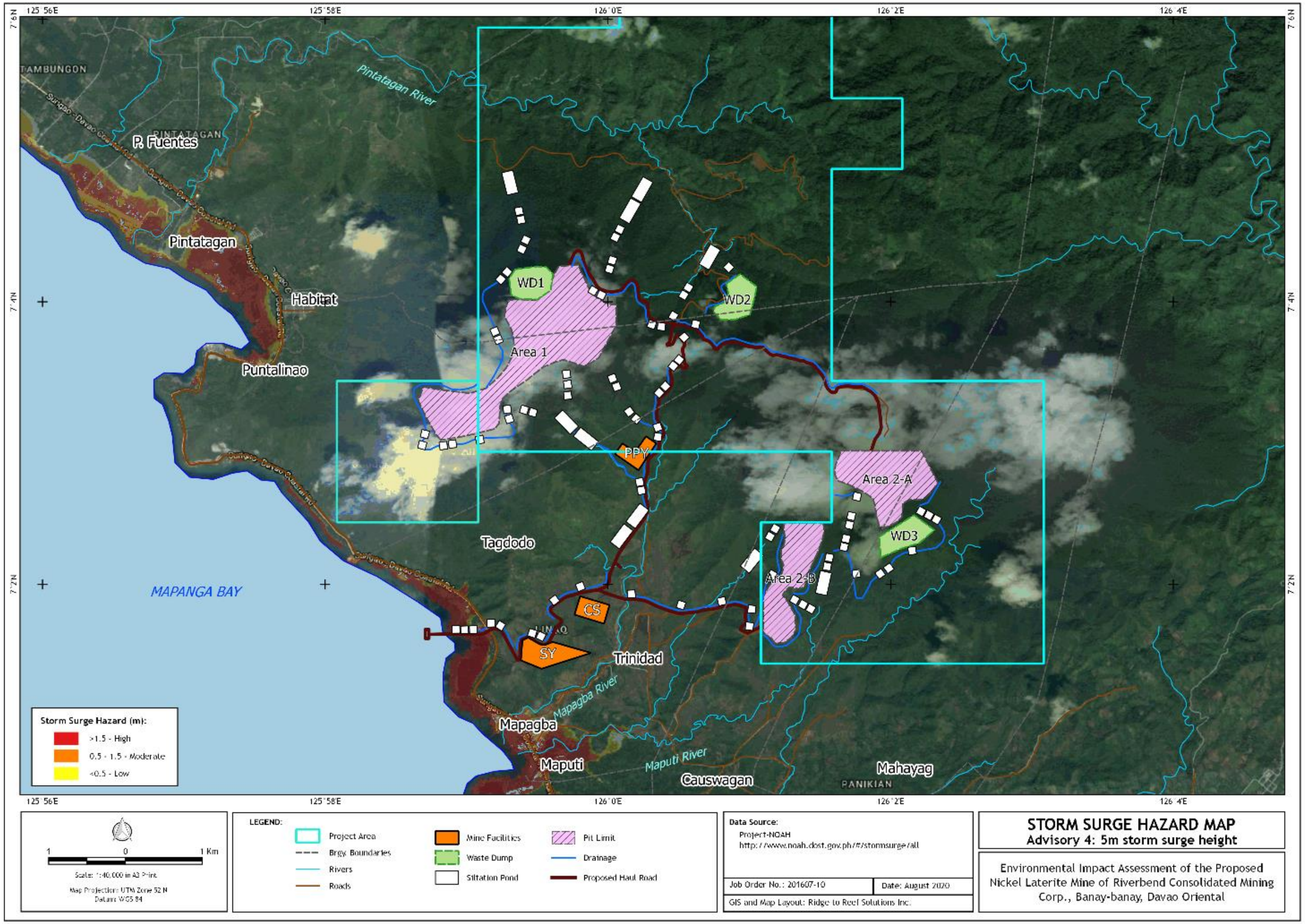


Figure 2.2-38: Storm Surge Hazard Map of the Project Site and the Vicinity (DOST-Project NOAH, 2016).

Sea Level Rise

There is a natural fluctuation in sea level in different areas around the world and within the geologic history of the earth. In the current epoch however there is an observed global sea level rise on the average. Sea level rise is attributed to the thermal expansion of the upper ocean layers and the melting of glaciers and ice sheets. These are all related to the increase in global air temperature. A study conducted by NOAA Laboratory for Satellite Altimetry, NASA and other space agencies utilizing satellite altimetry revealed that there is 2.6±0.04 mm/yr rate of sea level rise in the Pacific Ocean (**Figure 2.2-39**). The area with the greatest change is in the western Pacific side where the Philippines is situated (**Figure 2.2-40**). The rate in the Philippines is 5.8±0.6 mm/yr based on 1992 to 2011 data (Clavano, 2012). This is due to regional ocean – atmosphere dynamics, known as North Pacific Sub-tropical Gyre, wherein water is pushed clockwise in the northern hemisphere due to earth's rotation. The ocean current is further intensified by trade winds blowing westward. In the local scale sea level also varies due to other factors such as physiography, tectonic activity, tides, climate patterns and weather effects.

The average sea level rise in the western pacific region based on the Climate Change Synthesis Report prepared by IPCC in 2014 shows an increase of 60 to 70 cm for 2081 to 2100 as compared to the 1986 to 2005 data (**Figure 2.2-41Error! Reference source not found.**). A coastal vulnerability study conducted by Clavano (2012) showed an increase of about 20 cm in sea level in the Philippines in the next 40 years if the 1992-2011 values do not significantly varies. **Figure 2.2-42** (left) shows the absolute rise of sea level in the Philippines by 2050. The highest increase is along the Pacific seaboard. Clavano (2012) developed a vulnerability index incorporating the effects of other factors such as erodibility of coastal landforms, rate of erosion and deposition, coastal slope, wave heights and tidal range (**Figure 2.2-42**, right). The result shows that the sea-level in the coastline of Banaybanay and vicinity is projected to rise by 25 to 30 cm in the year 2050. The coastal vulnerability index in the municipality of Banaybanay, is classified as high. This could have an impact in low-lying areas with very flat topography, which could be severely affected by coastal flooding. These areas include the coastal barangays identified as part of primary and secondary impact areas. These are the same barangays that are susceptible to flood and storm surge. Aside from flood, sea-level rise could also push the freshwater-saltwater interface farther inland. The effect of this is that wells near the coasts would pump-out saltier groundwater.

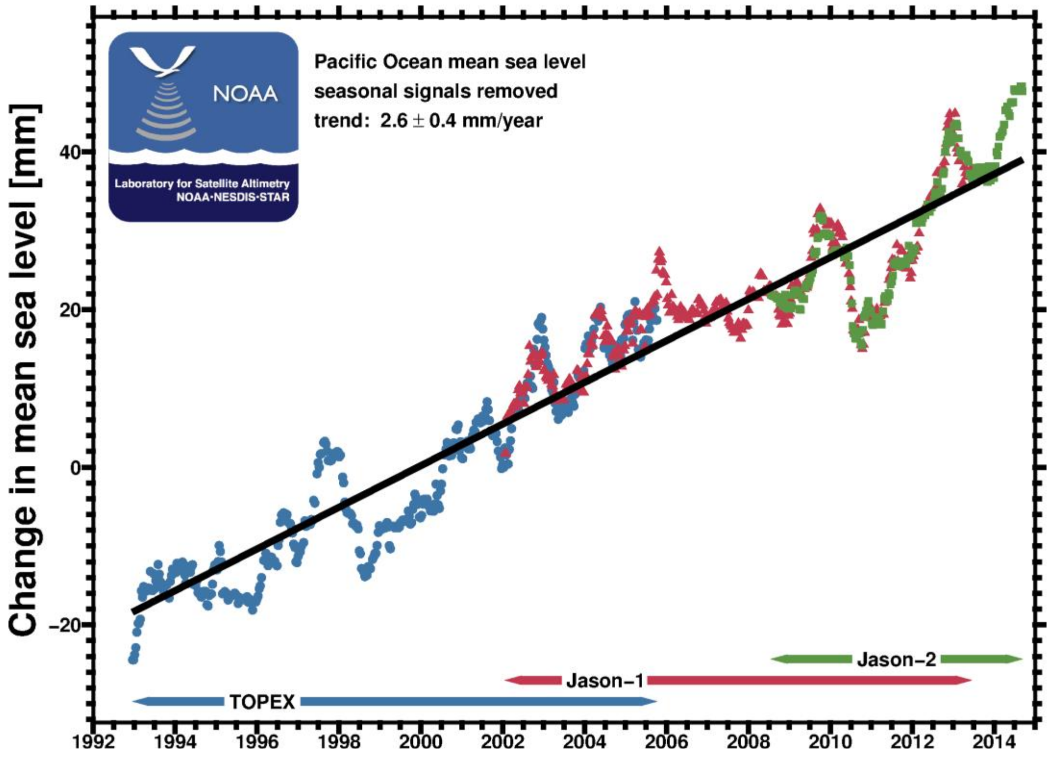


Figure 2.2-39. Sea level fluctuations in the Pacific Ocean from 1993 to 2014 (NOAA-STAR).

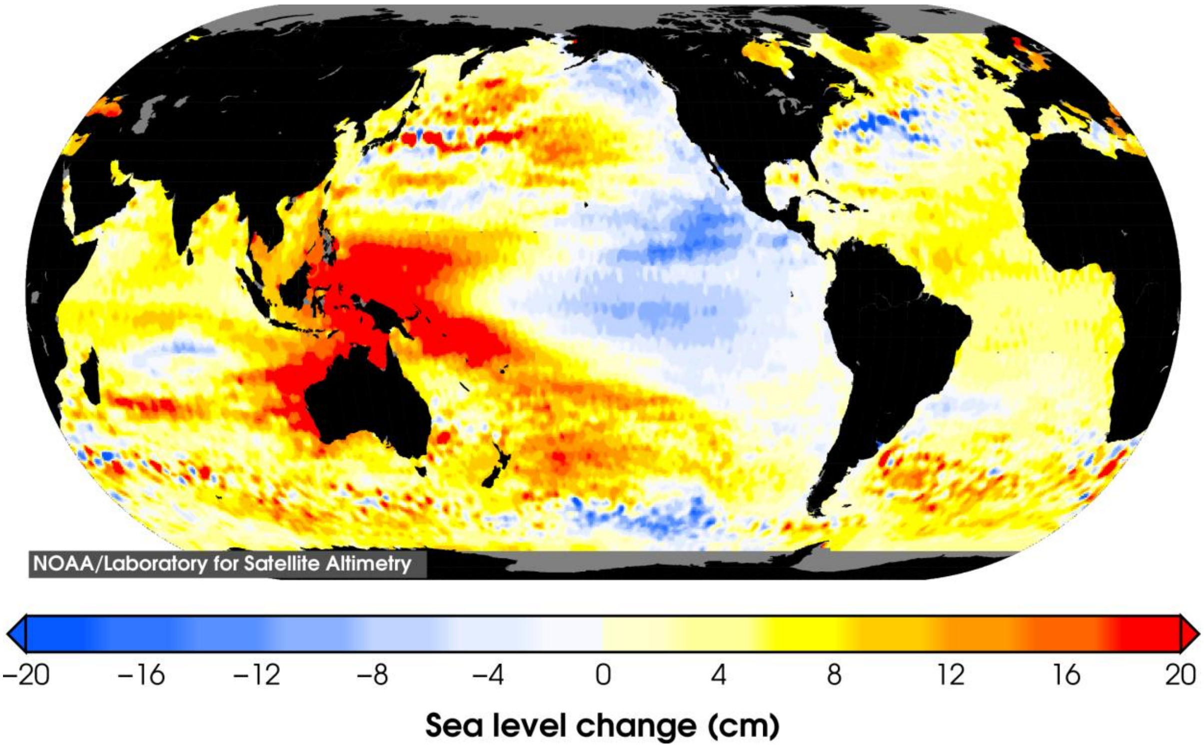


Figure 2.2-40. Global sea level changes (NOAA-STAR).

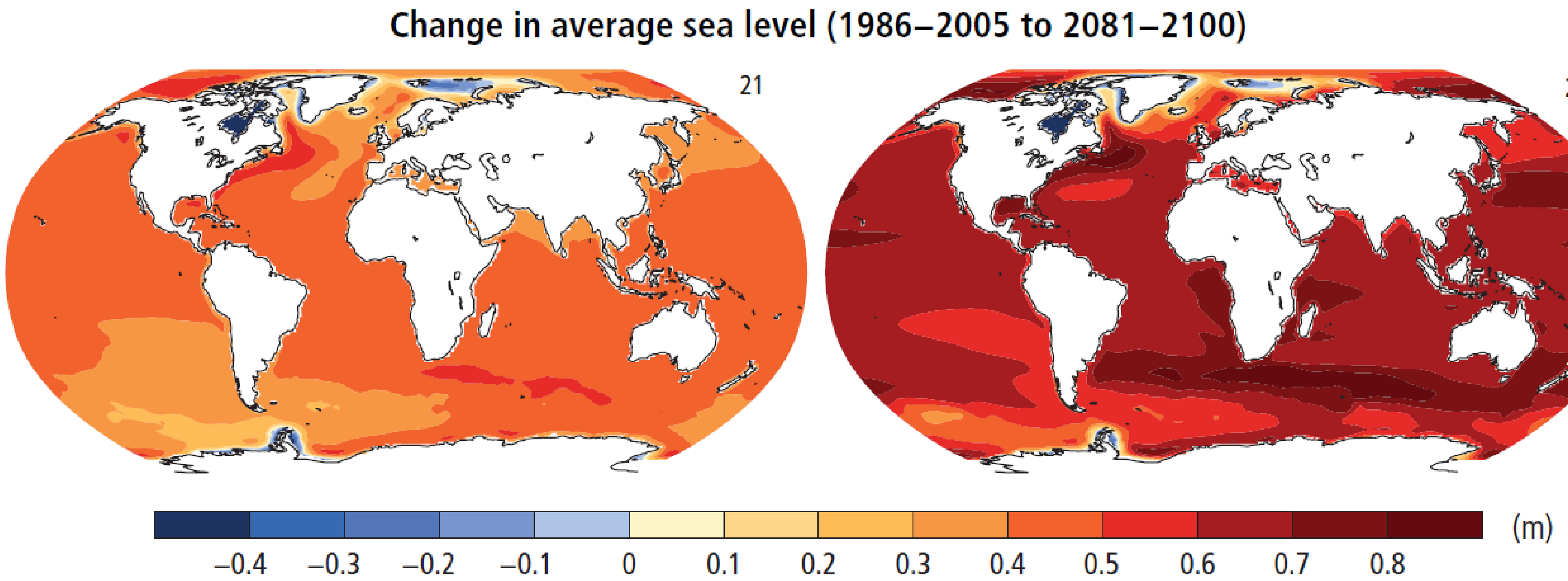


Figure 2.2-41. Projected change in average sea level for 2081 to 2100 based on the Climate Change Synthesis Report (IPCC, 2014).

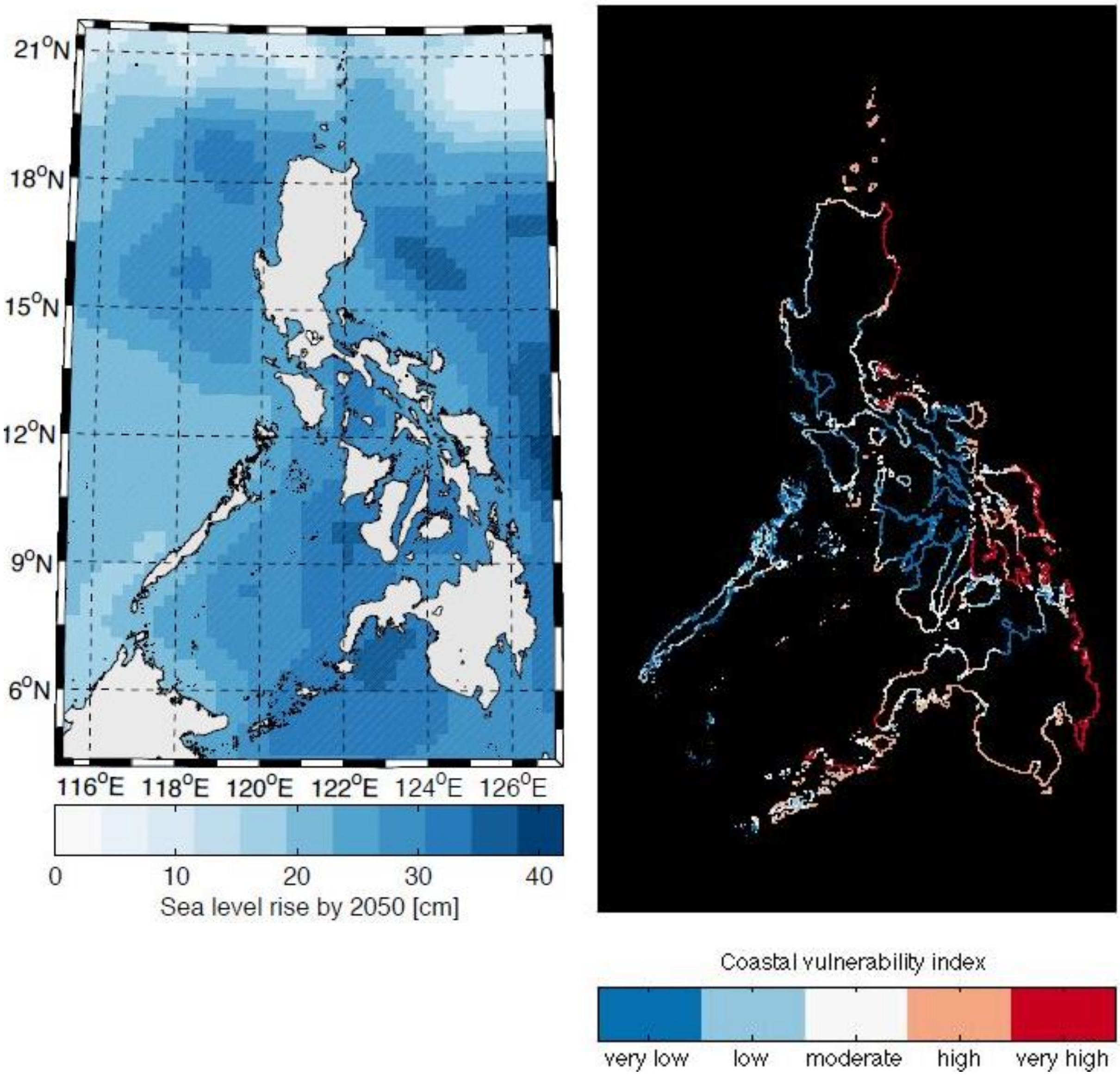


Figure 2.2-42. Left figure shows the projected sea level rise in the Philippines by 2050; Right figure shows the vulnerability index of the Philippine coastline (Clavano, 2012).

Table 2.2-43 Summary of Significant Baseline Findings

Parameter	Findings
Change in circulation pattern	As the project is at the upstream part of the watershed, changes in the baseline water movement in the project area were not considered further in the simulation. For baseline (existing) scenario, while both winds and tidal forces significantly influence current circulation in coastal environments in Davao Gulf, currents were predominantly governed by prevailing winds particularly in the project area. The results of the hydrodynamic simulation demonstrated that alongshore currents are consistent with the direction of the prevailing winds although tidal ebbing and flooding also affects current movement and mass transport within and out of the Gulf.
Change in Bathymetry	There is no permanent change in the configuration of the coast as there is no physical development to be introduced downstream of the project area. However, during construction of containment structures, stockpile, and other temporary works, as well as during the operational phase of the project, disturbance of the soil may potentially alter the existing bathymetric configuration of the immediate coastal area due to silt deposition in case sediment-laden storm water runoff from the site ended up in the coast. Such changes can be minimized thru sound engineering and construction management as well as putting up sediment control structures in the proposed mining area.
sediment transport	Based from hydrodynamic and sediment transport modeling studies so far conducted, changes in the existing suspended sediment immediate of the river mouths near the project area may be deemed potentially significant. Although the TSS plume emanating from river mouths is predicted not to dispersed away from the coastal zone towards the open sea, most of the TSS released are dispersed mainly towards the northwest and southeast and small portions move towards the innermost part of Davao Gulf with minimal concentration levels. Also, while the concentration of pollutant become lesser after such release mainly due to efficient transport and mixing processes in the area, the areas immediate of the river mouths may exceed the DENR Class SA marine water for TSS if the estimated sediment yields from the watershed ended up in the gulf. However, proper maintenance of existing and proposed mitigating measures are strongly recommended to ensure the confinement of the suspended material during the construction and operational phase of the project in case of say, accidental spillage of siltation ponds, stockpiled materials, high sediment laden flows during strong rainfall events, during transport of materials, etc. for maintaining the environmental integrity of the downstream coastal zone.

Table 2.2-29: Impact Assessment and Mitigation Measures

Potential Impact	P	C	O	A	Options for Prevention, Mitigation, Enhancement
Coastal siltation		PI	PS		Preventing accidental discharge of excavated/ fill materials during the civil works and during the mining operation. Proper maintenance of existing and proposed mitigating measures are strongly recommended to ensure the confinement of the suspended material during the construction and operational phase of the

Potential Impact	P	C	O	A	Options for Prevention, Mitigation, Enhancement
					project in case of say, accidental spillage of siltation ponds, stockpiled materials, high sediment laden flows during strong rainfall events, during transport of materials, etc. for maintaining the environmental integrity of the downstream coastal zone. Excavation work is to be avoided during storm event.
Inducement of flooding		PI	PI		Properly designed stormwater drainage system; rehabilitation and/or maintenance dredging of existing canals and waterways draining near the project area.
Change in bathymetry			PS		Maintenance dredging of the waterways and canals

P = preconstruction; C= construction, O = operation; A = abandonment or closure; Indicate in the columns P,C,O, & A the following: **A** – *adverse***, B** – *Beneficial* ,**PI** –*Potentially* i*nsignificant*, **PS** – *Potentially significant*, **LT** – *Long Term*, **ST** – *Short Term*, **R** – *Reversible*, **IR** – *Irreversible*. \

2.2.2 Water Quality

Water samplings were conducted to assess the quality of water of selected sites near the mine site as compared to the corresponding regulatory standards. The test results of surface water samples were compared to DENR Administrative Order No. 2016-08, Water Quality Guidelines.

Grab samplings were conducted on September 16, 2016. Collected samples were placed in plastic, glass and sterilized containers, properly sealed and labeled and preserved with ice at lower temperature inside coolers for storage and transport.

Presented below (**Table 2.2-30**) are the coordinates of the sampling stations while **Figures 2.2-43**, **2.2-44** and **2.2-45** show the locations of these stations. Freshwater samples were collected in Mapanga River and Maputi River.

Table 2.2-30: Coordinates of Stations

Sampling Stations		Latitude (N)	Longitude (E)
Groundwater	GW1	7° 3'56.22"N	125°57'38.84"E
	GW2	7° 0'54.38"N	125°59'26.86"E
	GW3	7° 1'4.21"N	125°59'16.20"E
	GW4	6°59'53.58"N	125°59'41.86"E
Fresh water	FW1	7° 1'3.37"N	125°59'18.41"E
	FW2	7° 1'4.67"N	126° 0'23.49"E
	FW3	7° 1'4.42"N	126° 0'45.53"E
	FW4	7° 0'48.98"N	125°59'27.85"E
Marine water	MW1	7° 3'59.25"N	125°56'22.09"E
	MW2	7° 2'9.24"N	125°57'56.13"E
	MW3	7° 0'47.36"N	125°58'56.61"E
	MW4	7° 1'21.72"N	125°57'36.11"E

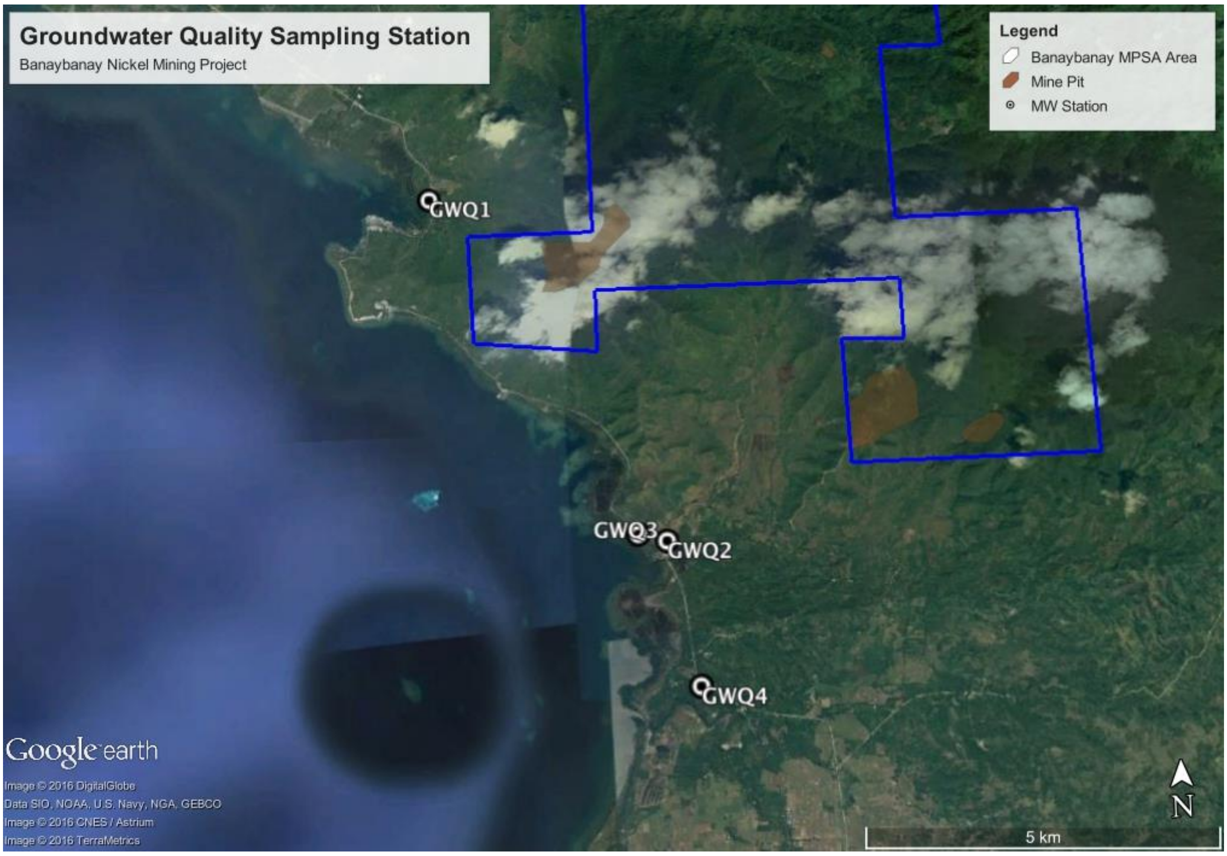


Figure 2.2-43: Groundwater Quality Sampling Location Map

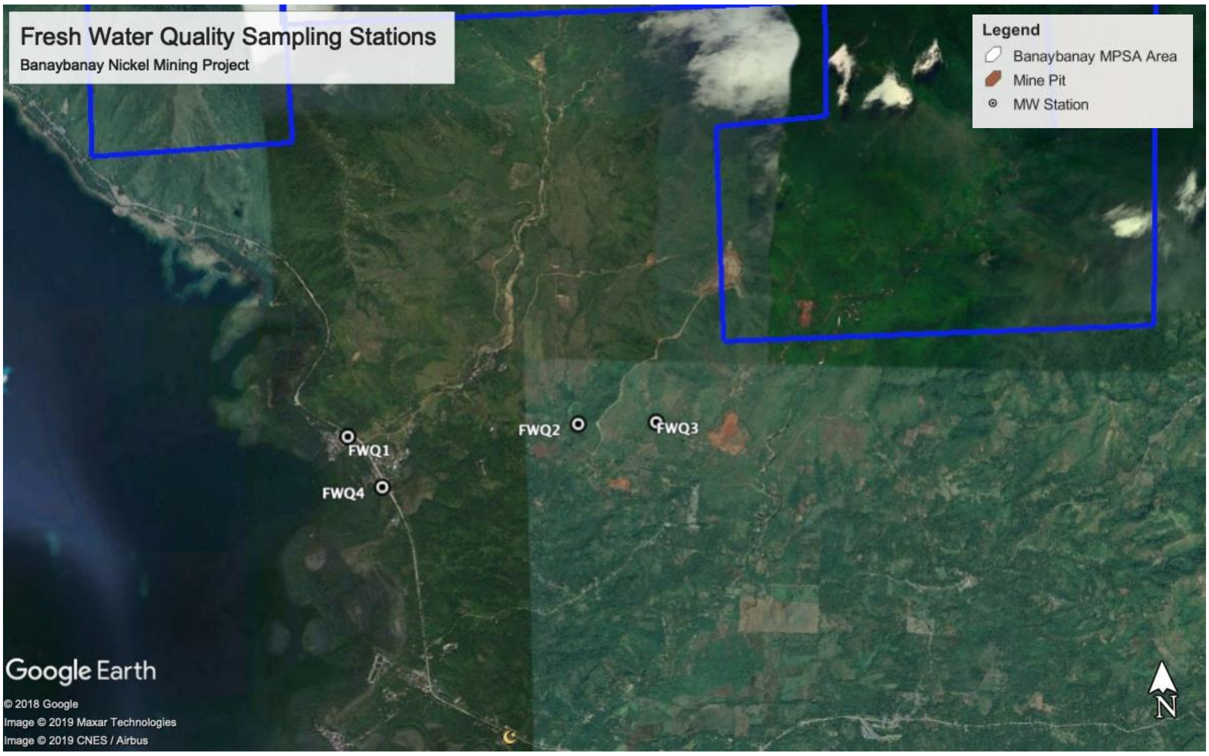


Figure 2.2-44: Fresh Water Quality Sampling Location Map

Figure 2.2-45: Marine Water Quality Sampling Location Map

2.2.2.1 Groundwater quality

The groundwater quality data and the appropriate quality criteria are presented in **Table 2.2-31**.

Table 2.2-31: Groundwater Quality Test Results

Parameters	GW1	GW2	GW3	GW4	GQG*
pH	6.2	6.2	6.5	7.1	
Temperature, ºC	26.9	26.8	27.2	27.8	
Dissolved Oxygen, mg/L	5.8	5.3	5.1	5.3	
COD, mg/L	8.6	22.9	28.6	10.0	-
TSS, mg/L	ND	ND	ND	4.0	65
Oil and Grease, mg/L	1.2	<1.0	<1.0	<1.0	1
Lead, mg/L	ND	ND	ND	ND	0.01
Cadmium, mg/L	ND	ND	ND	ND	0.003
Chromium, mg/L	ND	ND	ND	ND	0.01
Mercury, mg/L	<0.02	<0.02	<0.02	<0.02	0.001
Arsenic, mg/L	<0.02	<0.02	<0.02	<0.02	

***Adopted from the Water Quality Guidelines for Class B as per DAO 2016-08.**

Due to the existing beneficial uses of these groundwater sources (e.g. bathing and other primary contact recreation), the Groundwater Quality Guidelines to be used shall be adopted from the Water Quality Guidelines for Class B. Based on laboratory results, all parameters are within limits with the exception of Oil and Grease in Station GW1.

2.2.2.2 Fresh water quality

The fresh water quality data and the appropriate quality criteria are presented in **Table 2.2-32.**

Table 2.2-32: Fresh Water Quality Test Results

Parameters	FW1	FW2	FW3	FW4	FW5	FW6	WQG*
pH	7.1	6.8	6.6	7.2	7.3	7.3	6.5-8.5
Temperature, ºC	27.9	27.2	27.6	28.2	27.5	28.1	26-30
Dissolved Oxygen, mg/L	6.2	6.4	6.5	5.8	5.2	6.4	5
COD, mg/L	8.6	25.7	34.3	65.7	17.1	2.9	-
TSS, mg/L	ND	ND	ND	16.0	ND	2.0	80
Oil and Grease, mg/L	1.1	<1.0	<1.0	<1.0	<1.0	<1.0	2
Lead, mg/L	ND	ND	ND	ND	ND	ND	0.05
Cadmium, mg/L	ND	ND	ND	ND	ND	ND	0.005
Chromium, mg/L	ND	ND	ND	ND	ND	ND	0.01
Mercury, mg/L	0.09	<0.02	<0.02	<0.02	<0.02	<0.02	0.002
Arsenic, mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.001

***Water Quality Guidelines for Class C as per DAO 2016-08**

The rivers where the samples were taken have not yet been classified by DENR XI. For this study, the Water Quality Guidelines (WQG) for Class C water will be used due to the existing beneficial use of these rivers. Based on laboratory results, all parameters are within limits.

2.2.2.3 Marine water quality

The marine water quality data and the appropriate quality criteria are presented in **Table 2.2-33.**

Table 2.2-33: Marine Water Quality Test Results

Parameters	MW1	MW2	MW3	MW4	WQG*
pH	7.2	7.5	7.5	7.3	6.5-8.5
Temperature, ºC	28.5	27.9	28.2	28.2	26-30
Dissolved Oxygen, mg/L	6.1	6.8	6.9	7.3	6
COD, mg/L	903	771	531	943	-

Parameters	MW1	MW2	MW3	MW4	WQG*
TSS, mg/L	53.0	64.0	151	51.0	50
Oil and Grease, mg/L	<1.0	<1.0	<1.0	1.1	2
Lead, mg/L	ND	ND	ND	ND	0.01
Cadmium, mg/L	ND	ND	ND	ND	0.003
Chromium, mg/L	ND	ND	ND	ND	0.05
Mercury, mg/L	<0.02	<0.02	<0.02	<0.02	0.001
Arsenic, mg/L	<0.02	<0.02	<0.02	<0.02	0.001

***Water Quality Guidelines for Class SB (Davao Gulf) as per DAO 2016-08**

As shown in **Table 2.2-33**, TSS levels in all stations exceeded the limit. Station MW3 recorded the highest TSS level with 151 mg/L. Other parameters are within the limits. The COD levels, having no prescribed value, are generally comparable with other areas.

The sampling for water quality was done during the 1st (dry) season of the year. According to the Climatological Assessment (attached as annex) conducted for this project, they have concluded that, based on meteorological information, modeling and the terrain configuration presented in the study surrounding the project site, the establishment/selection and measurement of the sampling stations are technically acceptable and can represent the upstream and downstream source/receptor with due consideration of the two monsoon seasons of the year. Owing to their minimal differences or variations among meteorological elements and being under a Type IV climate, it is recommended that the baseline measurements of air, freshwater and marine water can be done once in the year.

2.2.3 Freshwater Ecology

2.2.3.1 1st Season Sampling (Dry Season) 2016

Sampling Stations

Sampling was conducted in the downstream of the project site on September 16, 2016. The flow of water within the project site are very minimal and intermittent that locals accounted that water is present during heavy rains only.

A total of 6 sampling stations were established within Barangays Punta Linao, Maputi and Causwagan as shown in **Figure 2.2-46**. Geographical coordinates are summarized in **Table 2.2-34**.

Table 2.2-34: Geographical Coordinates of Freshwater Ecology Sampling Stations

Station	Latitude	Longitude
1	7° 3.995'N	125° 58.113'E
2	7° 3.990'N	125° 57.699'E
3	7° 1.431'N	125° 59.948'E
4	7° 0.858'N	125° 59.679'E
5	7° 0.951'N	126° 0.138'E
6	6°59.566'N	126° 0.573'E

Figure 2.2-46: Freshwater Ecology Sampling Station Map

Photo 2.2-3: Station 6 in Barangay Causwagan

Materials and Methods

In each sampling station a 50 meter-transect was laid. For macroinvertebrates, a kick net with a 1m2 supported by 2 poles was used to collect samples in banks, riffles, exposed bedrock and leaf packs. The net was placed downstream while about 1m upstream of the net were disturbed. Collected specimens were transferred to a polyethylene bottle with 10% formalin solution for preservation and were later brought to the laboratory for identification and analysis. With the aid of forceps and dropper, all organisms in the sample bottle were sorted in a white pan. For every 80mL of the sorted samples, 5mL of the total volume will be extracted using a pipette with a widened tip that would serve as a subsample. Furthermore, subsamples were further examined under *Leica* compound microscope and *Leica* binocular microscope for identification. Naming and classification of organisms was up to its family level only.

2.2.3.1.1 Results and Discussion (2016)

Macroinvertebrates

The tables below the number of families and the relative abundance of macroinvertebrates. The top three (3) most abundant families are *Chironomidae, Hydropsychidae*, and *Elmidae.* The 2 least abundant families are *Phengodidae* and *Glossosomatidae.* Below is a macroinvertebrate under Family Chirominidae observed during the sampling.

The most abundant family is the *Chironomidae*, which are pollution-tolerant organisms. They thrive in river and stream bottoms and eat dissolved organics, algae, bacteria, feces and plants (http://www.wrc.wa.gov.au/ribbons, 2001). Availability of their food resources in the area can be a factor of their high abundance in the Pulangi River. They also have cuticular modifications that allow them to increase their dissolved oxygen extraction rate even without contact in the atmosphere (Jesus, 2008). The second most abundant, the family *Hydropsychidae*, is common in running water and is associated with oxygen availability (Jesus, 2008). They are very diverse, occurring in most freshwater types and adapted to all functional feeding groups (Sangpradub and Boonsoong, 2006). The third most abundant family is *Elmidae*. They have preference for rapidly flowing rocky streams and developed claws enabling them to cling on objects in swift streams (Edmondson, 1959). They are independent of water's dissolved oxygen so they can be found in much polluted ecosystems (Jesus, 2008).

Photo 2.2-4: *Chirominidae*

Table 2.2-35 shows the Family Biotic Index as proposed by Hilsenhoff for macroinvertebrates. It shows that all area has fairly poor water quality. The abovementioned index may have been affected by the anthropogenic activity in the area and by the heavy rain during the sampling period.

Table 2.2-35: Macroinvertebrate Family Counts

FAMILY	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Caenidae	2	2	3	6	12	9
Ceratopogonidae	11	0	1	5	3	2
Chironomidae	48	11	8	26	12	64
Corydalidae	0	0	1	2	0	0
Culicidae	2	0	1	0	0	0
Dysticidae	0	0	2	0	0	0
Elmidae	8	1	15	2	5	17
Gerridae	0	0	0	1	2	2
Glossosomatidae	0	0	1	0	0	0
Hydropsichidae	12	12	1	12	0	26
Baetidae	13	0	0	4	0	15
Micronectidae	0	0	0	2	0	0
Phengodidae	0	0	1	0	0	0

Table 2.2-36: Relative Abundance of Macroinvertebrates

FAMILY	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Ceratopogonidae	11.458	0	2.941	8.333	32.353	1.481
Chironomidae	50	42.308	23.529	43.333	141.176	47.407
Corydalidae	0	0	2.941	3.333	0	0
Culicidae	2.083	0	2.941	0	0	0
Dysticidae	0	0	5.882	0	0	0
Elmidae	8.333	3.846	44.118	3.333	14.706	12.593
Gerridae	0	0	0	1.667	5.882	1.481
Glossosomatidae	0	0	2.941	0	0	0
Hydropsichidae	12.5	46.154	2.941	20	0	19.259
Baetidae	13.542	0	0	6.667	0	11.111
Micronectidae	0	0	0	3.333	0	0
Phengodidae	0	0	2.941	0	0	0

Table 2.2-37: Levels of organic pollution and water quality based on the Field Biotic Index of macroinvertebrates

Station	Organic Pollution	Water quality
1	Fairly significant organic pollution	Fairly poor water quality
2	Fairly significant organic pollution	Fairly poor water quality
3	Fairly significant organic pollution	Fairly poor water quality
4	Fairly significant organic pollution	Fairly poor water quality
5	Fairly significant organic pollution	Fairly poor water quality

Station	Organic Pollution	Water quality
6	Fairly significant organic pollution	Fairly poor water quality

2.2.3.2 Freshwater Ecology and Riparian Ecology – 2nd Season Sampling (Wet season)

In Barangay Puntalinao, the area of the stream is located in the upper part of the mountain. It is covered with rocks and the area is hidden. The flow of the stream is slow, and the color of the water is light brown due to the soil color present in the area. The stream located at Barangay Maputi is open and accessible to the locals. There were lesser trees found alongside the stream. The water is shallow with the depth of above of the ankle. Also, the current of the stream is slow. Moreover, in Barangay Causwagan, the stream is located 20 meters from the road designed for motorcycles only. The stream is wide and deep. The upstream is wider than the midstream, which then the midstream is divided into three parts. There were presence of both small and bigger rocks. The current flow of the stream in Barangay Causwagan is faster compared to the other sampling sites.

Figure 2.2-47 shows the map for freshwater ecology, the outlets of the river were located near stations 4, 8 and 11. Specifically located at Barangay Piso, Barangay Puntalinao and Barangay Maputi. Freshwater species have a broad spectrum of migration strategies. There were no migratory fishes identified in the river and streams due to degraded breeding and feeding grounds of fishes.

Stream Usage

Based on DENR Administrative Order 2016-08 water body classification and usage, the streams covered in the sampling can be classified as Class A and Class B. According to the locals, the streams are currently using it for bathing and washing of clothes. In addition to the beneficial terms of the streams for the local community, the government built a reservoir near the stream of Barangay Causwagan, Banaybanay, Davao Oriental (see fig. 10). Therefore, classified as Class A for water supply that undergone treatment to meet standards for drinking water. Reservoirs are a part of the economic potential of any country and as serves as an investment construction. A major feature of reservoirs is their high degree of functionality which can store water supply for industry and agriculture use. The capability of storage of reservoirs is to dampen an incoming flood wave, even without controlling the passage of water.

Sampling Station

In Barangay Puntalinao, the area of the stream is located in the upper part of the mountain. It is covered with rocks and the area is hidden. The flow of the stream is slow, and the color of the water is light brown due to the soil color present in the area. The stream located at Barangay Maputi is open and accessible to the locals. There were lesser trees found alongside the stream. The water is shallow with the depth of above of the ankle. Also, the current of the stream is slow. Moreover, in Barangay Causwagan, the stream is located 20 meters from the road designed for motorcycles only. The stream is wide and deep. The upstream is wider than the midstream, which then the midstream is divided into three parts. There were presence of both small and bigger rocks. The current flow of the stream in Barangay Causwagan is faster compared to the other sampling sites. Freshwater species have a broad spectrum of migration strategies. There were no migratory fishes identified in the river and streams due to degraded breeding and feeding grounds of fishes.

Sampling was conducted in the downstream of the project site on October 03, 2019. Same sampling points were selected during the 1st season and 2nd season sampling. In addition to the beneficial terms of the streams for the local community, the government built a reservoir near the stream of Barangay Causwagan, Banaybanay, Davao Oriental **(see Photo 2.2-5).**

A total of 6 sampling stations were established within Barangays Punta Linao, Maputi and Causwagan as shown in **Figure 2.2-47**. Geographical coordinates are summarized in **Table 2.2-38**.

Table 2.2-38: Geographical Coordinates of Freshwater Ecology Sampling Stations

Sampling Site	Stations	Rivers/ Creeks	Coordinates	Elevation
Brgy. Puntalinao	1	Puntalinao River (Upstream)	7° 3'30.70"N, 125°58'44.90"E	364 m
	2	Puntalinao River(Downstream)	7° 3'59.38"N, 125°57'41.93"E	21 m
	3	Mapanga River (Main River)	7° 1'25.84"N, 125°59'56.90"E	34 m
Brgy Maputi	4	Mapanga River (Downstream)	7° 1'3.74"N, 125°59'20.62"E	29 m
	5	Maputi River (Downstream)	7° 1'3.29"N, 126° 0'18.33"E	22 m
	6	Maputi River (Upstream)	7° 1'42.72"N, 126° 1'26.17"E	118 m
Brgy. Causwagan	7	Maputi River (Downstream)	7° 0'53.52"N, 126° 0'27.58"E	36 m
	8	Maputi River (Downstream)	7° 0'48.58"N, 125°59'30.08"E	41 m
	9	Piso River (Upstream)	7° 1'35.86"N, 126° 1'48.10"E	113 m
	10	Piso River (Downstream)	6°59'33.95"N,126°0'34.40"E	13 m
	11	Piso River (Downstream)	6°59'35.37"N,125°59'20.18''E	18 m

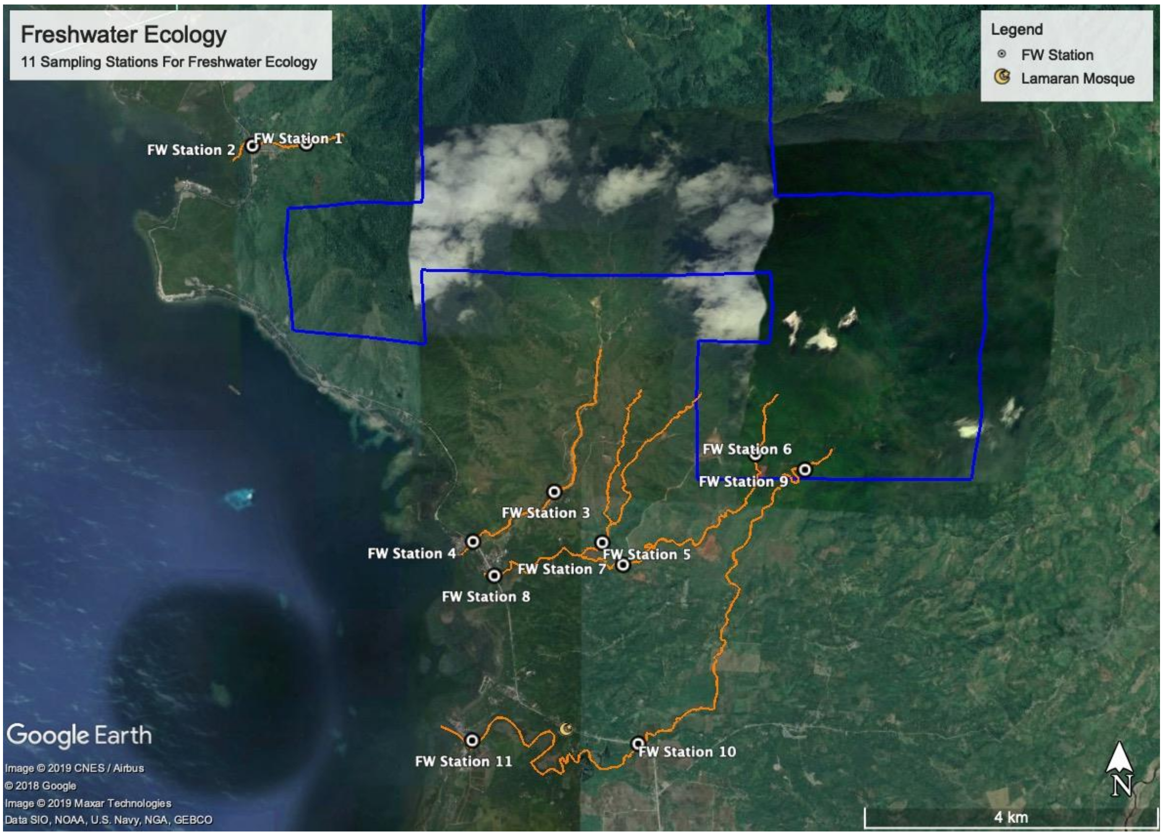


Figure 2.2-47. Freshwater Ecology Sampling Station Map

Sampling Method

Assessing freshwater ecology is important in determining the current condition of an aquatic habitat. Benthic macroinvertebrates were sampled quantitatively using a kick net.

A 1 m^2 kick net supported by 2 poles was used to collect samples. The net was placed downstream while about 1m upstream of the net was disturbed while slowly walking upstream, exposing the bedrocks and leaf pacts. Collected samples were preserved in the field with 70% ethanol. The samples were sorted and identified at family level due to the difficulty in identification because of complex taxonomy.

2.2.3.2.1 Results and Discussion

Macroinvertebrates

Relative Abundance

About 30.42% among all the family of macroinvertebrates identified were Chironomidae. Then, followed by Gerridae and Palaemonidae which has 19.58% and 12.26% abundance, respectively. Chironomidae are pollutant-tolerant organisms. The family Chironomidae is the most widely distributed and frequently the most abundant group of insects in freshwater environments. However, chrimonid species exhibit a distinct preference for a certain type of substratum which then, it is an important factor limiting the distribution of chironomid. The availability of the food resources of the sampling areas could offer can be the factor of high abundance of Chironomidae.

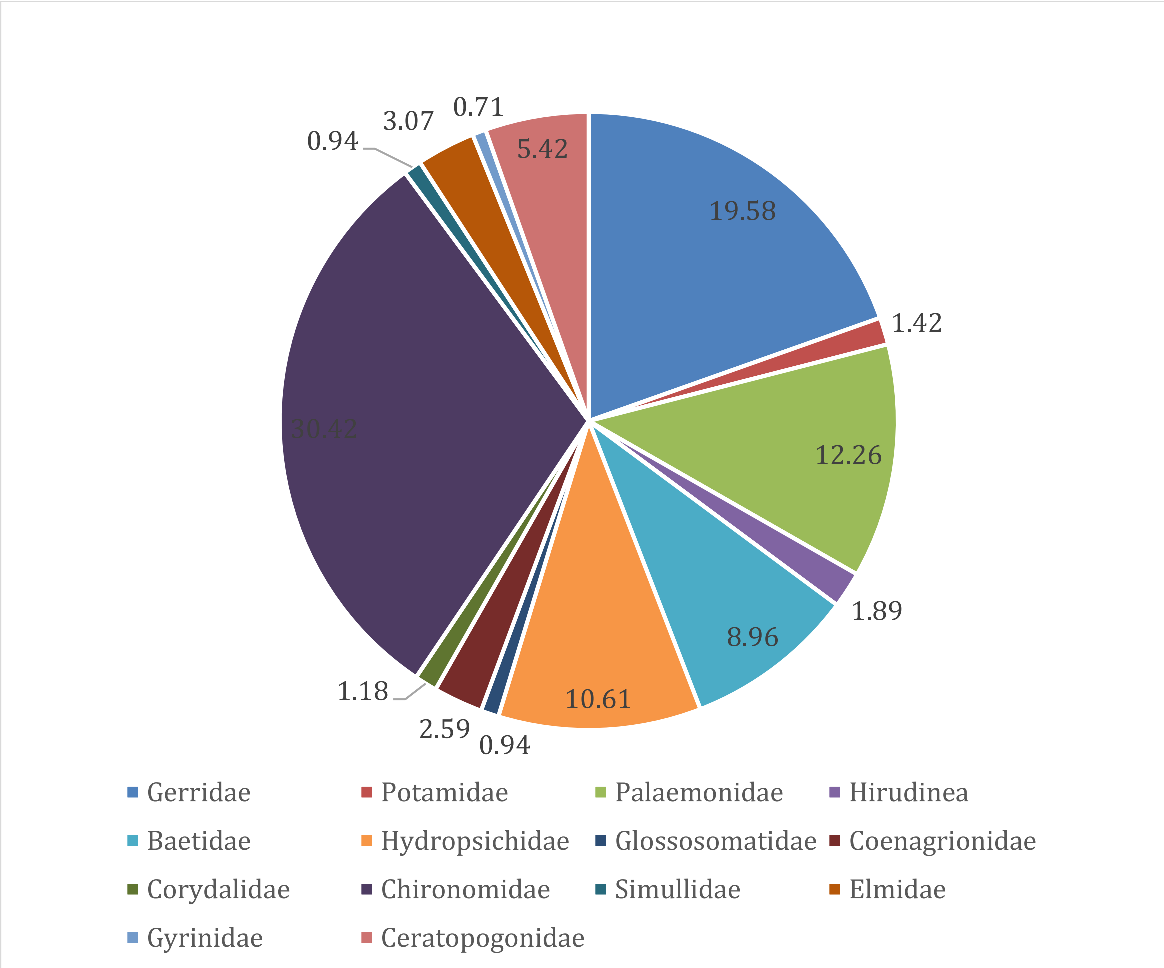


Figure 2.2-48. Relative Abundance of Macroinvertebrates in 2nd Season Sampling

Most ecosystems, streams are subject to habitat fragmentation which can result in a loop biodiversity of benthic macroinvertebrates. The construction of dams and reservoirs alters the natural physical structure of streams and rivers by creating an area of standing water and by changing, reducing or halting downstream flow. Ecologically, this could be classified as a kind of edge effect, where habitat is altered immediately at the outflow. The initiation of these smaller habitats has a direct impact on all of the species, their community structure, and the overall ecosystems of those fragments. The figure below is the area of the construction of reservoir where hits the sampling stations of freshwater ecology.

Photo 2.2-5. Figure 23. Visual Site of Seservoir in Baragay Causwagan

Species Occurrence

The samples were classified up to family level due to its complex taxonomy. A total of 11 stations for freshwater ecology were established. There are 424 number of individuals (macroinvertebrates) found in all sampling sites. Family with the most frequent occurrence of all sites is Chironomidae which also has the most abundant number of individuals. Then, followed by Gerridae, Baetidae and Ceratopogonidae which occurred in eight (8) stations. Base on the baseline study in 2016, Chironomidae were present in all sampling stations and has the highest relative abundance.

Table 2.2-39. Occurrence of Macroinvertebrates in each sampling station

Family	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
Gerridae	+	+	-	+	-	-	+	+	+	+	+
Potamidae	-	+	-	-	-	-	-	-	-	-	-
Palaemonidae	-	+	-	-	+	-	-	-	-	+	-
Hirudinea	-	+	-	-	-	-	-	-	-	-	-
Baetidae	+	+	+	+	-	+	+	+	-	+	-
Hydropsichidae	+	+	+	-	+	+	-	-	+	+	-
Glossosomatidae	+	-	+	-	-	-	+	-	-	-	+
Coenagrionidae	+	+	-	+	-	+	-	-	+	+	-
Corydalidae	-	-	-	+	+	-	-	+	-	+	-
Chironomidae	+	+	+	+	+	+	+	+	-	+	+
Simullidae	+	-	-	-	+	-	-	-	+	-	+
Elmidae	+	-	+	+	-	+	-	+	-	-	+
Gyrinidae	-	+	-	-	+	-	-	-	-	+	-
Ceratopogonidae	+	-	-	+	+	+	+	-	+	+	+

Pollution Indicator

Macroinvertebrates identified in the recent study belonged to Phylum Arthropoda. The assessed macroinvertebrates in both 2016 and 2019 study has the same most abundant organisms which is

Chironomidae. The Hilsenhoff - Family Biotic Index (FBI) was used to determine the relation of the presence of certain species in a family to the water quality of the streams in Banaybanay, Davao Oriental. The Biotic Index was originally developed by Hilsenhoff (1982) to provide a tolerance value which is the average of the tolerance values of all species within the benthic arthropod community. The Biotic Index was modified to the family-level with the tolerance values ranging from 0 (very tolerant) to 10 (highly tolerant) based in their tolerance to organic pollution. The formula used for the computation of FBI is:

$$\text{FBI} = \frac{\Sigma \text{xi t}}{n}$$

x_i= number of individuals within a taxon
t_i= tolerance value of a taxon
n= total number of organisms in the sample (100)

Table 2.2-40. Hilsenhoff Family Biotic Index

Family Biotic Index	Water Quality	Degree of Organic Pollution
0.00-3.75	Excellent	Organic pollution unlikely
3.76-4.25	Very good	Possible slight organic pollution
4.26-5.00	Good	Some organic pollution probable
5.01-5.75	Fair	Fairly substantial pollution likely
5.76-6.50	Fairly poor	Very substantial pollution likely
6.51-7.25	Poor	Very substantial pollution likely
7.26-10.0	Very poor	Severe organic pollution likely

The communities of aquatic insects are affected by several factors related to water quality. In this study of microbenthic invertebrates, there were 14 families of inverts identified with a total of 424 number of individuals. The most abundant family is Chironomidae with a tolerance of 6. These organisms are collectors or gatherers. The presence of Chironomidae indicates the balance of the community since it is a pollutant indicator organisms and less sensitive to environmental stress (Plafkin et al., 1989). In the table below, there are five families that belongs to predators when it terms to their trophic classification or feeding habit. As different chironomidae species vary in their sensitivities to environmental stressors, they can make good indicators of anthropogenic change (Bazzanti & Bambacigno, 1987; Cranston et al., 1997; Cranston, 2000a; Ruse, Herrmann & Sublette, 2000; Mousavi, Primicerio & Amundsen, 2003). The FBI values shown below appears to be the streams in the project site were fairly poor in terms of water quality and fairly substantial organic pollution in terms of degree of organic pollutants.

Table 2.2-41. Family Biotic Index in the Project Site

Family	Tolerance	Feeding Habit
Gerridae	9	PR
Potamidae	6	CG
Palaemonidae	6	CG
Hirudinea	8	PR
Baetidae	5	CG/SC
Hydropsichidae	4	FC
Glossosomatidae	1	SC
Coenagrionidae	8	PR
Corydalidae	4	PR
Chironomidae	6	CG

Family	Tolerance	Feeding Habit
Simuliidae	6	CF
Elmidae	5	CG
Gyrinidae	4	PR
Ceratopogonidae	6	PR

Ephemeropteran, Plecopteran, Tricopteran

Among aquatic insects, Ephemeroptera, Plecoptera and Trichoptera (EPT), comprise rich assemblages in low and medium order stony cobble streams. These organisms are sensitive to environmental perturbations and occur in clean and well oxygenated waters. Hence, EPT assemblages are frequently considered to be good indicators of water quality (Rosenberg and Resh, 1993). The EPT Index is under the three orders of aquatic insects that are commonly found in the benthic macroinvertebrate community: Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). There are numbers of species that are intolerant of pollutants and usually absent in polluted waters. The greater pollution, the lower species richness expected.

In this study, only Ephemeroptera and Trichoptera were present in the streams in the streams. These families are Baetidae under the Order Ephemeroptera and Glossosomatidae under the Order Trichoptera, which has 38 and 4 number of individuals in all sampling stations. The abundance of EPT and Chironomidae indicates the balance of the community, since EPT are considered to be more sensitive and Chironomidae are less sensitive to environmental stress (Plafkin et al., 1989). A good biotic conditioned community is considered only when there is an even distribution of the four groups (EPT and Chironomidae). A disproportionately high numbers of Chironomidae indicates environmental stress.

Water Use

Streams, rivers, wetlands and lakes are home for many small animals called macroinvertebrates. These animals include insects, crustaceans, molluscs, arachnids and annelids. Aquatic organisms are important elements in the ecological dynamics (Hynes, 1970) playing an important role in the cycle of materials and in tropic transfers. The communities of macroinvertebrates are affected by several factors related to water quality, number of organic pollutants, stream morphology, food availability and quality. In addition to the history of the ecology of the river, there were no migratory fishes found in the streams of Banaybanay, Davao Oriental.

Water bodies in the Philippines were classified according to its usage. According to DAO 2016-08, fresh surface water can be classified using the following respective characterization:

Table 2.2-42.Water Body Classification and Usage of Freshwater (DAO 2016-08)

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 the approved disinfection to meet the latest PNSDW
Class A	Public Water Supply Class II – Intended as sources of water supply requiring conventional treatment (coagulation, sedimentation, filtration and disinfection) to meet the latest PNSDW.
Class B	Recreational Water Class I – Intended for primary contact recreation (bathing, swimming, etc.)
Class C	1. Fishery water for the propagation and growth of fish and other aquatic resources 2. Recreational Water Class II – For boating, fishing or similar activities 3. For agriculture, irrigation and livestock watering
Class D	Navigatable Waters

Based on the above table of DENR Administrative Order 2016-08 water body classification and usage, the streams covered in the sampling can be classified as Class C. Locals are using it for agriculture and livestock watering. The tables below show the primary and secondary water parameters based on DAO 2016-08 of the Class C water classification.

Table 2.2-43. Class B Primary Parameters

Parameters	Unit	Class B
BOD	mg/L	5
COD	mg/L	250
Color	TCU	50
Dissolved Oxygen (minimum)	mg/L	5
Fecal Coliform	MPN/ 100 mL	100
Nitrate	mg/L	7
pH	-	6.5-8.5
phosphate	mg/L	0.5
Temperature	°C	26-30
Total Suspended Solids	mg/L	65

Table 2.2-44. Class B Secondary Parameters

Parameters	Unit	Class B
Ammonia	mg/L	0.05
Boron	mg/L	0.05
Fluoride	mg/L	1
Selenium	mg/L	0.01
Sulfate	mg/L	250
Arsenic	mg/L	0.01
Barium	mg/L	0.7
Cadmium	mg/L	0.003
Chromium	mg/L	0.01
Cooper	mg/L	0.02
Iron	mg/L	1
Lead	mg/L	0.01
Manganese	mg/L	0.2
Mercury	mg/L	0.001
Nickel	mg/L	0.04
Zinc	mg/L	2
Benzo(a)pyrene	μg/L	0.7
Benzene	mg/L	0.01
Toluene	mg/L	1
Ethylbenzene	mg/L	0.3
Xylenes	mg/L	0.5
Cyanide	mg/L	0.07
Organophosphate	μg/L	1
Oil and Grease	mg/L	1
Polychlorinated Biphenyls	μg/L	0.2
Phenol & Phenolic Substances	mg/L	< 0.001
Surfactants (MBAS)	μg/L	0.3
Trichloroethylene	μg/L	0.07
Total Organochloride Pesticides	μg/L	50
Aldrin	μg/L	n/a
Chlordane	μg/L	n/a
DDT	μg/L	n/a
Dieldrin	μg/L	n/a
Endrin	μg/L	n/a
Heptachlor	μg/L	n/a
Lindane	μg/L	n/a

Parameters	Unit	Class B
Methoxychlor	μg/L	n/a
Toxaphene	μg/L	n/a

Water Quality and Use

To understand more about how the communities (freshwater organisms) were structured and to identify the main environmental factors affecting the composition and abundance of freshwater ecology, there are physicochemical and biological measures and factors that has to be considered for biomonitoring and recovery of environments. These parameters include pH, biological oxygen demand (BOD), dissolved oxygen (DO) organophosphate. Many aquatic animals experience difficulties with calcium regulation when the pH values reach less than 5.5. Whereas, below pH 5.0 problems also arise in relation to sodium regulation. There are species belongs to the family Chironomidae that has a wide range of tolerance in terms of high pH. Temperature is one of the major factors controlling rates of growth and development in aquatic insects. With regards to direct effect on metabolism, temperature is also likely to have an indirect affect through its influence on food quality and quantity. Dissolved oxygen levels fluctuate seasonally and vary with water temperature and altitude. Cold water holds oxygen than warm water and water holds less oxygen at higher altitudes. As per biochemical oxygen demand (BOD), it is an indicator of the total organic content that is available to organisms plus any chemicals that spontaneously react with O_2. Respiration by aquatic animals, decomposition, various chemical reactions consume oxygen. The stream system both produces and consumes oxygen (Pinder, 1986).

Most ecosystems, streams are subject to habitat fragmentation which can result in a low of biodiversity of benthic macroinvertebrates. The construction of dams and reservoirs alters the natural physical structure of streams and rivers by creating an area of standing water and by changing, reducing or halting downstream flow. Ecologically, this could be classified as a kind of edge effect, where habitat is altered immediately at the outflow. The initiation of these smaller habitats has a direct impact on all of the species, their community structure, and the overall ecosystems of those fragments. (Monaghan et. Al, 2005). The figure below is the area of the construction of reservoir where hits the sampling stations of freshwater ecology.

Moreover, with respect to the community structure of the fishes in freshwater ecology, there are many requirements and factors to be considered for them to live successfully and abundantly. However, the streams in the project area did not meet the optimum range of the abiotic factors such as thermal tolerance, pH, nutrient availability and oxygen demand. Fishes require a place to live and reproduce with a clean water free from excess sediment or pollutants, water flow (upstream and downstream movements and habitat structure), water quality and numbers of predators and competitors.

Riparian Flora

The riparian zone or otherwise known as riparian area or river bank is the interface between land and river system. Vegetation within the riparian area is called riparian vegetation generally characterized by hydrophilic plants.

The riparian vegetation functions as a large sponge that reduces overland surface flow and absorbs pollution caught up in stormwater runoff. In addition, trees canopy in riparian zones provides shade, which helps maintain cooler water temperatures and high dissolved oxygen levels.

Species Richness

There is a total sixteen (16) species with thirteen (13) families present in the sampling area. The family with the most identified species is Myrtaceae with three (3) species present. Followed by Family Anacardiaceae with two (2) species present. The rest of the families have only one (1) species identified in the sampling area.

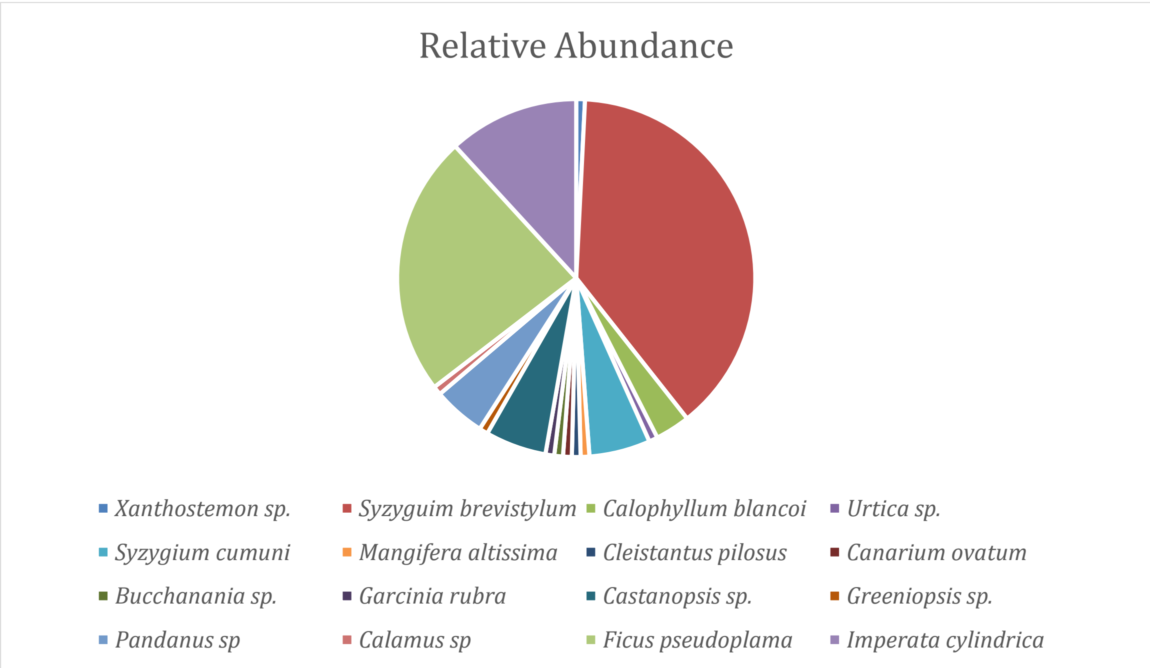
Table 2.2-45. Composition of species present

Family	Species Name	Common Name
Acoraceae	*Calamus* sp.	Pusan

Family	Species Name	Common Name
Anacardiaceae	*Buchanania* sp.	Manga-manga
	Mangifera altissima	Manga-manga
Burseraceae	*Canarium ovatum*	Pili-pili
Calophyllaceae	*Calophyllum blancoi*	Bitanghol
Clusiaceae	*Garcinia rubra*	Batwan
Fagaceae	*Castanopsis* sp.	Indang-indang
Moraceae	*Ficus pseudoplama*	Lubi-lubi
Myrtaceae	*Syzyguim brevistylum*	Sagimsim
	Syzygium cumini	Lumboy-lumboy
	Xanthostemon sp.	Magkuno
Pandanaceae	*Pandanus* sp.	Baliw
Poaceae	*Imperata cylindrica*	Kugon
Phyllanthaceae	*Cleistantus pilosus*	Banitlong
Rubiaceae	*Greeniopsis* sp.	Hambabalod
Urticaceae	*Urtica* sp.	Alingatong

Relative Abundance

A total of 127 individuals is present in the sampling stations. The most abundant species with 39% relative abundance (49 individuals) is S*yzygium brevistylum.* It is followed by *Ficus pseudoplama* with 24% relative abundance (30 individuals), and *Imperata cylindrica* with 12% relative abundance (15 individuals present). The species that has the least relative abundance of 1% includes *Xanthostemon* sp., *Urtica* sp., *Mangifera altissima*, *Cleistantus pilosus, Canarium ovatum, Bucchania* sp., *Garcinia rubra, Greeniopsis sp.* and *Pandanus sp.*



Figrue 2.2-49. Relative Abundance of Different Species present in the Riparian Flora

Conservation Status

The species that was identified according to genus level will not be included in determining the conservation status of the species since the criteria for IUCN and DAO 2017 can only be applied up to species level. The species *Mangifera altissima* is considered vulnerable for both IUCN and DAO 2017. *Canarium ovatum* and *Garcinia rubra* are listed as vulnerable in IUCN. The remaining species were considered as least concern and not yet assessed.

Table 2.2-46. Conservation Status of Riparian Species

Species Name	Common Name	IUCN	DAO 2017
Xanthostemon sp.	Magkuno	Not listed	Not listed
Syzyguim brevistylum	Sagimsim	Not listed	Not listed
Calophyllum blancoi	Bitanghol	Not yet assessed	Not Listed
Urtica sp.	Alingatong	Not listed	Not listed
Syzygium cumuni	Lumboy-lumboy	Least Concern	Not listed
Mangifera altissima	Manga-manga	Vulnerable	Vulnerable
Cleistantus pilosus	Banitlong	Not listed	Not listed
Canarium ovatum	pili-pili	Vulnerable	Not listed
Bucchanania sp.	Manga-manga	Not listed	Not listed
Garcinia rubra	Batwan	Vulnerable	Not listed
Castanopsis sp.	Indang-indang	Not listed	Not listed
Greeniopsis sp.	Hambabalod	Not listed	Not listed
Pandanus sp	Baliw	Not listed	Not listed
Calamus sp.	Pusan	Not listed	Not listed
Ficus pseudoplama	Lubi-lubi	Not yet assessed	Not listed
Imperata cylindrica	Kugon	Least concern	Not listed

Economic Importance

Five (5) of the species observed are used as food source, and nine (9) are used as medicine or medicine component. One species, *Xanthostemon* sp. Is used in logging and wood harvesting, while others are used as ornaments as well.

Table 2.2-47. Economic Importance of Riparian Species Observed

Species Name	Common Name	Biological Resource Use
Xanthostemon sp.	Magkuno	Logging, Wood Harvesting
Syzyguim brevistylum	Sagimsim	Food, medicine
Calophyllum blancoi	Bitanghol	Wood Harvesting, Medicine
Urtica sp.	Alingatong	Food, medicine
Syzygium cumuni	Lumboy-lumboy	Food, medicine
Mangifera altissima	Manga-manga	Food
Cleistantus pilosus	Banitlong	Medicine
Canarium ovatum	pili-pili	Food
Bucchanania sp.	Manga-manga	Medicine
Garcinia rubra	Batwan	Food, medicine
Castanopsis sp.	Indang-indang	Food, ornamental
Greeniopsis sp.	Hambabalod	Medicine
Pandanus sp	Baliw	Food, handicraft
Calamus sp.	Pusan	Ornamental
Ficus pseudoplama	Lubi-lubi	Food, medicine
Imperata cylindrica	Kugon	Ornamental

River System Productivity

River food webs are considered as complex than the other ecosystems. Field experiments conducted via river had documented chains of strong interaction that link predators through consumers to primary producers (Power et al, 1996). Food chain starts with a primary producer which is an autotroph organism. In rivers, the autotroph organisms include epilithic organisms, such as cyanobacteria and algal communities (Rott & Pfister, 2017). The trophic level of river system consists of two linked food chain: one from algae to predator-susceptible grazers to predatory fish and insects, and the other one is from algae to predator-resistant grazers (Wootton et al, 1996). The second trophic level which are the consumers includes the macroinvertebrates, such as mayflies, turf midges, armored or sessile grazers, and small predators (Power et al, 1996). Thus, the second trophic level primarily composed of herbivores. The higher trophic level organisms, such as predatory fishes and predatory insects, is composed of omnivorous organisms. Energy decreases as the trophic level of organisms became higher since the energy is lost as metabolic heat when an organism from one trophic level is being consume by another higher trophic level organism.

Soil Profile of the Riparian Area

The important function of soil resources includes plant production, buffering, transformation, filtering, geogenic, cultural heritage and infrastructure. The characteristics and fertility status of the soil are important especially in planning for suitable soil management strategies needed for sustainable and management used for mining operations. The major land use or vegetation cover of the area in this study includes forest over ultramafic rocks, shrubs, grasslands and perennial crops. The project area is not within a declared protected or preserved area, wildlife sanctuaries, national park or watershed reserve. Also, there was no historic, archaeological and scientific interest. Davao Oriental encompasses the southern part of the Pacific Cordillera in eastern Mindanao. The area is generally mountainous with sharp ridges and spurs surrounded by low hills.

To overcome the threat of droughts and erosion of the soils, a reasonable measure for cultivation and facilities of water conservation must have built on mountainous land. Such as building water reservoirs, dense planting, straw mulching and contour farming that adopted by local farmers in the soil areas. The type of soil that is associated in the riparian area has are often eroded owning to higher relief, greater slope and lighter texture.

Chemical Soil Parameters

The type of soil present in the project site is red soil with the coloration of reddish brown. The exchangeable cations of red soils are characterized by a high proportion of Aluminum The common acid-forming cations are hydrogen (H^+), aluminum (Al^{3+}) and iron (Fe^{2+} or Fe^{3+}), whereas common base-forming cations include calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^+) and sodium (Na^+). Mineralogically, red soils are desilicated and relatively enriched with iron and aluminum. The most common feature of a red soils is that they normally have low content of nutrients and mainly caused by their strong acidity. Soil pH is a measure of the soil solution's acidity and alkalinity. Soils are referred to as being acidic, neutral or alkaline (basic) which depends on the pH values on a scale approximately 0 to 14. Soil pH is influenced by both acid and base-forming ions in the soil. Also, red soils have low organic matter content due to the destruction of primary vegetation. In terms of nutrient availability, the exchange capacity of cations and anions are directly affected by soil pH. The soil's cation exchange capacity (CEC) is higher than the anion exchange capacity (AEC). A high CEC soil will also have a greater buffering capacity, increasing the soil's ability to resist change in pH. Plant nutrient availability is greatly influenced by soil pH. Hence, there are more available nutrients at lower pH than higher pH value.

The reason of the contribution to a low organic matter content of red soils is the destruction of the primary vegetation. Mostly, the organic content is less than 2% with generally an inadequate macro-nutrient level for good crop production. Also, due to the deficiency of some micro-nutrient, soil fertility is not high. The plants have an optimal ranges of nutrients, usually nutrients are available to plants at lesser amounts. The upland soils have generally a total phosphorus of 0.01-0.55%.

Table 2.2-48: Chemical Properties of Soil

Chemical properties	Method	Purpose
pH (water)	Electrometry	Potential nutrient supply, alkalinity or acidity of the soils
Nitrogen	Kjeldahl	Potential N supply
Organic matter (OM)	Walkley-Black	Nutrient availability, influences soil pH, cation and anion exchange capacity, soil stability and permeability, structure of the soil, and other relationships with other physical, chemical and biological properties
Total phosphorus	Modified Troug	Potential P supply
Potassium	Extraction-Flame AAS	Nutrient supply

Table 2.2-49: Chemical Properties of Soil with corresponding vales

Chemical Properties	Values	Adequate	Moderate	Deficient
pH	6.9	(5.5-7.0)		
Nitrogen	0.143	**	**	**
Organic Matter (OM)	2.213	>3	2-3	<2
Phosphorus	3.693	>10	6-10	<6
Potassium	208.72	>75	50-75	<50

Table 2.2-50: Abiotic Components

Sampling Points	Coordinates/ Elevation	Biotic Components	Abiotic Components	Ecological Relationship
Station 1	7° 3'30.70"N, 125°58'44.90"E	All stations have the presence of biotic components of Riparian Flora and Macroinvertebrates	The abiotic components which includes Chemical properties of soil parameters (pH, Nitrogen, Organic Matter, Total Phosphorous and Potassium) and water quality were present in all stations.	Abiotic components are limiting factors for plants' production and abundance of macroinvertebrates.
Station 2	7° 3'59.38"N, 125°57'41.93"E			
Station 3	7° 1'25.84"N, 125°59'56.90"E			
Station 4	7° 1'3.74"N, 125°59'20.62"E			
Station 5	7° 1'3.29"N, 126° 0'18.33"E			
Station 6	7° 1'42.72"N, 126° 1'26.17"E			
Station 7	7° 0'53.52"N, 126° 0'27.58"E			
Station 8	7° 0'48.58"N, 125°59'30.08"E			
Station 9	7° 1'35.86"N, 126° 1'48.10"E			
Station 10	6°59'33.95"N, 126° 0'34.40"E			
Station 11	6°59'35.37"N, 125°59'20.18"E			

Table 2.2-51: Biotic Components

Scientific Name	Common Name	Status	Economic importance	Distribution in the area
Calamus sp.	Pusan	Not Listed (IUCN and DAO 2017)	Ornamental	Native

Scientific Name	Common Name	Status	Economic importance	Distribution in the area
Buchanania sp.	Manga-manga	Not Listed (IUCN and DAO 2017)	Medicine	Native
Mangifera altissima	Manga-manga	Vulnerable (IUCN and DAO 2017)	Food	Native
Canarium ovatum	Pili-pili	Vulnerable (IUCN) and Not listed (DAO 2017)	Food	Introduced
Calophyllum blancoi	Bitanghol	Not yet assessed (IUCN) and Not listed (DAO 2017)	Wood Harvesting, Medicine	Native
Garcinia rubra	Batwan	Vulnerable (IUCN) and Not Listed (DAO 2017)	Food, medicine	Endemic
Castanopsis sp.	Indang-indang	Not Listed (IUCN and DAO 2017)	Food, ornamental	Endemic
Ficus pseudoplama	Lubi-lubi	Not yet assessed (IUCN) and Not Listed (DAO 2017)	Food, medicine	Native
Syzyguim brevistylum	Sagimsim	Not Listed (IUCN and DAO 2017)	Food, medicine	Native
Syzygium cumini	Lumboy-lumboy	Least Concern (IUCN) and Not listed (DAO 2017)	Food, medicine	Native
Xanthostemon sp	Magkuno	Not Listed (IUCN and DAO 2017)	Logging, Wood Harvesting	Native
Pandanus sp.	Baliw	Not Listed (IUCN and DAO 2017)	Food, handicraft	Native
Imperata cylindrica	Kugon	Least Concern (IUCN) and Not listed (DAO 2017)	Ornamental	Native
Cleistantus pilosus	Banitlong	Not Listed (IUCN and DAO 2017)	Medicine	Native
Greeniopsis sp.	Hambabalod	Not Listed (IUCN and DAO 2017)	Medicine	Native
Urtica sp.	Alingatong	Not Listed (IUCN and DAO 2017)	Food, medicine	Introduced

Family	Common Name	Status	Ecological importance	Distribution in the area
Gerridae	Water Striders	Not Extinct	Pollutant Indicator	N/a
Potamidae	Freshwater Crabs	Not Extinct	Pollutant Indicator	N/a
Palaemonidae	Shrimp	Not Extinct	Pollutant Indicator	N/a
Hirudinea	Leech	Not Extinct	Pollutant Indicator	N/a
Baetidae	Small Minnow Mayfly	Not Extinct	Pollutant Indicator	N/a
Hydropsichidae	Common Netspinning Caddisfly	Not Extinct	Pollutant Indicator	N/a
Glossosomatidae	Saddle-case Caddisfly	Not Extinct	Pollutant Indicator	N/a
Coenagrionidae	Narrow-wing Damselfly	Not Extinct	Pollutant Indicator	N/a
Corydalidae	Fishfly	Not Extinct	Pollutant Indicator	N/a
Chironomidae	Non-biting midge	Not Extinct	Pollutant Indicator	N/a
Simullidae	Black Fly	Not Extinct	Pollutant Indicator	N/a

Family	Common Name	Status	Ecological importance	Distribution in the area
Elmidae	Riffle Beetle Larva	Not Extinct	Pollutant Indicator	N/a
Gyrinidae	Whirligig Beetle Larva	No Extinct	Pollutant Indicator	N/a
Ceratopogonidae	Biting Midge	No Extinct	Pollutant Indicator	N/a

2.2.4 Marine Ecology

Base on the observations and the interviews, an allocation of fish cages were distributed in the coastal areas of Banaybanay, Davao Oriental. According to the response, these were permitted for economic benefit in order to provide livelihood and socio-economic growth.

2.2.4.1 1st Season Sampling – Dry Season

Marine ecosystem remained a vital source that sustain life on the face of the earth. However, such ecosystem remains sensitive to any changes not just on areas near the coastal but also in uplands. This effect on marine ecology may range from natural and small ones to massive and drastic changes. Due to this very reason, assessment and monitoring is a must to come up with an effective management to eliminate or reduce any negative impacts from any anthropogenic activities.

Sampling Stations

Corals, Coral Fishes and Mangrove Sampling Areas

The sampling areas involved four (4) different barangays in Banaybanay, Davao Oriental; Station 1 (Barangay Punta Linaw), Station 2 (Barangay Maputi), Station 3 (Piso) and Station 4 (Burias Island) conducted last September 16, 2016.

Seagrasses Sampling Areas

There were six sampling stations for the survey of the seagrasses. 3 barangays near the shore were chosen as sampling areas namely the barangays of Puntalinao, Piso and Maputi. Two transects were laid in barangay Puntalinao which was considered as Site 1 and Site 2. Barangay Piso has also two transects which served as Site 3 and 4. The fifth transect was laid in the boundary of barangay Maputi and barangay Piso.

Table 2.2-52: Geographical Coordinates of the Sampling Stations for Corals and Fishes

Location		Longitude	Latitude
Station 1	CF1	125.9482266	7.067468032
Station 2	CF2	125.961577	7.043092097
Station 3	CF3	125.9806908	7.027473347
Station 4	CF4	125.9597452	7.021758539

Table 2.2-53: Geographical Coordinates of the Sampling Stations for Seagrass

Location		Longitude	Latitude
Station 1	S1	125.9829494	7.001782146
Station 2	S2	125.9865257	7.010863931
Station 3	S3	125.9843551	7.016519622
Station 4	S4	125.9795368	7.019034817
Station 5	S5	125.9802443	7.026945914
Station 6	S6	125.9767815	7.031710341

Table 2.2-54: Geographical Coordinates of the Sampling Stations for Mangroves

Location		Longitude	Latitude
Station 1	M1	125.9846519	7.006377842
Station 2	M2	125.9914448	7.011594157
Station 3	M3	125.9839965	7.018808195
Station 4	M4	125.9837631	7.027092103

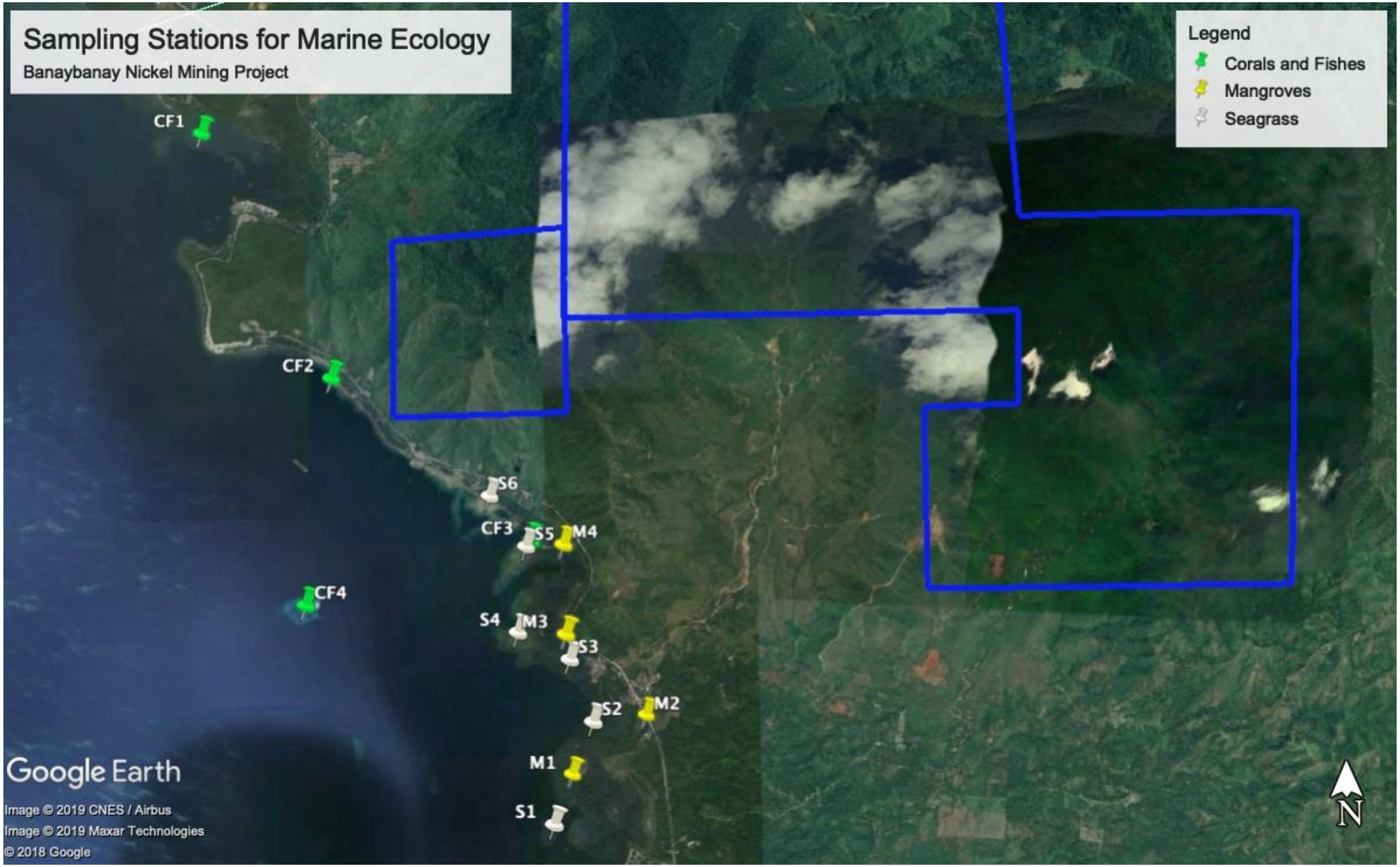


Figure 2.2-50: Marine Ecology Sampling Station Map

Description of Sampling Stations

While some traces of destructive fishing such as the use of dynamites are still visible in the sampling area, the whole sanctuary was classified under the AVERAGE condition with mean percent cover of 26.15% for live hard corals. The following photos provide visual presentation of the sampling stations assessed.

Photo 2.2-6: Station CF1 Sampling Area

Photo 2.2-7: Station CF4 Sampling Area

Corals

Underwater structures made from calcium carbonate by corals are called coral reefs. These are colonies of tiny animals found strictly in marine waters. Most of the known corals are built from compacted calcium carbonate, which has tiny pores where polyps are secreted. Coral Reef is often called as the rainforest of the sea by because it hosts the diverse organisms. In addition to being a colony of tiny animals, they provide shelter to mollusk, worms, crustaceans, echinoderms, sponges, tunicates and most especially the fishes. In tropical areas, coral reefs are commonly found in shallow depths but for some would reach to deep water.

The Philippines is a part of the Coral Triangle, which also includes Indonesia and Malaysia. Vast coral reef cover can be found in these areas. In this assessment percent cover of benthic life forms such as live coral, dead coral, algae, abiotic and other fauna was considered. Abiotic benthic lifeforms include sand and silt components. Other benthic lifeforms include sponges, zoanthids and other benthic fauna.

Materials and Methods

Depth, distance from shore and seawater (reef bottom) temperature data were collected on respective reefs. The coral cover photo quadrat surveys were undertaken using fixed photo transects (KFUPM/RI, 1985; Done, 1996; English et al., 1997; WCPI, 1997a, 1997b, 1998, 1999a). At each reef site, two 5 m long transect lines were set on the reef top. The transects were separated from each other by a distance of about 5 m. The transects were marked by concrete nails. These permanent markers provide positioning points for finding the same locations during subsequent sampling periods. In this technique, small sections of the reef are photographed periodically enabling the monitoring of individual corals through time. Voucher photographs, laminated in plastic, which could be taken underwater, are very useful in maintaining a more or less constant positioning of the photographic frame for each quadrat.

A Nikonos-V underwater camera with 28 mm lens, loaded with ASA 100 color film, and attached to a tetrapod camera stand frame was used to photograph 1 x 0.66 m sections of the tape. The field of view of the camera with 28 mm lens (wide angle) at a distance of four feet (1.2 m) coincided with the 0.66 m2 area defined by the camera stand frame. This frame carries a nameplate on the lower right-hand corner for site/transect identifier and date, which appears in each photograph. Similar equipments were utilized in determining coral coverage and changes with time in a number of other reef studies (Bohnsack, 1982; Done, 1981; Dodge et al., 1982; KFUPM/RI, 1985, 1988, 1993; DA-FSP, 1996), and in the previous monitoring studies/surveys carried out in Marinduque Island by Woodward-Clyde Philippines, Inc. (WCPI, 1997a, 1997b, 1998, 1999a).

The percentage distribution of the major parameters or attributes of the bottom cover from the photographs of the transect were estimated by recording the identity of items lying beneath a grid of 99 points on a template over laid on each print.

Overall Coral Cover

Coral cover in the sampling areas were characterize into six (6) classes. These are mainly (1) hard coral, (2) soft coral, (3) algae-covered (i.e. seaweeds and sea grass) corals, (4) abiotic (corals covered with non-living components such as sand, rocks, silts and rubbles), (5) others (other fauna cover such as sponges and anemone) and (6) tape, wand and shadow.

Figure 2.2-51 shows the average coral cover of all sampling sites. The greatest percentage (43%) of the corals are being covered with abiotic components such as sand and rocks. Soft corals and hard corals covered almost the same average percentage attributing 24% and 20% respectively

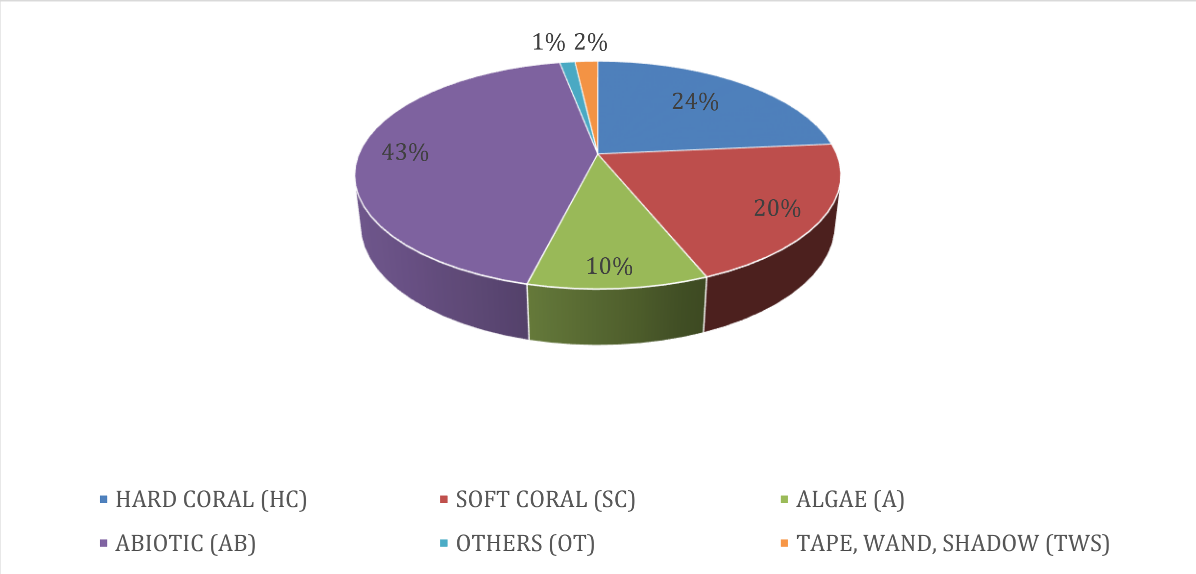


Figure 2.2-51: Overall Coral Cover

Hard coral cover was abundantly (36%) noted in barangay Maputi and was least (9%) observed in barangay Piso (**Figure 2.2-52**). Meanwhile, the greatest (56%) cover of soft coral was recorded in Barangay Piso. Algae covered an average percentage of 10% of the corals in all sampling sites and 40% was observed in Barangay Maputi. Furthermore, an average of 2% was accounted by tape, wand and shadow covers. 1% was covered with other faunal covers such as sponges which was abundantly (54%) noted in Barangay Punta Linaw.

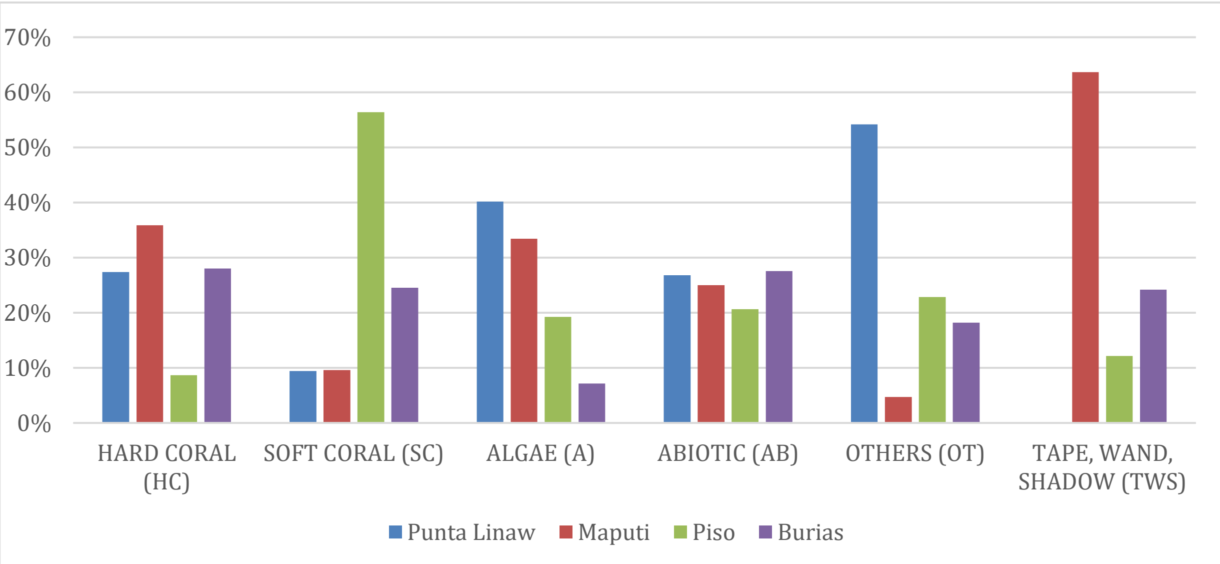


Figure 2.2526: Overall Coral Cover Comparison

Coral Cover

Site 1 - Punta Linaw

Figure below (**Figure 2.2-53**) presents the percentage cover of each coral cover classification in Station 1 (Punta Linaw). The greatest percentage (47%) was dominated by abiotic-covered corals. This was then followed by hard coral covering 26% of the sampled area in Barangay Punta Linaw. Algae-covered corals accounted for 16%, soft corals with 8% and other fauna with 3%.

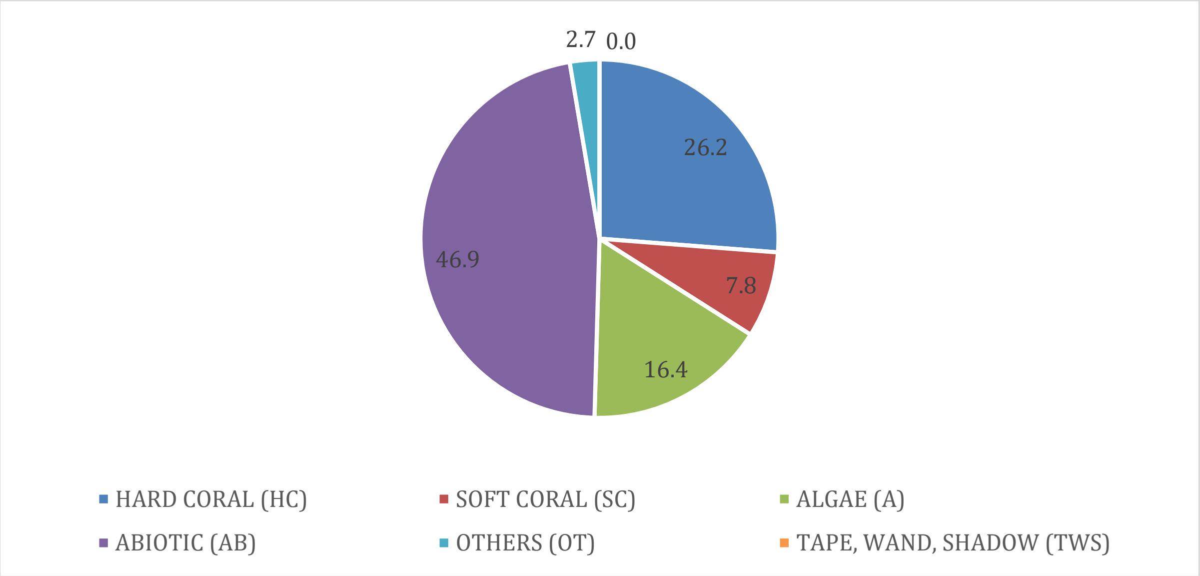


Figure 2.2-53: Station 1

Site 2 - Maputi

Like Punta Linaw, abiotic components such as sands and rocks covered the greatest percentage (44%) of corals in Barangay Maputi (**Figure 2.2-54**). Hard corals accounted for by 34%. Algae and soft corals covered a percentage of 14% and 8%, respectively. Tape, wand and shadow covers was accounted for by 5% and other covers attributed less than a percent.

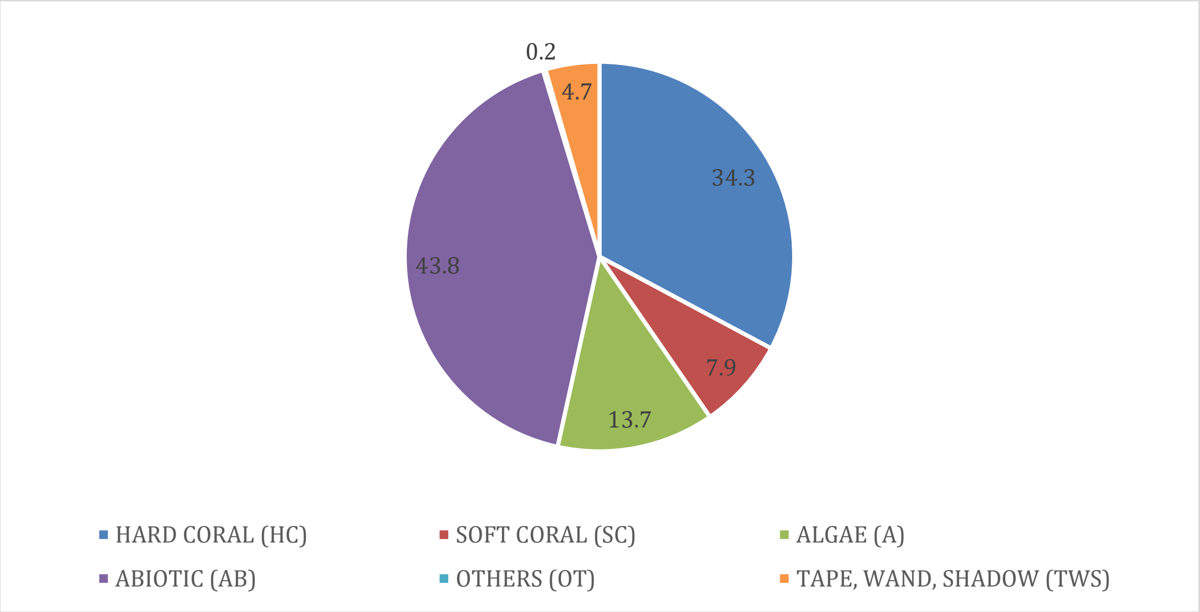


Figure 2.2-54: Station 2

Site 3 - Piso

It is interesting to note that unlike the first two barangays sampled, the percentage cover of soft coral was surprisingly found to be high in Barangay Piso (47%) compared to coral covered with abiotic components (36%). Meanwhile, both hard coral and algae covered the same percentage of 8% and only 1% was being covered by other fauna covers (**Figure 2.2-55**).

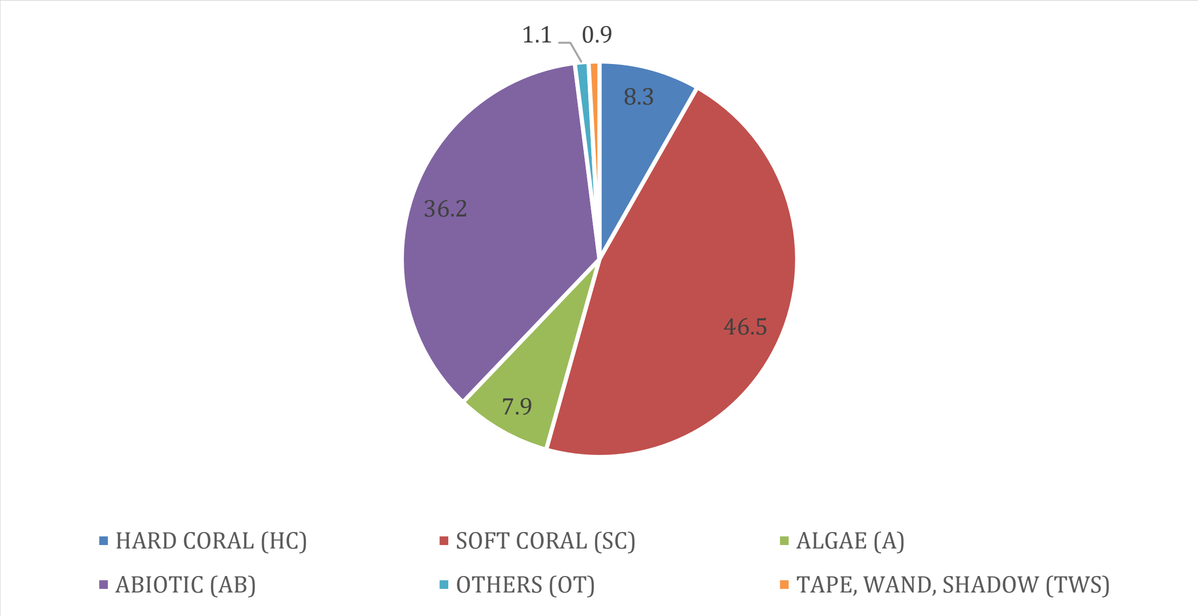


Figure 2.2-55: Station 3

Site 4 - Burias

In Barangay Burias, the following figure (**Figure 2.2-56**) shows the highest percentage cover being attributed by abiotic component (49%). Meanwhile, there is no big difference of percentage cover was observed between hard (27%) and soft (20%) coral. However, algae (3%), biotic (1%) components and tape, wand and shadow covers (2%) attributed a small percentage of coral cover in the said barangay.

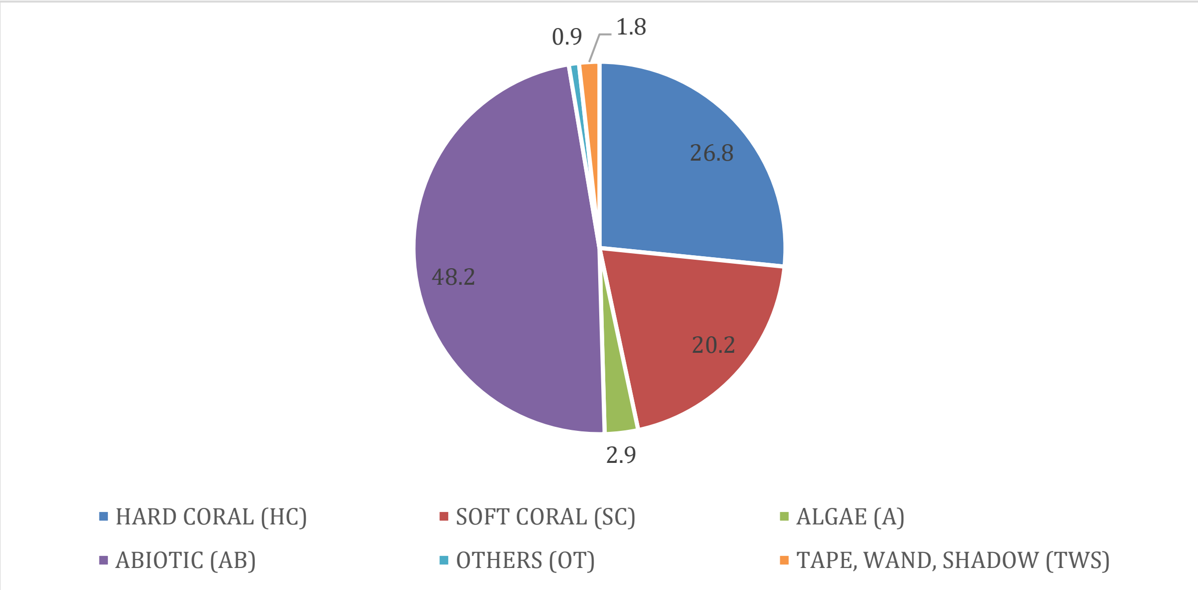


Figure 2.2-56: Station 4

Coral Fishes

Fishes play an important role in the ecosystem. They provide people with food for many centuries. However, people are so careless, many of the fishing ground are now overfished and some other fish species are now threatened.

Coral fishes are the most conspicuous inhabitants of the reef occurring in schools of up to thousands of individuals displaying striking colors, shapes and patterns. Fishes not only contribute to the aesthetic value of coral reefs, they also constitute a major component of total biodiversity, they are source of economic value and they contribute to the overall heath and resilience of coral reef ecosystems via a number of ecological processes.

Materials and Methods

The fish communities in selected reefs were surveyed using the daytime underwater fish visual census technique described in English et al. (1994). At each station, a 50-meter transect was laid parallel to the shoreline following the contour of the reef and maintaining a constant depth. Fish observed within 5 meters in front, above, and 5 meters on each side of the transect were recorded on underwater slates.

A total area of 500 m^2 was effectively surveyed at each station. Fish were identified to species level, sizes or total lengths estimated to the nearest centimeter and their abundance determined by actual counts. For schooling and aggregating species abundances were estimated based on the sizes of the fish and the clusters they formed.

Species Richness

On the four (4) sampled Barangays, eleven (11) families of fishes were noted. Station 4 (Barangay Burias) had the highest number (1,814) of individual fishes recorded followed by Station 3 (Barangay Piso) with 1,474 individuals. Station 1 (Barangay Punta Linaw) had a total number of 1,013 individual fishes recorded while Station 2 had the least number of 960 individual fishes.

Table 2.2-55: Species Richness

Family	Station 1	Station 2	Station 3	Station 4	Total
Pomacentridae	891	758	1440	1357	4,446
Aulostomidae	2	-	-	-	2
Pomacanthidae	56	181	10	221	468
Serranidae	5	-	1	4	10
Scaridae	4	6	2	10	22
Chaetodontidae	24	15	8	85	132
Acanthuridae	27	-	12	10	49
Siganidae	1	-	1	4	6
Labridae	2	-	-	2	4
Zanclidae	1	-	-	1	2
Caesionidae	-	-	-	120	120
Total	**1,013**	**960**	**1,474**	**1,814**	**5,261**

Most of the genus which made up the Pomacentridae family observed are Abudefduf, Amblyphidodon, Chromis, Pomacentrus and Dascyllus species.

Over-all Relative Abundance

Figure below shows the over-all relative abundance of each fish family. As mentioned earlier, the abundance of the fish's species from the family Pomacentridae was found to be consistent on all four sampling sites. It accounted the 84.5% of all the individuals recorded. While Pomacanthidae which follows contributes 8.9%.

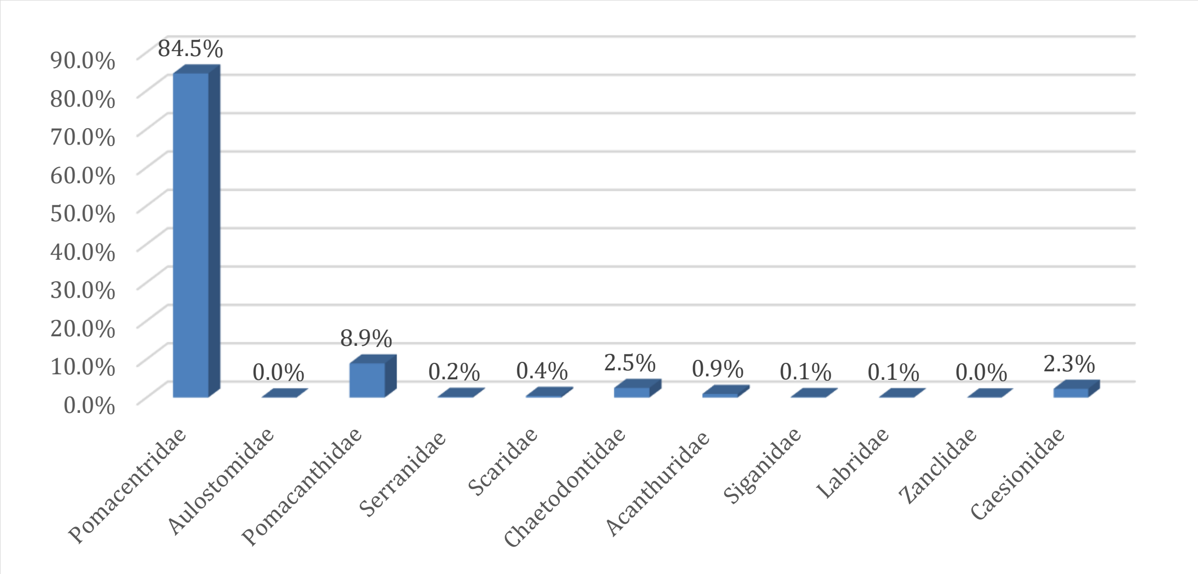


Figure 2.2-57: Overall relative abundance of corals

Relative Abundance

Site 1 - Punta Linaw

In the first station sampled, specifically, Punta Linaw, the highest number of fish observed came from the family of Pomacentridae (88.0%). It was then followed by the Family Pomacanthidae with percent abundance of 5.5. While the family Acanthuridae and Chaedontidae had almost the same percent abundance of 2.7 and 2.4 respectively. The rest of the families of fishes noted (Aulostomidae, Serranidae, Scaridae, Siganidae, Labridae and Zanclidae) only contributed less than a percent each.

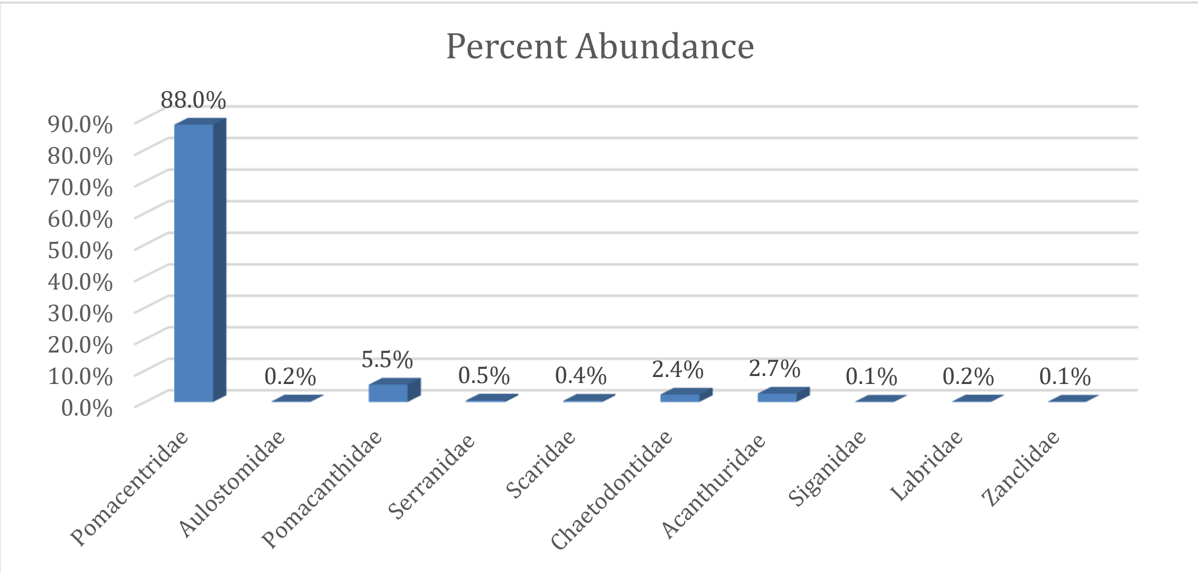


Figure 2.2-58: Relative Abundance at Station 1

Site 2 - Maputi

Only four (4) families of fish were observed in Maputi. Majority (79%) of them came from the Pomacentridae family. Pomacanthidae followed with relative abundance of 18.9%. On the other hand, Charodontidae and Scaridae only accounted for 1.6 and 0.6 respectively.

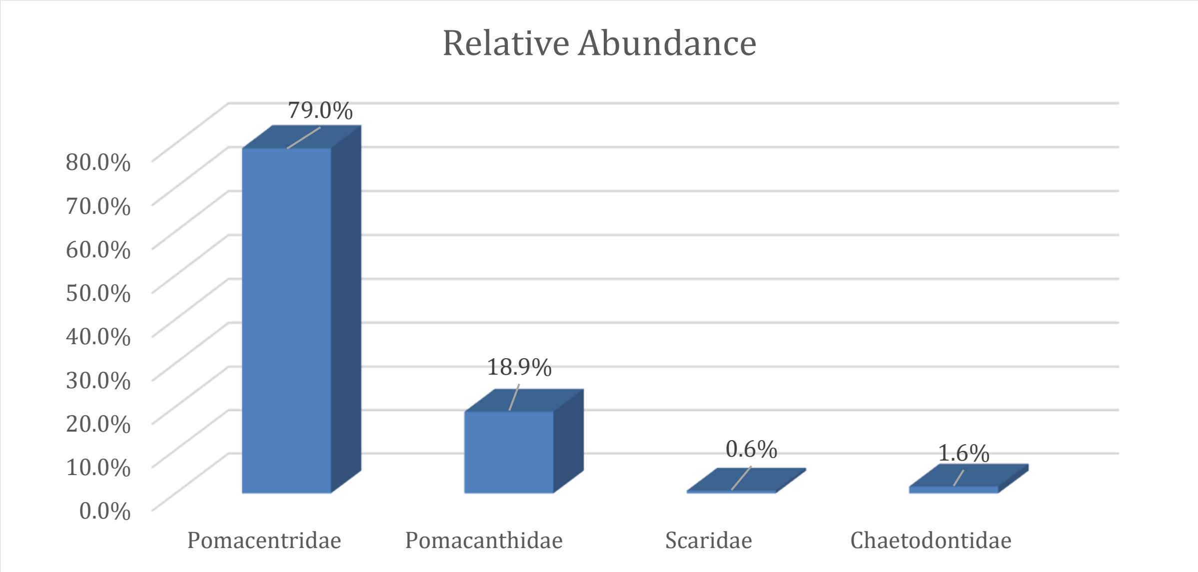


Figure 2.2-59: Relative Abundance at Station 2

Site 3 - Piso

Like the first two (2) sampled Barangays, in the third station (Barangay Piso), Pomacentridae attributed a great percentage of 97.7 %. The rest six (6) families namely, Acanthuridae, Pomacanthidae, Chaetodontidae, Serranidae, Scaridae and Sigaridae contributed less than a percent each.

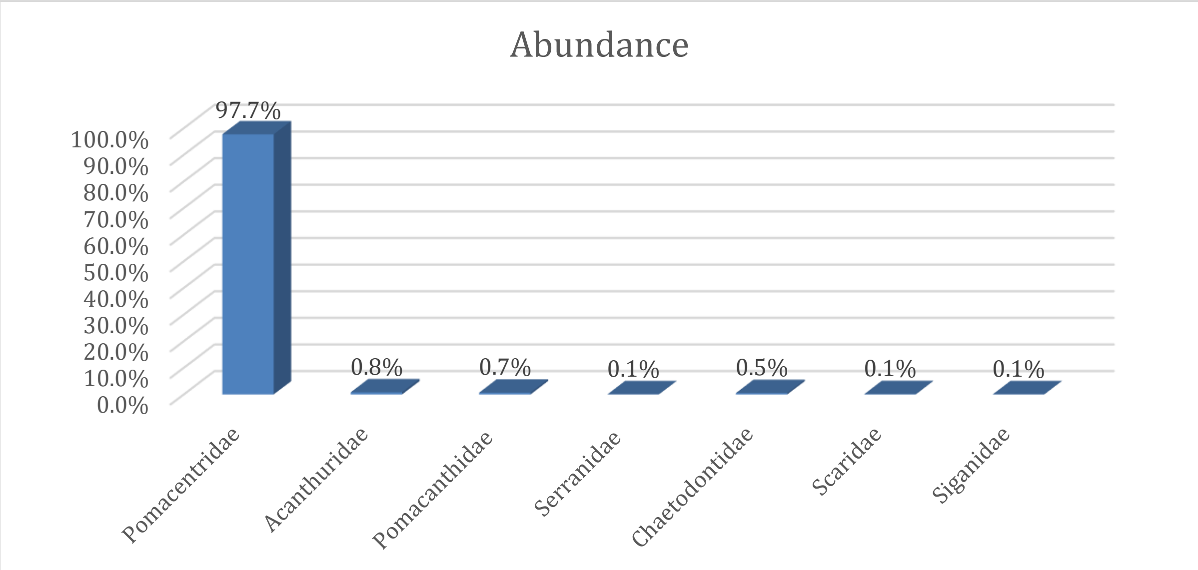


Figure 2.2-60: Relative Abundance at Station 3

Site 4 – Burias

In terms of families, burias had a total of ten (10) fish families noted. The highest percentage of 74.8% came from Pomacentridae family. Next is the Pomacanthidae family with relative abundance of 12.2% and was followed Caesionidae with 6.6%. Chaetontidae attributed 4.7% and the rest of the families accounted for less than a percent each.

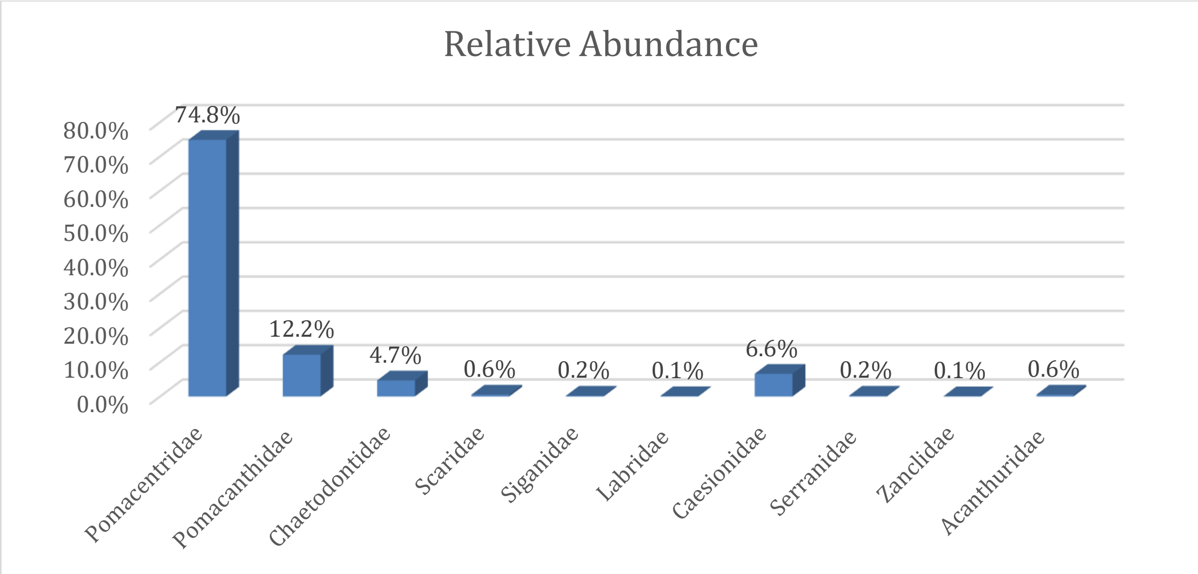


Figure 2.2-61: Relative Abundance at Station 4

Seagrass

Seagrasses are vital part of the marine ecosystem. They provide habitat and food for some species of marine invertebrates. Seagrass usually grows in the shallow part of the coast where it can maximize its level of productivity with the help of light. Also, it increases water clarity by trapping particles that are suspended in the water column.

Materials and Methods

The sampling of seagrasses was monitored using the transect-quadrat method where a 50-m transect was laid out perpendicular to the shoreline with 5-meters interval. Along the transect line, a 0.50 x 0.50-meter stainless steel quadrat was pressed where seagrass starts to grow. Percent cover of the seagrasses were estimated and each seagrass were identified up to species level.

Species Richness

Cymodocea rotundata

- *Cymodocea rotundata* has a flat, strap-like leaves with approximately 2 – 4mm width. Leaf tip is smooth and rounded. It has a smooth rhizome and can be usually found on shallow reef flats.

Enhalus acoroides

- It has a very long ribbon-like leaves with a length of 30 – 150 cm. The leaves have in rolled leaf margins. It has thick rhizome with long black bristles and cord-like roots.

Halodule pinifolia

- This species of seagrass has fine and delicate leaves with one central vein and grows up to 20cm long. Its central vein splits into two at the end of the rounded leaf tip. It has pale rhizome with clean black leaf scars. Usually it can be found on intertidal sand banks

Halophila ovalis

- Based from its name, this species of seagrass has oval shaped leaves in pairs with 8 or more cross veins. It has no hairs on the leaf surface. It's a common early colonizing species.

Thalassia hemprichii

- Thalassia hemprichii has short black bars of tannin cells in the leaf blade. Leaves are curved and are 10 – 40 cm long. It has thick rhizome with scars between shoots. Also, this is common on shallow reef flats.

Overall Relative Abundance

The figure below shows the overall relative abundance of the seagrasses among the 6 sampling stations. 5 species of seagrass were identified within the sampled area. *Cymodocea rotundata* has the highest average relative abundance of 47%. It was followed by *Halodule pinifolia* (28.2%). *Thalassia hemprivhii* and *Enhalus acoroides* have almost same average relative abundance of 12.2% and 11.6%, respectively. *Halophila ovalis* has the least average 1.1% relative abundance. Also, *Halophila ovalis* was only observed in Site 5 at the boundaries of barangay Maputi and barangay Piso.

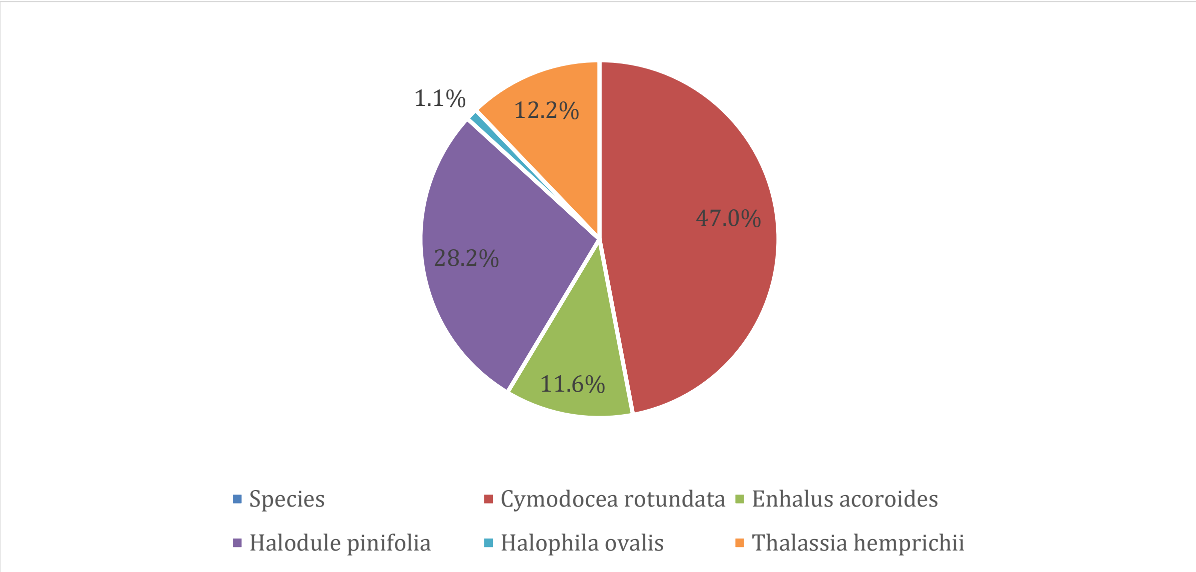


Figure 2.2-62: Overall Relative Abundance of Seagrass in all Sampling Stations

Relative abundance

Relative abundance of the samples was computed using the percent cover of each seagrass species per site over the total percent cover of the seagrass species in all sampling sites.

Site 1 – Barangay Puntalinao 1

Two species of sea grass was identified in the first sampling site. These area *Halodule pinifolia* and *Thalassia hemprichii.* The following figure shows the abundance of each sea grass species. It can be observed the Halodule is more abundant compared to other species.

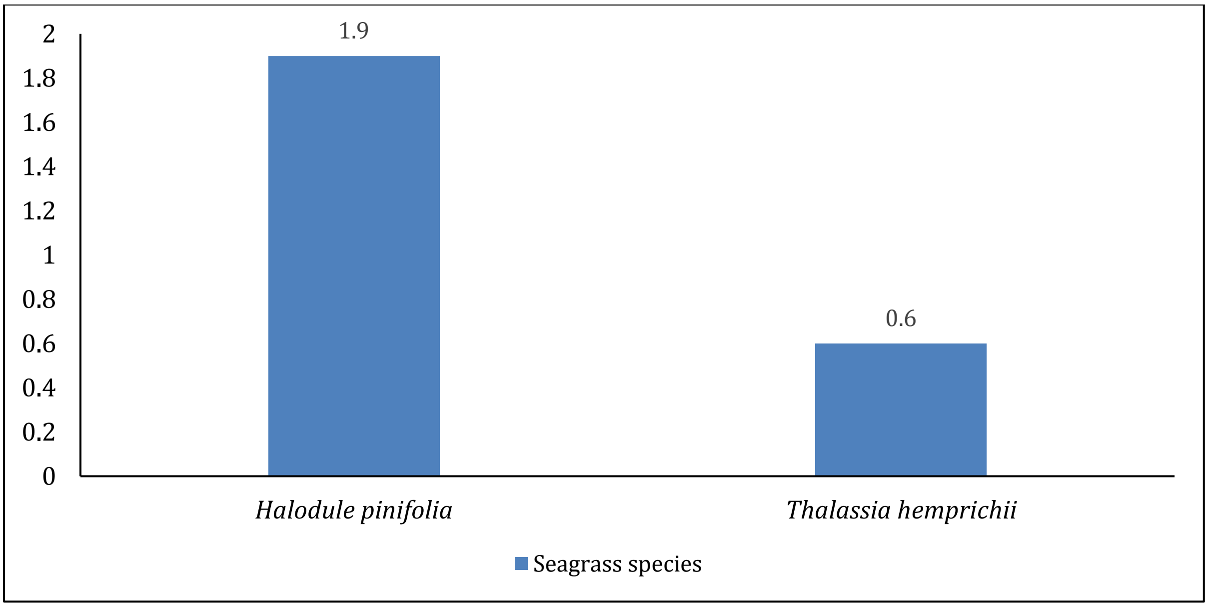


Figure 2.2-63: Relative abundance of seagrass in Site 1

Site 2 – barangay Puntalinao 2

In Site 2, only one species of seagrass was observed. *Halodule pinifolia* was observed between the transects laid in 5 to 15 meters with a total percentage cover of 1.2% and relative abundance of 0.009.

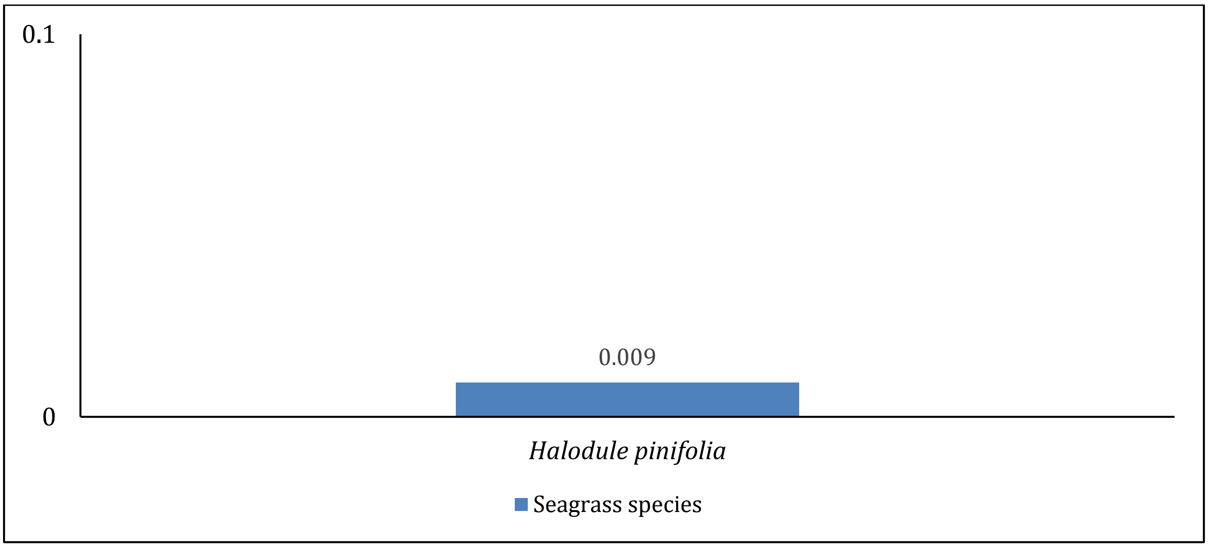


Figure 2.2-64: Relative abundance of seagrass in Site *2*

Site 3 – Barangay Piso 1

The figure below shows the *Cymodocea rotundata* has the highest percentage cover in Site 3 with 54% and a relative abundance of 0.39 followed by *Halodule pinifolia of 33.5%*. *Thalassia hemprichii* has the least percentage cover with a value of 7.5% and relative abundance of 0.22. Seagrass species were evenly distributed among the site having an average percent cover of 97%.

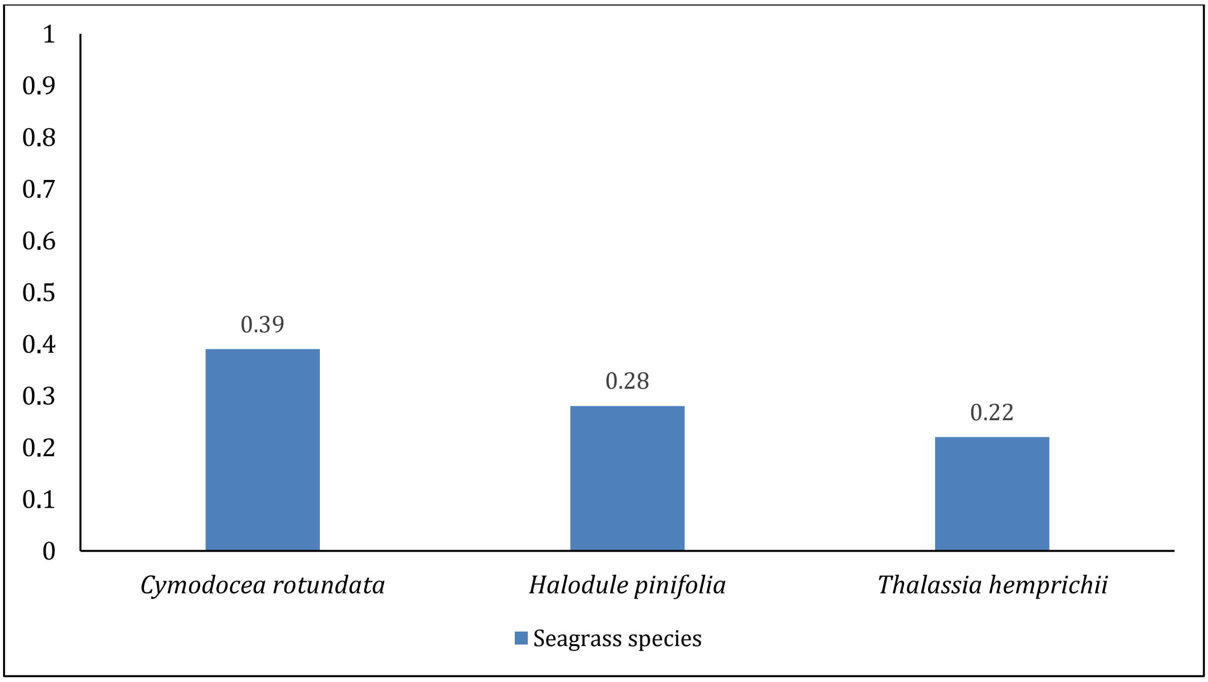


Figure 2.2-65: Relative abundance of seagrasses in Site 3

Site 4 – barangay Piso 2

In terms of average seagrass percent cover, Site 4 has the highest average seagrass percent cover of 99%. *Cymodocea rotundata* was the most evident species with a total cover of 42% while *Halodule pinifolia* was also close to the former, with a percent cover of 40%. *Thalassia hemprichii* has the least percent cover with 17% but has the highest relative abundance of 0.50. *Cymodocea rotundata* has the least relative abundance with 0.31 only.

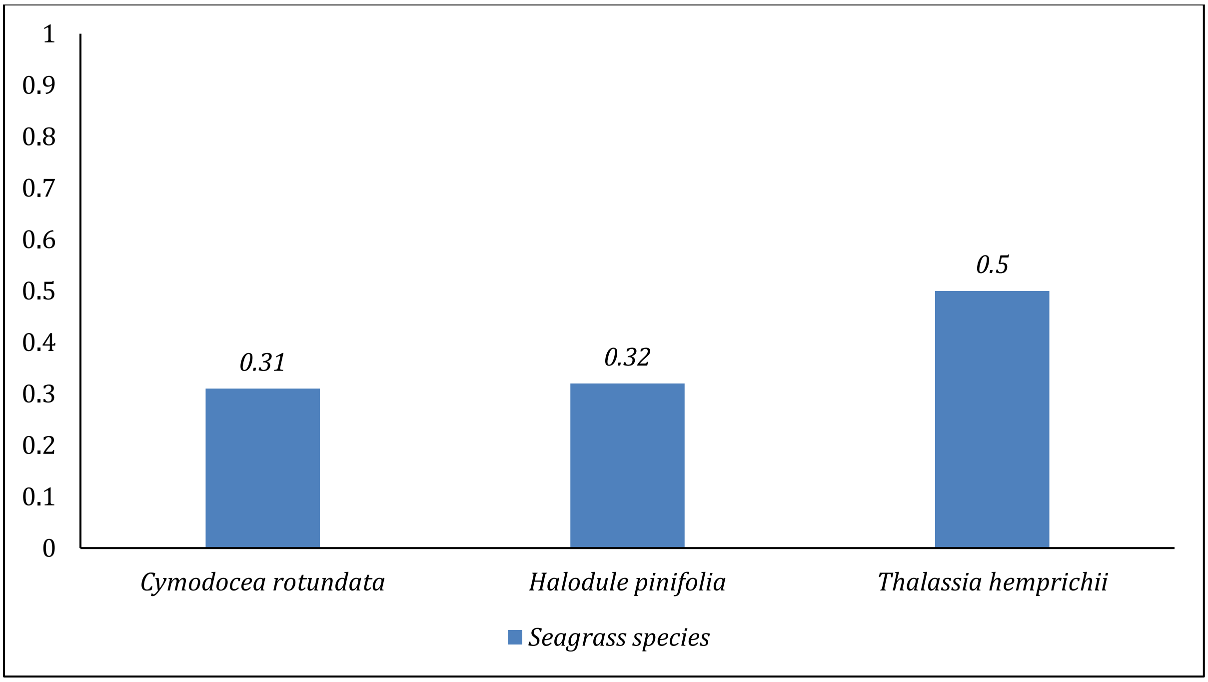


Figure 2.2-66: Relative abundance of seagrasses in Site 4

Site 5 – Barangay Maputi

Site 5 has the greatest number of seagrass species observed. *Halodule pinifolia* was the most abundant species in the site with a percentage cover of 47% and a relative abundance of 0.37. On the other hand, *Halophila ovalis* was the least abundant species which was only observed in Site 5 that has percentage cover of 1.5% and rendered a relative abundance of 1. *Halophila ovalis* was the highest relative abundance since it was only recorded in this site.

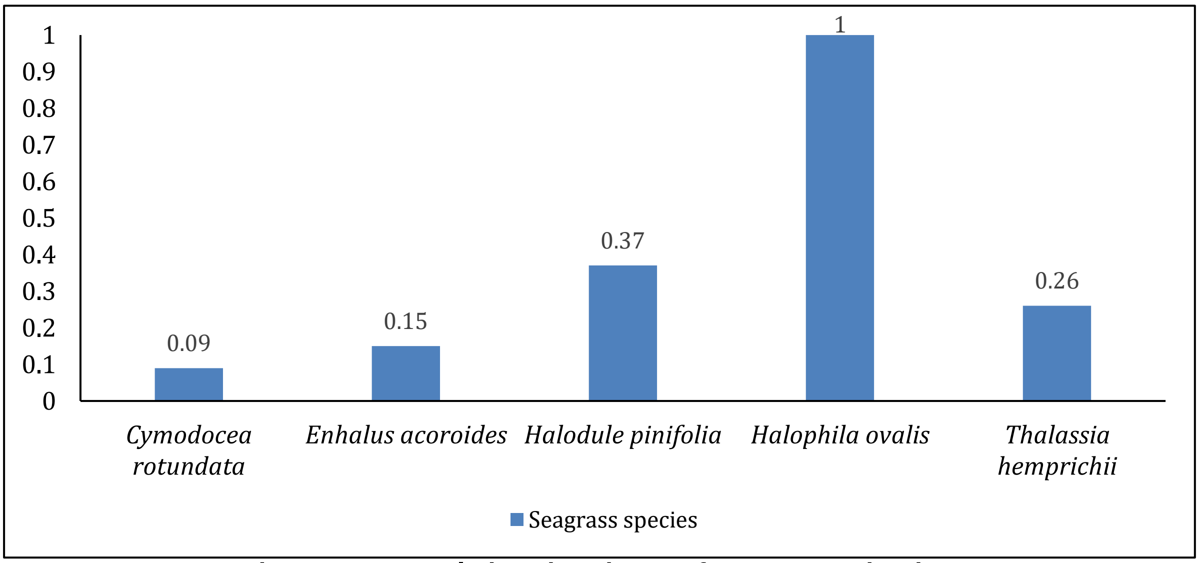


Figure 2.2-67: Relative abundance of seagrasses in Site 5

Site 6 – Barangay Maputi (Centro)

Only two species of seagrasses were recorded in this site. *Enhalus acoroides* was only observed in barangay Maputi which includes sites 5 and 6. In this site, *Cymodocea rotundata* was more abundant than *Enhalus acoroides* with a percentage cover of 29% while the latter has only 17.6% cover. However, *Enhalus acoroides* has a relative abundance of 0.85 which was higher than the other seagrass species since *Enhalus acoroides* was less scattered and was observed only in two sites.

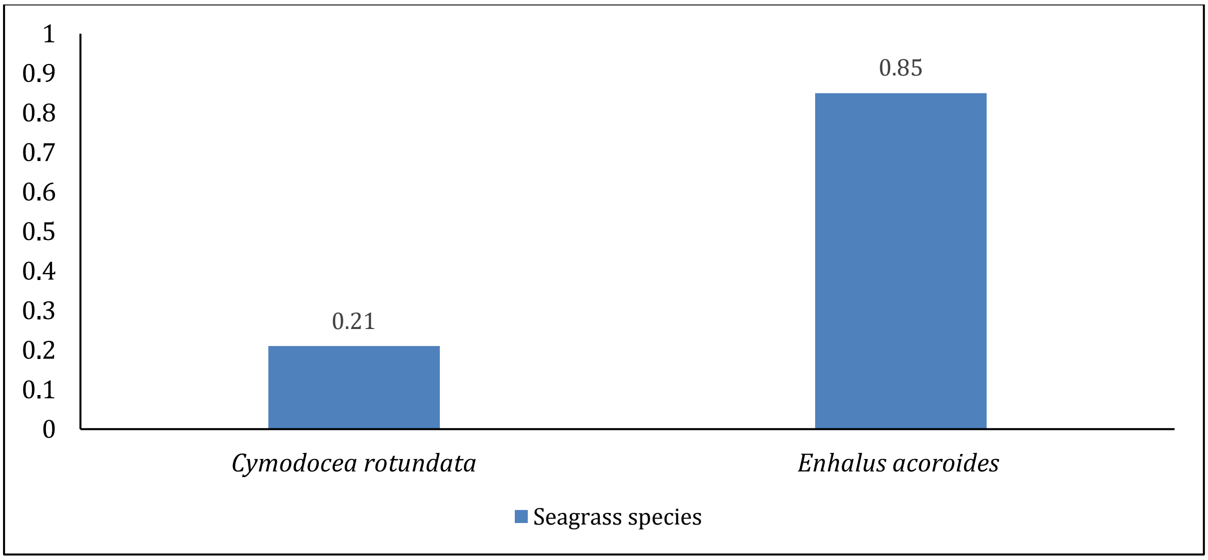


Figure 2.2-68: Relative abundance of seagrasses in Site 6

Mangroves

Mangrove ecosystem have been beneficial to humans in various ways. However, many failed to recognize its importance and even disregarded it. Although there are many people who directly benefit from it but it has a lot of indirect benefits, the reason why other people allotted less concern on the ecosystem compared to the other ecosystems. Mangroves serves as a breeding ground for many species, thus, maintain the biodiversity of many marine organisms. Furthermore, it also served as effective filter from the wastes that may end up in the sea during flooding season. Aside from the protection it offers to maintain the integrity of our seas, it is also barrier that protects the people living in the coastal areas from big waves and soil erosion on the sea coast. Many programs and projects have already been implemented to rehabilitate more mangrove areas and knowing the status of our mangrove ecosystem is critical for assessing one area's vulnerability from climate change manifestations such as typhoons.

Materials and Method

Four stations were established along the coastal area of Banaybanay Davao del sur. Plot method was used to assess the mangroves. A total of 12 plots measuring 10 x 10 m^2 was done; 3 plots in each station. In every 10 x 10 m^2 plot each mature mangrove tree species were counted and their girth measured at breast height or at a standard 1.3 meters from the base is measured. At the corner of the plot a 5 x 5 m quadrat was establish to count and identify the number of saplings; and within each quadrat a 1 x 1 m quadrat to count and identify the seedlings. Leaf, fruit and flower samples from each *Mangrove* species were collected and were photo documented for further identification in the lab. Samples collected were identified based on Calumpong, Hilconida P. and Ernani G. Meñez. 1997. Field Guide to the Common Mangroves of the Philippines by Calumpong et. Al and The field guide to the identification of some mangrove species in the Philippines by DENR.

Species Richness

A total of 5 species of mangrove were identified on the four sampling stations in Banaybanay. Out of 186 stands of mangroves sampled *Sonneratia caseolaris* was the most abundant with 107 stands followed by *Rhizophora apiculata, Avicennia marina* and *Rhizophoa muculata*, while the least abundant was *Luminitzera racemosa* with 5 stands (table 1). Barangay Puntalinao had the highest number of mangroves present with 70 stands while the boundary between barangays Maputi and Piso had the least.

The total density of mangroves for all the 4 stations in Banaybanay is 1550 stands/ ha. *Sonneratia caseolaris* wth 892 stands of mangroves per hectare while the least *Luminitzera racemosa* with 42 stands of mangroves per hectare.

Table 2.2-69: Species richness and density of mangroves species

	Number of Species in				**Total**	**Density (stand/ha)**
Species	**Site 1**	**Site 2**	**Site 3**	**Site 4**		
Lumnitzera racemosa	5	-	-	-	5	42
Sonneratia caseolaris	37	25	26	19	107	892
Avicennia marina	-	7	-	-	7	58
Rhizophora apiculata	28	14	8	11	61	508
Rhizophora muculata	-	6	-	-	6	50
Total per station	70	52	34	30	186	

In terms of species dominance, *Sonneratia caseolaris* is most dominant with a Total basal area of 7589.7 cm and relative dominance of 69 percent;being the most dominant and one if the largest species of mangroves in terms of body size and girth diameter . it is followed by *Rhizophora apiculata* with 25%, Avicenna marina with 3%, *Rhizophora muculata* with 2% and the least *Luminitzera racemosa* with 1%.

Overall Relative Abundance

All mangrove individuals sampled totaled to 186 individuals. *Sonneratia caseolaris* from the family of Lythracea has the highest over-all relative abundance of 57.5%. Next is the *Rhizophora apiculata* with relative abundance of 32.8%. While the three remaining species namely, Avicennia marina, Lumnitzera racemosa and Rhizophora maculate have almost the same relative abundance of 3.8%, 3.7% and 2.7%, respectively.

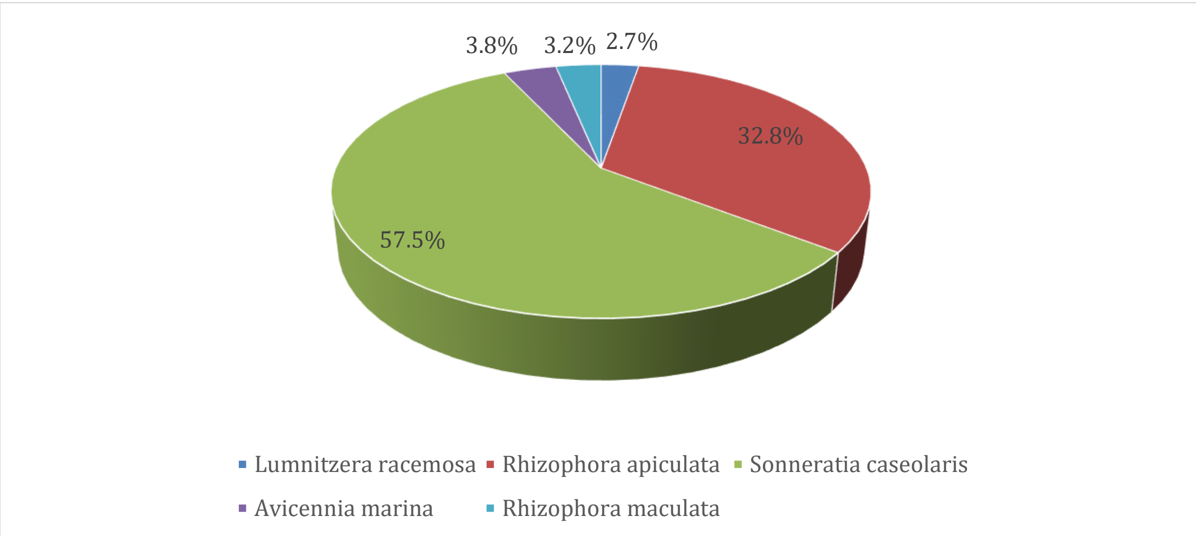


Figure 2.2-70: Overall relative abundance of mangrove species

Relative Abundance

Site 1

In the first sampling site plotted in Barangay Puntalinao, only three species of mangroves were noted. These are *Sonneratia caseolaris, Lumnitzera racemose and Rhizophora apiculate*. *Sonneratia caseolaris* was found to be the most abundant species with the highest relative abundance of 52.9%.

The next most abundant mangrove species is the *Rhizophora apiculate* (40.0%) and Lumnitzera had the least relative abundance of 7.1%.

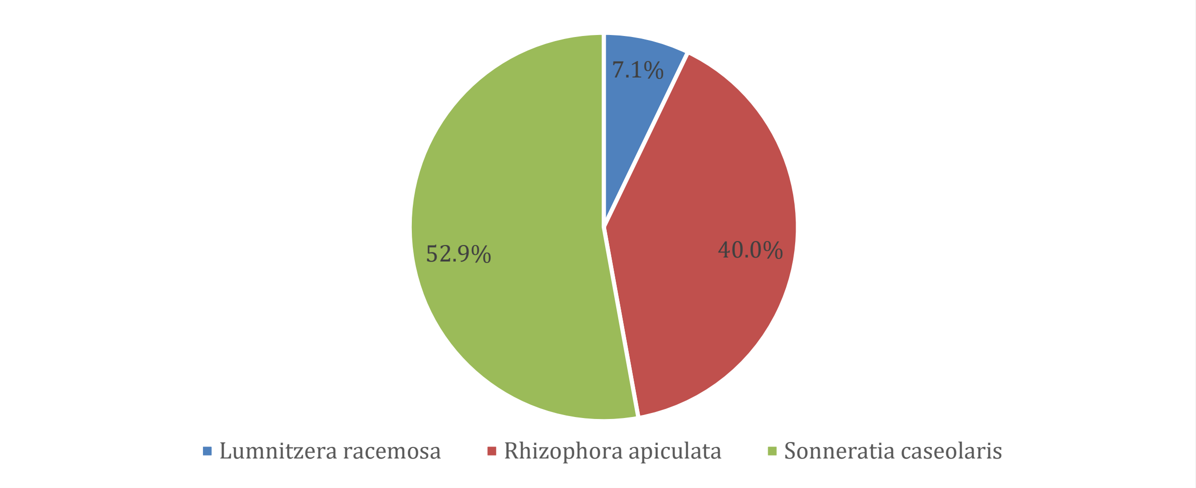


Figure 2.2-71: Relative abundance of mangroves in Site 1

Site 2

Meanwhile, in site 2 located in Barangay Piso, four species of mangrove species were identified. These are *Avicennia marina, Rhizophora apiculata, Sonneratia caseolaris and Rhizophora maculate.* The most abundant species is the Sonneratia caseolaris with relative abundance of 48.1%. *Rhizophora apiculata* had a relative abundance of 26.9% while *Avicennia marina* and *Rhizophora maculata* had relative abundance of 13.5% and 11.5%, respectively.

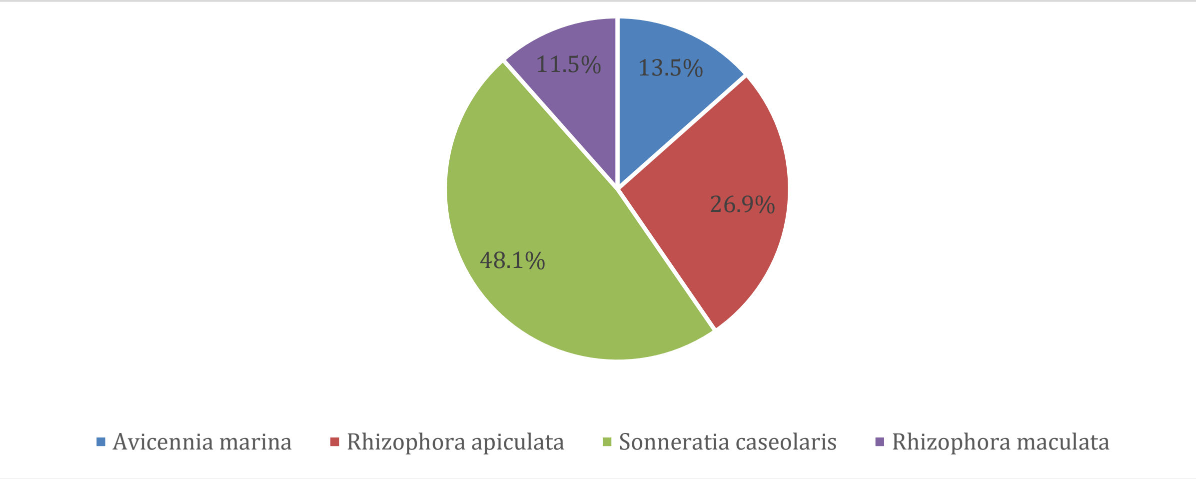


Figure 2.2-72: Relative abundance of mangroves in Site 2

Site 3

From the twenty-four mangrove individuals counted, fewer mangrove species was recorded on the third sampling site situated in Barangay Maputi. The only two species identified were *Sonneratia caseolaris* and *Rhizophora apiculata*. While the latter had higher relative abundance of 76.5%, the Rhizophora apiculate had relative abundance of 23.5%.

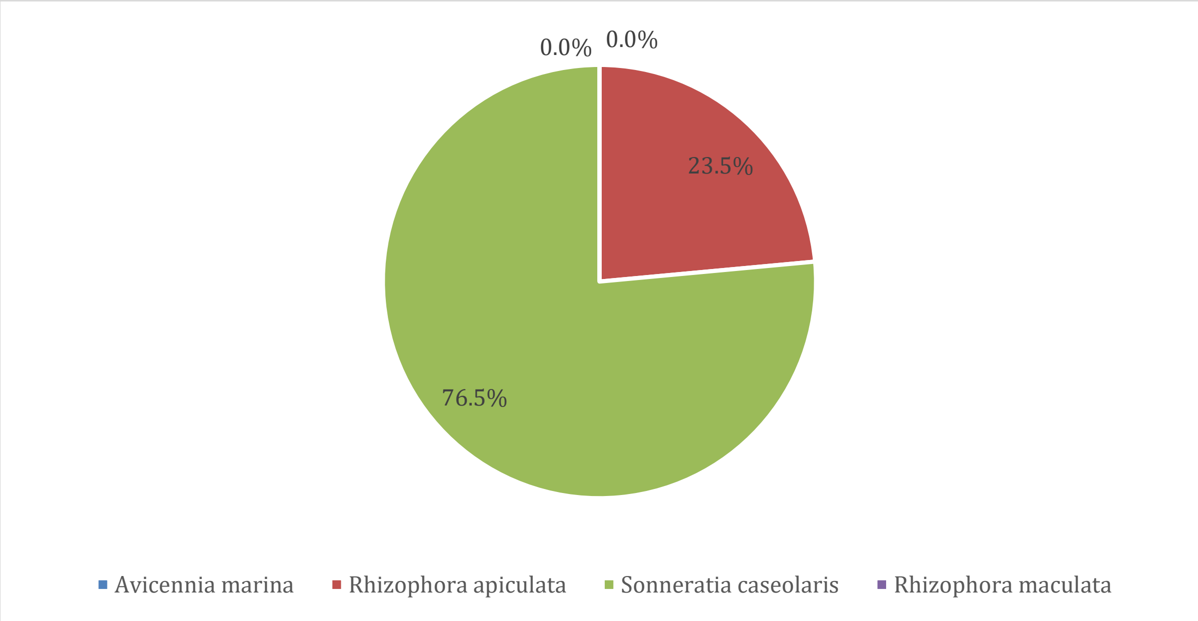


Figure 2.2-73: Relative abundance of mangroves in Site 3

Site 4

Due to problem in accessibility, the third sampling plots were laid in the boundary of Barangay Maputi and Piso. Two mangrove species were identified in the area, namely, *Sonneratia caseolaris* and *Rhizopora apiculata*. Compared to *Rhizophora apiculata* with relative abundance of 36.7%, *Sonneratia caseolaris* was observed to be more abundant (63.3%).

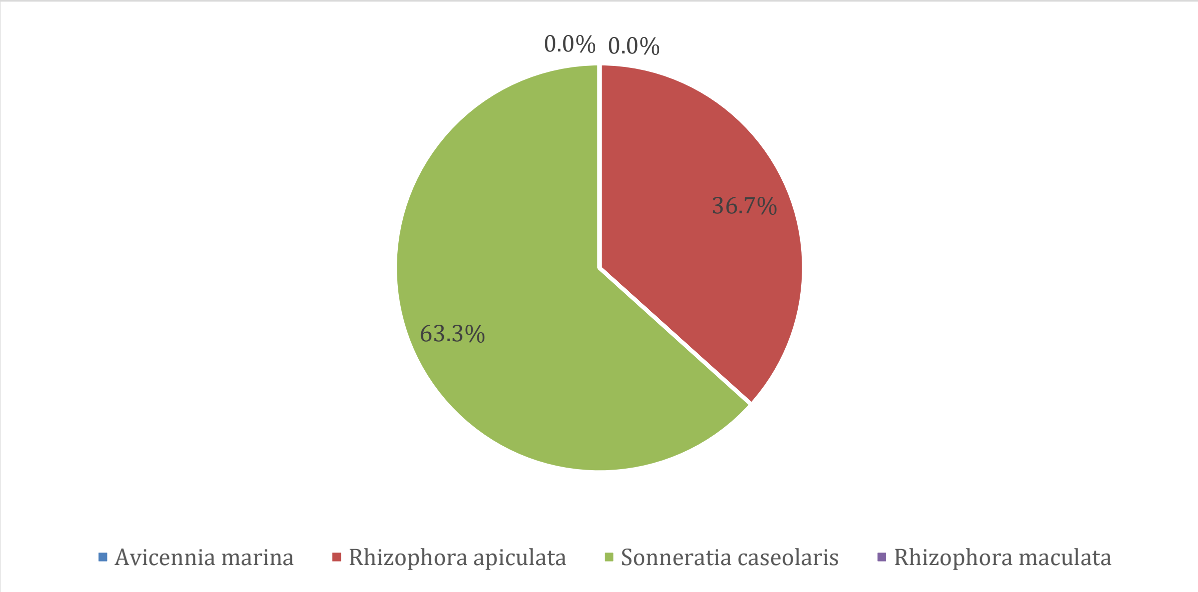


Figure 2.2-74: Relative abundance of mangroves in Site 4

2.2.4.2 2nd Season Sampling – Wet Season

Marine ecosystem is a diverse ecosystem found in the ocean. Thus, it is composed of complex of food chains. The food chain begins with an autotroph, which is responsible for converting sunlight into their own food. This organism is called phytoplankton in which they have the presence of chlorophyll thus allowing them to absorb the radiant energy. In this case, the second trophic level which is the primary consumers appear. They are known as zooplankton. They are drifters in the water and eats the primary producers. The third trophic level arise, which are the small fishes that consumes the primary consumers. Afterwards, another consumer will consume first consumer at its lower trophic level. The higher the trophic level, the lesser the energy they will absorb since it was lost during the metabolism period.

The primary producers, if not eaten, will soon die due to the environmental changes in the water. Once it dies, it will sink in the bottom and the primary producers will eat is decaying body. In this case, another food chain was created. Primary production depends on the amount of sunlight and to the optimum environment parameters it has. The consumers will always depend on the number of primary producers.

Description of the Sampling Stations

The sampling areas involved four (4) barangays namely: (1) Punta Linao, Maputi, Piso and Burias with a total of 5 sampling stations established. The activity was conducted last October 03, 2019.

Table 2.2-57. Geographical Coordinates for Marine Ecology

Stations	Coordinates	Elevation
1	7° 3'59.25"N, 125°56'22.09"E	0 m
2	7° 2'9.24"N, 125°57'56.13"E	1 m
3	7° 0'47.36"N, 125°58'56.61"E	0 m
4	6°59'36.63"N, 125°58'47.16"E	0 m
5	7° 1'21.72"N, 125°57'36.11"E	0 m

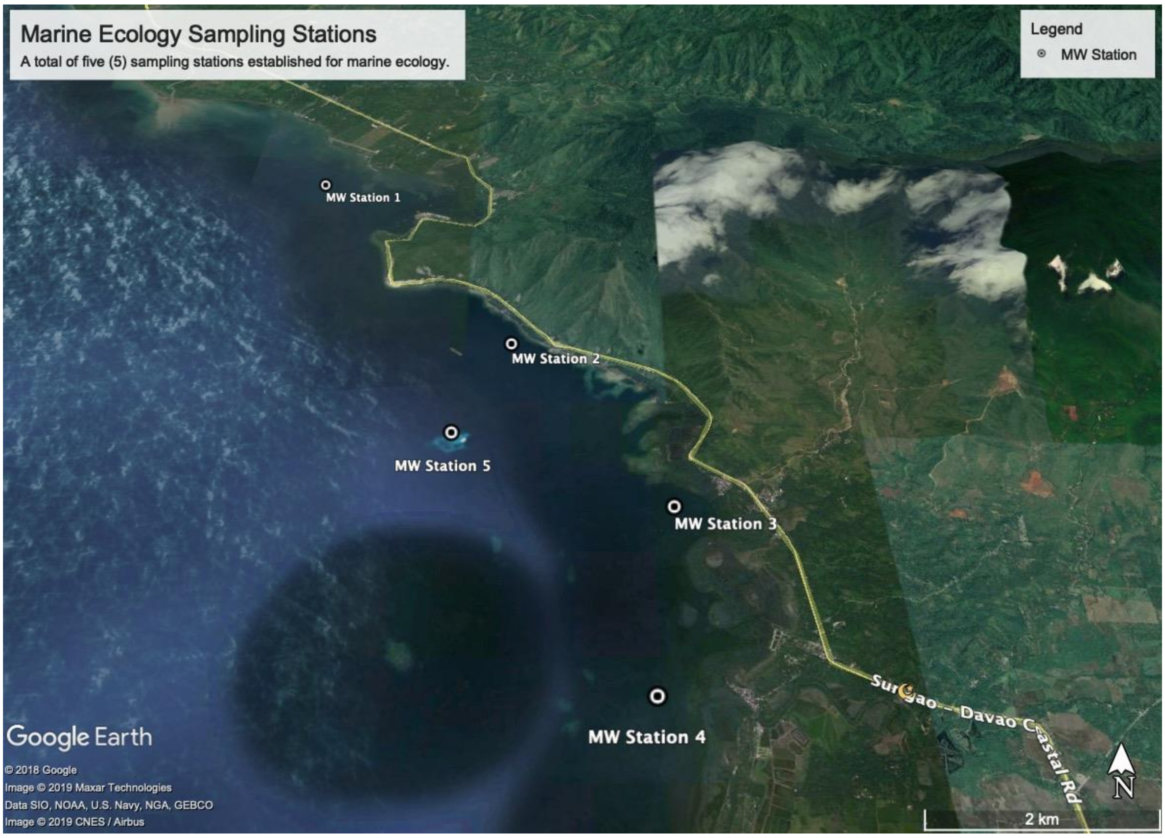


Figure 2.2-75. Sampling Map for Marine Ecology

Materials and Methods

Corals

Depth, distance from shore and seawater (reef bottom) temperature data were collected on respective reefs. The coral cover photo quadrat surveys were undertaken using fixed photo transects (KFUPM/RI, 1985; Done, 1996; English *et al*., 1997; WCPI, 1997a, 1997b, 1998, 1999a). At each reef site, two 5 m long transect lines were set on the reef top. The transects were separated from each other by a distance of about 5 m. The transects were marked by concrete nails. These permanent markers provide positioning points for finding the same locations during subsequent sampling periods. In this technique, small sections of the reef are photographed periodically enabling the monitoring of individual corals through time. Voucher photographs, laminated in plastic, which could be taken underwater, are very useful in maintaining a more or less constant positioning of the photographic frame for each quadrat.

An underwater camera with 28 mm lens, loaded with ASA 100 color film, and attached to a tetrapod camera stand frame was used to photograph 1 x 0.66 m sections of the tape. The field of view of the camera with 28 mm lens (wide angle) at a distance of four feet (1.2 m) coincided with the 0.66 m^2 area defined by the camera stand frame. This frame carries a nameplate on the lower right-hand corner for site/transect identifier and date, which appears in each photograph. Similar equipment were utilized in determining coral coverage and changes with time in a number of other reef studies (Bohnsack, 1982; Done, 1981; Dodge *et al.,* 1982; KFUPM/RI, 1985, 1988, 1993; DA-FSP, 1996), and in the previous monitoring studies/surveys carried out in Marinduque Island by Woodward-Clyde Philippines, Inc. (WCPI, 1997a, 1997b, 1998, 1999a).

The percentage distribution of the major parameters or attributes of the bottom cover from the photographs of the transect were estimated by recording the identity of items lying beneath a grid of 99 points on a template over laid on each print.

Fishes

The fish communities in selected reefs were surveyed using the daytime underwater fish visual census technique described in English et al. (1994). At each station, a 50-meter transect was laid parallel to the shoreline following the contour of the reef and maintaining a constant depth. Fish observed within 5 meters in front, above, and 5 meters on each side of the transect were recorded on underwater slates.

A total area of 500 m2 was effectively surveyed at each station. Fish were identified to species level, sizes or total lengths estimated to the nearest centimeter and their abundance determined by actual counts. For schooling and aggregating species abundances were estimated based on the sizes of the fish and the clusters they formed.

Seagrass

The sampling of seagrasses was monitored using the transect-quadrat method where a 50-m transect was laid out perpendicular to the shoreline with 5-meters interval. Along the transect line, a 0.50 x 0.50-meter stainless steel quadrat was pressed where seagrass starts to grow. Percent cover of the seagrasses were estimated and each seagrass were identified up to species level.

Mangroves

Four stations were established along the coastal area of Banay- Banay Davao del sur. Plot method was used to assess the mangroves. A total of 12 plots measuring 10 x 10 m2 was done; 3 plots in each station. In every 10 x 10 m2 plot each mature mangrove tree species were counted and their girth measured at breast height or at a standard 1.3 meters from the base is measured. At the corner of the plot a 5 x 5 m quadrat was establish to count and identify the number of saplings; and within each quadrat a 1 x 1 m quadrat to count and identify the seedlings. Leaf, fruit and flower samples from each Mangrove species were collected and were photo documented for further identification in the lab. Samples collected were identified based on Calumpong, Hilconida P. and Ernani G. Meñez. 1997. Field Guide to the Common Mangroves of the Philippines by Calumpong et. Al and The field guide to the identification of some mangrove species in the Philippines by DENR.

Fisheries

Fishery survey was conducted by interviewing fishermen in the area. There are at least 30 respondents whom interviewed according to fish catch, the fishing area, fishing gears and the trend of fishing. Photo documentation was also done for the report purposes.

2.2.4.2.1 Results and Discussions

Corals

Underwater structures made from calcium carbonate by corals are called coral reefs. These are colonies of tiny animals found strictly in marine waters. Most of the known corals are built from compacted calcium carbonate, which has tiny pores where polyps are secreted. Coral Reef is often called as the rainforest of the sea by because it hosts the diverse organisms. In addition to being a colony of tiny animals, they provide shelter to mollusk, worms, crustaceans, echinoderms, sponges, tunicates and most especially the fishes. In tropical areas, coral reefs are commonly found in shallow depths but for some would reach to deep water.

The Philippines is a part of the Coral Triangle, which also includes Indonesia and Malaysia. Vast coral reef cover can be found in these areas. In this assessment percent cover of benthic life forms such as live coral, dead coral, algae, abiotic and other fauna was considered. Abiotic benthic lifeforms include sand and silt components. Other benthic lifeforms include sponges, zoanthids and other benthic fauna.

Coral Cover

Coral cover in the sampling areas were characterize into six (6) classes. These are mainly (1) hard coral, (2) soft coral, (3) algae-covered (i.e. seaweeds and sea grass) corals, (4) abiotic (corals covered with non-living components such as sand, rocks, silts and rubbles), (5) others (other fauna cover such as sponges and anemone) and (6) tape, wand and shadow.

Figure 12 shows the average coral cover of all sampling sites. The greatest percentage (43%) of the corals are being covered with abiotic components such as sand and rocks. Soft corals and hard corals covered almost the same average percentage attributing 24% and 20% respectively.

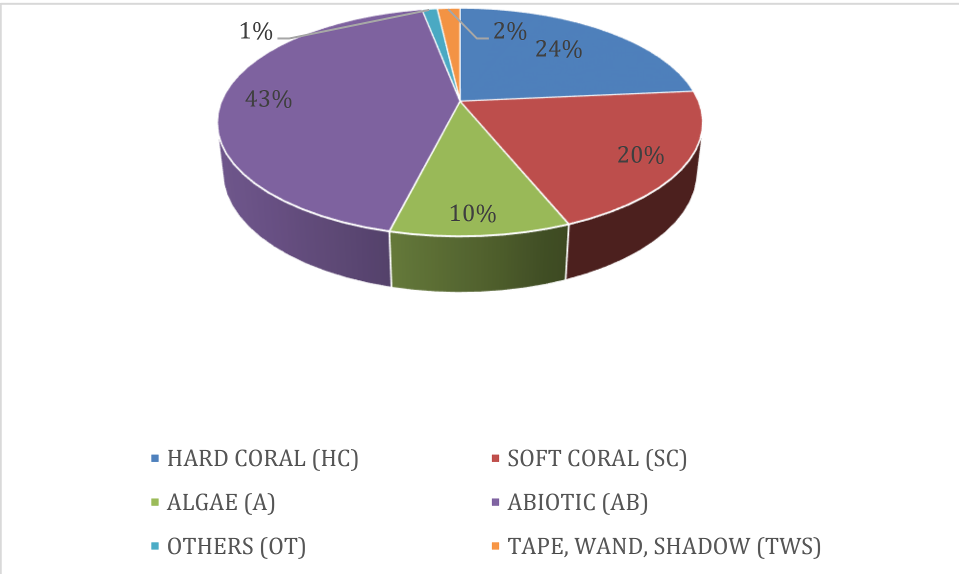


Figure 2.2-76: Over all Coral Cover

Hard coral cover was abundantly (36%) noted in barangay Maputi and was least (9%) observed in barangay Piso (Figure 13). Meanwhile, the greatest (56%) cover of soft coral was recorded in Barangay Piso. Algae covered an average percentage of 10% of the corals in all sampling sites and 40% was observed in Barangay Maputi. Furthermore, an average of 2% was accounted by tape, wand and shadow covers. 1% was covered with other faunal covers such as sponges which was abundantly (54%) noted in Barangay Punta Linaw.

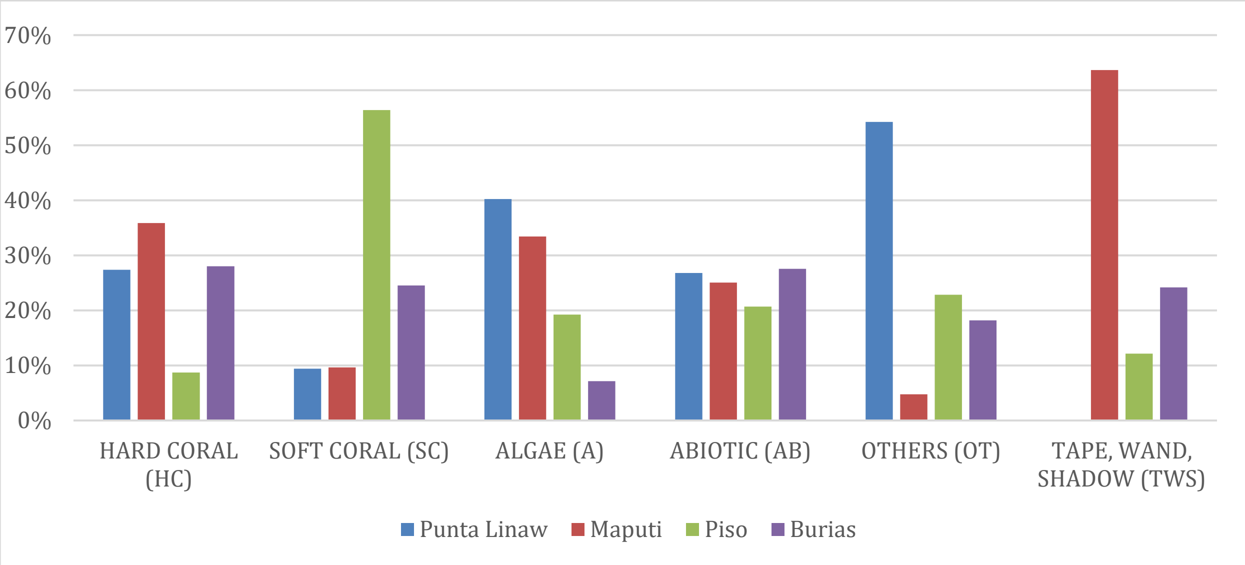


Figure 2.2-77: Over all Coral Cover Comparison per Station

Barangay Punta Linao

Figure below presents the percentage cover of each coral cover classification in Station 1 (Punta Linaw). The greatest percentage (47%) was dominated by abiotic-covered corals. This was then followed by hard coral covering 26% of the sampled area in Barangay Punta Linaw. Algae-covered corals accounted for 16%, soft corals with 8% and other fauna with 3%.

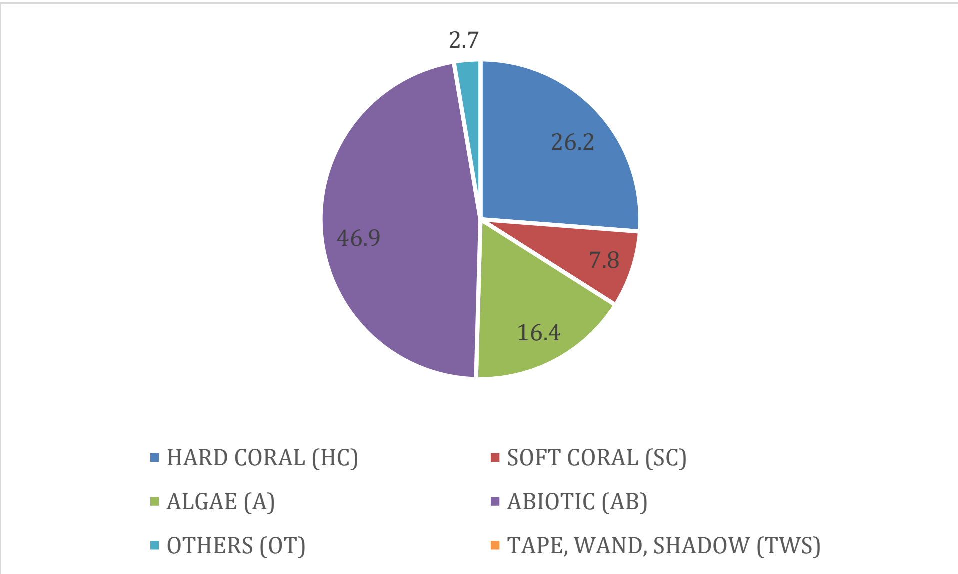


Figure 2.2-78: Percentage Cover of each Coral cover Classification in Station 1

Barangay Maputi

Like Punta Linaw, abiotic components such as sands and rocks covered the greatest percentage (44%) of corals in Barangay Maputi (Figure 15). Hard corals accounted for by 34%. Algae and soft corals covered a percentage of 14% and 8%, respectively. Tape, wand and shadow covers was accounted for by 5% and other covers attributed less than a percent.

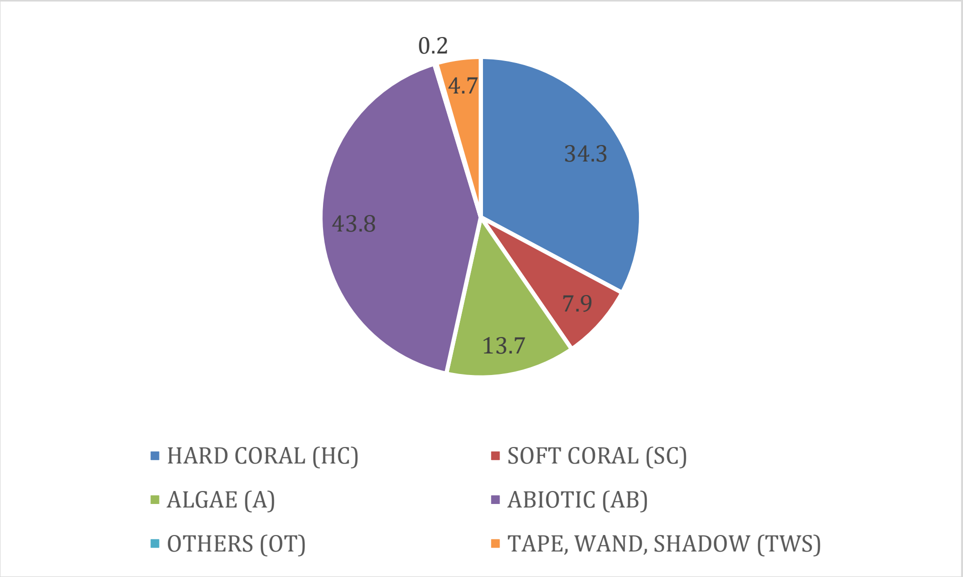


Figure 2.2-79: Percentage Cover of each Coral cover Classification in Station 2

Barangay Piso

It is interesting to note that unlike the first two barangays sampled, the percentage cover of soft coral was surprisingly found to be high in Barangay Piso (47%) compared to coral covered with abiotic components (36%). Meanwhile, both hard coral and algae covered the same percentage of 8% and only 1% was being covered by other fauna covers (see figure below).

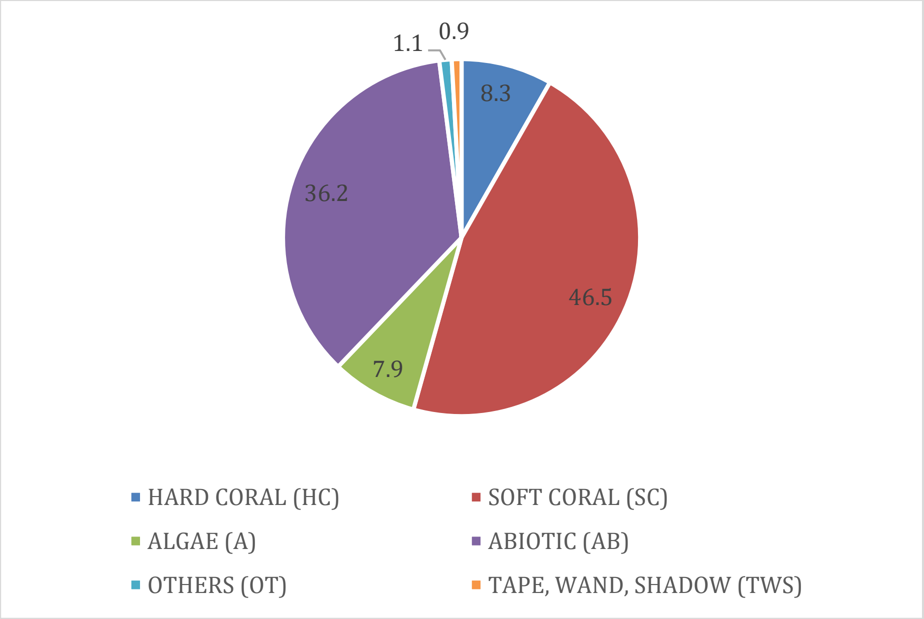


Figure 2.2-80: Percentage Cover of each Coral cover Classification in Station 3

Burias

In Barangay Burias, the following figure shows the highest percentage cover being attributed by abiotic component (49%). Meanwhile, there is no big difference of percentage cover was observed between hard (27%) and soft (20%) coral. However, algae (3%), biotic (1%) components and tape, wand and shadow covers (2%) attributed a small percentage of coral cover in the said barangay.

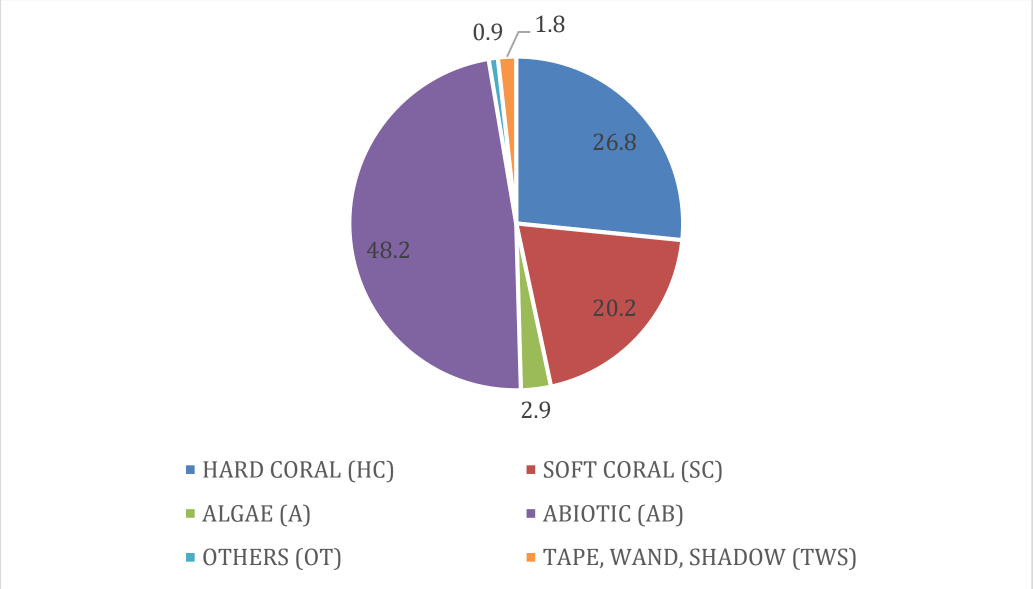


Figure 2.2-81: Percentage Cover of each Coral cover Classification in Station 4

Fishes

Fishes play an important role in the ecosystem. They provide people with food for many centuries. However, people are so careless, many of the fishing ground are now overfished and some other fish species are now threatened.

Coral fishes are the most conspicuous inhabitants of the reef occurring in schools of up to thousands of individuals displaying striking colors, shapes and patterns. Fishes not only contribute to the aesthetic value of coral reefs, they also constitute a major component of total biodiversity, they are source of economic value and they contribute to the overall heath and resilience of coral reef ecosystems via a number of ecological processes.

Species Richness

On the four (4) sampled Barangays, eleven (11) families of fishes were noted. Station 4 (Barangay Burias) had the highest number (1,814) of individual fishes recorded followed by Station 3 (Barangay Piso) with 1,474 individuals. Station 1 (Barangay Punta Linaw) had a total number of 1,013 individual fishes recorded while Station 2 had the least number of 960 individual fishes.

Table 2.2-58: Species Richness Comparison per Stations

Family	Station 1	Station 2	Station 3	Station 4	Total
Pomacentridae	891	758	1440	1357	4,446
Aulostomidae	2	-	-	-	2
Pomacanthidae	56	181	10	221	468
Serranidae	5	-	1	4	10
Scaridae	4	6	2	10	22
Chaetodontidae	24	15	8	85	132
Acanthuridae	27	-	12	10	49
Siganidae	1	-	1	4	6
Labridae	2	-	-	2	4
Zanclidae	1	-	-	1	2

Caesionidae	-	-	-	120	120
Total	**1,013**	**960**	**1,474**	**1,814**	**5,261**

Most of the genus which made up the Pomacentridae family observed are Abudefduf, Amblyphidodon, Chromis, Pomacentrus and Dascyllus species.

Relative Abundance

Figure below shows the over-all relative abundance of each fish family. As mentioned earlier, the abundance of the fish's species from the family Pomacentridae was found to be consistent on all four sampling sites. It accounted the 84.5% of all the individuals recorded. While Pomacanthidae which follows contributes 8.9%.

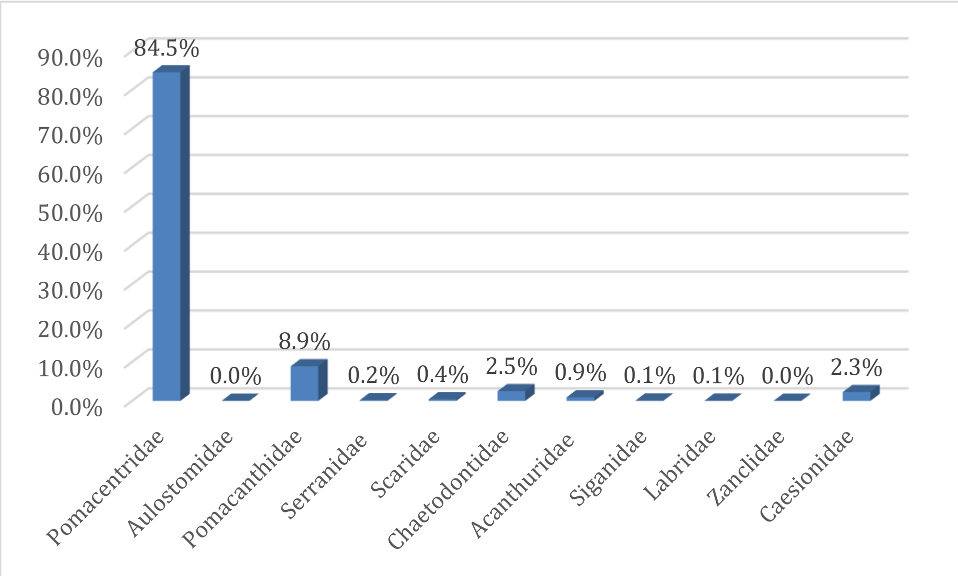


Figure 2.2-82: Over all Relative Abundance of Fishes

Barangay Punta Linao

In the first station sampled, specifically, Punta Linao, the highest number of fish observed came from the family of Pomacentridae (88.0%). It was then followed by the Family Pomacanthidae with percent abundance of 5.5. While the family Acanthuridae and Chaedontidae had almost the same percent abundance of 2.7 and 2.4 respectively. The rest of the families of fishes noted (Aulostomidae, Serranidae, Scaridae, Siganidae, Labridae and Zanclidae) only contributed less than a percent each.

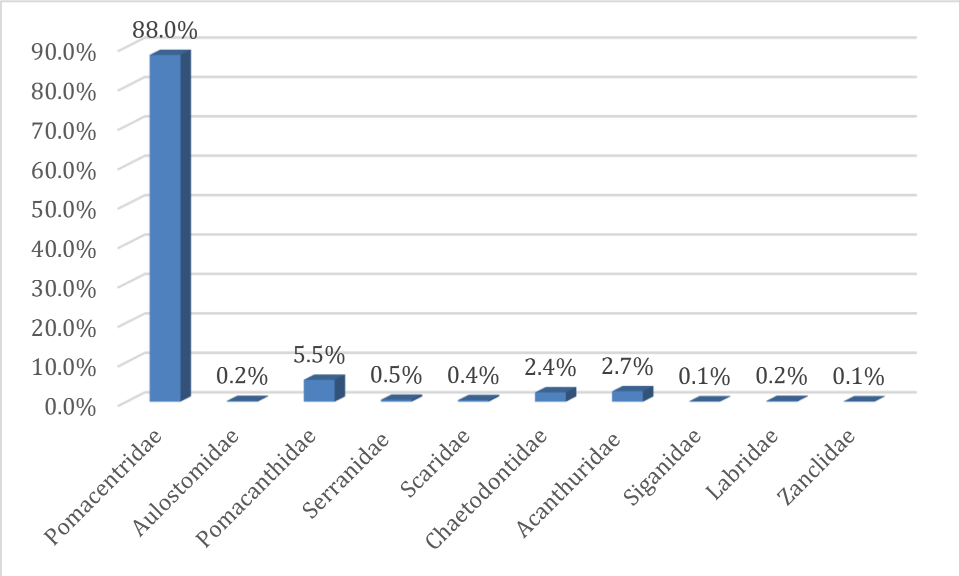


Figure 2.2-83: Relative Abundance of Fishes Station 1

Barangay Maputi

Only four (4) families of fish were observed in Maputi. Majority (79%) of them came from the Pomacentridae family. Pomacanthidae followed with relative abundance of 18.9%. On the other hand, Charodontidae and Scaridae only accounted for 1.6 and 0.6 respectively (Figure 20).

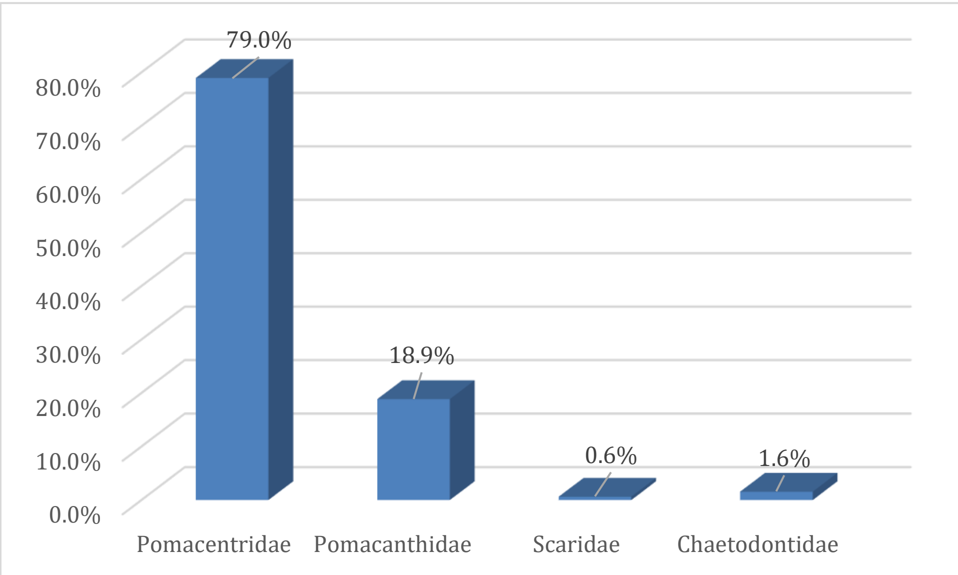


Figure 2.2-84: Relative Abundance of Fishes Station 2

Barangay Piso

Like the first two sampled Barangays, in the third station (Barangay Piso), Pomacentridae attributed a great percentage of 97.7 % (Figure 21). The rest six (6) families namely, Acanthuridae, Pomacanthidae, Chaetodontidae, Serranidae, Scaridae and Sigaridae contributed less than a percent each.

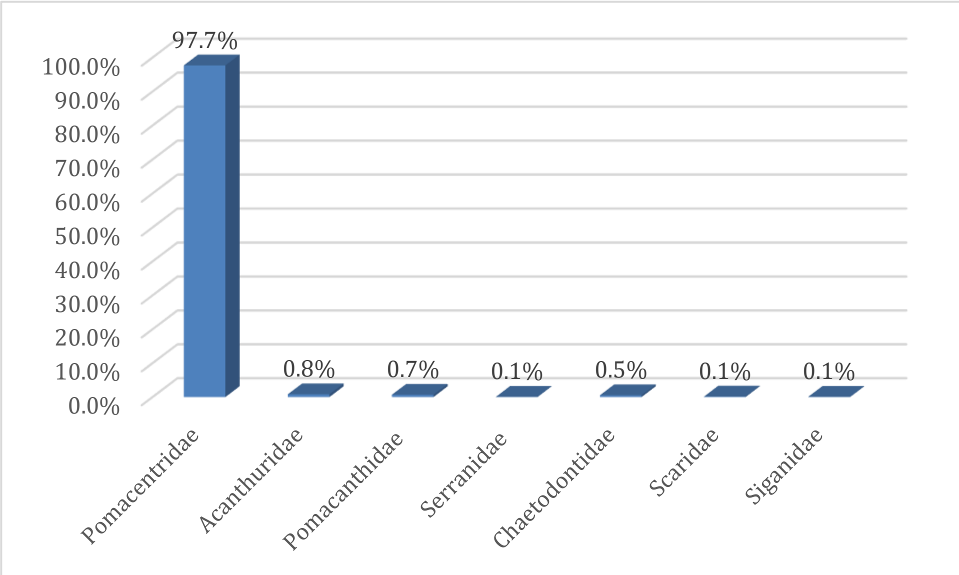


Figure 2.2-85: Relative Abundance of Fishes Station 3

Barangay Burias

In terms of families, burias had a total of ten (10) fish families noted (Figure 22. The highest percentage of 74.8% came from Pomacentridae family. Next is the Pomacanthidae family with relative abundance of 12.2% and was followed Caesionidae with 6.6%. Chaetontidae attributed 4.7% and the rest of the families accounted for less than a percent each.

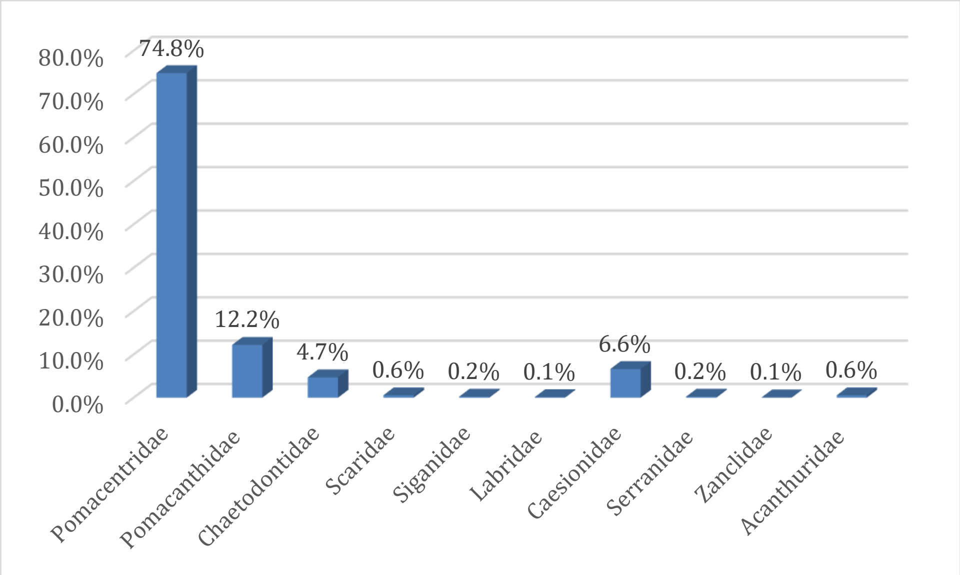


Figure 2.2-86: Relative Abundance of Fishes Station 4

Seasgrass

Seagrasses are vital part of the marine ecosystem. They provide habitat and food for some species of marine invertebrates. Seagrass usually grows in the shallow part of the coast where it can maximize its level of productivity with the help of light. Also, it increases water clarity by trapping particles that are suspended in the water column.

Species Richness

The following are the species observed in the area

1. Cymodocea rotundata - has a flat, strap-like leaves with approximately 2 – 4mm width. Leaf tip is smooth and rounded. It has a smooth rhizome and can be usually found on shallow reef flats.
2. *Enhalus acoroides* - It has a very long ribbon-like leaves with a length of 30 – 150 cm. The leaves have inrolled leaf margins. It has thick rhizome with long black bristles and cord-like roots.
3. *Halodule pinifolia* - This species of seagrass has fine and delicate leaves with one central vein and grows up to 20cm long. Its central vein splits into two at the end of the rounded leaf tip. It has pale rhizome with clean black leaf scars. Usually it can be found on intertidal sand banks
4. *Halophila ovalis* - Based from its name, this species of seagrass has oval shaped leaves in pairs with 8 or more cross veins. It has no hairs on the leaf surface. It's a common early colonizing species.
5. *Thalassia hemprichii* - has short black bars of tannin cells in the leaf blade. Leaves are curved and are 10 – 40 cm long. It has thick rhizome with scars between shoots. Also, this is common on shallow reef flats.

Relative Abundance

The figure below shows the overall relative abundance of the seagrasses among the 6 sampling stations. 5 species of seagrass were identified within the sampled area. *Cymodocea rotundata* has the highest average relative abundance of 47%. It was followed by *Halodule pinifolia* (28.2%). *Thalassia* *hemprivhii* and *Enhalus acoroides* have almost same average relative abundance of 12.2% and 11.6%, respectively. *Halophila ovalis* has the least average 1.1% relative abundance. Also, *Halophila ovalis* was only observed in Site 5 at the boundaries of barangay Maputi and barangay Piso.

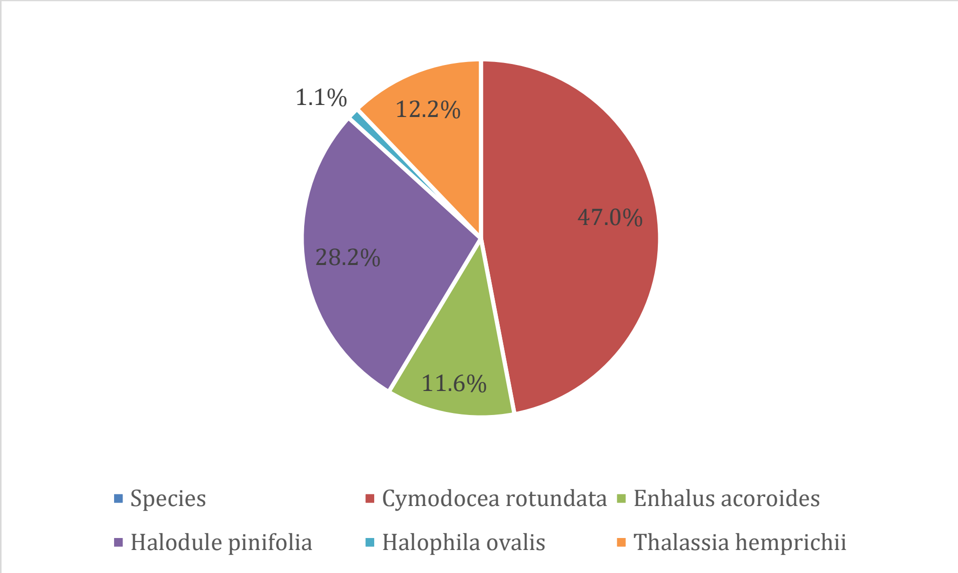


Figure 2.2-87: Overall Relative Abundance of the Seagrasses among the 6 Sampling Stations

Barangay Punta Linao 1

Two species of sea grass was identified in the first sampling site. These area *Halodule pinifolia* and *Thalassia hemprichii.* The following figure shows the abundance of each sea grass species. It can be observed the Halodule is more abundant compared to other species.

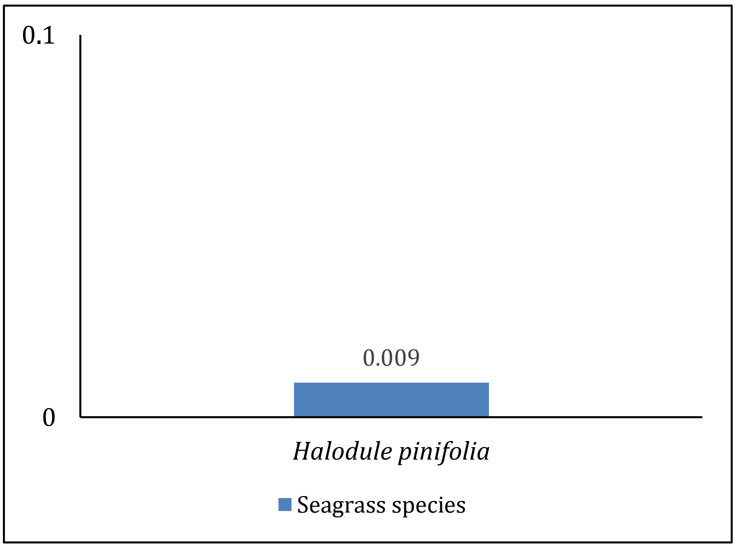


Figure 2.2-88: Relative Abundance of Seagrasses in Site 1

Barangay Punta Linao 2

In Site 2, only one species of seagrass was observed. *Halodule pinifolia* was observed between the transects laid in 5 to 15 meters with a total percentage cover of 1.2% and relative abundance of 0.009.

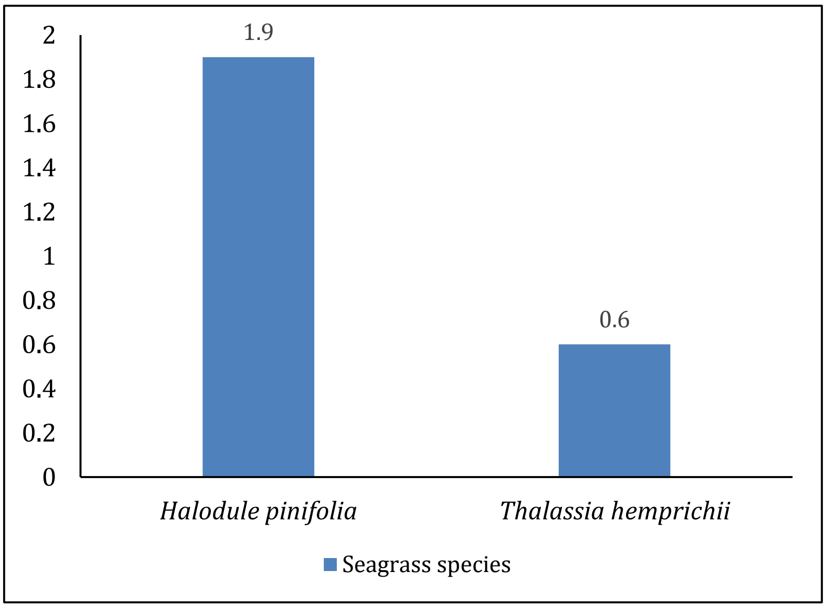


Figure 2.2-89: Relative Abundance of Seagrasses in Site 2

Barangay Piso 1

The figure below shows the *Cymodocea rotundata* has the highest percentage cover in Site 3 with 54% and a relative abundance of 0.39 followed by *Halodule pinifolia of 33.5%*. *Thalassia hemprichii* has the least percentage cover with a value of 7.5% and relative abundance of 0.22. Seagrass species were evenly distributed among the site having an average percent cover of 97%.

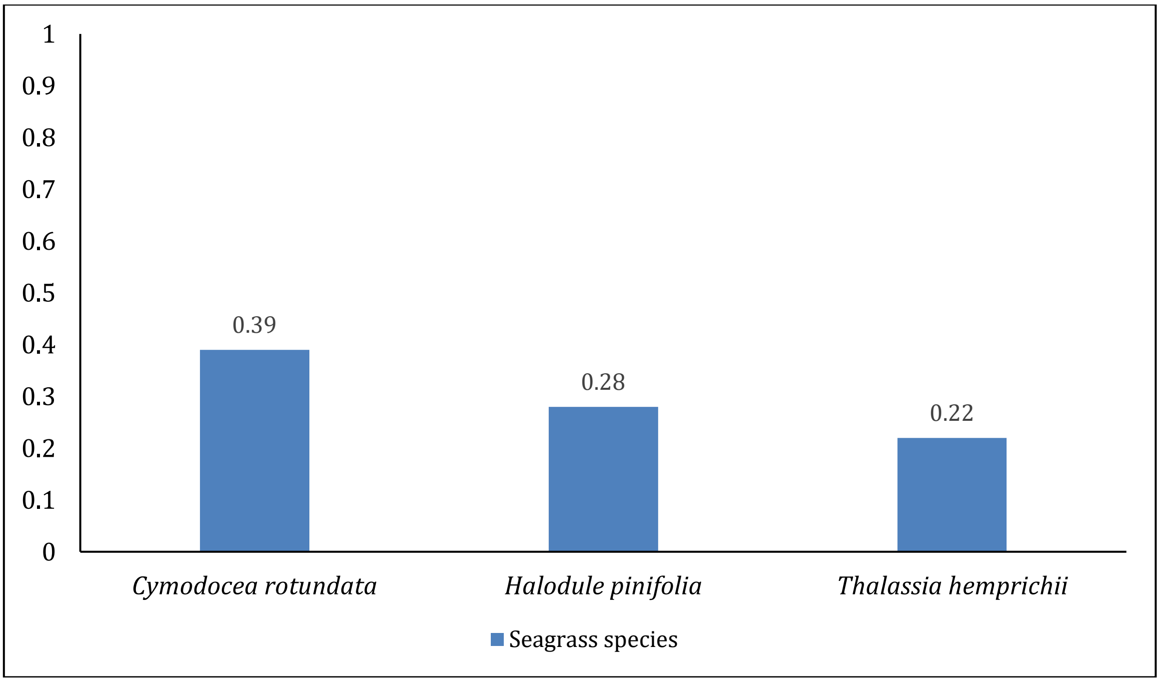


Figure 2.2-90: Relative Abundance of Seagrasses in Site 3

Barangay Piso 2

In terms of average seagrass percent cover, Site 4 has the highest average seagrass percent cover of 99%. *Cymodocea rotundata* was the most evident species with a total cover of 42% while *Halodule pinifolia* was also close to the former, with a percent cover of 40%. *Thalassia hemprichii* has the least percent cover with 17% but has the highest relative abundance of 0.50. *Cymodocea rotundata* has the least relative abundance with 0.31 only.

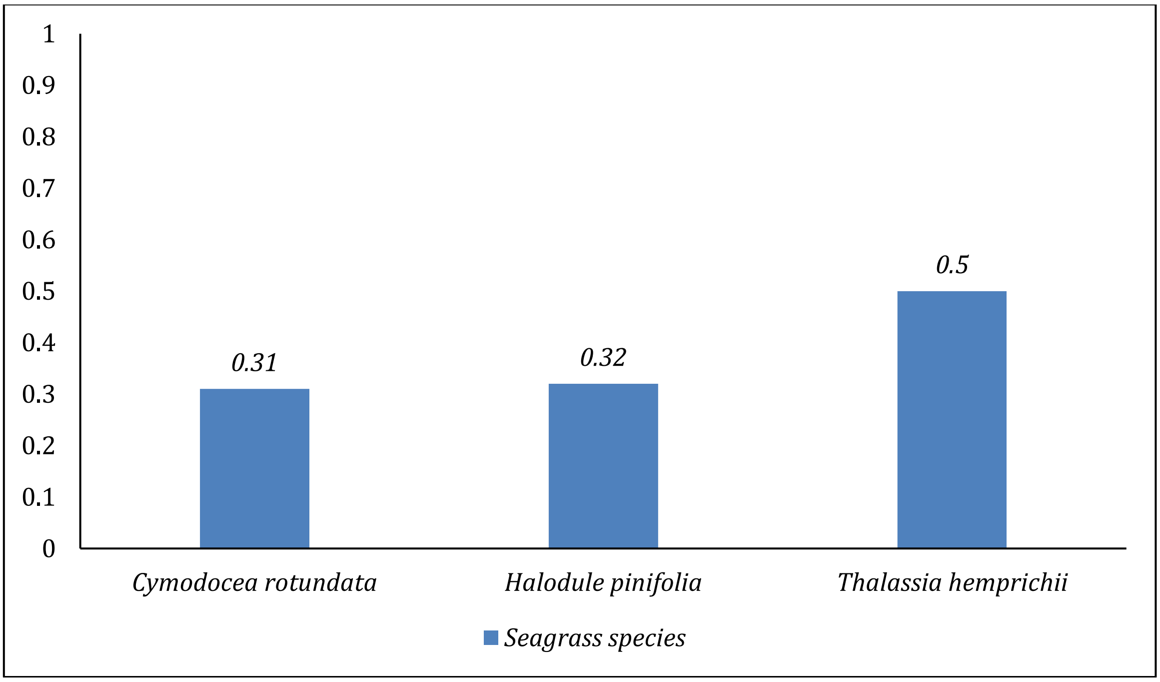


Figure 2.2-91: Relative Abundance of Seagrasses in Site 4

Barangay Maputi 1

Site 5 has the greatest number of seagrass species observed. *Halodule pinifolia* was the most abundant species in the site with a percentage cover of 47% and a relative abundance of 0.37. On the other hand, *Halophila ovalis* was the least abundant species which was only observed in Site 5 that has percentage cover of 1.5% and rendered a relative abundance of 1. *Halophila ovalis* was the highest relative abundance since it was only recorded in this site.

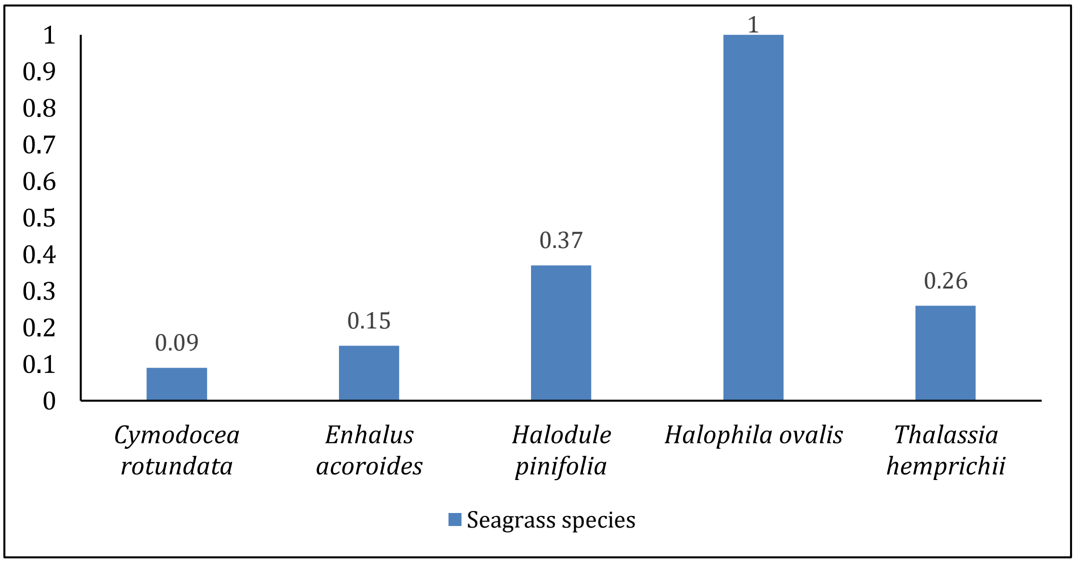


Figure 2.2-92: Relative Abundance of Seagrasses in Site 5

Barangay Maputi Centro

Only two species of seagrasses were recorded in this site. *Enhalus acoroides* was only observed in barangay Maputi which includes sites 5 and 6. In this site, *Cymodocea rotundata* was more abundant than *Enhalus acoroides* with a percentage cover of 29% while the latter has only 17.6% cover. However, *Enhalus acoroides* has a relative abundance of 0.85 which was higher than the other seagrass species since *Enhalus acoroides* was less scattered and was observed only in two sites.

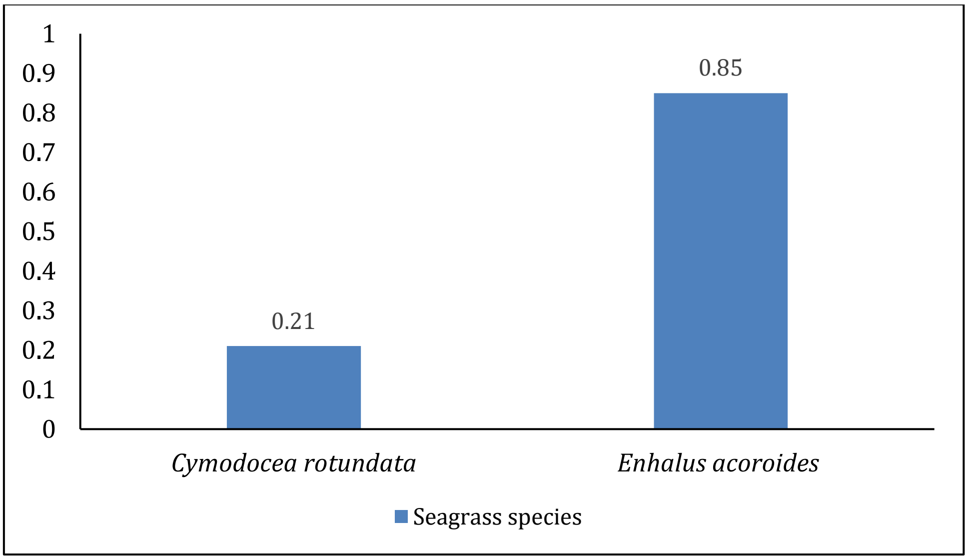


Figure 2.2-93: Relative Abundance of Seagrasses in Site 6

Mangroves

Mangrove ecosystem has been beneficial to humans in various ways. However, many failed to recognize its importance and even disregarded it. Although there are many people who directly benefit from it but it has a lot of indirect benefits, the reason why other people allotted less concern on the ecosystem compared to the other ecosystems. Mangroves serves as a breeding ground for many species, thus, maintain the biodiversity of many marine organisms. Furthermore, it also served as effective filter from the wastes that may end up in the sea during flooding season. Aside from the protection it offers to maintain the integrity of our seas, it is also barrier that protects the people living in the coastal areas from big waves and soil erosion on the seacoast. Many programs and projects have already been implemented to rehabilitate more mangrove areas and knowing the status of our mangrove ecosystem is critical for assessing one area's vulnerability from climate change manifestations such as typhoons.

Species Richness

A total of 5 species of mangrove were identified on the four sampling stations in Banaybanay. Out of 186 stands of mangroves sampled, *Sonneratia caseolaris* was the most abundant with 107 stands followed by *Rhizophora apiculata, Avicennia marina* and *Rhizophoa muculata*, while the least abundant was *Luminitzera racemosa* with 5 stands (**Table 2.2-40**). Barangay Puntalinao had the highest number of mangroves present with 70 stands while the boundary between barangays maputi and piso had the least.

The total density of mangroves for all the 4 stations in Banay banay is 1550 stands/ ha. *Sonneratia caseolaris* wth 892 stands of mangroves per hectare while the least *Luminitzera racemosa* with 42 stands of mangroves per hectare.

Table 2.2-59: Species Richness and Density of Mangrove Species

	Number of Species in				**Total**	**Density (stand/ha)**
Species	Site 1	Site 2	Site 3	Site 4		
Lumnitzera racemosa	5	-	-	-	5	42
Sonneratia caseolaris	37	25	26	19	107	892
Avicennia marina	-	7	-	-	7	58
Rhizophora apiculata	28	14	8	11	61	508
Rhizophora muculata	-	6	-	-	6	50
Total per station	70	52	34	30	186	

In terms of species dominance, *Sonneratia caseolaris* is most dominant with a total basal area of 7589.7 cm and relative dominance of 69 percent;being the most dominant and one if the largest species of mangroves in terms of body size and girth diameter. It is followed by *Rhizophora apiculata* with 25%, Avicenna marina with 3%, *Rhizophora muculata* with 2% and the least *Luminitzera racemosa* with 1%.

Relative Abundance

Barangay Punta Linao

In the first sampling site plotted in Barangay Puntalinao, only three species of mangroves were noted. These are *Sonneratia caseolaris, Lumnitzera racemose and Rhizophora apiculate*. *Sonneratia caseolaris* was found to be the most abundant species with the highest relative abundance of 52.9%. The next most abundant mangrove species is the *Rhizophora apiculate* (40.0%) and Lumnitzera had the least relative abundance of 7.1%.

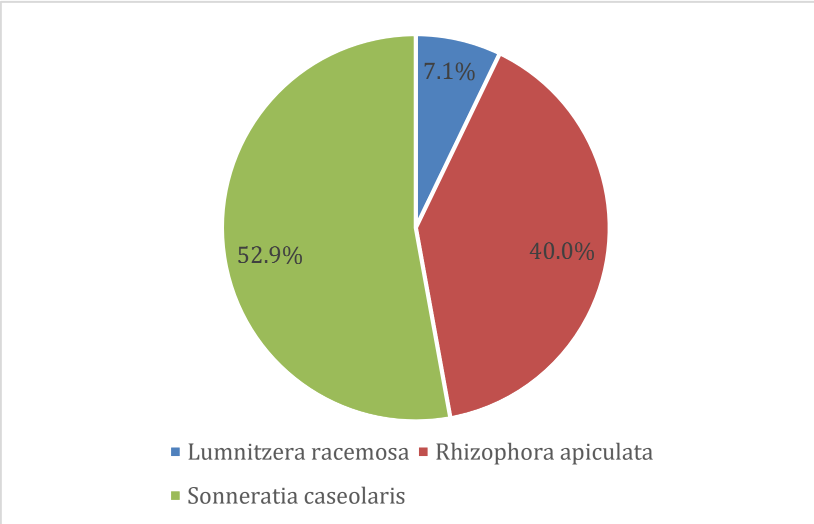


Figure 2.2-94: Relative Abundane of Mangroves in Site 1

Barangay Piso

Meanwhile, in site 2 located in Barangay Piso, four species of mangrove species were identified. These are *Avicennia marina, Rhizophora apiculata, Sonneratia caseolaris and Rhizophora maculate.*The most abundant species is the Sonneratia caseolaris with relative abundance of 48.1%. *Rhizophora apiculata* had a relative abundance of 26.9% while *Avicennia marina* and *Rhizophora maculata* had relative abundance of 13.5% and 11.5%, respectively.

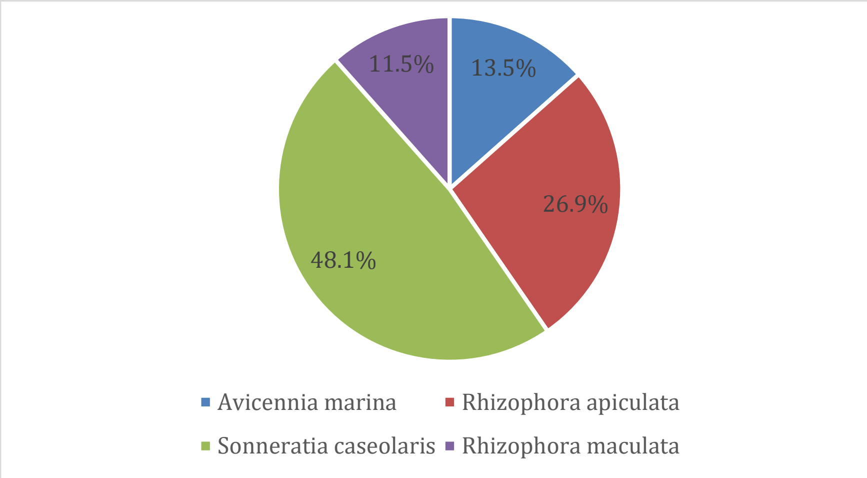


Figure 2.2-95: Relative Abundance of Mangroves in Site 2

Barangay Maputi

From the twenty-four mangrove individuals counted, fewer mangrove species was recorded on the third sampling site situated in Barangay Maputi. The only two species identified were *Sonneratia caseolaris* and *Rhizophora apiculata*. While the latter had higher relative abundance of 76.5%, the Rhizophora apiculate had relative abundance of 23.5% **(Figure 2.2-86).**

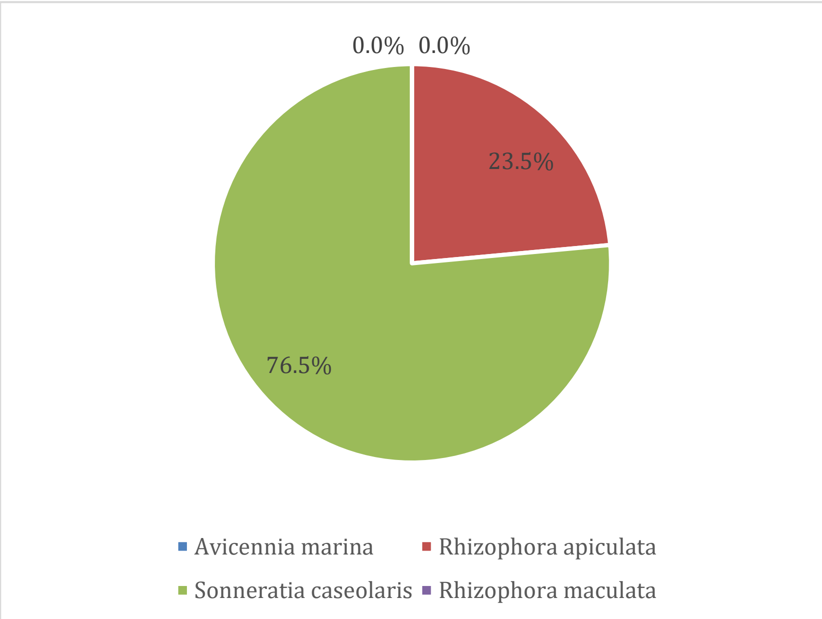


Figure 2.2-96: Relative Abundane of Mangroves in Site 3

Maputi – Piso Boundary

Due to problem in accessibility, the third sampling plots were laid in the boundary of Barangay Maputi and Piso. Two mangrove species were identified in the area, namely, *Sonneratia caseolaris* and *Rhizopora apiculata*. Compared to *Rhizophora apiculata* with relative abundance of 36.7%, *Sonneratia caseolaris* was observed to be more abundant (63.3%).

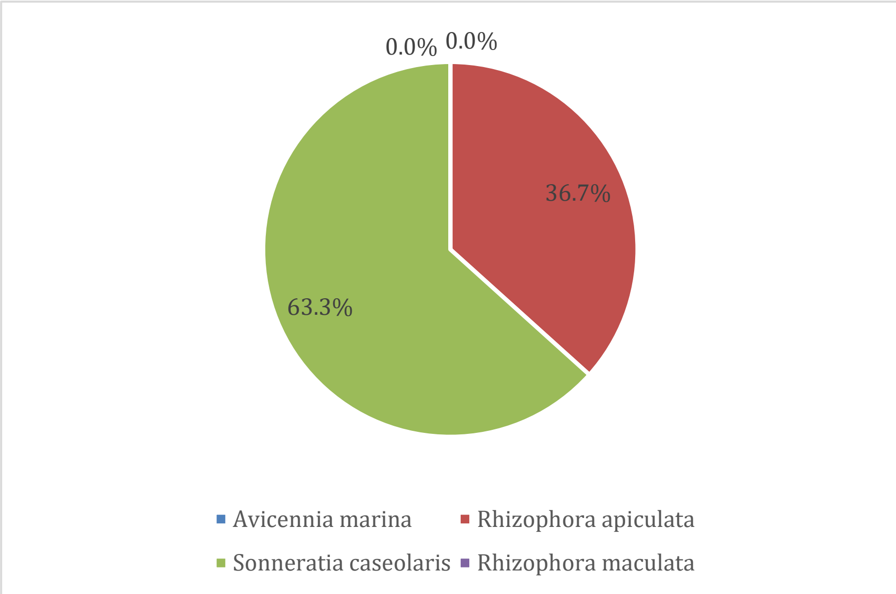


Figure 2.2-97: Relative Abundance of Mangroves in Site 4

All mangrove individuals sampled totaled to 186 individuals. *Sonneratia caseolaris* from the family of Lythracea has the highest over-all relative abundance of 57.5%. Next is the *Rhizophora apiculata* with relative abundance of 32.8%. While the three remaining species namely, Avicennia marina, Lumnitzera racemosa and Rhizophora maculate have almost the same relative abundance of 3.8%, 3.7% and 2.7%, respectively.

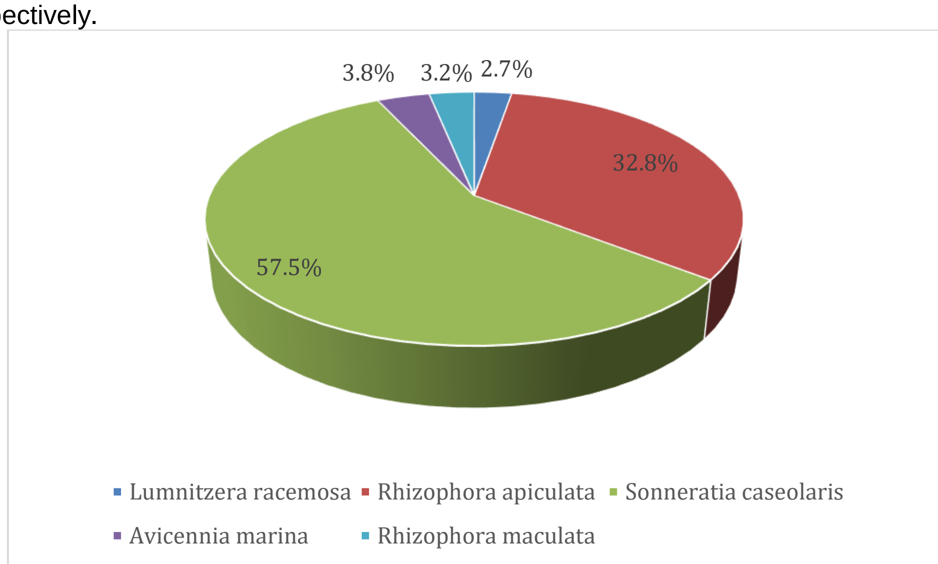


Figure 2.2-98: Over-all Relative Abundance of Mangrove Species

Fisheries

According to Food and Agriculture Organization of the United Nations, Philippines have ranked as one of the top fishes producing countries in the world. The country has been exporting and importing fish and fishery products since then up to the present years. However, in terms of aquaculture, Philippines' rank has fallen globally in the last 20 years. There were clear indications that fisheries production is approaching real limits to further growth. Almost all of its production is consumed locally.

Base on the observations and the interviews, an allocation of fish cages were distributed in the coastal areas of Banaybanay, Davao Oriental. According to the response, these were permitted for economic benefit in order to provide livelihood and socio-economic growth.

Wet Season Sampling

There are 16 respondents participated for the coastal fisheries survey conducted on October 5, 2019 in Banaybanay, Davao Oriental. According to FAO, various socio-economic data indicate that the ability of the sea to provide a cheap source of food and income for the Filipino population has been severely compromised. To ensure national food security, it is necessary to ensure the country's fish supplies, which means promoting sustainable fisheries for both the small-scale and commercial fishers. In order to sustain the needs of people, fishers must have a catch that are enough for the populace. This economic state requires fishermen to harvest fish as much and feasible as they can.

The average monthly income among all of the respondents according to the survey conducted, it ranges from 300-14,000 pesos per month. Some of them consider fishing as their sideline job. Those who have a salary of 5, 000 pesos and above catch fish seven times a week and in twelve hours per day.

About 53% of the respondents work or catch fish seven times per week. The surveyed area has cultured milkfish production set into fish cages. Some of the residents or locals had been working in the fish cages instead of having fish operations in the deep sea. About 85% of them catch fish once a day, however, it is equivalent into 12-24 hours. The figures below visualizes the percentage of trips in a week and day and its fishing time.

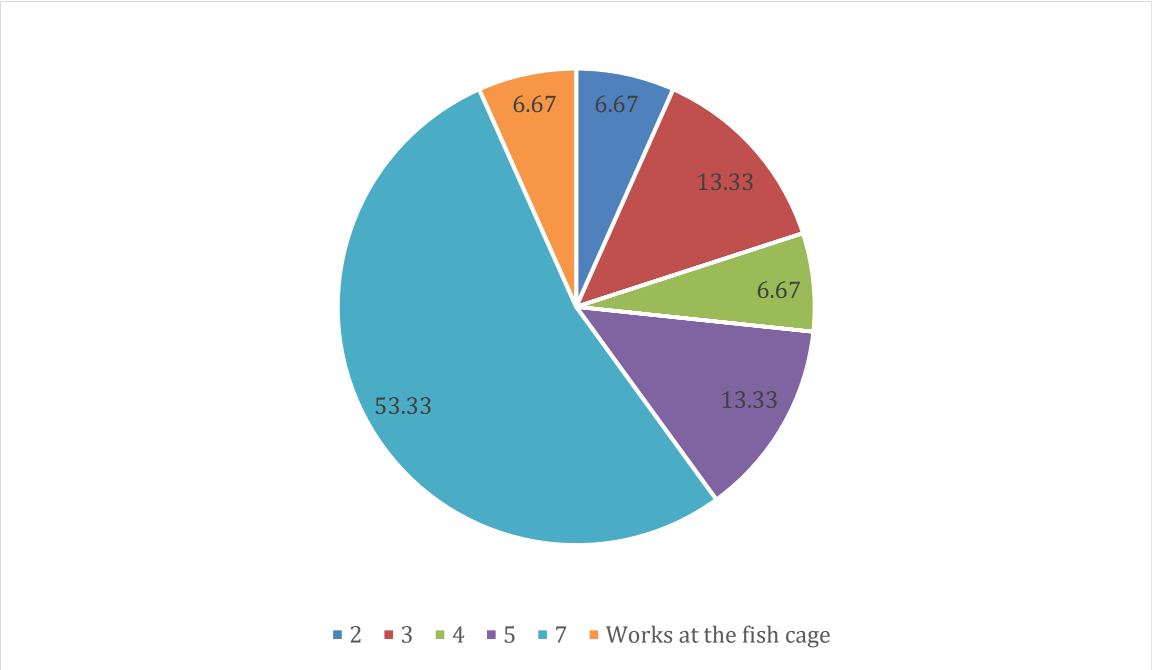


Figure 2.2-99: Fishers Trip in a Week

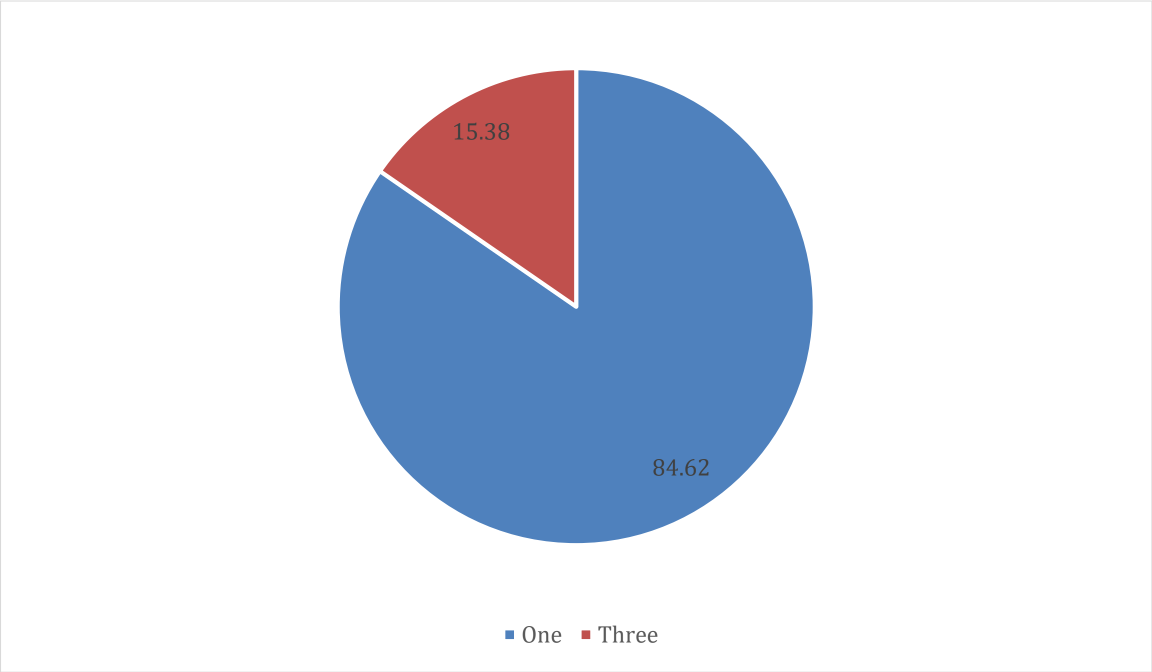


Figure 2.2-100: Fishers Trip in a Day

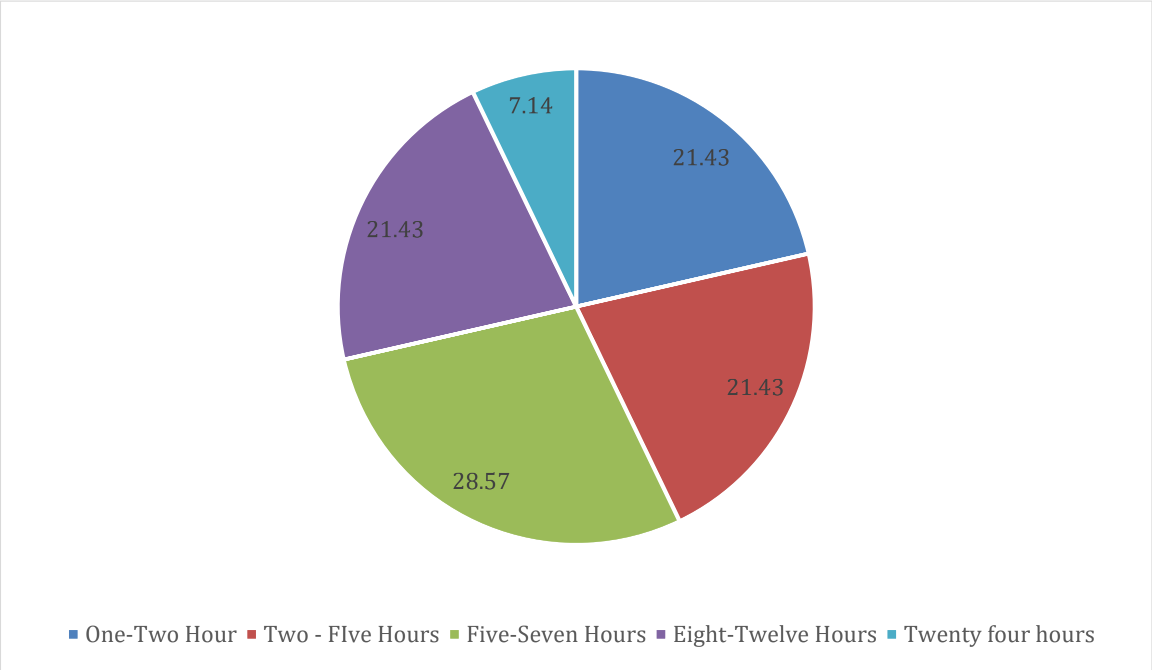


Figure 2.2-101: Hours per Trip

Fish Catch

The average catch of fishes has different ranges according to its family. Under carangidae (Caraballas, Matambaka, Samin-samin, Talakitok) ranges from 1 to 50kg per trip. Under Scombridae (Anduhaw, Karaw, Pirit, Tulingan) ranges from 1-500kg depend on the season of the fishes. Fishes with no values for selling price are for consumptions only. These catches are only less than 1 kg, the most expensive value per kilo belongs to Carangidae and Siganidae which is 250 per kilo.

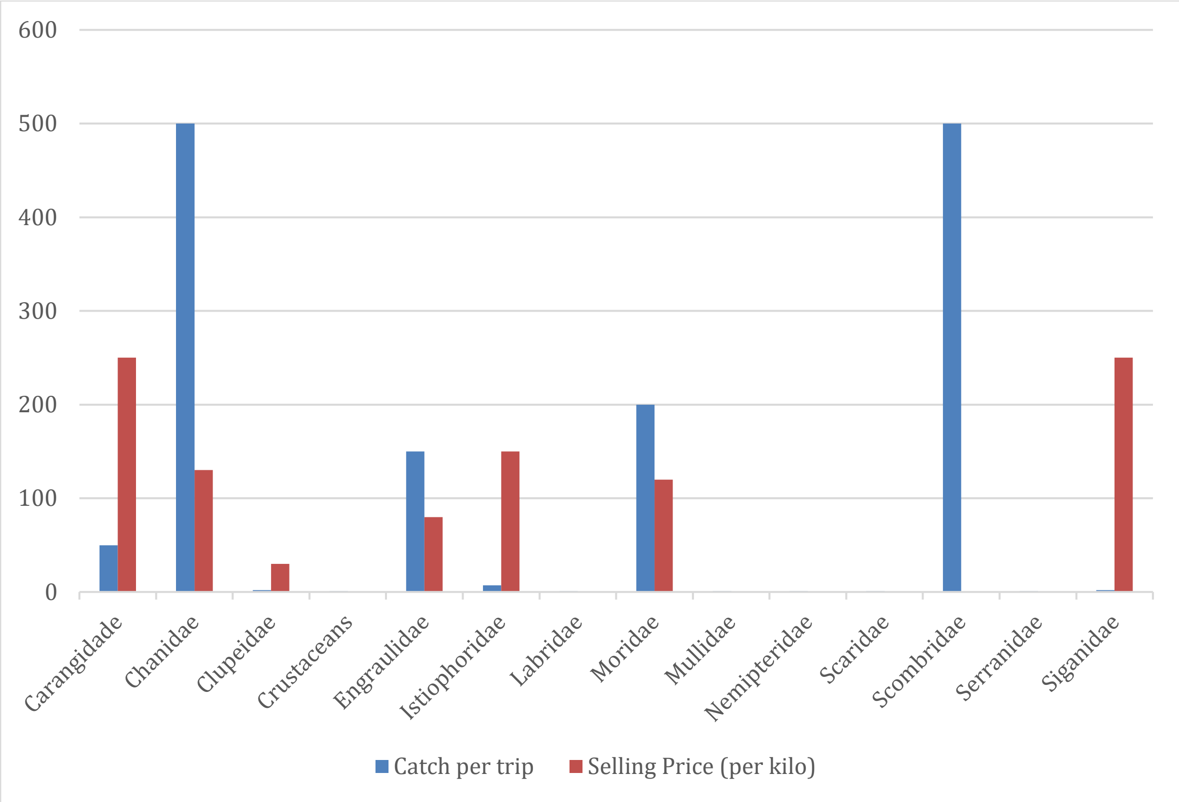


Figure 2.2-102: Average Catch of Fishes per Family

Fishing Area

The fishing areas and the usual distance of the fishing area is from 0.15km to 5km from the shoreline. According to the respondents, there is a conflict between the fish cages and the local fishers because of the chemical effects from the food of Milkfishes in the fish cages.

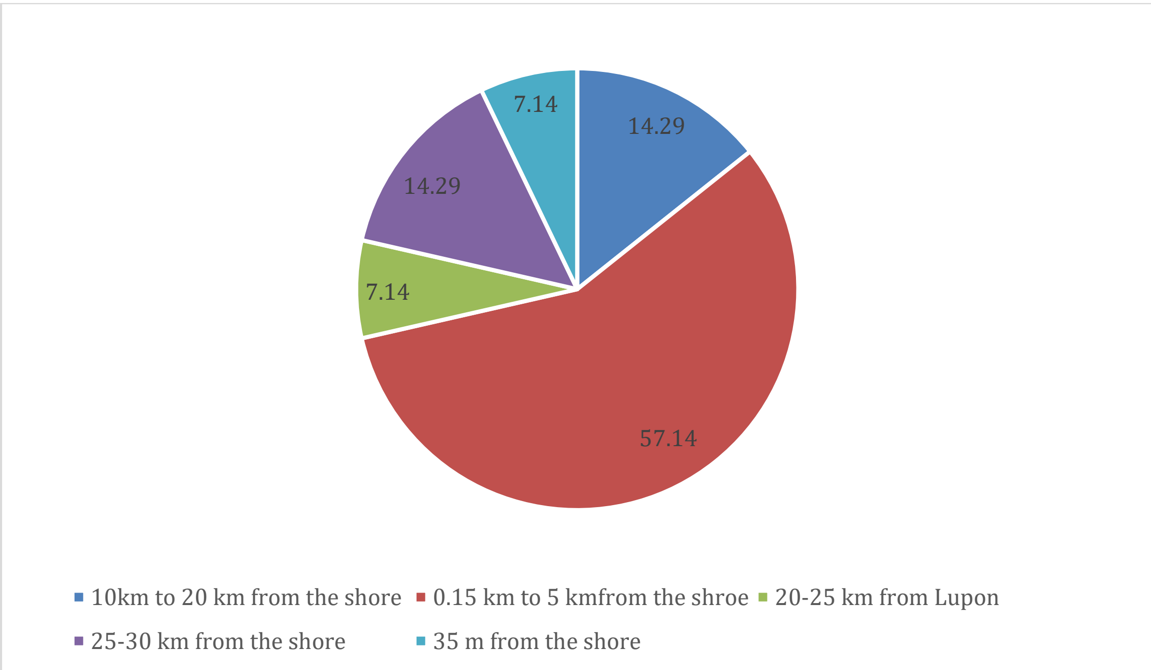


Figure 2.2-103: Fishing Area and its Distance

Fishing Gears

Table 2.2-60: Fishing Gears used

Fishing Gears	Specifications
Fishhooks	4 hooks at the end point, 10m nylon string 7 hooks, 2rolls of nylon string
Fish nets	2-2.5 inches mesh size 6-10inches mesh size 5-7inches mesh size
Fishing line	Made of nylon string
Landing net	Dip net; huge dip net with 6-7 inches mesh size
Modified Simple Handline	50-60 hook at the end point, circular position

Photo 2.2-8. Fishing Net

Photo 2.2-9. Landing Net or Dip Net

Photo 2.2-10. Fishing Hooks

About 40% of the local fishers use manual fishing vessel that's made out of wood. The motorized fishing vessels are designed for bigger fishing operations that export fishes internationally. The remaining 27% of the figure are those who do not use boats to catch fishes.

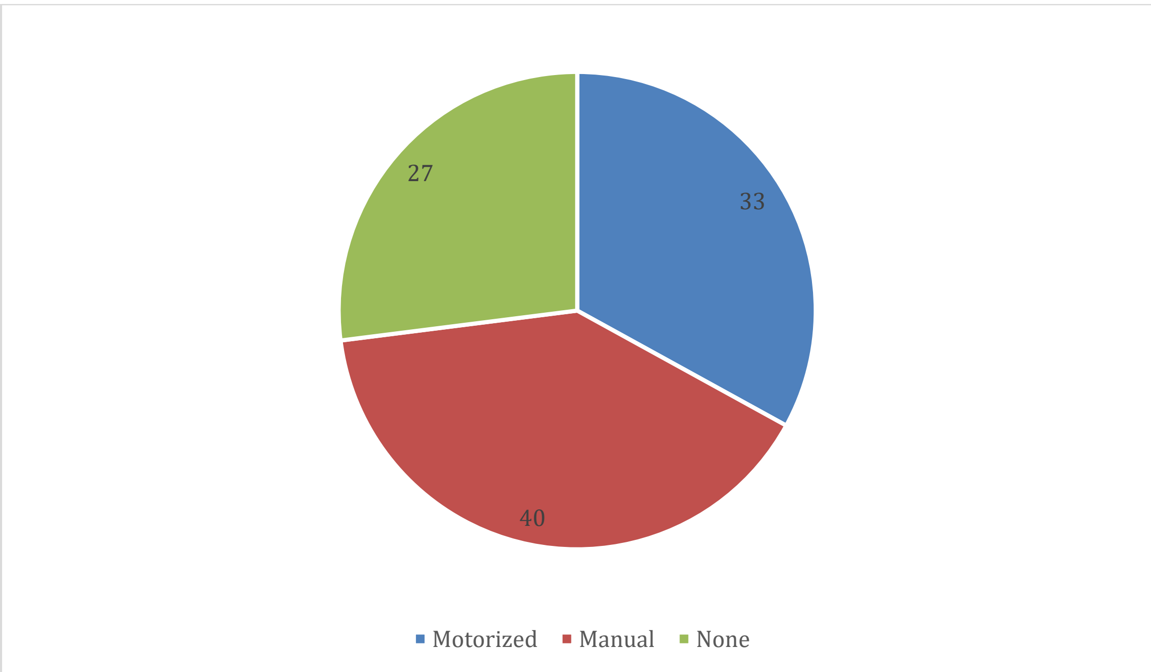


Figure 2.2-104: Fishing Vessel

Trends of Fisheries

About 90% of the responses have witnessed that the fisheries had been drastically decreasing due to several factors. These leads to competition and scarcity of resources which then causes poverty. According to the results of the survey, the respondents listed the causes of the trend of the fisheries (marine coastal and ecological problems); natural disaster, competition between fishermen, overpopulation, degraded fishery habitats and illegal fishing methods.

Classification of the Body of Water based on DAO 2016

The marine water quality data and the appropriate quality of the waters were classified as Class SB based on DAO 2016.

Table 2.2-61: DAO 2016-08

Classification	Intended Beneficial Use
Class SA	1. Protected Waters – Waters designated as national or local marine parks, reserves, sanctuaries, and other areas established by law (Presidential Proclamation 1801 and other existing laws), and/ or declared as such by appropriate government agency, LGUs, etc. 2. Fishery Water Class I – Suitable for shellfish harvesting for direct human consumption
Class SB	1. Fishery Water Class II – Waters suitable for commercial propagation of shellfish and intended as spawning areas for milkfish (*Chanos chanos*) and similar species 2. Tourist Zones – For ecotourism and recreational activities 3. Recreational Water Class I – Intended for primary contact recreation (bathing, swimming, skin diving, etc.)
Class SC	1. Fishery Water Class III – For the propagation and growth and other aquatic sources and intended for commercial and sustenance fishing 2. Recreational Water Class II – For boating, fishing, or similar activities 3. Marshy and/or mangrove areas declared as fish and wildlife sanctuaries
Class SD	Navigable waters

Movement of Soil Particles in to the Marine Environment

Banaybanay, Davao Oriental has a tropical climate. It belongs to the climate type IV (as per Modified Corona's Classification of Climate). There is significant rainfall in more or less evenly distributed throughout the year. The main factor for soil erosion includes rainfall, by its amount, frequency, duration and intensity, and wind, by its direction, strength and frequency of high intensity winds, which is coupled with drying-out of the soil. The movement of soil particles comes from the effect of rainfall intensity. Since it is a climate type IV, rainfall is present evenly in the year and due to rainfall, the soil will be eroded.

Soil erosion by water is more widespread and its impact greater than that by wind. Climate change is likely to affect soil erosion by water through its effect on rainfall intensity, soil erodibility, vegetative cover, and patterns of land use. General circulation models predict for many areas seasonally more intense drying, coupled with increased amounts and intensity of precipitation at other times, conditions that could lead to large increases in rates of erosion by water (McCool & Williams, 2008). Soil erosion also occurs by wind transport of soil particles by suspension, surface creep, or saltation over distances ranging from a few centimeters to hundreds of kilometers. Wind erosion not only transports soil particles around arid and semiarid landscapes but inputs into ecosystems and may even alter global climatic patterns. Wind erosion is particularly a problem on sandy and organic soils, which are subject to intermittent low-moisture contents and periodic winds. Currently wind erosion is mainly a feature of arid and semiarid conditions. Those areas where climate change is predicted to lead to more droughty soils under increasing temperatures will become increasingly vulnerable to wind erosion (Bullock, 2005). Although general circulation models have in the past been unable to predict changes in wind speed and frequency with any certainty, the latest models are predicting increased summer continental drying and risk of drought in midlatitude areas and an increase in tropical cyclone peak intensities in some areas, both sets of conditions favoring an increase in soil erosion by wind. However, it is important to note that erosion is site-specific, and different permutations of conditions can increase or decrease it (Phuong et. Al, 2017).

In the last few decades of the twentieth century, significant advances have been made in modeling erosion risk under different climate change scenarios. Research in the USA, using the EPIC model for two different sets of climatic conditions at 100 sites in the US Corn Belt, has shown that mean water erosion varies approximately linearly with mean precipitation, with approximately a 40% change for a 20% change in mean precipitation. By contrast, with a 20% increase in wind speed, erosion increased fourfold. This suggests that wind erosion is potentially more sensitive to climate change than is water erosion and secondly that, for wind-erosion predictions, it is important to understand and predict wind-speed threshold. These results and others using different models suggest that increased wind speed, rainfall amount and intensity and increased frequency of high-wind events are likely to lead to significant increases in soil erosion, thus exacerbating the already serious situation (O’neal et. Al, 2005).

2.2.5 Key Impacts and Mitigating Measures

Impact	Mitigation
Hydrology, drainage sedimentation	
Sediment yields from the watersheds will be accelerated due to increase in soil erosion.	• SMP will be developed and implemented prior to start of the project. SMP will address surface soil stripping methods, storage, and may include soil amelioration should there be a need to use it in the future, particularly for seedbed and vegetation. • Stockpiled soil quality will be improved through proponents' conservation program to reduce, if not prevent, soil degradation during the construction. • Settling ponds, sediment traps will be designed to accommodate enough runoff and sediment volume. • Regular sediment extraction from the settling ponds/sediment traps. • Adoption of fabric filter in critical drainage systems at the mine site.
Flooding	
Flooding of downstream areas due to silted river channels.	• Intensify erosion control at the mine site. • Regulate release of rain water from the mine pits. • Dredging of critical river sections to increase drainage capacity and sustain navigation.
Water Resource	
Increase water dependence from spring and groundwater due to high sediment concentrations of river flows.	• Develop communal water supply systems for affected communities. • Protection of spring water sources in the mine site.
Salt water intrusion due to excessive ground water extraction	• Use of spring waters rather than ground water source. • Coordinate for the regulation of ground water extraction especially in critical areas.
Water Quality	
Discharge from the siltation pond to the water bodies in the vicinity can potentially cause deterioration of the quality of these immediate water bodies.	• Regular effluent monitoring will be conducted and appropriate treatment of the effluent will be done as necessary prior to discharge.
Runoff from the mine operating areas can potentially increase TSS levels causing turbid waters.	• A water management system to control the runoff and sedimentation will be established to minimize water quality impacts. Regular water quality monitoring will be conducted in the streams immediate the mine site vicinity.
Chemical spills (acids, oils and other chemicals) from storage facilities may occur in case of accidental leaks or breach of containers.	• Storage facilities will be bunded to contain accidental breaches or leaks. Containment will be sufficient to contain 110% the volume of stored chemicals.
Various components of the mining project will generate solid waste and sewage that has the potential of contaminating land and water resources.	• A water management system will be established in the site to collect and treat wastewater. A solid waste management plan

Impact	Mitigation
	will also be established which will include a materials recovery facility and an engineered solid waste disposal site. Hazardous wastes from hospital/clinic will be collected by appropriate contractors or otherwise disposed-off in an ecologically sound manner.
Freshwater Ecology	
Garbage and Sewage disposal Construction workforce may result in an increase of pollution from solid waste to rivers and creeks that will drain to the coast.	• Strict solid waste management policy shall be implemented within the project site. • The environmental unit of the company shall conduct an information, education and communication drive to all workers to make fully aware of the proper waste segregation. • Septic tanks shall be constructed/installed in all comfort rooms that will be put up during the operation. Portalets shall be made available near the project site for workers to use instead the bodies of water, which they are currently doing.
Siltation Water quality impacts that may arise during heavy rains and silt that will be eroded	• Drainages shall be properly be designed where potential water ways will be directed to a centralized settling pond. • The settling pond shall be carefully design that would accommodate the volume of water with silt and allow silt to settle.
Marine Ecology	
Marine Water Pollution Construction workforce may result in an increase of pollution from solid waste to rivers and creeks that will drain to the coast.	• Strict solid waste management policy shall be implemented within the project site. • The environmental unit of the company shall conduct an information, education and communication drive to all workers to make fully aware of the proper waste segregation.
Threat to existence and/or loss of important local species Water quality impacts that may arise during heavy rains and silt that will be eroded will be released to the coastal that may smother the corals.	• Drainages shall be properly be designed where potential water ways will be directed to a centralized settling pond. • The settling pond shall be carefully design that would accommodate the volume of water with silt and allow silt to settle.

2.3 AIR

2.3.1. Meteorology/ Climatology

Regional Meteorology

The climate over Southern Davao generally falls under Type IV based on the Corona's Classification of Philippine Climate which means rainfall is more or less evenly distributed throughout the year. **Figure 2.3-1** shows the Climate Map of the Philippines. **Table 2.3-1** and **Table 2.4-2**, on the other hand, show the climatological normal and extremes, respectively, for the period 1981-2010.

The eastern portions of the region are directly exposed to the open sea. The presence of this open sea consequently promotes additional amount of sea moisture over Davao. The southwest wind (during the southwest monsoon season) from the extreme southern province of Davao Island moves parallel to the eastern and western coasts of the province. The wind arrives at Davao Province as southerly winds. When the southwest monsoon season intensifies, the southerly wind is more prevalent. During the transition of the NE monsoon, the N wind is the most prevalent wind over Davao.

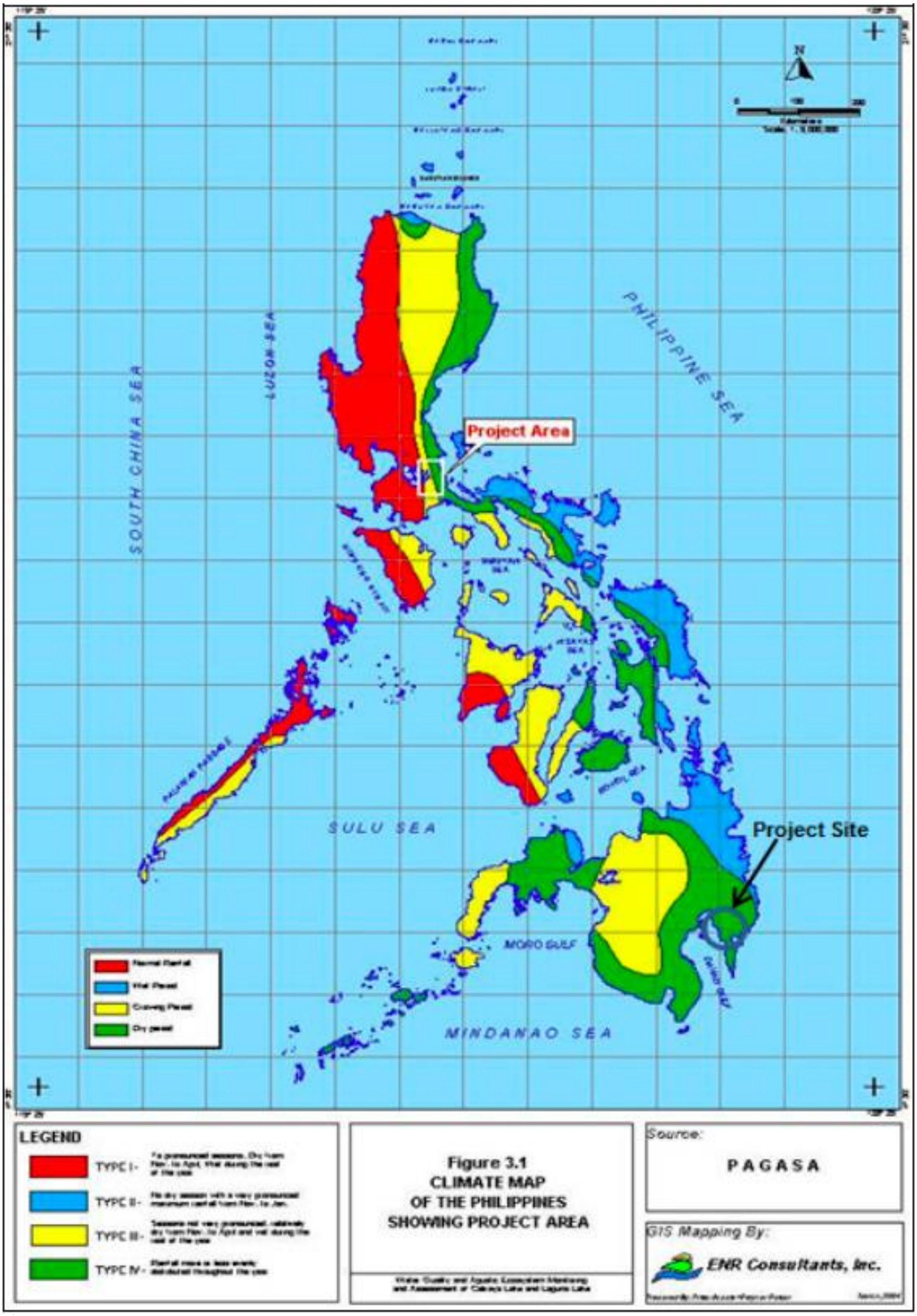


Figure 2.3-1: Climate Map of the Philippines ***(Source: PAGASA, 2016)***

Table 2.3-1: Climatological Normals at Davao PAGASA Synoptic Station (1981 – 2010)

NORMAL VALUES

Station Name : DAVAO CITY, DAVAO DEL SUR   Latitude : 07°18'00" N   Elevation: 18.0 m
Period : 1981 - 2010   Longtitude: 125°'50"00 E

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	
	Rainfall		Temperature									Wind			No. Days w/	
Month	Amount	No. of	Max	Min	Mean	Dry Bulb	Wet Bulb	Dew Pt.	Vapor Pressure	Rel. Hum.	MSLP	DIR	SPD	Cloud Amount	TSTM	LTNG
	(mm)	RD	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(mbs)	%	(MBS)	(16 pt)	(mps)	(okta)		
JAN	140.3	14	30.8	23.3	27.1	26.5	24.1	23.2	28.4	82	1009.9	N	2	6	3	4
FEB	109.4	12	31.2	23.3	27.3	26.7	24.1	23.1	28.2	81	1010.2	N	2	6	2	3
MAR	108.4	11	32.2	23.6	27.9	27.4	24.4	23.3	28.5	78	1010.1	N	2	5	5	5
APR	124.7	11	33.0	24.2	28.6	28.2	25	23.9	29.5	77	1009.4	N	2	5	8	10
MAY	158.7	16	32.6	24.6	28.6	28.2	25.5	24.6	30.8	80	1008.9	S	2	6	16	19
JUN	186.7	18	31.8	24.2	28	27.7	25.3	24.5	30.6	82	1008.9	S	1	6	14	16
JUL	165	16	31.5	23.9	27.7	27.4	25.1	24.3	30.3	83	1008.9	S	1	6	13	16
AUG	170	15	31.7	24	27.9	27.6	25.1	24.2	30.1	82	1008.9	S	2	6	14	16
SEP	170.4	15	31.9	23.9	27.9	27.6	25.1	24.2	30.1	82	1009.1	S	1	6	15	17
OCT	174.8	16	32.3	23.9	28.1	27.7	25.1	24.2	30.1	81	1008.8	S	1	6	17	19
NOV	138.1	16	32.1	23.9	28	27.5	25	24.1	29.9	82	1008.5	N	2	6	12	15
DEC	112.6	14	31.4	23.7	27.5	27.1	24.6	23.7	29.2	81	1009.2	N	2	6	6	8
ANNUAL	1759.1	174	31.9	23.9	27.9	27.5	24.9	23.9	29.6	81	1009.2	N	2	6	125	148

Table 2.3-2: Climatological Extremes at Davao PAGASA Synoptic Station (1981 – 2010)

Republic of the Philippines
Department of Science and Technology
Philippine Atmospheric, Geophysical and Astronomical Services Administration
Climatology and Agrometeorology Division
CLIMATE AND AGROMET DATA SECTION
PAGASA Science Garden Complex, Agham Road, Diliman Quezon City, Philippines
Telefax: (632)-434-2698

CLIMATOLOGICAL EXTREMES

STATION: **DAVAO CITY, DAVAO DEL SUR**   Lat: **07°07'40.41"N**   Long: **125°39'17.43"E**
YEAR: **AS OF 2012**

MONTH	TEMPERATURE (°C)				GREATEST DAILY RAINFALL (MM)		HIGHEST WIND (MPS)			SEA LEVEL PRESSURES (MBS)			
	HIGH	DATE	LOW	DATE	AMOUNT	DATE	SPD	DIR	DATE	HIGH	DATE	LOW	DATE
JAN	35.0	01-15-1973	17.0	01-10-1912	122.4	01-28-2000	22	N	01-25-1962	1018.6	01-17-1959	1000.1	01-22-1969
FEB	36.7	02-25-1915	16.1	02-03-1962	124.3	02-20-1970	20	NNE	02-08-2004	1018.4	02-27-1969	1001.9	02-13-2001
MAR	36.7	03-25-1915	17.4	03-16-1912	132.2	03-27-1988	15	N	03-03-1976	1018.5	03-30-1958	1000.1	03-19-2004
APR	37.0	04-30-1977	19.1	04-13-1912	193.0	04-02-1993	18	N	04-23-1974	1016.6	04-07-1965	1001.8	04-12-1985
MAY	37.3	05-05-1905	20.2	05-01-1914	174.3	05-08-1966	31	NNW	05-15-1976	1016.5	05-09-1957	1002.3	05-30-1970
JUNE	35.2	06-02-1905	20.3	06-10-1961	176.4	06-06-2008	21	NW	06-18-1962	1016.6	06-06-1966	1001.2	06-30-1970
JULY	35.6	07-16-1973	20.0	07-03-1917	179.6	07-02-1902	19	NE	07-06-2001	1016.0	07-02-1965	999.6	07-03-2001
AUG	36.0	08-02-1905	18.5	08-07-1918	242.6	08-02-1902	15	N	08-14-1998	1015.7	08-03-1965	1001.2	08-17-1990
SEP	35.1	09-17-1977	20.0	09-03-1916	123.7	09-21-1911	20	S	09-21-1983	1018.2	09-22-1950	1001.3	09-24-1970
OCT	35.6	10-06-2009	19.2	10-19-1918	149.6	10-08-1985	16	NW	10-22-1995	1016.1	10-07-1959	998.6	10-18-1970
NOV	36.2	11-17-1908	19.1	11-14-1911	114.4	11-24-2002	15	N	11-08-1974	1016.8	11-17-1965	999.8	11-06-1996
DEC	35.0	12-08-1987	16.2	12-24-1918	153.6	12-02-1910	15	N	12-15-1962	1016.7	12-12-2002	1001.2	12-05-2001
ANNUAL	37.3	05-05-1905	16.1	02-03-1962	242.6	08-02-1902	31	NNW	05-15-1976	1018.6	01-17-1959	998.6	10-18-1970
Period of Record	1903 - 2012				1902 - 2012		1950 - 2012			1949 - 2012			

PREPARED BY: CADS/CAD/PAGASA

Site Meteorology

The data used for site characterization were obtained from the Davao City Synoptic Station (PAGASA Synoptic Station) with available data record of sixty (60) years (1951-2010). This station is approximately 39.5 km west of the proposed project site (see **Figure 2.3-2**). **Figures 2.3-3** to **Figure 2.3-4** show the annual and monthly wind roses at Davao, respectively.

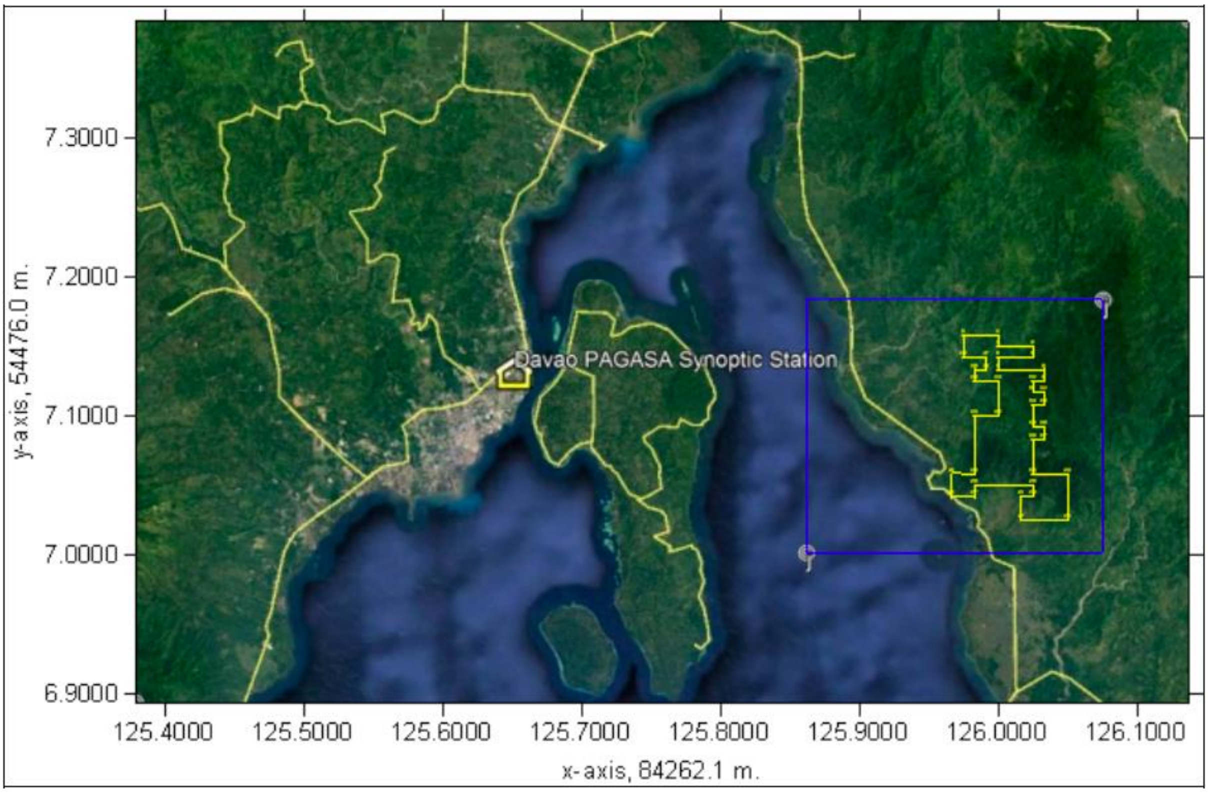


Figure 2.3-2. Relative Distance of Davao (station 753) PAGASA-Synoptic Station from the Project Site

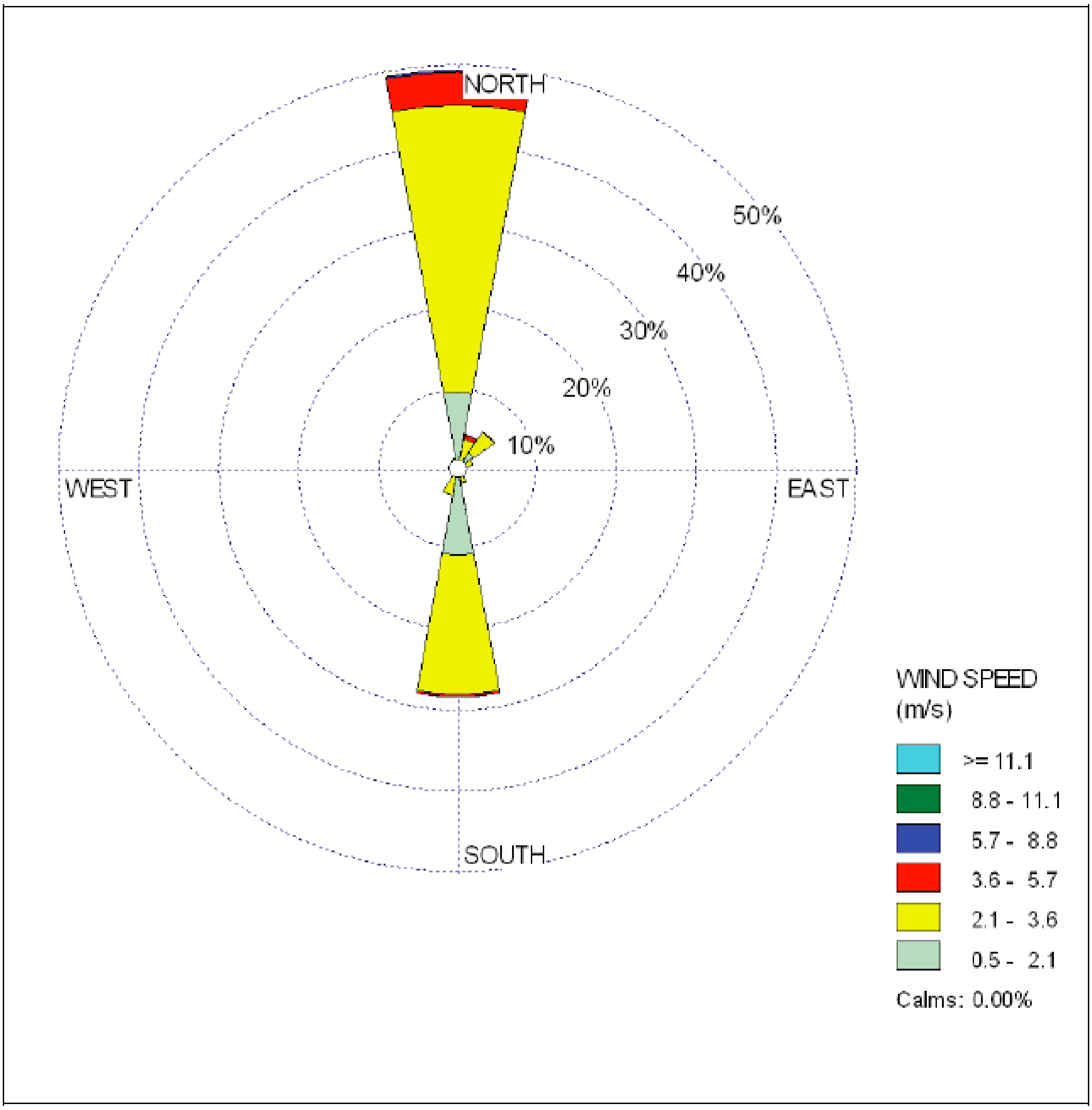


Figure 2.3-3. Annual Wind Rose Diagram, Davao 1951-2010 (Station 753)

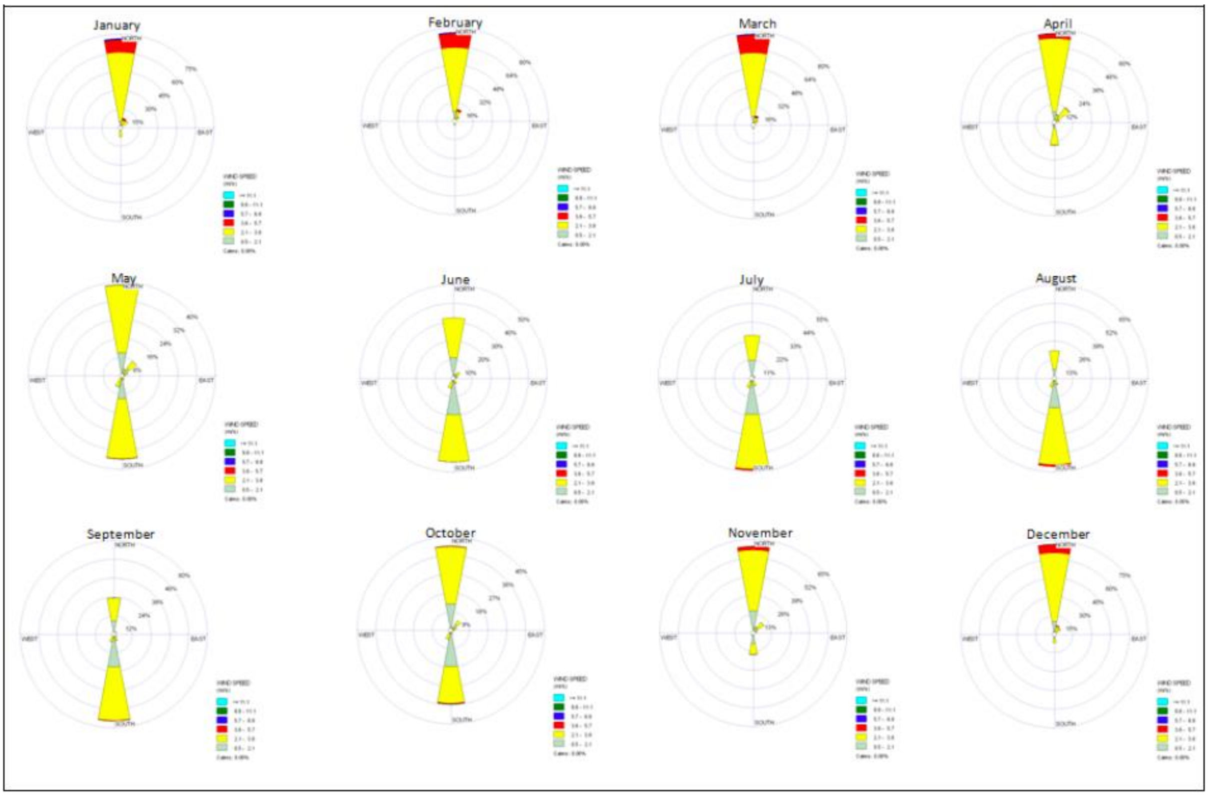


Figure 2.3-4. Monthly Wind Rose Diagram, Davao 1951-2010 (Station 753)

Table 2.3-3: Months Corresponding to the Southwest (May to October) and Northeast (November to April) Monsoon Season

NORMAL VALUES

Station Name : DAVAO CITY, DAVAO DEL SUR — Latitude : 07°18'00" N — Elevation: 18.0 m

Period : 1981 - 2010 — Longtitude: 125°'50'00 E

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)		
	Rainfall		Temperature									Wind			No. Days w/		TYPE OF SEASON
Month	Amount	No. of RD	Max	Min	Mean	Dry Bulb	Wet Bulb	Dew Pt.	Vapor Pressure	Rel. Hum.	MSLP	DIR	SPD	Cloud Amount	ISTM	LTNG	
	(mm)		(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(mbs)	%	(MBS)	(16 pt)	(mps)	(okta)			
MAY	158.7	16	32.6	24.6	28.6	28.2	25.5	24.6	30.8	80	1008.9	S	2	6	16	19	SOUTHWEST MONSOON
JUN	186.7	18	31.8	24.2	28.0	27.7	25.3	24.5	30.6	82	1008.9	S	1	6	14	16	
JUL	165.0	16	31.5	23.9	27.7	27.4	25.1	24.3	30.3	83	1008.9	S	1	6	13	16	
AUG	170.0	15	31.7	24.0	27.9	27.6	25.1	24.2	30.1	82	1008.9	S	2	6	14	16	
SEP	170.4	15	31.9	23.9	27.9	27.6	25.1	24.2	30.1	82	1009.1	S	1	6	15	17	
OCT	174.8	16	32.3	23.9	28.1	27.7	25.1	24.2	30.1	81	1008.8	S	1	6	17	19	
NOV	138.1	16	32.1	23.9	28.0	27.5	25.0	24.1	29.9	82	1008.5	N	2	6	12	15	NORTHEAST MONSOON
DEC	112.6	14	31.4	23.7	27.5	27.1	24.6	23.7	29.2	81	1009.2	N	2	6	6	8	
JAN	140.3	14	30.8	23.3	27.1	26.5	24.1	23.2	28.4	82	1009.9	N	2	6	3	4	
FEB	109.4	12	31.2	23.3	27.3	26.7	24.1	23.1	28.2	81	1010.2	N	2	6	2	3	
MAR	108.4	11	32.2	23.6	27.9	27.4	24.4	23.3	28.5	78	1010.1	N	2	5	5	5	
APR	124.7	11	33.0	24.2	28.6	28.2	25.0	23.9	29.5	77	1009.4	N	2	5	8	10	
ANNUAL	1759.1	174	31.9	23.9	27.9	27.5	24.9	23.9	29.6	81	1009.2	N	2	6	125	148	
max	186.7	18	32.6	24.6	28.6	28.2	25.5	24.6	30.8	83	1009.2		2	6	17	19	
min	112.6	14	31.4	23.7	27.5	27.1	24.6	23.7	29.2	80	1008.5		1	6	6	8	
difference	74.1	4	1.2	0.9	1.1	1.1	0.9	0.9	1.6	3	0.7		1.0	0.0	11.0	11.0	

Rainfall

Based on a 30-year (1981-2010) record (**Table 2.3-1**) from PAGASA, the total annual rainfall in Davao is about 1,759.1 mm. The amount of rainfall is relatively lower during the month of March with an average of eleven (11) rainy days. Based on the same reference, the annual average number of rainy days per year is 174 days or about 47% of the year (please see **Table 2.3-1** for monthly rainfall data from 1951 to 2010).

Temperature

Seasonal changes of atmospheric humidity and cloudiness greatly affect temperature changes in the region. The average monthly maximum temperature of Davao Province ranges from a high of 33.0°C in the month of April to a low of 30.8°C during the month of January. The mean annual temperature is 27.9 °C. Being located on a coastal region, the annual variation in the mean monthly is insignificant. The highest temperature ever recorded at the Davao station is 37.3°C on May 05, 1905 while the coldest is 16.1°C on February 3, 1962. **Table 2.3-4** shows the monthly values for maximum temperatures (1951-2010).

Relative Humidity, %

Atmospheric moisture content in the tropics is relatively higher than that of the upper latitude towards the continental areas. The Philippines is situated in the tropics; thus, the relative percentage of atmospheric humidity is higher. Data on relative humidity recorded in Davao show the annual average of 81%. The relative humidity (RH) for the rest of the year varies slightly from the mean. See **Table 2.3-1** for the monthly RH (1981-2010) value.

Cloud, octa

The mean annual cloud amount at Davao is 6 octas. Cloudy months are from January to December (12 months period). See **Table 2.3-5** for the monthly (1981-2010) cloudiness.

Wind Speed and Direction

Tables 2.3-6 and **2.3-7** show the monthly wind speed and direction summary (1951-2010) at the Davao Synoptic Station, respectively. **Figures 2.3-3** and **2.3-4** show the monthly and annual wind roses at the Davao Synoptic Station, respectively. **Table 2.3-8** shows the wind speed-direction counts and percentages. Generally, there are two major air streams that influence the wind pattern of the region. These are the north wind and south wind. The wind regimes are influenced by the mountain ranges dominating the central, eastern and western portion of Davao province. At Davao coastal areas, particularly at the site, the N wind prevails in the months of November until April. The S wind prevails in the months of May until October. The mean annual wind speed in the region is 2 mps.

Table 2.3-4: Monthly Maximum Temperature (1951-2010), °C

	Maximum Temperature, °C												
YEAR	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**MEAN**
1951	29.8	31.0	31.6	31.8	31.6	31.5	31.0	31.2	31.2	31.9	31.7	31.0	**31.3**
1952	31.3	30.9	32.4	33.1	32.1	31.2	30.6	31.5	31.0	31.4	31.6	31.1	**31.5**
1953	30.5	30.0	32.8	33.7	32.0	31.2	31.2	31.3	31.2	31.9	31.6	31.1	**31.5**
1954	32.5	31.9	32.3	33.3	32.6	31.1	30.6	31.1	31.1	31.6	31.6	30.6	**31.7**
1955	29.6	31.2	32.6	32.8	31.6	30.4	30.7	31.2	31.4	31.4	31.2	30.9	**31.3**
1956	29.8	31.3	32.4	31.4	31.1	31.6	31.1	30.7	30.8	31.6	31.7	30.1	**31.1**
1957	31.3	31.3	31.9	32.3	32.3	31.6	31.0	31.1	31.8	32.1	32.5	31.5	**31.7**
1958	31.8	32.6	33.4	34.3	32.9	31.5	31.5	31.4	31.5	31.9	31.7	31.8	**32.2**
1959	30.5	32.4	32.9	32.6	32.0	31.4	30.9	30.7	31.2	31.7	31.7	32.1	**31.7**
1960	31.5	31.4	32.4	32.5	32.8	31.3	31.5	31.4	31.6	32.0	31.2	30.8	**31.7**
1961	30.2	31.0	32.6	32.6	31.9	31.3	31.1	31.5	31.8	31.9	32.7	31.4	**31.7**
1962	29.1	29.3	31.2	32.5	32.1	31.7	30.9	31.6	31.2	32.6	31.6	31.1	**31.2**
1963	29.5	29.1	31.2	33.0	33.1	31.8	31.3	31.2	31.9	32.2	32.3	32.2	**31.6**
1964	31.8	30.1	32.1	32.0	32.2	31.3	31.7	31.7	31.6	32.0	31.7	31.6	**31.7**
1965	30.3	30.6	31.4	32.3	32.4	31.4	30.7	31.3	31.6	32.2	32.3	31.1	**31.5**
1966	30.6	31.8	33.4	33.3	31.8	31.9	31.1	31.4	32.3	31.9	32.3	31.7	**32.0**
1967	31.0	31.4	32.1	33.7	32.7	32.2	32.5	32.5	32.5	32.1	32.2	32.2	**32.3**
1968	30.4	31.1	32.3	33.9	32.8	32.3	32.1	31.9	32.5	31.9	32.7	29.6	**32.0**
1969	30.4	31.3	32.4	33.7	33.3	31.9	31.5	31.7	31.8	32.9	31.9	32.1	**32.1**
1970	31.3	31.5	31.9	33.0	33.0	32.2	31.9	31.8	32.9	32.1	32.0	30.8	**32.0**
1971	30.9	30.9	32.6	33.6	32.9	31.5	31.6	32.2	32.7	31.7	32.5	31.7	**32.1**
1972	31.8	31.7	31.5	33.5	32.9	32.1	32.9	32.4	32.0	33.2	32.5	32.4	**32.4**
1973	33.1	33.3	33.3	32.4	33.0	32.7	32.5	32.5	32.2	32.8	31.2	31.8	**32.6**
1974	29.8	29.7	31.3	31.8	32.2	31.4	31.4	31.7	32.1	31.0	31.6	30.8	**31.2**
1975	30.9	31.2	31.1	32.3	32.0	31.5	31.7	32.1	32.2	32.1	32.6	30.5	**31.7**
1976	31.2	31.2	31.9	33.2	33.0	32.0	31.8	32.0	31.6	32.6	32.8	32.4	**32.1**
1977	31.2	31.5	31.8	33.7	33.2	31.5	31.1	31.0	32.5	32.3	32.1	32.2	**32.0**
1978	32.0	32.3	33.5	33.6	32.5	31.7	31.4	31.4	32.0	32.1	32.6	31.8	**32.2**
1979	32.0	33.0	32.1	33.8	32.6	32.1	31.5	31.7	32.2	32.7	32.9	31.2	**32.3**
1980	30.7	30.7	33.0	32.9	33.0	31.6	31.5	31.5	32.1	32.2	32.7	32.2	**32.0**
1981	30.3	31.5	32.4	33.4	32.7	32.0	31.7	32.4	32.2	32.2	31.8	30.9	**32.0**
1982	29.9	30.4	32.9	33.0	32.7	31.6	31.6	30.9	31.3	32.4	32.7	32.2	**31.8**
1983	32.0	32.7	33.7	34.5	34.4	32.2	31.1	31.0	31.8	32.0	32.5	30.3	**32.4**
1984	29.8	29.8	31.5	32.0	32.3	31.5	31.2	31.8	31.2	31.7	32.1	31.3	**31.4**
1985	30.9	31.9	32.5	32.7	32.4	32.2	31.4	32.0	31.5	31.9	31.9	31.6	**31.9**
1986	29.8	31.0	31.1	33.4	33.0	31.8	31.4	32.3	31.9	32.6	31.9	32.4	**31.9**
1987	30.6	31.0	32.7	34.0	32.9	31.8	31.0	31.7	32.6	32.2	32.8	32.7	**32.2**
1988	33.2	31.2	32.6	33.0	32.5	31.6	31.8	31.7	31.9	32.2	31.9	30.5	**32.0**
1989	32.0	31.4	31.5	31.7	32.3	31.8	31.7	31.7	32.4	32.7	32.0	31.7	**31.9**
1990	31.5	32.4	32.7	33.6	32.4	32.3	31.7	32.4	32.0	32.2	32.0	31.9	**32.3**
1991	30.9	30.8	32.8	33.9	32.4	31.7	31.7	32.0	32.7	33.1	32.5	32.0	**32.2**
1992	32.2	32.9	33.8	34.4	33.7	32.3	31.8	32.3	33.0	32.5	32.4	30.3	**32.6**
1993	30.8	30.9	31.7	32.5	33.1	32.2	31.5	31.4	31.5	32.7	32.2	32.1	**31.9**
1994	31.6	31.5	32.1	33.0	32.5	31.6	31.8	31.9	32.2	32.6	32.8	31.0	**32.1**
1995	31.2	31.0	31.9	32.2	32.7	31.8	31.4	31.6	31.7	32.2	32.0	31.6	**31.8**
1996	29.4	29.9	32.1	32.9	32.6	31.4	31.3	31.3	31.7	32.1	31.4	30.6	**31.4**
1997	29.6	29.3	30.8	32.2	32.0	31.6	31.3	31.5	31.6	32.3	32.3	31.4	**31.3**
1998	31.0	32.1	33.4	33.9	33.2	32.0	31.7	31.9	31.9	31.8	31.3	31.0	**32.1**
1999	29.8	31.0	30.5	31.4	31.6	31.4	31.1	31.1	31.4	32.0	32.0	31.1	**31.2**
2000	29.7	30.4	31.1	31.7	32.4	31.3	30.9	31.3	32.0	31.4	30.9	30.9	**31.2**
2001	30.5	30.8	31.2	32.5	32.6	32.0	31.0	31.2	31.4	32.6	31.3	30.4	**31.5**
2002	30.6	30.8	32.0	33.3	32.2	31.5	31.5	31.1	31.3	32.4	32.2	31.9	**31.7**
2003	31.0	30.5	31.5	33.6	31.5	31.4	31.3	31.7	31.7	32.4	32.3	30.1	**31.6**
2004	31.9	31.0	32.2	33.9	32.0	32.4	31.2	32.2	31.6	32.8	33.2	32.1	**32.2**
2005	30.5	32.2	33.1	33.3	31.7	31.6	31.3	31.3	31.9	32.4	31.8	30.8	**31.8**
2006	30.3	30.7	31.8	32.7	32.8	31.5	32.0	31.1	31.3	32.0	32.0	32.3	**31.7**
2007	29.8	31.1	31.6	33.2	32.2	31.8	30.9	31.1	31.7	32.1	31.9	31.3	**31.6**
2008	31.0	31.0	31.4	32.2	31.9	31.4	30.9	31.4	31.9	31.7	31.3	31.1	**31.4**
2009	31.3	30.6	32.2	32.5	32.3	31.6	31.4	32.0	32.5	33.1	31.2	31.5	**31.9**
2010	30.5	32.5	33.4	32.5	32.8	32.6	31.7	31.9	32.3	32.4	32.1	32.0	**32.2**
Ave	**30.8**	**31.2**	**32.2**	**33.0**	**32.5**	**31.7**	**31.4**	**31.6**	**31.8**	**32.2**	**32.0**	**31.4**	

Table 2.3-5: Monthly Cloudiness (1951-2010), octa

	Cloudiness, octa												
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1951	6	6	5	5	6	7	6	6	6	6	6	6	5.9
1952	5	6	6	5	6	7	7	7	6	6	6	6	6.1
1953	6	6	5	5	6	7	6	6	6	6	6	6	5.9
1954	5	5	5	6	6	7	6	6	6	6	7	7	6.0
1955	6	6	5	6	6	7	6	6	6	6	6	6	6.0
1956	7	6	5	6	6	6	6	7	7	6	6	6	6.2
1957	5	6	6	6	5	6	7	6	6	6	5	6	5.8
1958	6	5	5	5	6	6	6	6	6	6	6	5	5.7
1959	6	4	5	6	6	6	7	6	6	6	6	2	5.5
1960	6	6	6	6	6	7	6	6	7	6	6	6	6.2
1961	6	7	4	5	6	7	7	7	6	7	5	7	6.2
1962	4	8	6	6	7	6	7	7	7	6	6	7	6.4
1963	7	7	7	4	6	6	6	7	6	6	6	4	6.0
1964	5	6	5	6	6	6	6	6	6	6	6	6	5.8
1965	6	6	6	5	6	6	7	6	7	6	6	6	6.1
1966	7	6	6	6	7	7	7	7	7	7	7	7	6.8
1967	8	7	7	7	7	7	7	7	7	7	7	7	7.1
1968	7	7	7	6	6	6	7	7	6	7	6	7	6.6
1969	6	6	6	5	6	7	6	6	7	6	7	5	6.1
1970	6	6	6	6	6	7	7	7	7	7	7	7	6.6
1971	6	7	7	6	7	7	7	6	6	7	7	7	6.7
1972	7	7	7	6	7	7	6	7	7	6	6	6	6.6
1973	5	5	6	6	7	7	7	6	6	6	6	6	6.1
1974	7	7	6	7	6	7	6	6	6	7	7	7	6.6
1975	6	6	7	6	6	7	7	7	6	6	6	7	6.4
1976	6	6	6	5	6	6	6	6	6	6	6	6	5.9
1977	6	6	5	5	5	6	7	6	6	7	6	7	6.0
1978	6	5	5	5	6	6	5	7	7	7	7	6	6.0
1979	6	5	6	5	6	7	7	7	6	7	6	6	6.2
1980	7	6	5	6	5	7	6	7	6	6	6	6	6.1
1981	7	6	5	5	6	7	7	6	7	6	6	6	6.2
1982	6	6	5	5	6	6	6	6	6	5	5	4	5.5
1983	4	3	3	3	4	6	7	6	6	6	6	7	5.1
1984	7	6	6	6	6	6	6	7	6	7	5	6	6.2
1985	6	6	5	6	6	6	6	6	6	6	6	6	5.9
1986	7	6	6	5	5	6	6	6	6	5	6	4	5.7
1987	6	6	5	4	5	6	6	6	6	6	6	5	5.6
1988	5	6	6	5	6	6	6	6	6	7	6	6	5.9
1989	6	6	6	6	6	6	6	6	5	6	5	5	5.8
1990	6	5	5	5	6	7	6	6	6	6	6	5	5.8
1991	6	6	5	5	6	6	6	6	7	6	6	5	5.8
1992	5	5	5	5	5	7	6	6	5	6	5	6	5.5
1993	5	6	5	5	5	6	6	7	6	6	5	6	5.7
1994	5	6	6	5	6	7	6	6	7	6	5	6	5.9
1995	6	6	6	5	5	6	6	6	7	6	6	6	5.9
1996	7	7	5	6	6	6	7	6	6	6	6	6	6.2
1997	6	7	5	5	6	6	6	7	6	6	5	5	5.8
1998	5	5	4	4	6	6	6	5	6	7	6	6	5.5
1999	7	6	6	7	6	7	6	7	6	6	6	6	6.3
2000	7	7	6	6	6	7	7	7	6	7	7	6	6.6
2001	6	6	6	6	6	7	7	7	6	6	7	6	6.3
2002	6	6	6	5	6	7	6	7	6	6	6	5	6.0
2003	6	6	6	5	6	6	7	6	6	6	6	7	6.1
2004	6	6	6	5	6	6	6	6	6	6	5	6	5.8
2005	6	5	5	5	6	6	6	7	6	6	6	6	5.8
2006	6	6	6	6	6	6	6	6	6	6	5	5	5.8
2007	7	6	5	5	6	6	6	6	6	6	6	6	5.9
2008	6	6	6	6	6	6	6	6	7	6	6	6	6.1
2009	6	7	6	6	6	6	7	6	6	6	6	5	6.1
2010	6	4	5	5	6	6	6	6	5	6	6	6	5.6
Ave	6.0	6.0	5.6	5.4	5.9	6.4	6.4	6.4	6.2	6.2	6.0	5.9	

Table 2.3-6: Monthly Wind Speed (1951-2010), MPs

Wind Spped, mps													
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1951	2	3	3	2	2	2	2	2	2	2	2	2	2.2
1952	3	3	3	2	2	2	2	2	2	2	2	2	2.3
1953	3	3	2	2	2	2	2	2	2	2	2	2	2.2
1954	3	2	3	2	2	2	2	2	2	2	2	3	2.3
1955	2	3	3	2	2	2	2	2	2	2	2	3	2.3
1956	3	3	3	2	2	2	2	2	2	2	2	2	2.3
1957	2	3	3	2	2	2	2	2	2	2	2	3	2.3
1958	3	3	3	3	2	2	2	2	2	2	2	2	2.3
1959	3	3	3	2	2	2	2	2	2	2	2	2	2.3
1960	2	3	2	2	2	2	2	2	2	2	2	2	2.1
1961	3	3	3	2	2	2	2	2	2	2	2	2	2.3
1962	1	3	2	2	2	2	2	2	2	2	2	3	2.1
1963	3	4	3	2	2	2	2	2	2	2	2	2	2.3
1964	3	3	3	2	2	2	2	2	2	2	2	2	2.3
1965	3	3	2	2	2	1	2	2	2	2	2	2	2.1
1966	3	3	2	2	1	2	1	2	2	1	2	2	1.9
1967	2	3	3	2	2	2	1	2	2	2	2	3	2.2
1968	2	3	3	2	2	2	1	1	1	2	1	2	1.8
1969	2	3	2	2	2	2	1	2	1	2	2	2	1.9
1970	2	3	2	2	1	1	1	1	1	2	2	2	1.7
1971	2	2	2	2	2	1	2	2	2	2	2	2	1.9
1972	3	3	4	3	2	2	2	2	2	2	2	3	2.5
1973	2	2	2	2	1	1	1	1	1	1	2	3	1.6
1974	4	4	5	3	3	2	2	3	3	2	3	3	3.1
1975	4	4	4	3	2	1	2	2	2	2	3	3	2.7
1976	4	4	4	3	2	2	2	2	2	2	2	2	2.6
1977	2	2	2	2	2	2	2	2	2	1	1	2	1.8
1978	3	3	4	4	1	2	3	3	3	3	3	4	3.0
1979	3	2	2	2	1	1	2	2	2	1	2	3	1.9
1980	2	3	3	2	2	2	2	1	1	1	2	2	1.9
1981	3	2	2	2	2	2	1	2	1	1	1	2	1.8
1982	2	2	2	1	1	1	2	2	2	1	1	1	1.5
1983	2	2	2	2	2	1	1	1	1	1	1	1	1.4
1984	1	2	1	1	2	1	1	2	1	1	1	2	1.3
1985	1	1	2	1	1	1	1	1	1	1	1	2	1.2
1986	2	2	2	2	2	1	1	1	1	1	1	2	1.5
1987	2	2	2	1	2	1	1	1	1	1	1	1	1.3
1988	1	1	2	1	1	1	1	1	1	1	1	2	1.2
1989	2	2	2	2	1	1	1	1	1	1	1	2	1.4
1990	2	2	2	2	1	1	1	2	1	1	1	2	1.5
1991	2	2	2	2	1	1	1	2	1	1	1	2	1.5
1992	2	2	2	2	2	1	1	1	1	1	2	3	1.7
1993	3	2	2	2	2	1	2	2	2	1	2	2	1.9
1994	2	3	3	2	2	2	2	2	2	2	3	3	2.3
1995	4	3	3	3	2	2	2	2	2	2	2	2	2.4
1996	3	3	2	2	2	2	2	2	2	2	2	3	2.3
1997	3	3	3	2	2	2	2	2	2	2	2	3	2.3
1998	3	2	2	3	2	2	2	2	2	1	1	2	2.0
1999	2	3	2	2	1	1	2	2	2	2	2	2	1.9
2000	3	2	2	2	2	2	2	2	2	2	2	2	2.1
2001	2	3	2	2	2	2	2	2	2	2	2	3	2.2
2002	3	3	3	2	2	2	2	2	2	2	2	2	2.3
2003	3	3	3	2	2	2	1	2	2	1	2	3	2.2
2004	2	3	2	2	2	2	2	2	2	1	2	2	2.0
2005	3	3	3	2	2	2	2	2	2	2	2	2	2.3
2006	2	2	2	2	2	2	2	2	2	1	2	2	1.9
2007	3	3	3	2	2	1	2	2	2	2	2	2	2.2
2008	2	2	2	2	1	2	1	2	2	2	2	2	1.8
2009	2	2	2	2	2	2	1	2	1	2	2	2	1.8
2010	2	3	3	2	2	2	1	2	2	2	2	2	2.1
Ave	2.5	2.7	2.5	2.1	1.8	1.7	1.7	1.9	1.8	1.7	1.8	2.3	

Table 2.3-7: Monthly Wind Directions (1951-2010)

	Wind Direction												
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
1951	N	N	N	N	N	N	N	N	N	N	N	N	N
1952	N	N	N	N	N	N	N	N	N	N	N	N	N
1953	N	N	N	N	N	N	N	N	N	N	N	N	N
1954	N	N	N	N	N	N	N	N	N	N	N	N	N
1955	N	N	N	N	N	N	S	S	S	N	N	N	N
1956	N	N	N	N	N	N	N	N	N	N	N	N	N
1957	N	N	N	N	N	N	N	N	N	N	N	N	N
1958	N	N	N	N	N	N	S	N	N	N	N	N	N
1959	N	N	N	N	N	N	N	S	N	N	N	N	N
1960	N	N	N	N	N	N	N	S	N	N	N	N	N
1961	N	N	N	N	N	N	N	N	N	N	N	N	N
1962	N	N	N	N	N	N	N	N	N	N	N	N	N
1963	N	N	N	N	N	N	N	N	N	N	N	N	N
1964	N	N	N	N	N	N	N	N	N	N	N	N	N
1965	N	N	N	N	N	N	N	S	N	N	N	N	N
1966	N	N	N	N	S	S	N	S	S	N	N	N	N
1967	N	N	N	N	N	S	S	S	S	N	N	N	N
1968	N	N	N	N	N	N	N	S	N	N	N	N	N
1969	N	N	N	N	N	N	N	S	N	N	N	N	N
1970	N	N	N	N	N	N	S	S	N	N	N	N	N
1971	N	N	N	N	N	N	N	N	S	N	N	N	N
1972	N	N	N	N	N	S	S	S	S	N	N	N	N
1973	N	N	N	N	N	S	S	S	S	N	N	N	N
1974	N	N	N	N	S	S	S	S	S	S	N	N	N
1975	N	N	N	N	S	S	S	S	S	S	NNE	N	S
1976	N	N	N	N	S	NNE	SSE	S	S	S	N	N	N
1977	N	N	N	N	S	S	S	S	S	S	S	N	S
1978	N	N	N	N	S	S	S	S	SSE	N	N	N	N
1979	N	N	N	N	SE	SSE	SSE	SSE	SE	N	N	N	N
1980	N	N	N	N	SSE	N	SSE	S	S	S	N	N	N
1981	N	N	N	N	S	S	S	S	S	S	N	N	N
1982	N	N	N	N	S	S	S	S	S	S	N	N	N
1983	N	N	N	N	S	S	S	S	S	S	N	N	N
1984	N	N	N	N	S	S	S	S	S	S	N	N	N
1985	N	N	N	S	S	S	S	S	S	S	N	N	S
1986	N	N	N	N	S	S	S	S	S	S	N	N	N
1987	N	N	N	S	S	S	S	S	S	S	S	N	S
1988	N	N	N	S	S	S	S	S	S	S	N	N	S
1989	N	N	N	N	S	S	S	S	S	S	N	N	N
1990	N	N	N	NE	S	S	S	S	S	S	S	N	S
1991	N	N	N	N	S	S	S	S	S	S	N	N	N
1992	N	N	N	S	S	S	S	S	S	S	N	N	S
1993	NNW	NNW	N	N	N	S	SSE	S	SSE	S	N	N	N
1994	N	N	N	N	S	S	S	S	S	S	N	N	N
1995	N	N	N	NE	S	S	S	S	S	SSW	N	N	N
1996	NNE	N	NNE	S	S	S	S	S	S	N	S	NNE	S
1997	NNE	N	NNE	NNE	S	S	S	S	S	SSW	NE	N	S
1998	NNE	NNE	N	NNE	SSW	SSW	S	SSW	S	N	N	N	N
1999	NNE	N	NNE	NE	S	S	S	S	S	S	N	N	S
2000	N	NNE	NE	ENE	S	S	S	S	S	N	N	N	S
2001	NNE	N	N	NE	S	S	S	S	S	S	N	N	S
2002	N	N	NNE	NE	S	S	S	S	S	S	N	N	S
2003	N	N	N	N	SSW	S	S	S	S	S	N	N	N
2004	N	NNE	N	NE	SSW	S	SSW	S	S	S	SSW	N	S
2005	NNE	N	N	N	S	S	SSW	S	S	SSW	N	NNE	N
2006	N	N	N	N	SSW	S	S	S	S	SSW	ENE	N	N
2007	NNE	N	N	NNE	SSW	SSW	SSW	S	SSW	SSW	S	N	SSW
2008	N	NE	NE	NE	S	ENE	SSW	SSW	SSW	SSW	N	NNE	SSW
2009	NNE	N	ENE	ENE	SSW	SSW	SSW	SSW	SSW	SSW	NNE	NE	SSW
2010	N	N	N	N	NE	S	S	S	S	S	N	N	N
ANNUAL	N	N	N	N	S	S	S	S	S	N	N	N	

Table 2.3-8: Wind Speed-Direction Frequency Counts and Percentage at Davao PAGASA Synoptic Station

Wind Speed-Direction Frequency, Counts							
Wind Direction	Wind Speed Class, mps						Total
	0.5 - 2.1	2.1 - 3.6	3.6 - 5.7	5.7 - 8.8	8.8 - 11.1	>= 11.1	
N	1989	7384	848	54	2		10277
NNE	141	828	117	4			1090
NE	556	770	25				1351
ENE	235	344	1				580
ENE	118	100					218
ESE	13	2					15
SE	55	115	2				172
SSE	113	300	15				428
S	2326	3630	61	4			6021
SSW	301	725	8				1034
SW	45	89					134
WSW	2						2
W	22	11	1				34
WNW	3	5					8
NW	36	88	2				126
NNW	77	197	23	2			299
Total	6032	14588	1103	64	2		21789
Calms							0
Missing/Incomplete							0

Wind Speed-Direction Frequency, %							
Wind Direction	Wind Speed Class, mps						Total
	0.5 - 2.1	2.1 - 3.6	3.6 - 5.7	5.7 - 8.8	8.8 - 11.1	>= 11.1	
N	9.13	33.89	3.89	0.25	0.01		47.17
NNE	0.65	3.80	0.54	0.02			5.00
NE	2.55	3.53	0.11				6.20
ENE	1.08	1.58	0.00				2.66
ENE	0.54	0.46					1.00
ESE	0.06	0.01					0.07
SE	0.25	0.53	0.01				0.79
SSE	0.52	1.38	0.07				1.96
S	10.68	16.66	0.28	0.02			27.63
SSW	1.38	3.33	0.04				4.75
SW	0.21	0.41					0.62
WSW	0.01						0.01
W	0.10	0.05	0.00				0.16
WNW	0.01	0.02					0.04
NW	0.17	0.40	0.01				0.58
NNW	0.35	0.90	0.11	0.01			1.37
Total	27.68	66.95	5.06	0.29	0.01		100.00
Calms							0
Missing/Incomplete							0
Frequency of Calm Winds							0
Average Wind Speed, mps							2.05

2.3.1.1 Change in the local climate

Changes in Precipitation

The projected seasonal temperature increase, seasonal rainfall change and frequency of extreme events in 2020 and 2050 under the medium-range emission scenario in the province in Region 11 are presented in the succeeding tables.

Table 2.3-9 Seasonal temperature Increases (in ºC) in 2020 and 2050 under medium-range emission scenario in the provinces of Region 11

PROVINCES	OBSERVED BASELINE (1971-2000)				CHANGE in 2020 (2006-2035)				CHANGE in 2050 (2036-2065)			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
Region 11												
COMPOSTELA VALLEY	26.7	27.8	27.6	27.6	0.9	1.1	1.2	1.1	1.9	2.3	2.4	2.1
DAVAO DEL NORTE	26.7	27.8	27.4	27.4	0.9	1.1	1.2	1.1	1.9	2.3	2.5	2.1
DAVAO DEL SUR	26.9	27.8	26.9	27.1	0.9	1.1	1.1	1.0	1.9	2.2	2.3	2.0
DAVAO ORIENTAL	26.8	27.8	27.5	27.6	0.9	1.0	1.1	1.0	1.8	2.0	2.4	2.0

Table 2.3-10: Seasonal rainfall change (in %) in 2020 and 2050 under medium-range emission scenario in provinces in Region 11

PROVINCES	OBSERVED BASELINE (1971-2000) mm				CHANGE in 2020 (2006-2035)				CHANGE in 2050 (2036-2065)			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
Region 11												
COMPOSTELA VALLEY	748.1	559.0	546.7	586.6	10.2	-11.3	-2.7	0.3	6.6	-21.9	-6.5	0.0
DAVAO DEL NORTE	637.0	496.5	535.6	556.2	9.2	-12.5	-3.6	-1.5	1.1	-22.2	-7.9	-2.2
DAVAO DEL SUR	288.1	347.1	494.1	442.3	18.1	-9.8	-7.8	-2.4	15.2	-12.0	-12.6	-4.5
DAVAO ORIENTAL	827.3	611.8	540.4	599.2	12.3	-5.7	-4.7	1.2	15.9	-16.1	-9.9	4.9

Table 2.3-11: Frequency of extreme events in 2020 and 2050 under medium-range emission scenario in provinces in Region 11

Provinces	Stations	No. of Days w/ Tmax >35 °C			No. of Dry Days			No. of Days w/ Rainfall >150mm		
		OBS (1971-2000)	2020	2050	OBS	2020	2050	OBS	2020	2050
DAVAO DEL SUR	Davao	109	2981	5373	7930	4789	5368	2	3	4

Note:

- For Davao del Norte, Davao Oriental and Compostela valley, data of Davao City were used
- *Source: PAG-ASA, Study on Climate Change in the Philippines*

To derive the values of seasonal mean temperature and seasonal rainfall in 2020 and 2050 in any of the provinces, the projections are added to the observed values (presented in each of the tables).

For the projected change in mean temperature and rainfall by 2020 and 2050 respectively, calculations are summarized in the tables below:

Table 2.3-12: Projected Temperature (in °C)

Months	2020			2050		
	Observed BL (1971-2000)	Change in 2020 (2006-2035)%	Projected Mean Temp.	Observed BL (1971-2000) mm	Change in 2020 (2006-2035)%	Projected Mean Temp.
DJF	26.80	0.90	27.70	26.80	1.80	28.60
MAM	27.80	1.00	28.80	27.80	2.00	29.80
JJA	27.50	1.10	28.60	27.50	2.40	29.90
SON	27.60	1.00	28.60	27.60	2.00	29.60

Table 2.3-13: Project Rainfall (in mm)

Months	2020			2050		
	Observed BL (1971-2000) mm	Change in 2020 (2006-2035) %	Projected Rainfall	Observed BL (1971-2000) mm	Change in 2020 (2006-2035) %	Projected Rainfall
DJF	827.3	12.30%	929.06	827.3	-15.90%	695.76
MAM	611.8	-5.70%	576.93	611.8	16.10%	710.30
JJA	540.4	-4.70%	515.00	540.4	9.90%	593.90
SON	599.2	1.20%	606.39	599.2	-4.90%	569.84

2.3.1.2 Contribution in terms of greenhouse gas emissions

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.
m
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.

For this project, Scope 1 and 2 emissions are estimated.

Calculation Approach for Inventory

GHG emission computed was based on the GHG Protocol Corporate Standard (2001), which is broadly accepted by NGOs, businesses and governments. This has been used as the standard basis for accounting and reporting of GHG emissions. Computation for GHG emission was based on the tools and guidelines consistent with the Intergovernmental Panel on Climate Change (IPCC).

GHG emission from (diesel) fuel consumption

Inventory of mobile vehicles, power consumptions and stationary facilities that are run by fossil fuel were surveyed. Diesel is the only type of fuel being used in the mining activity. Table 2.3-6 shows the estimated diesel fuel consumption from use of mobile vehicles, heavy equipment, barge and power generation (from generators run by diesel fuel) annually.

Heavy Equipment and Vehicles

The composite unit of heavy equipment (excavator/backhoe, dump truck, bulldozer, payloader, road grader, backhose with breaker, road roller, water truck, fuel/lube truck, water truck and service vehicles) would have an average daily fuel consumption of 61,612.80 liters. Operating at 26 days per month at 9 months in a year, the estimated total fuel consumption per year would be 14,170,293 L/yr.

LCT Barge

Operating hours per day :19.2 hours/day
Estimated fuel consumption
Total consumption per unit : 210 L/hour
Total consumption (8 units) : 1,680 L/hour
Total Consumption / day (8 units): 19.2 hours/day@1,680 L/hour = 32,256 L/day
26 days/mo@32,256 L/day = 838,656 L/mo
Total Consumption / yr (8 units) : 9mos@838,656L/mo = 7,547,904 L/yr

Generator Set (3 units)

Estimated Operating time per year : 52 days/year
Estimated consumption / hour (3 units) : 900 L/hour
Total Consumption / day (3 units) : 22 hours/day@900 L/hour = 19,800 L/day
52 days/year@19,800 L/day = 1,029,600 L/yr

Table 2.3-14: Estimated Fuel Consumption during the construction and operation phase

Project Phase	Estimated Fuel Consumption (L/year)
Fuel Consumption (mobile vehicles, heavy equipment, etc.)	14,170,293
Fuel Consumption (LCT Barge)	7,547,904
Power generation (gensets) – stand-by units	1,029,600
TOTAL	**21,821,157**

An estimated total of 21,821,157 liters of diesel fuel will be consumed by the mining company for its project. This includes 14,170,293 liters of diesel for heavy equipment and service vehicles, 7,547,904 liters for the LCT barge and 1,029,600 liters for its stand-by generators. Based on the computation below **(Figure 2.3-5),** the project will emit 11,630.6 MtCO2 to the atmosphere per year during its construction phase in which 81,414 trees are needed to offset its CO2 emissions.

Climate Change Impcat: your carbon dioxide (CO2) emissions can be calculated on the basis of your fuel consumption.

→ The indicative cost of your CO2 emissions is explained below.

Remember, with every liter of petrol fuel burned 2.35 kg of CO2 is emitted.
With every liter of diesel fuel burned 2.60 kg of CO2 is emitted.

Your current fuel consumption:	**21,821,157**	**L/yr of diesel**
	0	**L/yr of gasoline**
For diesel	**56,735,008**	**Kg CO2**
For gasoline	**0**	**Kg CO2**
and your current fleetwide CO2 emissions:	**56,735**	**tonnes/yr of CO2**

Offsetting your CO2 emissions can be done by planting trees. It is estimated that 1 up to 7 trees offset 1 tonne CO2 over the lifetime of the tree(s).
The actual number of trees per tonne of CO2 offset varies depending on factors such as climate, rainfall, species and soil type.
For example, in the UK you can offset 1 ton CO2 by planting 1 leaf tree and let it grow during 100 years.

	1 tree offsets 1 ton CO2		7 trees offset 1 ton CO2	
To offset your CO2 emissions you need to plant between	**56,735**	**and**	**397,145**	**trees every year***

Figure 2.3-5. Carbon dioxide emissions calculation based on the fuel consumption of the project *(Source: GHG Protocol Corporate Standard, 2001)*

Inventory of mobile vehicles, power consumptions and stationary facilities that are run by fossil fuel shall be surveyed.

Mobile emissions would include the company owned vehicles, heavy equipment and other mobile vehicles. Power generations would include generators and other energy producing facilities. Carbon emission for purchased electricity may be computed using the greenhouse emission factor of 0.59 GHG coefficient for Mindanao.

Carbon Offsetting

Offsetting the CO_2 emissions can be done by planting trees. An estimate of seven (7) trees is needed to offset 1 ton of carbon dioxide over the lifetime of the tree. The project should adapt an intensive plant propagation and progressive rehabilitation plan to address the matter on carbon offsetting considering the earth movement during mine operations.

2.3.2 Air Quality (& Noise)

The MPSA area does not have large scale source of air pollution such as major industries, and power plants. As such, it is generally considered based on qualitative observations that the air quality in the project area is acceptable. Major sources of pollution include chainsaw, motorized banca, tricycle and motorcycle, bus and other land transportation. Cargo trucks mostly carrying copra and fish products also contribute to pollution. It should be noted that the 2-stroke engine motorcycle which uses 2T oil as lubricant is highly inefficient and contributes to carbon monoxide pollution. However, the windy condition of the locality helps ease to disperse the pollution. The unpaved road also contributes to dust pollution during summer when the roads are dry. However, these are rare considering that the amount of rainfall is distributed all year round.

The project would involve earthmoving activities, which are expected to heavily affect air quality in terms of particulate dispersion. Considering that the mining process will not involve any material processing and will just involve surface mining method, emission of toxic gases is expected to be limited only to emission from the use of vehicles, heavy equipment and power generating units.

For the purpose of the study, baseline characteristics on air quality is done to determine parameters that will be relevant and significant in the mining operations, particularly those of SO_2, NO_2, TSP and PM_{10}.

2.3.2.1 Degradation of air quality

Air environment at the mine site, the host community, communities and areas where haul trucks traverse to transport the ore to the loading port will be affected by the number and frequencies of trips of haul trucks, contributing to air contamination from vehicle exhaust gases and fugitive dust generated at the haul roads.

The movement of vehicles and heavy equipment will generate particulates either from direct emissions from the burning of diesel fuels, from wear of tires, and vehicle-generated air turbulence on roadways. Tiny particles with diameter as minute as 2.5 micrometers, may also be generated from the action of wind on the dusty material that the vehicle may be carrying. By way of comparison, a human hair is about 100 micrometers, so roughly fine particles could be placed on its width.

Particles in the air affect both the quality of the air and visibility. Once in the air, particulate matter generally takes time to settle. They also may be washed from the air by rain. When they settle on land they may settle permanently or be re-entrained. In water particulates may settle, dissolve or both.
Potential Source of Air Pollution

Dust From Mining Activities

Dust will be generated from the following:

- Hauling roads;
- Waste dumps;
- Stockpile area;
- Transport of ores; and
- Spillages from transport of ores

Increase in Gaseous Emissions

Localized increase in gaseous emissions are limited to the use of heavy equipment and hauling/transport vehicles and generator sets. Continued inhalation of these pollutants may harm workers that can inhale these gaseous fumes. This impact will be insignificant since they can be readily dispersed.

Impacts Mitigation Measures

Dust Generation

- Air pollution due to mining and related activities can be minimized by planning the activities in such a manner that the generation of the pollutants is minimum possible. In addition, provisions may be made for arresting the dust by making suitable green belts or buffer zones. Some of the measures are outlined below.
- Generation of dust in the removal of the vegetation and soils can be minimized by maintaining adequate moisture in the soil via regular water sprinkling along the ore staging area, haul roads, and access roads. This can also be expected to improve the efficiency of these operations since a dusty atmosphere decreases the efficiency of man and machines.
- Proper maintenance of the haul roads can minimize the generation of air borne dust.
- Covering the trucks with tarpaulin or canvass thus enclosing the mineral handling and preparation units tend to reduce the contribution of the proponent to the atmosphere.

Increase in Gaseous Emissions

- Gas emissions will be minimized by using properly maintained motor vehicles and heavy equipment and by utilizing higher grade motor fuel during the construction and operations phases.
- Clean automotive diesel oil shall be used as fuel for all diesel-fueled vehicles. Regular maintenance of engines shall be implemented to ensure optimum engine performances.

- Regular maintenance of dump trucks and heavy equipment to reduce gaseous emissions of NOX and CO.

Characterization of ambient air quality:

Sampling Methodologies

The ambient air quality monitoring conducted was performed at an elevation of at least two (2) meters above the ground level and sampling was strategically stationed within the project site's perimeter. After sampling was conducted for each station, the samples were carefully recovered and were immediately submitted to the laboratory for analysis.

Filtration method by high volume sampler (TSP sampling)

Principle of Sampling - Ambient air was drawn through a glass fiber filter over a period of time. Particles having a diameter of 20-50 µm were collected ordinarily. The filter paper containing the sample was weighed; hence, the final weight of the sample over that of the standard volume of air sampled gave the concentration of TSP.

Absorption in liquids for gaseous pollutants (SO_2, NO_2 sampling)

Principle of Sampling - A known volume of air (0.5 L/min. for SO_2 and 0.4 L/min. for NO_2) was sampled with a wet-chemical system where a constant volume of air sample passes through a suitable reagent (absorbing reagent) that was reactive to the specific pollutant desired. As the air sample passes through the bubbler rack, the air diffuses forming air bubbles and slowly reacts to the chemical reagent forming a complex ion. The Kimoto/SKC personal sampler was calibrated with NIST traceable digital calibrator to assure its accuracy. The samples were then analyzed using prescribed and approved methods.

PM10 Sampling

Principle of Sampling – Ambient air, with particle size of less than 10 µm was entered in Graseby Andersen 10µ inlet by means of vacuum system. The air passes to venturi type casing resulting to a flow rate of approximately 40 cubic feet per minute. The particles were collected in a glass fiber filter and determined by measuring gravimetrically. The filter paper containing the sample was weighed hence the final weight of the sample over that of the standard volume of air sampled gave the concentration of PM10.

Tables 2.3-15 shows the geographical coordinates of the sampling stations as shown in **Figure 2.3-6**. **Table 2.3-16** presents the results of sampling and analysis conducted from the six (6) stations last September 2016 in comparison with the NAAQGVs (National Ambient Air Quality Guideline Values) as prescribed under Republic Act 8749 (Clean Air Act) Implementing Rules and Regulations.

Table 2.3-15: Geographical Coordinates of the Air Sampling Stations

Station	Latitude	Longitude
A1	7° 1.822'N	126° 1.137'E
A2	7° 1.067'N	126° 0.488'E
A3	7° 0.932'N	125° 59.528'E
A4	7° 2.073'N	125° 58.670'E

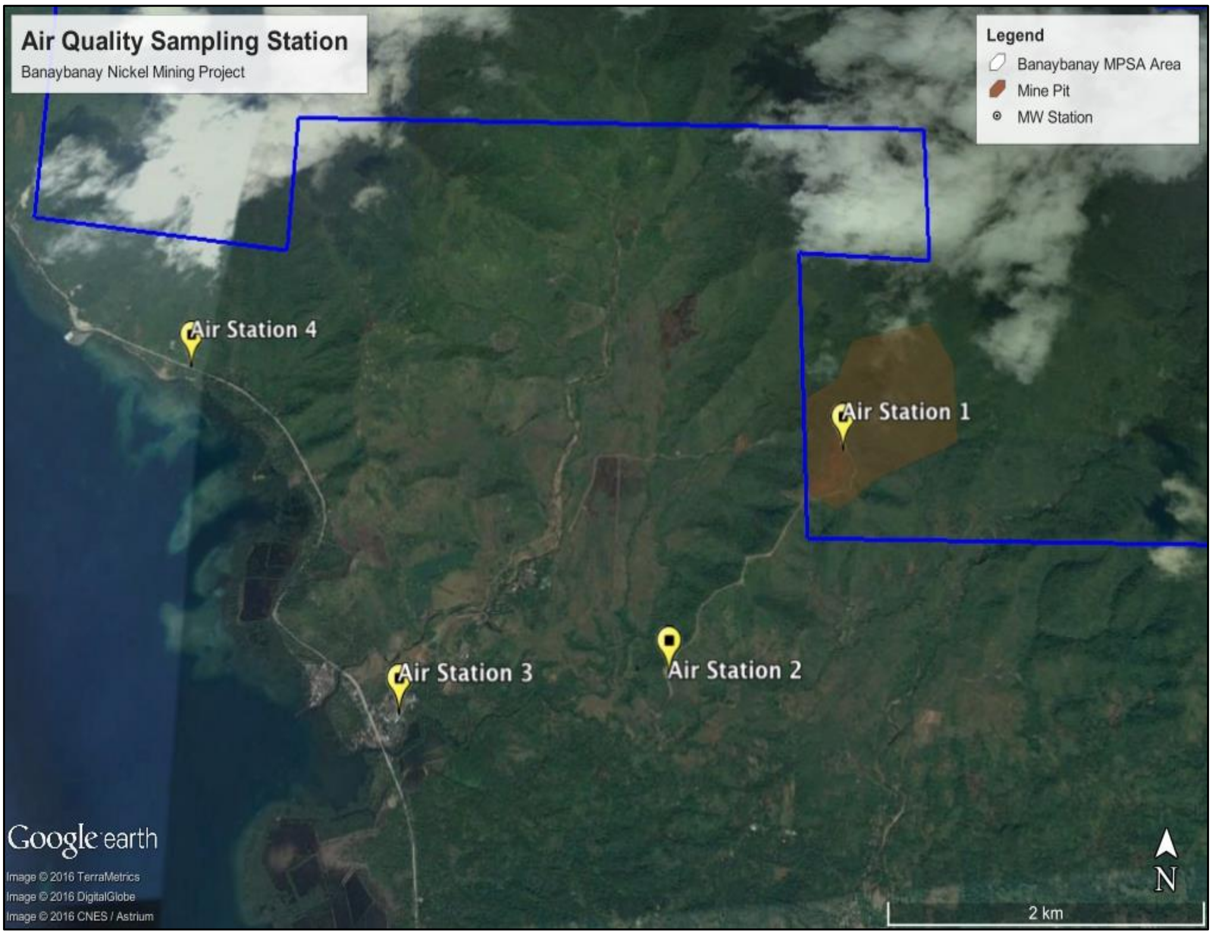


Figure 2.3-6: Air Quality Sampling Location Map
(Map Source: Google Earth, 2016)

Table 2.3-16: Ambient Air Sampling Results

Station	Date of Sampling	SO_2, µg/Ncm	NO_2, µg/Ncm	TSP, µg/Ncm	PM_{10}, µg/Ncm
A-1	September 9, 2016 (4:15 PM, Afternoon)	4.08	0.21	1,400	<0.15
A-2	September 9, 2016 (6:40 PM, Evening)	<0.20	0.17	1,300	<0.15
A-3	September 10, 2016 (8:35 AM, Morning)	0.53	0.28	1,100	<0.15
A-4	September 10, 2016 (10:20 AM, Morning)	0.90	0.07	800	0.16
A-5	September 10, 2016 (12:20 PM, Afternoon)	0.62	0.13	900	0.33
A-6	September 10, 2016 (2:10 PM, Afternoon)	1.06	0.30	800	<0.15
DENR NAAQGV (short term) as per DAO 2000-81		**180**	**150**	**230**	**150**

As shown in **Table 2.3-16**, the concentrations of SO_2 and NO_2 in the area are low. On the other hand, the concentrations of TSP in all stations exceeded the allowable limit of 230 µg/Ncm. The highest TSP concentration is recorded at Station A-1 with 1,400 µg/Ncm. This could be the most disturbed section of the mine site. Other factors that may have contributed to high TSP concentrations in the area include vehicular movement and dust generation from unpaved roads. The PM_{10} concentrations in all stations are way below the prescribed limit of 150 µg/Ncm.

The sampling for ambient air quality was done during the 1st (dry) season of the year. According to the Climatological Assessment (attached as annex) conducted for this project, they have concluded that, based on meteorological information, modeling and the terrain configuration presented in the study surrounding the project site, the establishment/selection and measurement of the sampling stations are technically acceptable and can represent the upstream and downstream source/receptor with due consideration of the two monsoon seasons of the year. Owing to their minimal differences or variations among meteorological elements and being under a Type IV climate, it is recommended that the baseline measurements of air, freshwater and marine water can be done once in the year.

2.3.2.2 Increase in ambient noise level

Noise generation from the project is expected. The noise generated from mining and associated activities poses potential health hazards to workers and heavy equipment operators who may be exposed to excessive noise and vibration during mine production. Since the project is far from residential areas, there are no nearby communities that may be affected. The workers/operators of heavy equipment that will be exposed to excessive noise will be provided with the proper PPEs.

Fauna species along active mining and peripheral areas may be disturbed causing temporary migration to another area. This impact is short term since wildlife species are mobile and can transfer to other areas once they are disturbed.

A. Sources of Noise Pollution

Vehicles

The immediate communities and areas where haul truck traverse to transport the ore to the loading port will be affected by the number and frequencies of trips of haul trucks. Excessive and unnecessary blowing of horns will cause noise pollution.

Earthmoving (Mining Equipment)

Surface mining highlights the pervasive use of heavy equipment such as hydraulic excavators, dump trucks, and front loaders. The mining equipment used for mining are confined in the active areas. Operators will be provided with PPEs

Corresponding noise level of equipment to be used for this project have been determined and measured through FHWA Roadway Construction Noise model from previous studies conducted. This model is used to measure highway and construction-related noise. Average maximum noise levels (L_{max}) at 50 feet from heavy equipment range from about 73 to 101 dBA, while stationary equipment such as generator sets that generally run continuously at relatively constant power and speeds, have an average maximum noise level of 68 to 88 dBA at 50 feet distance with pumps typically in the quieter range.

Table 2.3-17: Corresponding Noise Level of Equipment at 50 feet

List of Equipment	Noise Level (dbA)
Excavator/ Backhoe	85
Dump Truck	84
Bulldozer	85
Payloader	80
Road Grader	85
Backhoe with Breaker	85
Road Roller	80
Water Truck	90
Fuel/ Lube Truck	90
Generator set	82
Service Vehicle	55
LCT Barge	-

Source: Acoustical measurement in FHWA Roadway Construction Noise Model, June 2017

Powerhouse

The power requirement of the project is supplied by the local cooperative. Standby generator sets will be maintained in cases of power outage. During the interim period, these generator sets may emit a relatively low noise that can be overheard within 15 meters from the source.

B. Impacts Mitigation Measures (Noise)

- Restriction of Hours of Activity

Considering the distance of the extraction site and the permanent ore staging area inside the mining premises coupled with the sloping terrain surrounding the mineral properties, the noise that will be generated shall be dampened.

Mining activities are all underground and hauling activities will be done during daytime and during the dry months. Truck drivers will also be instructed to avoid excessive blowing of horns and over speeding.

- Proper Maintenance of Vehicles and Equipment

Regular and proper maintenance of all vehicles and equipment to be utilized during mining operations will conducted by the proponent in order to minimize noise during operations. Log will be maintained to monitor equipment performance and necessary repair will be done as necessary.

- Establishment of buffer zones in the motor pool area

The motor pool will be located at a designated distance from communities and sensitive areas in the mine areas so as not to disturb the residents and even birds and animals.

- Sound Insulation for Generator Sets

Gensets to be utilized during operations shall be provided with sound enclosures to restrain and minimize noise.

C. Characterization of ambient noise level

Noise measurement was conducted at four (4) points within the project area to determine current noise levels using a standard and calibrated noise meter. Measurements were conducted last September 2016.

The results of the noise level measurements shown above indicate that noise levels in four (4) station did not exceed the noise level standards set by the DENR for both residential and industrial areas.

Ambient Noise Level Measurement

Table 2.3-18: Noise Level Sampling Results

STATION	Date of Sampling	Noise Level (dB)
1	September 2016	34
2	September 2016	31
3	September 2016	46
4	September 2016	38
DENR STANDARD (Class A - Residential)		**55**
DENR STANDARD (Class D - Industrial)		**75**

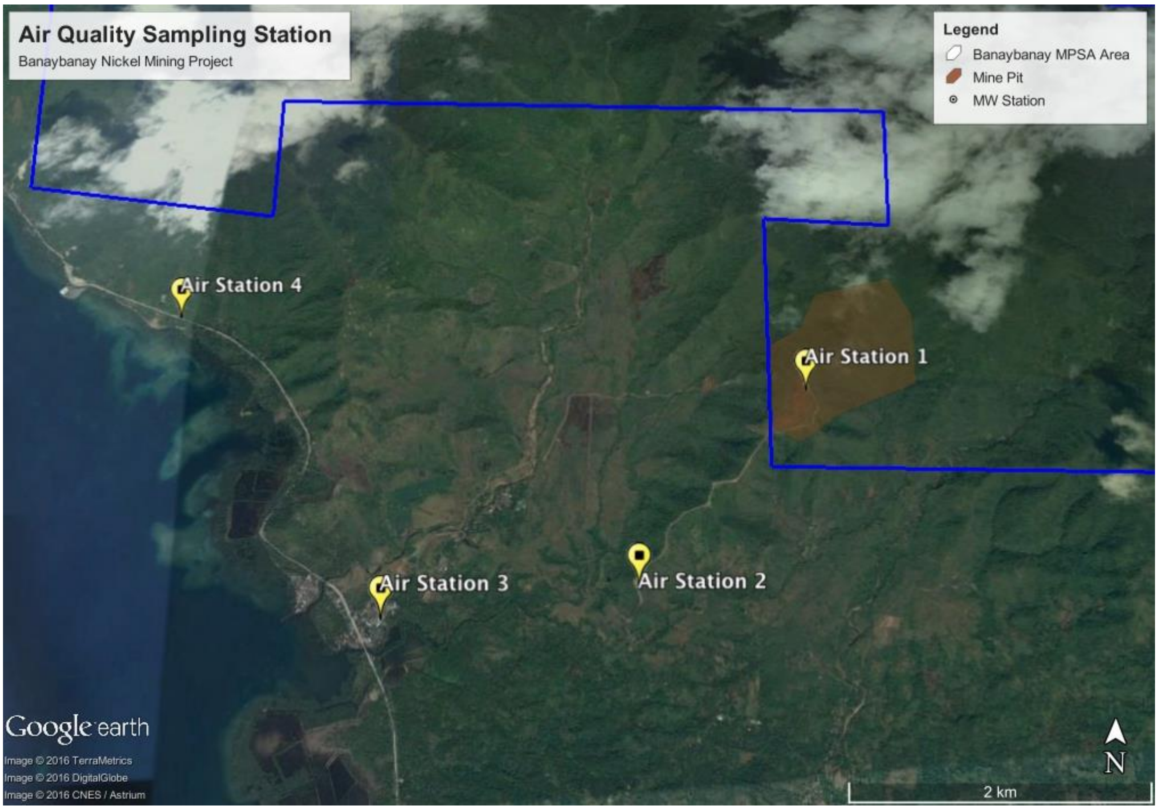


Figure 2.3-6a: Noise Level Sampling Location Map
(Map Source: Google Earth, 2016)

Plate 1: Photo of actual Noise Sampling at Station 1

Plate 2: Photo of actual Noise Sampling at Station 3

2.4 PEOPLE

The project will basically cover three (3) urban and three (3) rural barangays of the municipality. These six (6) barangays comprise 37,308 has. of the total 41,930 has. total area of the municipality or 89% of the total area. Barangay Acuswagan accounts for the largest barangay in terms of area at 29,518 has. In the project's Exploration report, it is accounted that the main mining pits are located in the Puntalinao and Causwagan Block.

The population of the municipality was recorded at 41,117 based on the 2015 Census of Population and Housing and growing at +0.95% per annum. Barangay Población has the highest population density, while Barangay Causwagan has the least.

Table 2.4-1 Population Densities, Gross Density and Built-up Density of Banaybanay per Barangay, 2010

Barangay	Population Density	Area (ha.)	Built-up Density
A. Urban			
1. Poblacion	9,142	1,077	8.49
2. Panikian	2,839	1,061	2.68
3. Mogbongcogon	2,935	873	3.36
4. Maputi	3,950	1,144	3.45
5. Calubihan	3,681	802	4.59
6. Puntalinao	2,759	2,040	1.35
Sub total	**25,306**	**6,997**	**4**
B. Rural			
1. Cabangcalan	1,391	384	3.62
2. Caganganan	1,972	292	6.75
3. Mahayag	871	29,518	0.03
4. Causwagan	647	2,021	0.32
5. Pintatagan	2,131	1,524	1.40
6. Piso Proper	2,370	395	6.00
7. Rang-ay	2,002	330	6.07
8. San Vicente	2,431	469	5.19
Sub total	**13,815**	**34,933**	**0**
Total	**39,121**	**41,930**	**0.93**

As shown in Table 2.4-2, the municipality recorded a total household population of 39, 121 households in 2010. The average household size was computed at 5.

Table 2.4-2 Household Populations by Urban and Rural Barangay and Average Household Size (2010)

Barangay	Population	Number of Household	Average Household Size
Urban			
1. Poblacion	9,142	1,828	5
2. Panikian	2,839	568	5
3. Mogbongcogon	2,935	587	5

Barangay	Population	Number of Household	Average Household Size
4. Maputi	3,950	790	5
5. Calubihan	3,681	736	5
6. Puntalinao	2,759	552	5
Rural			
1. Cabangcalan	1,391	278	5
2. Caganganan	1,972	394	5
3. Mahayag	871	174	5
4. Causwagan	647	129	5
5. Pintatagan	2,131	426	5
6. Piso Proper	2,370	474	5
7. Rang-ay	2,002	400	5
8. San Vicente	2,431	486	5
TOTAL	**39,121**	**7,822**	**5**

Land Area

The municipality of Banaybanay has a total land area of 41, 930 hectares and is political divided into fourteen (14) barangays. The project will be developed within the 6,023.8885-hectare portion of the MPSA area within the territorial jurisdiction of Barangays Puntalinao, Kauswagan, Pintatagan, Maputi, Panikian and Mahayag in the municipality of Banaybanay.

Gender and Age Profile

The table below shows the gender and age profile of the municipality based on the Census on Population of 2010.

Table 2.4-3 Population Composition by School-Age, Working Age, Dependent Age Group and Sex, 2010

Age Group	Both Sexes	Male		Female		Sex Ratio
		No.	Percentage	No.	Percentage	
Total	**39,121**	**20,102**	**51.39%**	**19,018**	**48.61%**	**100%**
Under 5	4,529	2,372	11.80%	2,157	11.34%	23.14%/2=11.57
9 y.o.	4,333	2,245	11.16%	2,088	10.98%	22.14%/2=11.07
14 y.o.	4,354	2,104	10.46%	2,250	11.83%	22.29%/2=11.15
15-19	4,390	2,255	11.21%	2,135	11.23%	22.44%/2=11.22

Age Group	Both Sexes	Male		Female		Sex Ratio
		No.	Percentage	No.	Percentage	
20-24	3,602	1,903	9.47%	1,699	8.93%	18.4%/2=9.20
25-29	2,868	1,514	7.53%	1,354	7.12%	14.65%/2=7.32
30-34	2,568	1,360	6.76%	1,208	6.35%	13.11%/2=6.56
35-39	2,468	1,253	6.23%	1,215	6.39%	12.62%/2=6.31
40-44	2,366	1,254	6.24%	1,112	5.84%	12.08%/2=6.04
45-49	2,013	1,036	5.15%	977	5.14%	10.29%/2=5.14
50-54	1,653	864	4.30%	789	4.15%	8.45%/2=4.22
55-59	1,213	625	3.11%	588	3.10%	6.21%/2=3.11
60-64	975	453	2.25%	522	3%	5.25%/2=2.62
65-69	738	364	1.81%	374	2%	3.81%/2=1.90
70-74	559	279	1.39%	280	1%	2.39%/2=1.20
75-79	315	147	0.73%	168	0.89%	1.62%/2=0.81
80-84	177	74	0.37%	103	0.54%	0.91%/2=0.46
School going population						
Pre-School (3-5)	1,139	683	3%	456	3.16%	6.16%/2=3.08
Elementary (7-12)	4,801	2,880	13.31%	1,921	13.31%	26.62/2=13.31
Secondary (13-16)	5,251	3,150	14.56%	2,101	14.55%	29.11/2=14.55
Tertiary (17-21)	3,602	2,161	9.99%	1,441	9.98%	19.97/2=9.99
Working age (15-64)	24,116	12,517	62.25%	11,599	61.34%	123.59/2=61.79
Labor Force (15 and over)	24,116	12,517	62.25%	11,599	61.34%	123.59/2=61.79
Dependent population	13,216	6,721	33.42%	6,495	35.15%	68.57/2=34.28
Young (0-14)	13,216	6,721	33.42%	6,495	35.15%	68.57/2=34.28
Old (65-over)	1,789	864	4.30%	925	4.43%	8.63/2=4.31

Literacy rate, profile of educational attainment

There are 1,139 individuals who completed Pre-school, of which 683 are males (59.96%) and 456 are females (40.04%). There are 4,801 individuals who only completed Elementary, of which 2,880 are males (59.99%) and 1,921 are females (40.01%). There are 7,708 individuals, whose highest educational attainment, are from 1st grade to 4th grade only, of which 4,624 are males (59.99%) and 3,084 are females (40.01%). There are 3,388 individuals, whose highest educational attainment, are from 5th grade to 7th grade only, of which 2,032 are males (67.94%) and 1,356 are females (32.06%). There are 6,554 individuals, whose highest educational attainment, are Undergraduates, of which 3,932 are males (59.99%) and 2,622 are females (40.01%). There are 5,251 individuals, whose highest educational attainment, are High School graduates, of which 3,150 are males (59.99%) and 2,101 are females

(40.01%). There are 190 individuals, of which 114 are males (60%) and 76 are females (40%), whose highest educational attainment is Post-secondary. There are 19 individuals, of which 11 are males (57.89%) and 8 are females (42.11%), are Undergraduates. There are 3,602 individuals, of which 2,161 are males (59.99%) and 1,441 are females (40.01%) are Graduates. There are 1,774 individuals, of which 1,064 are males (59.98%) and 710 are females (40.02%) are College Undergraduates. There are 1,593 individuals, of which 955 are males (59.95%) and 638 are females (40.05%) are Academic degree holders. There are 57 individuals, of which 34 are males (59.65%) and 23 are females (40.35%) have Post Baccalaureate.

Table 2.4-4 Educational Attainment, 2010

Highest Educational Attainment	Male		Female		Both Sexes	
	No.	%	No.	%	No.	%
No. Grade Completed						
Pre-School	683	59.96%	456	40.04%	1,139	100%
Elementary	2,880	59.99%	1,921	40.01%	4,801	100%
1st-4th Grade	4,624	59.99%	3,084	40.01%	7,708	100%
5th-7th Grade	2,032	67.94%	1,356	32.06%	3,388	100%
Under Graduate	3,932	59.99%	2,622	40.01%	6,554	100%
High School Graduate	3,150	59.99%	2,101	40.01%	5,251	100%
Post Secondary	114	60%	76	40%	190	100%
Under Graduate	11	57.89%	8	42.11%	19	100%
Graduate	2,161	59.99%	1,441	40.01%	3,602	100%
College Undergraduate	1,064	59.98%	710	40.02%	1,774	100%
Academic degree holder	955	59.95%	638	40.05%	1,593	100%
Post Baccalaureate	34	59.65%	23	40.35%	57	100%
TOTAL	21,640	100%	14,436	100%	36,076	100%

2.4.1 Displacement of settler/s

There are no settlers that will be displaced. The project area is considered a mine site in the past years before the proponent acquired it. Right of way to the project site has long been established and should there be a need to open other access points to the project, the proponent will secure proper clearances and rights for such access.

2.4.2 In-migration proliferation of informal settlers

The identified existing urban and land use of the Municipality of Banaybanay, are four identified urban areas. These are the following: Poblacion, Panikian, Mogbongcogon, Maputi, Calubihan and Puntalinao. While on the other hand, the identified rural areas are the following Cabangcalan, Caganganan, Mahayag, Causwagan, Pintatagan, Piso Proper, Rang-ay and San Vicente.

Of the total land area of Población, only 40.08 hectares or about 3.79% were being utilized as residential. Home-seeker colonies mushroomed along the national highway and NIA's road right of way. At present, the local government in coordination with the National Housing Authority and other concerned national government agencies have identified resettlements sites at Población, Cabangcalan, San Vicente, Maputi, Piso Proper, Calubihan, Pintatagan and Puntalinao for these victims of disasters, those living along danger zones and the landless. With these resettlement sites, it is expected that population in the urban areas will be dispersed. Already, a total of 31.0 has. had already been identified and acquired by the LGU for resettlement purposes.

At present, the numbers of socialized housing that the Municipality of Banaybanay have been established are the following: Habitat Housing Project in Barangay Puntalinao areas, Mapagba Resettlement area, Gawad Kalinga (GK) Housing Project at Mapanga Calubihan and LGU/ANCOP (Answering the Cry of the Poor) at Cabatan, Mogbongcogon & LGU acquired and funded housing at Barangay Pintatagan. For site development, and distribution to the ready beneficiaries in Barangays San Vicente, Mahayag, Mapanga phase II unoccupied area at Puntalinao Habitat, Causwagan and BALURIMCO Cabatan area.

There are no informal settlers within the project area. The area will be secured by the proponent to prevent possible illegal settlement within the area. While local qualified residents will be prioritized for employment, workforce that will be engaged from other areas will be provided with living quarters at designated facilities in the project site. The community has sufficient housing facilities for rent to accommodate migrants. The number of migrant workers however is not expected to be that many. Further, engagement of migrant workers will be coordinated with the barangay for proper clearance and recording.

2.4.3 Cultural/Lifestyle change

The Mansaka ethnic group is found in the provinces of Davao del Norte and Compostela Valley particularly in the cities of Davao and Tagum and other municipalities of the said provinces in Pantukan, Maco Mabini, Mawab, Nabunturan and Maragusan. On the other hand, the Mandayas are a group of non-Christian tribe non-Islamic people living in Eastern Mindanao, Philippines. Earlier accounts indicate that the Mandaya represented one of the most powerful tribes in these areas. Mandaya means “inhabitants of the Uplands”. The Mandayas are located in the provinces of Agusan, Davao, Surigao del Sur and del Norte, and the eastern areas of Cotabato. The Mandayas are also scattered throughout the eastern half of Davao province and northward Lianga, Surigao del Sur and Souther Agusan.

Generally fair with bridged noses, brown hair and oval faces, some scholars have classified the Mansaka as a distinctive subgroup of Mandaya. The Mandaya-Mansaka group of languages is often classified under the Manuvu linguistic group. This includes the dialects of the Tagacaolo of Davao del Sur, Davaoeno of Davao City, Mansaka or Mandaya of Davao del Norte and Isamal of Samal Island, linguistically speaking.

The Mansaka are faming people as described in an article. They are very particular in the management of whether when and where they will establish their farms. It is important that they do not go into anyone else’s territory. If ever this happens, atribal war ensues. This is the common cause of inter-tribal war – a member going into the territory of another indigenous group, which causes the death of many members. It is the tribal leader who has the full authority to resolve any problem and ease relationships anew.

The community assigns members to manage the farm. Men are tasked with tilling the land and other farm-related jobs. They do not farm on the same area though to maintain the fertility of the land and to prevent future soil erosion. Women, on the other hand, are tasked to produce clothing and weave mats. They also help in the farm during planting, weeding and harvesting times.

The Mansaka’s economic and political life is largely determined by the tribal elders or *matikadong* who are also baganis or tribal warriors.

As it is with other indigenous groups, any conflict that arises is resolved among the members of the community. The most frequent of conflicts revolves around land and river.

On the other hand, culturally Mandayas have retained their basic social, religious, and political organizations along with their traditional material crafts. The Mandaya religious structure centers on an elaborated hierarchy of spirits (anito) and a group of female mediums (balyari) who generally fuction as the interpreter of the supernatural to the natural environment.

Political authority among the Mandaya was vested in the headman, the Basani. Each Basani, before assuming the title and role, had to kill seven to nine men in battle or through surprise raids upon neighboring areas. Each basan had his domain of political authority where his rule was law.

The presence of Mansaka and Mandaya tribes have been noted in the neighboring area of the MPSA. In the initial consultations with their representatives, they have expressed support for the mining project but at the same time have expressed some concerns such as: 1) fear and insecurity due to bad experiences with previous mining companies, 2) loss of farmlands and inequitable payment for the lease of the ancestral domain and 3) employment and/or livelihood opportunities.

RCMC intends to abide by the provision of the law particularly in the preservation of local culture of the IP community and intends to implement programs to protect, preserve and enhance the lifestyle and culture of the local IPs. It has taken into consideration the provisions of the IPRA law in formulating an Indicative Indigenous Peoples Development Plant (IPDP), which will be finalized in coordination with the local IPs, the LGU and the NCIP. Currently, the proponent has forged a Memorandum of Agreement with the IPs and the doucment is herein attached as **Annex 10**.

2.4.4 Impacts on physical cultural resources

Banaybanay is known as the gateway to the province of Davao Oriental. It sits at the northernmost tip of the province. The municipality is highly agricultural area and is considered as the rice granary of the province because its main agriculture product is rice.

Banabanay is also endowed with beautiful natural resources that serves as tourist attractions and one of which is the Burias Island.

While the project is not within any tourism area or recognized physical cultural resources and will not pose a direct effect on what was mentioned above, it intends to partner with the local tourism office as well as other tourism agencies in programs that will enhance the municipality's cultural resources through its Social Development Programs.

Similarly, the proponent through responsible mining practices, it aims to set an example to the host community and encourage other stakeholders to support their programs on responsible mining and environmental protection.

The company will put up a Community Relations Office that will facilitate the community extension program of the company to the community. This office will be responsible in seeing that no major detrimental alterations in any cultural values and practices will occur in the area.

2.4.5 Threat to delivery of basic services/resource competition

The municipality has sufficient resources to accommodate the demands of the project for basic services as shown with the statistics below.

Water Supply

Hydrogeology study of the municipality show that it has available sources of ground water for domestic and other uses. Potential of underground source of Potable water are located at Poblacion area, Puntalinao, Maputi, Causwagan, Piso, Caganganan and Mahayag. There are five (5) sluggish rivers draining the municipality. They are Kalawangan River, Pongoton River, Pintatagan River, Mapagba River and Maputi River.

Pongoton River is for domestic, agricultural and non-point sources and it runs through Panikian and Piso. Pintatagan River is used for domestic, agricultural and non-point sources. Mapagba River and Maputi River is used for domestic, agricultural and non-point sources and it is located in Maputi. Sumlog River is for irrigation. It runs through Maputi in Banaybanay and in Barangay Lupon, which is another municipality of the province.

The Municipality's residents are fortunate enough to enjoy a very abundant water supply from both the shallow, deep well and spring sources. In the level I water supply, sources are deep well and springs which are generally located and used in the rural areas where houses are thinly scattered. For level II the communal faucets where houses are densely clustered a piped distribution system for every 6-8 households are provided with faucets. Currently, level III local waterworks system that is operating in the Municipality are located in the barangays of Piso, Pintatagan and Puntalinao. The Municipality has existing watersheds and surface water areas which support the irrigation system for domestic and agricultural areas particularly the rice production areas of the Municipality. These water sources are found in the tributaries of Sumlog river, Pongoton, Mapagba & Maputi and the Pintatagan rivers. Nowadays these water sources are highly, vulnerable to destruction brought about by the climate change, environmental degradation that poses hazard for both domestic and agricultural uses.

Power Supply

From the time the Municipality of Banaybanay was energized in 1980 to the current year, more or less 97 % of the total household is already enjoying the luxury of electricity as their main source of lighting & energy.

In the case of fuel for cooking, it shows that more than 90% of all the households are using woods for cooking while less than ten (10 %) present still uses LPG, the rest, which is about 2 %, uses charcoal.

Electrification

Except for very far-flung dwelling units in some sitios of barangays Pintatagan, Maputi, Causwagan, Mahayag & Panikian which are partly forestal, more or less 97 % of all households in the Municipality's AOR are already energized.

The project is expected to draw the project's power requirement from the local provider. However, to ensure continuous supply of power, the proponent will have stand-by generators for its operation especially in remote areas of the mine site.

Communications/transportation

The Municipality of Banaybanay has four (4) cell sites located in the different barangays in Poblacion, Maputi, Puntalinao and Pintatagan. Mostly, the area coverage of the cell sites ranges from 5 to 10 kilometers catch radius. The presence of the existing cell sites helps a lot in transmitting & delivering communication to the people domestically & around the world, through the use of cellphone and internet network. The Municipality has postal service which facilitates various mails and other services to the people in the 14 barangays. The volume of letter transactions is ranging from 100 to 150 letters per day with a maximum volume of 3,300 letters per month and 39,600 letters per year. The postal service has 2 letter carriers which deliver the letters daily to the different barangays. At present, no public telephone calling station is available, only few residents have subscription for telephone network (PHILCOM) within the 2 barangays Poblacion and Caganganan. There are also print media available that delivers news report to the people such as national, regional and local school papers. There is also available local FM radio station that serves the people, especially to the music lover & other religious. There are service providers that operate in the different barangays for internet, computers, photocopying & advertising. At present, no hazard can be found to any local communication service facilities located in the different barangays.

There are several types of public utility vehicles servicing the Municipality of Banaybanay whether it may be just within barangay, barangay to barangay, barangay to municipal center or coming from other municipality. There are 216 buses, 60 jeepneys, 80 taxi/FX/vans, 125 light vehicles, 40 tricycles, 89 motorcycles, 110 tri-motor, and 30 bicycles registered in the municipality for a total of 750-land transportation vehicles. Other mode of transport and facilities is a sea transport used to service boat fish landing daily and it is located in Puntalinao and Maputi.

The Francisco Bangoy International Airport in Davao City serves as primary entry point to the province in terms of air travel.

Peace and order/crime

Crime rate in Banaybanay has increased in the last 5 years due to deterioration of peace and order in the barangays. The LGU has vowed to improve police visibility, barangay tanods and volunteers in the barangays to lessen the incidences of crime.

The proponent will employ a private security group to address internal security requirements. In RCMC will also coordinate with the Barangya and local PNP in terms of establishing security protocols within the project site and its vicinity, response procedures in instances of emergencies and other external local security issues.

Education facilities

The Municipality of Banaybanay has a high literacy rate in terms of children's educational status & participation in the 14 barangays. The location of the schools in the barangays where it is located are very accessible to the public for any type of vehicle. Some of the educational facilities in other schools are very good but, others also need improvement like classrooms, comfort rooms, school libraries, canteens, social halls, laboratories, school clinics, playground and other facilities. The building structures present are in conformity with the space standards set forth by the national government. The enrollment is increasing every year which rose up to 1.1% and beyond. Although, there are some things to be upgraded by all stakeholders in preparation for future uses, such as: chairs, tables, desks, classrooms, teachers and other educational facilities and amenities. On participation rate, there is a minimal number of drop-out of school children at all grade level that was observed. However, the national DEPED, local government unit together with the parents of the children belonging to the out of school-youth, is maximizing effort and resources to entice them and bring them back to school and provide the necessary materials for schooling and secure their education for a better and brighter opportunities in the society. The Department of Education is always coordinating with the LGU on their plans, programs and proposed activities all-year round. In fact, the LGU is always supportive through the Local School Board (LSB), by appropriating funds and providing PARA-teachers to augment for the schools the present regular teaching force. At present, there is one private college that was established and fully operational which serves the community and the nearby towns.

Day Care center facilities are found various barangays like Pintatagan, Puntalinao, Maputi, Causwagan, Piso, Cabangcalan, San Vicente, Panikian, Mahayag, Poblacion, Rang-ay, Caganganan, Calubihan, and Mogbongcogon.

All 14 barangays have a public elementary and secondary schools however; there is only one (1) private school in the entire municipality.

The project will partner with local educators in strengthening its IEC activities to penetrate the mainstream impact communities. This will also raise the awareness in the area of responsible mining practices.

Recreational facilities/Sports facilities

Currently, the 14 barangays of the Municipality have their own respective Multi-Purpose Gym, covered court where they can hold their sports program, trainings, recreation and other related activities for public and private uses. They have their sports facilities like: Basketball court, volleyball equipment, badminton paraphernalia, chess board, billiard equipment and dama board. In Barangay Población there is an area for lawn tennis which is located at LGU compound. Most of these sports mentioned facilities are owned and managed by the MLGU, Barangay LGU. There are also sports facilities in the schools located in the 14 barangays. The conditions of the facilities in the 14 barangays are good and excellent. In Barangay Población, the Municipal Gym/covered court have concrete benches and colorful paints, enough to cater 7,000 individuals for any public and private activities especially on big events. The toilets are very functional and well-managed by the LGU personnel. The covered court and multi-purpose pavement in the 14 barangays are fully lighted. The sports and recreation activities can accommodate to the numbers of population who use the said facilities. The accessibility of the population going to the Sports and Recreation facilities from the adjacent town is ideal. But there are many sports facilities and amenities that are lacking, like the facilities for swimming, track & field, soccer field, boxing and many others. The lack of sports equipment for recreation and the rise in health and education problems could lead to drug addiction, poor mental and physical development. In the long run, this will result into social menace.

These public facilities may serve as venues in terms of activities to be undertaken by the proponent in terms of IEC and SDMP activities. RCMC will partner with the LGUs and encourage active participation in IEC activities of the proponent with most activities.

2.4.6 Threat to public health and safety

Availability of public services in terms of: health resources

Generally, the Municipality of Banaybanay have low incidence on crude death rate in every year. This is due to the primary concerns of the Municipal Officials, Municipal Health Personnel, Barangay personnel that includes the Barangay Nutrition Scholars (BNS) and the Barangay Health Workers (BHW), NGO's and other individuals in proper maintaining the health of the people, by eating the right kinds of foods, proper exercise and healthy lifestyle. Various activities that were held by the Municipal Health Personnel, for the people of the Municipality by having informed them the importance on their health status, such as: health information and the implications to health in smoking.

As of the present, the LGU is very supportive on the allocation of the Municipal budget intended for the Municipal Health Office, by procuring branded medicines, supplies and other medical equipment to be used by the people of Banaybanay. Hence, Municipal Health personnel are on 24/7 alert in times of emergency. Likewise, all barangays in the Municipality have their own BHW's to cater to the needs of the people.

Table 2.4-5 Morbidity and Mortality Rate

Health Indicator	2008	2009	2010	2011	2012
Morbidity					
General Medical	9,810	8,870	10,777	9,683	13,801
Mortality					

Health Indicator	2008	2009	2010	2011	2012
Crude Death Rate (CDR)	4.43	3.62	4.25	3.79	4.24
Infant Mortality Rate (IMR)	3.4	3.54	7.07	11.36	1.16
Young Child Mortality Rate (YCMR)	7.94	10.64	9.43	15.15	4.66
Maternal Mortality Rate (MMR)	2.27	0	0	0	0

Table 2.5-6 Common Diseases including endemic diseases

1. Hypertension	14 M / 12 F	9 M / 10 F	7 M / 11 F
2. Pneumonia	12 M / 10 F	8 M / 10 F	19 M / 13 F
3. Myocardial Infarction	11 M / 7 F	8 M / 3 F	9 M / 3 F
4. Arteriosclerosis	3 M / 11 F	10 M / 7 F	0
5. Cancer all forms	7 M / 7 F	4 M / 9 F	7 M / 8 F
6. Congestive Heart Failure	4 M / 8 F	5 M / 2 F	7 M / 2 F
7. Diabetes Mellitus Type 2	7 M / 3 F	6 M / 3 F	8 M / 5 F
8. Chronic Obstructive Lung Disease	5 M / 2 F	8 M / 2 F	9 M / 4 F
9. Traumatic Injury 2 degree vehicular accident	5 M / 1 F	0	0
10. Bleeding Peptic Ulcer	3 M / 2 F	5 M / 2 F	0
11. Congestive Heart Failure	0	5 M / 2 F	7 M / 2 F
12. Sepsis	0	3 M / 3 F	3 M / 2 F
13. Acute Renal Failure	0	0	4 M / 1 F
14. Sudden Unexpected natural death syndrome	0	0	1 M / 4 F
Total	212	167	379

The company's Social Development and Management Plan (SDMP) is expected to augment delivery of health services in the form of Social and Health Programs to be funded by the Social Development Fund allocation of the project.

Environmental Health and Sanitation Profile

There are 8,736 households in all 14 barangays of Banaybanay having a water-sealed, sewer/septic tank, closed pit type of toilet.

Waste Generators and the households were requested to use Bayong or any other recyclable material instead of using cellophane while they were in the market places. Most households are practicing Segregation at Source and Waste Diversion through the application of the famous 3R's (Reduce, Reuse & Recycle) and composted Organic Wastes were being utilized as fertilizers.

RCMC will establish its Health and Safety Unit and implement a Safety and Health policy that aims to address, protect and ensure the general well-being of its workers as well as its host community. An Emergency Response Team (ERT) will be formed by the proponent to develop and implement emergency response action plans with the intent to partner with the LGU in terms of Emergency response, training and enforcement. The ERT will operate in coordination with the Government Agencies such as National Disaster Risk Reduction Team, the local PNP and the Barangay and Municipal Health Units.

2.4.7 Generation of Local Benefits from the project

Socio-economic data

Main Sources of Income

The municipality has a total of 676 number of employments. Wholesale Trade and Retail has 80 with 25 % employed. Banking and Finance has 46 with 15% employed. Real estate/construction has 10 with 2% employed. Service has 486 with 53% employed. Various others have 54 with 5 % employed.

Table 2.5-7 On Commerce and Trade:

Type of Classification Kind of Business and Trade	No. of Employment	Revenue (in pesos)	Population Served Market	
			Local	Outside (Export)
Wholesale Trade and Retail	**80**	25% - P 4,535,435.00	Local	Outside (Export)
Banking and Finances	**46**	15% - P 2,721,261.00	Local	
Real Estate/Construction	**10**	2% - P 362,834.00	Local	
Services	**486**	53% - P 9,615,122.20	Local	
Others	**54**	5% - P 907,087.80	Local	
TOTAL	**676**	100% - P 8,141,740.00	Local	

Table 2.5-8 On Education (Hiring of Teachers):

Level	Year 1-3 (2013-2016)	Year 4-6 (2016-2019)	Year 7 (2019-2020)	Year 8 (2020-2021)	Year 9 (2021-2022)	Year 10 (2022-2023)
Projected Enrollment						
Banaybanay Central Elementary School						
Classroom	36	37	38	38	38	39
Teacher	**40**	**41**	**42**	**42**	**42**	**43**
Cabangcalan Elementary School						
Classroom	9	10	11	11	11	12
Teacher	**9**	**10**	**11**	**11**	**11**	**12**
Caganganan Elementary						

Level	Year 1-3 (2013-2016)	Year 4-6 (2016-2019)	Year 7 (2019-2020)	Year 8 (2020-2021)	Year 9 (2021-2022)	Year 10 (2022-2023)
School						
Classroom	8	9	10	10	10	11
Teacher	**10**	**11**	**12**	**12**	**12**	**12**
Causwagan Elementary School						
Classroom	6	7	8	8	8	9
Teacher	**5**	**6**	**7**	**7**	**7**	**8**
Dinagsaan Elementary School						
Classroom	7	8	9	9	9	10
Teacher	**7**	**8**	**9**	**9**	**9**	**10**
E. Angala Memorial Sr. Elementary School						
Classroom	4	5	6	6	6	7
Teacher	**5**	**6**	**7**	**7**	**7**	**7**
HABES						
Classroom	12	13	14	14	14	15
Teacher	13	14	15	15	15	16
Looc Puntalinao Elementary School						
Classroom	10	11	12	12	12	13
Teacher	**13**	**14**	**15**	**15**	**15**	**16**
Mahayag Elementary School						
Classroom	6	7	8	8	8	9
Teacher	**7**	**8**	**9**	**9**	**9**	**10**
Maputi Elementary School						
Classroom	14	15	16	16	16	17
Teacher	**20**	**21**	**22**	**22**	**22**	**23**
Mogbongcogon Elementary School						
Classroom	14	15	16	16	16	17
Teacher	**16**	**17**	**18**	**18**	**18**	**19**
Panikian Elementary School						
Classroom	11	12	13	13	13	14
Teacher	**14**	**15**	**16**	**16**	**16**	**17**
Pintatagan Elementary						

Level	Year 1-3 (2013-2016)	Year 4-6 (2016-2019)	Year 7 (2019-2020)	Year 8 (2020-2021)	Year 9 (2021-2022)	Year 10 (2022-2023)
School						
Classroom	19	20	21	21	21	22
Teacher	**20**	**21**	**22**	**22**	**22**	**23**
Piso Camp Elementary School						
Classroom	15	16	17	17	17	18
Teacher	**18**	**19**	**20**	**20**	**20**	**21**
Rang-ay Elementary School						
Classroom	9	10	11	11	11	12
Teacher	**9**	**10**	**11**	**11**	**11**	**12**
San Roque Elementary School						
Classroom	6	7	8	8	8	9
Teacher	**7**	**8**	**9**	**9**	**9**	**10**
San Vicente Elementary School						
Classroom	9	10	11	11	11	12
Teacher	**10**	**11**	**12**	**12**	**12**	**13**
T. Patricio Elementary School						
Classroom	8	9	10	10	10	11
Teacher	**8**	**9**	**10**	**10**	**10**	**11**
Panikian National High School						
Classroom	8	9	10	10	10	11
Teacher	**12**	**13**	**14**	**14**	**14**	**15**
Puntalinao National High School						
Classroom	10	11	12	12	12	13
Teacher	**7**	**8**	**9**	**9**	**9**	**10**
Leandro G. Japos National High School						
Classroom	10	11	12	12	12	13
Teacher	**7**	**8**	**9**	**9**	**9**	**10**
Guinez National High School (Banaybanay National High School)						
Classroom	42	55	60	60	60	65
Teacher	**63**	**71**	**75**	**75**	**75**	**79**

Table 2.5-9 On Agriculture:

Occupation Groups	Location	Urban	Rural	Total
Crop farmers	municipal wide	3,256	5,289	**8,545**
Orchard farmers	municipal wide	60	160	**220**
Ornamental and Other	municipal wide	100	200	**300**
Plant Growers	municipal wide	90	10	**100**
Livestock and	municipal wide	180	240	**420**
Dairy farmers	municipal wide		10	**10**
Poultry farmers	municipal wide	12	30	**30**
Other Animal	municipal wide	6	8	**14**
Producers	municipal wide			
Aqua-farm cultivators (for Inland and coastal)	municipal wide	24	25	**49**
Waters Fishermen	municipal wide	751	359	**1,110**
Deep Sea Fishermen	municipal wide	0		**0**
Other farm workers	municipal wide	100	100	**200**
not elsewhere	municipal wide			
classified	municipal wide			
TOTAL		4,579	6,431	**10,998**

Table 2.5-10 On Industry:

Barangay	Industrial Establishment	Area (ha)	Intensity Classification	Capitalization	Employment
Poblacion	Angala & Sons Dev't. Corp.	2.0 has.	Medium Scale Industry	Above 15 M – 60 M	**8**
Poblacion	Viaro Rice Mill Corp.	3.0 has.	Medium Scale Industry	Above 15 M – 60 M	**30**
Poblacion	MBG Development Corp.	2.0 has.	Medium Scale Industry	Above 15 M – 60 M	**8**
Poblacion	Agway Rice Mill Corp.	1.8 has.	Small Scale Industry	Above 1.5 M – 15 M	**5**
Poblacion	BAFASHCO Rice Mill	2.0 has.	Medium Scale Industry	Above 15 M – 60 M	**5**
San Vicente	Andico Rice Mill	0.5 ha.	Cottage- Industry	Above P150,000 – 1.5 M	**4**
Cabangcalan	Ganar Rice Mill	0.5 ha.	Cottage- Industry	Above P150,000 – 1.5 M	**4**
Mogbongcogon	Dacaldacal Rice Mill	1.0 ha.	Cottage- Industry	Above P150,000 – 1.5 M	**4**
Mogbongcogon	BALURIMCO Rice Mill	3.0 has.	Medium Scale Industry	Above 15 M – 60 M	**20**
Calubihan	Cantiga Rice Mill	0.5 ha.	Cottage- Industry	Above P150,000 – 1.5 M	**4**
Calubihan	Deypalubos Rice Mill	0.5 ha.	Cottage- Industry	Above P150,000 – 1.5 M	**4**
Caganganan	Bagayas Rice Mill	3.0 has.	Medium Scale	Above 15 M –	**30**

Barangay	Industrial Establishment	Area (ha)	Intensity Classification	Capitalization	Employment
			Industry	60 M	
Caganganan	Gadiane Rice Mill	0.5 ha.	Cottage- Industry	Above P150,000 – 1.5 M	**4**
Rang-ay	Rang-ay Rice Mill	0.5 ha.	Cottage- Industry	Above P150,000 – 1.5 M	**4**
Panikian	Panikian Rice Mill	0.5 ha.	Micro –Industry	P 150,000 and below	**3**

Table 2.5-11 On various Economic Activities:

Economic Activities	Year 1 – 2012		Year 2- 2013		% Inc/(Dec) Over Previous Year	
	No. of Establishment	No. of Employment	No. of Establishment	No. of Employment	No. of Establishment	No. of Employment
Wholesale and Trade Retail	10	**50**	16	**80**	6.25% (+)	**6.25% (+)**
Hotel & Restaurant, Transport & Storage	7	**40**	7	**40**	0	**0**
Communication	2	**4**	2	**4**	0	**0**
Financial Intermediation	8	**33**	11	**46**	7.27% (+)	**7.17% (+)**
Real Estate Renting & Business Activities	2	**10**	2	**10**	0	**0**
Other Community, Social & Personal Services Activities	227	**299**	258	**486**	8.8% (+)	**6.52% (+)**
Education	2	**10**	2	**10**	0	**0**
TOTAL	258	**446**	298	**676**	22.32%	**19.94%**

Poverty Incidence

Based on 2013 results of the survey of the Banaybanay Nutrition Scholars (BNS) of the Municipality, it showed that 68.79% belong to poverty level.

Sources of Livelihood

The Municipality of Banaybanay has a vast area devoted to agricultural lands. The major agricultural crop is rice production with irrigated areas. Presently, based on the record of the Municipal Agriculture Office, the rice production area has more or less 2,021 hectares with a volume 17,139 metric tons harvested per cropping at a value of P 308,502,000.00. Most of this rice production is distributed in the local market, provincial and the regional areas of Mindanao. The areas intended for the hybrid seeds production has a total land area of 494.40 hectares with a total volume of 7.018739 percent or 1,043.53 metric tons harvested per cropping valued at of P 156,528,900.00, while the inbred rice production has an area of 70.60 hectares with a total volume of 1.002271 percent or 224.04 metric tons total valued of P 7,841,400.00, respectively.

On the other hand, the area devoted to coconut production has 4,245 hectares and the areas intended for orchard production is more or less 814 hectares, respectively.

The remaining area of 1,456 hectares is planted with commercial rice is the average production of which is 125 bags of 55 kilos per bag or a total of 6.87 MT per hectare. At today's price of P 20/ kilo, the average gross income/ hectare is roughly P 137,500 but with a net income of more or less P 82,500 after deducting all production expenses.

All the 14 barangays of the Municipality, have CARPable land areas. And these, are registered at the Department of Agrarian Reform (DAR). The CARP beneficiaries enjoy the benefit of their labor through their shares from the land owner whose land area they tilled.

In the year 2013, the livestock and poultry production of the Municipality are mostly on backyard raising. Based on record from the Municipal Agriculture Office, livestock production which is composed of cattle, carabao, goats & swine has a total number of 5,988 heads. While, on poultry production chicken and ducks has a total number of 15,407 heads. Most of these, poultry and livestock production are marketed at the local and provincial areas.

In the marine areas aquatic and inland fishing resources, the Municipality has been blessed by the Almighty all throughout the years to all the fisherfolks and the people living in the Municipality. Based on the official record, there is an approximate 4 kilos of fish catch of per fisherman per day, enough to sustain their daily income and their daily living expenses. In the 6 coastal barangays, there is an approximate 500 fisherfolks which are dependent on marine and aquatic including inland fishing. Mostly are engaged on small fishing practices using hook called "pasol" which could catch medium size fish using the small boat/banca as their means of going to and from their fishing area.

The current and pressing development problems and constraints being experienced by the agriculture sector inclusive of the fishery sector are oftentimes unpredictable trend of production which affect their income either of rice, corn, coconut & other crops, livestock and poultry, marine and aquatic resources through inadequate market linkages, inadequate capital resources and technology and agriculture employment and income opportunities. But the main culprits of these uncertainties are: seasonality of production and income, limited area per farmer and still going smaller, high cost of production, and in case of high production is lack of market linkages which manipulate the cost of farmers' products and the fishermen's catch. While nobody could manipulate the erratic climate changes which contribute to the high or low farmers production and fishermen's catch, support could be will be given them through proper intensive education on:

- Appropriate farming and fishing technology;
- Upgrade agriculture and aquatic production;
- Indigenous research and technology
- Revival of intercropping/multiple cropping system and
- Adequate financial & logistic support.

The Municipal Agriculture Office is bringing their technology and resources to the community, the farmers and the fisherfolks to be able to improve their way of living. In fact, for the upland and the lowland areas, massive implementation and enforcement of "no to burning of rice hays". On the fishery sector, implementing of the Bantay Dagat on the Municipal Fishery ordinance and the coastal environmental laws particularly the "no to entry of fishing on commercial fishers at the fishing zone within the municipal waters and the use of small fishing nets and gears" within the fishing limits and the use of "dynamite fishing". Yet many changes and improvement on the support system have to be done by the government in terms of technology & logistic. On the part of the farmers & fishermen, continuing education and learning by doing should be instilled even without support and assistance.

Banking and Financial Institutions

The banks in Banaybanay are One Network Bank, 1st TruBank Inc. and Rural Bank of Tagum which are all located in Poblacion.

Commercial establishments and activities

As of 2014, a total of 6.98 hectares have been utilized as commercial area. This figure does not include those being used as residential and at the same time commercial. Being primarily agricultural area, business usually becomes alive during planting and harvest seasons. However, commerce and trade tend to surge at present because of the influx of investors and the phenomenal development the Municipality had achieved under the present administration.

The type of commercial areas found in Banaybanay ranges from Wholesale, Retail, Formal Banking/Finance, Credit institutions, Informal credit, Hotel and Restaurant, Tourist resort establishments and cottages, Transport and Storage, Communication, Real Estate Renting and Business Activities, Education and Schools, Services like having businesses, recreational facilities, mini-stores and groceries, gasoline stations, water purifier, rice/corn mill and manufacturing establishments.

Enhancement of employment and livelihood opportunities

The Proponent is committed in finding the right balance between investing in the affected communities and meeting the needs of the company. They strive to maximize local employment and training opportunities to ensure local communities continuously benefited from the mining operations.

The Proponent will also provide training and development to grow the local workforce and create a positive employment relationship between the management and the local employees and improve their obligatory and statutory requirements performance by abiding to the requirements promulgated by the Philippine Mining Act of 1995 and its IRRs.

Based on the Company's Operational Procedural Manual on Recruitment and Selection, all applicants are directly hired by the Company's HR Management and they have devised certain policies and consideration on hiring employees. This policies, considerations and guidelines includes: Equal Employment Opportunity Policy; Employment Status Policy; Employee Re-hiring Policy; and Recruitment and Selection Policy. See attached **Annex** __, for further details regarding the Company's policy and guidelines.

- *Equal Employment Opportunity Policy*

The company shall follow all state and local employment law and is committed on implementing equal employment opportunity to employees and applicants and will not tolerate any form of unlawful discrimination. They are also committed in providing equal opportunity without regard to race, color, religion, national origin, sex, age, marital status, sexual orientation, disability, political affiliation, personal appearance, family responsibilities, matriculation or any other characteristic protected under state or local law. Each person is evaluated on the basis of personal skill and merit. If the management proved that a violation of this policy has occurred, it will take appropriate disciplinary action.

- *Employment Status Policy*

The Company has set out policies on employment status defining standard criteria for confirming the best qualified employee for the achievement of its operational strategic goals and objectives. Its employment classification provides a tool for effective manpower and organization management because it will set lay down standard benefit package for full-time regular employees and facilitates both the management and employees to understand the job content and requirements and shall provide a basis for determining status of the employee in the company on result of the evaluation of performance.

All qualified and hired applicants may be appointed on the following employment status recognized by the company under law in any circumstances of the operations. See **Annex __** for detailed defining criteria and determinants of employment status.

a. Emergency;
b. Fixed Term or Job Order;
c. Probationary;
d. Project based;
e. Regular.

- *Employment Re-hiring Policy*

As a principle, the company prefers not to re-hire employees whose employment had been terminated or had voluntarily resigned of their position. Further, any employee who have voluntarily resigned cannot be re-hired by the company within two (2) years from his/her resignation. But it is still the management discretion to exempt an employee after voluntarily resigning his position to be re-hired by the company.

- *Recruitment and Selection Policy*

The Company provides Equal Employment Opportunity to all, and does not discriminate on race, religion, sex, national origin, age or disability. The purpose of the recruitment and selection policy is to ensure that the Company hires the most suitable and qualified person for the position. Strategic recruitment allows the Company to find and attract the most suitable person for the position. It gives its full backing to the appointment of staff and personnel who will support the mission, vision, philosophy and values, to create a sustainable competitive advantage for the company. See **Annex __** for complete Recruitment and Hiring Guidelines of the company.

During the operations phase of the project, a total of 1000 personnel will be needed. If the residents at the Project area are not qualified for the positions available, the company will hire non-residents and this will contribute to the increase in population in the project area.

Increased business opportunities and associated economic activities

Aside from the employees to be hired, secondary business opportunities will draw more people to the project area.

Whenever there is economic benefit that can be derived from an activity, people follow the source of the activity. Allied business opportunities shall be created whenever there is movement of people from one place to another. The mining project does not only provide direct employment but also creates a multiplier effect on the following industries:

- Housing services. Workers who may be relocated from their permanent residence may rent temporary apartments or rooms that can be shared among other transients.
- Restaurant and catering business may experience a sudden increase in sales as those workers who will not opt to prepare their own food would look for a place to dine.
- Transportation services will increase creating routes from their residence to the point of convergence where they shall be picked-up by company-provided transport services.
- Basic utilities like water and electricity including other needs for communication, cable television, and internet.
- Livelihood programs for local cooperatives
- Other services including but not limited to laundry grooming, recreation and entertainment.

Increased revenue of LGUs

Taxes to be generated will include:

- Income taxes
- Excise tax
- Value Added Tax
- Customs duties and fees
- Registration of vehicles/equipment
- Local business tax
- Occupation fees

These will accrue to the local and national governments. Based on the Local Government Code of 1991, the local government of Banaybanay is entitled to the 40% of the excise taxes generated from the mining operations.

It is expected that in the long term, the economic benefits from tax revenues, the funds from the mandated services of the inter-agencies and the socio-economic benefits from the Mining law will be the main sources of funds to sustain the implementation of the Project with the continuing support of the LGUs and surrounding communities.

2.4.8 Traffic Congestion

Road Network / Systems

The road network in Banaybanay is consist of National road, Provincial road, Municipal road, Barangay road (rural), old logging road, NIA road, Barangay road (urban). Road surface type ranges from concrete, asphalt, gravel and earth. Pintatagan Bridge is located in Pintatagan. Mapagba and Maputi Bridges are in Maputi. Pongoton and Bucana Bridges are in Piso. Panikian, Kalangawan, Cugot A and Cugot B Bridges are all located in Panikian. Santos Bridge is in Calubihan and Mahayag Bridge is in Mahayag.

Transportation and Traffic Situation

Banaybanay Public Terminal which is located in San Vicente is a holding area for passengers who want to ride the buses, vans and tricycles. Buses and vans usually travel to very distant places like from Banaybanay to Davao City vv, to Mati City vv, to Tagum City vv and to other Davao Oriental cities and municipalities. Some of the vans and buses, just like tricycles, will also service the commuters to other barangays of Banaybanay and to other neighboring municipalities.

The onset of the mining operations will add not only to traffic in the barangays but will also take its toll on road deterioration. With the mining operations, the haul roads shall be widened and improved by ballasting. Whenever necessary, lay by area shall be provided for narrow passes and hard to negotiate turns. This would allow two vehicles on opposite directions to pass through with one vehicle staying on the lay by while the other vehicle passes by. Ballasting and crowning of the haul road would prevent water from soaking it thereby increasing mobility of all vehicles passing through the barangay road.

With the influx of additional equipment during the mining operations, traffic inside the mine site is expected to be moderate to heavy. A detailed traffic management strategy will be formulated to include schedule of work shifts, traffic route to and within the mine pits, deliveries and other related elements. Sufficiency of haul roads will be assessed to ensure that increased traffic volume is accommodated. Corresponding traffic signages such as directional, speed control & limits will be put up to guide the workforce. Maintenance of haul roads will also be programmed to assure optimum and safe movement of all equipment.

Likewise, the main access to the project site will be evaluated to assess sufficiency of its carriage to accommodate increased traffic volume during transport of mined materials. Specific routes will be monitored and in coordination with the LGU, will be maintained. It is proposed that alternative routes where public traffic will be very minimal be sourced to minimize effects to the community. Similarly, signages will be installed along public access to ensure safety.

Public awareness and behavioral modification programs will be included in the proponent’s IEC plan, to include public awareness to traffic signs and road rules and related concerns.

PERCEPTION SURVEY RESULT

SURVEY/INTERVIEW

The perception survey was administered to the identified Direct Impact Barangays of Banaybanay. Barangays Puntalinao, Kauswagan, Pintatagan, Maputi, Panikian and Mahayag using a survey questionnaire indicating their demographic characteristics, source of livelihood, income, and health perception about the project and their perceived negative and positive impacts.

Sampling Design

There are 126 total of respondents, which consists of 62 males and 64 females, including the Mansaka and Mandaya household. The respondents are the community decision-makers (Barangay Chairperson, Barangay Council Members, the Tribal Leaders and the multi-sectoral representatives.

DEMOGRAPHIC CHARACTERISTIC

Of the 126 respondents, majority (51%) of the respondents are women and (49%) are men. Majority of them 63% were born in their barangay. Less than half (49%) are in the productive ages 21 to 50 years of age. Sixty-four percent of their ethnicity is Cebuano while only 8% are Mandayas/Mansakas, the local; Muslims (Kalagans (5%). Many or 43% have had High School education, 27% elementary with only 22% having had college education. Almost all 83% are married having 44% of 1- 3 daughters and 44% of 1-3 sons. Half of the respondents (51%) have 2-5 members kiving with them

MIGRATION /SETTLEMENT

Some 28% have stayed in the barangay from 31 to 40 years. This clearly indicates that most of the barangay have migrated to these communities.

PERCEPTION

Majority 56% of the respondents know about the mining project. Knowing about it from Barangay Officials. Around 43% of respondents suggested on what should be done before the project starts. Survey (21%), information about the project in posters (27%). Thirty eight percent (38%) of the respondents indicated that mining would be able to provide jobs although many had no answers (37%). Some (24%) indicated mining is destructive to nature. These ambivalent responses from the respondents indicate their lack of better understanding of the mining process and their exposure to the mining practice of the previous mining company.

HOUSEHOLD INCOME

Many (36%) of the respondents’ livelihoods are farming with only 14% in fishing and also 14% in selling. Fifty- seven (57 %) have no other source of income. For those who have other source of income the husbands (48%) usually are involved. Many of the respondents (41%) earn P1, 000 to P4, 999.

COMMUNITY

Majority or 58% of the respondents see lack of livelihood as a big problem of the community. On the question of what has been done, majority had unrealistic answers. The questions that followed in relation to what they would suggest resulted to few answers and were focused on jobs.

LAND RESOURCES

Some (20%) are within the Ancestral Domain of which 9% have CADTI the rest are either tenants (12%), renting (12%), and the rest without answers or maybe there are informal settlers comprises 35%. Most of their crops are banana (22%), vegetables (18%), camote (11%) and others (18 %).

ENVIRONMENTAL SITUATION

Compared to ten (10) years, changes have affected the trees which is 64 %; animals & birds with 58%; water from deep well; water and fish in the river comprises 56 %; and fresh ness of the air comprises 53 %.

HEALTH SITUATION

In the past year, 66% of the respondents had family members who became sick, 33% of them had one family member who got sick and majority (29 %) had fever. Some of them (30%) seek medical attention from the Health Centers and others (21%) from the private clinics.

Table 2.5-12 POSSIBLE IMPACTS AND MITIGATING MEASURES

Development/ Construction Phase Potential Impacts/source	Proposed Options for Management Measures (Preventive and Mitigative)	Responsible Parties
Social Impacts		
1. <u>Psycho-social</u> • Fear and Insecurity due to bad experiences with previous mining companies, loss of farmlands and inequitable payment for the lease of the ancestral domain. (for the IPs) • Loss of farmlands for informal settlers farming in forest lands. • Political and economic influence • Land Slide/ soil erosion • Opportunity loss from agricultural income due to removal of crops and use of the land for mine development and road works	• IEC on the tenement covered by the MPSA, and identified Ancestral domain the nature and operation of the Nickel Mine and mitigating measures with comparative matrix of previous mining practice. • Establishment/enhancement /maintenance of information and publicity centers where stakeholders can access information on the performance of the mining project. • Implementation of SDMP will put into emphasis for a strong partnership and collaboration with the affected communities and other relevant stakeholders towards a sustainable development and empowered mining	• MPDO • Barangay LGU • RCMC Legal Office /COMREL

Development/ Construction Phase Potential Impacts/source	Proposed Options for Management Measures (Preventive and Mitigative)	Responsible Parties
	communities. • The proponent is committed in abiding and complying with RA 7942 to its vision to have a peaceful and progressive community sustained thru responsible mining. • Equitable payment of affected land according to the Mining Act and identified lease agreement of IPs within the Ancestral domain • Alternative farm land be identified • IEC on the nature and operation of the Mine and mitigating measures and the Mining Act IIR • Appropriate mitigating measures according to law. - R.A. No. 8749 (Philippine Clean Air Act of 1999); - Philippine Clean Water Act of 2004) - R.A 9003 Ecological Solid Waste Management	
Economic • Generation of employment	• IEC on nature of jobs the proponents require and qualification. • Consultation on job requirements and qualification • Local hiring priority for qualified barangay residents • Skills training to upgrade local skills of residents that can be hired by the project	• Barangay LGU • RCMC COMREL • TESDA/TLRC
Economic • Generation of livelihood opportunities by putting-up food stalls, variety stores and other services near the mining area and access road which might cause problems of congestion, peace and order and security breaches.	• Coordination with the Barangay LGU to ensure authorized establishments and control of unauthorized entry of outsiders as well as the management of waste. • Buffer zones should be established around the perimeter of the mines.	Social Development Plan • Barangay LGU & Tanods • RCMC Security Force • NCIP IPDP
Health and Safety	• Management of entry of	• Barangay LGU

Development/ Construction Phase Potential Impacts/source	Proposed Options for Management Measures (Preventive and Mitigative)	Responsible Parties
• Entry of migrant workers with families which might cause health problems due to diseases, overuse of public utilities /services, competition of resources, social conflicts, peace and order, increase in pollution due to solid and liquid wastes.	migrant workers. • Increase and train barangay tanods to be deployed in areas where migrant workers reside. • Proponent provide Health clinic with a Doctor, Nurse and Health workers • Health certificate for workers prior to hiring into the project • Partner with the LGU the implementation of the Social Development Program	• RCMC Security Force • RCMC Community Relations • NCIP IPDP
Health & safety • Increase in traffic flow causing air (dust) and noise pollution	• IEC on proper scheduling of hauler trucks to avoid entry & dismissal of school children and late hours. • Sprinkling of roads during dry seasons.	• RCMC Project Supervisors
Impact of climate change such as La Niña and El Niño	• Gender Responsive Climate Change Adaptation. DENR Special Order 2007-653, • R.A.10121 Gender Responsive for Disaster Risk Reduction Management in the Barangays of men and women • Community-based Adaptation measures include the active participation of men, women, elderly and the youth in protection of water aquifer, conduct of massive information and education campaign, • Establishment of protection measures for determination of areas most vulnerable to natural hazards “to forewarn people,” and strengthening the protection of ecosystems	• MRRMC • MHO • RCMC COMREL • MRRMC/BRRMC LGU • Barangay Tanod • Barangay Health Workers
Psycho-social • Fear of loss of ancestral domain	• Certificate of Pre-condition R.A.8371 (IPRA law) granted	• NCIP • Barangay LGU • RCMC COMREL/ Legal Office
Economic • Loss of Livelihood	• Certificate of Pre-condition R.A.8371 (IPRA law) • Item 3. Livelihood Projects	• NCIP • Barangay LGU • RCMC COMREL

Development/ Construction Phase Potential Impacts/source	Proposed Options for Management Measures (Preventive and Mitigative)	Responsible Parties
	- Ph 50,000.00 for livelihood	
<u>Economic</u> • Employment Opportunities	• Certificate of Pre-condition R.A.8371 (IPRA law) • Item 4. Employment Opportunities - priority to members who are qualified and fit - Shall not exceed 60% of labor force	• NCIP • Barangay LGU • RCMC COMREL

3. IMPACT MANAGEMENT PLAN

The Impacts Mitigation Plan (IMP) discusses the measures that will be implemented to mitigate or enhance the most likely environmental impacts mentioned in the preceding chapters. The procedure for implementation and the schedule are also detailed and described. The measures indicated in the plan have been drawn up jointly by the proponent and the preparer to sustain the quality of the environment in the area where nickel ore will be extracted.

In general, the Environmental Management Plan provides the framework for the proponent to deal with pollution risks associated with nickel mining. The IMP, in essence, describes the processes that the company will follow to maximize its environmental compliance and minimize the impact to the environment. The IMP contains the following:

- Impacts identification during different phases of the project;
- Environmental aspects that will be affected by identified impacts;
- Options to enhance or mitigate the identified impacts;
- Roles and responsibilities of entities to implement the mitigating or enhancement measures and monitoring thereafter;
- Schedule of implementation;
- Corresponding costs of identified mitigating measures; and
- Staff training and awareness.

Since the identified negative impacts cited in this study can be avoided or mitigated, the measures presented in the succeeding table intend to reduce the magnitude of specific impacts. The recommended measures were based on the experience of similar mining projects locally and around the world as well as the proponent's experience from previous years of operating the aforementioned project. On the other hand, positive impacts such as employment generation and additional income for the municipality in the form of taxes are enhanced to further maximize its benefits to the stakeholders.

During the operational phase of the project, implementation of the environmental management plan shall be the sole responsibility of the proponent.

Table 3-1: Summary of Predicted Impacts and Options for Prevention, Mitigation and Enhancement Impact Management Plan (IMP)

Project Activity	Potential Impacts	Option for Prevention, Mitigation and/or Enhancement	Target Efficiency	Mandated Agency / Office to Monitor Compliance
Pre-Construction Phase				
• Existing land condition due to previous Ni laterite mining and exploration	Land degradation as a result of landslides and erosion within the MPSA area due to unmaintained roads	• Prioritize the rehabilitation of existing roads, landslide areas and drainage canals	• 100% effectivity when rehabilitation is implemented	• Proponent • MMT
	Erosion of laterite stockpiles in Causwagan Block	• Cover stockpiles with plastic sheeting; construct perimeter sediment barriers; Divert upstream drainage away from the stockpiles; install drainage canals and settling pond;	• 100% no erosion	
• Site Preparation, Land clearing and levelling during road construction, rehabilitation of existing roads, and construction of temporary site facilities	Increased surface runoff velocity due to land clearing, land levelling for facilities and access roads Water ponding due to obstructions of waterways Flooding of some area due to temporary blockade of natural waterways during construction of roads Natural flow paths will be changed with the construction of new drainage lines	• Schedule land clearing and earth moving works during dry season • Prioritize the rehabilitation of existing roads and drainage canals		
Construction Phase				
Rehabilitation of access roads Construction of haul roads, waste dumps, siltation ponds, drainage lines	Steepening of slopes which will promote instabilities; Creation of level areas in waste dumps, stockyard, prepile yard, campsite which are prone to water ponding;	• Provide slope stability measures to prevent or minimize slope failure • Flat areas will have sufficient gradient to direct runoff towards drainage lines • Natural flow paths will be restored during rehabilitation; diversion canals will be redirected towards original natural waterways	• 100% no slope failure and no water ponding will occur	• Proponent / MMT

Project Activity	Potential Impacts	Option for Prevention, Mitigation and/or Enhancement	Target Efficiency	Mandated Agency / Office to Monitor Compliance
	Natural flow paths will be changed with the construction of new drainage lines Siltation ponds will introduce depressions in topography			
	Landscape disturbance will expose the soil and rocks to erosion; will disrupt natural drainage; will contribute to entrainment and transport of sediments	• Concrete-lined drainage canals will be installed to channel sediment-laden water to settling ponds; • Sediment traps will be installed along ditches to help in slowing runoff velocities and allow suspended sediments to settle; • In steep waterways or gullies coming from disturbed slopes, series of check dams will be installed to catch coarse sediments; • Active gullies will be stabilized;	• 100% no erosion	• Proponent/MMT
• Site Preparation • Land clearing • Earthworks • Civil works • Construction of access road	Physical disturbance to the terrestrial ecosystem due to construction and operational phase	• Vegetation that will be removed should be documented such that native trees should be replanted back or re-introduced to the site after all mining activities will end • Introduction of exotic tree species in reforestation activities such as Gmelina and Mahogany should be discouraged • Tree replacement should be in accordance to DENR Memorandum No. 2012 – 02. Species that will be used for tree planting / rehabilitation should be based on the species listing found in the Terrestrial Ecology section of this EIS	• 100% conduct of assessment and monitoring be strictly implemented. • 1:100 replacement ratio for cut or relocated trees • 100% employees/contractors informed about the local biodiversity	• DENR – Community Environment and Natural Resources Office • Multipartite Monitoring Team • Environmental Unit of the Company

Project Activity	Potential Impacts	Option for Prevention, Mitigation and/or Enhancement	Target Efficiency	Mandated Agency / Office to Monitor Compliance
		• Progressive Rehabilitation shall be done. Planting should start on at the edge of the active mine sites to create a buffer zone between the mine area and community/ecosystem. • Information drive on local biodiversity shall be conducted to all employees and contractors. This information drive should include the discussions on biodiversity, laws and regulations protecting biodiversity and the Environmental Management Plan of the company.		
• Site Preparation • Land clearing • Earthworks • Civil works • Construction of access road	Clearing of vegetation for the establishment of various facilities resulting to an increase potential of run-offs and soil erosion	• All drainages should be directed to a settling pond to allow silts to settle. These should be properly designed and can sufficiently accommodate and allow silt to settle before draining it bodies of water. • Bare areas after construction of facilities should be planted to hold the soil and prevent siltation	• 100% conformance to DAO 2016-18	• DENR – Environmental Management Bureau • Multipartite Monitoring Team • Environmental Unit of the Company
• Noise Generated from the heavy equipment	Noise disturbance to existing fauna causing in the decrease of biodiversity in the area	• Heavy equipment should be properly maintained to lessen the noise generation. • Planting should be done at the edge of the active mine sites to create a buffer zone between the mine area and community/ecosystem.	• Maintained or increase in biodiversity in the area (to be based on the baseline biodiversity indices)	• Environmental Unit of the Company • DENR – Community Environment and Natural Resources Office

Project Activity	Potential Impacts	Option for Prevention, Mitigation and/or Enhancement	Target Efficiency	Mandated Agency / Office to Monitor Compliance
• Land clearing • Earthworks • Civil works	Vegetation removal in certain areas may be required. This will result to intensification of run-off and soil erosion which affects the turbidity of the water which deteriorates the water quality. This latter alters the photosynthetic activity of phytoplankton and benthic flora, disrupting the natural physiological processes of aquatic organisms.	• Stockpiling of overburden and alike should be done away from waterways. This should be covered with water-repealing material to prevent erosion. • Drainage will be constructed surrounding the stockpile area and mine area which will be directed to a silt pond. This silt pond should be designed to allow the silt to settle. • The natural easement of river/creeks should be maintained and/or enhanced by introducing vegetation within the riparian zone. • Proper Land Management should be implemented during the construction phase. Erosion control measures such canals should be installed and as much as possible, the removal of vegetation should be minimized.	• 100% conformance to DAO 2016-18 • No development within the natural easement	• Environmental Unit of the Company
	Generation of Solid Wastes	• The company will promote the 3R's of solid waste management • Color-coded garbage bins/trash bins will be placed in relevant areas • A material recovery facility will be constructed in the Camp site for temporary storage of recyclable materials	• 100% in compliance with RA 9003	• Proponent / Envi Unit • DENR-EMB • LGU Banaybanay • MMT
	Generation of Hazardous wastes, used oil	• A storage facility will be constructed for proper storage of hazardous wastes. This shall be disposed through a DENR accredited transporter and t treatment storage and disposal facility. • A separate storage specifically design to store used oil from maintenance of vehicles and equipment shall be provided	• 100% in compliance with RA 6969	• Proponent/ Envi. Unit • DENR-EMB • MMT

Project Activity	Potential Impacts	Option for Prevention, Mitigation and/or Enhancement	Target Efficiency	Mandated Agency / Office to Monitor Compliance
		• Grease traps shall be installed at the drain pipe of kitchen sink to prevent discharge of oily wastewater.		
	Generation of sewage	• Concrete septic tank and wastewater treatment facility for domestic and laboratory wastewater shall be established; • Septic vault will be installed and the design of the septic vault for infectious wastes will be impermeability of flooring, fully concrete with plastered walls, floor and cover, and provision of detachable cover for access of disposing infectious wastes	• 100% compliance to RA 9275	• Proponent/ Envi Unit • DENR-EMB • MMT
	Generation of wastewater	• Effluent from domestic wastewater treatment facility and siltation ponds when discharge to the receiving water body shall conform to the standard prescribed in DAO 2016-08. • Provide drainage, catch basin, and siltation ponds • Oil and water separator will be provided • Treated wastewater will be used for dust suppression activities, maintenance of nurseries and rehabilitation areas, and reserved for environmental emergencies.	• 100% compliance to RA 9275	• DENR-EMB • Proponent/ Envi Unit • MMT
Operation Phase				
• Clearing and Grubbing	Exposure of surface to heavy rainfall will lead to erosion	• Limit disturbance and removal of vegetation within the identified mining area scheduled for operation	• 100% no erosion	• Proponent/ MMT
• Rehabilitation of existing roads and drainage systems	• Increased surface runoff velocity due to land clearing land improvement of drainage systems	• Scheduled repair and maintenance works during dry season		

Project Activity	Potential Impacts	Option for Prevention, Mitigation and/or Enhancement	Target Efficiency	Mandated Agency / Office to Monitor Compliance
	• Water ponding/flooding due to obstructions of waterways	• Regular clearing of natural waterways and drainage systems to avoid blockage and flooding		
• Construction of Benches in Mining areas • Removal of topsoil and overburden • Ore extraction and loading	• Steepening of slopes which will promote instabilities; • Fresh to slightly weathered bedrock will be exposed to different agents of weathering; water will infiltrate the fractures and accelerate weathering; will degrade the rock mass quality • Overburden and topsoil in waste dumps will increase lithostatic pressure in underlying rocks	• Design gradient of active mining pit is 10% on the average but can increase to 12 up to 15% depending on the deposit; gradient must not exceed the natural slope along the ridge (8 to 30%) • Implement progressive rehabilitation immediately in mined-out areas to restore natural cover; • Removal of overburden and topsoil from waste dump during rehabilitation will decrease the lithostatic pressure	• 100% effectivity	• Proponent
• Stockpiling in pre-pile yard and waste dumps • Ore hauling to and stockpiling in stockyard	Landscape disturbance will expose the soil and rocks to erosion; will disrupt natural drainage; will contribute to entrainment and transport of sediments	• Topsoil and overburden must be stored separately; • Design gradient of active mining pit is 10% on the average but can increase to 12 up to 15% depending on the deposit; gradient must not exceed the natural slope along the ridge (8 to 30%) • Drainage in active mining area will be built close to the mine pits to restrict runoff and stormwater coming from disturbed slopes and stockpile areas; • Waters will be channeled to settling ponds or sumps located in areas with	• 100% effectivity	• Proponent

Project Activity	Potential Impacts	Option for Prevention, Mitigation and/or Enhancement	Target Efficiency	Mandated Agency / Office to Monitor Compliance
		adequate space and appropriate elevation to allow sediments to settle; • Surface lining will be installed in settling ponds to prevent leakage or outflow of silt-saturated water; • Settling ponds will be constantly monitored and desilted periodically or after heavy rainfall events; • Contour bunds will be installed at the side of berms to reduce overland flow and direct sediments to drainage canals; • Silt fence will be installed at the perimeter of the mining pit; • In mining areas where overland flow can come from upslope, cut-off drains and diversion canals will be installed to divert the surface runoff away from active mining pits; • Series of settling ponds will be constructed at appropriate elevations with gentle and stable slopes to serve as the final interceptors of sediment-laden waters coming from the mining areas; • Regular monitoring and maintenance of these structures will be conducted;		
Stockpiling in prepile yard and waste dumps	Stockpiles will create mounds in the landscape which could be destabilized by heavy rainfall and earthquake;	• Limit the stockpiles to a stable height and gradient; stockpiles which will not be used immediately must be protected from rainfall by covering with plastic sheeting or stabilized using coco net and vegetation	• 100% avoid erosion of stockpiled materials	• Proponent
	Stockpiling of ore, topsoil and overburden in waste dumps, prepile yard and	• Stockpiles must be covered with plastic sheeting if it will not be hauled		

Project Activity	Potential Impacts	Option for Prevention, Mitigation and/or Enhancement	Target Efficiency	Mandated Agency / Office to Monitor Compliance
	stockpile yard will create slopes that are sources of sediments that will be eroded during heavy rainfall	immediately or during times of heavy rainfall; • Temporary perimeter sediment barriers such as silt fence or berms must be installed; • Ring bunds will be installed at appropriate locations in the waste dumps, prepile yard and stockyard to reduce overland flow and direct sediments to drainage canals; • Topsoil and overburden stockpiles thhat will not be used immediately must be stabilized with permanent vegetation together with coco coir mats;		
Ore hauling to and stockpiling in stockyard	Hauling of ores and wastes will promote wind transport of very fine sediments	• Regular watering of mine pit and hauling/access roads using truck-mounted water sprinkler system will be conducted;	• 100% no dust particles suspended in air	• Proponent
	Generation of Solid Wastes	• The company will promote the 3R's of solid waste management • Color-coded garbage bins/trash bins will be placed in relevant areas • A material recovery facility will be constructed in the Camp site for temporary storage of recyclable materials • Biodegradable wastes shall be disposed to a compost pit, this will enrich the soil and will be used in nursery of seedlings for rehabilitation. While residual wastes shall be disposed in the municipal landfill.	• 100% in compliance with RA 9003	• Proponent / Envi Unit • DENR-EMB • LGU Banaybanay • MMT
	Generation of Hazardous wastes, used oil	• A separate storage specifically design to store used oil from maintenance of vehicles and equipment shall be provided	• 100% in compliance with RA 6969	• Proponent / Envi Unit • MMT • DENR-EMB

Project Activity	Potential Impacts	Option for Prevention, Mitigation and/or Enhancement	Target Efficiency	Mandated Agency / Office to Monitor Compliance
	Generation of sewage	• Septic vault will be installed and the design of the septic vault for infectious wastes will be impermeability of flooring, fully concrete with plastered walls, floor and cover, and provision of detachable cover for access of disposing infectious wastes	• 100% compliance to RA 9275	• Proponent / Envi Unit • MMT • DENR-EMB
	Generation of wastewater and oily wastes	• Effluent from domestic wastewater treatment facility and siltation ponds when discharge to the receiving water body shall conform to the standard prescribed in DAO 2016-08. • Oil and water separator will be provided for the motorpool; Grease traps shall be installed at the drain pipe of kitchen sink to prevent discharge of oily wastewater. • Treated wastewater will be used for dust suppression activities, maintenance of nurseries and rehabilitation areas, and reserved for environmental emergencies.	• 100% compliance to RA 9275	• Proponent / Envi Unit • MMT • DENR-EMB
Sustenance of domestic water supply	• Increased demand of domestic water supply due to improved economic activities resulting to over extractions both from springs and groundwater. • Excessive groundwater extraction may induce salt water intrusion	• Protection and rehabilitation of the watersheds of springs to sustain/improve water supply • Monitoring of groundwater quantity and quality. Regulate extraction of groundwater	• 100% watershed sustainably and effectively managed	• Proponent / Envi Unit
• Site Preparation • Land clearing • Earthworks • Civil works	Decline of water quality in Pintatagan River and Davao Gulf	• Strict implementation of water quality monitoring of the established stations; • Strict compliance to DAO 2016-08	• 100% in compliance with DAO 2016-08	• Proponent Envi Unit / • MMT • DENR-EMB

Project Activity	Potential Impacts	Option for Prevention, Mitigation and/or Enhancement	Target Efficiency	Mandated Agency / Office to Monitor Compliance
Construction of access road				
Shipping and loading to mother vessel	Wind transport of very fine sediments	• An appropriate moisture content will be maintained;	• 100% no fine particles suspended in air during transport	• Proponent / Envi Unit
Rehabilitation Phase / Abandonment Phase				
• Reshaping of mined-out • Backfilling of overburden and topsoil	• Will lessen slope gradient; • Will remove the temporary mounds in the stock yards, waste dumps;	• Rebuild slope to a stable angle similar to the natural slope before mining • Backfilling of siltation ponds • Natural flow paths will be restored during rehabilitation; diversion canals will be redirected towards original natural waterways;		• Proponent • MMT
• Backfilling of overburden and topsoil	• Clayey soil will limit water infiltration to fractures and fresh rock;	• Topsoil and overburden will be compacted similar to compaction level before mining;		• Proponent
Construction of efficient drainage system lined with concrete	Will divert runoff away from unstable slopes and will reduce infiltration;	• Ensure that the drainage canals are wide enough to accommodate the common size of sediment and debris present;		• Proponent
• Installation of coco nets • Planting of fast-growing native vegetation	Will protect soil from erosion;	• Fence the newly planted area to minimize plant disturbance by animals and humans	• 100% protection from soil erosion	• Proponent
Decommissioning of siltation ponds	Will remove external load due to water and accumulated sediments	• Backfilling of siltation ponds once the mined-out area is completely rehabilitated; planting of native trees in abandoned siltation ponds		• Proponent • MMT
	Improvement of groundwater recharge from mine pits converted to lake/reservoir	• Planning and maintenance of the mine pits by the proponent before turn over to the community/LGU		• Proponent / Envi Unit • MMT

4. ENVIRONMENTAL RISK ASSESSMENT (ERA) and EMERGENCY RESPONSE POLICY (ERP) AND GUIDELINES

4.1 Environmental Risk Assessment (ERA)

The Environmental Risk Assessment (ERA) in the context of Philippine EIS System (PD 1586) is concerned with human safety where risks are characterized by probabilities, consequences, accidental nature, and acute effects. The Revised Procedural Manual (RPM) of DENR Administrative Order (DAO) 2003-30 defines ERA as "a process of analyzing and describing the risks associated with a project or activity to ecosystems, human health and welfare".

The preparation of the Environmental Risk Assessment is characterized by three (3) levels. Under the guidelines in the DENR DAO 2003-30 they are leveled as:

a. Level 2 – for facilities that will use, manufacture, process or store hazardous materials in excess of Level 2 threshold inventory shall be required to conduct a Quantitative Risk Assessment (QRA) and prepare an Emergency/Contingency Plan based on the results of the QRA.

b. Level 1 – for facilities that will use, manufacture, process or store hazardous materials in excess of Level 1 threshold inventory shall be required to prepare Emergency/Contingency Plan based on the worst scenario.

c. Risk Screening Level – specific facilities or the use of certain process shall require the conduct of a risk screening study even the projected or estimated inventory does not reach threshold.

In order to conduct an ERA, the determination and coverage of the risks where identified. In the DENR DAO 2003-30 RPM Annex 2-7e are the activities that needs to undertake screening. The proposed project is an extraction process.

RCMC is committed to a safe and healthy working condition in its operations. The proponent aims to develop, enhance, promote and maintain safe and productive work practices and adhere to the highest standards of occupational safety and health for its human resources and vessels.

Generally, risk assessment identifies and assesses the potential risks to human health and safety. It is also intended to assess the proposed safety management schemes that would minimize if not eliminate such hazards and risks. The general risk assessment process is shown in **Figure 3-1**.

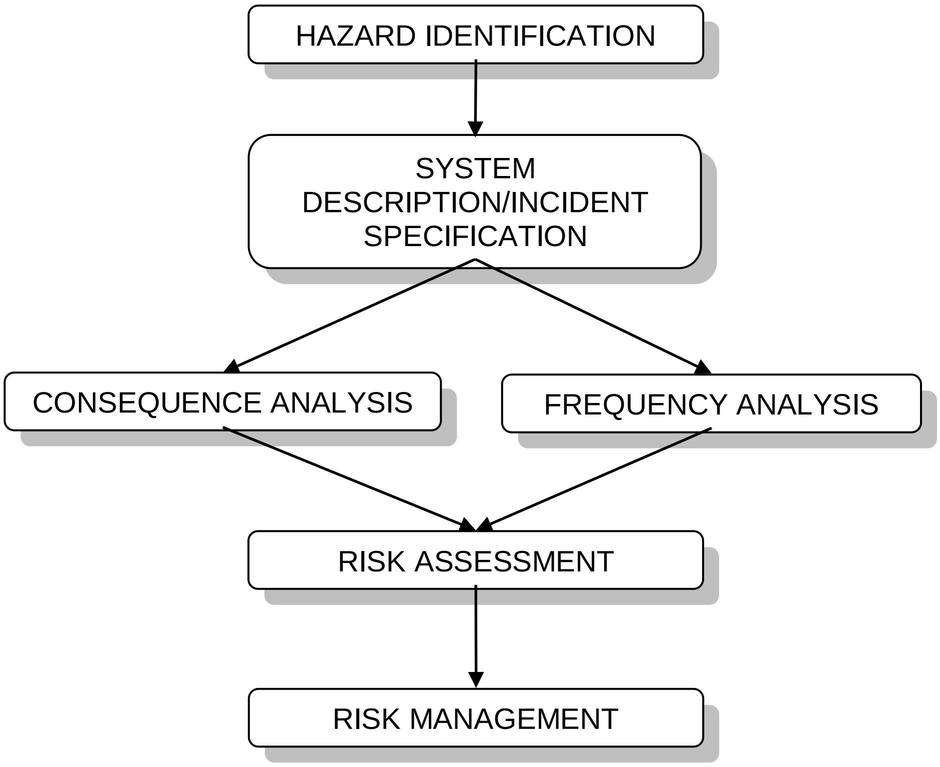


Figure 4-1: Flow Diagram of the Risk Assessment Process

Hazard identification is the first step in the risk assessment process. It involves the identification of all possible events or processes that could lead to disastrous or fatal incidents. It also entails defining the inherent and potential hazards of the substances or materials used, as well as process hazards with potential to adversely affect project personnel, the public, and the environment.

Consequence analysis is the second step, involving the estimation and/or assessment of the effects or results of an incident. It uses models beginning with release rates calculations, dispersion and physical effects.

Frequency analysis is the third step and may be defined as the estimation of the likelihood of occurrence of the identified hazard.

Risk is the product function of the frequency and consequence analyses.

Risk assessment is defined as the examination, analysis, evaluation, and estimation of an adverse or undesirable event occurring in a given project area which could cause unacceptable impacts or results, expressed as fatalities per million per year.

Risk management encompasses the risk assessment process. It is the term applied to a logical and systematic method of identifying, analyzing, assessing, treating, monitoring and communicating risks associated with any activity, function or process in a manner that would enable one to minimize losses and maximize opportunities.

Risk is defined as a measure of potential human injury/ death, economic loss, or environmental damage in terms of the probability of the loss, injury/ death or damage occurring and the magnitude of the loss, injury/ death or damage if it occurs. It is the product of the calculated consequence of a postulated accident scenario and the probability or frequency of occurrence of such event. Table 3-1 summarizes the definition of other terms as used in this report.

Table 4-1: Terminologies Used in this Report

TERM	DEFINITION
Accident	Specific unplanned event or sequence of events that has a specific undesirable consequence. Most accidents are caused by the failure of people, equipment, supplies or surroundings to behave or react as expected.
Consequence	The result of an accident. In this document it is the ultimate outcome of an accident. It is expressed in terms of fatality, health effects, and economic loss.
Event	Refers to an accident either as the cause or a contributing cause to an accident.
Hazard	Characteristic of the system/ plant/ process/ substance that represents a potential for an accident or an adverse effect on the public or the environment. It is the combination of a material and an operating environment such that certain unplanned events could result in an accident.
Hazardous	Capable of posing an unreasonable risk to health and safety or capable of doing harm.
Major Hazard	Any hazard which can result in accidents affecting persons outside the facility fence (off-site).
Probability	An expression for the likelihood of occurrence of an event or an event sequence during an interval of time.
Toxicity	The ability of a substance to produce injury by non-mechanical means once it reaches a susceptible site in or on the body.
"Worst Case" Consequence	Conservative (high) estimate of the consequences of the most severe accident identified.

Identification of Risk

It is the company's objective to integrate total loss control into the management system so that people, equipment, materials and the environment are amply protected from accidents and the hiring of line managers that will take direct responsibility in pursuing the objectives and standards.

For this particular project, risks that may compromise the Safety & Health of the workers range from:

- Erosion
- Risk due to weather conditions, storm surge and tsunamis;
- Earthquake
- Fire;
- Wastes substances;
- Pollution;
- Security Risk

Emergency Preparedness

To comply with Rule 637 of DENR Administrative Order 2000-98, RCMC shall prepare an Emergency Response and Preparedness Program (ERPP) covering its operations.

The coverage of the program shall initially cover identified risk inherent to the operation. Scenarios shall be prioritized in its likelihood to occur as well as the mitigation to be introduced to counter it. The persistency of any scenario despite of the mitigating measures to be incorporated shall be the subject of emergency response and preparedness drills that shall be conducted by RCMC in accordance with the existing statutory requirements.

The ERPP Program shall include the following:

1. Organization of crisis management group;
2. Purchase of appropriate logistics/equipment;
3. Provision for alarm/warning system;
4. Formulation of procedures or protocols to address the perceived threats/scenarios;
5. Selection and training of response teams in emergency procedures; and
6. Conduct of emergency response and preparedness drills.

For the Emergency response plan flow, please refer to **Figure 4.2**.

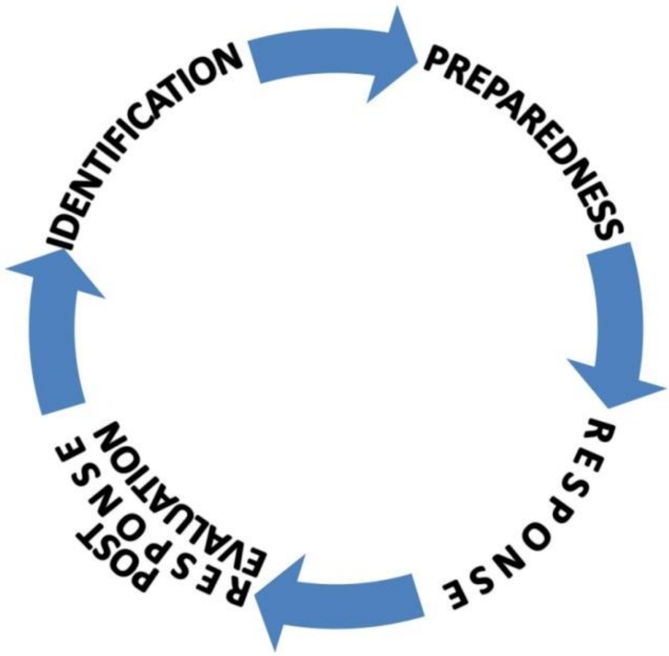


Figure 4.2 Emergency Response Plan and Flow Diagram

4.2 EMERGENCY RESPONSE POLICY AND GUIDELINES

4.2.1 Safety & Health and Environment Policy

Workplace safety is an important company goal. RCMC's Safety and Health programs involve every level of the organization, instilling a culture that reduces workplace accidents. Individuals within the organization have the right to a safe and healthy workplace with each person accepting personal responsibility ensuring and protecting the safety and health of others.

Riverbend Consolidated Mining Corporation (RCMC) pledges sustainable development and social responsibility through an environmentally sound mining operation through its conformity to Philippine Mining and Environmental Laws, pollution, prevention, control, environmental rehabilitation and information dissemination.

4.2.2 Emergency Response Policies and Guidelines

The General Safety Rules will be drafted outlining the standards of behavior at the workplace by prohibiting certain behaviors/work practices. The safety rules shall be issued to all employees and contractors and shall be included in the induction of new employees.

RCMC's corporate value of **"Prioritizing Life and Safety"** shall be the foundation for the commitments and outcomes towards the company's leadership focusing the achievement of Excellence in Health and Safety, aligned with the company's Code of Ethical Conduct**.**

Hence, to achieve excellence in Health and Safety, RCMC is committed:

- **To manage all risks,** as reasonably as possible, that are associated with its activities, processes, facilities, products or services.
- **To focus on prevention** strategies in the management of risks to the Health and Safety of people and the Safety of facilities;
- **To comply with Health and Safety** compulsory and voluntary legal requirements;
- **Continuous Improvement** in Health and Safety performance through the development of an effective Health and Safety management system, focusing on innovative solutions and people development;
- **To assure the evolution of service provider's Health and Safety performance;**
- To establish communication channels with the communities where RCMC operates and other stakeholders, in order to keep continually abreast of the influence of its operations in the health and welfare of people.

4.2.3 Identification of Potential Emergencies

Emergencies are sudden conditions or state of affairs that are caused either by natural forces or man-made that calls for immediate action so us to prevent or minimize the destructive effects to the people, property and to the environment.

As an initial step to develop effective and workable response policy, the possible emergency scenarios that could possibly occur during the operation of the project are identified and tabulated in **Table 4-2** below.

Table 4-2: Possible Emergency Scenarios

Possible Emergency Scenario	Possible Cause	Destructive / Negative Effects
1. Fires	Man made	Partial or total loss of properties such as building, equipment and machinery. Injuries and loss of lives of personnel.
2. Storm	Natural Calamity	• Partial or total destruction of properties and facilities. • Injuries and fatalities to Workers and resident of the

Possible Emergency Scenario	Possible Cause	Destructive / Negative Effects
		surrounding communities. • Loss of lives and properties including resident/s in the surrounding communities.
3. Hazardous (waste e.g. used oil) Material Spills	Man made	Pollution of the river system.
4. Security Related Emergencies	Man made	Injuries and fatalities to workers Partial or total destruction of properties.
5. Earthquake	Natural Calamity	• Injuries and fatalities to personnel and the people in the surrounding communities. • Partial or total destruction of facilities. • Injuries and fatalities to personnel and people in the surrounding communities.
6. Collapse of Mine Workings/Benches	Natural Causes / Man made	Rock falls during mining operations. Landslides in the mining area. Loss of lives and properties. Adversely affect the environment.
7. Siltation Pond Facility Incident	Man-made/ Natural Calamity	Pollution of the river system.

4.2.4 Safety Organization

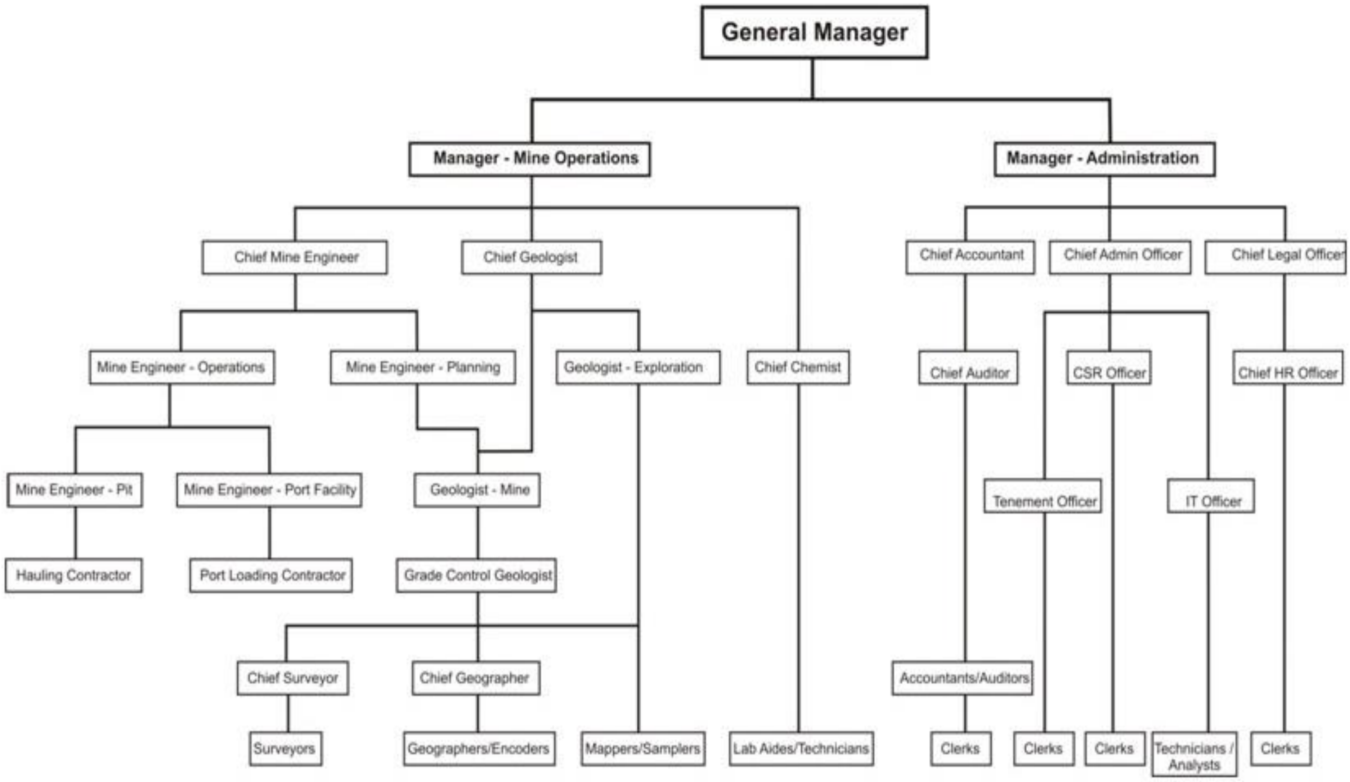


Figure 4.2 Organizational Chart

Responsibilities of the Safety Officer/s

- Formulate emergency response and disaster plan.
- Investigate and make report of inspection and inform the ESHS Manager the unsafe acts and conditions prevailing thereat.
- Keep to assist, advise or guide the employer in complying with the provisions of this Standards, including the development of health and safety programs;
- To make at least a quarterly appraisal of programs and safety performance of the establishment, including the activities of the safety committee;
- To be present during scheduled safety inspection by authorized government agents, and during regular safety committee meetings;
- Serves as Secretary to the Central Safety and Health and Committee meeting. As such, he shall:

    a. Prepare minutes of meetings;
    b. Report status of recommendations made;
    c. Notify members of the meetings; and
    d. Submit to the employer a report of the activities of the committee, including recommendations made.

- Acts in an advisory capacity on all matters pertaining to health and safety for the guidance of the employer and the workers.
- Conduct walkthrough inspection with project safety team.
- Strictly monitor the Contractor's Construction Safety and Health Program for particular project.
- Conducts investigation of accidents as member of the Health and Safety Committee and submits his separate report and analysis of accidents to the employer.
- Coordinates all health and safety training programs for the employees and employer.
- Conducts health and safety inspection as member of the committee.
- Maintains or helps in the maintenance of an efficient accident record system and coordinates actions taken by supervisors to eliminate accident causes.
- Provides assistance to government agencies in the conduct of safety and health inspection, accident investigation or any other related programs.
- For purposes of effectiveness in a workplace where numbers of full-time safety man are required base of OSHS in hazardous workplace, he shall report directly to the ESHS Manager.
- Prepares and submits weekly accomplishment reports to ESHs Manager, for reference & information of General Manager.
- The duty Safety Officer shall submit Safety Observation Report (SOR) daily to Duty Safety Superintendent for information and reference of Safety ESHS Manager information
- One Safety officer assigned for every ten (10) heavy equipment assisting the Heavy equipment in-charge in compliance to DOLE DO 13. Series of 1998.

Central Safety and Health Committee

The Central Safety and Health Committee are composed by:

Chairman	:	General Manager
Co-Chairman	:	Department Managers
Secretariat	:	Safety Manager
Members	:	Department Managers
		Physician
		Company Nurse
		Security In-charge/manager
		Supervisor's/Foreman representative
		Worker's Representative
		Contractors
		Union representative, if necessary
TWG	:	Compose of Safety Officer, PCO, Nurse, HR representative

4.2.5 Emergency Response Procedures

The Proponent will establish a disaster management program in coordination with the local government. The program will include first-aid and medical emergency plans, set-up of a medical clinic within the project site, mechanisms for referrals and utilization of local health units and hospitals in the event of disasters and emergencies, preparation of disaster management plan and a health risk communication plan for the affected communities.

The Proponent will also develop and implement a recording and reporting system for monitoring, conducting consultative meetings with stakeholders in resolving issues and conflicts regarding safety, health and environment. It will also observe safety and health policies, emergency response and accident reporting policies in accordance with prevailing mining laws.

The Proponents intends to implement enhanced safety, environment and health policies particularly in the area of awareness and prevention. With the influx of additional manpower due to its operation, the following shall be implemented:

- The safety and health committee shall implement additional programs that will bring more active participation and awareness of its workers including its contractors on safety and emergency measures;
- Regular evaluation on the efficiency of its safety and emergency policies and procedures;
- Introduce new and updated modules on health, safety and emergency response trainings and seminars;
- More frequent conduct of safety drills; and
- Procure additional safety and emergency equipment as a result of the expansion of the operation.

4.2.5.1 Accident / Incident Investigation and Reporting

Submission of documentation of General accident/incident report

- All accident/incident including near miss incident occurs must be reported within 24 hrs. to RCMC Safety department.
- Accident/incident report submitted by concern department/person must specify the route cause and submit preventive recommendation measure so that it will not happen in the future.
- All accident/incident must discuss to Central Safety and Health Committee (CSHC) meeting during discussion.
- RCMC ESH Manager must submit monthly CSHC minutes of meeting to MGB Regional Office and DOLE regional officer near the area.
- All work accidents or occupational illnesses in places of employment, resulting in disabling condition or dangerous occurrence as defined in Rule 1053.2 shall be reported by the employer to the Regional Labor Office or duly authorized representative in duplicate and a copy furnished the employee or his duly authorized representative using form DOLE/BWC/HSD-IP-6.
- The formal report shall be submitted by the employer on or before the 20th day of the month following the date of occurrence of the accident or when the illness, is established and an investigation report in the prescribed form shall be submitted by the Regional Office or duly authorized representative on or before the 30th day of the same month.
- In case of temporary total disability where the injured or ill employee has not reported back to duty on the closing date of reporting, an estimate of the probable days of disability shall be made and entered in the report and corrected after the return of the injured. In all computations, this estimate shall be used. After the return of the injured, the corrected days of absence shall be used.
- Where the accident or fitness results in death or permanent total disability, the employer, in addition to the written report required under sub-paragraph (1) above, shall initially notify the Regional Labor Office or duly authorized representative within twenty-four (24) hours after occurrence using the fastest available means of communication.
- All deaths and permanent total disabilities shall be investigated by the Regional Office or duly authorized representative within forty-eight (48) hours after receipt of the initial report of the employer, prepared in duplicate using the prescribed form DOLE/ BWC/OHSD-IP-6a.

Upon receipt of the accident report, the accident/investigation committee shall conduct further investigation and submit **initial and** final report to various concerned departments and agencies such as the Mines and Geosciences Bureau (MGB), Department of Labor and Employment (DOLE), Philippine National Police (PNP) and concerned Local Government Unit (LGU). Accident/incident investigation will include all near-miss accidents, first aid cases, disabling and non-disabling injuries, property damages and occupational illness.

4.2.5.2 Natural Emergencies, Calamities or Disasters

General Procedures

4. In case of Typhoon:

- After being informed of the typhoon, all concerned employees shall immediately undertake the following procedures:
- Secure all equipment, tools and other devises and materials needed in the performance of assigned task of which could be affected by the typhoon.
- Secure all files, papers, plans, drawings, and other important documents of which could be affected by the typhoon.
- Keep all precision instruments, motors, machinery, stocks and other commodities from being damaged by water and wind.
- Stay away from tree which may be uprooted of blown by heavy winds.
- Stay clear from sliding portion of hills and ridges.
- Stay away from creeks, gullies and other places where there is danger of mudflow, flood or both.
- If it cannot be avoided to work outdoors employee must have at least one (1) companion. Working alone outdoors in a stormy weather is risky.
- Always keep in touch with the supervisors or the General/Department Managers.
- In order not to disrupt the operations, workers must stay in their post until properly relieved and or have been given permission by their immediate supervisor.

b. In case of Earthquake:

- Earthquake occurs without warning and affects large areas. It is the obligation of all employees to familiarize themselves with the following procedures:
- Pre-select a safe area in the workplace of which is automatically occupied in case of earthquake occurrence.
- Remain calm. Never panic.
- Turn off gas appliances. An earthquake can turn into a major disaster if it causes a fire.
- If inside the building during earthquake:
- Take under a heavy furniture piece, like a table, bed or couch that will absorb the shock of falling object, walls and the like.
- Stay away from glass windows or under electrical fixtures.
- Open all doors and windows to secure an exit. It is difficult to go outside later if doors or windows are warped in an earthquake or when fire occurs.
- Do not go outside in panic. Being outdoors can be dangerous because it is likely exposed to broken pieces of glass, and falling objects.
- If outside the building, in the road, between tall structures or near high bank/bench:
- Take cover under any strong structures until tremors subside.

- Stay away from hanging objects and move further away from heavily cracked and slabbing benches and road shoulders.
- Beware of electrical posts and wires, billboards, street signs and the like.
- Walk to the evacuation site. Driving would be more dangerous.
- Protect head with a helmet or skull guard.
- If inside a moving vehicle, stop the vehicle in a safe place away from tall structures tending to collapse.

c. In case of Fire:

- If a fire is discovered, extinguish the same using fire extinguisher or call the Fire Department immediately if it seemed uncontrollable. Do not panic and evacuate the premises calmly.
- Alarm and notify all people around about the existence of the fire and where it is located.
- In case of fire, the smoke is more dangerous than the flames. Keep down on the floor to avoid inhaling smoke. Cover mouths with a wet towel or handkerchief then proceed to the nearest safe exit. Crawl if necessary, since smoke tends to rise above the floor.
- If the stairs cannot be used, leave building via a fire escape or evacuation device usually installed in the balcony.
  - Do not worry about the physical appearance or the personal possessions or valuables. Evacuate quickly and do not attempt to return.
- In case of fire in the office, evacuation of company properties shall be determined according to priorities.

To prevent any downgrading incident resulting from any kind of emergency, it is very important to remind employees to always be calm, composed and never panic whenever an emergency occur.

D. In case of Tsunami:

Company employees as part of its Emergency Plan shall observe the following measures before, during and after a tsunami:

Before a Tsunami

- The company will obtain data from the NDRRMC about tsunami risk and local warning arrangements.
- Develop Emergency response Plan and have a getaway ready.
- Prepare evacuate procedure and protocol
- Prepare water and foods for 1week
- Prepare basic equipment to be use
- Prepare basic hygiene and sanitation
- Prepare basic cooking and utensils
- Prepare medical supplies
- Team leader must have ERT Check list at all time

During a tsunami

- Employee will take getaway kit with them if possible, never to travel into the areas at risk to get kit or belongings.
- Move immediately to the nearest higher ground, or as far inland as possible. Evacuation maps are present and follow the routes shown.

- Walk or bike if possible and drive only if essential. If driving, keep going once well outside the evacuation zone to allow room for others behind.
- If tsunami cannot be escaped, employee will go to an upper storey of a sturdy building or climb onto a roof or up a tree, or grab a floating object and hang on until help arrives.
- Boats are usually safer in water deeper than 100 meters than if they are on the shore. Move boats out to sea only if there is time and it is safe to do so.
- **Never go to the shore to watch for a tsunami.** Stay away from at-risk areas until the official all-clear is given.
- Listen to local radio stations as emergency management officials will be broadcasting the most appropriate advice for the community and situation.

After a tsunami

- Continue to listen to the radio for civil defense advice and do not return to the evacuation zones until authorities have given the all-clear.
- Be aware that there may be more than one wave and it may not be safe for up to 24 hours, or longer. The waves that follow the first one may also be bigger.
- Check yourself for injuries and get first aid if needed. Help others if you can.
- Do not go sightseeing.
- When re-entering homes or buildings, use extreme caution as floodwaters may have damaged buildings. Look for, and report, broken utility lines to appropriate authorities.

4.2.6 Employees Training Program Needs

<u>Pre-Employment Policies and Orientation</u>

All newly hired employees will be subjected to physical examination prior to their employment to be conducted by a physician free of charge to the employee. This will include eye examinations, urinalysis, chest x-ray, blood chemistry, drug testing and ear examination to determine the capability to discharge his duties once employed.

During employment or before a newly hired worker can be assigned to his work, the following orientation topics will be discussed:

- Basic safety orientation
- Hazard awareness and reporting
- General safety rules and regulations
- Organization safety and health policy
- Legislative requirements
- Company policies on the rules of conduct and behavior
- Separate safety orientation for contractors with corresponding penalty

All applicants for possible hiring/employment with the company will be required to submit their resume for evaluation and verification from the previous employer/s and to check their performance and capability of the position applied for.

Applicants for mobile equipment operator will be required to present driver's license as a requirement in hiring operators of mobile equipment.

Information checks with former employers and other references of operators of all mobile equipment and critical machinery are being made to determine past performance.

All foreign staff shall be required to submit proper working permits prior to engagement. They shall likewise undergo a cultural orientation to facilitate the employee's immersion to his work environment.

The following essential comprehensive training and relevant general instruction and information shall be taken by the respective employees in order to be efficient in dealing with their jobs:

General/Department Managers and Staff Members

- First Aid and Basic Life Support training
- Fire Fighting
- Personal communication technique
- Equipment safety and operating principle
- Fire protection and safety
- Proper job analysis and standard job procedure formulation
- Confine Space Entry
- Basic Electrical Safety Training
- Basic Occupational and Health Training
- Construction Safety and health Training
- Basic Occupational Health training for Nurse (OHNAP)
- Loss Control Management for Safety Officer supervisory level II
- Training of Trainers for Supervisory and Managerial position
- Basic safety orientation for all workers including contractor/s workers
- Fire Safety Training
- Defensive driving training
- Competency Training for Skilled workers and Heavy equipment operators

PPE Standards/Rules and Procedures

- All PPEs used in the project site must be approved by RCMC safety department before recommend to purchasing department.
- All PPEs used in the project site must be ANSI standard.
- All suppliers must have updated Approved accredited testing center by DOLE/BWC
- Standard PPE shall be provided free of charge to everybody upon employment and always be made available to all employees.
- Workers are required to wear prescribed PPE all the time while at work.
- Wearing of standard PPE shall always be enforced and failure to follow this rule will be dealt with accordingly.
- RCMC shall have to maintain spare PPE in good condition and ready for issuance all the time.
- Equipment is replaceable free of charge until such time as specified herein or when damaged while performing his normal duty.
- Employee/s shall be charged with corresponding amount due to loss or damage of equipment/s because of negligence or due to some other unreasonable circumstance/s.
- PPE such as for respiratory and eye protections required for employees shall be given special attention.
- Employee/s shall be properly instructed in the need and use, cleaning and proper maintenance of PPE. Reminders shall be done during safety meetings and pep talks.
- PPE standards, rules and procedures shall be translated into sufficient languages so that all employees will understand.
- Proper storage facilities for PPE shall be provided
- All PPE items shall regularly be maintained and in good condition.
- Monthly inventory of PPE shall be maintained and kept at the company field office.

Enforcement of Standards

The following standard protective equipment showing its percentage applicability (PA) to the total workforce and corresponding frequency of issuance consistently is enforced.

- Head protection – skull guard shall be worn at all times within the hardhat area as specified by the safety department.
- Respiratory protection – respirators shall be distributed to employees particularly the drill rig operators who are exposed to dusts.
- Toe/leg/in step protection – rubber boots and/or steel toe shoes shall be issued. Wearing of safety rubber boots/safety shoes are applicable both in operation and maintenance group.
- Eye protection – face shield, welding mask and eye goggles shall always be worn while welding, grinding and cutting. It shall be replaced at once when damaged or worn out.
- Hand/arm/chest/body protection – welding gloves and apron and rubber gloves and raincoats shall be provided to welders. It shall be replaced at once when damaged or worn out.
- Hearing protection – earmuffs or earplugs shall be provided to the employees to reduce excessive sound level during drilling. Issuance of their ear protection for the employees involved with very high sound level is a must to eliminate ear injury to the workers.

Health Control and Services

Below are listed some of the potential health hazards and their corresponding preventive controls:

Table 4-3: Potential hazards and Preventive Controls

Potential Health Hazard	Preventive Controls
Dust, fumes and gases	Use of PPE, adequate ventilation
Excessive noise	Use of PPE
Oil spills	Proper housekeeping

Following are the types of controls being applied for identified hazards as appropriate:

Engineering Controls

- To maintain and disseminate proper work standards, specifications and/or design criteria to the workers.
- To isolate or enclose dangerous processes and/or machines.

Work Practices

Adhere to the strict implementation of standard work procedures, rules and regulations.

Administrative Controls

- Strictly enforce the established safety rules and regulations and the safety and health/loss control program.
- Conduct regular monthly meetings and daily pep talks.
- Employees' education and training relative to safety and their respective specific trades.

First Aid Facilities and Equipment

First aid station/s equipped with a first aid cabinet with adequate supply of medicines shall be in place. The treatment station is posted with a directive to report injury/illness and is readily accessible to ensure immediate treatment of injuries. An ambulance provided with support of other service vehicle in the project site.

4.2.7 Program Evaluation System

The following elements are included in a comprehensive audit of management's compliance with the standards of the safety and health/loss control program at least yearly.

- Leadership and administration
- Planned inspection
- Job/task analysis and procedures
- Accident/incident investigation
- Emergency preparedness
- Organizational rules
- Employee training
- Personal protective equipment
- Health control and services
- Personal communications
- Group meetings
- Purchasing and engineering controls
- General promotions
- Hiring and placement
- Records and reports
- Accident/Incident analysis
- Program evaluation program
- Off-the job safety

Annual comprehensive audit is conducted to determine management compliance with organizational and legislative standards for general physical conditions.

4.2.8 General Safety Promotion Program

a. Safety Bulletin Board

There shall be an adequate number of bulletin boards for safety and health/loss control purposes.

Safety and health materials posted are being translated to sufficient languages so that all employees can understand. The safety bulletin boards are strategically located such that every employee has an opportunity to see at least once during each working day. Safety posters are also located appropriately and being selected to support programs aimed at accident problems and updated in a monthly basis.

The following are items which will be placed in safety bulletin boards:

- Safety memoranda and general information
- General safety rules and regulations
- Safety posters

- Minutes of monthly safety meetings
- Safety statistics
- Safety Alerts

b. Safety Recognition Program

The purpose of the Employee Safety Recognition Program (Program) is to foster a culture that values safety by recognizing staff who demonstrate exceptional dedication and leadership to improve workplace safety, and by enabling employees to recognize each other for their safe actions. This program is intended to motivate employees to take an active role in improving safety for themselves and their co-workers.

Aligned with RCMC's Occupational Health, Safety, Environment & Community (OHSEC) Management System and Zero Harm objective, this Program also aims to boost the confidence and self-esteem of those who actively support a good culture and promote participation in safety initiatives.

The Program described here involves multiple recognition opportunities, including peer to peer recognition, Spot Recognition by supervisors and managers, and Star Recognition by the Safety Committee for exemplary safety actions. These recognition opportunities are intended to reward and promote safety leadership through direct and immediate recognition of staff.

This is an evolving program and will be continually monitored by the HSE Officer, the Safety Committee, General/Department Managers to assess its success and identify improvements. The program specifics will be updated as needed to better meet the goals of fostering a safe workplace and safety culture in accordance with RCMC's Mission, Vision and Values.

4.2.9 Security

To maintain peace and order and ensure the security of personnel and company assets, the company will seek services from legitimate security agencies to perform the task. The company with its security team shall establish close coordination and communication with the local PNP to address other security issues in the project area.

Further, guests visiting the project site and any of its facilities shall undergo induction proceedings to educate them on and ensure adherence to on-site security and safety protocols.

4.2.10 Yearly Drill (indicative Schedule)

1st quarter Fire and Rescue drill
Heavy equipment Rescue drill
2nd quarter Earthquake and Rescue drill
3rd quarter Tsunami search & drill
4th quarter Typhoon search & Rescue drill

5. SOCIAL DEVELOPMENT and MANAGEMENT PLAN (SDMP) AND INFORMATION, EDUCATION, COMMUNICATION (IEC) PLAN

5.1 Social Development Management Plan (SDMP)

The Community-Based Indicative Social Development Plan (ISDP) was done through a series of consultation with some sectors of the project affected barangay, the Barangay Council, Local Government Units (LGUs) and the Government agencies such as, the, MSWD, MHO,DA, Dep ED, NGOs, POs and the Community Relation Officer of Riverbend Consolidated Mining Corporation (RCMC).

Table 5-1: IEC /Consultation/Scoping Schedule

	Date of Scoping
• Barangay Councils of Impact Barangays	Dec. 2016 and Jan. 23-27, 2017
• Municipality of Banaybanay	Dec. 2016
• Other Stakeholders	Dec. 2016

The objective was to:

- Identify the basic needs and welfare of the community (IPs & Non- IPs) as basis for the framework of IP development plan and MGB social development and Management program of the project affected Barangay within the Riverbend Consolidated Mining Corporation (RCMC) MPSA.
- Prepare a sustainable indicative plan based on the Barangay Development Plans and the mandated support of RCMC.
- Establish a working relation with RCMC and the various community stakeholders with the goal of improving the quality of life of the project affected community by enabling them to becoming self-reliant.

The ISDP also provides an opportunity for identifying the following:

- Addressing key issues and concerns by the various stakeholders, including those that were raised during the Public Scoping;
- Identifying and designing the recommended measures in response to the issues and concerns that were raised;
- Identifying the lead agency or organization responsible in implementing the measures; and
- Setting of timelines to implement these measures consistent with the plans and programs of the lead agencies.

It is expected that in the long term, the economic benefits from tax revenues, the funds from the mandated services of the inter-agencies and the socio-economic benefits from the Mining law will be the main sources of funds to sustain the implementation of the Project with the continuing support of, the LGUs and surrounding communities.

The information collected from the perception survey will also form part of the ISDP that mainly address the following issues:

- Perceived fears of environmental “destruction” or degradation due to pollution of land, air, water and resources, and health risks;
- Possibility of losing their homes and farmlands
- Possibility of losing their source of livelihood

Thus, the overall focus of the ISDP is recommend mitigating measures which includes health and safety programs, environmental preservation and alternatives to livelihood programs of the affected community. RCMC will take the local needs in making strategic partnerships with all concerned stakeholders that include the local government units, non-government organizations, and people's organizations.

Likewise, This IPDP operationalize the Government's MTIP-DP following the Indigenous Peoples' Rights Act of 1997 (Republic Act 8371), the cornerstone of national policy on indigenous peoples. The IPRA concretizes the constitutional mandate to recognize, protect and promote the rights of indigenous peoples within the context of national unity and development, specially their rights to their ancestral lands and domain, to the preservation and development of their cultures, traditions and institutions, and to their human rights and freedoms as mandated in the 1987 Constitution.

It is a plan drafted to address the issues of IPs, in cooperation with the National Commission on Indigenous Peoples (NCIP) as the institution that facilitates the planning and implementation of programs in coordination with the Local Government. The importance of the IPs/ICCs protection and development is recognized by the National Government such that it enshrined its commitment in the Medium-Term Philippine Development Plan for 2001 – 2004, Chapter 13 – Protecting Vulnerable Groups – Assistance to specific vulnerable groups – of which the Mandayas of Banaybanay is one. The government in coordination with the Local government and Proponent would have to provide economic opportunities to uplift majority of them from poverty. The implementation of the Indigenous People Social Development Plan shall thus be guided according to the MTIP-DP.

METHODOLOGY:

The process was to identify and design specific and appropriate community-based development programs that would be implemented once the RCMC. project becomes fully operational. The various program identified as per recommended by MGB were in the areas of health and safety, education, peace and order, and environment and sanitation including spiritual. Multi-sectoral representatives were the Inter-agency Government Offices (MSWD, DA, MPDO/ENRO, MHO, PNP) from the youth, senior citizens, POs, church/religious organizations, farmers & fishing groups, and the LGUs. The Indicative Social Development Plan/ Indigenous People Development Plan was conceptualized by considering the mandates of the government interagency (MSWD, DA, MPDO/ENRO, MHO, PNP) in consideration of their mandate to deliver services to the Barangays in coordination with the LGU. The process considered the Barangay Development Plans to maximize the resources with the RCMC's Socio-economic commitments as mandated by law. For sustainability, the MGB in coordination with the Barangay Social Development Technical Working Group sits as Ad hoc Committee in coordination with RCMC Barangay Relations Officer to oversee the implementation of the SDMP and make their report to MGB and the Multi-partite Monitoring Team. Following are the details of the major programs and summary of proposed activities in Table 5.2 below:

Table 5-2: Social Development and Management Plan
For the Municipality of Banaybanay Direct Impact Barangays –
Brgys. **Puntalinao, Causwagan, Pintatagan, Maputi, Panikian, and Mahayag**
(based on the Government Mandated programs and results of the FGD, Perception Survey and Profiles)

	Concern	Responsible Community Member / Beneficiary	Government Agency/ Non-government Agency and Services (indicate specific services)	Indicative Timeline	Source of fund	Schedule of Implementation
	Land purchase / Lease	Barangay Chairman • Project affected land owners (as applicable)	• MGB • LGU Municipal Assessor based on cadastral surveys	• Preconstruction	20% IRA 75% SDMP or (1.25% of the 1.5%)	Prior to Operation
2	Gender Responsive <u>Livelihood and Credit Facilities</u> (Men, Women, Youth & Elderly) • women handicraft skills • high value crops for farmers <u>Employment</u> • job priority • skills training to qualified workers	Association Chairperson • Qualified Project Affected Men, Women, Youth, & Elderly	LGU - MPDO - MSWDO • Kaunlaran livelihood projects - TESDA • Skills training in handicraft and technical mechanic, driving - MAO / DA	• Pre-construction • Construction • Operation	20% IRA 75% SDMP or (1.25% of the 1.5%)	Continuing Program during Operation

	Concern	Responsible Community Member / Beneficiary	Government Agency/ Non-government Agency and Services (indicate specific services)	Indicative Timeline	Source of fund	Schedule of Implementation
			• Technical training farming methods • sProvide seedlings • Provide production training for high valued crops			
3	Health and Safety • Renovation of Brgy. Health Center • Health services • potable water • supplemental feeding to malnourshed children • assistance to Senior Citizens and Persons with disability	Barangay Kagawad for Health	MHO • provide Health services • Provide potable water • Provide supplemental feeding to malnourshed children • Provide assistance to Senior Citizens and PWDs • Barangay Disaster Management Training	• Pre-construction • Construction • Operation	20% IRA 75% SDMP or (1.25% of the 1.5%)	Continuing Program during Opearation

	Concern	Responsible Community Member / Beneficiary	Government Agency/ Non-government Agency and Services (indicate specific services)	Indicative Timeline	Source of fund	Schedule of Implementation
4	Education and Recreation • Scholarchip for qualified students • Non-formal education • Maintenance of Culture and Sports school activities	Barangay Kagawad for Education • Barangay schools	DepEd and Proponent • Setting-up of scholarship program for qualified students • Literacy programs & Non-formal education	• Pre-construction • Construction • Operation	20% IRA 75% SDMP or (1.25% of the 1.5%)	Continuing Program during Opearation
5	Environment and Sanitation • Reforestation • Brgy. Solid Waste Management Plan • Water sealed toilets	Barangay Kagawad for Environment	- MPDO/ENRO Formulate training in Solid Waste Management R.A. 9003 • Reforestation (tree planting) • Establishment forest nurseries • Environmental monitoring-training - BFAR / MAO • Establish Marine sanctuary	• Pre-construction • Construction • Operation	20% IRA 75% SDMP or (1.25% of the 1.5%)	Continuing Program during Opearation

	Concern	Responsible Community Member / Beneficiary	Government Agency/ Non-government Agency and Services (indicate specific services)	Indicative Timeline	Source of fund	Schedule of Implementation
			- MHO • Health programs • Provide water sealed toilets			
6	Peace and order - Barangay Tanods to maintain peace & order	Barangay Kagawad for Peace and order	LGU/ PNP/ Capacitate & Strengthen Barangay tanods in peace keeping	• Pre-construction • Construction • Operation	20% IRA 75% SDMP or (1.25% of the 1.5%)	Continuing Program during Opearation
7	Spiritual	Barangay Assigned Catholic Priest, Pastor of different denomination	• Parish Priest • Pastor	Construction and Operation	20% IRA 75% SDMP or (1.25% of the 1.5%)	Continuing Program during Opearation

5.2 Information, Education and Communication (IEC)

The Information, education and communication framework is meant to bridge the proponent and the host community through various media. The basic objective is to promote awareness and understanding among the residents of host community on the different programs RCMC is doing for them. This will build confidence and will promote better understanding and harmony between the two parties.

The Information, Education, and Communication Plan of the company shall focus on the project information dissemination, predicted impacts of mining activities to the environment particularly to the people and their inherent resources, the benefits that the community and the people may derived from such operation, and the cost and benefit analysis of the mining operations with regard to environmental protection, and the future of local folks after the abandonment of the project.

The IEC will focus on the following: employment, water quality, noise, emergency response procedures, and the ECC conditions. The program will be handled by a Community Organizer. He or she will organize local meetings and reach out the community to convey RCMC's programs for the community.

Table 5-3: INFORMATION, EDUCATION AND COMMUNICATION PLAN for
Riverbend Consolidated Mining Corporation – Proposed Nickel Mining Project

NEEDS	IMPLEMENTATION	COMMUNITY IMPLEMENTATION PLAN (Strategies)	GOVERNMENT/ NON-GOVERNMENT AGENCY SERVICES	PROPONENT	COST ESTIMATE
PROVINCE OF DAVAO ORIENTAL, PHILIPPINES MUNICIPALITY OF BANAYBANAY, BARANGAYS PUNTALINAO, KAUSWAGAN, PINTATAGAN, MAPUTI, PANIKIAN & MAHAYAG, (6) CONTAINING AN AREA OF 6,023.89 HECTARES ❑ Full Information about: The EIA processes ❑ The operation of Nickel Laterite Mining ❑ The remuneration for identified land areas to be used by the mining operation within and out of the ancestral domain ❑ The consequential impacts on the	Before project implementation	1. Primer/ Brochure/ (print media in tarpaulin) This strategy is effective in explaining in detail the subject matter, done in a simplified manner and in the language of the people. This strategy likewise, uses illustrations to further clarify the processes that is to be done. A. The EIA process illustrated and simplified in the language of the affected community written in English & Bisaya B. The FREE-Prior and Inform Consent process as stipulated by R.A. 8371 C. The Mining Project: (Print Media /Poster tarpaulin posted in the Barangay Hall and strategic areas such as sari-sari stores) This shall contain: ❑ the project description, project time frame, project facilities, management of Social and Environmental impacts, potential project benefits a graphic illustration about the process of nickel mining operation and the mitigating measures ❑ the process of Environmental Impact Assessment, roles and responsibilities of stakeholders ❑ The Social Development and Management Plan Gender Responsive Livelihood and Credit Facilities ❖ Education and Recreation	1. Provincial, Municipal & Barangay Information Officers 2. NATIONAL COMMISION ON THE INDIGENOUS PEOPLE 3. Municipal and Barangay Leaders 4. Elementary and High School Students 5. Barangay Committee on Education and Culture 6. Sangguniang Kabataan Barangay 7. NGO	RCMC Information Officer COMREL	Php. 500,000.00

NEEDS	IMPLEMENTATION	COMMUNITY IMPLEMENTATION PLAN (Strategies)	GOVERNMENT/ NON-GOVERNMENT AGENCY SERVICES	PROPONENT	COST ESTIMATE
residents of the community ❑ The benefits of the Project on their Socio-cultural/economic and bio-physical environment of the affected residents as they address the major issues of: air and water Pollution using Information, Communication and Information ❑ Climate Change		❖ Health and Safety ❖ Environment and Sanitation R.A.9003 ❖ Peace and order ❖ Spiritual ❑ On Climate Change DENR Special Order 2007-653, adaptation measures include protection of water aquifer, conduct of massive information and education campaign, establishment of protection measures for coastal areas, determination of areas most vulnerable to natural hazards “to forewarn people,” and strengthening the protection of ecosystems ❑ On the residents who will be affected by the mining activities showing their right to complain for violations of ECC conditionalities. 2. Consultations with Barangay Leaders and Multi-sectoral representatives (These are face to face encounters where participants and facilitators of knowledge and skills develop strategies to respond to the needs of the communities in the context of what is appropriate for their capabilities and resources) ❑ Using the interpersonal approach, RCMC’s Community Relations shall maintain regular consultations with the barangays for an open dialogue on the issues, problems and concerns related to the implementation and sustainability of the project. This approach shall compliment the Multi-partite Monitoring Team in terms of monitoring the compliance of the proponent to the conditions of the ECC.			

NEEDS	IMPLEMENTATION	COMMUNITY IMPLEMENTATION PLAN (Strategies)	GOVERNMENT/ NON-GOVERNMENT AGENCY SERVICES	PROPONENT	COST ESTIMATE
	During project operations	This will also serve as an avenue for stakeholders to register feedbacks, concerns, and issues related to the operation of the project. An indicative procedure for addressing stakeholder concerns is summarized below: ➢ Through the Community Relations Office (CRO), stakeholders may register their concerns. ➢ The CRO shall acknowledge receipt of the stakeholder concern and provide a tag / reference number for tracking purposes. The method of tracking stakeholder concerns may vary depending on the scale of the concern at hand. ➢ Review and Investigation. For the mechanism to work, all concerns should be handled as promptly as possible. Depending on the nature and complexity of the matter, some concerns may be easily resolved. Other concerns can be quite complex, such as those involving multiple parties and land ownership. In these cases, management, contractors, and even external experts may become involved in the investigation. In circumstances where the resolution process takes time, the mechanism must ensure that the stakeholder is informed of the progress. ➢ Formulation of Resolution Options, Response/s and Close out – Like the process itself, resolutions may vary in complexity. More complex and controversial issues, especially those raised by large groups of people, usually involve overlapping issues with			

NEEDS	IMPLEMENTATION	COMMUNITY IMPLEMENTATION PLAN (Strategies)	GOVERNMENT/ NON-GOVERNMENT AGENCY SERVICES	PROPONENT	COST ESTIMATE
		no obvious solution. Resolution of these issues may benefit from access to independent bodies that can provide the credibility that comes with impartiality. Such independent bodies can foster dialogue and collaboration between companies and affected communities as they undertake the often-lengthy process of exploring resolution options. Regardless of the outcome, all concerns should receive a response. ➢ Monitoring, Reporting and Evaluation – Monitoring and reporting are management tools to gauge the effectivity of the mechanism and efficiency of resources. Monitoring will also help the Proponent track recurring concerns which may entail or result to evaluation of policies or enhancement of operating procedures. This will also enable the Proponent establish baseline information which they can report back to the community. ❑ Workshop on the Mining Law of 1985 ❑ Secure the FREE PRIOR CONSENT Agreement and the implementation schedule. NCIP AO 1.2006 ❑ Group discussion of the sectoral groups which will be affected by the mining activities, the legal processes with the application of priority job placement, and other benefits ❑ Workshops on Solid Waste Management R.A.9003 and Preparation of IEC materials ❑ Workshops on Clean and Green/ Reforestation Activities			

NEEDS	IMPLEMENTATION	COMMUNITY IMPLEMENTATION PLAN (Strategies)	GOVERNMENT/ NON-GOVERNMENT AGENCY SERVICES	PROPONENT	COST ESTIMATE
		❑ Workshop on community Disaster Risk Reduction Management as related to Climate change 3. Posters, Wall Comics and Signage in strategic areas if the barangays • A graphic illustration of information on "What is Nickel Laterite?" and the rationale of the project in the context of their experiences in relation to mining in Bisaya and Mandaya • Community-Based Solid Waste Management and information about R.A.9003 • Restriction Signages on areas where mining activities are on- going **4.** Cell phone Patch Consultation ❑ Using the Cell Phone feed-back mechanism through the GABAY SA MAMAYAN ACTION CENTER in all project affected barangays. **5.** Community Forum and Phone Patch up This strategy enables the Company to discuss the progress of the project with key-persons of the company/resource persons weekly. This also encourages multi-sectoral interest groups to ask questions through phone patches.			

The proponent has also conducted different programs and activities for the communities such as:

(a) Pamaskong Handog para sa mga Senior Citizens – conducted last December of 2019 lead by Mr. Enrique Regio and RCMC Team together with SB Member Mr. Rabsalom Lamaran at the covered court of Barangay Puntalinao.
(b) Liga ng mga Barangay Year End Evaluation with SB Member Lamaran and Banaybanay Vice Mayor Bagayas
(c) Rice Distribution for San Isidro Prish, Kagan Tribe, and Mandaya Tribe led by Ms. Lotis Labial, and local geologic aides of RCMC, conducted last July 2020.
(d) A meeting was conducted this August 2020 by the proponent together with the SM Members and Tribe Chieftains at the Municipal Hall of Banaybanay.

Documentation of the said activities will be attached as Annex of this report.

Grievance Redress Mechanism

Also discussed below is the indicative Grievance Mechanism Procedure, whose objective is to provide the community and workers access to contact the proponent regarding concerns and questions and to achieve remedies that will allow both real and perceived impacts to be addressed. It should flow from the company's broader process of stakeholder engagement and business integrity principles, and integrate the various elements of engagement. Further, this guide aims to:

- Establish a mechanism for responding to complaints in a transparent and culturally appropriate manner;
- Provide an accessible, transparent and an efficient complaint procedure for stakeholders;
- Facilitate dialogue and open communication with the stakeholders;
- Manage expectations and/or negative perceptions about the project;
- Establish a system of inquiry, response and complaint resolution;
- Minimize grievances regarding the Project.

It is also expected to improve the Proponent's social performance by evaluating complaints as a basis for taking remedial or preventive actions or developing responsive initiatives.

The Company Relations Officer (CRO/ComRel) is responsible for receiving and registering the stakeholders concerns and/or complaints and publicize. The CRO shall acknowledge receipt of the concerns and provide a tag or reference number for tracking response. In addressing the concerns, this may vary depending on the scale of the concerns at hand. All concerns should be handled as promptly as possible. Depending on the nature of the matter, some concerns may be easily resolved and are actually requests for additional information, while other concerns can be quite complex and may require involvement of management, contractors, and external experts, and resolution process takes time. The proponent must ensure that the stakeholder is informed of the progress and timeline of addressing the concern.

General Procedures

A. Types of Complaints

   The Proponent may receive complaints such as those about local hiring, environmental concerns (e.g. air quality, noise, etc.), unfulfilled expectations regarding employment and procurement/sale of goods, opportunities, and infrastructure damage (e.g., complaints to the government, NGOs, contractors, public engagement process, Social and environmental performance, cultural issues, behavior of contractors' personnel, lack of information about the Project, compliance issues, etc.)

B. Identification and/or Receipt Complaints

C. Contact to local authorities (as necessary)

D. Registration of Complaints

E. Validation or Analysis of Complaints

F. Resolution of Complaints

G. Disclosure, Monitoring and Close Out

5.3 Indicative Indigenous Peoples Development Plan (IPDP)

Table 5.4 The Indigenous People Social Development Plan of the Mandayas of the Province of DAVAO ORIENTAL, Municipality of Banaybanay, Barangays Puntalinao, Causwagan, Pintatagan, Maputi, Panikian, and Mahayag

INDIGENOUS PEOPLE DEVELOPMENT PLAN INDICATIVE (MANDAYA)

CONCERN	Responsible Community Member / Beneficiary	Government Agency/ Non-government Agency and Services (indicate specific services)	PROPONENT	Indicative Timeline	Source of fund
1. Land Lease Gender Responsive Sec.3 of FPIC Livelihood and Credit Facilities (Men, Women, Youth & elderly) • -weaving of rattan & pandan handicrafts ○ backyard livestock & vegetable production • Sec.4.FPIC Employment Opportunities • mechanics, drivers & other technical jobs	• Datu and Council of Elders • IP Datu & Council of Elders • IP Affected Men, Women, Youth & Elderly	NCIP A.O No. 1 Omnibus Rules on Delenation and Recognition of Ancestral Domain and Lands of 2008 NCIP – coordinate MSWD - SEA KAUNLARAN credit facilities TESDA/TLRC • Technical training for drivers, mechanics & other technical jobs • Training for new handicraft designs DA - Training for livestock & vegetable production	COMREL lead implementor coordinated by Community Relations Officer	Pre-construction	RCMC RCMC / FPIC Ph 50,000
				Construction	1% ICC/IPs
				Operation	1% ICC/IPs
2. Health and Safety Sec.3 .FPIC		• NCIP coordinating	COMREL lead implementor	Pre-construction	Proponent FPIC

CONCERN	Responsible Community Member / Beneficiary	Government Agency/ Non-government Agency and Services (indicate specific services)	PROPONENT	Indicative Timeline	Source of fund
• Health services • Disaster Management	• IP Datu & Council of Elders • Barangay Kagawad for Health	• MHO • Assign health worker • Provide medical supplies • Barangay Disaster Management training	coordinated by Community Relations Officer		Ph 18,000
				Construction	1% ICC/IPs
				Operation	1% ICC/IPs
3. Education and Recreation • School Building Sec.5. FPIC • Scholarships Sec. 6. FPIC	• IP Datu & Council of Elders • Barangay Kagawad for Education	• NCIP coordinating • DepEd - Basic Non- formal Education for the adult & elderly - Formal education for children	COMREL lead implementor coordinated by Community Relations Officer	Pre-construction Construction Operation	COMREL FPIC Ph 10,000/yr
4. Environment and Sanitation -Sec. 12. FPIC Environmental protection and enhancement - Solid Waste Management	• IP Datu & Council of Elders • Barangay Kagawad for Environment	• NCIP coordinating • MPDO/ ENRO - contextual training of solid waste management • MHO - training in sanitary practices	COMREL lead implementor coordinated by Community Relations Officer	Pre-construction Construction Operation	COMREL FPIC
5. Peace and order Sec. 9 & 10 FPIC - ICC rights and interest	• IP Datu & Council of Elders • Barangay Kagawad for Peace and order	LGU- - Municipal NCIP monitors the implementation of Sec. 9& 10 of the FPIC PNP - coordinates with Municipal NCIP	COMREL lead implementor coordinated by Community Relations Officer & Chief Security Officer	Pre-construction Construction Operation	COMREL 1% ICC/IPs
6. Culture Sec. 33 R.A 8371/ FPIC Sec. 10 Respect & protection of ICC culture	IP Datu & Elders	Municipal NCIP monitors the implementation of Sec.10 of the FPIC	COMREL lead implementor coordinated by CRO	Pre-construction Construction Operation	1% ICC/IPs

CONCERN	Responsible Community Member / Beneficiary	Government Agency/ Non-government Agency and Services (indicate specific services)	PROPONENT	Indicative Timeline	Source of fund

Clarification on the Mine Facilities Located Outside the MPSA Area

Riverbend Consolidated Mining Corp. has begun its due diligence on the real properties outside the MPSA where mine facilities are to be set up by the Company for its mining operations, and has initiated talks with the property owners (see Letters of Intent received by landowners attached as Annex). Based on the progress of its due diligence, the Company is confident that the property owners are amenable to the occupation and use of their property by the Company for its mining operations, with payment for just compensation for such occupation and use.

The stated specific locations for the mine facilities outside the MPSA are priority areas, and the Company commits that it will not change these locations during actual mining operations.

Clarification on the Precious Mining Activities on the Area

Sometime in 2017, the Proponent have received reports that a certain group was conducting mining operations at an area located at Barangay Pintatagan, Banaybanay, Davao Oriental, within the MPSA area of the Company. Upon investigation and validation by the Company, it was discovered that mining activities were being conducted by RAM AGGREGATES AND CONSTRUCTION SUPPLY owned by Mr. Mangosong, illegally and under the guise of a Notice of Award from the Natural Resources Development Corporation (NRDC).

The Company, nor the previous MPSA holder, SINOPHIL MINING AND TRADING CORP. are not, in any way, connected to this group of illegal miners. In fact, the Company had submitted complaints to various government agencies, even to Office of the President to stop illegal mining operations, and had filed a case for injunction against the abovementioned group.

RCMC was never involved in any of the mining activities and operations of this group or of other previous mining activities and operations, if any, whether legal or not, conducted by other persons or entities, on the MPSA area.

6. ENVIRONMENTAL COMPLIANCE MONITORING

6.1 Self-Monitoring Plan

The Environmental Monitoring Plan describes: (i) mitigation measures, (ii) location, (iii) measurement method, (iv) frequency of monitoring and (v) responsibility (for both mitigation and monitoring).

A program of monitoring will be conducted to ensure that all parties take the specified action to provide the required mitigation, to assess whether the action has adequately protected the environment, and to determine whether any additional measures may be necessary.

Table 6-1: Summary Matrix of the Environmental Monitoring Plan (EMoP) with Quality Performance Levels (EQPLs)

Key Environmental Aspects per Project Phase	Potential Impacts Per Envt'l Sector	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost	EQPL MANAGEMENT SCHEME					
								EQPL RANGE			MANAGEMENTMEASURE		
			Method	Frequency	Location			ALERT	ACTION	LIMIT	ALERT	ACTION	LIMIT
I. PRE-CONSTRUCTION PHASE													
Environmental Aspect # 1	(baseline purposes only)	Soil Quality, Marine/Water, Air Quality (Baseline Data gathering only)	Grab sampling; RA9275 lab analysis method	Once	Indicate coordinates	Proponent	Included in proponent's financial program (approx. P50,000)			For baseline – none actual results recorded	Initial conditions gathered for purposes of Establishing Baseline Data only.)		
Environmental Aspect # 2	People	Securing of permits and clearances from various national and local government agencies	IRRs of respective government agencies and the LGU	As IRR dictates	National and Local government offices	Proponent	Included in proponent's financial program	NA					
		In-migration (as applicable)/ Employment	Qualified locals will be given priority in hiring	variable	Host barangay / city	Proponent	Included in proponent's financial program (salaries & wages)	NA					
II. CONSTRUCTION PHASE													
Environmental Aspect # 1	Air	Emission of CO_2, SO_2 and NO_2	24-hour sampling/ RA8749 lab analysis method	Monthly	Project Area	PCO	P100,000	TSP = 115 PM10= 75 NOx= 75	TSP= 115-230 PM10 = 75-150 NOx=75-150	AIR (µg/ncm) TSP = 230 PM10= 150	Report actual status on a periodic basis, document results.	Prepare incident report highlighting the findings, for the information of Management. Provide recommendations if necessary.	Execute remedial measures. If called for, temporarily limit operations to prevent damage to the

Key Environmental Aspects per Project Phase	Potential Impacts Per Envt'l Sector	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost	EQPL MANAGEMENT SCHEME					
								EQPL RANGE			MANAGEMENTMEASURE		
			Method	Frequency	Location			ALERT	ACTION	LIMIT	ALERT	ACTION	LIMIT
								SOX= 90	Sox=90-180	NOx=150 SOX= 180			immediate environment.
	Air	Emission from generator sets	24-hour sampling/ RA8749 lab analysis method	Once every two (2) years	Project Area	PCO	P50,000 / sampling	TSP = 115 PM10= 75 NOx= 75 SOX= 90	TSP= 115-230 PM10 = 75-150 NOx=75-150 Sox=90-180	AIR (µg/ncm) TSP = 230 PM10= 150 NOx=150 SOX= 180	Report actual status on a periodic basis, document results.	Prepare incident report highlighting the findings, for the information of Management. Provide recommendations if necessary.	Execute remedial measures. If called for, temporarily limit operations to prevent damage to the immediate environment.
	Noise	Noise level	Observation using corresponding measuring equipment	Monthly	Project Area (sampling stations considered in the study)	PCO	Purchase of noise meter = P 15,000	Class D (indl) = 37	Class D (indl) = 37-75	NOISE dB(A) Class D (indl) = 75	Report actual status on a periodic basis, document results.	Prepare incident report, highlighting the findings, for the information of Management. Provide recommendation if necessary.	Execute remedial measures. If called for, temporarily limit operations to prevent damage to the immediate environment.
Environmental Aspect #2	Water quality: Siltation	Total Suspended Solids (TSS)	Grab sampling; RA9275 lab analysis method	Monthly	At sampling stations considered in this study	PCO	P200,000	TSS mg/L =30 mg/L increa se	TSS mg/L =30-60 mg/L increase	Not more than 60 mg/L increase	Report actual status on a periodic basis, document results.	Prepare incident report, highlighting the findings, for the information of Management. Provide recommendation if necessary.	Execute remedial measures. If called for, temporarily limit operations to prevent damage to

Key Environmental Aspects per Project Phase	Potential Impacts Per Envt'l Sector	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost	EQPL MANAGEMENT SCHEME					
								EQPL RANGE			MANAGEMENTMEASURE		
			Method	Frequency	Location			ALERT	ACTION	LIMIT	ALERT	ACTION	LIMIT
													the immediate environment.
		Other parameters such as pH, DO, Oil and grease	Grab sampling; RA9275 lab analysis method	Monthly	At sampling stations considered in this study	PCO		pH:6.5 -9 DO:5 mg/L O&G: 1.5 mg/L	pH:6.5-9 DO:5mg /L O&G: 1.75 mg/L	pH:6.5-9 DO:5mg/ L O&G: 2mg/L	Report actual status on a periodic basis, document results.	Prepare incident report, highlighting the findings, for the information of Management. Provide recommendation if necessary.	Execute remedial measures. If called for, temporarily limit operations to prevent damage to the immediate environment.
	Freshwater Ecology	Abundance of Macroinvertebrates	Kick net	Biannual	Stations identified in EIS	Pollution Control Officer	PHP 50,000	N/A	N/A	N/A	N/A	N/A	N/A
Environmental Aspect #3	Land: solid waste generation	Transport and disposal/treatment	Desktop monitoring	Quarterly	Project Area	PCO	P40,000	10T	10-20T	Volume of Waste=20 T	Report actual status on a periodic basis, document results	Prepare incident report, highlighting the findings, for the information of Management. Provide recommendations if necessary.	Execute remedial measures. If called for, temporarily limit operations to prevent damage to the immediate environment
	Displacement and/or loss of flora and fauna	Replanting trees	Desktop monitoring	Semi-annual	Mining and working areas	PCO and Envi Officer	P250,000						
		Biodiversity	Quantitative and Qualitative Inventory of Flora and Fauna	Annual	To be ascertained upon establishment of the MMT	PCO and Envi Officer	P250,000						
Environmental Aspect #3	Terrestrial Ecology	- Abundance and diversity	Transect Method	Biannual	Stations identified in EIS	Pollution Control Officer	PHP 500,000	N/A	N/A	N/A	N/A	N/A	N/A

Key Environmental Aspects per Project Phase	Potential Impacts Per Envt'l Sector	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost	EQPL MANAGEMENT SCHEME					
								EQPL RANGE			MANAGEMENTMEASURE		
			Method	Frequency	Location			ALERT	ACTION	LIMIT	ALERT	ACTION	LIMIT
		of Tree Species											
		- Abundance and diversity of Fauna such as Birds, Bats, Volant and Non-Volant Mammals	Transect Method and Misting	Biannual	Stations identified in EIS	Pollution Control Officer	PHP 500,000	N/A	N/A	N/A	N/A	N/A	N/A
III. OPERATION PHASE													
Environmental Aspect #1	Air	Emission of CO_2, SO_2 and NO_2	24-hour sampling/ RA8749 lab analysis method	Monthly	At sampling stations considered in this study	PCO	P10,000	TSP = 115 PM10= 75 NOx= 75 SOX= 90	TSP= 115-230 PM10 = 75-150 NOx=75-150 SOx=90-180	AIR (µg/ncm) TSP = 230 PM10= 150 NOx=150 SOX= 180	Report actual status on a periodic basis, document results.	Prepare incident report highlighting the findings, for the information of Management. Provide recommendations if necessary.	Execute remedial measures. If called for, temporarily limit operations to prevent damage to the immediate environment.
		Emission from generator sets	24-hour sampling/ RA8749 lab analysis method	Once every two (2) years	Project Area	PCO	P50,000 / sampling	TSP = 115 PM10= 75 NOx= 75	TSP= 115-230 PM10 = 75-150 NOx=75-150	AIR (µg/ncm) TSP = 230 PM10= 150	Report actual status on a periodic basis, document results.	Prepare incident report highlighting the findings, for the information of Management. Provide recommendations if necessary.	Execute remedial measures. If called for, temporarily limit operations to prevent damage to the

Key Environmental Aspects per Project Phase	Potential Impacts Per Envt'l Sector	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost	EQPL MANAGEMENT SCHEME					
			Method	Frequency	Location			EQPL RANGE			MANAGEMENTMEASURE		
								ALERT	ACTION	LIMIT	ALERT	ACTION	LIMIT
								SOX= 90	Sox=90-180	NOx=150 SOX= 180			immediate environment.
	Noise	Noise level	Observation using corresponding measuring equipment	Monthly	At sampling stations considered in this study	PCO	Purchase of noise meter = P 15,000	Class D (indl) = 37	Class D (indl) = 37-75	NOISE dB(A) Class D (indl) = 75	Report actual status on a periodic basis, document results.	Prepare incident report, highlighting the findings, for the information of Management. Provide recommendation if necessary.	Execute remedial measures. If called for, temporarily limit operations to prevent damage to the immediate environment.
Environmental Aspect #2	Water quality:	DO, and Oil and grease TSS	Grab sampling; RA9275 lab analysis method	Monthly	At sampling stations considered in this study	PCO	P200,000	TSS mg/L 30 mg/L increase BOD (mg/L) =5 DO (mg/L) =1.5 Grease= 5-7	TSS mg/L = 30-60 mg/L increase BOD (mg/L) =5-10 DO (mg/L) =1.5-3.0 Oil &Grease = 7-15	TSS mg/L = Not more than 60 mg/L increase BOD (mg/L) =10 DO (mg/L) =3 Oil & Grease= 10-15	Report actual status on a periodic basis, document results	Prepare incident report, highlighting the findings, for the information of Management. Provide recommendations if necessary.	Execute remedial measures. If called for, temporarily limit operations to prevent damage to the immediate environment
Environmental Aspect #3	Land: solid waste generation	Transport and disposal/treatment	Desktop monitoring	Quarterly	Project Area	PCO	P40,000	10T	10-20T	Volume of Waste=20 T	Report actual status on a periodic basis, document results	Prepare incident report, highlighting the findings, for the information of Management. Provide recommendations if necessary.	Execute remedial measures. If called for, temporarily limit operations to prevent damage to the

Key Environmental Aspects per Project Phase	Potential Impacts Per Envt'l Sector	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost	EQPL MANAGEMENT SCHEME					
			Method	Frequency	Location			EQPL RANGE			MANAGEMENTMEASURE		
								ALERT	ACTION	LIMIT	ALERT	ACTION	LIMIT
													immediate environment
IV. ABANDONMENT PHASE													
Environmental Aspect #1	Land: Solid waste generation	Transport and disposal/treatment Loss of Vegetation	Desktop monitoring Desktop monitoring / Monitoring of Progressive rehabilitation	Quarterly Semi-annual	 Mining and work area	PCO / envi Officer PCO / Envi Officer	P40,000 P	10T	10-20T	Volume of Waste=20 T	Report actual status on a periodic basis, document results	Prepare incident report, highlighting the findings, for the information of Management. Provide recommendations if necessary.	Execute remedial measures. If called for, temporarily limit operations to prevent damage to the immediate environment
Environmental Aspect #2	Water quality: Siltation Water Quality: Contamination	Total Suspended Solids (TSS) DO, and Oil and grease	Grab sampling; RA9275 lab analysis method Grab sampling; RA9275 lab analysis method	Monthly Monthly	At sampling stations considered in this study At sampling stations considered in this study	PCO PCO	P200,000	TSS mg/L 30 mg/L increase	TSS mg/L = 30-60 mg/L increase	TSS mg/L = Not more than 60 mg/L increase	Report actual status on a periodic basis, document results	Prepare incident report, highlighting the findings, for the information of Management. Provide recommendations if necessary.	Execute remedial measures. If called for, temporarily limit operations to prevent damage to the immediate environment

The Project Environmental Monitoring and Audit Prioritization Scheme (PEMAPS) Questionnaire in Annex 2-7d of the RPM is attached as Annex.

6.2 Multi-Sectoral Monitoring Framework

Riverbend Consolidated Mining Corporation (RCMC) will follow all the ECC conditions to be imposed by the DENR, and will strengthen the multi-sectoral monitoring team of the multipartite monitoring team (MMT). The MMT will be responsible for monitoring the proponent's compliance to the ECC conditions. Based on DAO 2017-15, the MMT will be composed of the representatives from LGU, RHU and concerned Barangay Chairman, LGU-accredited non-government organization (NGO), representatives from locally recognized community leaders, PENRO, Community ENRO and Mines and Geosciences Bureau Region 11. A representative either from PENRO, CENRO, or lead government agency shall serve as the MMT Chair in case that the representative do not accept the chairmanship, the MMT members will elect among themselves. Summary of Multi-sectoral Monitoring framework is presented in Table 6-2.

The project's MMT will meet quarterly to validate the proponent's compliance to the conditions of the current ECC. Results of these quarterly meeting will be incorporated in the reports submitted to the MGB and EMB regional offices as part of their Self-Monitoring Report (SMR) and the Compliance Monitoring Validation Report (CMVR).

Table 6-2: Summary of Multi-Sectoral Monitoring Framework

	Stakeholder	Basis for Selection	Specific Organization	Proposed Role in the MMT/ Scope of MMT responsibilities/activities	Strategy in Establishing and Monitoring EQPLs
1	Brgy.Nangan, Surop and Tiblawan (Chairmen and Council with Sitio leaders and lead health worker)	LGU is a "must" invite due to its direct political jurisdiction over the area	LGU	The Local Government Units shall participate in actual monitoring work. Advise the MMT of any complaints, information or reports from LGUs concerning the project, in order that remedial measures if warranted and feasible can be undertaken.	To be established upon finalization of the MMT's Operating Manual
4	MPDC, Banaybanay				
5	MENRO, Banaybanay				
6	MHO, Banaybanay				
7	MAO, Banaybanay				
8	MSWDO, Banaybanay				
9	Office of the Mayor/SB, Banaybanay				
10	PPDO, Davao Oriental				
11	POs / NGOs	Entities that may be directly or indirectly affected by impact	Registered Sectoral Representatives	The NGO/PO and other stakeholder groups shall participate in actual monitoring work, and concur	

	Stakeholder	Basis for Selection	Specific Organization	Proposed Role in the MMT/ Scope of MMT responsibilities/activities	Strategy in Establishing and Monitoring EQPLs
		resulting from the project's development		with and/or sign the monitoring reports, or take exception to them as the case may be. The representatives shall advise the MMT of any complaints, information or reports from their respective constituencies concerning the project, in order that remedial measures if warranted and feasible can be undertaken.	
12	MGB, Region XI	DAO 2015-02	DENR	Responsibilities and specific roles shall be based on the provisions of DAO 2015-02 and DAO 2018-18	Implement specific provisions of DAO 2015-02 and DAO 2018-18
13	Provincial Environment and Natural Resources Office (PENRO) and Community Environment and Natural Resources Office (CENRO)	DAO 2017-15			

6.3. Contingent Liability and Rehabilitation Fund (CLRF)

In line with harmonizing the implementation of the Philippine EIS System and the Philippine Mining Act as per DAO 2015-02, its General Provisions provides for the management and joint audit of the Mine Rehabilitation Fund (MRF) and the Environmental Trust Fund (ETF) by the EMB and the MGB.

Further, Chapter 18 of DAO 2005-07 titled as Contingent Liability and Rehabilitation Fund establishes the financial mechanism for the Environmental Management and Guarantee Funds. Collectively, this environmental guarantee fund mechanism is known as the Contingent Liability and Rehabilitation Fund (CLRF). The CLRF is basically composed of the Mine Rehabilitation Fund (MRF), the Mine Waste and Tailings Reserve Fund (MWTRF) and the Final Mine Rehabilitation and Decommissioning Fund (FMRDF). These funds shall be managed by the CLRF Steering Committee.

The CLRF assures that all proposed mining projects ensure compensation for damages, cost of monitoring, and progressive and sustainable rehabilitation for any adverse effect of a mining operation.

6.3.1 Mine Rehabilitation Fund (MRF)

a. *Rehabilitation Cash Fund (RCF)*

The RCF is established to ensure compliance with the approved rehabilitation activities and schedules as declared in the project's Environmental Protection and Enhancement Program (EPEP) or its Annual EPEP (AEPEP). The RCF is equivalent to 10% of the total EPEP cost or 5 Million whichever is lower. For this project, 10% of its EPEP cost is PhP 1,750,000.00. Hence, the RCF is initially set at this amount.

b. *Monitoring Trust Fund (MTF)*

The Monitoring Trust Fund is established for the exclusive use in monitoring of environmental management programs approved by the Mine Rehabilitation Fund Committee (MRFC). The deposited amount should not be less than PhP 150,000.00. The proponent however may be requested to increase this amount by the MRFC.

c. *Environmental Trust Fund (ETF)*

The ETF is established to pay for mining related compensable damages other than those caused by mine waste and mill tailing. It is contained in the MOA entered into by and among the stakeholders. ETF is pegged at a minimum of PHP 50,000.00.

6.3.2 Mine Waste and Tailings Reserve Fund (MWTRF)

MWTF are fees collected semi-annually from each operating mill tailing it generated for the said period. The amount of fees collected shall accrue to a Mine Waste and Tailings (MWT) Reserve Fund and shall be deposited in a Government depository bank to be used for a payment of compensation for damages caused by any mining operations. The MWTRF shall also be utilized for research project duly approved by the CLRF Steering Committee which are deemed necessary for the promotion and furtherance of its objectives.

MWTRF shall be computed as P0.05/MT of the Mine Waste produced and/or P0.10 mill tailing generated from processing. In the case of this project, it will be computed from the Mine Waste considering that there will be no processing involved. At an estimated mine waste of 9,833,400 MT, the MWTRF's estimated amount is PhP 491,670.00. This is just the estimated waste and a more realistic value will be computed as the actual mine site condition is determined during actual operations. Stockpile of mine wastes may also be recoverable and still sold when there is a demand in low grade nickel.

The Contingent Liability and Rehabilitation Fund (CLRF) therefore is computed as follows:

MRF		:	PhP 1,950,000.00
	RCF	= PhP 1,750,000.00	
	MTF	= 150,000.00	
	ETF	= 50,000.00	
MWTRF		:	PhP 491,670.00
CLRF		**:**	PhP 2,441,670.00

7. REHABILITATION / DECOMMISSIONING / ABANDONMENT POLICIES

7.1 Rehabilitation Plan

Objective and Methodology

The objective of rehabilitation is the attainment of safe, stable, revegetated mined-out areas. The methodology will be revegetation in coordination with the host community. The final land configuration will incorporate road network to make as many areas accessible as possible with provisions for drainage system.

The proposed final land uses for each project component will determine the rehabilitation of the Project. The disturbed area will be cleared and revegetated and/or restored as in the case of areas designated for support facilities that are not within the mining or MPSA area. Involvement of the host community will be the prime strategy to ensure the success of rehabilitation.

The preparation of the area will be done using heavy equipment such as dump trucks, loaders, bulldozers, etc.

Goals of the Rehabilitation Plan

- Rehabilitate/re-vegetate all the disturbed areas within the MPSA areas affected by mining operations by reshaping/re-contouring affected areas prior to re-vegetation;
- Minimize the long-term visual impacts caused by mining through application of innovative measures creating landforms and vegetation compatible with the surrounding landscape;
- Manage and control off-site contamination, including water pollution, siltation and erosion by defining drainage systems, fortifying environmental control structures and enhancing slope stabilization;
- Remove all unnecessary mine facilities and equipment used in operations and rehabilitate or restore the areas prior to abandonment; and
- Conduct post rehabilitation monitoring and implement improvement and enhancement programs

Final Land Use

The final land use for the project will be a stable and revegetated mined-out area that is sustainable and promotes the recolonization of the pre-project flora and fauna.

The bases in the selection of the final land use were the following:

- Hazard in the area that may render it unusable or unfit for other productive land use. There are no naturally occurring hazards in the area. The area is not traversed by major active faults, it is not located within typhoon belt, it is not located in steep and landslide prone areas, etc. Hence, the area can be revegetated after the commercial life of the Project.

- Level of environmental and social impacts cause by the operation. The environmental impacts of the project will not render the area unusable after the life of the project.

- The expected post-closure operational use of the land. The post-closure operational use can be a Community Based Forest Management (CBFM) Project.

- The productivity of the land surrounding the site. The surrounding areas are currently non-productive and also cater to other mining projects. The denuded state of the area will change once the revegetation is accomplished.

The major elements of the plan include the following table:

Table 7.1 Final Land Use of Mine Components

Mining Component	Final Land Use
Mining Area	Revegetated area May be placed under DENR's Community Based Forest Management (CBFM) program
Facilities such as staff house, parking area, laundry, water tank, motor pool area, powerhouse, nursery, Contractors' yard, assay laboratory	Facilities/structures that are usable will be donated to the community. Non-usable facilities will be dismantled and the materials removed from the site Fixed facilities that can be used by the community will not be removed. Those are not required to be removed and their footprint rehabilitated or restored. To be done after the life of the MPSA is attained. It must be emphasized that the company may opt to renew the MPSA for another 25 years.
Siltation Ponds	Revegetated area. All siltation ponds in the mining area will be maintained until full rehabilitation of the mined-out parcels. As rehabilitation is progressive, settling ponds that are no longer required will be decommissioned and rehabilitated. The excavated materials may, in the future, have economic value, otherwise, these will be used for backfill, grading or removed from the site May be placed under DENR's CBFM program
Haul roads and mine access roads	If considered useful by the community, internal haul road can be left. If not required, these will be re-planted; water diversion measures will be installed for run-off interception and to enhance revegetation. Signs, guard trails and barriers will be removed or retained depending upon the consultation with the stakeholders.
Unused laboratory chemicals and wastes	Remaining chemicals, such as petrochemicals, reagent and other associated chemicals will be collected and taken away from the affected areas by engaging a DENR-accredited hazardous waste transporter. Due to the progressive waste disposal policy, residual waste will be minimal.

The proponent will implement a progressive rehabilitation plan for mined out areas. Backfilling of mined out areas should be done first to put a proper substrate for the plants to establish themselves. Without the top soil, reforestation would just be an exercise in futility.

During operation, mining will be done by sections in accordance with the approved mine development plan. Once a section is mined out, rehabilitation should immediately commence so that there would be a shorter time frame in the abandonment and rehabilitation phase. During the rehabilitation of the areas, the beneficiary communities will be involved and organized so that by the end of the abandonment time frame, the communities are ready to take over the responsibility with the local DENR.

Prior to reforestation, staking of the areas to be planted should be done, digging holes for planting, raising the species in the nursery for out-planting, etc. are also part of the whole reforestation / rehabilitation activity.

It is estimated Twenty-Five Million Five Hundred Fifty Thousand Pesos (PhP 25,550,000.00) shall be set up for the Final Mine Rehabilitation and Decommissioning Cost to cover rehabilitation of the mined-out areas and other decommissioning activities.

The over-all objective is that at the completion of the mining operation, the significant features such as mined-out areas, waste dumps, and environmental control infrastructures are decommissioned and developed into stable landforms. These landforms will be re-vegetated using endemic species and fast-growing tree species or put into agricultural uses, where appropriate. The rehabilitation activities will be undertaken with the involvement of the local community.

The progressive rehabilitation scheme will minimize the extent of disturbance and the time of exposure of disturbed areas. This will be complemented by mulching of disturbed areas and covering of dried ore in the stockyard area. Below are the details of the progressive rehabilitation scheme to be implemented:

1. Planning
   - 1.1 Set up and build appropriate plant nursery right at the 1st stance of the mobilization as equipment needed is already available.
   - 1.2 Collect and condition endemic plant species during clearing & grubbing
   - 1.3 Preparation of fast growing trees which could be planted 5 months period.
   - 1.4 Soil testing will be needed to test acidity and type of tree plants is suitable, including fertilizers.
   - 1.5 Keep close coordination with the local CENRO office for assistance to produce more species of seedlings suitable for the area.

2. Implementations
   - 2.1 Fast track the progress of the targeted mined out area for immediate ground preparation even if after 5-6 months operations to initially commence at 10 has.
   - 2.2 Reshape the area as ground preparation in progress making a ground slope less than 40 degrees.
   - 2.3 Design proper drainages system to avoid the creation of ripples across the slope that will cause erosion.
   - 2.4 Drainage should be at the toe line of the slope and not at the crest line where water will pool in during heavy rains.
   - 2.5 Backfill the area by overburden mixed with top soil.
   - 2.6 Coco net is always installed in unstable ground slope to avoid or minimize erosions.

Sequence of rehabilitation includes the following activities:

- Slope stabilization. The angle of slope of all steep walls prone to landslide will be reduced to 45 degrees angle to attain stability. Engineering intervention may be implemented such as the use of geotextile or biomacs to enhance re-vegetation process;
- Clean-up of the disturbed areas by removing domestic and industrial waste from site and transferred to the MRF or storage area for hazardous materials in the case of used oil and grease;
- Contaminated materials or soil shall be considered as hazardous waste and therefore shall be disposed with the hazardous waste materials;
- Overburden previously stockpiled in waste stockpile areas will be return as backfill materials;
- Levelling of the mine pit and settling ponds to ensure that no voids will be left open for safety reason;
- Planting of endemic species over the disturbed areas; and
- Maintenance of the planted species to ensure high survival rate.

7.2 Decommissioning / Mine Closure

The completion criteria are a set of indicators which, upon being met, will demonstrate the success of rehabilitation. The completion criteria presented are specific to the project component being rehabilitated or closed.

The company is aiming for a post land use similar or close to the pre-mining state. Hence, revegetation thru progressive rehabilitation of the affected areas is proposed and the focus of this FMRDP. Minimum standard includes a stable and revegetated mine area. The provisions by law for the periodic review of the FMRDP every two (2) years will provide the necessary tool to ensure the success of progressive rehabilitation.

Table 7.2 Mine Closure Criteria

Mine Component	Post Mining Land Use	Criteria
Mining Area	Revegeted area	80% survival rate and self-thriving plants
Facilities such as staff house, parking area, laundry, water tank, motor pool area, powerhouse, nursery, Contractors' yard, assay laboratory	Donated to community	Deed of donation
Siltation Ponds	Revegeted area	80% survival rate and self-thriving plants
Haul roads and mine access roads	Retained for access	Usable roads

Decommissioning is the transitional stage period between cessation of operations and actual closure that begins near, or at, the cessation of production and ends with the removal of all unwanted infrastructures.

7.2.1 Decommissioning Strategy

RCMC will implement the following decommissioning strategy and target schedule:

Table 7-3: Decommissioning Strategy

Decommissioning Strategy	Timeframe
1. Formation of the RCMC Closure Team. Start of IEC Campaign as part of social participation.	Closure planning. Two (2) years before closure.
2. Inventory of all equipment and facilities by the RCMC Closure Team.	Part of closure planning. Within 2 years before closure.
3. Assessment of the conditions of equipment and facilities by the RCMC Closure Team. Assessment of progressive rehabilitation.	Part of closure planning. Within 2 years before closure.
4. Planning and review of decommissioning procedures vis-a-vis the standard operating procedures. Coordination with the contractors.	Part of closure planning. Within 1 year before closure.
5. Cross matching of company personnel and residents with the decommissioning tasks. Trainings/seminars will be provided as the need arises. Consultation with stakeholders. Strengthening of IEC Campaign as part of social preparation.	Part of closure planning. Within 1 year before closure.

Decommissioning Strategy	Timeframe
6. Decommissioning of equipment and facilities.	Decommissioning and rehabilitation phase. Within 6 months after closure.
7. Post assessment by the RCMC Closure Team on the decommissioned equipment and facilities.	Decommissioning and rehabilitation phase. Within and after 1 year of closure.
8. Rehabilitation of the decommissioned project component.	Decommissioning and rehabilitation phase. Within and after 1 year of closure.

The RCMC closure Team will be composed of the following:

- Resident Manager – Team Head
- Heads of Operations, Administration, Personnel and Legal Departments
- Safety and Health
- MEPEO and the Environmental Unit
- Community Relations Unit

7.2.2 Decommissioning of Equipment

Most of the equipment used for the Project are mobile and provided by a contractor/s. Decommissioning of the equipment will be the responsibility of the contractor/s subject to RCMC's safety rules and policies.

7.2.3 Social Plans

Retrenchment Policies

Retrenchment is allowed for closing or cessation of operation of the establishment or undertaking. The requirements of the law for a valid retrenchment of workers are as follows:

- Written notice to the employees and to the Department of Labor and Employment (DOLE) at least one month prior to the intended date of retrenchment; and

- Payment of separation pay equivalent to one month pay or at least 1/2 month pay for every year of service, whichever is higher.

A retrenchment package will be given to company personnel. The enumerations will be based, at the very least, on provisions of law and may be increased depending on the financial considerations of RCMC during the time of closure.

Labor Support Policies and Programs

RCMC will soften the impact of closure to company personnel by providing a broad range of placement services. This will assist the employees to make the transition to alternative jobs or in becoming self-employed. These services can be any of the following:

Job Search. Provision of information to mine workers on labor markets and job-openings. Transfer to other company projects.

Skills Training and Education Programs. Provision of job-related courses/trainings or courses focused toward a future career which may vary from office skills to artisan multiskills training, computer technology, mechanical trades and similar vocations. Coordination with TESDA will be conducted.

Enterprise Awareness. To sensitize and/or motivate those who consider self-employment but have not yet seen such as a viable alternative; and

Counseling. To help workers cope both socially and financially after the loss of their job and should be focused on money matters and property management.

For the host community, livelihood trainings and support to micro-business projects will be continued for the duration of the FMRDP.

Transfer of Social Assets and Services

The transfer and social assets and services will depend on the outcome of the consultation with the stakeholders in the future. Facilities such as staff house, parking area, laundry, water tank, motor pool area, powerhouse, nursery can be transferred to the LGU after the life of the MPSA.

8. INSTITUTIONAL PLAN FOR EMP IMPLEMENTATION

In compliance to the requirements of the DENR and other concerned government agencies, Riverbend Consolidated Mining Corporation (RCMC), shall appoint a Mine Environmental Protection and Enhancement Office (MEPEO)

The MEPEO shall have the following functions:

- Formulation and implementation of environmental conservation plans;
- Implementation of environmental impact and management procedures;
- Timely submission of Self-Monitoring and related reports;
- Coordination with the Multi-Partite Monitoring Team (MMT);
- Community programs during project operation;
- Compliance with all regulations imposed by the DENR, the MGB and other concerned agencies (e.g. LGU, other agencies).
- Implementation of the Final Mine Rehabilitation and Decommissioning Plan.

The MEPEO shall report directly to the President and the General Manager of the company. Under the MEPEO's supervision will be the Pollution Control Officer (PCO), Health and Safety Officer (HSO) and the Community Relations Officer (CRO). The MEPEO will be a Mining Engineer or Geologist as stipulated in DAO 96-40. The MEPEO will take lead in the implementation of the Impacts Management Plan (IMP) and the Environmental Monitoring Plan (EMoP) as presented in this EIS.

The MEPEO shall implement the following:

- ➢ Planning and managing the implementation of the approved EPEP/AEPEP;
- ➢ Monitoring compliance of Contractors on their implementation of provision of EPEP and AEPEP;
- ➢ Monitoring and evaluating the effectiveness of the mitigation and enhancement measures;
- ➢ Planning, proposing and implementing modification or additional measures deemed necessary to effectively protect the environment;
- ➢ Coordinating with relevant oversight agencies and other entities including the local government units to ensure their effective participation in the implementation of the EPEP and AEPEP;
- ➢ Initiating planning and implementing rehabilitation and abandonment programs;
- ➢ Liaise with the Community Relations Officer (CRO) and the Mine Safety Personnel in creating a holistic Safety and Health, Environmental and community relation program for the Project.
- ➢ Implementation of the Environmental Management & Monitoring Plan and Self-Monitoring Report. Coordinate with EMB-DENR, Multi-Partite Monitoring Team, and other agencies and stakeholders relative to compliance with other environmental regulations that the DENR, MGB and other concerned agencies may impose. Work with the Community Relations Officer in coordinating the activities of the Multi-partite Monitoring Team (MMT).

The Pollution Control Officer (PCO) is tasked to:

- ➢ Proper and regular monitoring of water quality, compliance to all permit conditions, and all sampling and monitoring activities are done in accordance to the required methodologies;
- ➢ Regular submission of compliance reports;
- ➢ With the MEPEO, conduct spot and regular audit procedures to ensure implementation of established environmental management protocols and impact management plans;
- ➢ In coordination with the MEPEO, report on the efficiency of environmental management measures and assist the management in implementing corresponding mitigating measures as required;

The HSO is tasked to:

- ➢ Ensure that comprehensive Health and Safety protocols are in place and implemented. Such policies shall be complied with not only by the proponent but also by all contractors and personnel involved in the project.

- Conduct regular safety trainings and audits similar to environmental audits for all its personnel, directly hired and contracted.
- Ensure conduct of health examinations for all personnel prior to engagement and on a periodic during the duration of the project.

The CRO on the other hand shall have the following functions:

- Maintain constant communication and establish positive relationship with concerned government agencies (e.g. MGB, DENR, LGU, PCG, etc.) and stakeholder groups to address environmental concerns and implement environment-related programs in coordination with the PCO and the MEPEO;
- Implement a regular and intensive information, education and communication (IEC) program to promote Corporate Social Responsibility advocacies in environmental protection and other social development programs (SDP);

Additional manpower will be needed for the implementation of the Social Development Programs and Environmental Protection and Management projects.

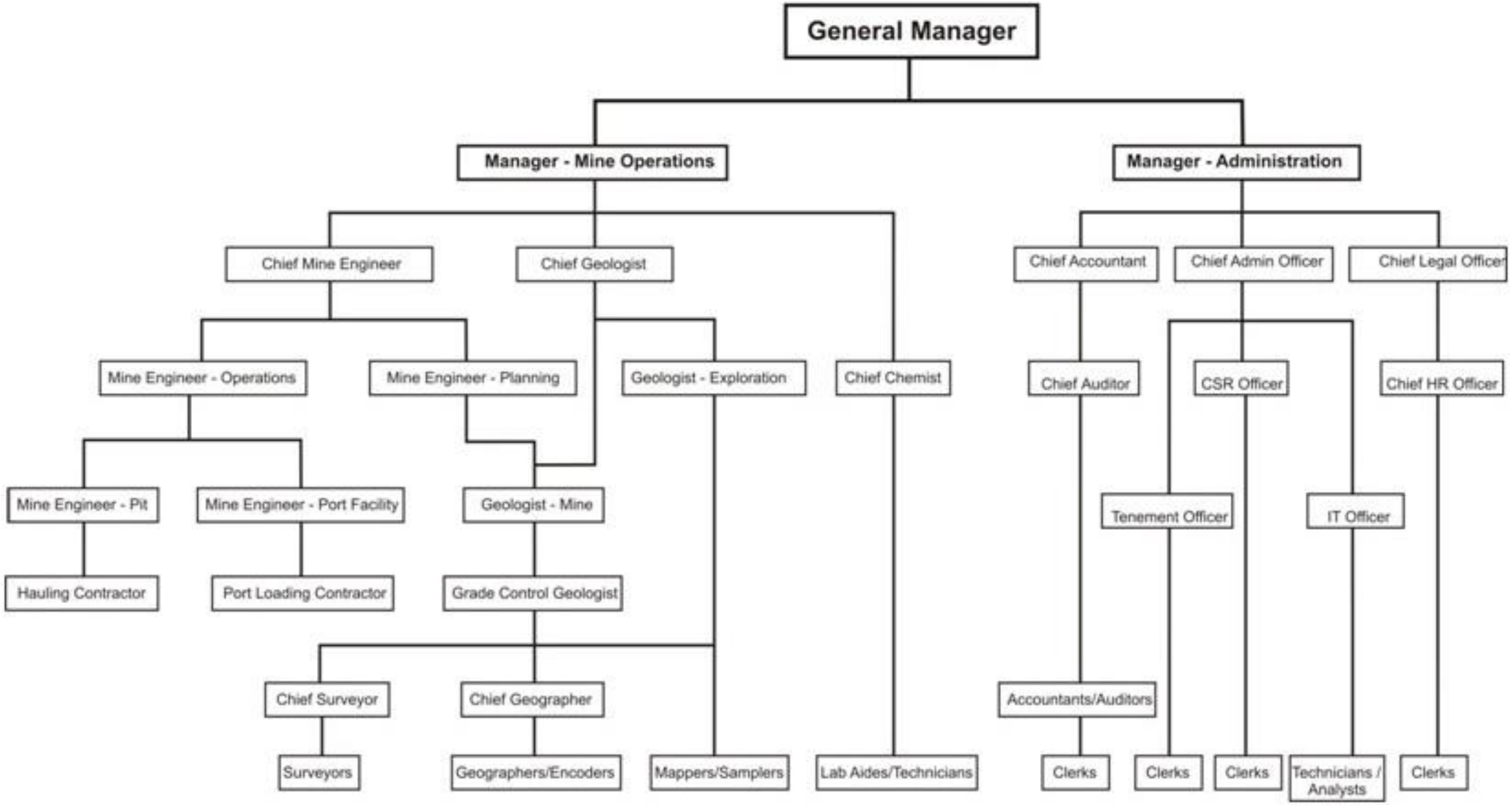
The project is projected to create an employment opportunity for 1000 employees. The company shall give priority on the hiring of qualified local applicants from the municipality. Female hirees will be accounted for in the workforce and will depend on their qualification for specific positions.

Table8-1: Manpower Requirement

Division/Group	Departments	No. of Personnel
Mine Operations	Production	100
	Mine Engineering, Planning and Survey	20
	Mine Geology, Resource and Grade Control	30
	Safety and Emergency Response	30
	Assay	30
Administration	Central Administration, Legal and HR	20
	Accounting and Audit	20
	Materials, Purchasing and Warehouse	30
	IT and Communication	20
	Motor pool and Weighbridge	20
	Infirmary/Hospital	20
	Security	20
General Support	Exploration	50
	Environment and Forestry	30
	Corporate Social Responsibility	20
	Tenement and Lands Management	10
	Engineering and Construction	30
Contractors	Hauling and Port Loading	400
	Security	100
	TOTAL	1,000

In accordance with mining regulations, the proponent will study previous undocumented environmental issues and long-term impacts such as subsidence by including research programs in their environmental protection and enhancement program, and by allowing the allocation of a portion of the environmental guarantee fund for independent studies and researches. The company can adopt such a framework and devote a portion of the resources of the foundation it intends to put for its social development program for research on the environmental impacts of nickel mining.

Figure 9-1: Table of Organization



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PROJECT ENVIRONMENTAL MONITORING AND AUDIT PRIORITIZATION SCHEME (PEMAPS) QUESTIONNAIRE

Project Name	Proposed Banaybanay Nickel Laterite Mining Project
Location	Barangays, Puntalinao, Causwagan, Pintatagan, Maputi, Panikian, and Mahayag, Municipality of Banaybanay, Province of Davao Oriental
Project Area	6,363.3368 hectares (MPSA) / 1,072.20 hectares for partial declaration
Nature of Project	Extraction of metallic ores/minerals
Name of Proponent	Riverbend Consolidated Mining Corporation
Address	Unit 1602, 16th Flr., 139 Corporate Center, 139 Valero St., Bel-Air, Makati
Contact Details	Contact No.: (632) 9413764

I. PROJECT CONSIDERATIONS

1.1 Size and Type

1.1.1 Size based on number of employees

Specify number of employees: 1000 employees

1.1.2 Type

ECP (in either ECA or Non-ECA)	x
Non-ECP but in ECA	
Non-ECP and Non-ECA	

1.2 Waste Generation and Management

1.2.1 Enumerate Waste Type and Specify Quantity of Wastes generated in your facility. (Identify /Enumerate)

Category	Waste	Type		Quantity
		Hazardous	Non-Hazardous	
	Solid wastes		✓	
	Residual wastes	✓	✓	
	Used oil	✓		
	Waste Tailings		✓	

1.3 Pollution Control System (PCS)

1.3.1 Enumerate PCS or Waste Management Method used in your facility. (Identify /Enumerate)

Category	PCS/Waste Management Method Used	Remarks
Solid	Waste segregation	
Hazardous wastes	Accredited Waste transporter	
Waste Tailings	Provisions of siltation/ tailings ponds	

II. PATHWAYS

2.1 Prevailing wind towards barrio or city? Yes _x___ No ____

2.2 Rainfall (impacts surface & groundwater pathways)

2.2.1 Average annual net rainfall:
Specify amount: 1,472.9 mm (Mati Station)

2.2.2 Maximum 24-hour rainfall:
Specify amount: mm

2.3 Terrain (select one and mark) Flat ___ Steep _ x __

2.4 Is the facility located in a flood-prone area? (select one and mark) Yes _____ No _____

2.5 Ground Water

Depth of groundwater table (meter) (select one and mark)

0 to less than 3	_________
3 to 10	_____x___
Greater than 10	_________

III. RECEIVING MEDIA/RECEPTORS

3.1 Air (Distance to nearest community) (select one and mark)

0 to less than 0.5 km	_________
0.5 to 1 km	___x_____
Greater than 1 km	_________

3.2 Receiving Surface Water Body ***Piso-Catangawan, Mapagba, Maputi, Pintatagan, Punta Linao Rivers***

3.2.1 Distance to receiving surface water: (select one and mark)

0 to less than 0.5 km	_________
0.5 to 1 km	____x ____
Greater than 1 km	_________

3.2.2 Size of population using receiving surface water

Specify number: >2,000

3.2.3 Fresh Water ***Piso-Catangawan, Mapagba, Maputi, Pintatagan, Punta Linao Rivers***

3.2.3.1 Classification of fresh water

AA	__________
A	___________
B	___x______
C	
D	____ ___

3.2.3.2 Size of fresh water body

Specify size: sq.km.

3.2.3.3 Economic value of water use (may select more than one of the criteria below)

Drinking	___________
Domestic	_____x_____
Recreational	_____ _ _____
Fishery	_____ __ ___
Industrial	____x_____
Agricultural	____x_____

3.2.4 Salt water

3.2.4.1 Classification of salt water (select one and mark)

SA	___________
SB	___ _______
SC	_____x____
SD	___________

3.2.4.2 Economic value of water use (may select more than one of the criteria below)

Fishery	_____x_____
Tourist zone or park	___________
Recreational	_____ x_____
Industrial	____________

3.3 Ground Water

3.3.1 Distance to nearest recharge area

0 to less than 0.5 km	__________
0.5 to 1 km	____x____
Greater than 1 km	__________

3.3.2 Distance to nearest well used

0 to less than 0.5 km	
0.5 to 1 km	
Greater than 1 km	x

3.3.3 Groundwater use within the nearest well

Drinking	x
Industrial	
Agricultural	x

3.4 Land

3.4.1 Indicate current/actual land uses within 0.5 km radius:

Residential	x
Commercial/Institutional	
Industrial	
Agricultural/Recreational	x
Protected Area	
Alienable and disposable	x

3.4.2 Potential/proposed land uses within 0.5 km

Residential	
Commercial/Institutional	
Industrial	
Agricultural/Recreational	
Protected Area	
Revegetated area	x

3.4.3 Number of affected Environmentally Critical Areas within 1 km:

Specify number:	0

3.4.4 Distance to nearest ECA (select one and mark)

0 to less than 0.5km	
0.5 to 1 km	
Greater than 1 km	x

IV. ENVIRONMENTAL PERFORMANCE (FOR EXISTING PROJECTS FOR EXPANSION)

3.5 Compliance (pls. take note that this will be double-checked with PCD files)

Law	Violation (check if any)	Type (pls. specify number of times committed) STANDARD				Type of Admin Violation	Additional Remarks/Status of Compliance
		Emission/Effluent/ Discharge	Ambient	Human Impact	Admin/ ECC		
RA 8749	Not Applicable						
RA 9275	Not Applicable						
RA 6969	Not Applicable						
PD 1586	Not Applicable						
RA 9003	Not Applicable						

3.6 Number of Valid Complaints

3.6.1 Citizen and NGOs

Specify number: __none_______

3.6.2 Others (other Govt. Agencies, Private Institutions)

Specify number: __none_______

(To be filled up by EMB Personnel)

RECOMMENDATION/S:

Assessed By: ____________________

Noted By: ____________________