TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ANNEXES

EXECUTIVE SUMMARY

Project Fact Sheet

Name of Project	2x335 MW Coal-Fired Power Plant Project	
Project Location	Brgys. Nalvo Sur and Carisquis, Luna, La Union	
Project Area	Approximately 41 hectares	
Nature Type of Project	Thermal power plant	
Combustion Technology	Supercritical pulverized coal	
To be Installed Capacity	2X300 MW(net), 2x335MW(gross)	
Summary of Major Components	**Major Components**	**Brief Description**
	Jetty	150m-300m
	Boiler System	2 units x 335 MW – SPC Boiler System
	Steam Engine	2 units x 335 MW
	Coal handling and coal feed system	2 Covered Coal stock piles; 10m high; 150,000 tons total capacity (29 day worth for 2 boiler units) 2 Covered coal conveying streams; 700 tph capacity each
	Ash handling system	For bottom ash only; 1.5 hectares sufficient for 5 years
	Electrostatic Precipitator	1 set for each boiler; ≥99.7% efficiency
	Seawater Fluegas Desulfurizer	2 units (including 2 absorber and 2 Seawater Treatment Systems)
	Stack	Single stack (180m high); Will consist of an outer cylindrical reinforced concrete shell and steel fuel
	Cooling Water Intake Pipe	Length: 341.390m Depth: 15m Cooling water requirement: 111,624 tons/hour
	Cooling Water Outfall	Length: 417.902m Depth: 11.5m Flow rate: 33.33m^3/s
	Fuel oil system	Fuel oil pump: 35m^3/hr; 150m Oil storage tank: 400m^3
Project Cost	Approximately PhP80 Billion	
Construction Period	3.5 years	
Commercial Operation Date	First quarter of 2022	
Operation	PSA period is for 25 years	
Proponent Name	Global Luzon Energy Development Corporation (GLEDC)	
Proponent Authorized Representative	Jaime T. Azurin (President – GBP) Emil Garcia (VP – GLEDC)	
Proponent Address and Contact Details	22nd Floor GT Tower International, 6813 Ayala Avenue, Makati City	
Environmental Impact Assessment (EIA) Preparer	Aperçu Consultants, Inc.	
Preparer Contact Person	Lilli Beth S. Yazon Managing Director	
Preparer Address and Contact Details	Unit 307 Philippine Social Science Center, Commonwealth Avenue Quezon City Telephone No.: (02) 929-2778 / (02) 455-2778 E-mail Address: inquiry @apercu.biz.ph	

Project Description Summary

This Environmental Impact Statement (EIS) has been prepared for the application of an Environmental Compliance Certificate (ECC) for a Coal-Fired Power Plant Project with a 670 (2x335) megawatt generation capacity. The project is to be located in a 41-hectare land area in Barangays, Nalvo Sur and Carisquis in the Municipality of Luna, La Union.

The site is located approximately 260 aerial kilometers north-west of Manila. The project land area is currently classified as a special industrial zone (based on The Comprehensive Land Use Plan 2014-2023) with an elevation of about 15masl across the road while the beach front has an elevation of 3-7 masl. The beach front along the Lingayen Gulf coast can also be utilized for industrial purposes as stated in the latest comprehensive land use plan (CLUP).

The project will make use of two (2) state-of-the-art supercritical-pressure pulverized coal boilers producing three hundred thirty-five (335) MW of power. Pollution control devices such as a Desulphurization system and an Electrostatic precipitator (ESP) will be installed. The proposed power plant will have the following major components: Boiler system, Steam Engine, Coal handling and coal feed system, Ash handling system, Pollution control systems, Process systems, Stack, and Fuel oil system.

This proposed project will help address the demand for reliable and affordable power supply, given the country's rapidly growing economy. This will not only provide sufficient electricity to Filipino communities and industries but also contributes to the national development.

As a developing country, the Philippines' energy usage is increasing because of growth in our industries and the growing demand from households. Daily activities in large and small businesses, hospitals, schools, offices, government agencies and households are heavily dependent on electricity. However, the power supply from existing power plants is not enough to meet the continually increasing demand.

EIA Process Documentation

EIA Team

The environmental impact assessment (EIA) was conducted by a team of specialists and consultants from Aperçu who have acknowledged expertise in their respective fields, in close coordination with the project management and technical team of GLEDC (**Table ES-1**).

Table ES-1
EIA Team Composition

Module/Section	Team Member	EMB Registry No.	Company
Project Management	Lilli Beth S. Yazon	IPCO-094	Aperçu
Project Coordination	Cordia Walter B. Jimenez Marife M. Abrajano	IPCO-074 IPCO-389	Aperçu
Geology, Geomorphology, Land Use and Pedology	Armie Jean H. Perez, MSc	IPCO-071	Apercu
Terrestrial Ecology – Wildlife	Diane Shiela C. Castillo, MSc	IPCO-295	Aperçu
Terrestrial Ecology – Vegetation	Tomas D. Reyes, Ph.D.	IPCO-386	Aperçu
Hydrology and Hydrogeology	Odessey C. Herrera	IPCO-391	Aperçu
Bathymetry	Engr. Leoncio L. Apit, Jr.	-	Aperçu
	Pete P. Peralta	IPCO-254	Aperçu
Freshwater Ecology	Edzel V. Pares	IPCO-390	Aperçu
Thermal Plume Modeling	Cesar L. Villanoy, Ph.D.	-	Aperçu
Oceanography	Robert R. Pabiling	IPCO-107	Aperçu

Table ES-1 continued

Module/Section	Team Member	EMB Registry No.	Company
Marine Ecology	Benjamin S. Francisco	IPCO-038	Aperçu
Fisheries and Macro-invertebrates	Michael Francisco	IPCO-172	Aperçu
Ambient Air Quality	Ronald E. Jose	IPCO-384	Aperçu
Air and Noise Modeling	Engr. Jethro Alden C. Hipe	IPCO-005	Aperçu
Environmental Risk Assessment	Thelma Dela Cruz, MSc	IPCO-387	Aperçu
Public Health	Roselmo Doval-Santos, M.D.	IPCO-385	Aperçu
Socio-economics	Krishna Buenaventura, Ph.D.	IPCO-093	Aperçu
	Gabriel Tilde	IPCO-388	Aperçu

From the proponent's side, project management was spearheaded by Mr. Grant Clark, Mr. Erickson Omamalin, Mr. Alan Aguinaldo, and Mr. Janssen Dela Cruz.

EIA Schedule

The following major activities were undertaken to complete the EIA:

Table ES-2
EIA Study Schedule

Activity	Date	
IEC Activities	14-16 June 2016; 8 September 2016	
Public Scoping	13 July 2016	Municipality of Luna
Technical Scoping	9 August 2016	
Primary Data Gathering	**Module**	**Date**
	Geology and Pedology	18 August 2016; 3-4 October 2016
	Vegetation	25-29 July 2016
	Wildlife	28 July – 1 August 2016
	Hydrology	2-3 August 2016
	Oceanography	25-28 September 2016
	Water Quality	21 August 2016
	Freshwater Ecology	21 August 2016
	Marine Ecology	22-25 July 2016
	Ambient Air and Noise	12-23 August 2016
	Socio Economic	10-13 August 2016; 13-14 September 2016
	Health Study	2-3 August 2016
	Traffic Study	19-20 August 2016
Secondary Data Gathering	**Data Gathered**	**Date**
	PAGASA and MGB Data	Date acquired: July- December 2016
	NAMRIA (Topographical Maps and Land Cover Map)	
	Host province, municipality and barangays data (CLUP and Health data)	25 June 2014 Date acquired: 16 June 2016

EIA Study Area

The environmental impact assessment for the project was conducted within the five (5) barangays in the municipality of Luna. These are the barangays identified to be the project's direct and indirect impact areas. Brgys. Carisquis and Nalvo Sur, where the project site is going to be located, are identified as the direct impact areas (DIA) while Brgys. Darigayos, Nalvo Norte and Pila are the indirect impact areas (IIA).

EIA Methodologies

The environmental impact assessment was conducted using guidelines from Presidential Decree 1586, DAO 2003-30 ("Revised Procedural Manual"); from EMB Memorandum Circular 2014-05 ("Guidelines for Coverage Screening and Standardized Requirements under PEISS amending relevant portions of MC 2007-02"), from DAO 2017-015 ("Standardization of Requirements and Enhancement of Public Participation in Streamlined Implementation of the PEISS") and other relevant laws pertaining to the protection of the environment. Primary data were gathered through ocular inspection, on-site observations and field sampling in pre-determined sites based on the project impact areas. Secondary data relevant to the assessment and documentation of the existing physical and biological conditions at the proposed project site were gathered through the review of related literature, data from government offices and extensive research. The methodologies used per module are listed in **Table ES-3.**

Table ES-3
EIA Methodology

Module/Section	Baseline Sampling Methodology	Parameters/ Indices
Land		
Geology/Geomorphology, Pedology, Land Use and Classification	▪ Secondary data gathering ▪ Site Visit – Ocular Inspection ▪ Soil Quality sampling at 4 stations ▪ Mapping	▪ Soil Quality Laboratory Analyses Techniques: Glass Electrode (pH), Kjeldahl (N), Titrimetric (P), Flame AAS (K), Diphenylcarbazide (Cr^{+6}), Hydride Generation AAS (As), Cold Vapor AAS (Hg), Flame AAS (Pb), Flame AAS (Cd), Walkley – Black Titration (Organic Matter)
Terrestrial Ecology – Flora and Fauna	▪ Quadrat Sampling, Transect Walks and Mist Netting ▪ Interviews, Surveys, Inventory and Ocular inspection ▪ Vegetation with 135 plots and Wildlife with 6 sites	▪ Parameters: Density, dominance, abundance, frequency, importance value, species diversity, evenness, endemicity, and conservation status
Water		
Hydrology/hydrogeology	▪ Secondary data gathering ▪ Spring and well inventory ▪ Flow measurements (volumetric and float methods) ▪ Interviews and photo-documentation ▪ CORMIX software was used for thermal plume modeling ▪ Delft3D-PART software was used for hydrodynamic and particle dispersion modeling	▪ Secondary data gathered was used to assess and formulate water balance analysis, flow duration, and groundwater recharge and production analysis. ▪ PAGASA Climate Change Projections 2020 and 2050 were incorporated in the analysis for the entire Water Module.
Water Quality	Water quality sampling for: ▪ Groundwater at 3 stations ▪ Freshwater at 3 stations ▪ Marine water at 4 stations	Water Quality Laboratory Analyses Techniques: ▪ Glass Electrode (pH), Mercury-filled Thermometer (Temperature), Visual Comparison (Color), Azide Modification-Dilution Technique (BOD_5), Gravimetric dried at 103-105° (TSS), Gravimetric dried at 180°C (TDS), Diphenylcarbazide (Cr^{+6}), Iodometric (DO), Gravimetric-Petroleum Ether Extraction (Oil & Grease), Hydride Generation AAS

Table ES-3 continued

Module/Section	Baseline Sampling Methodology	Parameters/ Indices
		(As), Flame AAS (Cd, Pb), Cold Vapor AAS (Hg) and Multiple Tube Fermentation (Total Coliform)
Freshwater Ecology	▪ Carter's Habitat Assessment Form ▪ Surface water sampling at 3 stations located in Darigayos River	▪ *In-situ* measurements of basic limnological variables such as DO, pH and temperature ▪ Analysis of freshwater biota, macrobenthos and plankton
Marine Water Ecology	▪ Secondary data gathering from government offices ▪ Conduct of Marine Wildlife Survey and Key Informant Interviews ▪ 20 Manta Tow Survey Stations ▪ 3 Line Intercept Transect Stations ▪ 3 Fish Visual Census Survey Stations ▪ 4 Seagrass Stations ▪ 2 Macro-invertebrate Sampling Stations ▪ Site dive ▪ Quadrat Sampling ▪ Phototransect ▪ Market visit	Characterization and assessment of marine communities included the following parameters: community composition, abundance, biomass and relative cover of the coral reefs, plankton, seagrass and invertebrate fauna. The Marine Wildlife Survey included Key Informant Interviews (KIIs) with fisher folks.
Air		
Meteorology/Climatology	Secondary data gathering: ▪ Climate map of the Philippines ▪ Climate normal data from 1981 to 2010 ▪ Annual windrose at the Dagupan City Station from 1971 to 2000 ▪ Climate extremes data as of 2016 ▪ Tropical cyclone maps	▪ PAGASA Climate Change Projections 2020 and 2050 were incorporated in the analysis
Air Dispersion Modeling	AERMOD Software Secondary data gathering: ▪ Climate map of the Philippines ▪ Annual windrose at the Dagupan City Station from 1971 to 2000 ▪ Climate extremes data as of 2016 ▪ Tropical cyclone maps	▪ The EMB Air Dispersion Modeling Guidelines (EMB Memorandum Circular 2008-003) were incorporated in the analysis
Ambient Air Quality and Noise	▪ Air Quality Sampling at 6 stations ▪ 1 hr sampling (As, Cd, Cr, Pb) ▪ 24 hr sampling (SO2, NO2, TSP, PM10, Hg) ▪ Use of Kimoto Gas bubbler for No_x and SO_x; Staplex High Volume Sampler for TSP; Multi-Rae Plus Gas meter with Photo-Ionization Detector for CO; and Ecotech High Volume Sampler with 10 micron inlet. ▪ Results were compared to the National Ambient Air Quality Guidelines Values, Rule VII, Part II and the National Ambient Air Quality Standards for Source Specific Air Pollutants from ▪ Industrial Sources/Operations Section 1 Rule XXVI Part VII of the Clean Air Act IRR	▪ Air Quality Laboratory Analyses Techniques: - Pararosaniline (SO_2) - Griess Saltzman (NO_2) - Gravimetric (PM_{10} and TSP) - Flame AAS (Cd and Pb) - Hydride Generation AAS (As) - Diphenylcarbazide (Cr^{+6}) - Cold Vapor AAS (Hg)

Table ES-3 continued

Module/Section	Baseline Sampling Methodology	Parameters/ Indices
People		
Socio-economics	▪ Secondary data gathering ▪ Conduct of public participation activities ▪ Survey of 306 households ▪ Information, Education, Communication (IEC) campaign ▪ Key Informant Interviews (KIIs) ▪ Focus Group Discussions (FGDs) ▪ Public Scoping	▪ Demographic profile ▪ Availability of public services ▪ Socioeconomic data i.e. sources of income, employment profile, etc.
Public health	▪ Secondary data gathering ▪ Conduct of EHIA ▪ KII and FGDs with the Brgy. Health Workers, Rural Health Unit Medical Staff and Doctor ▪ Public Health Survey	▪ Availability of public services in terms of health resources ▪ Morbidity and mortality rates ▪ Environmental health and sanitation profile
Environmental Risk Assessment		
ERA	Risk screening	

Public Participation Activities

The conduct of IEC campaigns, FGDs, and Public Scoping were successfully carried out from June to July 2016. Various stakeholders including the LGU, NGOs, fisher folk, farmers, women, youth, senior citizens, health personnel, religious sector representatives, academe members, anti-crime organizations, OFWs, transport and professional/civic groups participated in the activities. The program included presentations and handouts that provided information about the proposed project, the proponent, the EIA process and the scope of the EIA Study. The various public participation activities undertaken for this EIS are listed in **Table ES-4**. The stakeholders also provided their inputs, insights, concerns and issues regarding the proposed project (**Annex J**). These concerns were considered in the EIA Study.

Table ES-4
List of Public Participation Activities

Activity	Venue	Date	Participants
IEC Meeting	People's Hall, Municipal of Luna, La Union	14 June 2016 8:00 am – 12:00 nn	Municipality of Luna officials, department heads and Association of Barangay Chairmen (ABC)
IEC Campaign	People's Hall, Municipal of Luna, La Union	14 June 2016 2:00 pm – 5:00 pm	Academe, school heads and religious sector representatives
IEC Campaign	Barangay Hall of Carisquis, Municipal of Luna, La Union	15 June 2016 9:00 am – 12:00 nn	Host community – Brgy. Carisquis (women, men, senior citizen, barangay officials, youth, fisher folk, media, Defend Ilocos, etc.)
IEC Campaign	Barangay Hall of Nalvo Sur, Municipal of Luna, La Union	15 June 2016 2:00 pm – 5:00 pm	Host community - Barangay Nalvo Sur (Barangay officials, women, men, farmers, fisher folks, etc.)
IEC Campaign	People's Hall, Municipal of Luna, La Union	16 June 2016 9:00 am – 12:00 nn	Neighboring communities – Barangays Nalvo Norte, Darigayos and Pila
Public Scoping	Luna Sports Complex, Municipality of Luna, La Union	13 July 2016	LGUs, Fisher folk, Farmers, Religious Sector, Civic groups, Women, Youth, Academe, OFWs

EIA Summary

Summary of Alternatives

Table ES-5
Summary of Alternatives

Preliminary Options	Major Considerations
Site Selection	
Site 1 (Luna, La Union)	▪ Pebble picking activities on the beach front ▪ Presence of a municipal landmark situated at the beach – head ▪ Presence of agricultural farms on the property ▪ Site is owned by several landowners ▪ Target depth of 16-18m for the jetty is reached at 500m from the shoreline ▪ Land use classification: agricultural
Site 2 (Rosario, La Union)	▪ Presence of few residential houses ▪ Property composed of farmlands and fishponds ▪ Target depth of 16-18m for the jetty is reached at 1km from the shoreline ▪ Land use classification: agricultural
Proposed Project Site (Luna, La Union)	▪ Rolling hills terrain ▪ No residential houses will be affected by the project ▪ Target depth of 16-18m for the jetty is reached at 150-350m from the shoreline ▪ Project land area is classified as a special industrial zone; beach front is classified as agricultural but can be utilized as industrial as stated in the CLUP (2014-2023) ▪ Luna's topography is well-suited for a coal-fired power project because of its flat terrain, its ease of accessibility and its close proximity to the sea. ▪ Project site is not prone to landslides; has low susceptibility to flooding; is not exposed to extreme climatic conditions and is outside of the areas with liquefaction potential. ▪ Project site is located in a tsunami and surge prone area. The plant will thus be built at an elevation equal to or above the national road and will be designed to withstand wave heights above 2m. ▪ Project site is located near potential seismic generators thus structures will be designed using a *g* factor of 0.4
Technology Selection	
Supercritical Pulverized Coal Technology	Supercritical Pulverized Coal (SPC) Technology was chosen over the PC and CFB technologies. SPC technology uses higher temperatures and pressures to achieve better efficiency, reduced fuel consumption and produces less greenhouse gases on a per kilowatt hour basis.
Resource Selection	
Wind	NREL's Philippine Wind Energy Resource Atlas classifies the wind in the La Union as marginal (4.4-5.6m/s). Wind utility –scale power plant required wind speeds of 10m/s to 15m/s to operate.
Solar	Data from the US-based National Renewable Energy Laboratory show that Luna does not have the minimum solar irradiation and wind speed necessary for a utility scale power plant to be feasible.
Hydropower	The nearest river, Darigayos River, is about 2 km away from the project site which has a computed power generating capacity of 1MW based on the available stream flow.

Preliminary Options	Major Considerations
Coal	Coal is considered the most abundant fossil fuel with significant reserves available. Coal comprises majority of the electric power generation mix in the world because of its availability and affordability. Coal will be imported from Indonesia and other foreign sources.
Water supply	The area is assessed as an area with less productive aquifer and therefore groundwater will not be used. The nearest freshwater source is 2km away and will not be tapped by the project. Freshwater will be provided by desalination and demineralizer facilities that may be augmented by water service providers, as needed.
Environmental Assessment of Type of Power Plants	
Wind Plant	
Solar Plant	
Hydropower Plant	
LNG Plant	
Coal Plant	

Summary of Key Environmental Impacts and Management Plan

Table ES-6
Impacts and Mitigation Summary

Environmental Component	Potential Impact	Prevention or Mitigation or Improvement
I. PRE-CONSTRUCTION PHASE The pre-construction phase includes activities such as planning, conducting of the feasibility study, detailed engineering, ocular survey, and permit procurement. No perceived impacts during this phase.		
II. CONSTRUCTION PHASE		
A. Land	Change/Inconsistency in Land Use	• Project site is compatible with the existing comprehensive land use and zoning plan of Luna – the area is categorized as a special industrial zone. A buffer zone will be created around the proposed coal fired power plant to separate the neighboring residential and tourism establishments.
	Tenurial /Land Issue	• Tenurial issues are not expected since the proposed site is a private property that has been acquired by the project proponent. The property is covered by a Transfer Certificate of Title.
	Encroachment in Protected Areas under NIPAS	• Encroachment in protected areas under NIPAS is not expected. There are no known protected areas within the immediate vicinity of the project site.
	Encroachment in other ECAs	• Project site falls within 3 ECA categories – (1) areas which constitute the habitat of critical or endangered species; (2) areas frequently affected by natural hazards; (3) water bodies that support fishing activities; • Ensure that necessary pollution control equipment to manage the project's environmental impact will be installed.
	Impairment of visual aesthetics	• The project is not expected to cause impairment of visual aesthetics.
	Devaluation of land value as a result of improper solid waste management and other related impacts	• Comply with the Ecological Solid Waste Management Act of 2000 implemented by the LGU, such as: ▪ Solid waste diversion through re-use, recycle, and composting activities; and ▪ Solid waste segregation from point of waste source to "compostable", "non-recyclable", "recyclable" "special wastes";

Environmental Component	Potential Impact	Prevention or Mitigation or Improvement
	Change in surface landform/topography/terrain/slope	• Install appropriate slope protection; • Remove loose rocks to prevent occurrence of rock fall; and • Provide appropriate drainage design for roads that will be constructed to avoid road failure.
	Change in sub-surface/underground geomorphology	• The project is not expected to lead to changes in sub-surface or underground geomorphology since the foundation of buildings and other structures that will be constructed on site is expected to be suitable for the substrate in the project site.
	Inducement of subsidence or collapse	• Conduct further geotechnical studies prior to construction to determine presence or absence of solution cavities; and • Comply with the recommended foundation design of the geotechnical engineer.
	Inducement of landslides or other natural hazards	• The project is not expected to induce landslides or other natural hazards since coastal portion of the project site is essentially flat and has low susceptibility to landslide hazards; and • The sloping hilly portion of the project site has low to moderate susceptibility to mass movement hazards such as landslides and rock fall.
	Soil erosion/loss of topsoil/ overburden and bank stability	• Limit excavation and land clearing to what is required for project construction; and • Stabilize stockpiles of excavated soils to minimize occurrence of erosion particularly during the rainy season.
	Change in soil quality/fertility	• Inspect and maintain vehicles and machinery regularly • Provide cemented area for vehicles; • Use oil sumps in engine rooms and vehicle equipment maintenance areas; • Collect and store oil sludge in oil sludge tanks that are lined with impermeable materials; and • Dispose through a DENR accredited hazardous waste transporter and treater.
	Vegetation removal and loss of habitat	• Establish a 5m wide vegetated buffer around the project site; • Implement a conservation and rehabilitation program; • Collect seeds and wildlings of threatened plants, specifically narra, mahogany, bani, bolong eta, danglin, is-is, and molave, prior to construction; • Establish a nursery using important local species that will be used to vegetate the buffer zone • Establish and maintain permanent vegetation around the project site; and • Limit vegetation clearing and movement of workers to designated areas only.
	Threat to existence and/or loss of important local species	• Limit development activities within the proposed project area; • Delineate areas to be cleared to avoid unnecessary clearing.
	Threat to abundance, frequency and distribution of important species	• Limit vegetation clearing to designated areas only.
	Disturbance or loss of species due to habitat loss	• Limit vegetation clearing and movement of workers to designated areas only; • Ensure compliance with all regulations relevant to minimizing noise generated from construction of the power plant..
	Hindrance to wildlife access	• Contain construction materials and equipment in designated places to allow movement of wildlife in areas adjacent to project site as they find temporary places for forage and refuge during construction. Situation will be back to normal as soon as

Environmental Component	Potential Impact	Prevention or Mitigation or Improvement
		reforestation and other efforts are performed by the proponent.
B. Water	Change in drainage morphology/inducement of flooding/reduction in stream volumetric flow	• Design an efficient drainage system with silt traps and storm water outfall discharging to the sea; • Provide channel ditches and/or pipe drains to carry the generated flows around the area being developed going to the main storm water outfall leading to the West Philippine Sea.
	Depletion of water resources/ competition in water use	• Freshwater demands of the power plant during both construction and operation phases will be supplied by desalination and demineralizer facilities and augmented by a water service provider, as needed; • There are no NWRB water grantees within the project boundary.
	Occurrence or aggravation of flooding in nearby areas	• Provide drainage channels around active construction sites • Design an efficient drainage system with silt traps and storm water outfall discharging to the sea
	Degradation of groundwater quality	• Maintain equipment, machinery and trucks to be used during the course of work in perfect condition and free of oil leaks; • Repair impaired machinery and vehicles in a designated cemented maintenance area with proper drainage and oil absorbing materials; • Orient workers and contractors to effectively implement safe environmental management practices within the construction sites; • Provide on-site toilets and facilities at work areas; and • Establish and implement ecological solid waste management plans.
	Degradation of surface water quality	• Provide on-site toilets and facilities at work areas; • Establish and implement ecological solid waste management plan; and • Re-vegetate construction sites to prevent erosion.
	Degradation of coastal/marine water quality	• Create and implement a sedimentation and erosion control plan. Set up devices to retain sediments and materials that may find its way to the sea; • Dispose excess soil in order to prevent storm water from carrying the particles into the coastal waters; • Orient workers and contractors to effectively implement safe environmental management practices within the construction sites; and • Provide on-site toilets and facilities at work areas.
	Threat to existence and/or loss of important local species and habitat	• Determine the most suitable location of pylons, away from corals; • Assess and select a jetty area/angle with the least coral occurrence; • Install silt curtains and entrapment mechanisms to prevent sediments and silt from blanketing coral reef areas; • Protect and induce expansion of seagrass colonies; • Adopt innovative engineering design to ensure that pipe lying will have the least disturbance to coral colonies; • Design supporting structures to have least damage to bottom substrate; • Conduct coral transplantation, where feasible; • Install fish shelters in suitable sites; and • Avoid building of permanent structures in sensitive areas where bivalves are assessed to reproduce.

Environmental Component	Potential Impact	Prevention or Mitigation or Improvement
	Threat to abundance, frequency and distribution of species	• Support efforts to improve habitats, fish production, and recruitment; • Support campaign against use of fine mesh nets; and • Employ silt curtains and entrapment mechanisms to prevent sediments and silt from blanketing coral reef areas.
C. Air	Change in local micro-climate	• Establish a Greening Program in cooperation with PENRO.
	Contribution in terms of greenhouse gas emissions *Applicable only for projects with significant GHG emissions	• Regular maintenance of heavy equipment and motor vehicles.
	Degradation of air quality	• Undertake dust suppression measures, e.g., water application, speed restrictions minimize (15-20kph), in active construction areas; • Replace vegetation in non-structure areas to minimize wind erosion of topsoil; • Conduct compacting of exposed soil surfaces; • Provide tarpaulin cover on trucks loaded with construction materials; • Hauling of spoils/excavated earth materials immediately after excavation; • Regular maintenance of heavy equipment and motor vehicles; • Install Continuous Emission Monitoring System; and • Install pollution control devices i.e. Electrostatic Precipitator, Seawater Flue Gas Desulfurizer, low NOx burner and CO reduction system.
	Increase in ambient noise level	• Regular maintenance of mufflers of standby generators and other pertinent equipment; • Provision of ear plugs to workers directly exposed to high noise equipment; • Use of effective noise-attenuating materials for the plant's structure and walling; and • Planting of the appropriate vegetation around the plant.
D. People	Displacement/ disturbance of properties	• There are no residents within the project site that will be displaced.
	Change/conflict in landownership	• The proposed site is a private property that has been acquired by the project proponent. The property is covered by transfer certificate titles and a contracts to sell.
	Change/conflict in Right of Way	• The proposed project site has already been acquired by the proponent and is covered by transfer certificate titles and contracts to sell; conflict in right-of-way is not likely to occur.
	In-migration	• Conduct job fairs in one place to ensure migrants are tracked and legitimate residents are given priority in the selection process.
	Proliferation of Informal Settlers	• Assist the LGU in setting-up a migration information center in barangay halls for easier migrant tracking; and • Report visitors staying in the area for more than a month.
	Cultural/lifestyle change (especially on indigenous people)	• There are no indigenous people residing in the project area thus, there are no perceived effects on cultural change.
	Impacts on physical cultural resources	• No foreseen impacts present as there are no physical cultural resources within the impact areas.
	Threat to delivery of basic services/resource competition	• Proper planning of community resources; • Proper implementation of the CLUP; and • Preparation of Barangay Development Plans and Barangay Disaster Risk Reduction Management Plan for barangays

Environmental Component	Potential Impact	Prevention or Mitigation or Improvement
		Carisquis and Nalvo Sur, to be led by LGU and assisted by GLEDC.
	Threat to public health and safety	For power plant employees: • Provide safety and environmental awareness trainings for workers; • Orient workers on occupational health and safety; • Provide Personal Protective Equipment (PPE); • Implement safety protocols; • Provide ample potable water within the construction site; and
		• Provide first aid facilities at the community centers/halls and designate a safety officer to monitor safe working conditions. For threats to public health due to pollutants: • Install pollution control devices to meet emission limits; • Provide proper sanitation and sewage at work sites, enforce sanitation discipline among workers; and • Re-vegetate disturbed soil as soon as possible Implement solid waste and hazardous materials management systems.
	Generation of local benefits from the project	• Assist in the development of a more active Barangay Development Council (BDC) to coordinate and enhance local benefits.
	Enhancement of employment and livelihood opportunities	• Provision of skills training to residents of the community prior to the hiring process to increase the likelihood of barangay residents being hired because of their qualifications; • Assist the LGU in identifying and preparing documentary requirements for the projects eligible under ER 1-94; and • Coordinate Corporate Social Responsibility (CSR) initiatives with the barangay.
	Increased business opportunities and associated economic activities	• Provide business management seminars to local residents who plan to initiate small scale businesses.
	Increased revenue of LGUs	• Assist the LGU in identifying and preparing documentary requirements for the projects eligible under ER 1-94.
	Traffic Congestion	• Implement a construction traffic management plan; and • Provide traffic signs to ensure public safety and avoid potential traffic incidents.
III. Operation Phase		
A. Land	Inducement of subsidence or collapse	• Subsidence, caused by excessive groundwater withdrawal, is not expected from the project since the project will not draw excessive volume of groundwater.
	Change in soil quality/fertility	• Inspect and maintain equipment and machinery to avoid oil spills and leaks; • Use oil sumps in engine rooms and vehicle equipment maintenance areas; • Ensure that maintenance areas have cemented surface and ash-pond is lined with HDPE; • Collect and store oil sludge in oil sludge tanks that are lined with impermeable materials; and • Dispose hazardous waste through a DENR accredited hazardous waste transporter and treater.
	Vegetation removal and loss of habitat	• Additional impact on vegetation is not expected during the operation phase. Proponent will continuously conduct Greening Program and enhance vegetation in designated conservation sites.
B. Water	Change in drainage morphology/	• The project is not expected to cause any additional impact on

Environmental Component	Potential Impact	Prevention or Mitigation or Improvement
	inducement of flooding/ reduction in stream volumetric flow	drainage morphology nor will the project induce flooding and cause reduction in volumetric flow during the operation phase.
	Change in water circulation pattern	• Adapt a discharge pipe design that will promote very rapid and efficient mixing.
	Degradation of groundwater quality	• Ensure integrity of HDPE lining by establishing monitoring stations in the vicinity of the ADA
	Degradation of coastal/marine water quality	• Use discharge pipe design that promotes very rapid and efficient mixing; and • Ensure that the wastewater treatment plant effluents will meet the DENR effluent standards under the Clean Water Act.
	Threat to existence and/or loss of important local species and habitat	• Declare a focal conservation point (coral transplantation and seagrass conservation) in the inter-tidal area with adequate tidal movement and replenishment.
	Threat to abundance, frequency, and distribution of species	• Continuously support strategies to improve fish production and recruitment such as campaign against use of fine mesh nets, and restocking, where ecologically feasible. Jetties usually become a natural recruitment area thru time due to the structural relief and stable substrate that it provides.
C. Air	Change in local microclimate	• Proponent will continuously conduct a Greening Program in cooperation with PENRO.
	Air pollution from stack emissions	• Ensure operation and maintenance of PC boilers are according to specifications; and • Ensure proper operation and maintenance of ESP, SWFGD, and NOx and CO reduction systems.
	Air pollution from standby generators and vehicle emissions	• Ensure proper operation and maintenance of generator set engines; • Use of low-sulfur fuel; and • Formulate and implement a motor vehicle maintenance program, including emissions testing.
	Carbon dioxide emissions	• Continuously conduct the Greening Program
D. People	Threat to public health and safety	For power plant employees: • Provide safety and environmental awareness trainings for workers; • Orient workers on occupational health and safety; • Provide Personal Protective Equipment (PPE); • Implement safety protocols; • Provide first aid facilities at the community centers/halls and designate a safety officer to monitor safe working conditions; and • Put up appropriate safety signage around the plant. For threats to public health due to pollutants: • Ensure proper operation and maintenance of pollution control devices and water treatment facilities to meet emission limits; and • Promote proper sanitation and sewage storage at work sites enforce sanitation discipline among workers.
	Threat to delivery of basic services/resource competition	• Assist the LGU to plan community resources efficiently; • Assist the LGU in implementing the updated Comprehensive Land Use Plan of the Municipality of Luna; and • Assist LGU in the preparation of Barangay Development Plans and Barangay Disaster Risk Reduction and Management Plans for Brgys Nalvo Sur and Carisquis.
	Generation of local benefits from the project	• Provide employment opportunities for local residents; • Livelihood opportunities for local residents that are enterprising

Environmental Component	Potential Impact	Prevention or Mitigation or Improvement
		like selling food or providing board and lodging facilities to the workers; • Pay revenue to concerned LGUs; and • Assist the LGU in identifying and preparing documentary requirements for the projects eligible under ER 1-94.
IV. ABANDONMENT PHASE		
A. Land	Displacement of habitat for flora and fauna	• Perform Assisted Natural Regeneration (ANR) right after dismantling all the structures.
	Threat to existence and/or loss of important local species	• Plant readily available planting stocks of indigenous timber and fruit trees on open spaces.
B. Water	Disposal of wastes (ash and sludge)	• Supervise proper waste disposal; • Ensure appropriateness of the selected land fill site for coal-derived waste products; and • Re-vegetate the project site.
	Abandonment of jetty and other offshore structures	• Remove structures and monitor recovery of the coastline from any previous accretion and scouring.
C. People	Impact on employment and livelihood	• Conduct community development planning prior to abandonment so that residents whose source of income and livelihood is the power plant would be prepared for the proponent's eventual abandonment of the project.

In summary, one of the main impacts of the project on the land environment would be the removal of threatened floral species such as mahogany, narra, is-is, and bolong eta, danglin, bani and molave. Since seedlings and saplings of these species will be collected prior to land clearing and replanted in a nursery that will eventually be the source of plants for the buffer zone, this will ensure that propagation of the threatened species will continue. Other land impacts are those normally associated with clearing and earthmoving activities (erosion, sediment laden run-off, localized flooding, solid waste generation) all of which will be addressed by GLEDC with sufficient mitigating measures to prevent these from occurring. With the various mitigations that will be in place, the only residual impact on the land will be having a substantially built up area due to the power plant structure to replace what was once partly a tree plantation area.

For the water module, the main impact would be during the operation phase due to thermal discharges. This will be a continuing and residual impact for as long as the power plant is operating. The impact area is however away from the corals with fair cover. These corals will however be impacted when the coastal structures are built. The mitigation measures to prevent the dispersal of disturbed sediment will thus be crucial in ensuring that the impacts are temporary enough to allow the corals to recover after the construction phase.

Power plant emissions are the main impact to the air quality but the provision of a 180m stack, pollution control devices such as the ESP, the SWFGD among others, ensures that emission will meet DENR air quality standards. No residual air impacts are foreseen based on the air dispersion modeling done.

The residents in the host barangays of Carisquis and Nalvo Sur will mostly be impacted in a beneficial way with employment opportunities being provided during the construction phase and as recipients of GLEDC's CSR programs during both the construction and operation phases of the project. The LGU will also be positively affected with mainly with the payment of taxes and fees. The residual effect of this would be an overall economic upliftment for the residents of the host barangays and the LGU.

No major risks and uncertainties are identified based on the findings of the EIA.

I. PROJECT DESCRIPTION

1.0 BASIC PROJECT INFORMATION

1.1 Project Information

Name of Project	:	2x335 MW Coal-Fired Power Plant Project
Project Location	:	Brgys. Nalvo Sur and Carisquis, Luna, La Union
Project Area	:	Approximately 41 hectares
Project Type/ Nature	:	Thermal power plant
Combustion Technology	:	Supercritical pulverized coal
Source of Main Fuel	:	Indonesia and other countries
Type of Fuel	:	Bituminous or sub-bituminous coal
Scale of Production	:	2x300MW (net), 2x335MW (gross)
Construction Period	:	3.5 years
Commercial Operation Date	:	First Quarter of 2022
Operation Duration	:	25 years

1.2 Proponent Profile

Name of Proponent	:	Global Luzon Energy Development Corporation (GLEDC)
Address	:	22nd Floor GT Tower International, 6813 Ayala Avenue, Makati City
Contact Details	:	+63 (32) 464-1600
Authorized Representative for ECC Application	:	Jaime T. Azurin (President - GBP) Emil Garcia (VP - Vivant)

Global Luzon Energy Development Corporation is the special purpose company formed for the execution of the project. It consists of companies with experience in the development and operations of power plants located across the Philippine Islands.

2.0 PROJECT LOCATION AND AREA

2.1 Project Location

The proposed coal-fired power plant project will be situated in Barangays Nalvo Sur and Carisquis, Luna, La Union. The project land area is currently classified as a special industrial zone (based on the Comprehensive Land Use Plan (CLUP 2014-2023). The CLUP further states that the beach front along the Lingayen Gulf coast can also be utilized for industrial purposes. The project location showing the region and barangays is presented in **Figure PD-1**.

Figure PD-2 shows the 41-hectare project site through which the national highway traverses. The project site is bounded by a barangay road in the south, Barangay Pila in the east, Nalvo Sur in the north, and the West Philippine Sea in the west. Both sides of the national road consist of mahogany plantations which form part of the project site. These plantations will likely be cleared giving way to the construction of power plant structures. Thus, trees which will be affected by site clearing activities shall be replaced following the replacement ratio indicated in DENR Memorandum Order No. 2012-02, which is 1:50 for private and forest lands. Beach vegetation, consisting predominantly of talisay and aroma, are also found along the shore.

Figure PD-1. Project Location Map	LEGEND: No legend	SCALE: 1:45,000	PAGE: 16
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT		DATA INFORMATION/SOURCE: **Basemap:** GOOGLE EARTH IMAGERY, 2017 **Project Boundary**: GLEDC, 2017 **Boundaries:** LUNA CLUP, 2014-2023 **Imagery Date**: DECEMBER 1, 2016 **Created by:** APERCU CONSULTANTS, INC (2017)	apercu CONSULTANTS INC.

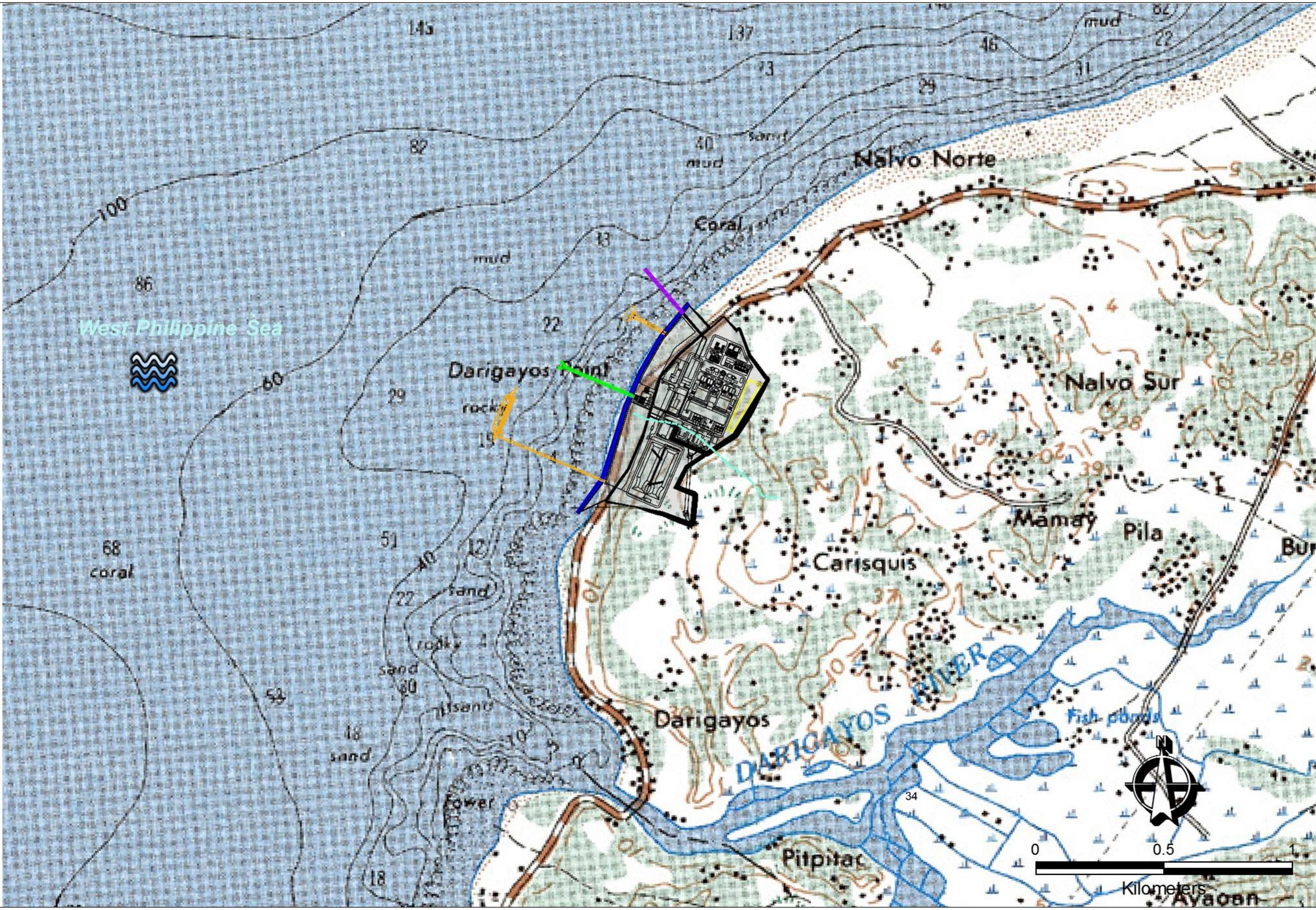


Figure PD-2. NAMRIA Topographic Map of the Project Site

ENVIRONMENTAL IMPACT STATEMENT
2x335MW COAL-FIRED POWER PLANT PROJECT

LEGEND:
- Project Layout
- Ash Pond
- Jetty/ Temporary Jetty
- Cooling Pipe
- Outfall Pipe
- Foreshore Area
- Ground Depression

SCALE: 1:15,000

DATA INFORMATION/SOURCE:
Basemap and Boundary: NAMRIA Topographic Bangar Sheet 3034-I
Project Boundary: GLEDC 2017
Created by: APERCU CONSULTANTS, INC (2017)

apercu CONSULTANTS INC.

The 41-hectare project site comprises of five privately-owned properties supported with transfer certificate of titles, which are the subject of the Contract to Sell (CTS) executed between the landowners and GLEDC (**Annex K-2**).

The CTS contains a provision allowing the buyer, GLEDC, to conduct pre-development activities on the properties. Eventually, title and ownership will be transferred to GLEDC after full payment of the purchase price and execution of a Deed of Absolute Sale.

Based on the parcellary survey (**Annex K-3**), the national road passing through the project site forms part of the 41-hectare property acquired, taking up 1.5 hectares of its total land area. The national road is included in the project area since various power plant structures such as the coal conveyors, cooling water intake and discharge pipes, and electrical and communication cables will traverse through it above ground (overhead) or underground. Accordingly, clearances will be secured from appropriate government agencies while the design and construction shall be compliant to regulatory and other related standards. Other than the structures that will be traversing it, GLEDC intends to keep the national road and will consider its right-of-way and easement on the final layout of the other power plant structures, most of which will be located on the larger section of the property (~30ha) east of the national road.

The parcellary survey also reveals seawater encroachment of around 4.3 hectares on the property's total land area. A foreshore lease agreement will be applied because certain project components such as the jetty, intake and discharge structures will be built on the foreshore and offshore areas. Based on the foreshore survey conducted, the foreshore area is around 2.4 hectares.

Moreover, there is a ground depression lying from east to west of the project site as noted on the topographic survey conducted on the properties.

2.2 Project Shape File

Figure PD-3 depicts the site's configuration and provides the geographic coordinates using WGS 84 datum.

2.3 Vicinity and Accessibility

The project site is located about 300km north-west of Metro Manila. It can be reached via the North Luzon Express way (NLEX), then through the Subic-Clark-Tarlac Expressway (SCTEX) and the Tarlac-Pangasinan-La Union Expressway (TPLEX) exiting at the town of Binalonan, Pangasinan. Travelling via MacArthur Highway thereafter will lead straight to the province of La Union. Municipalities along the way include Rosario, Agoo, Aringay, Caba, Bauang, the city of San Fernando, San Juan, Bacnotan, Balaoan, and finally Luna. Travel time usually takes 4 to 6 hours. Landmarks in the province that indicate proximity to the site include the Noble Tower Resort. **Figure PD-4** is the Vicinity Map.

2.4 Project Impact Areas

The project impact areas are delineated into direct and indirect impact areas. The Direct Impact Area (DIA) for this proposed GLEDC power plant includes the 41-hectare property within Barangays Carisquis and Nalvo Sur. Additionally, the results of the air dispersion modeling predicts that at normal conditions, the potential highest Ground Level Concentrations of NOx, the particular pollutant of concern, may occur 7km southeast of the stack (refer to **Section 3.2** of this EIS for the modeling results). Thus, the mountainous area where GLCs may occur was likewise designated as a DIA. As shown in **Figure PD-5,** barangays Carisquis and Nalvo Sur are included within the DIA.

ID	Latitude	Longitude	Notes
1	16°50'21.47"N	120°20'12.92"E	
2	16°50'18.09"N	120°20'16.41"E	
3	16°50'19.59"N	120°20'18.68"E	
4	16°50'17.90"N	120°20'20.90"E	
5	16°50'13.82"N	120°20'22.95"E	
6	16°50'10.23"N	120°20'25.93"E	Ash pond area
7	16°50'1.26"N	120°20'21.01"E	Ash pond area
8	16°49'56.26"N	120°20'13.11"E	8-13 Coal Stockpile
9	16°49'53.51"N	120°20'12.17"E	
10	16°49'52.35"N	120°20'14.87"E	
11	16°49'47.39"N	120°20'14.40"E	
12	16°49'48.82"N	120°20'9.33"E	
13	16°49'50.90"N	120°19'59.77"E	
14	16°49'49.02"N	120°19'55.66"E	
15	16°49'54.03"N	120°19'58.90"E	15-17 Jetty
16	16°50'0.22"N	120°19'42.30"E	
17	16°50'7.50"N	120°19'44.78"E	
18	16°50'11.68"N	120°19'52.74"E	Cooling Pipe
19	16°50'20.02"N	120°20'2.83"E	Temporary Jetty
20	16°50'26.91"N	120°20'5.69"E	Outfall Pipe

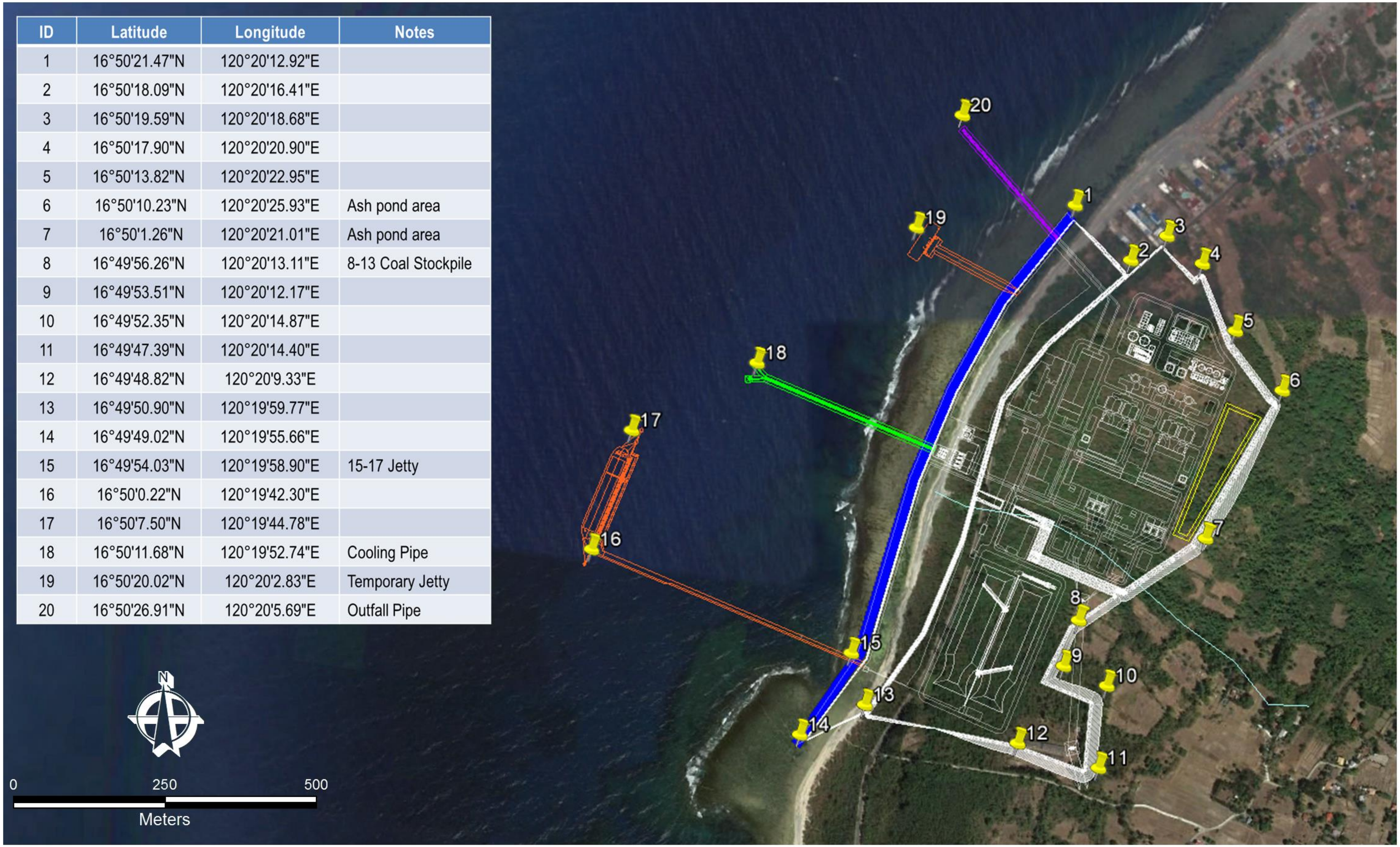


Figure PD-3. Shapefile Configuration Map

ENVIRONMENTAL IMPACT STATEMENT
2x335MW COAL-FIRED POWER PLANT PROJECT

LEGEND:
Footprint Points
Project Layout
Ash Pond
Jetty/ Temporary Jetty
Cooling Pipe
Outfall Pipe
Foreshore Area
Ground Depression

SCALE: 1: 6,000

DATA INFORMATION/SOURCE:
Basemap: NAMRIA Contour, 2016
GPS Setting: WGS 84 datum
Project Boundary: GLEDC, 2017
Created by: APERCU CONSULTANTS, INC (2017)

aperçu CONSULTANTS INC

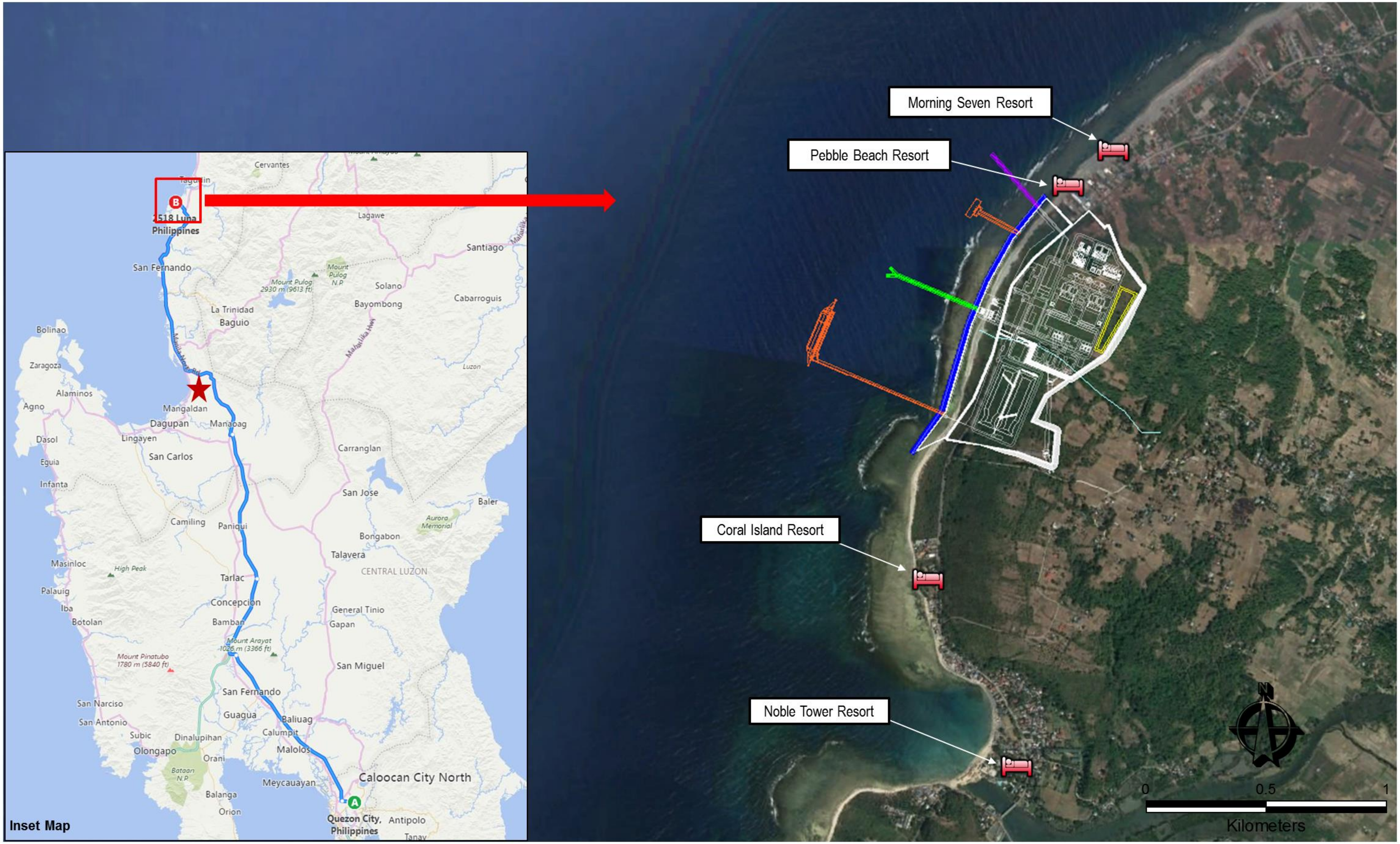


Figure PD-4. Vicinity Map

ENVIRONMENTAL IMPACT STATEMENT
2x335MW COAL-FIRED POWER PLANT PROJECT

LEGEND:

- Route from Manila
- Project Layout
- Ash Pond
- Jetty/ Temporary Jetty
- Cooling Pipe
- Outfall Pipe
- Foreshore Area
- Ground Depression
- Alternative Site of the Project

SCALE: 1:25,000
DATA INFORMATION/SOURCE:
Basemap: GOOGLE EARTH IMAGERY, 2017
Project Boundary: GLEDC, 2017
Boundaries: NAMRIA BOUNDARY, 2016
Imagery Date: DECEMBER 1, 2016
Created by: APERCU CONSULTANTS, INC (2017)

aperçu CONSULTANTS INC

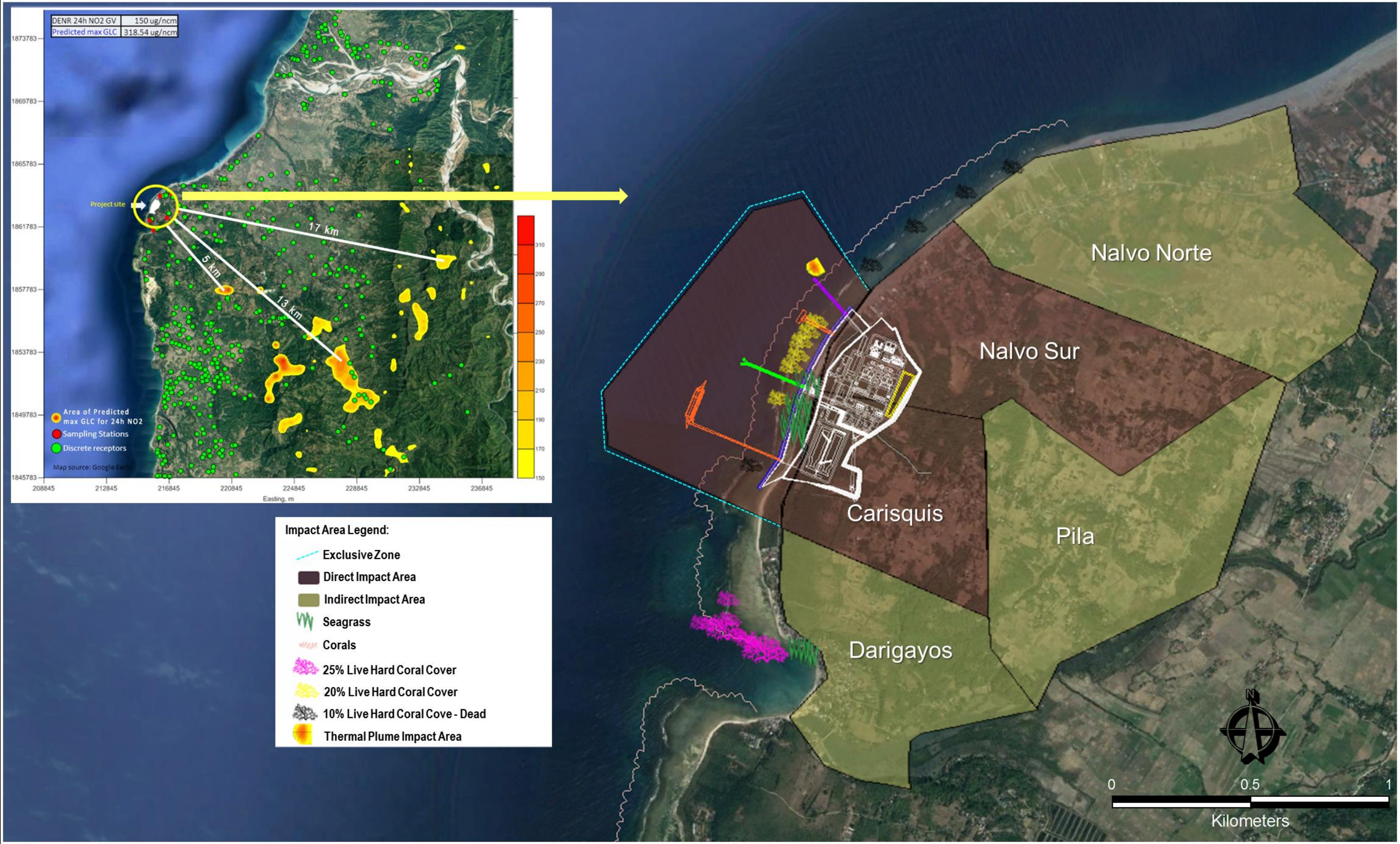


Figure PD-5. Impact Area Map

ENVIRONMENTAL IMPACT STATEMENT
2x335MW COAL-FIRED POWER PLANT PROJECT

LEGEND: *(Impact Area Legend As Above)*

Project Layout
Ash Pond
Jetty/ Temporary Jetty
Cooling Pipe
Outfall Pipe
Foreshore Area
Ground Depression

SCALE: **1: 15,000**
DATA INFORMATION/SOURCE:
Basemap: GOOGLE EARTH IMAGERY, 2017
Project Boundary: GLEDC, 2017
Boundaries: NAMRIA BOUNDARY, 2016
Imagery Date: DECEMBER 1, 2016
Created by: APERCU CONSULTANTS, INC (2017)

aperçu
CONSULTANTS INC.

Specifically, the DIA delineated in **Figure PD-5** include:

- Land – 41 hectares of land covered by the project footprint
- Water –
  - Areas of the West Philippine Sea fronting the project site where marine resources are present
  - Leased foreshore area - 23,529m^2
  - Area designated as the temperature compliance monitoring point of the thermal effluents (672m^2)
- Air – area 7km southeast from the stack, where the highest GLCs for the 24hr NO_2 exceedances are predicted to occur
- People – residents within barangays Carisquis and Nalvo Sur.

The Indirect Impact Area (IIA) is the area outside of the DIA. The IIA, as per MC 2010-14, is clearly delineated only after the EIA study is done and is more accurately established during post-ECC monitoring. The municipality of Luna and the barangays not included in the DIA are considered indirect impact areas.

3.0 PROJECT RATIONALE

3.1 Project Need at the National Level

Given the country's rapidly growing economy, the proposed power project will help augment the demand for reliable and affordable baseload power supply. The proposed power plant will not only supply enough electricity to Filipino households and businesses but will also contribute to national development.

As a developing country, the Philippines' energy usage is increasing because of growth in our industries and the growing demand from households. Daily activities in large and small businesses, hospitals, schools, offices, government agencies and households are heavily dependent on electricity. However, the power supply from existing power plants is not enough to meet the continually increasing demand. The capacity additions requirement of the country is presented in **Table PD-1** (DOE PDP, 2016-2040).

Table PD-1
Capacity Additions Requirement, 2016-2040

Year	National Grid			
	Peaking	Mid-range	Baseload	Total
2016		2,500	105	2,605
2017		2,600	105	2,705
2018		2,700	105	2,805
2019		2,700	187	2,887
2020		2,900	269	3,169
2021		3,600	538	4,138
2022	150	4,400	807	5,357
2023	250	5,000	1,234	6,484
2024	300	5,400	2,043	7,743
2025	450	5,700	2,957	9,107
2026	450	6,200	3,953	10,603
2027	550	6,600	5,002	12,152
2028	650	7,000	6,021	13,671
2029	950	7,300	7,152	15,402
2030	1,150	7,800	8,388	17,338
2031	1,250	8,300	9,759	19,309
2032	1,550	8,800	11,130	21,480
2033	1,900	9,300	12,583	23,783
2034	2,100	10,000	14,059	26,159

Year	National Grid			
	Peaking	Mid-range	Baseload	Total
2035	2,400	10,500	15,752	28,652
2036	2,650	11,200	17,445	31,295
2037	2,950	12,000	19,220	34,170
2038	3,250	12,700	21,235	37,185
2039	3,600	13,500	23,250	40,350
2040	4,000	14,500	25,265	43,765

3.2 Project Need at the Regional and Local Level

According to the Power Development Plan (2016-2040) of the Department of Energy, the Luzon grid will need an additional capacity of 2,750MW by 2022 (the expected commercial operations of the project) and 24,385MW by 2040 (**Figure PD-6**). The proposed power plant aims to address in part, the requirements of the grid as a baseload plant.

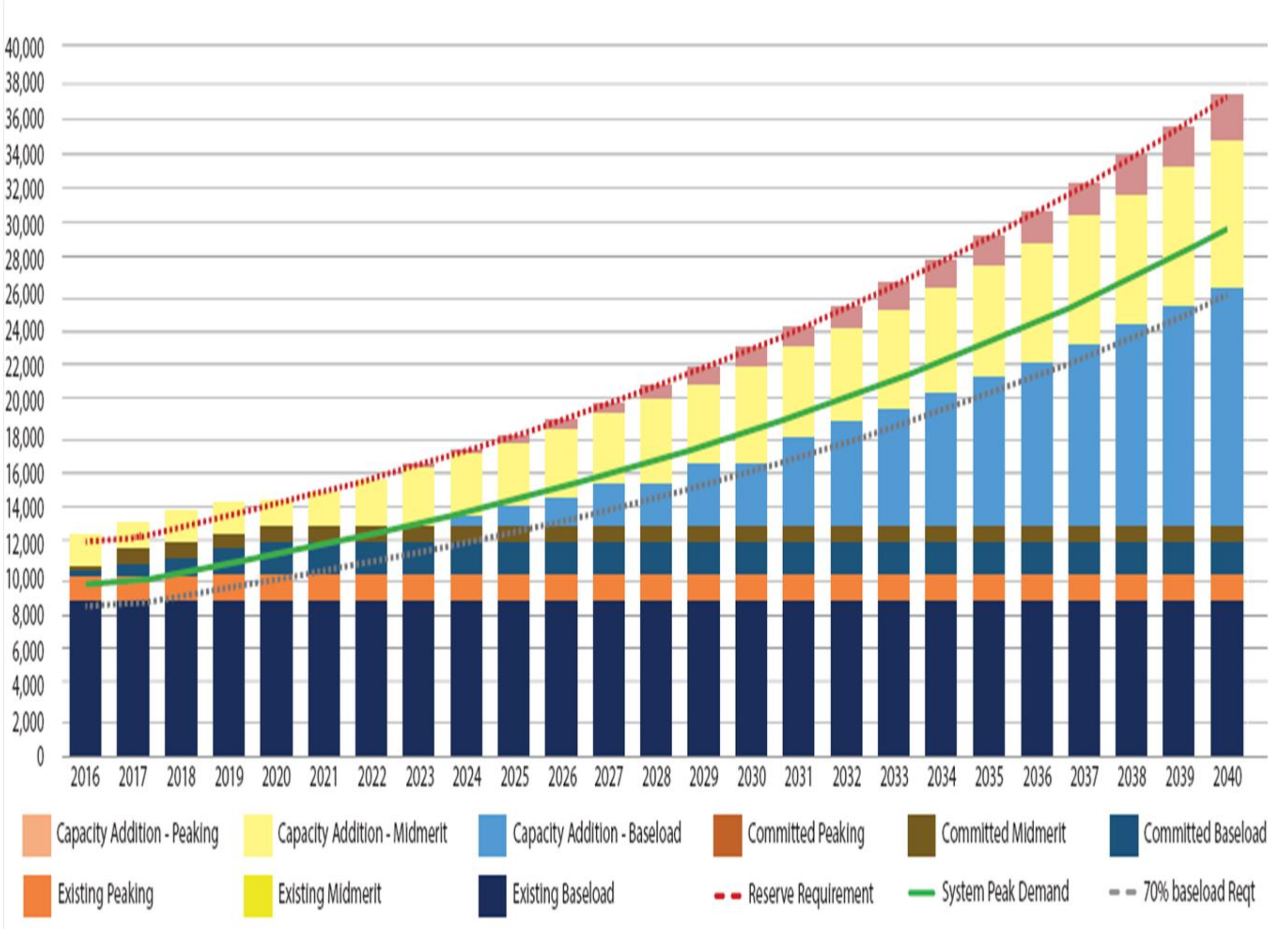
Luzon accounts for the highest electricity sales and consumption among all three grids being the country's center for commerce, business activities and major developments (DOE PDP 2016-2040). Among others, the Luzon Grid serves the nation's capital where Manila Electric Company (MERALCO) currently holds the exclusive franchise to distribute power. As the largest electric distribution company in the Philippines, MERALCO's franchise area covers 36 cities and 75 municipalities measuring over 9,685 square kilometers. Aside from Metro Manila, MERALCO is the exclusive power distributor of the surrounding provinces of Bulacan, Cavite, Rizal and certain cities/municipalities/barangay of Batangas, Laguna, Quezon and Pampanga.

On its Distribution Development Plan for 2015-2024, MERALCO's energy sales is forecasted to grow by a compounded average growth rate of 3.7% (**Table PD-2)**. With the expected increase in demand and load growth, MERALCO has entered into a bilateral power supply contract with GLEDC to source a portion of its additional capacity requirement from the proposed power plant. Upon expected commercial operations in 2022, the proposed power plant's net capacity of 600MW and its annual associated energy of 4,608,000 MWh shall be made available and provided to MERALCO.

Table PD-2
MERALCO Supply-Demand Surplus (Deficit), 2015-2024

Year	Total Direct Sales to Customers	Utility's Energy Consumption	Total Energy Requirement	Total Supply from All Generation Facilities		Supply-Demand Surplus/ (Deficit)		
	MWh	MWh	MWh	Capacity (kW)	Energy (MWh)	Capacity (kW)	Capacity Margin	Energy (MWh)
2015	35,938,797	2,565,006	38,503,803	4,459,000	28,407,952	**(1,818,871)**	**-29%**	**(10,095,851)**
2016	37,245,194	2,658,245	39,903,439	4,349,000	27,573,723	**(2,157,016)**	**-33%**	**(12,329,716)**
2017	38,509,108	2,748,453	41,257,561	4,349,000	28,197,562	**(2,327,859)**	**-35%**	**(13,059,999)**
2018	39,868,205	2,845,453	42,713,658	4,269,000	25,515,722	**(2,705,269)**	**-39%**	**(17,197,936)**
2019	41,287,002	2,946,715	44,233,717	4,089,000	21,900,895	**(3,123,108)**	**-43%**	**(22,332,822)**
2020	42,883,337	3,060,648	45,943,985	2,415,000	16,038,753	**(5,075,960)**	**-68%**	**(29,905,232)**
2021	44,523,445	3,177,705	47,701,149	2,415,000	14,483,880	**(5,362,457)**	**-69%**	**(33,217,269)**
2022	46,259,614	3,301,618	49,561,232	2,415,000	16,803,536	**(5,665,735)**	**-70%**	**(32,757,696)**
2023	48,097,210	3,432,770	51,529,979	2,415,000	17,041,957	**(5,986,731)**	**-71%**	**(34,488,022)**
2024	50,041,964	3,571,570	53,613,534	2,415,000	17,405,441	**(6,326,445)**	**-72%**	**(36,208,093)**

The proposed power plant will also help to stimulate the local and provincial economy. It will provide employment opportunities to the working-age population of Luna and neighboring localities during the construction period and over the plant's commercial operation.



Year	Total Existing Available Capacity	Total Commited Capacity, MW	System Peak Demand, MW	Reserve Requirements (25% Peak Demand), MW	Total Capacity Addition, MW
2016	10,361	569	9,726	2,432	1,500
2017	10,361	1,442	9,870	2,467	1,500
2018	10,361	1,871	10,368	2,592	1,500
2019	10,361	2,241	10,895	2,724	1,500
2020	10,361	2,650	11,.451	2,863	1,500
2021	10,361	2,650	12,000	3,000	2,000
2022	10,361	2,650	12,579	3,145	2,750
2023	10,361	2,650	13,187	3,297	3,485
2024	10,361	2,650	13,828	3,457	4,275
2025	10,361	2,650	14,501	3,625	5,165
2026	10,361	2,650	15,210	3,802	6,005
2027	10,361	2,650	15,955	3,989	6,980
2028	10,361	2,650	16,739	4,185	7,920
2029	10,361	2,650	17,564	4,391	8,945
2030	10,361	2,650	18,432	4,608	10,070
2031	10,361	2,650	19,342	4,836	11,180
2032	10,361	2,650	20,298	5,074	12,390
2033	10,361	2,650	21,301	5,325	13,700
2034	10,361	2,650	22,353	5,588	15,010
2035	10,361	2,650	23,457	5,864	16,355
2036	10,361	2,650	24,616	6,154	17,800
2037	10,361	2,650	25,832	6,458	19,345
2038	10,361	2,650	27,108	6,777	20,925
2039	10,361	2,650	28,447	7,112	22,605
2040	10,361	2,650	29,852	7,463	24,385

Figure PD-6. Capacity Addition Requirement of Luzon Grid by 2040	**Legend:** As Above	**SCALE:** Not To Scale	**PAGE:** 24
ENVIRONMENTAL IMPACT STATEMENT **2x335MW COAL-FIRED POWER PLANT PROJECT**		**DATA INFORMATION/SOURCE:** **Source Map:** DOE PDP (2016 – 2040) **Modified by:** APERCU CONSULTANTS, INC (2017)	aperçu CONSULTANTS INC.

In addition to employment opportunities, other benefits, such as revenue share (as mandated by the Law) and local taxes will be made available to the community. The plant may also encourage other businesses to the area, both related and unrelated.

3.3 Project Benefits

The construction and operation of a power plant in the Municipality of Luna will be a major investment. As discussed in the land use section, the only major industries in the municipality are agriculture and tourism, relegating it as a 3rd class municipality. Establishing a power plant in Luna will result in the following benefits:

1) Additional income to the LGU through the collection of taxes, fees from various permits and clearances.
2) Increased employment opportunities especially during the construction phase where about 2500 skilled and unskilled workers will be hired; long term employment to qualified residents during the operation phase.
3) Indirect employment opportunities will be generated from allied services like transportation, accommodations, commercial, food service and consumption.
4) Social assistance and generation of livelihood programs such as aquaculture, food production and processing, and skills training, as part of GLEDC's Corporate Social Responsibility (CSR).
5) Benefits from the implementation of ER 1-94 where an estimated contribution of Php 50M/year will be dedicated to the host community.
6) Real property tax and other local business taxes for the land and business operations.

4.0 Project Alternatives

4.1 Site Selection

Presented in **Table PD-3** are the sites that were considered for selection on the location of the proposed project. The considerations and reasons for selection of the current project site are as well presented in the table.

Table PD-3
Preliminary Assessment of Possible Sites of the Proposed Power Plant

Site	Considerations
Site 1 Luna, La Union	▪ Presence of pebble collecting activities on the beach front ▪ Presence of a municipal landmark is situated at the beach – head ▪ Presence of agricultural farms on the property ▪ Site is owned by several landowners ▪ Target depth of 16-18m for the jetty is reached at 500m from the shoreline ▪ Land use classification: agricultural
Site 2 Rosario, La Union	▪ Presence of few residential houses ▪ Property composed of farmlands and fish ponds ▪ Target depth of 16-18m for the jetty is reached at 1km from the shoreline ▪ Land use classification: agricultural
Site 3 (Project Site)	▪ Rolling hills terrain ▪ No residential houses will be affected by the project ▪ Target depth of 16-18m for the jetty is reached at 150-350m from the shoreline ▪ Project land area is classified as a special industrial zone; beach front is classified as agricultural but can be utilized as industrial as stated in the CLUP (2014-2023)

As shown in the above table, the site located in Brgys. Nalvo Sur and Carisquis in Luna, La Union was eventually selected and preferred over the two alternative sites. The characteristics and condition of the selected site are summarized as follows:

- No presence of residential dwellers in the site; thus, the project proponent will not have to deal with resettlement issues.

- The properties comprising the proposed site have been idle for years compared to the agricultural farms and fish ponds that are found on the two other sites.
- The site is highly accessible with the national road traversing it while a barangay road bounds on the southern part.
- The nature of the proposed project in the site is consistent with Luna's designation of the area as a special industrial zone per Comprehensive Land Use Plan for 2014-2023.
- Support from the host communities as evidenced by the project endorsement issued by the barangay, municipal and provincial councils (**Annex A-1**).
- No indigenous people were noted in the site and surrounding areas based on the field-based investigation conducted by NCIP personnel in October 2017. Hence, GLEDC expects a certificate of non-overlap will be issued eliminating issues concerning ancestral domain.
- Since the site is located on a coastal area, the sea offers a possible source for cooling water requirements as well as a possible location of the jetty that will be used in the transport and delivery of coal.
- The site is also found to be outside identified areas with liquefaction potential; not prone to landslides and other mass movement hazards; not exposed to extreme climatologic conditions; and has low susceptibility to flooding.

4.2 Technology Selection

In view of the demand for a reliable and affordable baseload power supply, a coal-fired power plant project is proposed over the other types of baseload power plants such as geothermal and natural gas. Geothermal power plants are site-specific and, so far, there are no geothermal fields that have been found on the selected site or on its nearby areas. Likewise, no sufficient liquefied natural gas (LNG) supplies are found in proximity to the selected site.

Two types of technology are available for high power generating coal-fired power plants. These are the Pulverized Coal (PC) technology and the Circulating Fluidized Bed (CFB) technology. A comparison of these technologies is presented in **Table PD-4.**

Table PD-4
Technology Selection

Technology	Description
PC	PC boilers are widely used in large commercial units ranging from 300 MW to above 1000MW. It usually uses either sub-critical, supercritical or ultra-supercritical pressure. The supercritical technology is selected for this project because it yields higher thermal efficiency than the sub-critical type while the ultra-supercritical technology is being relatively less deployed, hence the environment impact would be lessened in comparison to less efficient sub-critical unit of same output. The Supercritical Pulverized Coal (SPC) technology uses super critical pressure and higher main steam temperature which mostly ranges from 540 to 566ºC. The NOx formation in the furnace of a PC boiler is controlled using low-NOx burners or a combination of combustion optimization systems (low NOx burners, Flue Gas Recirculation, and Over-fire air) depending on the target furnace concentration. Sulfur dioxide is efficiently removed using a standalone Seawater Flue Gas Desulfurization System.
CFB	Circulating Fluidized Bed (CFB) technology offers excellent multi-fuel capabilities and is a good option for burning low grade coal, or combinations of diversified fuel. The use of relatively lower furnace temperature compared to the PC technology results to lower NOx emissions. Sulfur dioxide is removed through addition of limestone in the furnace, which converts the SO_2 to sulphates during the combustion and circulation that goes out with the ash. Commercial Unit capacities with CFB technology, however, are limited to 200~300 MW range, when 600MW commercial CFB boiler has been operated under very limited occasion for mostly demonstration purpose.

The proposed project will use the **Supercritical Pulverized Coal (SPC) Technology** because it is an efficient technology. SPC uses higher temperatures and pressures to achieve better efficiency, reduced fuel consumption and less greenhouse gas emissions on a per kWh of electricity output. Thus, the project's technology will not only address the country's demand for cheap electricity but will meet stringent environmental standards as well.

4.3 Resource Selection

The proposed power plant will use coal as the primary fuel in electricity generation. Among fossil fuels, coal is considered the most abundant therefore significant reserves are available. According to *BP Statistical Review of World Energy in 2016*, the reserve-to-production ratio or the estimated time the reserve for coal will last considering the current of production is 114 years, compared to 52.8 years for natural gas and 50.7 years for oil. Thus, because of its availability and affordability, coal comprises majority of the electric power generation mix in the world.

Although not considered baseload, renewable energy sources such as solar, wind and hydro were likewise assessed on the selected project site. Reports from the US-based *National Renewable Energy Laboratory* (NREL) were used to determine the solar and wind energy potential of the site.

The renewable energy potential of the project site are detailed as follows:

- Solar

  The project site's solar irradiation or the radiant energy from the sun averages annually at 4.5 to 5 kWh/m^2/day (**Figure PD-7**). The solar resource map shows that La Union is not among the best sites for solar as compared to the provinces of Ilocos, Tarlac, and Pampanga, among others wherein utility-scale solar power plants are developed. Moreover, it would take around 1 hectare for solar panels to produce 1 MW of power, while coal, in the case of this project, can produce 600 MW in just 40 hectares.

- Wind

  For the wind resource potential of the site, NREL's Philippine Wind Energy Resource Atlas (**Figure PD-8**) classifies it as marginal with wind speed ranging only from 4.4 to 5.6 m/s**.** On the other hand, wind turbines used in wind utility-scale power plants will require a wind speed of at least 10 to 15 m/s to operate.

- Hydro

  The nearest river – Darigayos River is approximately 2 kilometers away from the project site. After considering the five water permittees of the river, the remaining streamflow of the Darigayos River is around 14.9 liters per second with equivalent power generating capacity of 1MW compared to the 600MW generating capacity using coal.

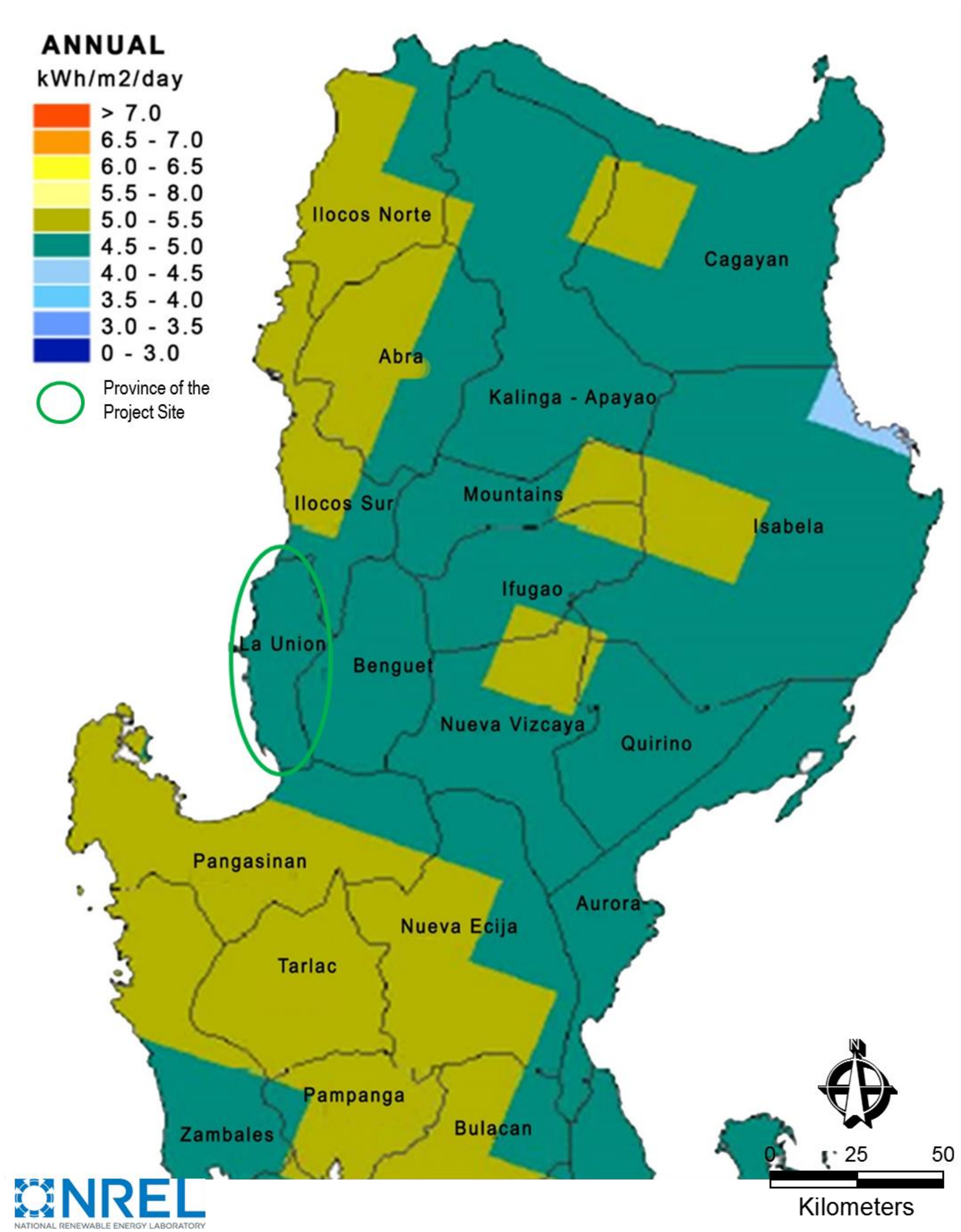


Figure PD-7 North Luzon Solar Irradiation Map	LEGEND: As Above	SCALE: 1:1,200,00
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: Source Map: National Renewable Energy Laboratory Modified By: APERCU CONSULTANTS, INC (2017)	aperçu CONSULTANTS INC PAGE: 28

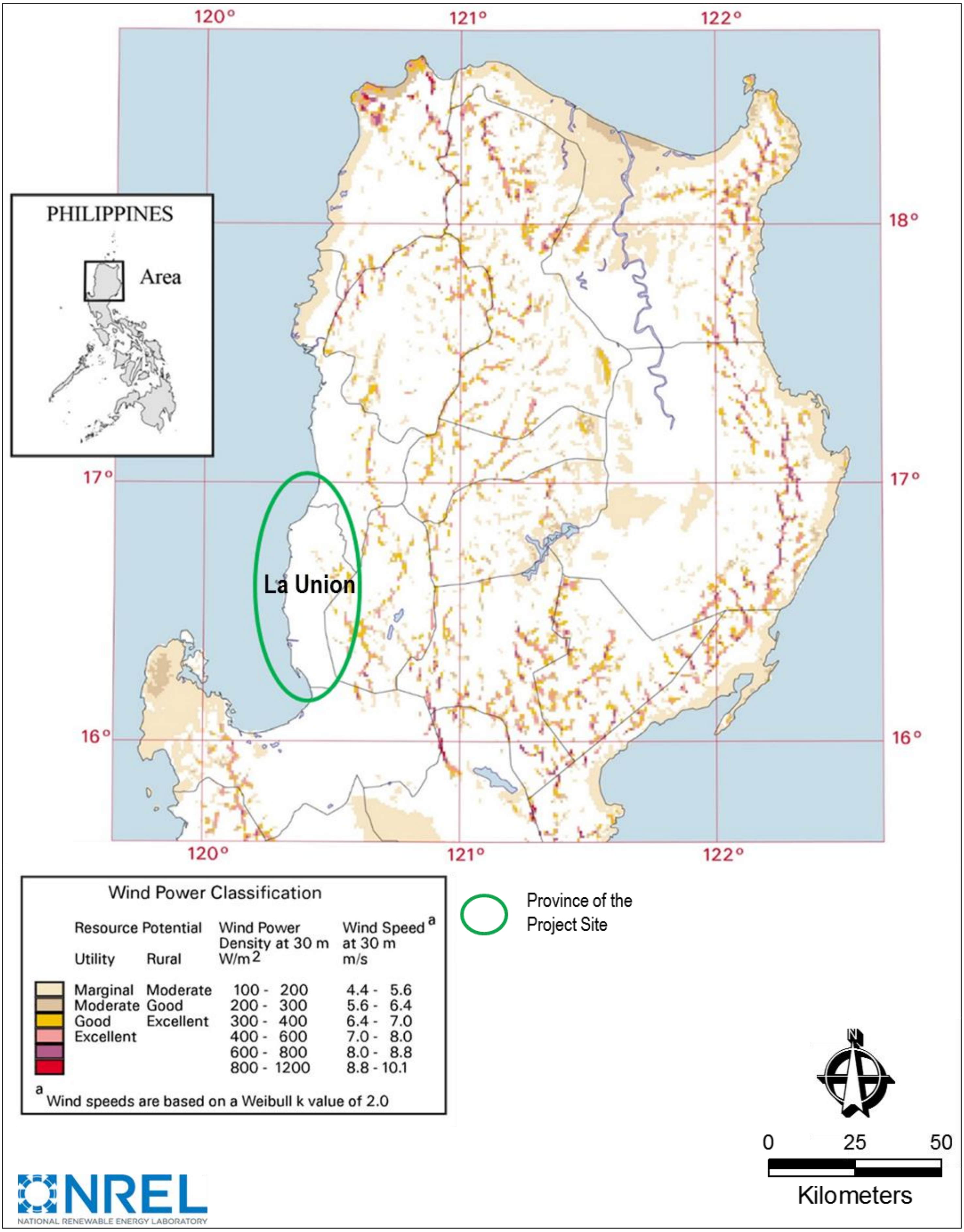


Figure PD-8 North Luzon Wind Resource Map	**LEGEND: As Above**	**SCALE: 1:1,200,00**
ENVIRONMENTAL IMPACT STATEMENT **2x335MW COAL-FIRED POWER PLANT PROJECT**	**DATA INFORMATION/SOURCE:** **Source Map: National Renewable Energy Laboratory** **Modified By:** APERCU CONSULTANTS, INC (2017)	aperçu CONSULTANTS INC. **PAGE: 29**

4.4 Summary of Environmental Assessment of the Site

Based on the preliminary assessment conducted by GLEDC, the chosen project site in Luna, La Union is suitable for the proposed project given the required elevation and depth, the appropriate land classification, and the absence of residential houses within the project site. The proposed project will use the SPC technology due to its efficiency and reduced emissions as compared to the alternative. An environmental assessment was also conducted to determine the natural hazards that may impose risks within the area. **Table PD-5** summarizes the assessment.

Table PD-5
Assessment of Natural Hazards on the Project Site

Hazard	Assessment
Earthquake-induced landslides, volcanic eruptions	The project site is not prone to landslides and other mass movement hazards.
Rain-induced landslide and flooding	The project site has low susceptibility to flooding.
Extreme climatologic conditions	The project site is not exposed to extreme climatologic conditions. It is under the Type I climate with two distinct seasons - dry from November to April and wet the rest of the year. The area has a normal mean temperature ranging from 25.8°C to 29.5°C and a normal seasonal mean temperature difference of 3.7°C.
Liquefaction	The project site is outside the identified areas with liquefaction potential.
Ground Shaking	Area is located near potential seismic generators namely the Manila Trench, the Philippine Fault Zone, the East Zambales Fault, the Abra River Fault, the Pugo Fault, and one unnamed fault with the last three having potential magnitudes ranging from 6.56 to 7.24. To mitigate this, the structures will be designed taking into consideration a g factor of 0.4.
Ground Rupture	The recorded ground rupture nearest to the site happened in June 1990 due to an earthquake generated by the Digdig Fault, whose epicenter was near Rizal, Nueva Ecija.
Tsunami	The project site is located in a tsunami prone area. Mitigation measures include building the plant at an elevation at least equal or above the national road and implementing an early warning system and workable evacuation plan.
Storm Surge	The project site is prone to storm surges with wave heights ranging from 1.01m to 2m. Adequate mitigation measures to ensure plant safety from wave heights above 2m will be incorporated into the design.

4.5 No Project Option

In April 2016, the National Grid Corporation of the Philippines declared a red alert in Luzon, signifying that the available power supply was lower than the area's demand. DOE also declared a red alert for Luzon three months after the NGCP declaration stating that power supply has remained unstable and was even reduced by 3000MW due to continued outages from major energy facilities. If the 2x335MW coal-fired power plant or any power development project in Luzon does not push through, the increasing demand in the Luzon grid, which is expected to require an additional capacity of 2,750 MW by 2022, will not be met. Consequently, distribution utilities will be forced to implement rotating brownouts and longer power interruptions. If this happens, not only will the economic growth of Luzon be affected but also that of the whole country.

The Municipality of Luna foresees agri-industry as one of its secondary roles in the future. The municipality also aims to be an industrial center in northern La Union. In fact, the municipality is anticipating that a 100-hectare area in barangays Nalvo Norte, Nalvo Sur, and Carisquis will be used for a power plant. Thus, if the power plant will not be realized, the anticipated development and economic growth in the municipality may be delayed by several years

5.0 PROJECT COMPONENTS

5.1 General Layout

The general layout of the plant is presented in **Figure PD-9.** The major components of the power plant will be situated in the project area east of the national highway. The two boiler units will be located adjacent to each other at the northern part of the project area. The steam turbine building, which houses the steam turbine generators, will be located to the south of the boiler system. North of the boiler units will be the electrostatic precipitator filters followed by the FGD absorbers with the stack located in between them. The coal yard will be located on the southern part of the project area while the on-site ash pond will occupy the northeast portion.

Several power plant structures will traverse the national road. These structures shall be designed and constructed compliant to regulatory and other related standards. The coal conveyor will traverse over the national road and will have a minimum height of 4.5 meters or higher as required by DPWH standards. Structures for the cooling water intake pipe, the discharge pipe, as well as electrical and communication cables that will likewise traverse the national road will be built underground and will be protected by concrete casings.

The project area is composed of several types of vegetation as discussed in detail in Chapter 2, Land Module **Section 1.4.3**. These will likely be cleared to give way to the construction of the power plant structures. Replacement planting to the lost vegetation will be done by the project proponent in accordance with DENR Memorandum Order No. 2012-02. Remnants of an abandoned poultry house can be seen on the southeast corner of the project area. The poultry house was already demolished when the properties were acquired in 2015. A house which serves as the residence of the properties' caretaker can also be found on the northern part, a few meters away on the east side of the national road. Aside from these, there are no other structures found on the project area.

The foreshore area measuring 2.3529 hectares will be leased out for this project. This is plotted in **Figure PD-9** in conjunction with the general plant layout. The identified area is based on the foreshore survey that was commissioned to prepare a lot plan as part of the requirements of the foreshore lease application. The lot plans have been submitted to PENRO-La Union for approval.

Additionally, an exclusive zone with dimension: 350m left of jetty, 500m seaward and 200m right of discharge (based on thermal plume modeling) will be established within a certain distance from the project site. Access will be restricted to the general public to ensure safety due to the high risk activities that will take place in the area. The restriction is also intended to protect the power plant facilities located on this area such as the jetty, discharge and intake structures. Access will however be allowed beyond the area.

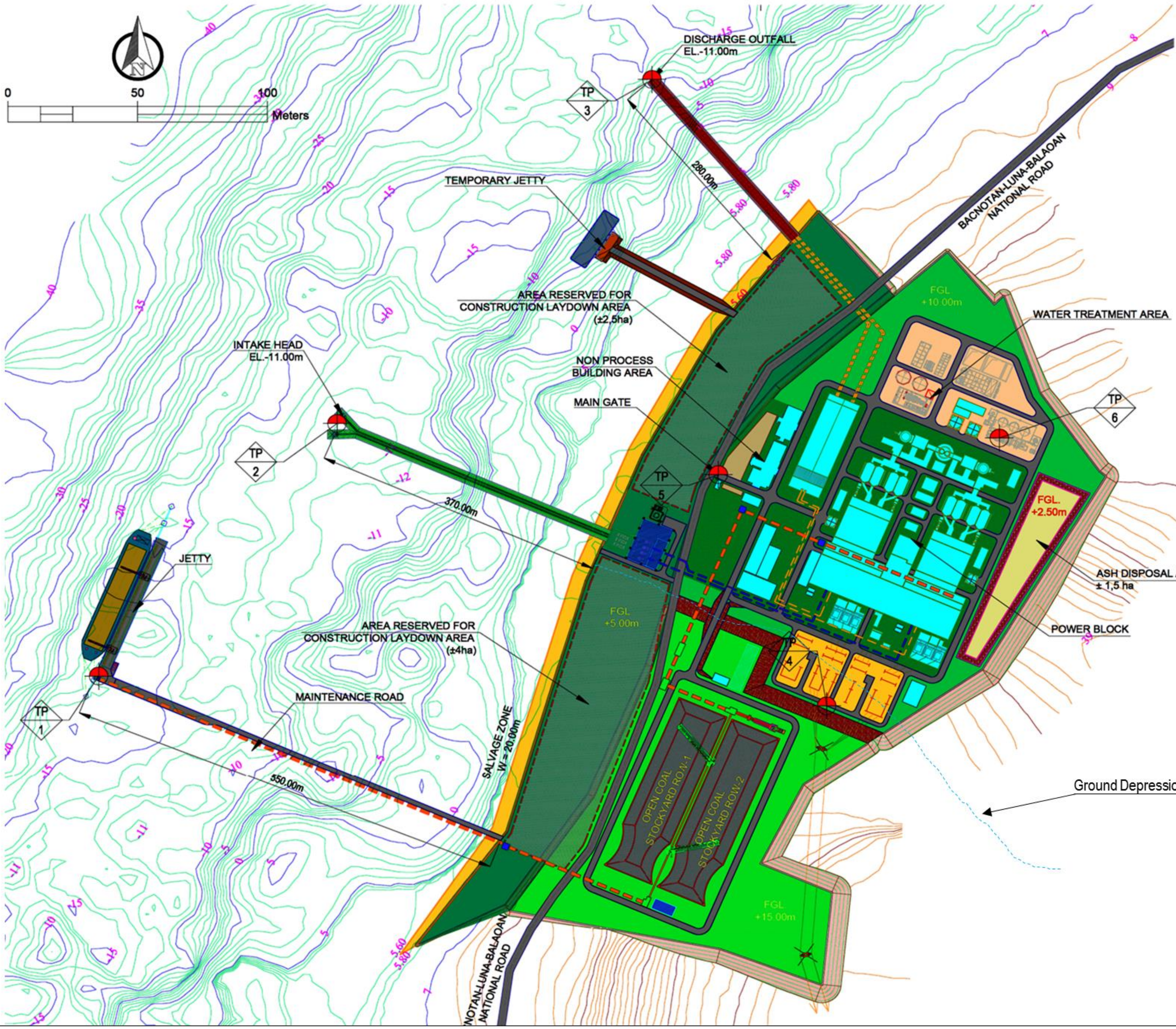


Figure PD-9. General Plant Layout	Legend: As Above	SCALE: As Above	PAGE: 32
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT		DATA INFORMATION/SOURCE: Source Map: GLEDC, 2017 Modified by: APERCU CONSULTANTS, INC (2017)	aperçu CONSULTANTS INC.

5.2 Components List

The project components are listed in **Table PD-6**. The detailed operational descriptions of the various components are discussed in the succeeding sections.

Table PD-6
List of Project Components

Project Systems	Components	Specifications
Jetty	Jetty	Net x 2 x 300MW
Boiler system	Boilers (supercritical pulverized coal reheat type)	Gross 2 x 335MW Approximately 150 m to 300m
	Air preheaters, sealing and primary air fans	Regenerative air preheater
Steam Turbine, Generator and Auxiliaries	Steam turbines (supercritical reheat type)	Gross 2 x 335MW Net 2 x 300MW
	Generator and auxiliaries	Gross 2 x 335MW Net 2 x 300MW
	Soot blowing system	Retractable steam soot blower
	Steam condensing system	Once through seawater condenser
Coal handling and coal feed system	Enclosed Coal Yard	2 covered coal stock piles at 10m high, total capacity of 150,000 tons for 29 day worth
	Covered belt conveyors and weighers	2 covered coal conveying streams; 700 tph capacity each
	Emergency reclaimer	1 unit, 700 tph
Ash handling system	Bottom Ash Silo	2 units, 72-hr capacity
	Coarse and fine ash silos	2 for each unit, for 72-hr Capacity, 1200m^3
	Fly ash pneumatic conveyor system	1 unit
	Lined ash pond for bottom ash only	Approximately 1.5 hectares for five-year storage capacity
Cooling Water System (intake and Outfall)	Intake pipe	1 x ~ 341.390m
	Sea water intake tower	2
	Discharge pipe (outfall)	1 x ~ 417.902m
Pollution control systems	Electrostatic precipitators	1 set for each boiler; ≥99.7% efficiency
	Seawater Flue Gas Desulfurization (SWFGD)	2 units (including 2 absorber and 2 Seawater Treatment Systems)
	Wastewater Treatment facilities	106,179 tph
Process systems	Plant water system	111,792 tph
	Condensate system	106,124 tph
	Closed cycle cooling water system,	111,624 tph
	Desalination and demineralization system	156 tph, 39 tph
	Electro-chlorination system	257 tph
Stack	One common stack to serve both units	180 m
Fuel Oil system	Fuel oil transfer pump	35m^3/hr; 150m
	Fuel oil tank	400m^3 , 1 storage tank
Support systems	Instrumentation and control	Distributed control system (DCS); Programmable logic control (PLC) system
	Firefighting system	Electrical fire pump with redundant diesel engine pump, NFPA and Philippine Code compliant
	Continuous Emission Monitoring System	1 system to provide monitoring for NOx, SOx, total particulate, CO, CO_2, O_2, and stack gas flow rate and temperature
Electrical and transmission system	Double circuit 500kV transmission line	160 km to Bolo substation from project site, subject to SIS

6.0 Process Description

6.1 Technology Description

The proposed project will use the Supercritical Pulverized Technology with the objective of producing power supply in the most efficient way. This type of technology first came into operation in the early 1960s. The main development in pulverized-coal combustion technology includes raising steam pressure and temperature used at the boiler outlet/steam turbine. This process increases thermal efficiency and thus lowers plant emissions while also ensuring the units' operational reliability. The process flow diagram of the power plant is presented in **Figure PD-10.**

6.2 Boiler System

The proposed power plant will have 2 boiler units. The function of the boiler is to provide steam to a reheat, condensing steam turbine generator set by transferring heat produced by the combustion of fuel into water. Each boiler unit will have the capacity necessary to ensure that the steam turbine generator will deliver the gross power output equal to or to exceed the Turbine Normal Continuous Rating (TNCR) of 335MW. This is to be done over the full range of climatic conditions at the site and fuel quality throughout the design life of the plant, including due allowance for unavoidable degradation of the performance of the plant that will occur despite operation and maintenance of the plant. The net output of 300MW per unit is the target unit capacity that will be exported to the grid.

6.3 Steam Engine

The steam turbine will be used to transform the thermal energy of the steam, generated from the boilers, into kinetic energy which is then transformed into electric energy by the generators. The gross output of 335MW is achieved at the generator terminal at TNCR. The steam turbine-generator set will consist of one High Pressure, one Intermediate Pressure, and one Low Pressure casing exhausting downwards into the condenser. All components are well-proven standardized modules. The turbine is of the tandem compound design.

6.4 Coal Handling and Coal Feed System

6.4.1 Coal Specifications

The project is designed for burning bituminous coal and imported coals from Indonesia and other foreign sources, while diesel oil will be used as secondary fuel for start-ups. The coal analysis is presented in **Table PD-7**.

Table PD-7
Coal Analysis for High Gross Calorific Value Specification

Component	Units	Coal 1 (Indonesia)	Coal 2 (Indonesia)	Coal 3 (Indonesian)	Coal 4 (Russia)	Coal 5
Gross calorific value (ARB)	Kcal/kg	5500	5604	5900	5921	6100
Total Moisture (AR)	%	21	20	16	14.4	-
Proximate Analysis						
Volatile Matter (ADB)	%	-	42	42.51	33.8	-
Fixed Carbon (ADB)	%	-	43.6	43.09	52.6	-
Ash (ADB)	%	6	3.2	5.25	9	-
Total Sulphur (ADB)	%	.8	1.0	0.43	0.43	-
Inherent Moisture (ADB)	%	-	11.6	9.15	4.6	6
HGI		-	45	43	59	40
Source		East Kalimantan Sumatra	East Kalimantan Sumatra	East Kalimantan	Sachalin	-

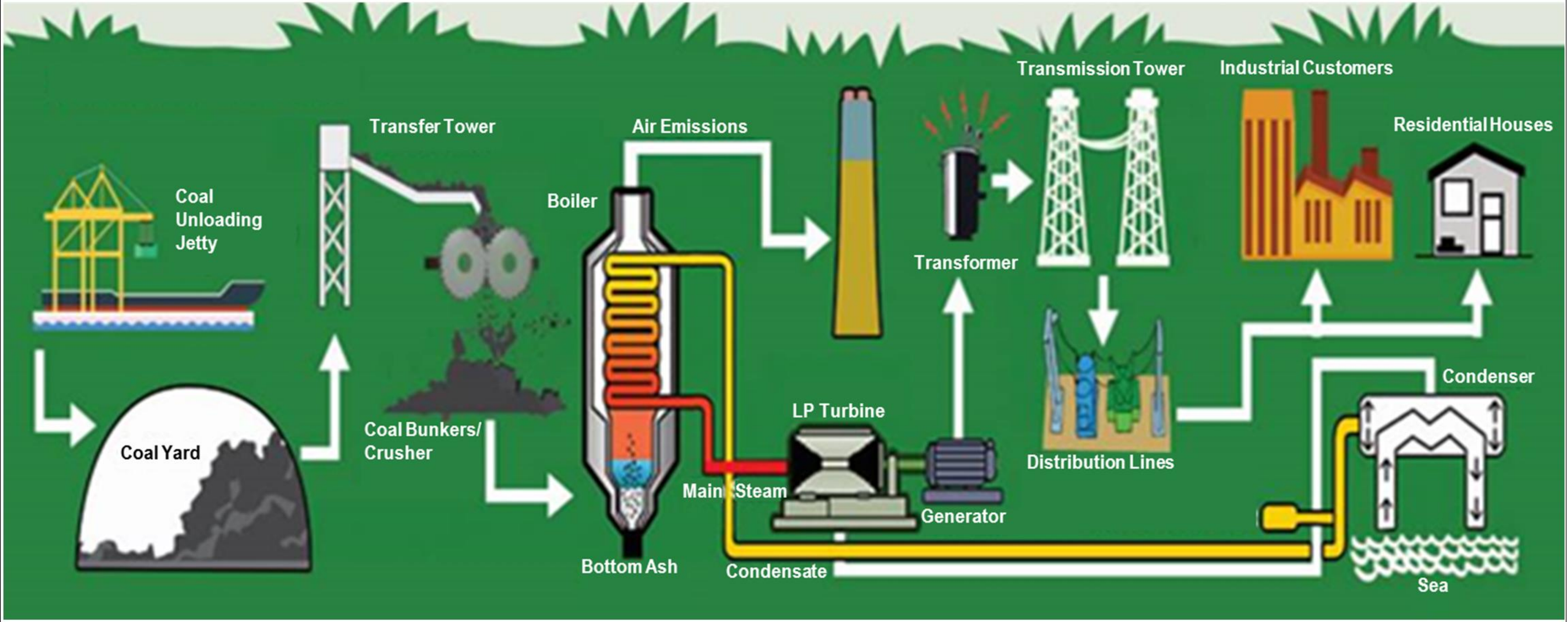


Figure PD-10. Process Flow Diagram of the Power Plant	Legend: As Labelled Above	SCALE: Not To Scale DATA INFORMATION/SOURCE: **Source Map:** GLEDC, 2017 **Modified by:** APERCU CONSULTANTS, INC (2017)	PAGE: 35
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT			aperçu CONSULTANTS INC

The coal for the entire plant will be transported from the jetty to the plant stock piles using a conveyor system. Four coal stock piles totaling 150,000 tons of storage capacity will be provided to meet the requirements for the two units. At TNCR condition, average coal consumption is estimated to be 106.5 tons/hr for each unit or 2,556 tons/day.

6.4.2 Conveyors

There will be two coal conveying streams at the plant, each having the capacity of 700 TPH. All conveyors will be covered and weather protected by galvanized metal hoods.

6.4.3 Transfer Towers

In the transfer tower, the conveyors will discharge coal through flap gates to the tail end of the tripper conveyor. Tripper Conveyors will be equipped with a traveling tripper to discharge coal to Unit 1 & Unit 2 bunkers.

6.4.4 Coal Yard

The coal yard will be rectangular enclosed type to reduce the exposure of the stock piles to any weather phenomena and prevent dust dispersion during stacking/reclaiming operations. The enclosed coal storage yard will have a 150,000-ton storage capacity distributed into 2 stock piles. Coal pile height will be set at 10 meters to minimize spontaneous combustion of coal in the stock pile. The coal yard will be enclosed with walls and a roof to prevent fugitive dust from escaping the storage area due to wind and avoid water contamination from moisture and rainfall. One stacker and re-claimer will be provided and coal shall be reclaimed through bull-dozing in reclaim hoppers in case of emergency. It will also have a fire fighting system.

The covered coal yard will require controlled air circulation to lessen the occurrence of spontaneous combustion. Possible designs that will be considered is to incorporate louvers at the lower portion of the covered coal yard or to extend/overlap roofing with the coal yard concrete foundation in order to allow controlled air and light to pass through. Trees will also be planted around the covered coal yard to serve as natural wind barriers.

The conceptual design of the coal yard is attached in **Annex L.**

6.4.5 Crushers

Uncrushed coal will be crushed by capacity crushers in the crusher house. Uncrushed coal from the stock piles will be transferred in the crusher house by a series of conveyors. In an emergency, uncrushed coal will be transferred from the jetty conveyor directly to the crusher house, increasing system flexibility.

The crusher house will be equipped with two screens and two crushers. From the crusher house, a series of conveyors will transport the coal to the tripper conveyors located above the bunker for Unit 1 and Unit 2 boilers.

6.4.6 Dust Extraction /Suppression System

Dust extraction and dust suppression systems will be provided at the different transfer points and at the crusher house. In addition, roof extraction fans will be provided in essential areas like the crusher house and the boiler bunker floors. Dust suppression will be provided at the discharges of conveyors. The transfer towers' bunker and tripper enclosures will be vented through dust collection systems.

6.5 Fuel Oil System

Fuel oil will be delivered by road tankers to the plant. An unloading station will be provided for unloading fuel oil. A pumping system with an unloading station will be provided. Fuel oil will be used for start-up and shutdown of the steam generator and to support low load operations. It will be supplied from the fuel oil tank with a capacity of 400m^3 and a failure rate/unit of 5.00E-06 as discussed in the Risk assessment. Redundant fuel oil transfer pumps, fuel oil forwarding pipelines and return oil pipelines will also be provided.

The Fuel Oil system shall be designed to transfer fuel oil for boiler startup, and to supply the emergency diesel generator (EDG) and diesel-driven fire pump. The same pumps will be used to supply fuel oil to a separate Day Tank to meet the fuel oil requirement of the EDG and the diesel-driven fire pump.

6.6 Process Systems

6.6.1 Plant Water System

The water balance diagram for the proposed power plant is presented in **Figure PD-11.** The total water requirements of 111,792 tons/hr is broken down as follows:

- Cooling water requirements – 111,624 tons/hr
- Freshwater requirements – 78 tons/hr, net of filtered backwash waste and reverse osmosis reject of 12 tons/hr and 78 tons/hr, respectively. The freshwater requirements is further broken down as follows:
    - Service water – 38 tons/hr
    - Demineralized water – 39 tons/hr
    - Potable water – 1 ton/hr

6.6.2 Water Supply

During the construction phase, the water requirements will be primarily provided by water service providers. In cases when the freshwater supply cannot accommodate the water demand of the construction, GLEDC may opt to put up a desalination plant and draw water from the West Philippine Sea.

On the other hand, water requirements for the power plant's operations will be drawn out from the nearby West Philippine Sea. Additionally, water service providers will be tapped to augment the freshwater requirements.

6.6.3 Desalination System

The power plant components will include a desalination system with a capacity of 156 tons/hr. The Water Treatment Plant will house the Sea Water Reverse Osmosis (SWRO), Brackish Water Reverse Osmosis (BWRO) and Mixed Polisher facilities, among others. The desalinated water shall be transferred to the Service/Fire Water Storage Tank and Desalinated Water Storage Tank. It shall be suitable for use as service water, fire water, and potable water and feed water for boiler make-up water production. The desalinated water stored in the Desalinated Water Storage Tank shall be further demineralized in mixed bed polishers (MBP) for the production of boiler make-up water in the water treatment system.

6.6.4 Demineralization System

A demineralization system, with a capacity of 39 tons/hr, shall be provided to manage dissolved minerals to the desalinated water that will be used in the service and potable water systems. The minerals shall be injected into the pipes to Service/Fire Water Storage Tank. The Service Water Pumps will continuously supply pressurized service water for facility services, such as wash down provisions. Desalinated water from Service/Fire Water Storage Tank shall be the source of potable water. Sufficient treatment systems, and equipment required for treatment of the desalinated water to meet potable water standards shall be provided. Potable Water Pumps shall be provided to supply potable water to the Administrative Building overhead tank and Steam Turbine Building overhead tank for further distribution to the plant.

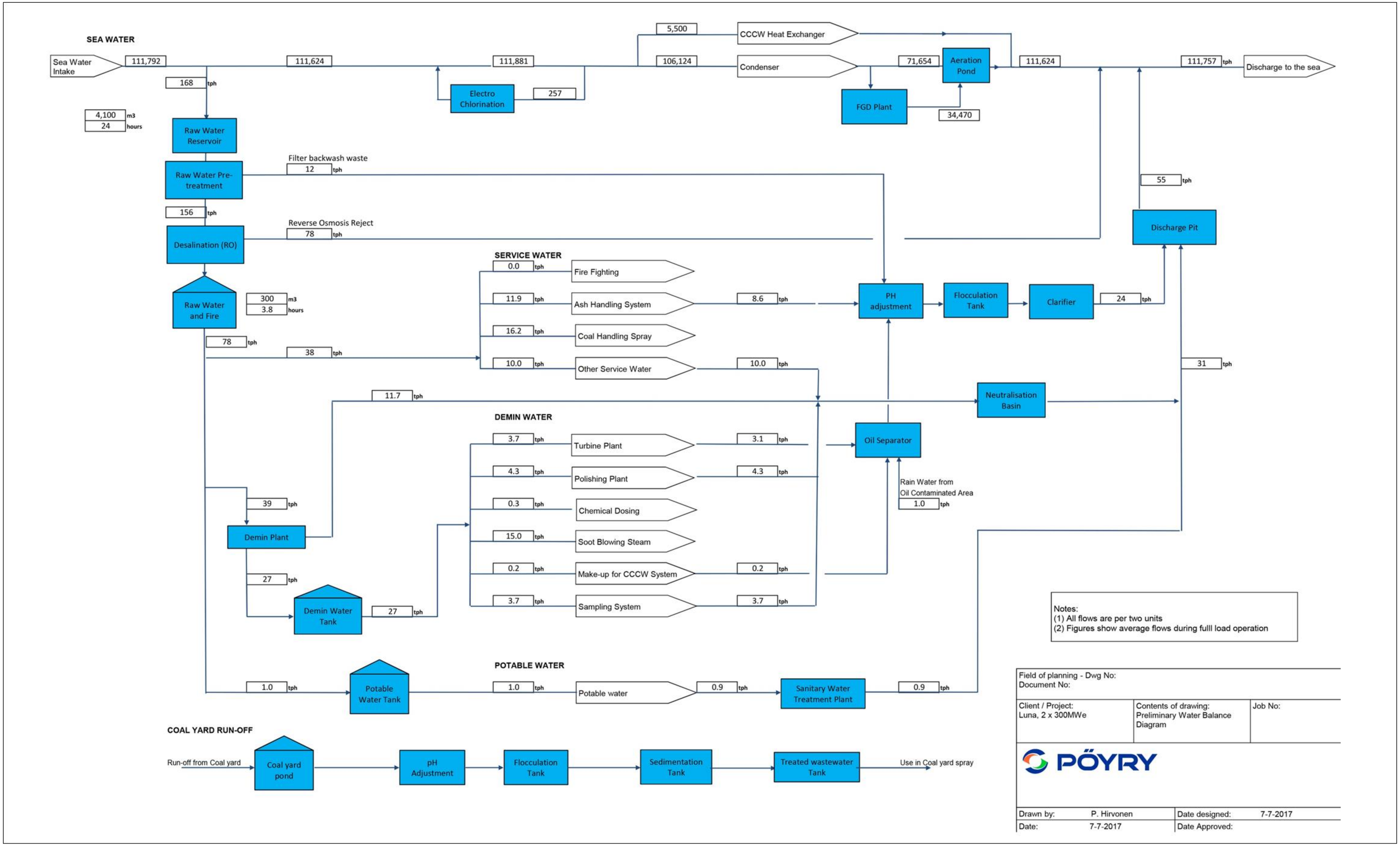


Figure PD-11. Water Balance Diagram	**Legend: As Labelled Above**	**SCALE: Not To Scale**	**PAGE: 38**
ENVIRONMENTAL IMPACT STATEMENT **2x335MW COAL-FIRED POWER PLANT PROJECT**		**DATA INFORMATION/SOURCE:** **Source Map:** GLEDC, 2017 **Modified by:** APERCU CONSULTANTS, INC (2017)	aperçu CONSULTANTS INC.

6.6.5 Freshwater Requirements

The daily freshwater requirement of the proposed power plant is estimated at 1,872 tons. Of the total daily requirement, 912 tons will be used as service water for ash and dust suppression and firefighting. Around 24 tons will be allotted as potable water that will be stored on the potable water tank. The demineralized water storage tank will use 648 tons which will be the source of condensate water. This will come from the desalinated water wherein after treatment procedures, 288 tons will go to waste to be directed to the neutralization basin prior discharge.

The requirement will be sourced from sea water. GLEDC will utilize a water desalination system to source its water requirements. A demineralization facility shall be included to manage dissolved minerals in the water. Water service providers will also be tapped to augment the requirements.

6.6.6 Cooling Water Intake and Circulating System

Water for the cooling water system will be drawn from the West Philippine Sea through a 15m deep intake pipe then conveyed to an intake pumping chamber. At the entry of the intake channel, a bar screen equipped with a trash rake will be provided to screen any large debris entering into the pump house. The trash rake, with a semi - automatic trash clearing arrangement, will be provided to clear the bar screen from getting clogged. Intake pumps will be located in the chamber for each unit. Each pump chamber will be provided with Stop log gates to facilitate maintenance, by isolating individual pump bays, and by providing screens at the entry of chamber. Cranes will be provided in the pumping station also for maintenance.

A once-through type cooling water system will be provided for condensing the steam received by the condenser from the exhaust of the steam turbine and dissipating the thermal load of other plant auxiliaries. The cooling water requirement of the condenser is estimated at 106,124 tons/hr subject to final design. The cooling water for condenser cooling will be pumped by CW pumps for each unit and the hot water from the condenser outlet will be discharged to the Circulation Water Discharge Point through the FGD aeration basin.

Closed Cycle Cooling Water System

The closed cycle cooling water system provides the cooling water for the turbine's auxiliaries, the boiler's auxiliaries, the compressors, and the vacuum pump. The closed cycle cooling water system uses passivated DM Water as the cooling medium. The system includes closed cycle circulating cooling water pumps and plate type heat exchanger. The system is equipped with an expansion tank that will stabilize the system pressure, to eliminate the water flow fluctuations and absorb the thermal expansion of water. The expansion tank will also provide the closed cycle cooling water pump with sufficient net positive suction head.

6.7 Pollution Control Devices

Several pollution control devices are provided for the GLEDC power plant, to ensure that plant emissions meet the following standards:

Table PD-8
DENR Emission Limit

Parameters	Limit
Sulphur dioxide (SO_2)	700 mg/Nm^3 at 6% O_2
Nitrogen dioxide (NO_2)	1000 mg/Nm^3 at 6% O_2
Total particulates	150 mg/Nm^3 at 6% O_2
Opacity	20%

6.7.1 Electrostatic Precipitator

An electrostatic precipitator, with at least 99.7% efficiency, will be installed to meet the particulate matter limit of 150mg/Nm^3. The foundations of the ESP supporting structure will be of reinforced concrete isolated/combined footing resting on soil. The general area below electrostatic precipitators shall be paved with gravel. Drains from the equipment will be collected at a pumping out facility that will be connected to the site drainage system. Separate foundations for the duct supporting structure and the fan handling structure shall also be provided adjacent to the ESP supporting structure foundations.

6.7.2 SWFGD Systems

Seawater Flue Gas Desulfurization (SWFGD) System is a technology designed to remove $SO_{2,}$ before effluents are released to the environment, ensuring that the SO_2 emission limit of 700mg/Nm3 at 6% O_2 is met. The liquid absorbent (the circulating seawater downstream from each condenser for the power plant) and the flue gas produced by the power plant, meet through the perforated plates and packing. SO_2 contained in the flue gas is absorbed efficiently in the liquid absorbent, which is later treated in the seawater treatment system (SWTS) composed of the coarse-aeration and fine aeration system, before it is released back to the sea, ensuring that there will be no harmful effect on the environment. **Figure PD-12** shows an overview of a typical SWFGD process.

The contact between the flue gas and seawater in the absorber brings forth the following chemical reactions:

$$SO_2 + HCO_3^- \rightarrow HSO_3^- + CO_2$$
$$SO_2 + H2O \rightarrow HSO_3^- + H^+$$
$$HSO_3^- + 1/2O2 \rightarrow SO_4^{2-} + H^+$$

After the above reactions, bisulfite ion (HSO3-) is generated and then it is partially oxidized to sulfate ion ($SO4^{2-}$). As a result, the pH value of the spent seawater is reduced due to increased hydrogen ions.

6.7.3 Low NOx Burners

A low NOx burner will be included in the combustion system to meet the Philippine regulatory limit of 1000mg/Nm^3. The low NOx burners control fuel and air mixing to create larger and more branched flames. As the peak flame temperature is reduced, less NOx is formed. This also enhances burner efficiency as the improved flame structure reduces the amount of oxygen available in the hottest part of the flame.

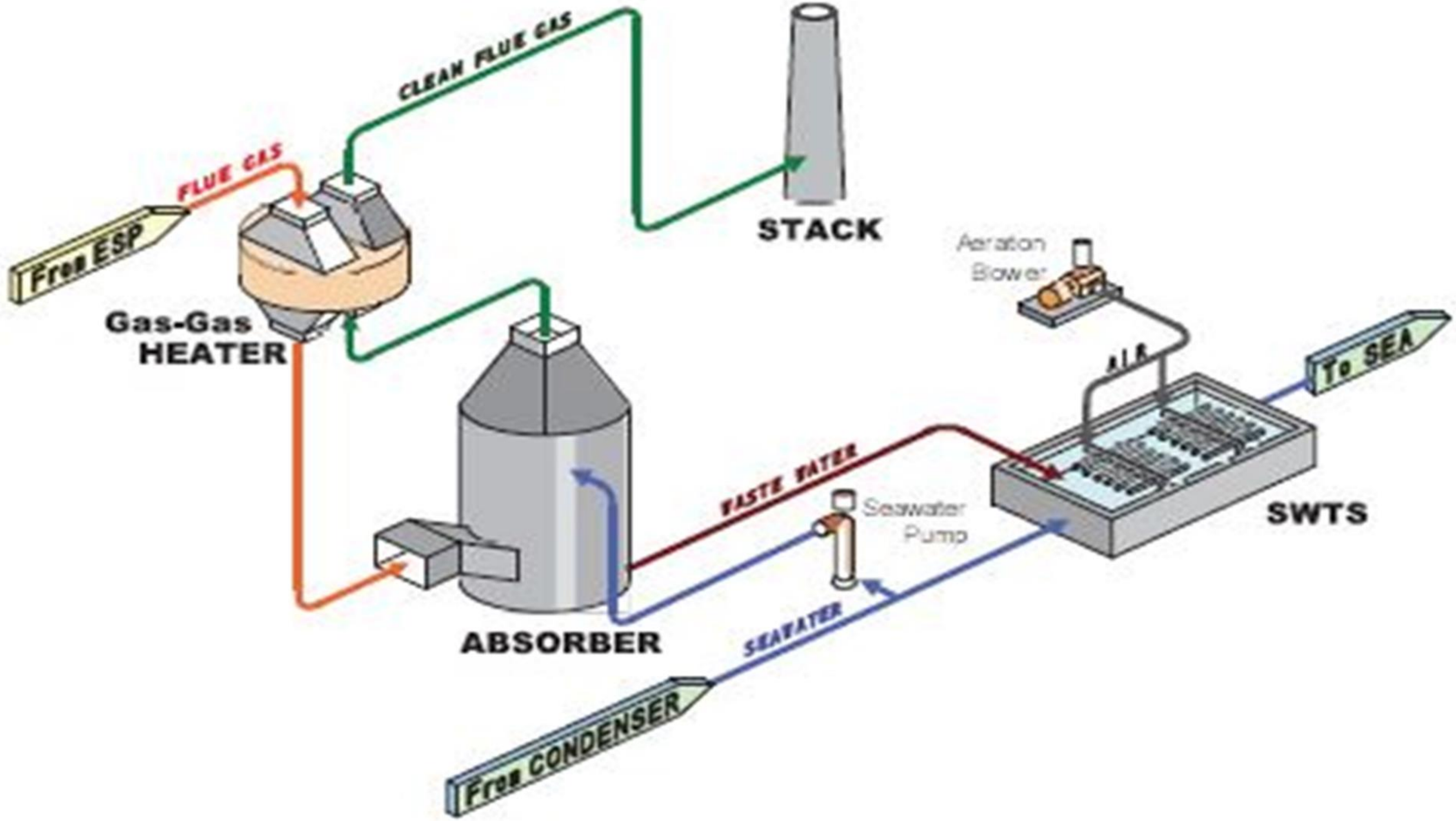


Figure PD-12. Overview of Typical SWFGD Process	Legend: As Labelled Above	SCALE: Not To Scale	PAGE: 41
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT		DATA INFORMATION/SOURCE: Source Map: GLEDC, 2017 Modified by: APERCU CONSULTANTS, INC (2017)	aperçu CONSULTANTS INC.

6.7.4 Stack

One stack common for both units will be provided to discharge the exhaust gases from the boiler to the atmosphere. The stack will consist of an outer cylindrical reinforced concrete shell and steel flue supported on RC foundation mat on soil. The height of the stack will be 180 meters. The air dispersion modeling, as discussed in detail in Chapter 2 Section 3 – Air Module, predicted the following ground level concentrations (GLCs) at normal operating conditions:

Table PD-9
3rd Quartile Predicted GLCs at Grid Receptors (μg/Ncm)

Pollutant	Scenario	GLC	CAA
SOx	1hr	91.15	340
	24hr	36.46	180
NOx	1hr	156.95	260
	24hr	62.78	150
CO	1hr	0.17	35
	8hr	0.10	10
TSP	1hr	41.21	300
	24hr	16.48	230
PM_{10}	1hr	0.11	200
	24hr	0.05	150

6.7.5 Ash Handling System

The power plant's ash handling system is unitized. The unit will have dry ash handling for both fly ash and bottom ash system. The bottom ash (BA) is conveyed through mechanical conveyors to the bottom ash silo. The fly ash (FA) from ESP is transported by pneumatic means to the fly ash silo. There are two units of fly ash and bottom ash silos, two transport air compressors and three fluidizing blowers.

Fly Ash

Fly ash is formed due to combustion of pulverized coal in the steam generator. Coarse fly ash from the economizer hopper, the air preheater hopper and the first field of the ESP are collected in a coarse ash silo while fine fly ash from other fields of the ESP and stack hopper are collected in a fine ash silo. The fly ash handling system for each unit will be designed to collect all fly ash in dry form using positive pressure pneumatic conveying system. There will be two fly ash transport pipes. Each pipe shall be designed for 30 tons/hr ash flow. Both the pipes are connected to the fly ash silos with 72-hour storage capacity. Bulk unloader will be on standby at all times.

100% of the fly ash is expected to be sold to cement manufacturing plants. The generated fly ash from the power plant shall be hauled by cement plants to be utilized as cement additive.

Bottom Ash

The dry type air cooling bottom ash handling system will be adopted by the power plant. When the furnace bottom ash fall to the conveying steel tape, temperature will be reduced from 850ºC to 100ºC through natural air cooling during conveyance. Using the negative pressure in the boiler, the air used for cooling the slags is sucked in from the outside to the dry type extractor inlet. After being heated, the hot air will go into the furnace bringing with it the heat which has been brought out by hot slag back into furnace. The heat loss is reduced this way, and the boiler efficiency could be increased. This project will be furnished with a set of air cooling slag extractor, whose capacity is not less than maximum bottom ash discharged in BMCR condition, and 25% margin is considered. The bottom ash, after slag extractor is crushed by a slag crusher and then conveyed to the ash silo through a bucket conveyer. The ash concentrated in the ash silo is discharged to a truck regularly and transported to the ash disposal area.

Ash Disposal Area

The expected total ash (bottom and fly ash) that will be generated by the power plant is around 460.08 tons/day or 156,428 tons/year. The material balance diagram is shown is **Figure PD-13.** Over the course of the plant's 25-year operations, a total area of 38 hectares (BA – 8 hectares; FA – 30 hectares) shall be required for ash storage/disposal, assuming there will be no out-takes. However, just like other coal-fired power plants, GLEDC expects that all generated fly ash will be sold to cement manufacturing plants. When this is taken into consideration, the area requirement for ash disposal/storage will be reduced to 8 hectares.

The on-site ash disposal area located on the northeastern part of the project site is intended for the bottom ash only. The area is approximately 1.5 hectares and will be around 8.33 m deep. At such dimensions, the on-site ash pond is expected to hold an initial 5-year storage capacity considering the annual bottom ash production of approximately 31,287 tons or 25,030 cubic meters.

The area designated for ash disposal in the project site will be developed using active dry cells. As illustrated in **Figure PD-14**, each cell will be made up of compacted soil lined with clay and high-density polyethylene (HDPE). When cells become full, these will be covered with soil and then vegetated on top. To prevent overflows, there will be perforated pipes to collect leachates. The collected leachates are then pumped to the wastewater treatment facility for neutralization and treatment prior to discharge. During the dry season when the ash disposal area becomes dry and dusty, GLEDC will conduct intermittent water spraying as needed to prevent dust dispersion. Groundwater monitoring wells in the vicinity of the ash disposal area will be established and monitored on a regular basis.

Accordingly, other sites are being eyed for ash disposal/storage subject to a separate study and environmental compliance certificate application. GLDEC will locate a suitable area within a reasonable road haul distance where the ash will be deposited, compacted and stored. GLEDC will also consider environmental concerns on truck movements when deciding on the final location of the ash disposal/storage.

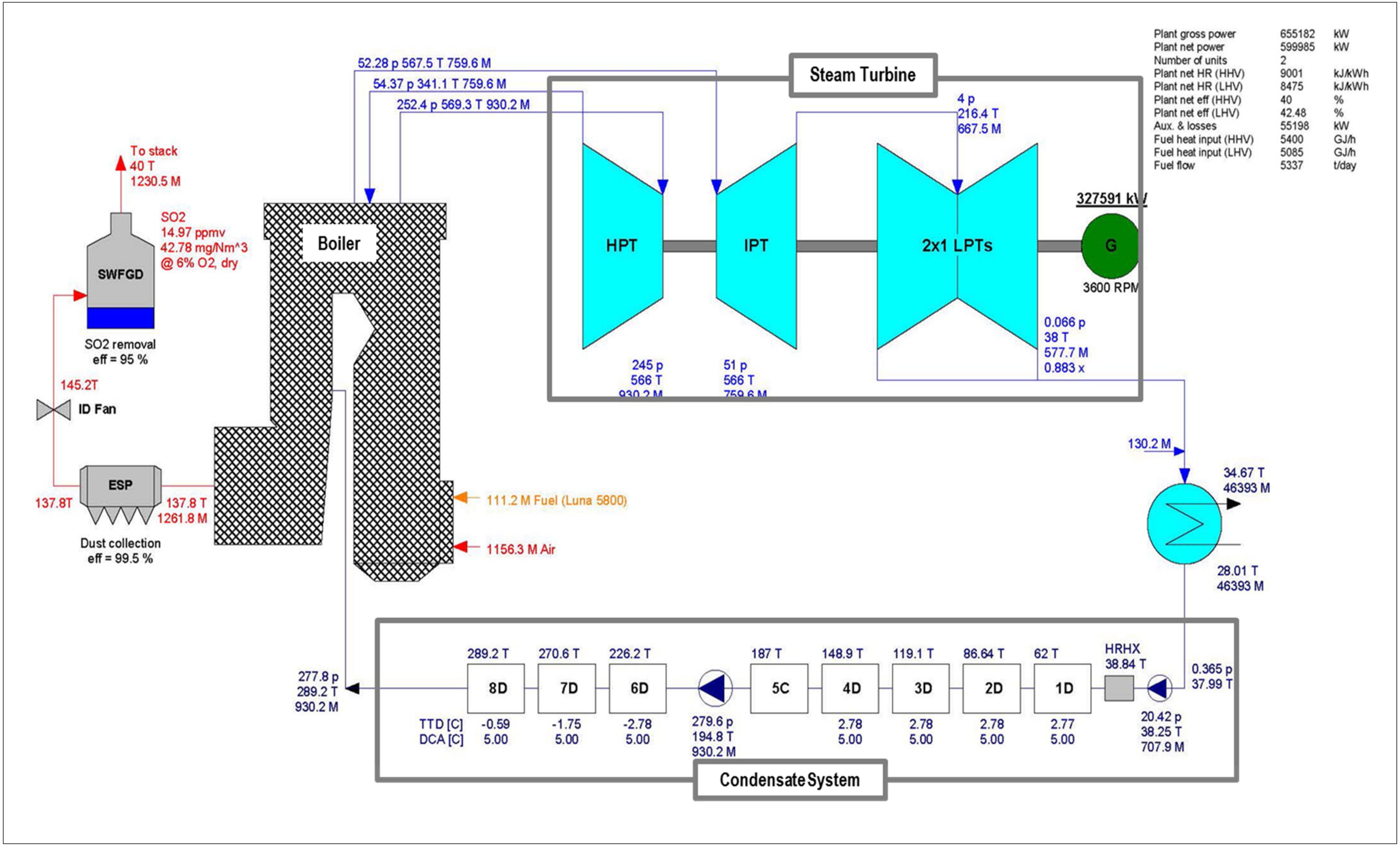


Figure PD-13. Material Balance Diagram

ENVIRONMENTAL IMPACT STATEMENT
2x335MW COAL-FIRED POWER PLANT PROJECT

Legend:

Condenser

Seawater

SCALE: Not To Scale

DATA INFORMATION/SOURCE:
Source Map: GLEDC, 2017
Modified by: APERCU CONSULTANTS, INC (2017)

aperçu CONSULTANTS INC

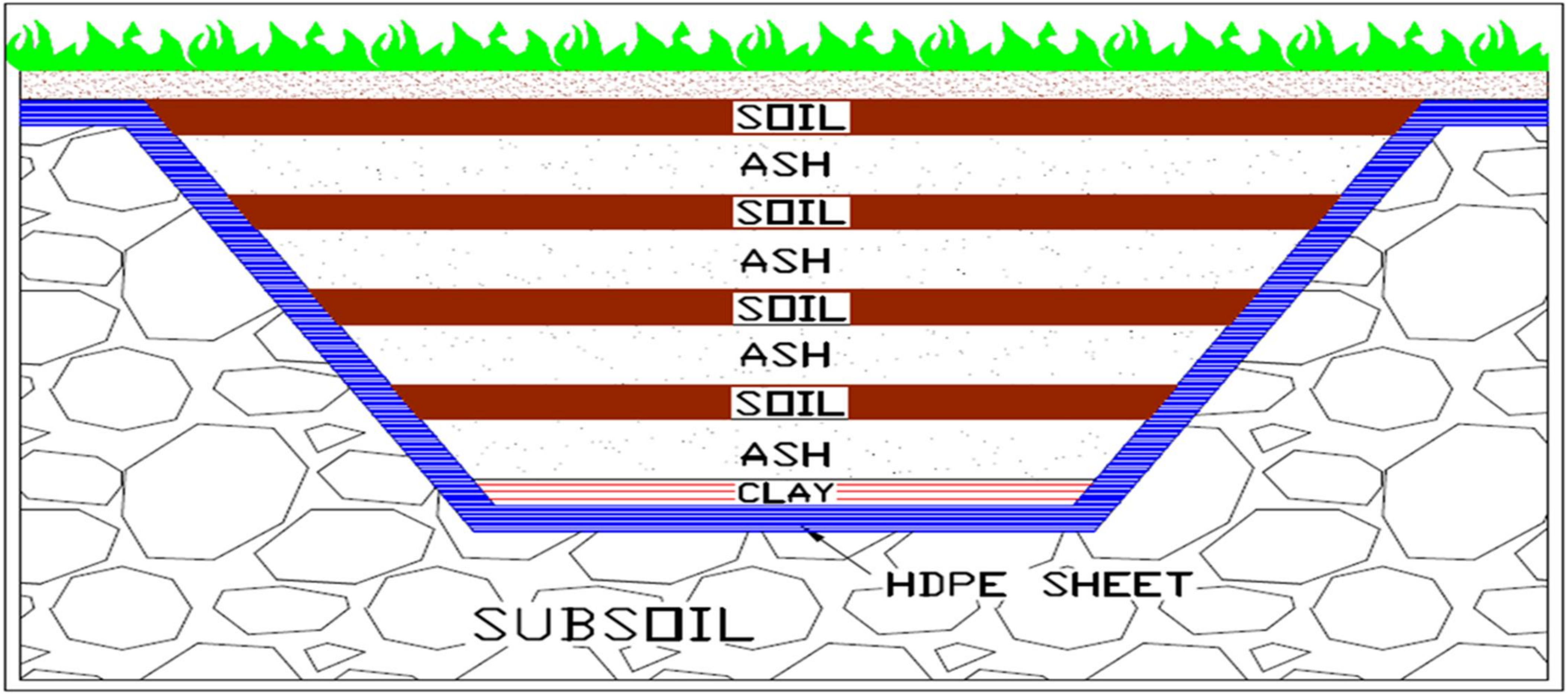


Figure PD-14. Ash Storage Cell Diagram	Legend: No Legend	SCALE: Not To Scale	PAGE: 45
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT		DATA INFORMATION/SOURCE: Source Map: GLEDC, 2017 Modified by: APERCU CONSULTANTS, INC (2017)	apercu CONSULTANTS INC.

6.7.6 Aeration Basin

An aeration basin will be installed as a common structure for the two boiler units, with two compartments for each unit. The aeration basin will receive the seawater used in the closed cooling system and SWFGD. It will also serve as the seal pit for the condenser cooling water system. To ensure that no harmful effluent is released to the environment, this seawater treatment system neutralizes the pH of spent seawater, which was extremely lowered during SO_2 removal. It will also remove the chemical oxygen demand (COD) while it recovers dissolved oxygen (DO). In the course of aeration, CO_2 gas dissolved in the spent seawater is stripped to gaseous phase, which contributes to pH increase. The discharge from the aeration basin is conveyed through the buried pipe around 300m offshore.

6.7.7 Wastewater Disposal

The power plant will include wastewater treatment facilities with a total capacity of 106,179 tons/hr. GLEDC will adopt necessary measures to ensure that all discharges of the power plant conform to the water quality and effluent standards set forth in DENR DAO 2016-08. This will involve the establishment of facilities for temporary storage, monitoring and treatment before any effluent is finally drained to the West Philippine Sea. All discharges of the plant shall be properly channeled to a defined outflow location.

Table PD-10 lays out the significant effluent parameters for coal-fired power projects identified in Section 7.1 and the corresponding effluent standards set in Section 7.3 under water body classification "Class SC."

Table PD-10
Significant Effluent Parameters and Standard

Significant Effluent Parameters	DAO 2016-08
Temperature change, degree Celsius at temperature compliance monitoring point	3
pH Value	6.0 – 9.0
COD, mg/L	200
Total Suspended Solids, mg/L	100
Phosphate, mg/L	1
Sulfate, mg/L	550
Nitrate as NO_3-N, mg/L	20
Ammonia as NH_3-N, mg/L	0.5
Chloride, mg/L	-
Boron, mg/L	20
Chromium, mg/L	0.1
Nickel, mg/L	0.3
Copper, mg/L	0.04
Zinc, mg/L	1.5
Arsenic, mg/L	0.04
Cadmium, mg/L	0.01
Mercury, mg/L	0.004
Lead, mg/L	0.1
Oil & Grease, mg/L	10

Boiler, Firefighting & Filter Flushing Effluents

Wastewater from the boiler area, firefighting and filter flushing will be discharged to a preliminary basin for temporary storage. Water from the drainage system will be discharged to a special retention basin. Quality of the combined effluent will be analyzed and treated onsite with a Wastewater Treatment Plant (WWTP) to ensure compliance to effluent standards before being discharged to the West Philippine Sea.

Chemical Effluents

The effluents from the chemical water treatment/regenerations will be handled in a special neutralization basin for treatment prior to discharge into West Philippine Sea. The discharge procedures and quality will both be in conformity with DENR DAO 2016-08 and RA 6969 or the Toxic Substances and Hazardous and Nuclear Wastes Control Act of 1990.

Coal Yard and Ash Yard Effluents

Water runoff from the coal storage and ash disposal areas will be treated in the water treatment system and directed to the storm water drainage system. Its discharge will be monitored to ensure conformance to DENR Effluent Standards.

Oil Containing Effluents

Oily water from vehicles from the equipment area and from the containment areas of fuel oil tanks and transformers will be treated in an Oily Wastewater Treatment System (OWTS) and the WWTP.

6.8 Electrical and Transmission System

The electricity generated by the power plant is proposed to be transmitted to the Luzon Grid via a 500kV double circuit overhead transmission line which will be connected to the Bolo substation that is approximately 160km away from the project site (**Figure PD-15)**. The System Impact Study (SIS) and the Facility Study are currently being undertaken and will require the approval of the National Grid Corporation of the Philippines (NGCP) (**Annex J**). This will also be subject to a separate environmental compliance certificate application.

6.9 Support Systems

6.9.1 Instrumentation and Control

The I&C system will be composed of Distributed Control System (DCS), housed in the Central Control Room and Electronic Equipment Room, and the Programmable Logic Controllers (PLC). PLCs will control the following systems in designated locations:

- Electrostatic Precipitator (ESP)
- Flue Gas Desulfurization (FGD)
- Electro-chlorination
- Waste water treatment
- Water treatment
- Ash handling system
- Coal handling system
- Polisher system
- Sea water screen
- Low NOx burners

Field instruments will include hazardous area protection, field transmitters, control valves, temperature elements, vibration transmitters, weather station, and analyzer system. Galvanized cable tray will be provided and signal energy level wise segregation such as separation of power cables and other signals will be applied. Armored cables, galvanized steel wire armor with PVC outer sheath, flame retardant, will be applied to field cables.

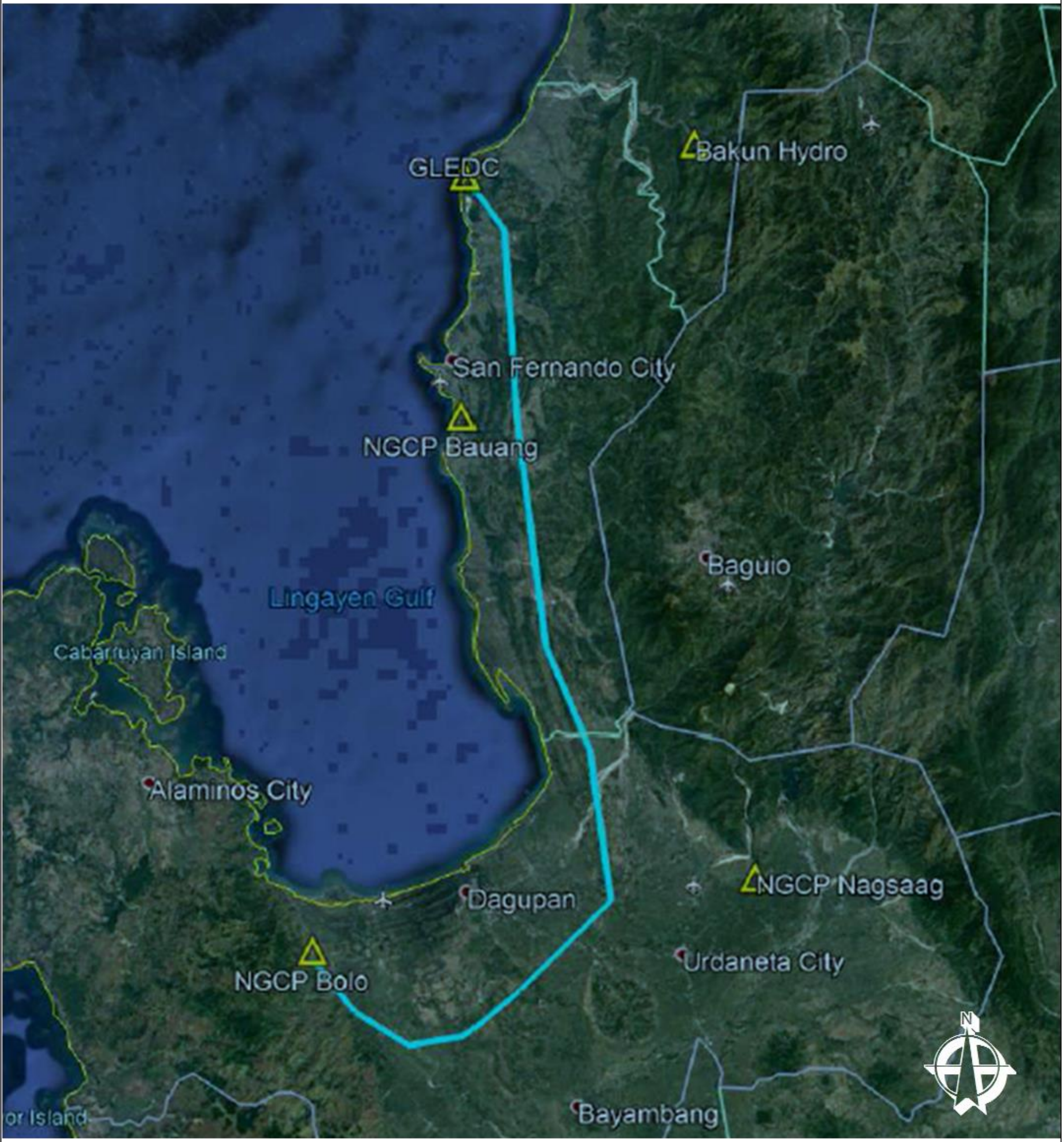


Figure PD-15 Transmission Line Route	LEGEND: Transmission Line Route	
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	**Basemap:** GOOGLE EARTH IMAGERY, 2017 **T.L Route:** GLEDC, 2017 **Imagery Date:** DECEMBER 1, 2016 **Created by:** APERCU CONSULTANTS, INC	aperçu CONSULTANTS INC PAGE: 48

6.9.2 Fire Fighting System

The Fire water pumps will be located in a Fire Water Pump House. The Fire Protection Water Supply System shall consist of the following major components:

- Electric motor driven horizontal fire water pump set
- Diesel engine driven horizontal fire water pump set
- Electric Motor driven jockey pump sets
- Utility pump set

It will be provided with a fire hydrant system, spray water system, clean agent system, fire detection and alarm system, and a portable fire extinguishing system.

6.9.3 Continuous Emission Monitoring System (CEMS)

One (1) Continuous Emission Monitoring System (CEMS) will be provided for monitoring of NOx, SOx, total particulate, CO, CO2, O2, stack gas flow rate, and temperature. A CEMS analyzer will be housed in analyzer field cabinet with an air conditioning system located in a non-hazardous area. It will be interlocked with the operation of the plant and will automatically reduce the capacity of the plant in case it detects any abnormality.

7.0 PROJECT SIZE

The project will make use of a state-of-the-art supercritical pulverized coal technology. The total net capacity of the project is 600 MW (**Table PD-11**). The supercritical technology has a fast start-up which is very important for the power plant to meet the grid requirements.

Table PD-11
Power Plant Components and Corresponding Capacities

Parameters	Values
Total project area	41 hectares 23,529m^2 of foreshore area
Gross output of each unit	335 MW
Net output of each unit	300 MW
Net heat rate at 100% load	9,000 - 9,200 kJ/kWh HHV
Jetty	150m - 300m
Coal	5112 tons/day / 2 units
Coal Storage	150,000 tons (29 days' worth for 2 units)
Ash pond	For bottom ash only Area: 1.5ha
Waste Water Treatment Facility	106,179 tph
Demineralizer	39 tons/hr
Cooling water	111,624tons/hr
Stack	180m
Transmission line	500kV double circuit transmission line to be connected to Bolo Substation approx.160 km from project site, subject to compliance to SIS

8.0 DEVELOPMENT PHASES AND PROJECT SCHEDULE

8.1 Project Phases

8.1.1 Pre-Construction

Activities included for the pre-construction phase of the project are:

- Land Acquisition - Proponent was able to acquire the land and is covered by a Transfer Certificate Title.
- Preliminary Engineering Studies - The following preliminary engineering studies were undertaken:
  - Geological Mapping
  - Topographic surveys
  - Cadastral surveys
  - Seismic profiling
  - Bathymetric surveys

- Other Activities during the pre-construction phase will include:
  - Contractor Selection
  - Application of local government permits needed for the construction phase
  - Finalization of engineering designs (final layout of the power plant's facilities)

8.1.2 Construction Phase

The construction phase of the project will include building of major facilities, project components and ancillary facilities of the power plant. Activities under this phase will include:

- Vegetation Clearing - The vegetation and trees on site will be cleared. The waste generated shall be properly disposed of through the municipal garbage collection system.
- Earthworks - Activities such as filling and excavation will be done in the proposed project site. The project area will be filled to reach appropriate elevation (at least the same as the level of the national road).
- Delivery of construction materials to and from the site
- Laydown of construction materials
- Operation and movement of heavy equipment
- Construction of offshore structures

During the construction, power requirements will be organized by the selected EPC contractor through the local distribution utility, La Union Electric Cooperative (LUELCO). Temporary construction power line and transformer with switchgear will be furnished and installed to supply the power needs for construction machinery, office and staff barrack. Subcontractors shall also provide diesel generator set to facilitate work for individual work areas per their agreement with EPC contractor. The construction load requirement ranges from 1 MW to 5~10 MW depending on the stage of construction. The EPC contractor shall also furnish an environment management program in which water management and waste management are defined, this also has to be approved by GLEDC and LGU. GLEDC will also coordinate with the local water district and private water contractors for water supply source arrangement.

In the commissioning phase, power requirement will be initially accommodated by National Grid Corporation (NGCP) through LUELCO at cold commissioning period. However, after units pass initial single equipment commissioning stage and unit startup tests, units are able to generate power to satisfy its in house demand, which means no external power supply is needed most of time at this stage. Overall commissioning, functional test and performance test prior to plant takeover would take around 180,000~250,000 tons of coal and 500~1,000 tons of diesel (depending on startup burner technology), and at same time, the units is able to generate 250,000~300,000 MWs electricity over same period of time.

While coal is used in all generation test, diesel is mostly used during unit startup attempts and steam blow which is universal requirement to clean up all debris and deposits left inside high pressure steam pipes during construction. Emission during test and commissioning will be managed through air pollution control device as much as technology allows, however, by nature upset condition will happen more often than any other operating stages due to unstable condition, but all upset conditions will be governed by local EMB through and special emission permit shall be obtained prior to commissioning stage, furthermore, all emission guarantee test will be certified by DENR authorized third party.

Likewise, during commissioning, the plant open/close cooling water supply will be managed by internal systems, Reverse Osmosis (RO) and Demineralizing plant will be able to generate quality water supply by processing seawater to sustain test and commissioning activities. Any external water resource will not be used to supply the plant water demand during test and commissioning period. Waste water treatment system will be commissioned prior to any other waste water discharging activities, therefore, no untreated waste water is expected to be discharged to the sea.

8.1.3 Operation Phase

Significant activities of the power plant during operation phase include the following:

- Electricity generation – GLEDC will generate electricity from the 2x335MW generation units starting plant commissioning. The electricity generated will be evacuated to the Luzon Grid. The operation of the SPC boilers is discussed in Section 6.0 of the Project Description.
- Delivery of coal to the plant – Coal will be sourced from Indonesia and other foreign sources and will be delivered to the site via a coal carrier. Annual coal consumption is approximately 1,492,704 tons.
- Disposal of ash – Daily operations of the power plant for the 2x335MW will result in ash estimated at 460.08 tons/day. Fly ash will be sold to cement manufacturing plants while the bottom ash will be disposed in ash disposal/storage area lined with clay and HDPE. The power plant includes an on-site ash disposal area good for 5-years; thus, GLEDC is looking for other suitable sites for the remainder of the power plant's operations.
- Extraction of freshwater for domestic plant use – The volume of freshwater requirements of the power plant will be around 1,872 tons per day. Seawater will be drawn from the West Philippine Sea and processed in a desalination system to provide the freshwater requirements. This may be augmented by sourcing from water service providers.
- Extraction of seawater for cooling purposes – The power plant will draw 111,624 tons per hour of seawater from the West Philippine Sea and return this as heated effluent.
- Discharge of cooling water – The power plant will comply with DAO 2016-08 i.e. temperature change will be at most 3ºC above ambient at temperature compliance monitoring point.
- Wastewater from various plant processes – The power plant components will include wastewater treatment facilities with total capacity of 106,179 tons/hr to treat effluents prior to discharge and ensure compliance to the effluent standards of DAO 2016-08.
- Plant Emission – Estimated emissions are shown in Table PD-10 based on the result of the Air Dispersion Modeling. A seawater FGD will be provided to meet SO_2 emission limit of 700 mg/Nm^3. The plant will also use an ESP to meet particulate emission and opacity limits of 150 mg/Nm^3 and 20%, respectively. Low NOx burners will be incorporated in order to meet NO_2 emission limit of 1000 mg/Nm^3.

8.1.4 Abandonment Phase

The power plant is expected to operate for 25 years. Prior to abandonment, an abandonment plan will be established. Environment will also be assessed and corresponding actions will be implemented.

A general outline of the Abandonment Plan is provided below. A more detailed plan will be developed prior to actual abandonment of the Project.

Abandonment Plan

1.0 Background

1.1 Description of Facilities and Site
1.2 Reason for Abandonment

2.0 Abandonment Plan

2.1 Identification of Possible Site Contaminants

2.1.1 Organic Contaminants
2.1.2 Inorganic Contaminants
2.1.3 Biological Contaminants

2.2 Remedial Actions and Alternatives

2.2.1 Contaminated Site Remediation
2.2.2 Leachate Prevention
2.2.3 Waste Disposal

2.3 Scope of Work and Implementation Schedule

2.3.1 Removal and Disposal of Materials, Equipment, and Solid Wastes
2.3.2 Excavation and Removal of Hazardous Wastes
2.3.3 Gas and Liquid Waste Removal
2.3.4 Covering of Site
2.3.5 Site Reclamation Procedures
2.3.6 Implementation Schedule
2.3.7 Impact Assessment and Environmental Management Plan for the Abandonment Activities

2.4 Maps

2.5 Estimated Cost of Site Remediation Activities

3.0 Future Use of Abandonment Area

8.2 Project Schedule

The overall project construction schedule is estimated to be thirty-six (36) months for unit 1 and forty-two months (42) for unit 2. The proposed construction schedule is projected to commence not later than August 2018 and the plant is expected to operate for 25 years. The project schedule is presented in **Figure PD-16.**

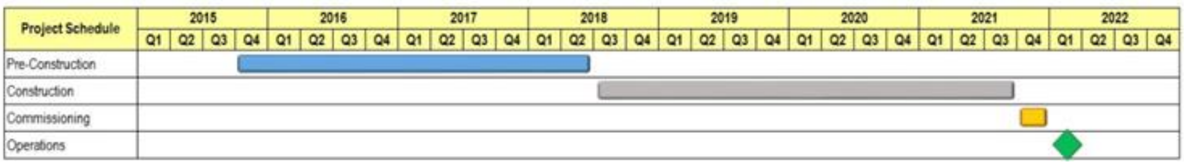


Figure PD-16. Indicative Project Schedule

9.0 MANPOWER REQUIREMENTS

GLEDC will prioritize the employment of qualified Luna residents for its manpower requirements during the construction and operation phases. It shall closely coordinate with the local government of Luna and the barangays who are capable in identifying their respective legitimate residents. Likewise, GLEDC will coordinate with the Technical Education and Skills Development Authority (TESDA) in order to provide skills training to qualify residents from the host barangays for the quality of work that will be required by the company.

The anticipated manpower requirement for the project is presented in **Table PD-12.**

Table PD-12
Projected Manpower Requirement of the Power Plant

Project Phase	Manpower Requirement	Expertise/Skills needed
Construction	2500 – 3000	60% Skilled and 40% unskilled workers
Operation & Maintenance		
Plant Management and Engineering	~ 20	O&M management professionals, Mechanical/Electrical engineering degrees or comparable levels of experience or training
Operations Department	~ 60	Mechanical/Electrical engineering degrees or comparable levels of experience or training, 85% Chemistry degrees, 15%
Maintenance Department	~ 55	Mechanical/Electrical engineering degrees or comparable levels of experience or training
Material Handling Department	~ 35	Mechanical/Electrical engineering degrees or comparable levels of experience or training, heavy equipment operator
Administrative Department	~30	PCO, CSR, HR, Safety, Accounting, Firemen, Warehouse/Procurement, Training, Performance
Others	~100	Security, 30% Housekeeping/janitorial, 20% Food preparation, 5% Support and Maintenance, 40%

10.0 PROJECT COST

The project is estimated to cost about Php80 billion (depending on several factors i.e. foreign exchange rate, borrowing costs, transmission costs, other arrangements, etc.).

II. ASSESSMENT OF ENVIRONMENTAL IMPACTS

1.0 Land Module

1.1 Land Use

1.1.1 Methodology

Existing secondary data was reviewed to determine the municipal land use of Luna. The 2014-2023 Comprehensive Land Use Plan of the municipality was the major document referenced. Land use within the project site was determined from ocular investigation. The Environmentally Critical Area (ECA) classification matrix is based on the ECA classifications defined in EMB Memorandum Circular 005 and was used to assess the impacts of the proposed project in relation to land use. Based on the assessment of impacts, measures to manage and mitigate potential adverse impacts are recommended.

1.1.2 Municipal Land Uses

The municipality of Luna in the Province of La Union is politically subdivided into 40 barangays, four of which are urban barangays while 36 are rural barangays. There are two coastal urban barangays and 12 coastal rural barangays.

The municipality has a total land area of 4,361.62 hectares. A total of 761.62 hectares or about 17% of the land is classified by DENR as Forestland while the rest is classified as Alienable and Disposable. **Table EL-1** presents the land uses in the municipality based on the Integrated Coastal Management Plan of Luna.

Table EL-1
Land Classification in the Municipality of Luna, Province of La Union

Land Use	Area (hectares)	Percentage
Built up areas		
Residential	524.50	12.02
Commercial	18.40	0.42
Industrial	1.90	0.04
Institutional	26.60	0.61
Parks, playgrounds and open spaces	10.50	0.24
Cemeteries	6.50	0.15
Idle/vacant lands	10.00	0.23
Tourism center	112.50	2.58
Agricultural lands	2,479.90	56.86
Agro-forestland	153.00	3.51
Forestland	761.52	17.46
Sandy/stony land	198.00	4.54
Brackish pond/fishpond	58.30	1.34
Total	**4,361.62**	**100.00**

Source: Integrated Coastal Management Plan of Luna which was based on the Comprehensive Land Use Plan of the Municipality of Luna (2014-2023)

The municipal land area allocated for agricultural use is about 57%, which are devoted to palay, corn, peanut, tobacco, vegetables, and root crop production. Portions of the farmlands are also utilized as fishponds. Agricultural lands also include the hilly and mountainous portions of the municipality that are utilized for poultry and livestock-raising.

Built up areas include lands devoted to residential, commercial, industrial and institutional use. Parks, playgrounds, and cemeteries are also classified as built up areas. The entire built up area of the municipality is about 579 hectares comprising an estimated 13% of the municipal land area.

Residential clusters are concentrated in the urban core and distributed among barangays that are mostly clustered along the roads. The urban residences follow a grid pattern and form rectangular blocks that is characteristic of the Spanish colonized center.

Commercial areas are generally concentrated in the urban core near the municipal building and the Roman Catholic Church named St. Catherine of Alexandria Parish. Commercial land uses include the public market and major business establishments such as drug stores, gasoline stations, grocery stores, funeral parlors, furniture shops, automotive repair shops, canteens and eateries, telephone stations, dental and medical clinics, etc.

Existing industrial activities in the municipality include pottery, production of hollow blocks, vulcanizing shops, and radio and watch repair shops. **No major industry exists within the municipality, a situation that will be changed should the power plant development push through.**

Institutional land uses include the municipal hall and plaza, the Luna Sports Center, rural health unit, barangay health stations, schools, religious institutions and other public buildings.

Agro-forestlands account for 153 hectares of the municipal land area. These areas are found along the coastal barangays and are mostly used for firewood production and fruit and root crop production.

Major inland fishponds in Luna are found in Barangays Mamay, Darigayos and Pitpitac, along Darigayos River. These are used for the culture of tilapia, milkfish (*bangus)*, hito, bunog, malaga and shrimps.

The sandy/stony beaches are found along the coastal areas of the municipality. Gravel, cobbles and sand deposits abound in these areas. Some residents undertake quarrying of sand and gravel in the coastal areas of the municipality. These are mostly sold to contractors, real estate developers and construction firms in the municipality.

The coastal barangays at the southwest portion of the municipality, including Barangays Darigayos, Carisquis, Nalvo Sur and Nalvo Norte have been allocated for tourism use. White sand beaches are found in these barangays while gravel and sand deposits are found in the other coastal barangays. **There are no resorts within the project site boundary but there are resorts to the north of the project site. Effects of the power plant development to beach resorts include increase in occupancy rates, especially during the construction phase.**

Figure EL-1 shows the proposed land use map under the 2014-2023 Comprehensive Land Use Plan of the municipality. The location of the 41-hectare project site of the proposed coal-fired power plant in Barangays Nalvo Sur and Carisquis is presently classified as a special industrial zone. Thus, the project is compatible with the municipality's designated land use for the area.

The project site is located approximately 7km north of the Holcim Cement Plant, another industrial establishment along the coastal area of La Union but within the municipality of Bacnotan. Similar to the Holcim Cement Plant, the proposed coal-fired power plant will be located along the coast, adjacent to tourism establishments.

Hence, despite the project site being compatible with the existing comprehensive land use and zoning plan of Luna, a vegetated area will be established around the project boundary to separate the project site from the neighbouring tourism establishments. It will also serve as mitigation against noise during the construction and operation phases.

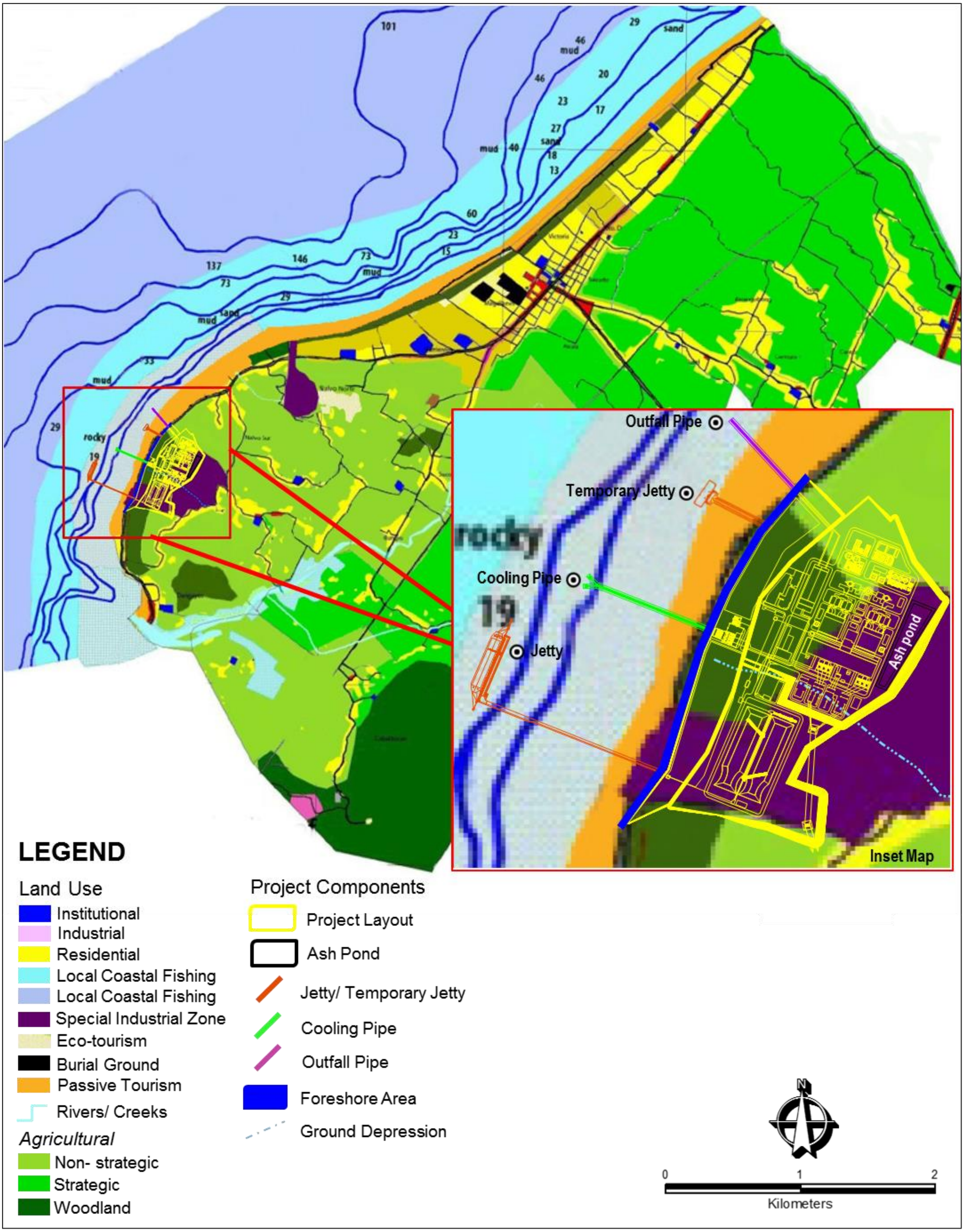


Figure EL-1 Proposed Land Use Map of the Municipality of Luna, Province of La Union	**LEGEND: As Above**	**SCALE: 1:38,000**
ENVIRONMENTAL IMPACT STATEMENT **2x335MW COAL-FIRED POWER PLANT PROJECT**	**DATA INFORMATION/SOURCE:** **Data Source:** Approved CAD Map; Primary Survey; Google Earth; MPDO **Prepared by:** The Municipal Planning Team of Luna **Modified By:** Aperçu_AConjares	aperçu CONSULTANTS INC. **PAGE 56**

1.1.3 Project Site Land Uses and Tenurial Concerns

The coastal area of the project site is covered with beach vegetation that is dominated by talisay and aroma, among others (**Plate EL-1**). **Mahogany plantations and shrubs are found on both sides of the national road** (**Plate EL-2**), **but are not covered under CARP.** Farther to the east, land cover in the project site consists of trees, shrubs and grass (**Plate EL-3**). An abandoned poultry stands in the southeast corner of the project site while the barangay road leading to Barangay Carisquis bounds the site on the south. Small rice fields are located to the north (**Plate EL-4**) while residential areas and tourism establishments are found to the west-northwest of the project site (**Plate EL-5**), all of which are outside the project property.

The project site is not located within CARP areas or CALC/CADT areas and there are no informal settlers within the project site. Tenurial issues are not expected since the property is covered by a Transfer Certificate Title (**Annex K-1**). The site is private property and currenty being acquired by the project proponent with an executed Contract to Sell (**Annex K-2**). Title transfer under the proponent's name will be done after full payment of purchase price and execution of Deed of Absolute Sale. The contract to sell includes a provision that allows the proponent to conduct pre-development activities in the properties.

Plate EL-1. Beach vegetation consisting predominantly of talisay and aroma were observed near the shoreline.

Plate EL-2. Mahogany plantations were observed on both sides of the national road.

Plate EL-3. Trees, shrubs and grass are the dominant land cover in the central and eastern parts of the project site.

Plate EL-4. Small rice fields are adjacent N-NW of the project site. The trees in the photo delineate the project site boundary.

Plate EL-5. Houses and tourism establishments are found on the north-northwest, outside of the project site.

1.1.4 Environmentally Critical Areas

Based on the ECA classification matrix presented in **Table EL-2**, the project site falls within at least three (3) ECA categories: (1) areas which constitute the habitat of critical or endangered species (due to the presence of mahogany), (2) areas frequently affected by natural hazards, and (3) water bodies that support fishing activities. **Although the project site is located adjacent to tourist spots, the project site is classified as a "special industrial zone", as mentioned in the Comprehensive Land Use Plan (2014-2023) of the municipality.**

There are no known protected areas under the National Integrated Protected Areas System (NIPAS) within the immediate vicinity of the project site.

Table EL-2
ECA Classification Matrix for the Luna Coal Fired Power Plant in La Union Province

12 ECA Categories	Project Falls within ECA Description	Remarks
1. All areas declared by law as national parks, watershed reserves, wildlife preserves, and sanctuaries ▪ Areas declared as such under Republic Act No. 7586 or the National Integrated Protected Areas System (NIPAS) Act ▪ Areas declared as such through other issuances from pertinent national and local government agencies such as presidential procalmations and executive orders, local ordinances and international commitments and declarations	No	The project is not located within a protected area declared under the NIPAS Law.
2. Areas set aside as aesthetic potential tourist spots ▪ Aesthetic potential tourist spots declared and reserved by the LGU, DOT or other appropriate authorities for tourism development ▪ Class 1 and 2 caves as cited in EMB MC 2014-004 and defined under DENR MC 2013-03 and significant caves as may be determined by BMB and EMB	Yes	Several tourist spots/ sites are located in the Municipality of Luna (**Figure EP-1**). Nearest are the Pebble Beach Resort and Morning Seven Resort Hotel which is both located in Barangay Nalvo Sur beside the project site boundary (approximately 105m and 210m northeast, respectively).

12 ECA Categories	Project Falls within ECA Description	Remarks
3. Areas which constitute the habitat of any endangered or threatened species of indigenous Philippine wildlife (flora and fauna) ▪ Areas identified as key biodiversity areas (KBAs) by BMB ▪ Areas declared as Local Conservation Areas (LCA) through issuances from pertinent national and local government agencies such as presidential proclamations, executive orders, local ordinances, and intenational commitments and declarations	Yes	Mahogany and narra plantations, which are categorized as vulnerable and endangered species based on IUCN (2016), can be found insite the project site boundary. Clearing of vegetation during site preparation will affect these species.
4. Areas of unique historic, archaeological, geological or scientific interests ▪ All areas declared as historic sites under RA 10066 by NHCP ▪ The whole barangay or municipality, as may be applicable, where archaeological, paleontological and anthropological sites/reservations are loated as proclaimed by the National Museum ▪ The whole barangay or municipality, as may be applicable, of cultural and scientific significance to the nation as recognized through national or local laws or ordinances (e.g. declared geological monuments and scientific research areas and areas with cultural heritage significance as declared by the LGUs or NCCA)	No	The project site is not within this ECA category.
5. Areas which are traditionally occupied by cultural communities or tribes ▪ Areas issued Certificate of Ancestral Domain Title (CADT) or Certificate of Ancestral Land Title (CALT) by National Commission on Indigenous People (NCIP) ▪ Areas issued Certificate of Ancestral Domain Claim (CADC) or Certificate of Ancestral Land Claim (CALC) by the DENR ▪ Areas that are historically/traditionally occupied as ancestral lands or ancestral domains by indigenous communities as documented in reputable publications or certified by NCIP	No	There are no known ancestral domains in the municipality.
6. Areas frequently visited and/or hard-hit by natural calamities. The area shall be so characterized if any of the following conditions exist:		
6.1 Geologic hazard areas: ▪ Areas claasified by the MGB as susceptible to landslide ▪ Areas identified as prone to land subsidence and ground settling; areas with sinkholes and sags as determined by the MGB or as certified by other competent authorities 6.2 Flood-prone areas:	No No	The flat areas of the municipality including the project site are not prone to landslides and other mass movement hazards. The eastern and southern hilly and mountainous portions of the municipality have moderate susceptibility to landslides (**Figure EL-14**) The project site has low susceptibility to flooding as shown in the MGB flood and

12 ECA Categories	Project Falls within ECA Description	Remarks
▪ Areas with identified or classified by MGB or PAGASA as susceptible or prone to flood		landslide hazard susceptibility map of the Bangar Quadrangle (MGB 2010) (**Figure EL-14**).
6.3 Areas frequently visited or hard-hit by typhoons: ▪ For purposes of coverage, depressions, storms and typhoons will be covered in the category ▪ This shall refer to all provinces affected by a tropical cyclone in the past	Yes	The coastal areas of Ilocos Region are frequently affected by typhoons and flooding.
6.4 Areas prone to volcanic activities/earthquakes: ▪ This refers to all areas around active volcanoes designated by Philippine Institute of Volcanology and Seismology (PHILVOCS) as Permanent Danger Zone as well as areas delineated to be prone to pyroclastic flow hazard, lava flow hazard, lahar hazard and other volcanic hazard as found applicable per active volcano ▪ This refers to all areas identified by Philippine Institute of Volcanology and Seismology (PHILVOCS) to be transected by active faults and their corresponding recommended buffer zones, as well as areas delineated to be prone to groundshaking hazard, liquefaction hazard, earthquake-triggered landslide hazard and tsunami hazard.	Yes	The project site is categorized as an ECA in this section because of tsunami hazards. Nonetheless, other hazards such as liquefaction and volcanic-related hazards, are not found to be within the project site.
7. Areas with critical slope This shall refer to all lands with slope of 50% or more as determined from the latest official topographic map from NAMRIA	No	The site is generally flat.
8. Areas classified as prime agricultural lands Prime Agricultural lands shall refer to lands that canbe used for various or specific agricultural activities and can provide optimum sustainable yield with a minimum of inputs and developments costs as determined by DA, NIA or concerned LGU through their zoning ordinance	No	The project site is still classified as agricultural land but not of the prime category. Further, a municipal resolution declaring the area as special industrial zone has been passed (**Annex A).**
9. Recharge areas of aquifers ▪ Recharge areas of aquifers shall refer to sources of water replenishment where rainwater or seepage actually enters the aquifers ▪ Areas under this classifcication shall be limited to all local or non-natinal watersheds and geothermal reservations	No	The NWRB recharge/aquifer map has indicated the project site as a “less productive aquifer”
10. Water bodies All natural water bodies (e.g., rivers, lakes, bay) that have been classified or not	Yes	The West Philippine Sea fronting the project is being utilized for fishing activities The approximate fishing ground of fisher folks in the municipality is shown in **Figure EW-54**. (Source: Luna Municipal Government and Key Informant Interview)
11. Mangrove areas characterized by one or any combination of the following conditions:	No	Mangroves were not observed within and in the vicinity of the project site.

12 ECA Categories	Project Falls within ECA Description	Remarks
▪ with primary and pristine and dense young growth ▪ adjoining mouth or major river system ▪ near or adjacent to traditional productive fry or fishing grounds ▪ which acts as natural buffers against shore erosion, strong winds and storm floods ▪ on which people are dependent for their livelihood, pursuant to and taking into consideration RA No. 7161 which prohibits the cutting of mangrove species		
12. Coral reefs characterized by one or any combination of the following conditions: ▪ with 50% and above live coralline cover ▪ spawning and nursery grounds for fish ▪ which act as a natural breakwater of coastlines	No	Coral reefs are found a few kilometres offshore from the project site. However, average live coral cover are as follows: Manta Tow Survey: 10% Line Intercept Survey: 26.52%

The geologic structures that can pose seismic hazards (e.g., liquefaction, ground shaking and tsunami) to the project site include the Manila Trench, Philippine Fault Zone, Abra River Fault and Pugo Fault. The hilly portion of the project site has low to moderate susceptibility to landslides due to the thin soil cover, gentle to moderate slope, and the relatively stable nature of the limestone substrate. The coastal area of western Luzon, including the project, site is prone to storm surges with wave heights ranging from 1.01 to 2m (Lapidez et al 2015).

To address the project impacts on the water body that supports fishing activities, the proponent will ensure that necessary pollution control equipment will be installed. These include facilities for wastewater and sewage treatment, air pollution control installations, and lined stockpile areas for coal and waste ash, among others. Replacement planting of lost vegetation will also be done using indigenous and endemic plant species, foremost being mahogany species. The equivalent number of replacement trees will follow the recommended uniform replacement ratio for cut or relocated trees as indicated in DENR Memorandum Order No. 2012-02. The replacement ratio for planted trees in private and forest lands is 1:50 while the replacement ratio for naturally growing trees is 1:100.

A no-fishing zone will be established within a certain distance from the project site but fishing can still be done beyond this section. The no fishing zone is recommended for the safety of the plant facilities as well as the safety of local fishermen. A power plant is a vital installation and ensuring its safety is of utmost priority.

A foreshore area of 2.3529 hectares will be applied for a foreshore lease agreement with the DENR. The identified area is based on the foreshore survey commissioned by the proponent. The lot plans have been submitted to PENRO-La Union for approval, which is a pre-requisite requirement in the filing of application for foreshore lease agreement. Several power plant components that will be built or traverse the foreshore area include the jetty, intake and discharge structures. The location, final design and layout of these structures will be finalized in time for the formal filing of foreshore lease application. These will form part of the requirements that will be submitted during application.

GLEDC will implement an appropriate emergency evacuation plan and regular execution of earthquake drills in response to the natural hazards present in the area.

1.1.5 Impairment of Visual Aesthetics

Various stages of Project development will inject new elements into the existing landscape and visual environment. During the pre-construction and construction phases, the following activities have the potential to impact on the visual aesthetics on site:

- Clearance of existing vegetation in the project site, and,
- Presence of heavy equipment, machinery and vehicles on site.

During the operation phase, the establishment of the project site will result in permanent changes to the visual landscape of the area with the introduction of new and non-natural elements.

Visual impairment during the pre-construction and construction phases are unavoidable impacts but temporary. GLEDC will designate a specific spoils dump area thereby preventing the presence of several construction areas that are potential eyesores. These areas will also be selected to minimize visual impact. Other measures that GLEDC will employ to reduce the visual impacts during the construction phase include:

- **Create greenery in exposed areas**
- **Develop exposed areas in line with the landscape**
- **Ensure maximum utilization of spoils/debris and muck for construction purposes, thereby decreasing the amount that needs to be stockpiled**
- **Disposal of rock from both surface and underground excavation works will be undertaken with careful consideration.**

1.1.6 Solid Waste Management Scheme

The municipality pays attention to waste management due to increasing urbanization. While garbage collection is confined only within the poblacion area, most burn their solid wastes or bury them in their backyard pits. At present, the urban areas' garbage is being dumped at the municipal dumpsite in Barangay Sucoc Norte, outside of the poblacion area.

In addition to the improvement of the landfill facilities, solid waste management activities are also being undertaken like waste segregation, clean and green projects, reforestation, and building of material recovery facilities for recycling. As for biodegradable waste, it is being used in the production of organic fertilizer in a vermicomposting facility installed in the area. In terms of sewage disposal facility, Luna has yet to have one installed.

Solid wastes from the proposed project may be generated from construction activities such as removed vegetation; waste materials from daily activities of construction workers (papers, plastics, and biodegradable wastes); construction wastes such as wooden crates and various steel pieces, wastes from offices (papers, plastics, carton, bulbs, etc); and hazardous wastes that include used engine oil and lubricants. If left unmanaged, spills and leaks of hazardous materials could reach and contaminate surrounding soils and may consequently lead to devaluation of land value.

To mitigate potential impacts, solid and hazardous wastes will be disposed properly by the proponent. Specifically, the proponent will coordinate with the LGU to determine if the wastes from the project can be accommodated. At the same time, the proponent will participate in the waste management scheme implemented by the LGU. A Solid Waste Management Plan (SWMP) will also be developed to engage all workers within the site to manage and recycle wastes. Trash bins will also be provided throughout the site following the segregation scheme of the municipality.

Waste management within the project site will be monitored regularly by visual inspection.

1.1.7 Summary of Potential Impacts and Mitigation Measures for Land Use

The following **Table EL-3** summarizes the potential impacts and proposed mitigation for land use.

Table EL-3
Summary of Impacts Related to Land Use

Project Phases and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
I. Construction Phase			
Impact in terms of compatibility with existing land use	Land Use and People	The land area for the project site is already compatible with the proposed lanse use.	▪ Project site is compatible with the existing comprehensive land use and zoning plan of Luna – **the area is categorized as a special industrial zone**. ▪ A vegetated area will be created around the proposed coal fired power plant to separate the neighboring residential and tourism establishments.
Impact in terms of compatibility with classification as an ECA	Land Use; Water; and People	The project will overlap/ impact on the following ECAs: ▪ Areas set aside as aesthetic potential tourist spots ▪ Areas which constitute the habitat of any endangered or threatened species of indigenous Philippine wildlife (flora and fauna); ▪ Areas frequently visited and/or hard-hit by natural calamities (geologic hazards, floods, typhoons, volcanic activity, etc.); and, ▪ Water bodies characterized by one or any combination of the following conditions: tapped for domestic purposes; within the controlled and/or protected areas declared by appropriate authorities; which support wildlife and fishery activities.	▪ Secure a tree cutting permit ▪ Collect seedling of indigenous species and establish a nursery with these ▪ The power plant will be build at an elevation at least equal to elevation of the national road ▪ The proponent will ensure that necessary pollution control equipment will be installed. ▪ Replacement planting of lost vegetation will be done using indigenous and endemic plant species, foremost being mahogany species. The replacement ratio for planted trees in private and forest lands is 1:50 while the replacement ratio for naturally growing trees is 1:100.
Impairment of visual aesthetics	Land Use; People	Various stages of Project development will inject new elements into the existing landscape and visual environment.	▪ Designattion of a specific spoils dump area to prevent the presence of several construction areas that are potential eyesores. ▪ Employ the following to reduce the visual impacts during the construction phase: ○ Create greenery in exposed areas

Project Phases and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
			○ Develop exposed areas in line with the landscape ○ Ensure maximum utilization of spoils/debris and muck for construction purposes, thereby decreasing the amount that needs to be stockpiled ○ Disposal of rock from both surface and underground excavation works will be undertaken with careful consideration.
Devaluation of land value as a result of improper solid waste management and other related impacts	Land Use; People	Solid wastes from the proposed project may be generated from construction activities such as removed vegetation; waste materials from daily activities of construction workers (papers, plastics, and biodegradable wastes); construction wastes such as wooden crates and various steel pieces, wastes from offices (papers, plastics, carton, bulbs, etc); and hazardous wastes that include used engine oil and lubricants. If left unmanaged, spills and leaks of hazardous materials could reach and contaminate surrounding soils and may consequently lead to devaluation of land value.	▪ Comply with the Ecological Solid Waste Management Act of 2000 implemented by the LGU, such as: ○ Solid wastes diversion through re-use, recycle, and composting activities; ○ Solid wastes segregation from point of waste source to “compostable”, “non-recyclable”, “recyclable”< “special wastes”
II. Operation Phase – no identified impacts			

1.2 Geology /Geomorphology

1.2.1 Methodology

The regional geology is based on secondary data from the Mines and Geosciences Bureau (MGB), Philippine Institute of Volcanology and Seismology (PHIVOLCS) and published articles on the geology of the Ilocos region. Seismic and tectonic information are based on PHIVOLCS maps and publications while stratigraphic data is based on the Geology and Mineral Resources of the Philippines published by MGB. Description of regional geomorphology is based on interpretation of NAMRIA topographic maps encompassing the project site and vicinity. Discussion on flood and landslide hazards is based on the MGB flood and landslide hazard map of the Bangar Quadrangle (MGB 2010).

Description of site geology is based on field observations. Observed rock outcrops were described and photographed for future reference. Assessment of project impacts to geology is based on previous similar projects and on geologic site assessment. Based on the outcome of these assessments, measures to manage and mitigate potential adverse impacts are recommended.

1.2.2 Regional/General Geology

The Municipality of Luna in the Province of La Union is a coastal municipality located on the northwest section of Luzon Island. The coastal plain where the municipality is located is bound by the West Philippine Sea to the west, the Cordillera Mountains to the east and the Lingayen Gulf Region to the south. The municipality lies within geographic coordinates 16^{0}48' to 16^{0}53' longitude and 120^{0}18' to 120^{0}26' latitude.

The active tectonic structures in the area include the east-dipping Manila Trench to the west, the East Zambales Fault to the southwest, and the northerly segments of the Philippine Fault Zone to the east (**Figure EL-2A** & **Figure EL-2B**). The Umingan-Lingayen Fault, which forms the northwest boundary of the Caraballo and Cordillera Mountains with the Central Luzon Plain, is located offshore a few kilometers west of the municipality. The known active faults within 25km of the project site include the Pugo Fault, the Abra River Fault and an unnamed fault. These are further discussed in the seismic hazard section of this report.

Rocks in the general vicinity of the project site include sedimentary rocks consisting of sandstones and shales with minor conglomerates and limestone lenses. These are capped with alluvial deposits in the river floodplains and the coastal plain. The geologic map of Northern Luzon is shown on **Figure EL-3**.

1.2.3 Geomorphology of the Project Site

The coastal plain located north of Lingayen Gulf is narrow and consists mostly of alluvial and piedmont deposits. The northern part of Luna Municipality consists of the coastal plain while the southern part consists of hills with narrow valleys in between. In some places like Barangays Carisquis and Darigayos, the foothills extend into the sea. The highest elevation in the municipality is about 68.6m in Mt. Cangisitan in Brgy. Ayaoan.

The slope ranges from 0-3% in the coastal plains and 3-15% in the rolling areas. The hilly and mountainous portions have slopes ranging from 15-65%. A slope map of the Darigayos River basin, where the project site lies, was generated using the STRM digital elevation and is presented in **Figure EL-4**.

The site of the proposed coal-fired power plant is located along Darigayos Point between Barangays Carisquis and Nalvo Sur and is divided into the coastal and hilly areas. The coastal area has an elevation ranging from 0-10m above sea level and a width of around 20m. The berm is elevated by about 1-1.5m from the shoreline. The coastal portion of the project site is overlain by white coralline sand, angular to well-rounded pebbles with diameters ranging from >1cm to about 5-6cm, and dead coral fragments (**Plate EL-6**). Coralline limestone was observed in several areas along the shoreline and a large outcrop was observed near the mouth and on the bed of an unnamed creek (**Plate EL-7**).

The hilly portion of the project site is found east of the national road and bound on the south by the road leading up to Brgy Carisquis. This area has an elevation ranging from 10-20m with maximum elevation of 37m. The foothills abut into the sea. Outcrops of coralline limestone were observed along the road to Barangay Carisquis (**Plate EL-8**). The project site has thin soil cover with coralline limestone cropping out in some areas. South of this hilly area is Darigayos River which drains to the West Philippine Sea in Brgy Darigayos. This river has a wide floodplain and drains most of the southern and eastern barangays of Luna municipality (**Figure EL-5**).

The project will have minimal changes to the surface landform, topography, terrain or slope of the site. Most of the plant facilities are to be located on the gently sloping coastal portion of the project site and the slope in this area is expected to be maintained during the construction and operation phases of the power plant. However, site preparation works such as land grading will alter the surface landform and slope of the hilly portion of the project site.

There are no important landscapes in the vicinity of the project site such as caves, rock monuments, springs, natural leisure parks, as shown in the topographic map (Figure EL-5).

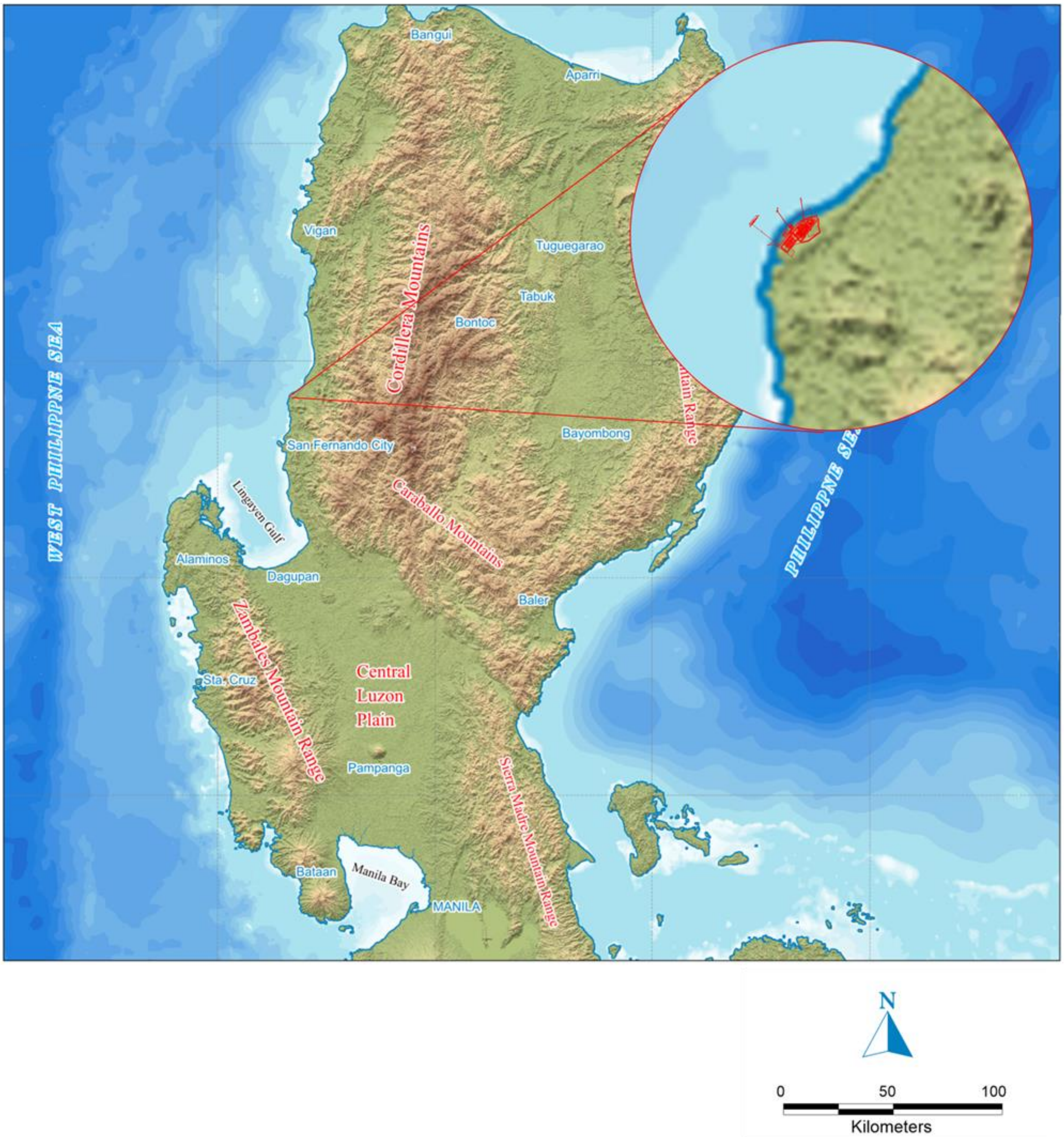


Figure EL-2A. Relief Map of Northern Philippines Showing Physiographic Features of the Area	LEGEND: As above	SCALE: 1:2,500,000
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: Mateo and Siringan, 2007 (retrieved on: September, 2016) Created by: Apercu Consultants, Inc_PP (2017)	aperçu CONSULTANTS INC PAGE 66

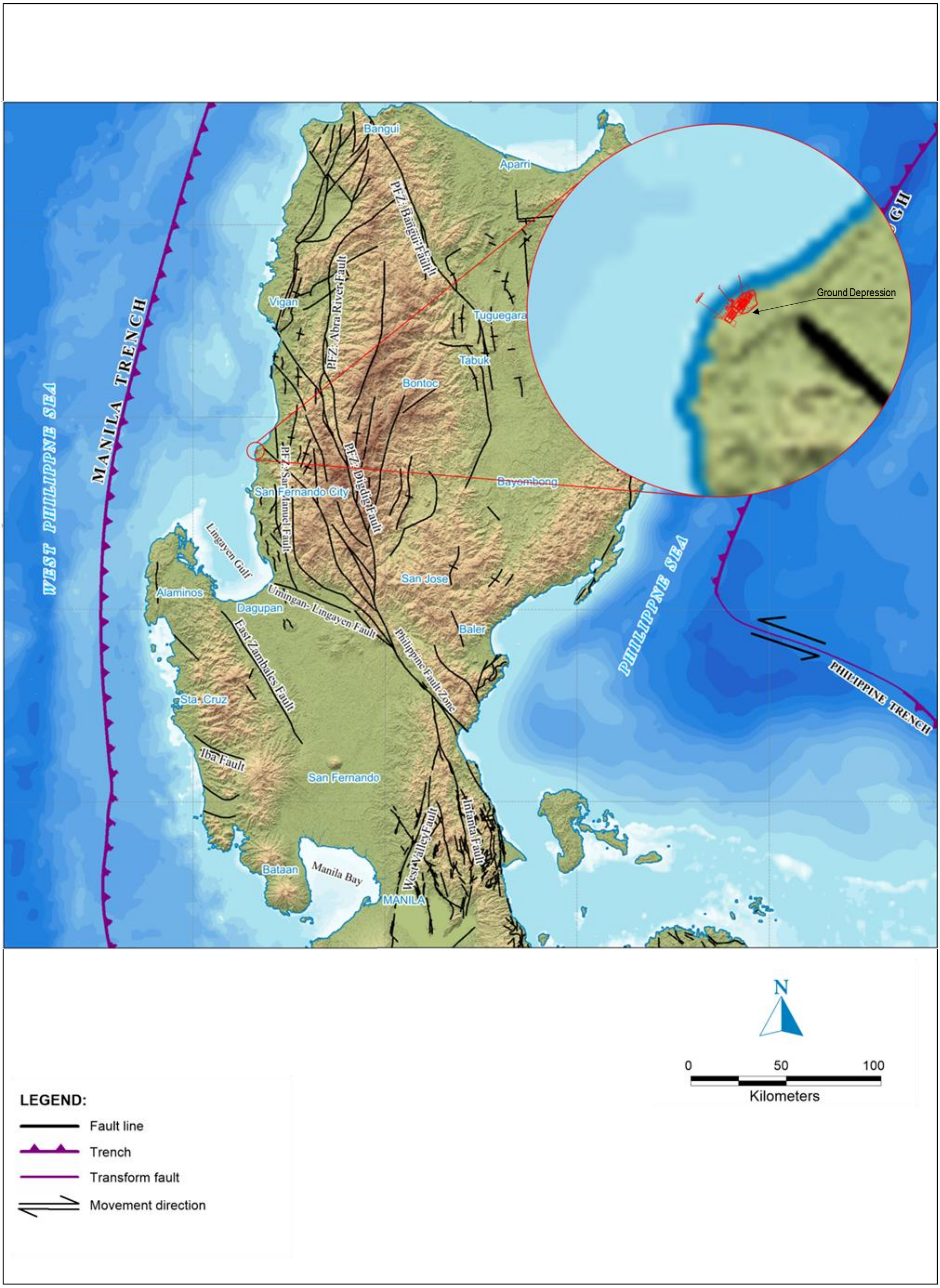


Figure EL-2B. Relief Map of Northern Philippines Showing Structural Features of the Area	LEGEND: As above	SCALE: As above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: Mateo and Siringan, 2007 (retrieved on: September, 2016)	aperçu CONSULTANTS INC. PAGE 67

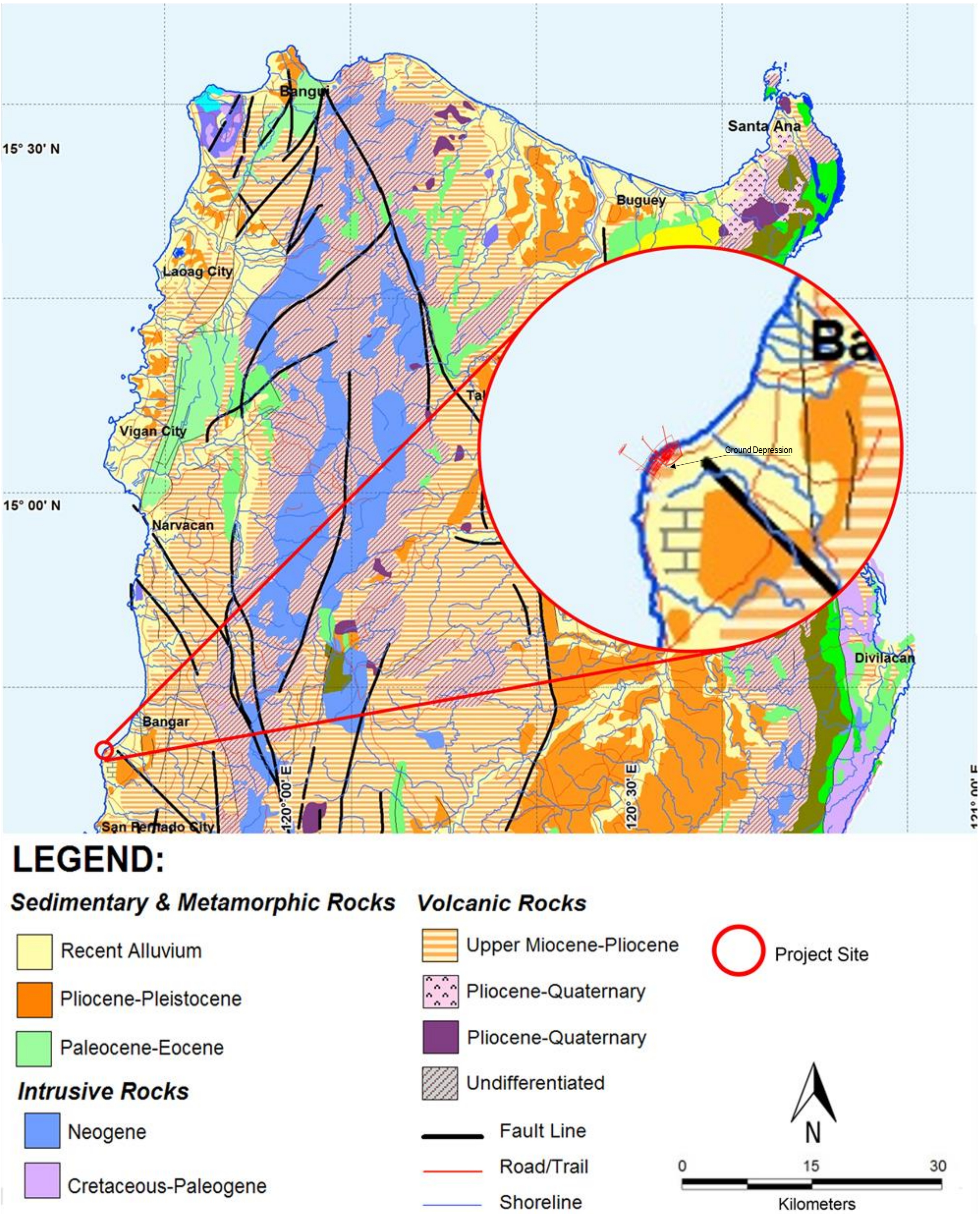
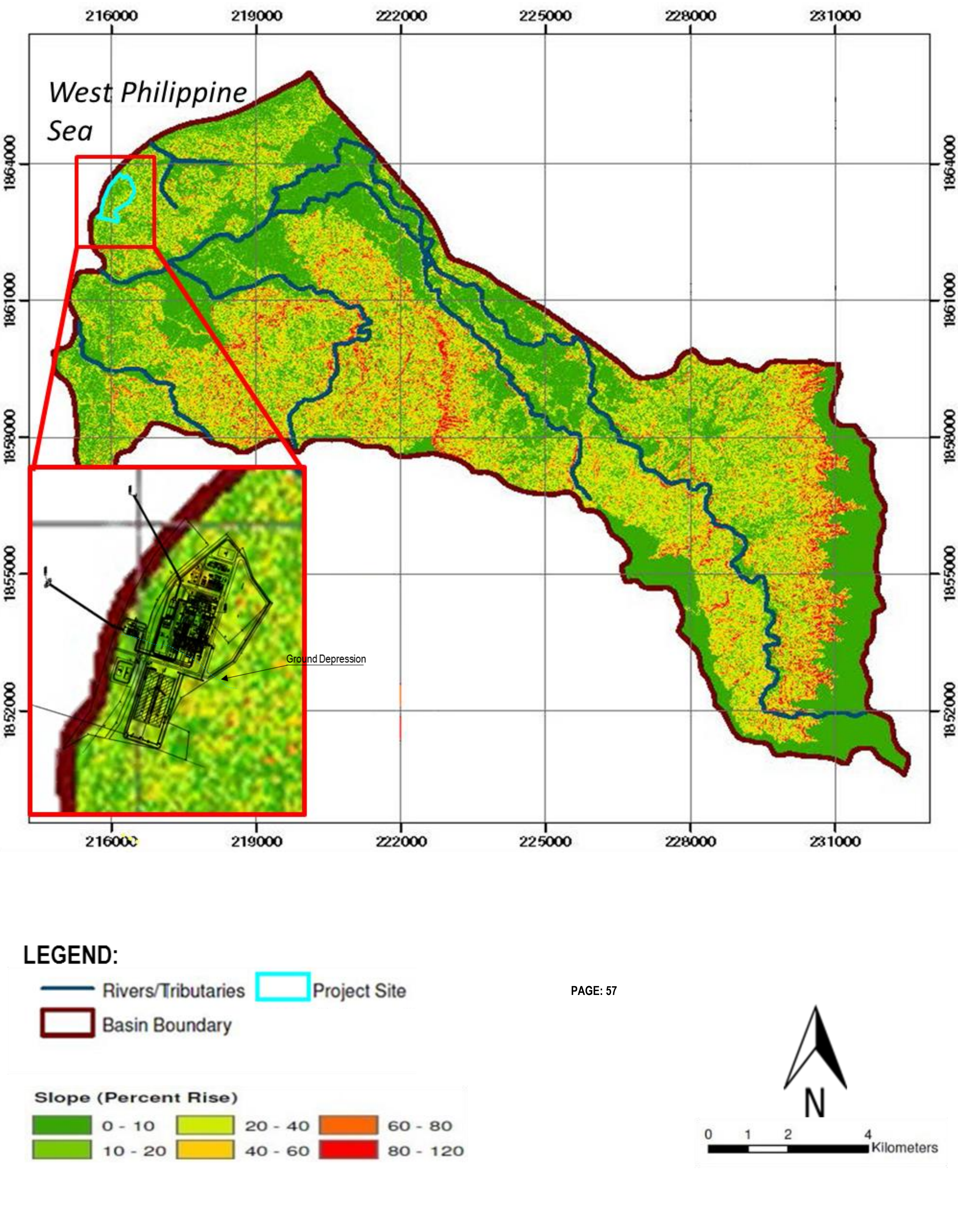


Figure EL-3. Geologic map of Northern Luzon	LEGEND: As Above	SCALE: 1:1,000,000
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: Mines and Geosciences Bureau (retrieved on: September, 2016)	aperçu CONSULTANTS INC PAGE 68



PAGE: 57

Figure EL-4. Generated Slope Map of Darigayos River Basin	LEGEND: As Above	SCALE: 1:50,000
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: Shuttle Radar Topography Mission (STRM) – Digital Elevation Model (DEM) (retrieved: September 2016)	aperçu PAGE 69

The project is expected to utilize the existing barangay road and national road as access to the project site. Internal roads will be developed both in the coastal and hilly portions of the project site. The cut and fill method will be used, particularly in the hilly area where the limestone bedrock is shallow.

Change in slope and topography due to excavation and other site preparation works will be managed by installing the appropriate slope protection. All loose rocks will be removed in order to prevent the occurrence of rock fall. Roads that will be constructed will have an appropriate drainage system to avoid road failure.

The project is not expected to lead to changes in sub-surface or underground geomorphology. The foundation of the buildings and other structures that will be constructed will be suitable for the substrate (limestone) in the project site. All excavations will be filled up as construction works progress.

Plate EL- 6. The coastal area of the project site is overlain by coralline sand, angular to well-rounded pebbles and dead coral fragments.

Plate EL-7. Outcrop of coralline limestone near the mouth of an unnamed creek.

Plate EL-8. Outcrop of coralline limestone observed along the road leading to Barangay Carisquis.

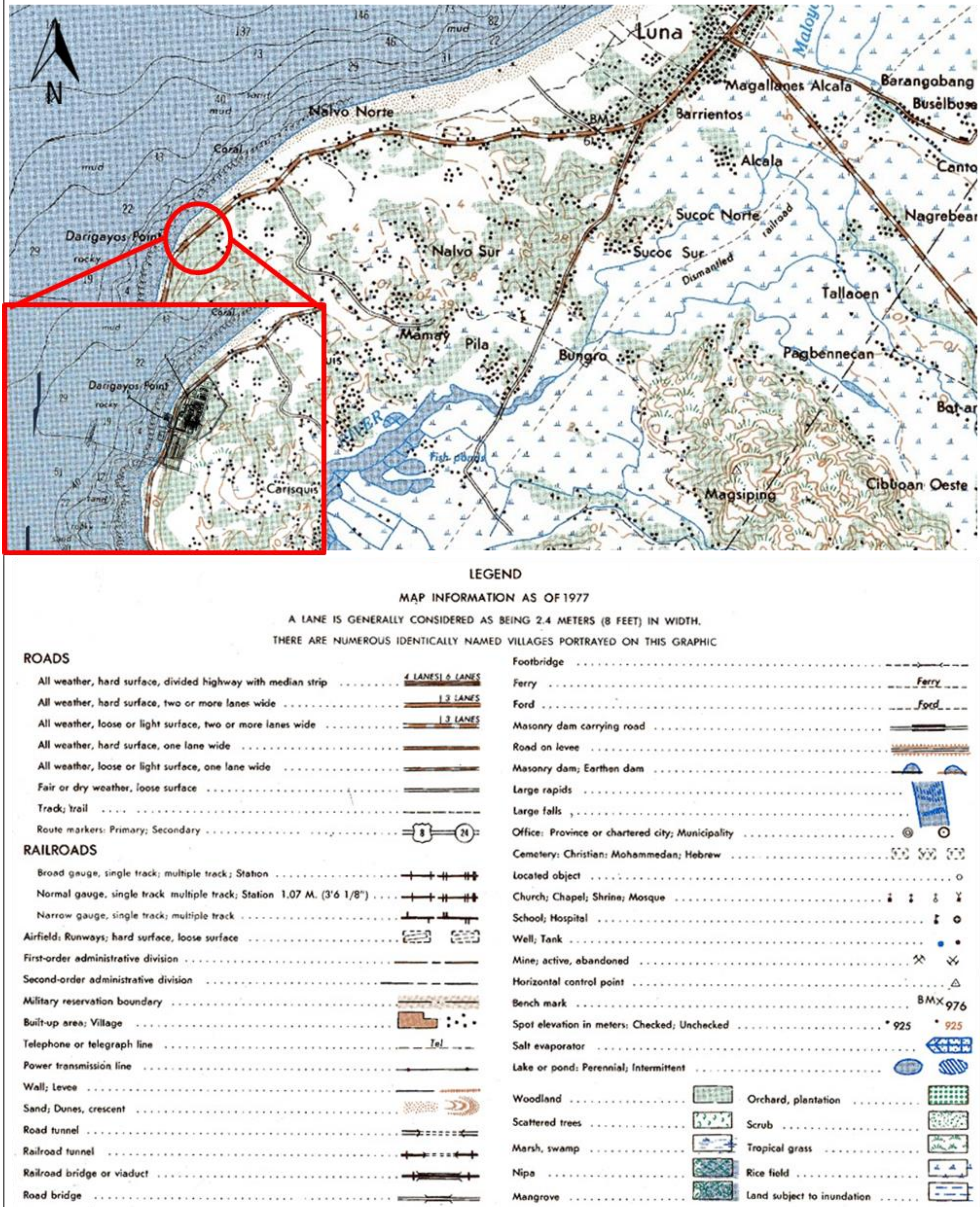


Figure EL-5. Topographic Map of the Project Site and Vicinity and of Bangar Quadrangle	LEGEND: As above; Project site	SCALE: 1:50,000
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: National Mapping and Resource Information Authority (retrieved: September 2016)	aperçu CONSULTANTS INC PAGE 71

Inducement of subsidence or collapse

Limestone is normally a sound foundation material but it often contains solution cavities of variable sizes. These solution cavities influence rock strength and make the limestone susceptible to failure. Joints on the limestone outcrops were observed only on the shoreline and not on the hilly portion of the project site. Thus, the presence of solution cavities, if any, will be the only cause of concern during project development.

To eliminate the risk of foundation collapse, further studies should be done prior to construction to determine presence or absence of solution cavities. These can include geotechnical analysis that will extend sufficiently into the limestone bedrock using instruments such as a ground penetrating radar, among others. As shown during the 2013 earthquake in Bohol, the main cause of failures of the foundation was the presence of sinkholes at shallow depths. Sampling of the limestone will be maximized so that extensive strength tests are done on limestone with variable degrees of cavitation. The recommended foundation design of the geotechnical engineer will also be complied with.

Subsidence is normally associated with excessive groundwater withdrawal. The project is not expected to lead to subsidence or collapse during the operation phase since seawater will be used for the cooling water requirement of the power plant.

1.2.4 Geologic and Other Natural Hazards

1.2.4.1 Seismic Hazards

Based on the preliminary earthquake assessment for the proposed Luna coal-fired power plant project, the potential seismic generators located near and in the vicinity of the project site include the Manila Trench, the Philippine Fault Zone, the East Zambales Fault, the Abra River Fault, the Pugo Fault and an unnamed Fault. The last three seismic generators have potential magnitudes ranging from 6.56 to 7.24 and can cause peak ground accelerations ranging from 0.25g to 0.31g in medium soil (corresponding to the underlying sedimentary and alluvialdeposits in the project site). The g factor contour map for medium soils, according to Thenhaus et al, is presented in **Figure EL-6**. **Power plant structures will be built using a g factor based on the actual geotechnical properties of soil and/or rock materials at the project site. Based on the National Structural Code of the Philippines, the recommended seismic factor of Luna, which falls under the Zone 4 classification, is 0.4.**

Among the destructive earthquakes that have affected the Philippines, at least three have epicentres located about 150km to 200km from the project site. These include the Casiguran earthquake on 02 August 1968 (Ms 7.3), the Laoag earthquake on 17 August 1983 (Ms 6.5) and the Luzon earthquake on 16 June 1990 (Ms 7.9). The seismicity map of Northern Luzon is presented in **Figure EL-7**. As gleaned from the map, shallow seated and low magnitude earthquakes have affected the project site and vicinity. **Power plant structures will be designed with due consideration of the nearby fault lines and past earthquake occurences in nearby/surrounding areas.**

The June 1990 earthquake has the highest magnitude and the closest epicentre (about 150km) to the project site. This quake was generated by the Digdig Fault, a splay of the Philippine Fault. The ground rupture generated during this earthquake measured about 125km along the fault's trace.

As part of its emergency plan, GLEDC will have an earthquake evacuation plan and will conduct earthquake drills regularly.

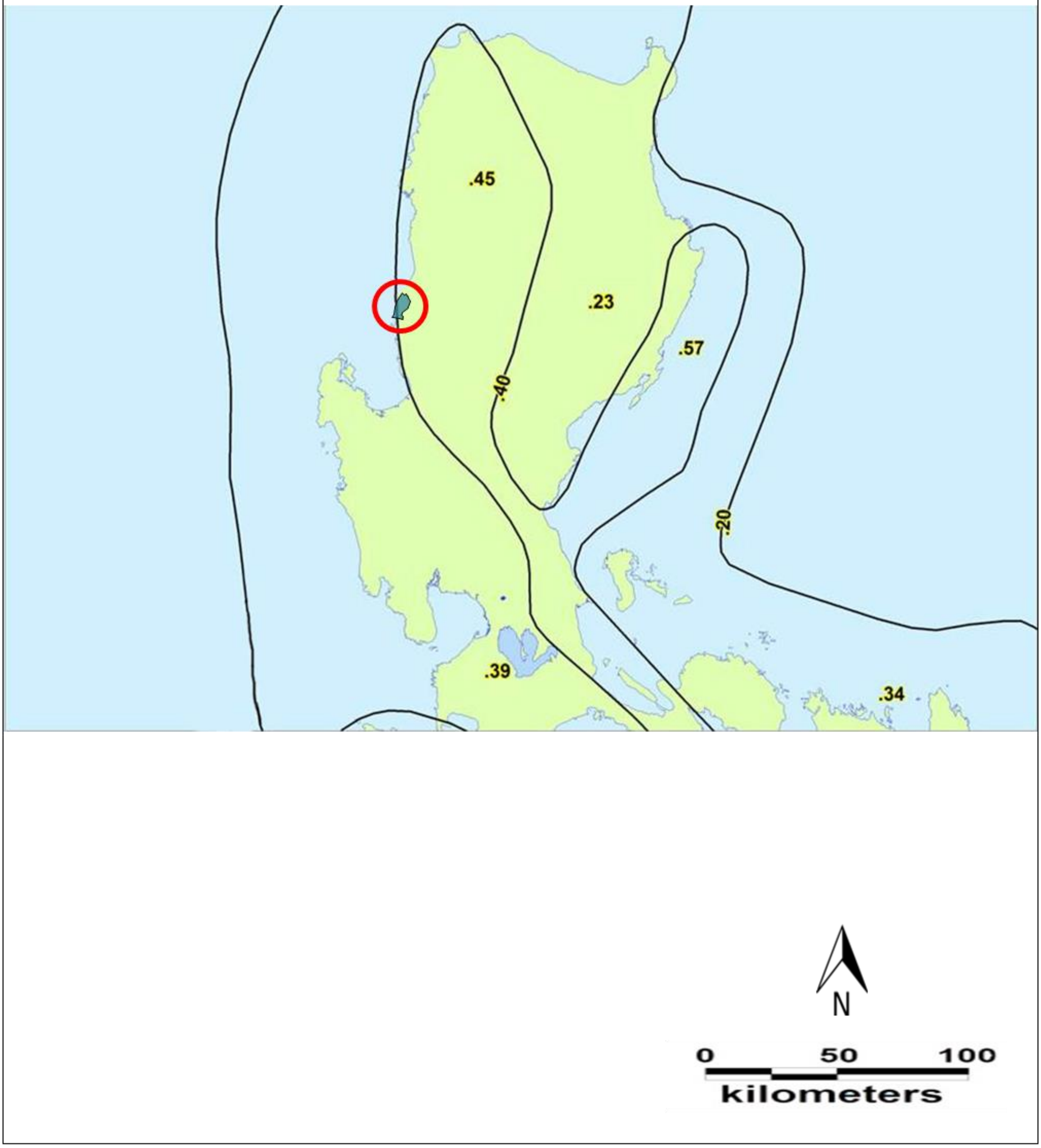


Figure EL-6. Peak Ground Acceleration Contour Map for Medium Soils	LEGEND: g Value; Project Site	SCALE: As Above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: Thenhaus et. Al, 1994 (retrieved on: September, 2016)	aperçu PAGE 73

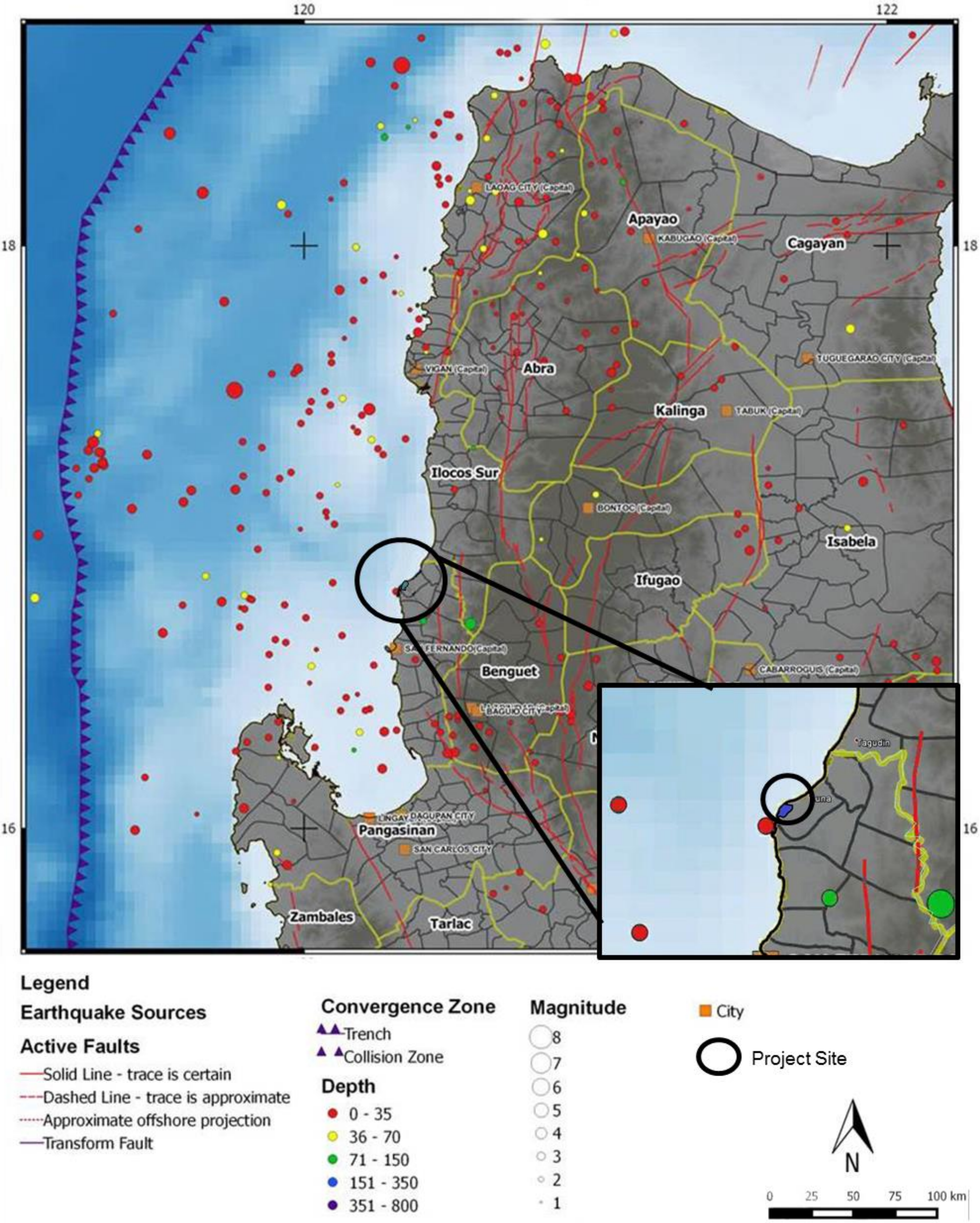


Figure EL-7. Seismicity map of Northern Luzon	LEGEND: As Above	SCALE: As Above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: Department of Science and Technology PHILIPPINE INSTITUTE OF VOLCANOLOGY & SEISMOLOGY Geology & Geophysics R&D Division Active Faults Mapping Group February 2000 (retrieved on: September, 2016)	aperçu CONSULTANTS INC. PAGE 74

1.2.4.2 Liquefaction

Liquefaction, which results from strong ground shaking during an earthquake, causes water-saturated and loosely packed non-cohesive soil to lose stiffness and liquefy. Liquefaction is a major hazard in the areas mapped by PHIVOLCS (**Figure EL-8**). The areas affected by liquefaction during the 1990 earthquake were mostly located within the alluvial complexes of the Agno and Tarlac River systems within the Luzon Central Plains. The coastal plain east of Lingayen Gulf, from Agoo to north of San Fernando City, is also susceptible to liquefaction as shown by the PHIVOLCS map**.**

Figure EL-8 shows the zoomed-in section of the power plant site and indicates that the project site is just outside of the identified areas with liquefaction potential. The municipal CLUP 2014-2023 indicates that the areas prone to liquefaction are in the northeastern part of the municipality, particularly Oaqui, Rissing and Napaset.

The liquefaction potential of the project site will be determined when GLEDC undertakes the detailed geotechnical studies of the project site. This hazard can be mitigated and the risk can be reduced to acceptable levels through the construction of small structures with limited floor area, limiting the number of people on the site to what is necessary, to limit the people exposed to the risk, and use of appropriate foundation design to overcome the constraint posed by the type of substrate in the project site.

1.2.4.3 Tsunami

Tsunami is another seismic hazard in the project site. **Figure EL-9** shows the coastal areas of the Philippines that are prone to tsunamis. The coastal areas of northwest Philippines, including the project site, have experienced tsunamis in the past and these areas have high potential of experiencing other tsunamis in the future. The municipal CLUP 2014-2023 also indicates that, although no records are available, a tsunami was felt in Darigayos, which caused the sea level to rise but was observed to quickly subside and did not cause damage or loss to life. The estimated maximum wave height of a tsunami that can affect the project site and vicinity is 8.15m (see **Figure EL-9**). Since the project site has elevation ranging from 0-10m, the lower portions of the project site will be prone to coastal flooding when a tsunami occurs.

Since the project site is prone to tsunamis, a tsunami emergency and evacuation plan will be included in the plant's overall emergency plan. The plant structures will also be built at an elevation at least equal or above the elevation of the national road. Another measure to address the possible impact of tsunami and storm surge to the project site is the construction of a storm surge or flood barrier that will be left open to allow water passage during normal conditions but will be closed when threat of a tsunami or storm surge is imminent.

1.2.4.4 Storm Surges

The western side of Luna is prone to storm surges, since it is located along the shores of the West Philippine Sea. The hazard mapping of MGB Region I have also identified Barangay Nalvo Sur as having moderate susceptibility to coastal erosion, storm surge and tsunami.

The storm surge hazard map of the Philippines is shown in **Figure EL-10**. As shown on the map, the coastal areas of NW Luzon are expected to have storm surge heights ranging from 1.01m to 2m (Lapidez et al 2015). Storm surges during super-strong typhoons such as Super-typhoon Yolanda that affected the VIsayas in 2013 can reach heights of 5-6m. Since the elevation at the project site ranges from 0-10m, the lower portions of the project site near the coast will be prone to coastal flooding when a storm surge occurs. Climate change projections for Region 1 indicate that days with rainfall >300mm are expected to increase in 2020 and 2050, which are expected to coincide with strong typhoons. Thus, occurrence of storm surge is also expected to increase in the future.

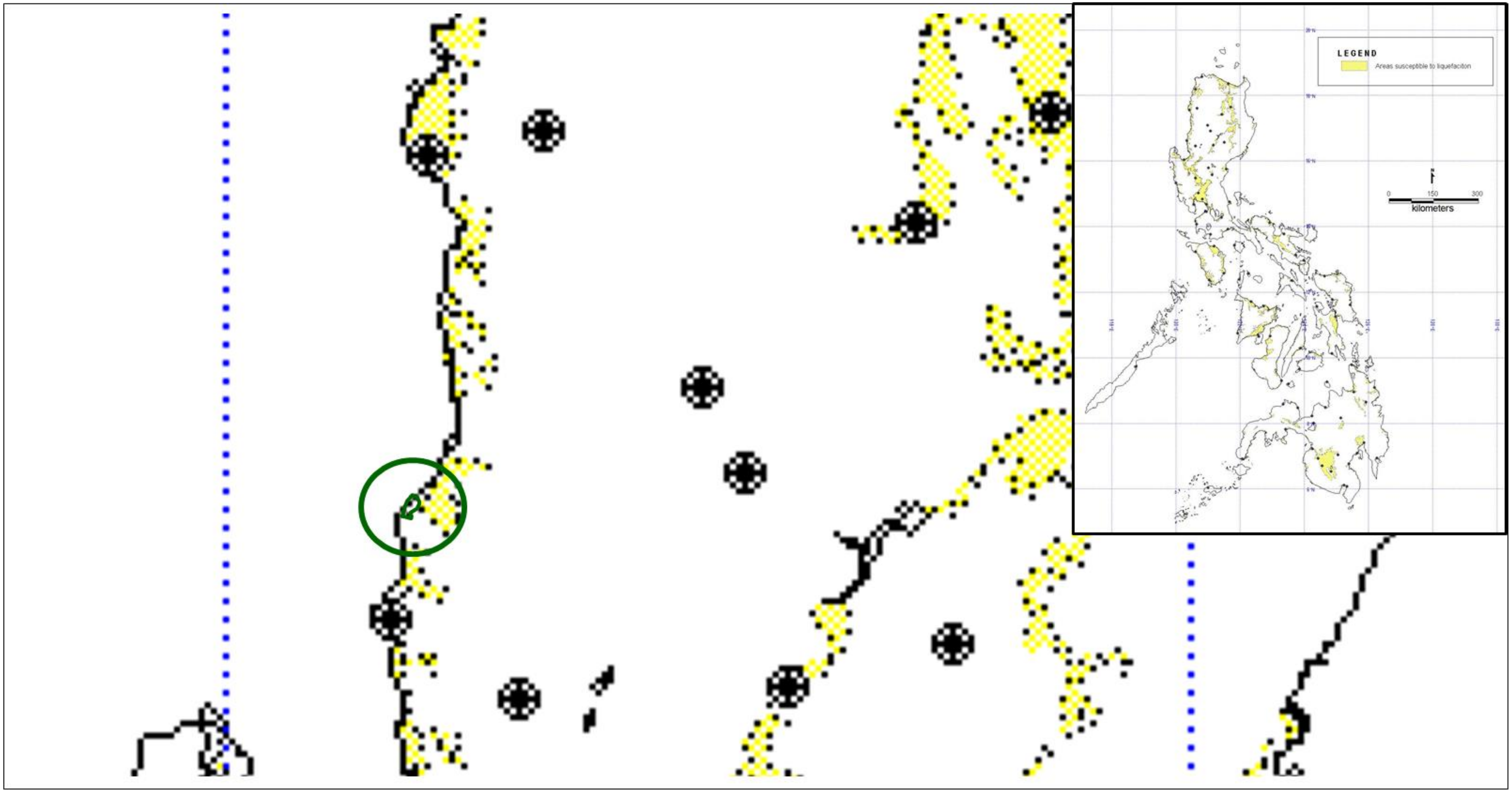
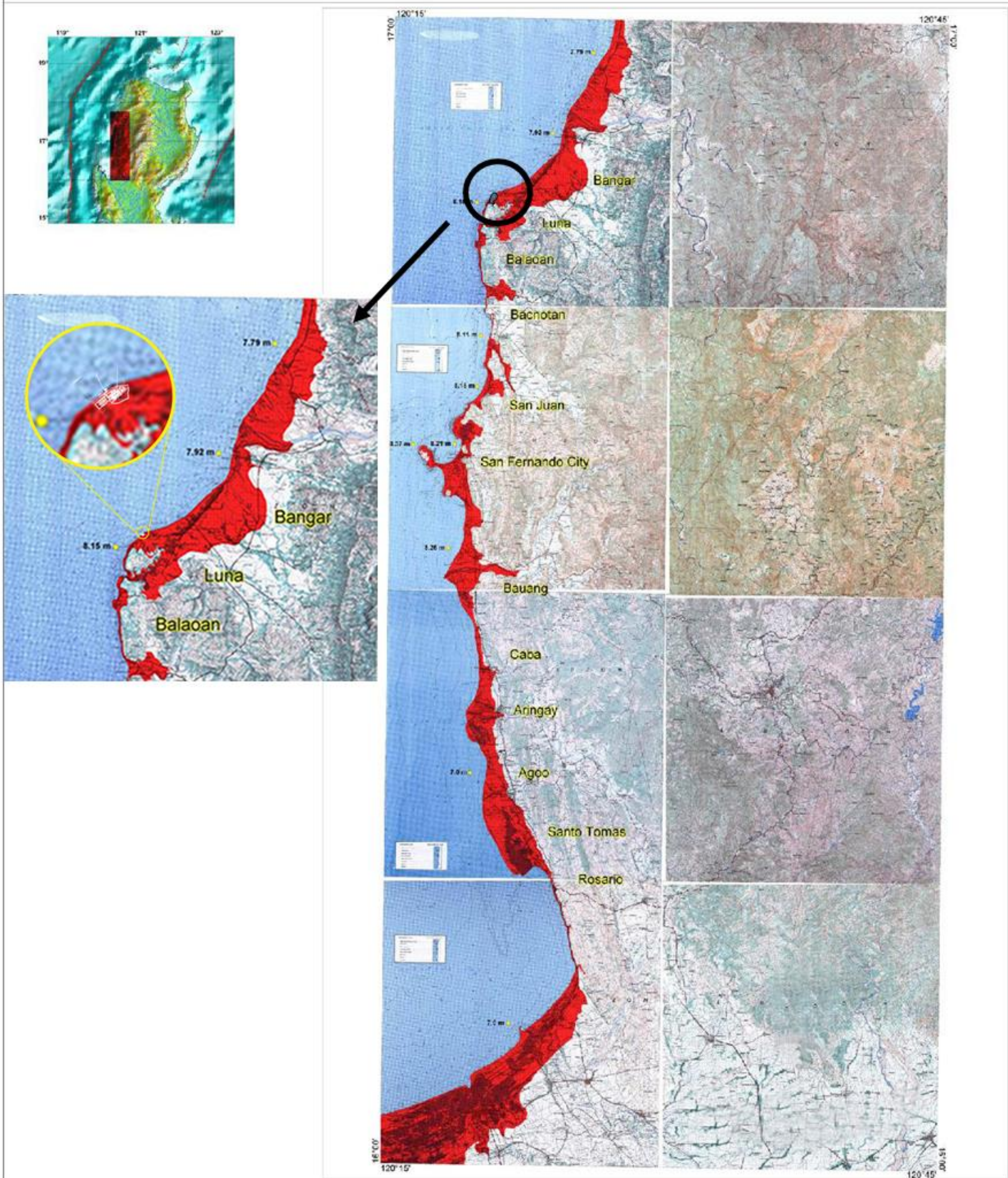


Figure EL-8. Liquefaction Susceptibility Map of the Project Site	LEGEND:	SCALE: Not drawn to scale	DATA INFORMATION/SOURCE:	PAGE 76
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	Areas Susceptible to Liquefaction Project Site		Department of Science and Technology PHILIPPINE INSTITUTE OF VOLCANOLOGY & SEISMOLOGY Geology & Geophysics R&D Division Active Faults Mapping Group February 2000 (retrieved on: September, 2016)	aperçu CONSULTANTS INC

TSUNAMI HAZARD MAP
Province of La Union



Explanation:

This indicative map is based on maximum computed wave height and inundation using worst case scenario earthquakes from major offshore source zones. The indicated wave height decreases away from the shoreline.

Figure EL-9. Map Showing Areas in La Union Province Prone to Tsunami	LEGEND: Tsunami Inundation Area; Tsunami Wave Height at Coastline; Project site		SCALE: 1:50,000
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: Data Source: Modeling results using REDAS Software based on empirical equations of Abe (1989), Hall and Watt (1953), Prist (1995), and Hills and Mader (1999) (retrieved on: September, 2016)	Map Prepared By: Philippine Institute of Volcanology and Seismology (PHIVOLCS) - Department of Science and Technology (DOST) Under the DOST-GIA Program December 2007	aperçu CONSULTANTS INC

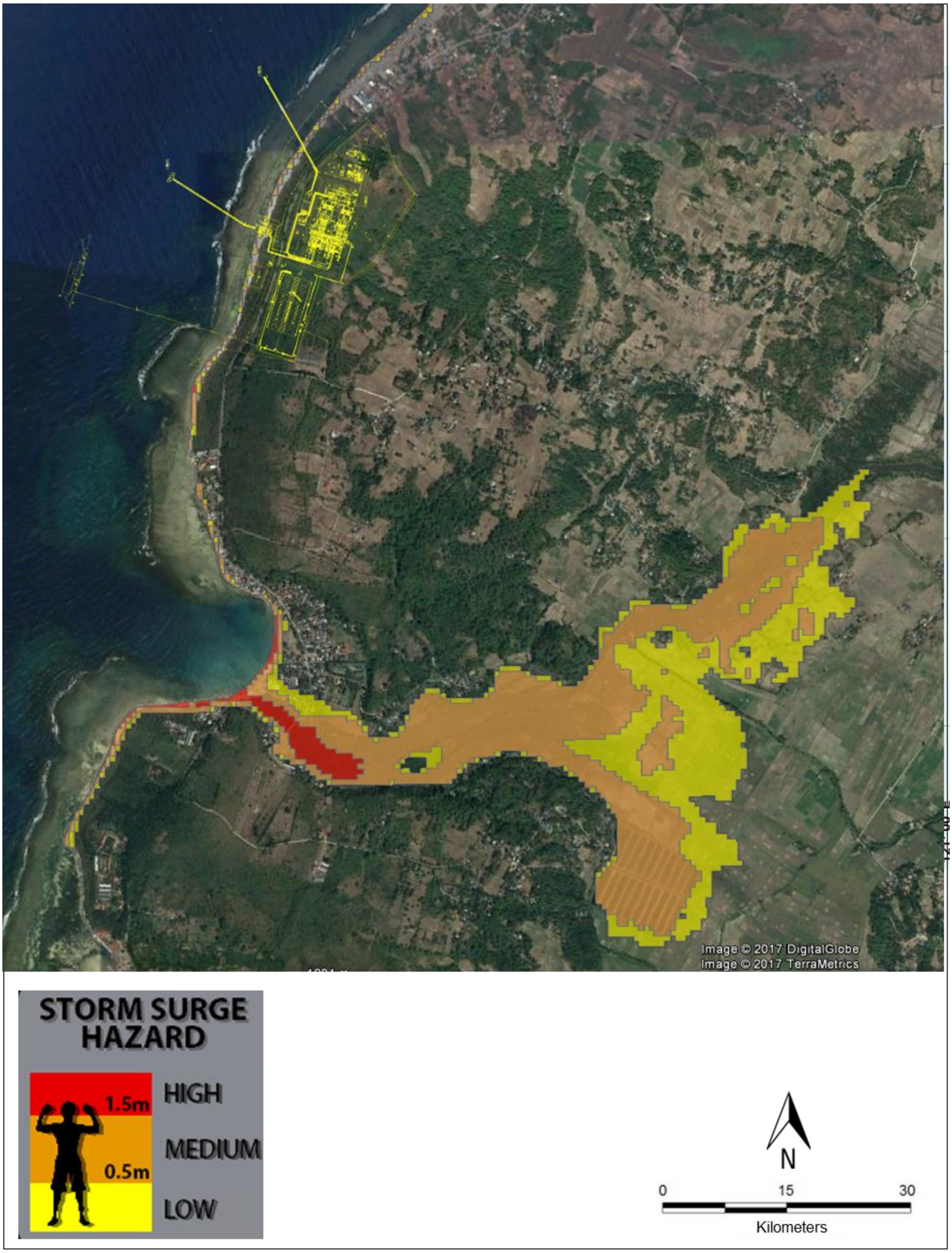


Figure EL-10. Storm Surge Hazard Map of the Project Site Based on Predicted Storm Surge Height; SSA 1:2m storm surge height	**LEGEND: As Above**	**SCALE: 1:1,000**
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	**DATA INFORMATION/SOURCE:** **Nationwide Operational Assessment of Hazards (retrieved on: September, 2017)**	aperçu CONSULTANTS INC **PAGE 78**

Since the area is prone to storm surges, GLEDC will design the plant, especially the coastal area to prepare against any potential occurrences of a storm surge. The impact of natural hazards such as storm surge, coastal flooding and flash floods can be mitigated by incorporating the appropriate measures in the project design such as shore protection, levees and proper drainage layout. A storm evacuation plan will be in place and will be implemented during the occurrence of strong typhoons. Design of project facilities will be compliant with the national building code and local zoning ordinances.

1.2.4.5 Volcanic Hazards

The project site has low susceptibility to volcanic hazards. **Figure EL-11** shows that there are no active volcanoes within the vicinity of the project site.

1.2.4.6 Landslide Hazard

The flat areas of the municipality including the project site are not prone to landslides and other mass movement hazards. The eastern and southern hilly and mountainous portions of the municipality have moderate susceptibility to landslides (**Figure EL-12**). The hilly portion of the proposed site of the coal-fired power plant has low to moderate susceptibility to landslides due to the thin soil cover, gentle to moderate slope and relatively stable nature of the limestone substrate.

The project is not expected to induce landslides or other natural hazards. The coastal portion of the project site is essentially flat and has low susceptibility to landslide hazards. The sloping hilly portion of the project site has low to moderate susceptibility to mass movement hazards such as landslides and rock fall. However, since the project site is located in a tsunami prone area, the proponent will prepare an early warning system together with a workable evacuation plan. The plant's safety officer will include logging on to the US Geological Survey (USGS) and PHIVOLCS websites on a regular basis for any imminent occurrences of these hazards.

1.2.4.7 Flooding Hazard

The flat areas of the municipality that are occupied by settlements and agricultural areas are prone to flooding when the rivers and creeks overflow during heavy and prolonged rains.

The project site has low susceptibility to flooding as shown in the MGB flood and landslide hazard susceptibility map of the Bangar Quadrangle (MGB 2010) (**Figure EL-12**). The project site is located in a slightly elevated area several kilometers north of Darigayos River, which is the major river system that causes flooding in the low-lying areas on the southern part of Luna municipality.

To prevent any flooding in the project site due to the development, proper drainage channels will be built to divert flood waters away from the plant structures with due consideration of the actual hydrological properties of river catchments. The ground depression, which according to the guides was widened to allow for rainwater runoff to drain to the sea, will be maintained with culverts ensuring that outflow to the sea will continue unimpeded and flooding will not occur in the area.

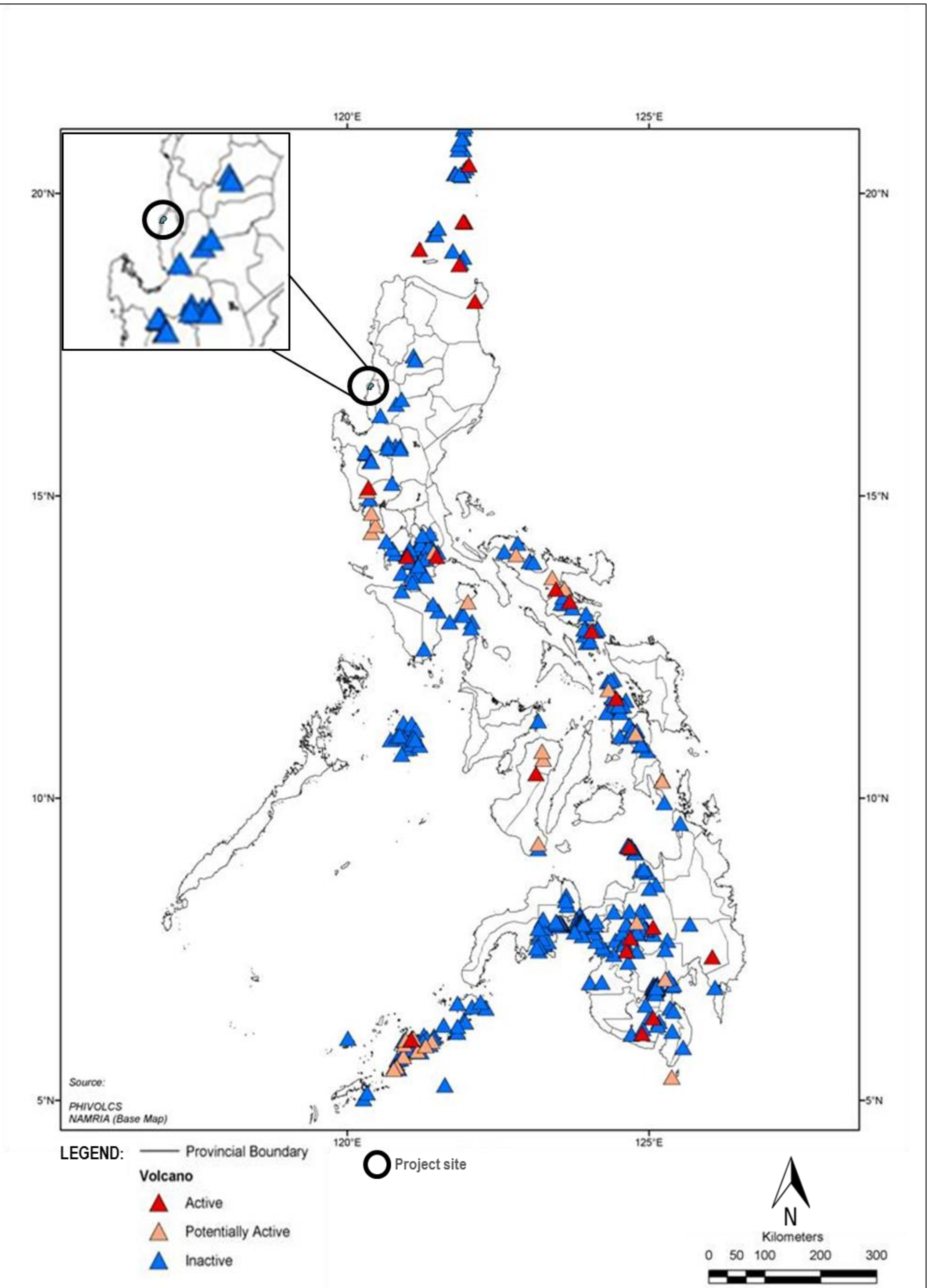
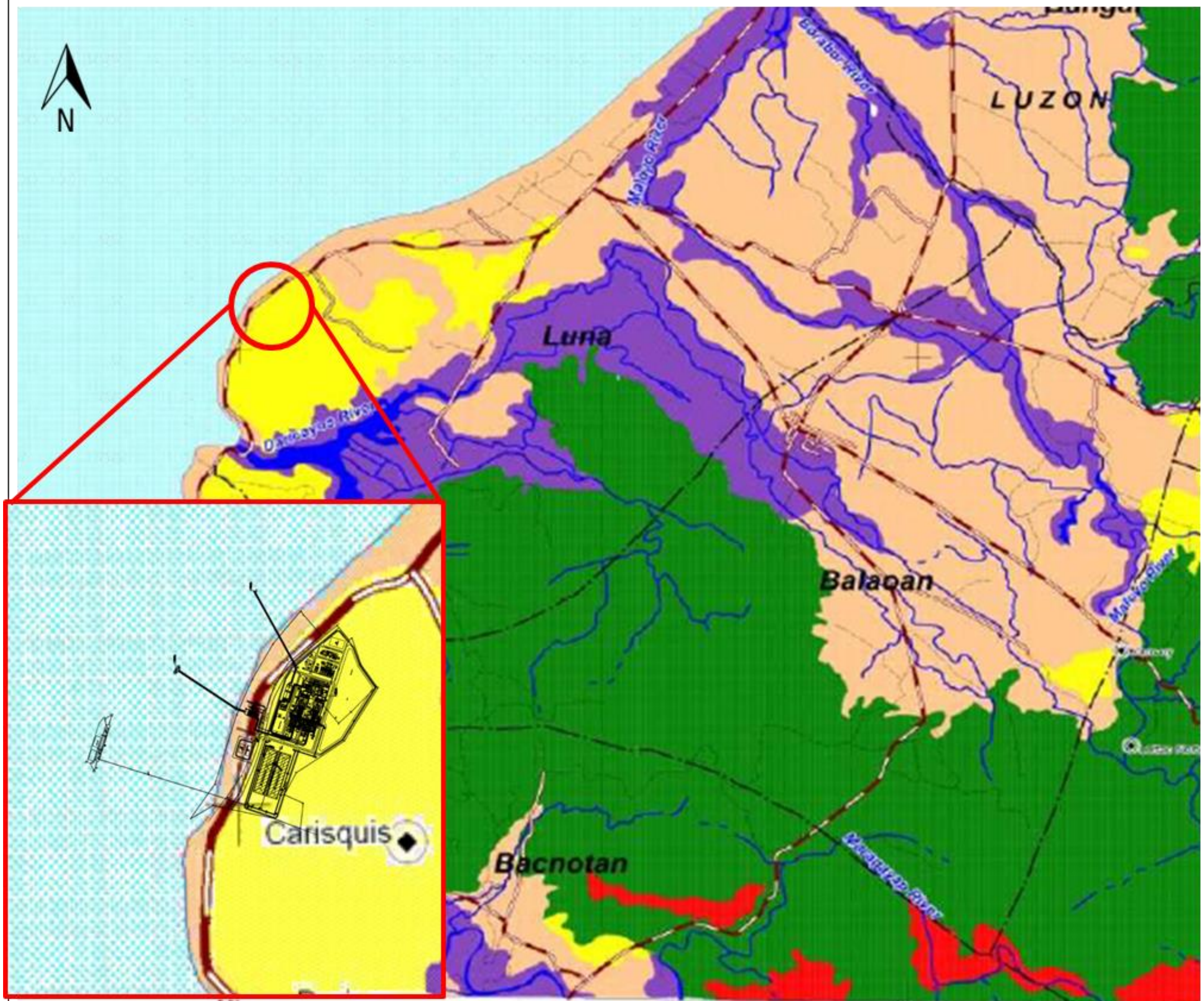


Figure EL-11. Distribution of Volcanoes in the Philippines	LEGEND: As above	SCALE: As above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: MANILA OBSERVATORY DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES (retrieved on: September, 2016)	aperçu



LEGEND:

- **High susceptibility to landslide**
  Areas with high landslide susceptibility rating have active/recent landslides and tension cracks that could directly affect the community. Those with steep slopes and drainages that are prone to landslides damming are also highly susceptible to landslides.
- **Moderate susceptibility to landslide**
  Areas with moderate landslide susceptibility rating have inactive/old landslides and tension cracks which are located away from the community. These areas usually have moderate slopes.
- **Low susceptibility to landslide**
  Areas with low to gentle slopes and lacking tension cracks have low landslide susceptibility rating
- Project site
- **High susceptibility to flooding**
  Areas with greater than 1 meter flood height. These areas are usually flooded for several hours during heavy rains; include landforms of topographic lows such as active river channels, abandoned river channels and areas along river banks, also prone to flashfloods.
- **Moderate susceptibility to flooding**
  Areas with less than 1 meter flood height. These are usually inundated during prolonged and extensive heavy rainfall or extreme weather condition.
- **Roads**
- **River**
- **Municipal boundary**
- **Barangay center location**

Figure EL-12. Landslide and Flood Susceptibility Map of a Portion of Bangar Quadrangle	**LEGEND:** As above	**SCALE:** 1:50,000
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: MINES AND GEOSCIENCES BUREAU (2010)	aperçu **PAGE 81**

1.2.5 Summary of Potential Impacts and Mitigation Measures for Geology and Geomorphology

Table EL-4 presents the summary impacts and mitigation measures for Geology and Geomorphology.

Table EL-4
Summary of Impacts Related to Geology and Geomorphology

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
I. Construction Phase			
Changes in geomorphology of the project site	Geomorphology	The project will have minimal changes to the surface landform, topography, terrain or slope of the site. Most of the plant facilities are to be located on the gently sloping coastal portion of the project site and the slope in this area is expected to be maintained during the construction and operation phases of the power plant. However, site preparation works such as land grading will alter the surface landform and slope of the hilly portion of the project site. The project is expected to utilize the existing barangay road and national road as access to the project site. Internal roads will be developed both in the coastal and hilly portions of the project site. The cut and fill method will be used, particularly in the hilly area where the limestone bedrock is shallow.	Change in slope and topography due to excavation and other site preparation works will be managed by installing the appropriate slope protection. All loose rocks will be removed in order to prevent the occurrence of rock fall. Roads that will be constructed will have an appropriate drainage system to avoid road failure.
Changes in geomorphology of the project site	Sub-surface or underground geomorphology	The project is not expected to lead to changes in sub-surface or underground geomorphology. The foundation of the buildings and other structures that will be constructed will be suitable for the substrate (limestone) in the project site.	All excavations will be filled up as construction works progress.
Inducement of subsidence or collapse	Subsidence	Limestone is normally a sound foundation material but it often contains solution cavities of variable sizes. These solution cavities influence rock strength and make the limestone susceptible to failure. Joints on the limestone outcrops were observed only on the shoreline and not on the hilly portion of the project site. Thus, the presence of solution cavities, if any, will be the only cause of concern during project development.	Further studies should be done prior to construction to determine presence or absence of solution cavities. Sampling of the limestone will be maximized so that extensive strength tests are done on limestone with variable degrees of cavitation. The recommended foundation design of the geotechnical engineer will also be complied with.
II. Operation Phase			

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
Inducement of subsidence or collapse	Subsidence	Subsidence is normally associated with excessive groundwater withdrawal. The project is not expected to lead to subsidence or collapse during the operation phase since seawater will be used for the cooling water requirement of the power plant.	• No mitigation measures needed.
Geologic and other natural hazards	Storm surge	The western side of Luna is prone to storm surges, since it is located along the shores of the West Philippine Sea. The hazard mapping of MGB Region I have also identified Barangay Nalvo Sur as having moderate susceptibility to coastal erosion, storm surge and tsunami.	• GLEDC will design the plant to prepare against any potential occurrences of a storm surge. • Incorporate the appropriate measures in the project design such as shore protection, levees, and proper drainage layout. • A storm evacuation plan will be in place and will be implemented during the occurrence of strong typhoons. • Design of project facilities will be compliant with the national building code and local zoning ordinances.
Geologic and other natural hazards	Tsunami	Tsunami is another seismic hazard in the project site. Figure EL-9 shows the coastal areas of the Philippines that are prone to tsunamis. The coastal areas of northwest Philippines, including the project site, have experienced tsunamis in the past and these areas have high potential of experiencing other tsunamis in the future.	• A tsunami emergency and evacuation plan will be included in the plant's overall emergency plan. • The plant structures will also be built at an elevation at least equal or above the elevation of the national road. • Construction of a storm surge or flood barrier.
Geologic and other natural hazards	Landslides	The project is not expected to induce landslides or other natural hazards. The coastal portion of the project site is essentially flat and has low susceptibility to landslide hazards. The sloping hilly portion of the project site has low to moderate susceptibility to mass movement hazards such as landslides and rock fall.	• The proponent will prepare an early warning system together with a workable evacuation plan. • The plant's safety officer will include logging on to the US Geological Survey (USGS) and

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
			PHIVOLCS websites on a regular basis for any imminent occurrences of these hazards.
Geologic and other natural hazards	Seismic hazards	Based on the preliminary earthquake assessment for the proposed Luna coal-fired power plant project, the potential seismic generators located near and in the vicinity of the project site include the Manila Trench, the Philippine Fault Zone, the East Zambales Fault, the Abra River Fault, the Pugo Fault and an unnamed Fault.	• Power plant structures will be built using a g factor based on the actual geotechnical properties of soil and/or rock materials at the project site. • Power plant structures will be designed with due consideration of the nearby fault lines and past earthquake occurences in nearby/surrounding areas. • GLEDC will have an earthquake evacuation plan and will conduct earthquake drills regularly.
Geologic and other natural hazards	Liquefaction	The liquefaction potential of the project site will be determined when GLEDC undertakes the detailed geotechnical studies of the project site.	• Construction of small structures with limited floor area, limiting the number of people on the site to what is necessary, to limit the people exposed to the risk, and use of appropriate foundation design to overcome the constraint posed by the type of substrate in the project site.
Geologic and other natural hazards	Flooding	The project site has low susceptibility to flooding as shown in the MGB flood and landslide hazard susceptibility map of the Bangar Quadrangle (MGB 2010). The project site is located in a slightly elevated area several kilometers north of Darigayos River, which is the major river system that causes flooding in the low-lying areas on the southern part of Luna municipality.	• Proper drainage channels will be built to divert flood waters away from the plant structures with due consideration of the actual hydrological properties of river catchments. • The ground depression, which according to the guides was widened to allow for rainwater runoff to drain to the

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
			sea, will be maintained with culverts ensuring that outflow to the sea will continue unimpeded and flooding will not occur in the area.

1.2.6 Monitoring Plan for Geology and Geomorphology

Monitoring for the presence of solution cavities and sinkholes will be done during the excavation for building foundation. Foundation of structures will not be constructed on areas where cavities and sinkholes are found.

1.3 Pedology / Soils

1.3.1 Methodology

Soil samples were obtained from four stations to assess the soil quality in the project site and vicinity. Soil samples were taken from the surface and at 0.5m-1m depth. The soil samples were placed in pre-labeled Zip-lock plastic bags and were submitted to Ostrea Mineral Laboratories, Inc. for analysis of the following parameters: nitrogen, phosporus, potassium, pH, organic matter, hexavalent chromium, arsenic, cadmium, lead and mercury.

The soil characterization is followed by an assessment of potential impacts that could arise due to the construction and operation of the project on soil quality. Based on the outcome of these assessments, measures to manage and mitigate potential adverse impacts are recommended.

The location and description of the soil quality sampling stations are presented in **Table EL-5** and **Figure EL-13**.

Table EL-5
Soil Quality Sampling Station Description

Station ID	Coordinates	Elevation	Site Description
S1	16°50'12.50"N 120°20'16.15"E	16m	In the proposed power block
S2	16°50'5.47"N 120°20'11.68"E	18m	In the proposed coal yard
S3	16°49'52.22"N 120°20'6.86"E	22m	In the proposed ash disposal area
S4	16°49'30.04"N 120°20'13.15"E	33m	Control Station in Brgy. Darigayos approximately 700m away from the south of the project site

1.3.2 Soil Types

Based on the soil map series retrieved from the BSWM, most of the surface soil in Luna consists of San Manuel Silt Loam. This soil type is well drained and not prone to flooding. Its parent materials include old alluvium, recent alluvium and coastal deposits. The surface soil is coarse granular while the subsoil ispale brown silt loam to fine sandy loam. San Manuel Silt Loam has moderate to high fertility and found extensively on the alluvial plains of the municipality where crops are grown.

The other soil types in the municipality according to the Luna Comprehensive Land Use Plan (2014-2023) include Vigan Clay Loam, Bauang Clay, Bolinao Clay, gravel deposits, beach sand and hydrosol. The different soil types of the municipality are shown in the soil map on **Figure EL-14**. As gleaned from the map, most of the municipality is overlain by San Manuel Silt Loam while the coastal area, where the project site is located, is overlain by beach sand.

Soil erosion and loss of topsoil/overburden will occur during project development, especially during land clearing and excavation for building foundation. Excavation and land clearing will thus be limited to what is required for project construction. Stockpiles of excavated soils will be stabilized to minimize occurrence of erosion, particularly during the rainy season.

The sediment sources in the project site and vicinity include the alluvial deposits of Darigayos River as well as the marine sediments from the West Philippine Sea. The beach sand deposits in the project site can be easily eroded by wind and wave action.

During the construction phase of the coastal structures (jetty, intake and outfall pipes) when erosion and siltation is most likely to happen, prevention measures like levees, and siltation ponds or silt traps will be installed.

There are no major rivers traversing the project site, thus riverbank stability will not be a concern during project development. The banks of the ground depression within the project site are thickly vegetated and lined with limestone boulders. Thus, the creek bank is stable. In addition, culverts will be installed to ensure unimpeded flow of water during rain events.

1.3.3 Soil Quality

The results of the soil sample analysis are presented in **Table EL-6**. In the absence of Philippine soil quality guideline values, the results are compared to the Dutch Target and Intervention Values (2000) which identifies guideline values for various soil quality parameters. All other soil quality data to be obtained for the proposed power plant project will be compared to the Dutch Target and Intervention Values (2000).

Values of organic parameters are presented in **Figure EL-15** while values of pH and organic matter are presented in **Figure EL-16.** In the absence of agricultural activities within the project site, nitrogen and potassium in soil samples is presumed to be from natural sources.

Values of heavy metals (e.g. hexavalent chromium, arsenic, cadmium, lead and mercury) are low and are well within the Dutch Target and Intervention Values (2000) for these parameters (**Figure EL-17**).

Change in soil quality/fertility due to oil leaks/spills of construction equipment and machinery and from the vehicles used in the site can occur during construction.

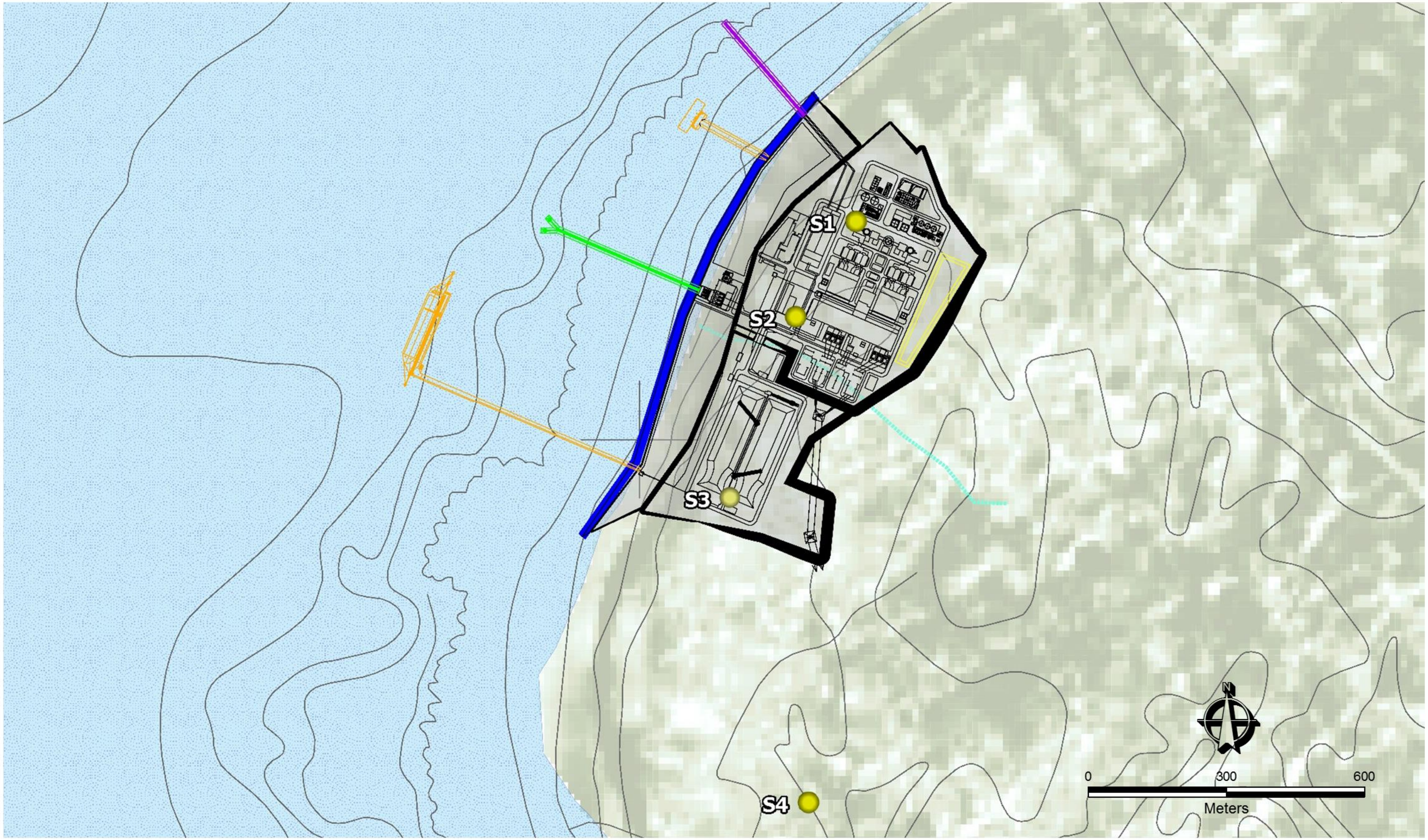


Figure EL-13 Soil Quality Sampling Map	LEGEND:	SCALE: 1:8,000	PAGE: 87
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	Soil Quality Sampling Points; Project Layout; Ash Pond; Foreshore Area; Jetty/ Temporary Jetty; Cooling Pipe; Outfall Pipe; Ground Depression	**DATA INFORMATION/SOURCE:** **Contour:** NAMRIA Contour, 2016 **Project Boundary:** GLEDC 2017 **Created by:** Aperçu_AConjares	aperçu CONSULTANTS INC.

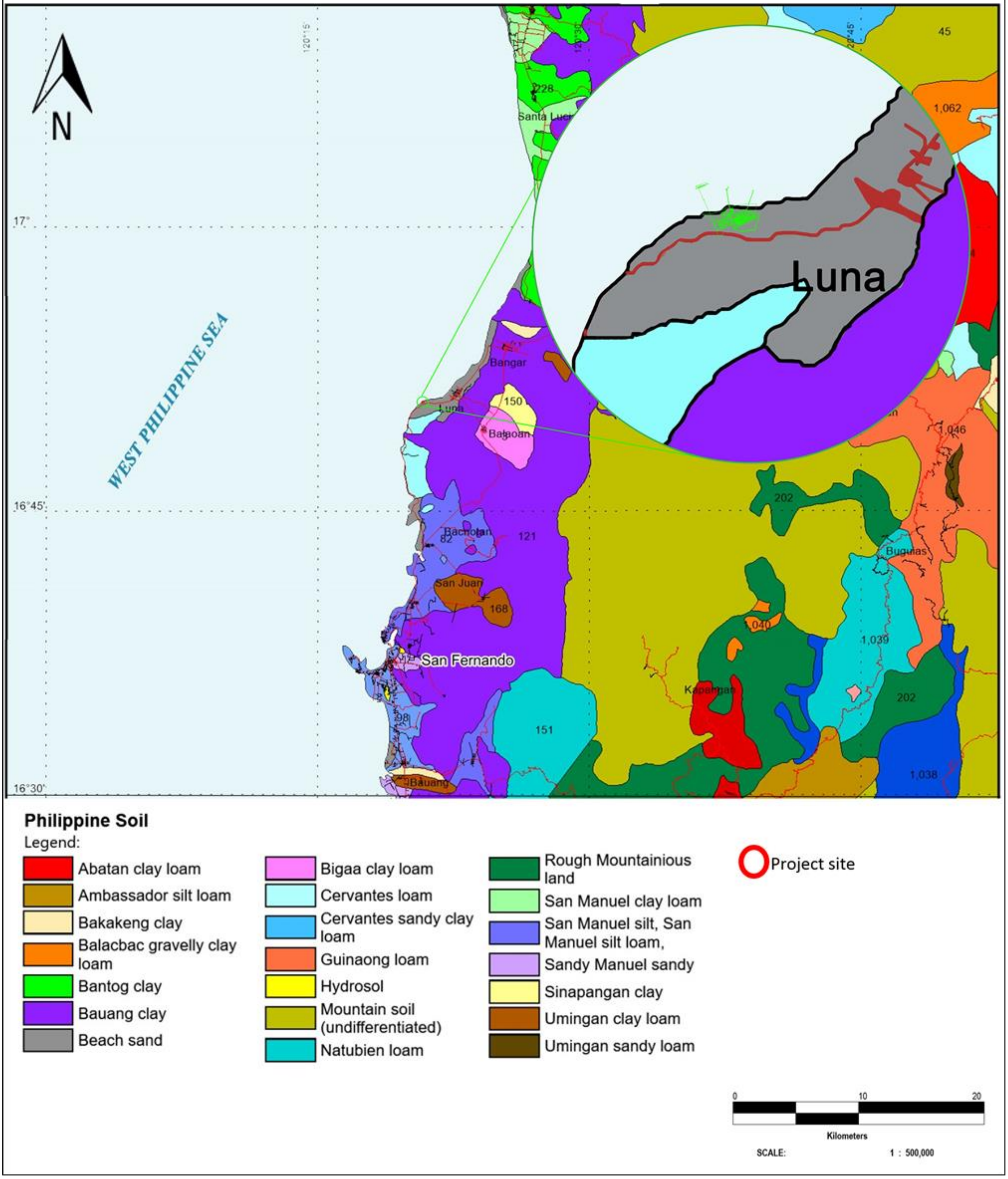


Figure EL-14. Soil Map of Northwestern Luzon	**LEGEND: As above**	**SCALE: As above**
ENVIRONMENTAL IMPACT STATEMENT **2x335MW COAL-FIRED POWER PLANT PROJECT**	**DATA INFORMATION/SOURCE:** **BSWM Soil Map Series** **(retrieved: 2016)**	**PAGE 88**

Table EL-6
Results of Soil Quality Analysis

Parameters	Units	Station S1 A	Station S1 B	Station S2 A	Station S2 B	Station S3 A	Station S3 B	Station S4 A	Station S4 B	Dutch Target (TV) and Intevention Values (IV) in mg/kg	
										TV	IV
Nitrogen (N)	%	0.22	0.29	0.28	0.09	0.23	0.18	0.27	0.26	N/A	N/A
Phosphorus (P)	%	0.116	0.106	0.102	0.088	0.121	0.086	0.123	0.094	N/A	N/A
Potassium (K)	mg/kg	931.08	1176.61	939.34	957.98	1241.17	1291.61	785.78	767.50	N/A	N/A
pH	-	7.5	8.2	7.3	6.9	7.5	7.8	8.3	8.3	N/A	N/A
Organic Matter	%	8.24	3.23	7.51	3.20	2.03	3.01	4.68	2.46	N/A	N/A
Hexavalent Chromium (Cr)	mg/kg	4.45	<0.10	3.40	1.56	0.81	<0.10	0.36	<0.10	100	380
Arsenic (As)	mg/kg	9.39	9.76	6.69	7.78	6.00	6.67	7.35	7.00	29	55
Cadmium (Cd)	mg/kg	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.8	12
Lead (Pb)	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	85	530
Mercury (Hg)	mg/kg	0.096	0.074	0.088	0.068	0.110	0.054	0.043	0.074	3	10

Source of soil target values: *Dutch Target and Intervention Values, 2000 (the new Dutch list)*

The regular inspection and maintenance of vehicles and machineries is a mitigating measure that GLEDC will implement and this will be done in a designated and cemented area. Use of oil sumps in engine rooms and vehicle equipment maintenance areas will be employed to allow oil and grease in oily wastewater to settle before the wastewater is discharged to the drains. Oil sludge will be collected and stored in oil sludge tanks that are lined with impermeable materials. Disposal will be through a DENR accredited hazardous waste transporter and treater.

During operation, changes in soil quality can be caused by oil spills and leaks from equipment, machinery and vehicles. Coal ash can also affect soil quality within the immediate vicinity of the ash pond.

A designated and cemented area for vehicle maintenance and repair will be established for the operation phase. The area will be equipped with oil absorbing materials and receptacles for oil contaminated waste and will have proper drainage channels to carry runwater to a settling pond prior to discharge.

The ash pond will be lined with clay and HDPE to prevent leachate from contaminating soil.

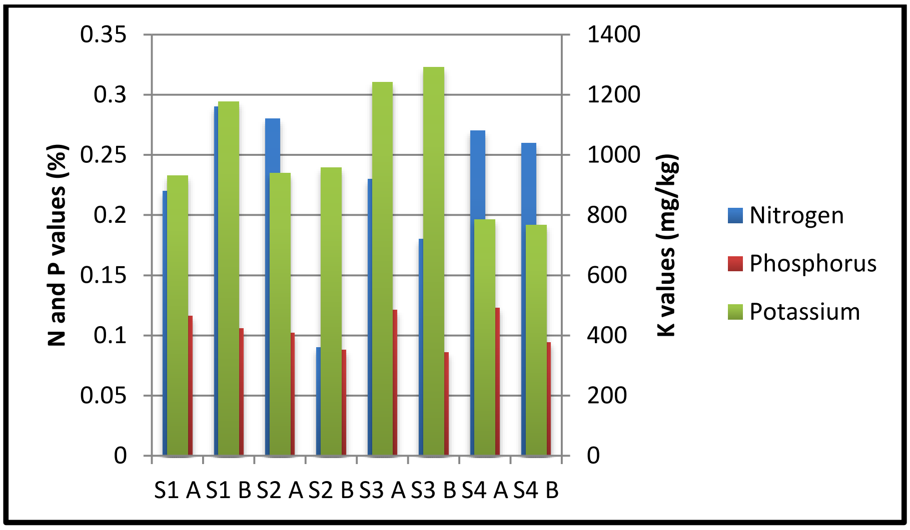


Figure EL-15. Values of organic parameters in soil samples from the project site and vicinity.

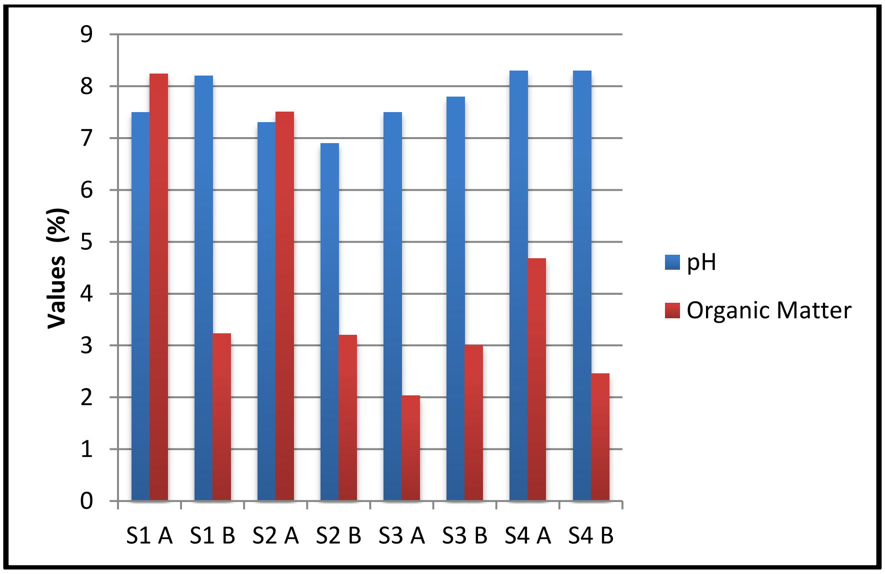


Figure EL-16. Values of pH and organic matter in soil samples from the project site and vicinity.

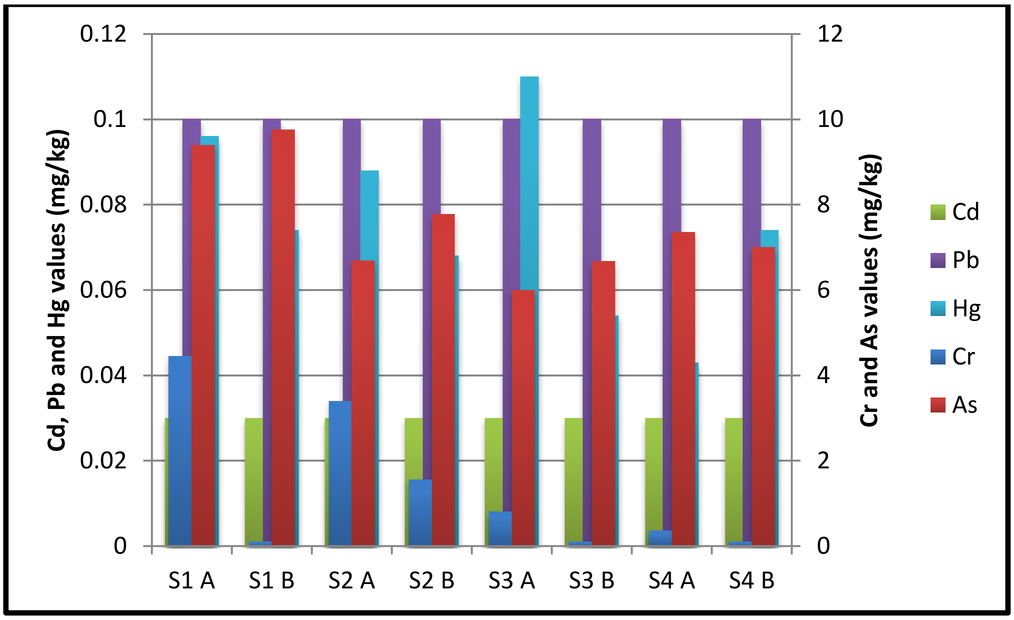


Figure EL-17. Heavy metal values in soil samples from the project site and vicinity.

1.3.4 Summary of Potential Impacts and Mitigation Measures for Pedology

Table EL-7
Summary of Impacts Related to Pedology

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
I. Construction Phase			
Soil erosion and loss of topsoil	Soil types	Soil erosion and loss of topsoil/overburden will occur during project development, especially during land clearing and excavation for building foundation.	• Excavation and land clearing will thus be limited to what is required for project construction. • Stockpiles of excavated soils will be stabilized to minimize occurrence of erosion, particularly during the rainy season. • Levees, and siltation ponds or silt traps will be installed.
Degradation of riverbank stability	Soil types	There are no major rivers traversing the project site, thus riverbank stability will not be a concern during project development. The creek bank is stable.	• Culverts will be installed to ensure unimpeded flow of water during rain events.
Degradation in soil quality/fertility	Soil quality	Change in soil quality/fertility due to oil leaks/spills of construction equipment and machinery and from the vehicles used in the site can occur during construction.	• Regular inspection and maintenance of vehicles. • Use of oil sumps in engine rooms and vehicle equipment maintenance areas will be employed. Oil sludge will be collected and stored in oil sludge tanks that are lined with impermeable materials. Disposal will be through a DENR accredited hazardous waste transporter and treater.

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
II. Operation Phase			
Degradation in soil quality/fertility	Soil quality	Changes in soil quality can be caused by oil spills and leaks from equipment, machinery and vehicles. Coal ash can also affect soil quality within the immediate vicinity of the ash pond.	• A designated and cemented area for vehicle maintenance and repair will be established. The area will be equipped with oil absorbing materials and receptacles for oil contaminated waste and will have proper drainage channels to carry runwater to a settling pond prior to discharge. • The ash pond will be lined with clay and HDPE to prevent leachate from contaminating soil.

1.3.5 Monitoring Plan for Pedology

Annual monitoring during the construction and operation phases of the power plant is recommended for the following soil quality parameters: nitrogen, phosphorus, potassium, arsenic, mercury, chromium, and cadmium. The soil samples should be collected in areas adjacent to the power plant facilities. Soil samples should be collected from the surface and at 0.5m to 1m depth. Annual sampling is recommended for organic and heavy metal parameters. Annual sampling for total petroleum hydrocarbon in soil samples near the diesel tank is recommended for the first five years of operation and this can be discontinued if results show that values of DRO and ORO remain low and within the Canadian soil quality guideline values.

The summary of recommended monitoring plan for soil quality is provided in **Table EL-8** while the recommended location of monitoring stations is shown in **Figure EL-18**.

Table EL-8
Summary of Recommended Monitoring Plan for Soil Quality

Parameters	Sampling Stations	Method	Frequency
Arsenic Mercury Chromium Cadmium Lead	• Northwest (S1) and Southwest (S2) of uncrushed covered coal stockpile; • S1 location of construction laydown area • North (S2) and northwest (S6) of ash pond; • Near sedimentation basin (S5) • S3 location of construction laydown area • S4 down gradient of ashpond	Collection of soil samples from surface and at 0.5m to 1m depth Analysis of soil samples by an accredited DENR laboratory	Once a year during construction an operation phases of power plant
Total petroleum hydrocarbon (DRO and ORO)	• Adjacent to diesel tank and oil tank (S6)	Collection of soil samples from surface and at 0.5m to 1m depth	Once a year during construction and operation phases of power

In the absence of Philippine soil quality guideline, the Dutch Target and Intervention Values (2000) guidelines were used for the monitoring plan for soil quality.

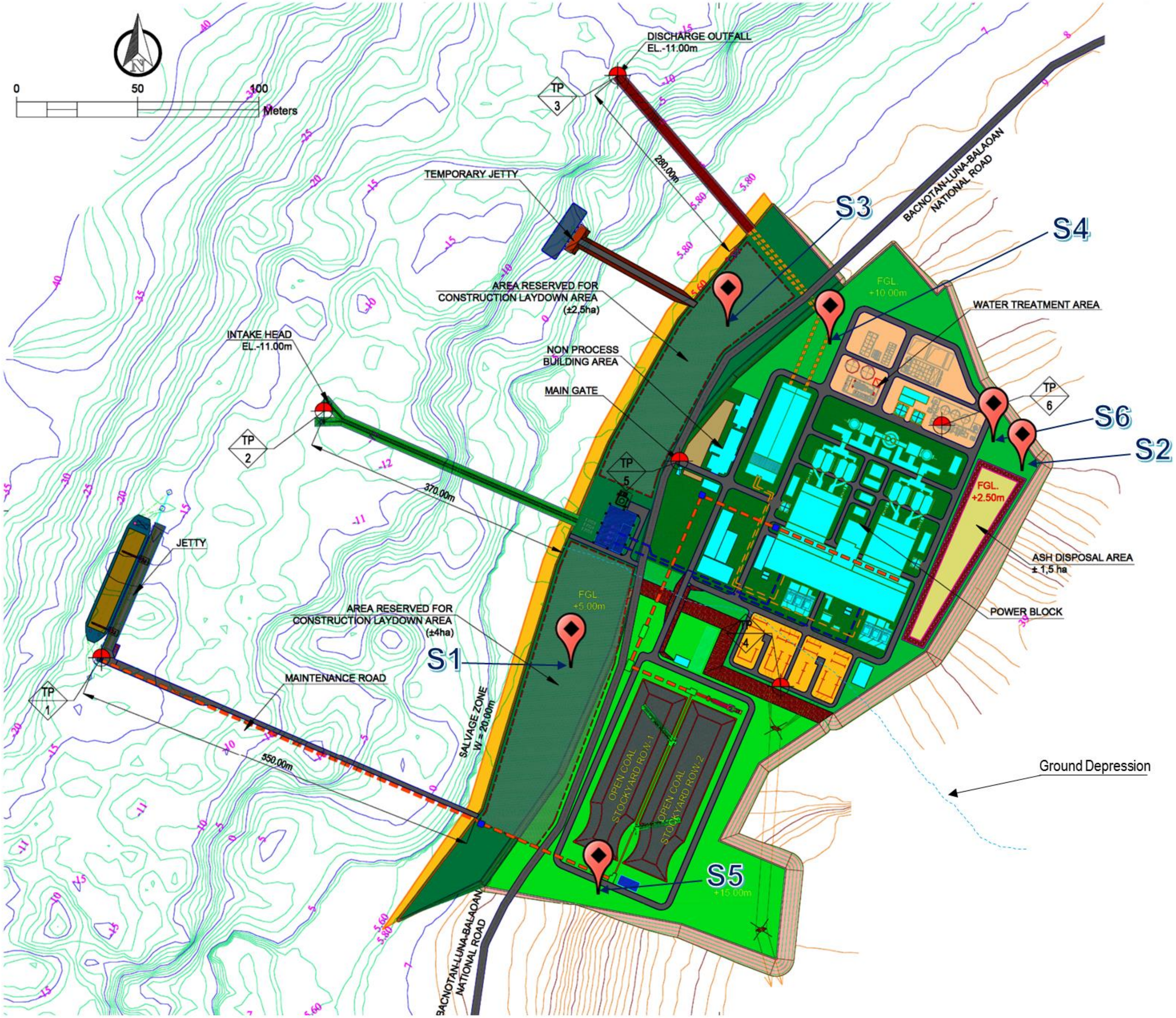


Figure EL-18 Recommended Soil Quality Monitoring Stations	**LEGEND:** Recommended Sampling Points	**SCALE:** As Above	**PAGE:** 93
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT		**DATA INFORMATION/SOURCE:** **Project Boundary**: GLEDC 2017 **Created by:** Aperçu_AConjares	aperçu CONSULTANTS INC.

1.4 Terrestrial Ecology - Flora

1.4.1 Methodology

Sampling Stations

The field data collection was done on July 25 to 29, 2016. Purposive quadrat sampling technique was used in the survey. This sampling technique was chosen with the intention of recording as many plant species as possible. The plots [=quadrats], with a dimension of 10m x 10m each, were laid one by one as new plant species was encountered in its location. The locations of all these plots are shown in **Figure EL-19**. About 135 plots were established in the project site. These exclude the 124 smaller nested plots (2m x 2m) purposely utilized to facilitate listing of understorey plants and weeds. The distribution of plots (big and small) among the habitat types surveyed is provided in **Table EL-9**.

Table EL-9
Distribution of Big and Small Plots among the Vegetation Types Surveyed
Luna, La Union

Habitat/Vegetation Type	Big Plot (100 m^2)	Small Plot (4 m^2)
Beach thicket	7	7
Brushland	94	94
Riparian strip	20	0
Mahogany plantation	12	12
Narra Plantation	2	2
Grassland	0	9
Total	**135**	**124**

Apart from species identification, bio-measurements such as diameter at breast height (DBH in cm), total height (TH in m) and crown cover (CC in %) were noted. For the weeds and undergrowths, only number of individuals and percent crown cover were recorded.

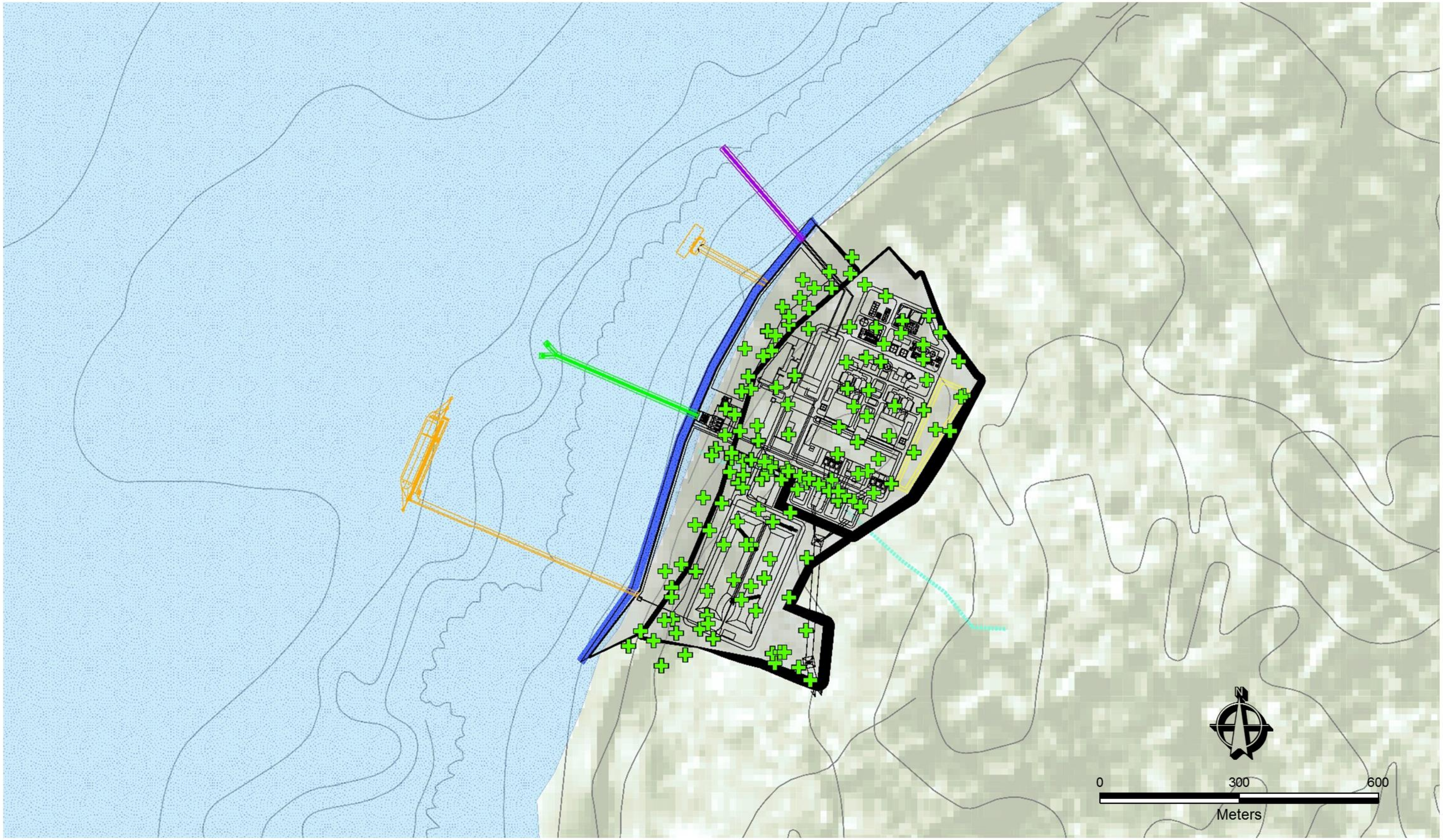


Figure EL-19 Vegetation Sampling Map

ENVIRONMENTAL IMPACT STATEMENT
2x335MW COAL-FIRED POWER PLANT PROJECT

LEGEND:

- Vegetation Plots
- Project Layout
- Ash Pond
- Foreshore Area
- Jetty/ Temporary Jetty
- Cooling Pipe
- Outfall Pipe
- Ground Depression

SCALE: 1:8,000

DATA INFORMATION/SOURCE:
Basemap and Boundary: NAMRIA Topographic Bangar Sheet 3034-I
Project Boundary: GLEDC 2016
Created by: Aperçu_AConjares

Computation of Importance Value

Species dominance in each vegetation type was determined either by computing the species importance value (IV) of canopy plants such as trees and shrubs or by estimating the crown cover of each species with respect to plot size for grasses and understorey vegetation. Importance value is the sum of the relative frequency, relative density and relative dominance.

The formulas to derive the IV (based on Brower, 1989 as cited by Fernando *et al*., 1998) are provided below:

$$Density = total\ number\ of\ individuals\ of\ a\ species$$

$$Relative\ Density = \frac{Density\ of\ a\ species}{Total\ densities\ of\ all\ species}\ x\ 100$$

$$Dominance = \frac{Crown\ area\ of\ a\ species}{Total\ area\ sampled}$$

$$Relative\ Dominance = \frac{Dominance\ of\ a\ species}{Total\ dominances\ of\ all\ species}\ x\ 100$$

$$Occurence = \frac{Number\ of\ times\ a\ species\ is\ encountered}{Total\ number\ of\ plots\ established}\ x\ 100$$

$$Frequency = \frac{Number\ of\ occurrences}{Total\ number\ of occurrences}\ x\ 100$$

$$Relative\ Frequency = \frac{Frequency\ of\ a\ species}{Total\ of\ frequencies}\ x\ 100$$

$$Importance\ Value\ (IV) = Relative\ Density + Relative\ Dominance + Relative\ Frequency$$

Computation of Diversity Indices

On the other hand, diversity indices were also determined using the richness and dominance computation following the equations of Magurran (1988) and Brower (1989) as cited by Fernando *et al*. (1998). Species richness is measured by the Shannon diversity index (H') which assumes that individuals are randomly sampled from an indefinitely large population. It equally considers that all species are represented in the sample. Evenness (E), which is a measure of dominance, is the ratio of observed diversity to maximum diversity. Both were assessed using the following formula:

$$Species\ Diversity\ (H') = -\sum pi(\log pi)$$

where: $pi = \frac{IV\ of\ a\ species}{Total\ IVs\ of\ all\ species} = \frac{cumulative\ crown\ cover\ of\ a\ species}{Total\ cumulative\ crown\ covers\ of\ all\ species}$

$$Evenness\ Index\ (E) = H' / \mathrm{LN}(s)$$

where: $s = number\ of\ species$

The species diversity index (**Table EL-10**) is the ratio between the number of species or importance values that may be expressed as the number of individuals, biomass productivity and the like (Odum, 1971). A high index value usually means a large number of rare species – "rare" in the sense that, it is represented by a low number of individuals as opposed to high counts for a few common species. The index of dominance, on the other hand, expresses the degree to which the dominance is concentrated in one, several, or many species (Odum, 1971).

Table EL-10
Ordinal Classification of Species Richness and Evenness Indices
(adopted from Fernando *et al.*, 1998)

Relative Value Rating	Species Diversity (H')	Evenness (E)
Very High	3.50 – 5.00	0.75 – 1.00
High	3.00 – 3.49	0.50 – 0.74
Moderate	2.50 – 2.99	0.25 – 0.49
Low	2.00 – 2.49	0.15 – 0.24
Very Low	0.00 – 1.99	0.05 – 0.14

Determination of Threatened Status

The global threatened status of each species was determined from the IUCN Red List of Threatened Species 2016 using the link "http://www.iucnredlist.org/search" and from DAO 2007-01 for the Philippine threatened status.

Impact Assessment and Mitigation Measures for Terrestrial Flora

An assessment of potential impacts that could arise due to the construction and operation of the project on terrestrial flora was conducted based off the baseline data gathered. Based on the outcome of these assessments, measures to manage and mitigate potential adverse impacts are recommended.

1.4.2 Regional Land Use and Vegetation Cover

No specific record, as of this date, has been written to describe the regional land use and vegetation cover of Luna. However, based on the published book of Fernando et al. (2008) and the relative location of the project site, it can be inferred that the facade of the site facing the West Philippine Sea was once a lush beach forest extending about 50-100 meters from the coastline and the inner portion of the project site was an evergreen tropical forest. The muddy substrates near the project site were once before covered with thick mangrove forest. Human interventions (i.e. agricultural and built-up conversion; resource exploitation and land use change) have changed the pristine vegetation cover to its current state.

1.4.3 Existing Habitat Types within Study Area

Site Characteristics

The whole project site is composed of several vegetation types (**Figure EL-20**), though a big portion of the whole area is dominated by brushlands. The beach thicket of shrubs and small trees bound the western part of the proposed project site facing the West Philippine Sea. On both sides of the main road a stretch of mahogany plantation is situated. A stand of mahogany is also found in the northern part of the project site. Narra plantation, composed of more than 50 trees, is also seen next to the mahogany plantation on the right side of the main road. A riparian strip along a ground depression is located in the middle portion of the project site bisecting the main road. Lastly, grasslands occupy the open gaps and the areas around the abandoned poultry facility and the old pasture land. According to the hired field guides, almost half of the whole area was utilized as pasture land by the previous owner years ago.

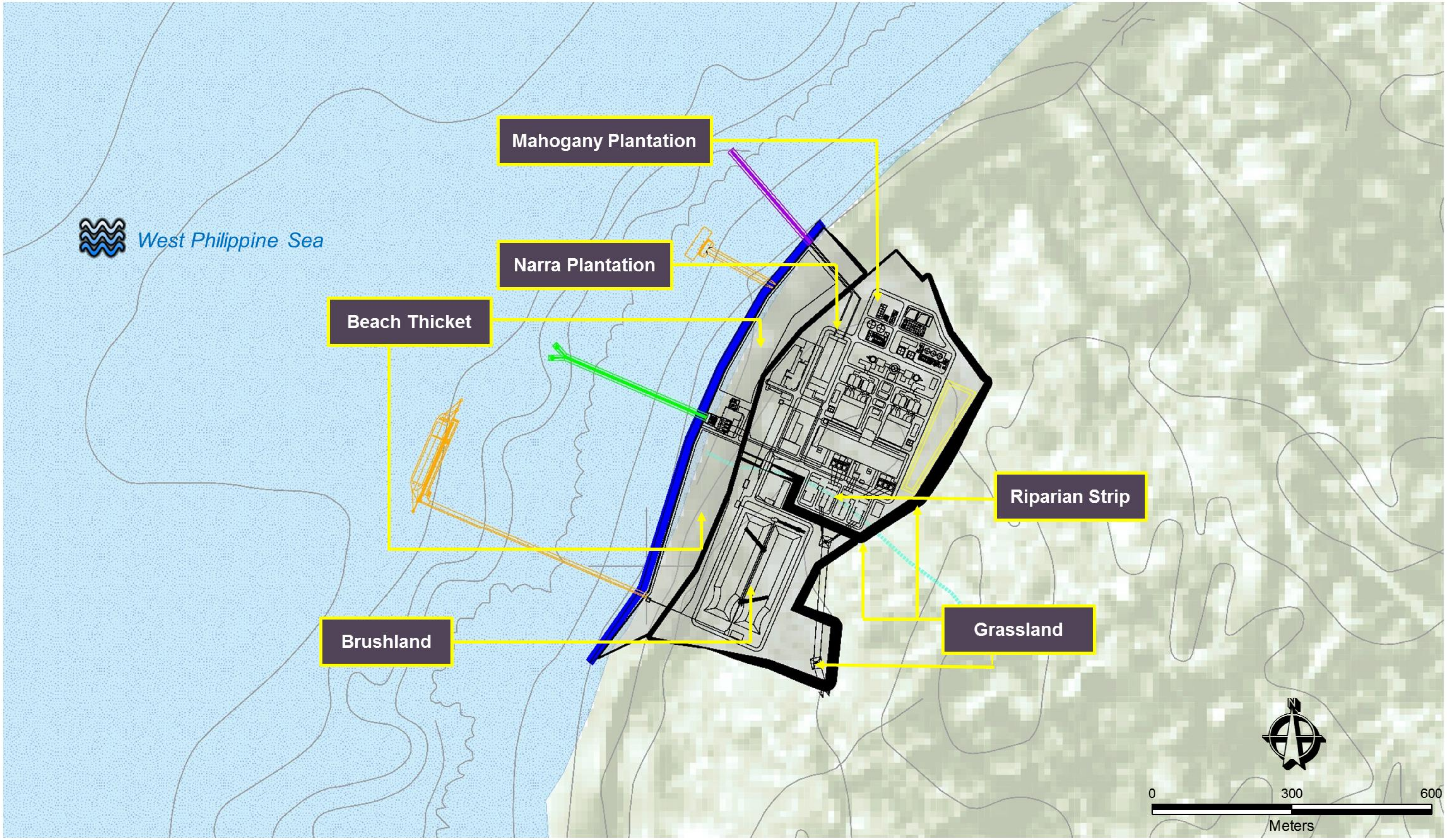


Figure EL-20 Vegetation Types in the Project Site	LEGEND:	SCALE: 1:8,000	PAGE: 98
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	Project Layout, Ash Pond, Foreshore Area, Jetty/ Temporary Jetty, Cooling Pipe, Outfall Pipe, Ground Depression	DATA INFORMATION/SOURCE: **Basemap and Boundary:** NAMRIA Topographic Bangar Sheet 3034-I **Project Boundary:** GLEDC 2016 **Created by:** Aperçu_AConjares	aperçu CONSULTANTS INC.

A total of 119 plants were identified in the proposed project site. These belong to 113 genera under 49 families. Trees and shrubs were abundant in the site among all other plant types in terms of number of species **(Table EL-11).** The most represented families were Fabaceae (legumes) and Euphorbiaceae (euphorbs) with 15 and 13 genera, and 14 and 13 species, respectively (**Table EL-12**).

Table EL-11
Number of Species based on Plant Type

Plant Type	Species
Fern	1
Herb	22
Shrub	30
Straggling fig	1
Tree	54
Vine	12
Total	**119**

Table EL-12
Family with the Most Number of Genera and Species

Family	Genera	Species
Fabaceae	14	15
Euphorbiaceae	13	13
Poaceae	6	6
Lamiaceae	3	5

Note: Only families with $\geq$ 5 representative species are included in the table

Land clearing in the proposed project area will result to permanent loss of local species including Bolong eta, Isis, Mahogany, Molave, and Narra, which are threatened, endangered, and vulnerable species. This will decrease the abundance of the local population.

Cutting of trees was one of the concerns raised by the host community during the scoping activities. To address this concern and mitigate the impact, a complete inventory of trees that will be affected by the project will be conducted by the proponent. Thereafter, the proponent will apply for and secure a tree-cutting permit from the local, regional and national DENR offices. Based on the inventory of trees, the proponent, in coordination with the DENR, will initiate seedling replacement strategies. It is expected that the threatened plants [listed in Table EL-20] which will be affected during the construction phase will be the focus of the tree replacement program.

Collection of seeds and wildlings of indigenous plants will be done. Nurseries will be established where the seedlings of the identified endangered and vulnerable species within the site will be nurtured and will be used for the replacement program. A vegetated buffer area will be established around the project site. GLDEC will look for another site where a greening program will be implemented, in close coordination with the LGU and the local PENRO/CENRO offices.

1.4.4 Project Site Species Composition

Beach Thickets

Based on the seven (7) big plots established in the beach stretch of the project site, around nine (9) species of shrubs and trees were identified. The most common was talisai (*Terminalia cattappa*) with an importance value of 77.51%. This was followed, in decreasing order, by ipil-ipil (*Leucaena leucocephala*), kakauate (*Gliricidia sepium*), and aroma (*Acacia farnesiana*) with computed importance values of 69.27%, 48.53% and 43.44%, respectively. Other species with less than 40% importance values were binunga, alim, kamachile and mala-molave. Among the listed species in **Table EL-13**, talisai, aroma, bangkoro and kamachile were found naturally growing in the beach area. These were all written in the list of beach forest plants of Fernando et al. (2008). Other species in the list were observed distributed all throughout the project site, these being sun-loving plants.

Table EL-13
Species of Trees and Shrubs in the Beach Thickets of Luna, La Union

Species	Scientific Name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Talisai	*Terminalia cattapa*	29.82	27.27	20.41	77.51
Ipil-ipil	*Leucaena leucocephala*	24.56	18.18	26.53	69.27
Kakauate	*Gliricidia sepium*	17.54	13.64	17.35	48.53
Aroma	*Acacia farnesia*	14.04	18.18	11.22	43.44
Bangkoro	*Morinda citrifolia*	7.02	4.55	16.33	27.89
Binunga	*Macaranga tanarius*	1.75	4.55	3.06	9.36
Alim	*Melanolepis multigladulosa*	1.75	4.55	2.04	8.34
Kamachile	*Pithecelobium dulce*	1.75	4.55	2.04	8.34
Mala-molave	Local name only	1.75	4.55	1.02	7.32
Total		**100.00**	**100.00**	**100.00**	**300.00**

The stocky[1] vegetation along the beach stretch, generally, serves as barriers to strong wind currents especially during typhoon events. The beach plants, aroma talisai, bangkoro and kamachile, in particular were all resistant to salt sprays, protecting other plants in the landward side from drying up. They also served as habitat for wildlife.

As observed, the limited number of plant species in the beach front was brought by the combined disturbance of typhoons occasionally visiting the area and the frequent strong wind velocity and exposure to salt sprays, apart from the impact of heavy human pressure (e.g. firewood collection). Edaphic factors (i.e. soil physical and chemical characteristics) had little contributions in the present species composition in the area.

The most common plant in the understorey of the beach vegetation was pandakaki (*Tabernaemontana pandacaqui*) with a computed cumulative crown cover of 115, amounting to 24.06% of the total crown cover (**Table EL-14**). Pandakaki is a shrub with wide ecological amplitude. It grows commonly in the open and may also survive under the shade of big trees (Fernando *et al*., 2004). Its fruits are eaten by frugivorous birds and that ecological role perhaps is the reason for its wide dispersal over the project site. It was found fruiting during the field survey. Hagonoi (*Chromolaena odorata*) and coronitas (*Lantana camara*) followed with cumulative crown cover values of 91 and 80, respectively. These values fell within the total crown cover percentage range of 15-20%. Both species are naturalized in the country and are now widespread and very common (Reyes, 2006; Fernando *et al*., 2004; Fernando et al., 1998; Quimio, 1996).

Other vegetation, with crown cover percentages below 10%, were aroma, uoko, ipil-ipil, *Zizyphus* and others.

Beach vegetation will be cleared during the construction phase, when the coastal structures such as the jetty, which will accommodate delivery of equipment and material by the sea, are going to be built. None of the species found on the beach, however, are considered threatened or vulnerable and therefore for this section, removal of vegetation will not affect any important species.

[1] The term *stocky vegetation* is commonly used in forest ecology which means thickset, sturdy, solid, stout, chunky, and the like.

Table EL-14
Understorey Species in the Beach Thickets of Luna

Species	Scientific Name	Cumulative Crown Cover	Percentage
Pandakaki	*Tabernaemontana pandacaqui*	115	24.06
Hagonoi	*Chromolaena odorata*	91	19.04
Coronitas	*Lantana camara*	80	16.74
Aroma	*Acacia farnesiana*	45	9.41
Uoko	*Mikania cordata*	41	8.58
Ipil-ipil	*Leucaena leucocephala*	30	6.28
Zizyphus	*Zizyphus* sp.	30	6.28
Palis	*Callicarpa erioclana*	15	3.14
Dilang butiki	*Centrosema pubescens*	11	2.30
Tridax	*Tridax procumbens*	10	2.09
Balloon vine	*Cardiospermum halicacabum*	5	1.05
Kamariang gubat	*Selaginella cuppresina*	5	1.05
Total		**478**	**100.00**

Brushlands

The habitat type or vegetation formation with the most number of species was the brushland. A total of 58 species of trees and shrubs were identified in 94 big plots established (**Table EL-15**). Ipil-ipil (*Leucaena leucocephala*) had the highest importance value of 42.78%, which is a naturalized fast-growing tree species that is very widespread in the country (Fernando *et al*., 1998). It was introduced in the Philippines as a reforestation species in the 70s or perhaps earlier. It can grow in almost all types of soil and may resist drought for almost a year (Reyes, 2006; Quimio, 1996). In other parts of the country, its seeds are broadcasted in idle farms to restore the nutrients in the soil (Reyes, 2006). Ipil-ipil, together with kakauate (*Gliricidia sepium*), according to the CLUP of Luna, La Union (2014), is the most common species in the municipality. Other common tree and shrub species in the brushland included: *Guioa* sp., raintree (*Samanea saman*), mala-apanang, matang hipon (*Breynia rhamnoides*), kalios (*Streblus asper*), achuete (*Bixa orellana*), Philippine gmelina (*Gmelina philippinensis*) and others.

Brushlands are among the ecosystems with a vast number of plant species. It is the mid-stage in the forest succession process when and where most of the sun-loving tree species preponderate (Reyes, 2006). In the project site, anthropogenic, in addition to edaphic and climatic factors, have contributed much in the predominance of pioneer species. Among these pioneers are: *Guioa* sp., mala-apanang, matang hipon (*Breynia rhamnoides*), kalios (*Streblus asper*), kakauate (*Gliricidia sepium*), Philippine gmelina (*Gmelina philippinensis*), himbabao (*Brousonnetia luzonica*), alim (*Melanolepis multiglandulosa*), alahan (*Guioa koelreuteria*), tubang bakod (*Jatropha curcas*), malubago (*Hibiscus tiliaceus*), pandakaki (*Tabernaemontana pandacaqui*), dita (*Alstonia scholaris*), governor's plum (*Flacourtia* sp.), magilik, ligas (*Semecarpus cuneiformis*), sablot (*Litsea sebifera*), isis (*Ficus nota*), binunga (*Macaranga tanarius*), nino (*Morinda bracteata*), balinghasai (*Buchanania arborescens*), and katagpo (*Psychotria* sp.).

The site was once utilized as pasture land for raising cattle and other ruminants (CLUP of Luna, La Union, 2014). Low stature vegetation dominated by grasses was the main crops in the past. In addition, frequent cutting of trees may have limited the growth of large vegetation. The remnants of the original vegetation indicate that the area was once forested (fully vegetated). This is supported by the presence of the trees bolong eta (*Diospyros pilosanthera*), molave (*Vitex parviflora*), kusibeng (*Sapindus saponaria*), kuratan (*Linociera* sp.), and wildlings of magabuyo (*Celtis luzonica*). The first two (2) species (bolong eta and molave) and the last species (magabuyo) are recorded in the "red list" as threatened (vulnerable and/or endangered) species in both IUCN 2016 and DAO 01-2007.

Of the species listed in Table EL-15, three (3) trees are considered vulnerable: Mahogany, Molave and Isis. The relative densities of these trees are very low with all of them having a density of less than one (with the highest density being 22 for Ipil-ipil trees). These vegetation will be removed during the construction

phase to make way for the plant structures. During the operation phase, these vulnerable species will be used for greening and landscaping of the power plant site.

Several fruit and food trees, including achuete, himbabao, atis, kamachile, siniguelas, malunggai, kamias, manga, lemonsito and sampaloc will also be removed during the construction phase. Whenever possible, trees with less than 15cm diameter will be balled and replanted as landscape species during the operation phase.

Two tree species – Dita and Bani – are considered of least concern in the IUCN listing but will also be included as species in the nursery and used for landscaping during the operation phase.

Table EL-15
Species of Trees and Shrubs in the Brushlands of Luna

Species	Scientific Name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Ipil-ipil	*Leucaena leucocephala*	22.34	16.79	20.18	59.31
Guioa	*Guioa* sp.	16.83	10.94	11.34	39.11
Raintree	*Samanea saman*	4.75	7.38	16.36	28.49
Mala-apanang	Local name only	7.41	5.09	3.63	16.13
Matang hipon	*Breynia rhamnoides*	5.80	3.31	5.05	14.16
Kalios	*Streblus asper*	4.28	5.09	4.55	13.91
Achuete	*Bixa orellana*	3.42	5.60	2.51	11.53
Kakauate	*Gliricidia sepium*	2.57	4.33	3.55	10.44
Philippine gmelina	*Gmelina philippinensis*	3.61	2.04	3.76	9.41
Bolong eta	*Diospyros pilosanthera*	2.00	3.82	3.45	9.26
Himbabao	*Brousonnetia luzonica*	2.38	4.33	1.35	8.05
Alim	*Melanolepis multiglandulosa*	3.61	2.29	2.04	7.94
Bangkoro	*Morinda citrifolia*	2.38	1.78	3.44	7.60
Kamachile	*Pithecelobium dulce*	2.57	2.04	1.36	5.97
Mala-sudiang	*Vaccinium* sp.	1.14	1.27	2.53	4.95
Mala-molave	Locally identified	1.52	1.02	1.51	4.05
Talisai	*Terminalia catappa*	1.14	1.78	0.78	3.71
Suding	*Ixora macrophylla*	1.05	2.04	0.40	3.48
Alahan	*Guioa koelreuteria*	0.86	1.78	0.62	3.25
Tubang bakod	*Jatropa curcas*	1.24	1.27	0.66	3.17
Malubago	*Hibiscus tiliaceus*	0.38	0.76	1.75	2.89
Pandakaki	*Tabernaemontana pandacaqui*	0.38	1.02	1.33	2.73
Dita	*Alstonia scholaris*	0.57	1.27	0.76	2.60
Sua	*Capparis* sp.	1.14	0.76	0.36	2.27
Mahogany	*Swietenia macrophylla*	0.48	0.76	0.90	2.14
Sampalok	*Tamarindus indica*	0.57	1.27	0.24	2.08
Golden shower	*Cassia fistula*	0.38	0.76	0.25	1.40
Molave	*Vitex parviflora*	0.29	0.76	0.24	1.29
Sineguelas	*Spondias purpurea*	0.38	0.51	0.36	1.25
Malunggai	*Moringa oleifera*	0.19	0.51	0.36	1.06
Duhat	*Syzygium cumini*	0.19	0.25	0.60	1.05
Governor's plum	*Flacourtia* sp.	0.29	0.51	0.22	1.01
Magilik	*Helictres umbellata*	0.48	0.25	0.18	0.91
Ligas	*Semecarpus cuneiformis*	0.19	0.51	0.18	0.88
Kawayan tinik	*Bambusa blumeana*	0.38	0.25	0.24	0.88
Sablot	*Litsea sabifera*	0.10	0.25	0.48	0.83
Isis	*Fiscus nota*	0.10	0.25	0.36	0.71
Bani	*Pongamia pinnata*	0.19	0.25	0.24	0.69
Binunga	*Macaranga tanarius*	0.19	0.25	0.24	0.69

Species	Scientific Name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Atis	*Annona squamosa*	0.29	0.25	0.07	0.61
Kusibeng	*Sapindus saponaria*	0.29	0.25	0.05	0.59
Nino	*Morinda bracteata*	0.10	0.25	0.24	0.59
Kamias	*Averrhoa bilimbi*	0.19	0.25	0.12	0.57
Anonas	*Annona reticulata*	0.10	0.25	0.18	0.53
Apanang	*Neotrewia cumingii*	0.10	0.25	0.12	0.47
Kuratan	*Linociera* sp.	0.10	0.25	0.12	0.47
Mangga	*Mangifera indica*	0.10	0.25	0.12	0.47
Balinghasai	*Buchanania arborescens*	0.10	0.25	0.12	0.47
Neem tree	*Azadirachta indica*	0.10	0.25	0.12	0.47
Bignai	*Antidesma bunius*	0.10	0.25	0.10	0.45
Kangko	*Aphanamixis perrottetiana*	0.10	0.25	0.06	0.41
Hagiwis	*Pouteria* sp.	0.10	0.25	0.06	0.41
Malabulak	*Bombax ceiba*	0.10	0.25	0.02	0.37
Lemonsito	*Tryphasia triflora*	0.10	0.25	0.02	0.37
Biriba	*Rollinia deliciosa*	0.10	0.25	0.02	0.37
Katagpo	*Psychotria* sp.	0.10	0.25	0.01	0.36
Subiang vine	*Bridelia stipularis*	0.10	0.25	0.01	0.36
Albutra	*Arcangelisia flava*	0.05	0.20	0.01	0.26
Magabuyo	*Celtis luzonica*	0.05	0.05	0.01	0.11
Total		**100.00**	**100.00**	**100.00**	**300.00**

The understorey vegetation of the brushlands harboured a total of 63 plants (**Table EL-16**). Hagonoi (*Chromolaena odorata*), among all understorey plants, led in terms of cumulative crown cover with a value of 1,324 and an equivalent cover percentage share of 23.52%. Other commonly associated species with more than 400 cumulative crown cover values were: ipil-ipil, coronitas, dilang butiki, and pandakaki. Their crown cover percentage shares ranged from 7 to 13% of the total crown cover. The rest were infrequent as defined by their crown cover percentage shares of less than 5%.

Table EL-16
Understorey Species in the Brushlands of Luna

Species	Scientific Name	Cumulative Crown Cover	Percentage
Hagonoi	*Chromplaena odorata*	1324	23.52
Ipil-ipil	*Leucaena leucocephala*	698	12.40
Coronitas	*Lantana camara*	500	8.88
Dilang butiki	*Centrosema pubescens*	450	7.99
Pandakaki	*Tabernaemontana pandacaqui*	449	7.98
Digitaria	*Digitaria ciliaris*	193	3.43
Guioa	*Guioa* sp.	192	3.41
Saluyot	*Corchorus olitoreus*	178	3.16
Sua	*Capparis* sp.	159	2.82
Baling-aui	*Flagellaria indica*	145	2.58
Pongapong	*Amorphophalus campanulatus*	103	1.83
Kalios	*Streblus asper*	87	1.55
Kamote-kamotehan	*Ipomoea triloba*	87	1.55
Passion fruit	*Passiflora edulis*	85	1.51
Tubang bakod	*Jatropha curcas*	82	1.46
Aroma	*Acacia farnesia*	75	1.33
Gatas-gatasan	*Euphorbia hirta*	64	1.14
Wild ampalaya	*Momordica charantia*	64	1.14
Wild sampaguita	*Jasminium* sp.	62	1.10
Baling-uai	*Flagellaria* sp.	60	1.07
Tikog	*Fimbristylis dichotoma*	60	1.07

Species	Scientific Name	Cumulative Crown Cover	Percentage
Crab's eye plant	*Abrus precarious*	58	1.03
Landrina	*Commelina benghalensis*	45	0.80
Susong dalaga	*Acalypha indica*	40	0.71
Kulitis	*Amaranthus spinosus*	31	0.55
Mala-apanang	*local name only	30	0.53
Uoko	*Mikania cordata*	29	0.52
Maramani	*Alysicarpus vaginalis*	24	0.43
Cactus	*Echinopsis* sp.	20	0.36
Tuhod manok	*Synedrella nodiflora*	20	0.36
Sablot	*Litsea sabifera*	18	0.32
Raintree	*Samanea saman*	17	0.30
Alim	*Melanolepis multiglandulosa*	16	0.28
Alternanthera	*Alternathera sessilis*	15	0.27
Sampa-sampalukan	*Phyllanthus amarus*	15	0.27
Apoy-apoyan	*Cleome rutidosperma*	10	0.18
Biriba	*Rollinia deliciosa*	10	0.18
Croton	*Croton* sp.	10	0.18
Matang hipon	*Breynia rhamnoides*	10	0.18
Albutra	*Arcangelisia flava*	7	0.12
Walis-walisan	*Sida acuta*	7	0.12
Atis	*Annona squamosa*	6	0.11
Makahiyang lalake	*Mimosa invisa*	6	0.11
Palis	*Callicarpa erioclana*	6	0.11
Paragis	*Eleusine indica*	6	0.11
Gooseberry plant	*Physalis angulata*	5	0.09
Krus-krosan	*Dactylactenium aegyptium*	5	0.09
Lemonsito	*Triphasia trifolia*	5	0.09
Magilik	*Helictres umbellata*	5	0.09
Neem tree	*Azadirachta indica*	5	0.09
Oplismenus	*Oplismenus compositus*	5	0.09
Tubli	*Derris philippinensis*	5	0.09
Castor oil bean	*Ricinus communis*	3	0.05
Danglin	*Grewia multiflora*	3	0.05
Dioscorea	*Dioscorea* sp.	3	0.05
Binunga	*Macaranga tanarius*	2	0.04
Hauili	*Ficus septica*	2	0.04
Himbabao	*Brousonnetia luzonica*	2	0.04
Siling labuyo	*Capsicum frutescens*	2	0.04
Banato	*Mallotus philippinensis*	1	0.02
Lagundi	*Vitex negundo*	1	0.02
Albutra	*Arcangelisia flava*	1	0.02
Talisay	*Terminalia cattapa*	1	0.02
Total		**5629**	**100.00**

The construction activities will require the clearance of land to give way to the plant facilities. This will result in the loss of vegetation from direct impact areas. The removal of vegetation in the proposed project area will result to permanent loss of brushland, shrubs and small trees, Mahogany and Narra plantations, and grassland vegetation.

Removal of the understorey in the brushland area will not involve any vulnerable or threatened species but involves species used as food and considered medicinal. These can easily be planted in the nursery during the construction phase and replanted in the plant site and vicinity during the operation phase. These species are highlighted in yellow in the table above.

Riparian Strip

The riparian strip is formed along the ground depression situated almost at the middle of the project site. During the survey, there was no water flowing on the creek. According to the hired field guides, this was intentionally widened to drain out flood water during heavy and extended rains in the rainy season. No unique species was noted in the riparian ecosystem of the site (even if 20 big plots had been laid strategically for the inventory). This could be due to the seasonal disturbances experienced annually. No small plots were established to survey the understorey vegetation since there were no plants to be noted in the understorey layer.

All of the 24 species of plants along the riparian strip were found present in the brushlands (**Table EL-17**). Likewise, ipil-ipil, *Guioa*, raintree, sablot and matang hipon dominated this type of vegetation. Ipil-ipil stood out to be the most common species with an importance value of 99.32%.

Table EL-17
Species of Trees and Shrubs in the Riparian Strip of Luna

Species	Scientific Name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Ipil-ipil	*Leucaena leucocephala*	38.83	25.00	35.49	99.32
Guioa	*Guioa* sp.	14.89	10.53	8.54	33.96
Raintree	*Samanea saman*	4.79	7.89	20.54	33.22
Sablot	*Litsea sabifera*	8.51	7.89	6.16	22.57
Matang hipon	*Breynia rhamnoides*	7.45	7.89	4.43	19.77
Himbabao	*Brousonnetia luzonica*	3.19	6.58	4.81	14.58
Alim	*Melanolepis multiglandulosa*	2.66	3.95	2.89	9.50
Ligas	*Semecarpus cuneiformis*	3.19	3.95	1.99	9.13
Talisai	*Terminalia cattapa*	2.66	3.95	2.25	8.85
Mala-sudiang	*Vaccinium* sp.	3.19	1.32	1.54	6.05
Kalios	*Streblus asper*	1.06	2.63	1.28	4.98
Takipan	*Caryota rumphiana* var. *philippinensis*	1.06	2.63	0.83	4.53
Pandakaki	*Tabernaemontana pandacaqui*	0.53	1.32	2.25	4.09
Kakauate	*Gliricidia sepium*	2.13	1.32	0.51	3.96
Alahan	*Guioa koelreuteria*	1.06	1.32	1.28	3.66
Tubang bakod	*Jatropha curcas*	0.53	1.32	1.60	3.45
Igyo	*Dysoxylum gaudichaudianum*	0.53	1.32	0.64	2.49
Bikal	*Dinochloa acutiflora*	0.53	1.32	0.64	2.49
Atis	*Annona squamosa*	0.53	1.32	0.64	2.49
Dita	*Alstonia scholaris*	0.53	1.32	0.64	2.49
Isis	*Fiscus nota*	0.53	1.32	0.32	2.17
Magilik	*Helictres umbellata*	0.53	1.32	0.32	2.17
Wild sampaguita	*Jasminium* sp.	0.53	1.32	0.32	2.17
Mala-apanang	Local name only	0.53	1.32	0.06	1.91
Total		**100.00**	**100.00**	**100.00**	**300.00**

Of the above listed species of trees and shrubs in the riparian strip of Luna, one is identified as of Least Concern (Dita) and one is vulnerable (Is-is), based on IUCN 2016. These will also be cleared during construction activities. This will result in the loss of important vegetation species. To mitigate this, seedlings of these 2 species will be part of the nursery species and will be used for the buffer zone and for landscaping during the operation phase.

The easements of the ground depression will be protected using engineering and/or vegetative structures.

Mahogany Plantations

Mahogany plantations are purposely established to provide timber and lumber. Plantations aid in carbon storage during the period of production. In addition, they also prevent surface runoff, encourage water table recharge, and serve as habitat for wildlife.

There were 18 species of trees identified in the mahogany stands of Luna. Kakauate (*Gliricidia sepium*) and raintree (*Samanea saman*) were the most common associates of mahogany (*Swietenia macrophylla*) with importance values of 29.71% and 15.35%, respectively. Fruit trees such as anonas (*Annona* sp.) and atis (*Annona squamosa*) were also found planted within the mahogany stands. The rest of the species in **Table EL-18** had importance values less than 15%.

Table EL-18
Species of Trees and Shrubs in Mahogany Plantations of Luna

Species	Scientific Name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Mahogany	*Swietenia macrophylla*	71.67	29.27	68.72	169.65
Kakauate	*Gliricidia sepium*	3.33	12.20	14.18	29.71
Raintree	*Samanea saman*	3.33	7.32	4.70	15.35
Ipil-ipil	*Leucaena leucocephala*	5.00	7.32	2.43	14.75
Anonas	*Annona* sp.	3.89	7.32	2.59	13.80
Talisai	*Terminalia cattapa*	1.67	7.32	2.03	11.01
Alim	*Melanolepis multiglandulosa*	1.67	2.44	1.22	5.32
Bolong eta	*Diospyros pilosanthera*	2.22	2.44	0.32	4.99
Himbabao	*Brousonnetia luzonica*	1.67	2.44	0.32	4.43
Narra	*Pterocarpus indicus*	1.11	2.44	0.81	4.36
Pandakaki	*Tabernaemontana pandacaqui*	0.56	2.44	0.81	3.80
Kalios	*Streblus asper*	0.56	2.44	0.41	3.40
Guioa	*Guioa* sp.	0.56	2.44	0.41	3.40
Mala-apanang	Local name only	0.56	2.44	0.41	3.40
Phaenthus	*Phaenthus* sp.	0.56	2.44	0.24	3.24
Binunga	*Macaranga tanarius*	0.56	2.44	0.16	3.16
Sablot	*Litsea sebifera*	0.56	2.44	0.16	3.16
Atis	*Annona squamosa*	0.56	2.44	0.08	3.08
Total		**100.00**	**100.00**	**100.00**	**300.00**

Together with mahogany, bolong eta (*Diospyros pilosanthera*) and narra (*Pterocarpus indicus*) were among the threatened (vulnerable and critically endangered based on IUCN 2016) species. Both narra and mahogany, though included in the red list, are very common in the project site. Further, these trees were also observed planted in tree farms along the roadsides of Luna. According to Fernando *et al*. (1998) and Quimio (1996), these were the common reforestation species in the country, which thrive in almost all types of soil. These species will thus be used in the for the replacement and greening programs.

The understorey plants of the mahogany plantation were composed of 25 species. Hagonoi (*Chromolaena odorata*) was the dominant species, seconded by pandakaki, matang hipon, and dilang butiki, with more than 50% cumulative crown cover values. Each of the remaining associated species had less than 50% cumulative crown cover value (**Table EL-19**).

Narra Plantation

There were about 33 narra trees in the two (2) big plots within the established plantation. The plantation seemed to be well-maintained, thus no other species were noted in the tree and shrub layer. However, around 8 plants were recorded in its understorey with hagonoi as the most dominant species. Other associated plants such as dilang butiki, sua, pandakaki, kalios, matang hipon, coronitas and saluyot were listed as associates (**Table EL-20**).

Table EL-19
Understorey Species in Mahogany Plantations of Luna

Species	Scientific Name	Cumulative Crown Cover	Percentage
Hagonoi	*Chromolaena odorata*	135	22.46
Pandakaki	*Tabernaemontana pandacaqui*	64	10.65
Matang hipon	*Breynia rhamnoides*	63	10.48
Dilang butiki	*Centrosema pubescens*	58	9.65
Pongapong	*Amorphophalus campanulatus*	40	6.66
Aroma	*Acacia farnesiana*	30	4.99
Talisay	*Terminalia cattapa*	30	4.99
Uoko	*Mikania cordata*	30	4.99
Ipil-ipil	*Leucaena leucocephala*	26	4.33
Coronitas	*Lantana camara*	25	4.16
Raintree	*Samanea saman*	22	3.66
Mala-apanang	Local name only	15	2.50
Guioa	*Guioa* sp.	10	1.66
Wild bougainvilla	*Bougainvillea spectabilis*	10	1.66
Alim	*Melanolepis multiglandulosa*	7	1.16
Binunga	*Macaranga tanarius*	5	0.83
Kamote-kamotehan	*Ipomoea triloba*	5	0.83
Magilik	*Helictres umbellate*	5	0.83
Matang araw	*Melicope triphylla*	5	0.83
Zizyphus	*Zizyphus* sp.	5	0.83
Passion fruit	*Passiflora edulis*	3	0.50
Sua	*Capparis* sp.	3	0.50
Kalios	*Streblus asper*	2	0.33
Saluyot	*Corchorus olitoreus*	2	0.33
Kulot-kulotan	*Triumfeta triloba*	1	0.17
Total		**601**	**100.00**

Table EL-20
Understorey Species in Narra Plantation of Luna

Species	Scientific Name	Cumulative Crown Cover	Percentage
Hagonoi	*Chromolaena odorata*	20	31.25
Dilang butiki	*Centrosema pubescens*	10	15.63
Sua	*Capparis* sp.	10	15.63
Pandakaki	*Tabernaenamontana pandacaqui*	9	14.06
Kalios	*Streblus asper*	5	7.81
Matang hipon	*Breynia rhamnoides*	5	7.81
Coronitas	*Lantana camara*	3	4.69
Saluyot	*Corchorus olitoreus*	2	3.13
Total		**64**	**100.00**

Narra is identified as a vulnerable species under the IUCN Threatened Status (2016), and critically endangered under the Philippine Threatened Status (DAO 07-01). Existing Narra plantations will be included in the removal of vegetation during project construction. Given the current conservation status of the species, an additional Special Cutting Permit will need to be secured by the proponent as mandated by the DENR. Narra seedlings will comprise the nursery that will be set up during the construction phase and these will be planted in the buffer zone area during the operation phase.

Grassland

Grasslands are home to enormous number of insects and other grazing animals. A big portion of the project site was once utilized for pasture.

From the 9 plots established in the grasslands, 26 broadleaves, grasses and sedges were recorded (**Table EL-21**). Hagonoi, similar to other vegetation types, stood out in terms of computed cumulative crown cover. Its value was 145 which are 18.19% of the total crown cover percentage. Kulitis and *Alternanthera sessilis* were also common with cumulative crown cover values and crown cover percentage shares of 85 and 82, and 10.66% and 10.29%, respectively.

Table EL-21
Weed Species in Grasslands of Luna

Species	Scientific Name	Cumulative Crown Cover	Percentage
Hagonoi	*Chromolaena odorata*	145	18.19
Kulitis	*Amaranthus spinosus*	85	10.66
Alternanthera	*Alternathera sessilis*	82	10.29
Cadena de amor	*Antigonon leptopus*	65	8.16
Digitaria	*Digitaria ciliaris*	65	8.16
Zizyphus	*Zizyphus* sp.	60	7.53
Makahiyang lalake	*Mimosa invisa*	45	5.65
Saluyot	*Corchorus olitoreus*	38	4.77
Coronitas	*Lantana camara*	32	4.02
Gatas-gatasan	*Euphorbia hirta*	32	4.02
Walis-walisan	*Sida acuta*	30	3.76
Ipil-ipil	*Leucaena leucocephala*	25	3.14
Cyperus	*Cyperus* sp.	20	2.51
Landrina	*Commelina confusa*	18	2.26
Balloon vine	*Cardiospermum halicacabum*	10	1.25
Krus-krosan	*Dactylactenium aegyptium*	10	1.25
Castor oil bean	*Ricinus communis*	5	0.63
Kamote-kamotehan	*Ipomoea triloba*	5	0.63
Maramani	*Alysicarpus vaginalis*	5	0.63
Pandakaki	*Tabernaemontana pandacaqui*	5	0.63
Wild ampalaya	*Momordica charantia*	5	0.63
Raintree	*Samanea saman*	4	0.50
Paragis	*Eleusine indica*	2	0.25
Sua	*Capparis* sp.	2	0.25
Balatong aso	*Cassia* sp.	1	0.13
Sarat	*Scleria scrobiculata*	1	0.13
Total		**797**	**100.00**

Species Diversity

The species diversity and evenness indices for the vegetation types in the project site ranged from very low to high and high to very high, respectively. The brushland's tree and shrub layer had the highest species diversity index value of 3.07, which is interpreted as high. Its evenness index was computed to be very high with a numerical value of 0.76 (**Table EL-22**). These high and very high values are expected since this vegetation type had the most number of species compared to other vegetation types. In addition, the importance values were almost evenly distributed to more than five (5) plant species.

On the other hand, mahogany plantation's tree and shrub layer had the least species diversity index value of 1.78, though evenness was computed high. The very low species diversity was due to the few number species of plants recorded in this type of vegetation and the dominance of mahogany amounting to more than half of the computed total importance value. Given the same reasons, the narra plantation understorey and the beach thicket tree and shrub layer also had very low species diversity index values.

Table EL-22
Species Diversity and Evenness in the Habitat/Vegetation Types of Luna

Habitat/Vegetation Type	Species Diversity	Interpretation	Evenness	Interpretation
Beach thicket				
a. Tree and shrub layer	1.88	Very low	0.86	Very high
b. Understorey layer	2.11	Low	0.85	Very high
Brushland				
a. Tree and shrub layer	3.07	High	0.76	Very high
b. Understorey layer	2.09	Low	0.70	High
Riparian strip	2.43	Low	0.76	Very high
Mahogany plantation				
a. Tree and shrub layer	1.78	Very low	0.61	High
b. Understorey layer	2.64	Moderate	0.82	Very high
Narra plantation				
a. Tree and shrub layer	-		-	
b. Understorey layer	1.87	Very low	0.90	Very high
Grassland	2.70	Moderate	0.83	High

1.4.5 Summary of Potential Impacts and Mitigation Measures for Terrestrial Flora

Table EL-23
Summary of Impacts Related to Terrestrial Flora

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
I. Construction Phase			
Impacts to terrestrial flora and habitat	Existing Habitat Types within Study Area - Project site	Land clearing in the proposed project area will result to permanent loss of local species including Bolong eta, Isis, Mahogany, Molave, and Narra, which are threatened, endangered, and vulnerable species. This will decrease the abundance of the local population.	• A complete inventory of trees that will be affected by the project will be conducted by the proponent. • The proponent will apply for and secure a tree-cutting permit from the local, regional and national DENR offices. Based on the inventory of trees, the proponent, in coordination with the DENR, will initiate seedling replacement strategies. • Collection of seeds and wildlings of indigenous plants will be done. • Nurseries will be established where the seedlings of the identified endangered and vulnerable species within the site will be nurtured and will be used for the replacement program. • A vegetated buffer area will be established around the project site. GLDEC will look for another site where a greening program will be implemented.
Impacts to terrestrial flora and habitat	Existing Habitat Types within Study Area - Brushlands	Of the species listed in Table EL-12, 3 trees are considered vulnerable: Mahogany, Molave and Isis. This vegetation will be removed during the construction phase to make way for the plant structures. Several fruit and food trees, will also be removed during the construction phase.	• During the operation phase, these vulnerable species will be used for greening and landscaping of the power plant site. • Whenever possible, trees with less than 15cm diameter will be balled and replanted as landscape species during the operation phase.

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
			• Two tree species – Dita and Bani – are considered of least concern in the IUCN listing but will also be included as species in the nursery and used for landscaping during the operation phase.
Impacts to terrestrial flora and habitat	Existing Habitat Types within Study Area - Riparian strip	Of the listed species of trees and shrubs in the riparian strip of Luna, one is identified as of Least Concern (Dita) and one is vulnerable (Is-is), based on IUCN 2016. These will also be cleared during construction activities. This will result in the loss of important vegetation species.	• Seedlings of these 2 species will be part of the nursery species and will be used for the buffer zone and for landscaping during the operation phase. • The easements of the ground depression will be protected using engineering and/or vegetative structures.
Impacts to terrestrial flora and habitat	Existing Habitat Types within Study Area - Mahogany plantation	Together with mahogany, bolong eta and narra were among the threatened species. Both narra and mahogany, though included in the red list, are very common in the project site. Further, these trees were also observed planted in tree farms along the roadsides of Luna.	• These species will be used in the for the replacement and greening programs.
Impacts to terrestrial flora and habitat	Existing Habitat Types within Study Area - Narra plantation	Narra is identified as a vulnerable species under the IUCN Threatened Status (2016), and critically endangered under the Philippine Threatened Status (DAO 07-01). Existing Narra plantations will be included in the removal of vegetation during project construction.	• An additional Special Cutting Permit will need to be secured by the proponent as mandated by the DENR. • Narra seedlings will comprise the nursery that will be set up during the construction phase and these will be planted in the buffer zone area during the operation phase.

1.4.5 Monitoring Plan for Terrestrial Flora

An inventory of all plants to be affected by the project will be conducted during the preconstruction phase especially on the impact zone. During the operational phase, monitoring of the survival of the planted seedlings on rehabilitation sites will be conducted monthly for the first year and quarterly for the succeeding year. Restocking (replacement of dead individuals) will be done whenever necessary. Riparian management, protection and tending will be conducted. During the abandonment phase, reforestation and ANR will be conducted in appropriate areas. Inventory of seedling survival and appropriate replacement program will be effectuat.

Table EL-24
Complete List of Plant Species Encountered in the Proposed Project Site with Conservation Status

Species	Latin Name	Family Name	Plant Type	IUCN Threatened Status (2016)	Philippine Threatened Status (DAO 2007-01)	Distribution	Habitat Type					
							Beach thicket	Brushland	Mahogany plantation	Narra plantation	Riparian	Grassland
Achuete	*Bixa orellana* L.	Bixaceae	S	NE/NA	NI	P		+++				
Alahan	*Guioa koelreuteria* (Blanco) Merr.	Sapindaceae	T	NE/NA	NI	N		+++			+++	
Albutra	*Arcangelisia flava* (L.) Merr.	Menispermaceae	V	NE/NA	NI	P		++				
Alim	*Melanolepis multiglandulosa* (Reinw. ex Blume) Rechb. f. & Zol.	Euphorbiaceae	T	NE/NA	NI	P	+++	+++	+++		+++	
Bonga-bonga	*Alternanthera sessilis* (L.) R. Br. Ex Roem.& Schult.	Amaranthaceae	H	NE/NA	NI	P		+++				++++
Anonas	*Annona reticulata* L.	Annonaceae	T	NE/NA	NI	EN		+++	+++			
Apanang	*Neotrewia cumingii* (Muell.-Arg.) Pax & K. Hoffm.	Euphorbiaceae	T	NE/NA	NI	P		+++				
Apoy-apoyan	*Cleome rutidosperma* DC.	Cleomaceae	H	NE/NA	NI	EN		+++				
Aroma	*Acacia farnesiana* (L.) Willd.	Fabaceae: Mimosoideae	S	NE/NA	NI	P	++++	+	+			
Atis	*Annona squamosa* L.	Annonaceae	T	NE/NA	NI	EN		+++	+++		+++	
Balatong aso	*Cassia tora* L.	Fabaceae: Caesalpiniodeae	S	NE/NA	NI	N						+++
Balinghasai	*Buchanania arborescens* (Blume) Blume	Anacardiaceae	T	NE/NA	NI	P		+++				
Baling uai	*Flagellaria indica* L.	Flagellariaceae	H	NE/NA	NI	NI		+++				
Balloon vine	*Cardiospermum halicacabum* L.	Sapindaceae	V	NE/NA	NI	P	+++					+++
Banato	*Mallotus philippinensis* (Lam.) Muell.-Arg	Euphorbiaceae	T	NE/NA	NI	P		++				
Bangkoro	*Morinda citrifolia* L.	Rubiaceae	T	NE/NA	NI	P	+++	+				
Bani	*Pongamia pinnata* Pierre.	Fabaceae	T	LC	NI	P		++				
Bignai	*Antidesma bunius* (L.) Spreng	Euphorbiaceae	T	NE/NA	NI	P		+++				
Bikal	*Dinochloa acutiflora* (Munro) S. Dransf.	Poaceae	V	NE/NA	NI	P					+++	
Binunga	*Macaranga tanarius* (L.) Muell.-Arg.	Euphorbiaceae	T	NE/NA	NI	NI	+++	+++	+++			
Biriba	*Rollinia deliciosa* L.	Annonaceae	T	NE/NA	NI	EN		++				

Species	Latin Name	Family Name	Plant Type	IUCN Threatened Status (2016)	Philippine Threatened Status (DAO 2007-01)	Distribution	Habitat Type					
							Beach thicket	Brushland	Mahogany plantation	Narra plantation	Riparian	Grassland
Bitaog	*Calophyllum inophyllum* L.	Clusiaceae	T	NE/NA	NI	P		+				
Bolong eta	*Diospyros pilosanthera* Blanco	Ebenaceae	T	NE/NA	Endangered	N		++	+			
Cactus	*Echinopsis* sp.	Cactaceae	H	NE/NA	NI	EN		+++				
Cadena de amor	*Antigonon leptopus* Hook. & Arn.	Polygonaceae	V	NE/NA	NI	EN						+++
Castor oil bean	*Ricinus communis* L.	Solanaceae	S	NE/NA	NI	EN		+++				+++
Dilang butiki	*Centrosema pubescens* Benth.	Fabaceae: Papilionoideae	V	NE/NA	NI	P	+++	+++	+++	+++		
Coronitas	*Lantana camara* L.	Verbenaceae	S	NE/NA	NI	EN	++++	++++	++++	++++		++++
Crab's eye plant	*Abrus precatorius* L.	Fabaceae: Mimosoideae	V	NE/NA	NI	P		+++				
Croton	*Croton* sp.	Euphorbiaceae	T	NE/NA	NI	P(?)		+++				
Cyperus	*Cyperus* sp.	Cyperaceae	H	NE/NA	NI	NI						+++
Danglin	*Grewia multiflora* Juss.	Malvaceae	S	NE/NA	Vulnerable	P		+++				
Digitaria	*Digitaria setigera* Roem. & Schult	Poaceae	H	NE/NA	NI	P		++				+++
Dioscorea	*Dioscorea* sp.	Dioscoreaceae	V	NE/NA	NI	P		+++				
Dita	*Alstonia scholaris* (L.) R. Br.	Apocynaceae	T	Lower Risk/Least Concern	NI	P		+++			+++	
Duhat	*Syzygium cumini* (L.) Skeels	Myrtaceae	T	NE/NA	NI	EN		+++				
Gatas-gatasan	*Euphorbia hirta* L.	Euphorbiaceae	H	NE/NA	NI	P(?)		+++				+++
Golden shower	*Cassia fistula* L.	Fabaceae: Caesalpiniodeae	T	NE/NA	NI	EN		++				
Gooseberry plant	*Physalis angulata* L.	Solanaceae	S	NE/NA	NI	P		+++				
Governor's plum	*Flacourtia rukam* Zoll. & Moritzi	Flacourtiaceae	T	NE/NA	NI	P		++				
Hagiwis	*Pouteria* sp.	Sapotaceae	T	NE/NA	NI	N		+				
Hagonoi	*Chromolaena odorata* (L.) R.M. King & M. Robinson	Asteraceae	S	NE/NA	NI	P	++++	++++	++++	++++		++++
Hauili	*Ficus septica* Burm. f.	Moraceae	S	NE/NA	NI	P		+++				
Himbabao	*Broussonetia luzonica*	Moraceae	T	NE/NA	NI	P		++++	+++		++++	
Igyo	*Dysoxylum gaudichaudianum* (A. Juss.) Miq.	Meliaceae	T	NE/NA	NI	NI					+++	

Species	Latin Name	Family Name	Plant Type	IUCN Threatened Status (2016)	Philippine Threatened Status (DAO 2007-01)	Distribution	Habitat Type					
							Beach thicket	Brushland	Mahogany plantation	Narra plantation	Riparian	Grassland
Ipil-ipil	*Leucaena leucocephala* (Lam.) de Wit	Fabaceae	T	NE/NA	NI	EN	++++	++++	++++		++++	++++
Isis	*Ficus ulmifolia* Lam.	Moraceae	S	Vulnerable	NI	N		+++			+++	
Tubang bakod	*Jatropha curcas* L.	Euphorbiaceae	S	NE/NA	NI	P		+++			+++	
Kakauate	*Gliricidia sepium* (Jacq.) Walp.	Fabaceae	T	NE/NA	NI	EN	+++	++++	+++		++++	
Kalios	*Streblus asper* Lour.	Moraceae	T	NE/NA	NI	P		++++	+++	+++	+++	
Kamachile	*Pithecellobium dulce* (Roxb.) Benth.	Fabaceae: Caesalpiniodeae	T	NE/NA	NI	EN	++	+++				
Kamias	*Averrhoa bilimbi* L.	Oxalidaceae	T	NE/NA	NI	NI		+++				
Kamote-kamotehan	*Ipomoea triloba* L.	Convolvulaceae	V	NE/NA	NI	P		+++	+++			+++
Kangko	*Aphanamixis perrottetiana* A. Juss.	Meliaceae	T	NE/NA	NI	P(?)		+++				
Katagpo	Psychotria sp.	Myrsinaceae	T	NE/NA	NI	N(?)		+++				
Kawayan tinik	*Bambusa blumeana* J.A. & J.H. Schultes	Poaceae	T	NE/NA	NI	EN		+++				
Krus-krosan	*Dactylactenium aegyptium* (L.) Beauv.	Poaceae	H	NE/NA	NI	P						+++
Kulitis	*Amaranthus spinosus* L.	Amaranthaceae	H	NE/NA	NI	P(?)		+++				
Kulitis	*Amaranthus viridis* L.	Amaranthaceae	H	NE/NA	NI	P(?)						+++
Kulot-kulotan	Triumfeta rhomboidea Jacq.	Malvaceae	S	NE/NA	NI	EN			+++			
Kuratan	*Linociera philippinensis* Merr.	Oleaceae	T	NE/NA	NI	N		+				
Kusibeng	*Sapindus saponaria* L. forma *microcarpa* Radlk.	Sapindaceae	T	NE/NA	NI	N		+				
Lagundi	*Vitex negundo* L.	Lamiaceae	S	NE/NA	NI	P(?)		+++				
Landrina	*Commelina benghalensis* L.	Commelinaceae	H	NE/NA	NI	P(?)		+++				+++
Lemonsito	*Triphasia trifolia* Lour.	Rutaceae	S	NE/NA	NI	P(?)		+++				
Ligas	*Semecarpus cuneiformis*	Anacardiaceae	T	NE/NA	NI	P		+++			+++	
Magabuyo	*Celtis luzonica* Warb.	Celtidaceae	T	NE/NA	NI	N		+				
Magilik	*Helictres umbellata*	Malvaceae	T	NE/NA	NI	N		+++	+++		+++	
Mahogany	*Swietenia macrophylla* King	Meliaceae	T	Vulnerable	NI	EN		+++	++++			
Makahiyang lalake	*Mimosa invisa* (L.) DC	Fabaceae: Mimosoideae	H	NE/NA	NI	EN		++				+++
Mala-apanang	*locally identified only	Euphorbiaceae	T	NE/NA	NI	N		+++	+++		+++	

Species	Latin Name	Family Name	Plant Type	IUCN Threatened Status (2016)	Philippine Threatened Status (DAO 2007-01)	Distribution	Habitat Type					
							Beach thicket	Brushland	Mahogany plantation	Narra plantation	Riparian	Grassland
Malabulak	*Bombax ceiba* L.	Malvaceae	T	NE/NA	NI	P		++				
Mala-molave	*Vitex* sp.	Lamiaceae	S	NE/NA	NI	N	+++	+++				
Mala-sudiang	*Vaccinium* sp.	Ericaceae	T	NE/NA	NI	P(?)		+++			+++	
Malubago	*Hibiscus tiliaceus* L.	Malvaceae	T	NE/NA	NI	P		+++				
Malunggai	*Moringa oleifera* Lam.	Moringaceae	S	NE/NA		EN		+++				
Mangga	*Mangifera indica* L.	Anacardiaceae	T	Data Deficient	NI	P		+++				
Maramani	*Alysicarpus vaginalis* L.	Fabaceae: Papilionoideae	H	NE/NA	NI	P		+++				++++
Matang araw	*Melicope triphylla* (Lam.) Merr.	Rutaceae	S	NE/NA	NI	N			++			
Matang hipon	*Breynia rhamnoides* (Retz.)	Euphorbiaceae	S	NE/NA	NI	NI		++++	+++	++	+++	
Melodinus vine	*Melodinus* sp.	Menispermaceae	V	NE/NA	NI	N		+++				
Molave	*Vitex parviflora* Juss.	Lamiaceae	T	Vulnerable	Endangered	P		+++				
Narra	*Pterocarpus indicus* Willd.	Fabaceae	T	Vulnerable	Critically Endangered	P			+++	++++		
Neem tree	Azadirachta indica A. Juss.	Meliaceae	T	NE/NA	NI	EN		++				
Nino	*Morinda bracteata* Roxb.	Rubiaceae	T	NE/NA	NI	P		+++				
Oplismenus	*Oplismenus compositus* (L.) Beauv.	Poaceae	H	NE/NA	NI	P		+++				
Palis	*Callicarpa erioclana* Schauer	Lamiaceae	S	NE/NA	NI	P	+++	+++				
Pandakaki	*Ervatamia pandacaqui* (Lam.) Pichon	Apocynaceae	S	NE/NA	NI	P	++++	++++	++++	++++	++++	++++
Paragis	*Eleusine indica* L.	Poaceae	H	NE/NA	NI	P		+++				+++
Passion fruit	*Passiflora edulis* Sim.	Passifloraceae	V	NE/NA	NI	P		+++	+++			
Phaenthus sp.	*Phaenthus* sp.	Annonaceae	T	NE/NA	NI	N(?)			+			
Phil. gmelina	Gmelina philippinensis	Lamiaceae	S	NE/NA	NI	N		+++				
Pongapong	*Amorphophallus campanulatus* (Roxb.) Blume ex Decne	Araceae	H	NE/NA	NI	P(?)		+++	++			
Raintree	Samanea saman (Jacq.) Merr	Fabaceae: Mimosoideae	T	NE/NA	NI	EN		++++	+++		+++	+++
Zizyphus	*Zizyphus* sp.	Rhamnaceae	S	NE/NA	NI	N(?)	++		+++			++
Sablot	*Litsea sebifera* (Willd.) Persoon.	Lauraceae	T	NE/NA	NI	P		+++	+++		+++	
Saluyot	*Corchorus acutangulus* Lam.	Malvaceae	S	NE/NA	NI	P(?)		+++	+++	+++		++++

Species	Latin Name	Family Name	Plant Type	IUCN Threatened Status (2016)	Philippine Threatened Status (DAO 2007-01)	Distribution	Habitat Type					
							Beach thicket	Brushland	Mahogany plantation	Narra plantation	Riparian	Grassland
Sampalok	*Tamarindus indica* L.	Fabaceae: Caesalpiniodeae	T	NE/NA	NI	P(?)		++				
Sampa-sampalukan	*Phyllanthus amarus* Schum and Th. Kongl.	Euphorbiaceae	H	NE/NA	NI	P		+++				
Guioa	*Guioa* sp.	Sapindaceae	T	NE/NA	NI	N(?)		++++	+++		+++	
Sarat	*Scleria scrobiculata* Nees	Cyperaceae	H	NE/NA	NI	P						+++
Selaginella	*Selaginella cuppresina*	Selaginellaceae	F	NE/NA	NI	P(?)	+++					
Siling labuyo	*Capsicum frutescens*	Solanaceae	S	NE/NA	NI	N(?)		+++				
Sineguelas	*Spondias purpurea* L.	Anacardiaceae	T	NE/NA	NI	EN		+++				
Sua	*Capparis* sp.	Capparaceae	T	NE/NA	NI	N(?)		+++	+++	+++		+++
Subiang vine	*Bridelia stipularis* (L.) Bl. Budr.	Euphorbiaceae	S	NE/NA	NI	N(?)		+++				
Suding	*Ixora macrophylla* L.	Rubiaceae	S	NE/NA	NI	N(?)		+++				
Susong dalaga	*Acalypha indica* L.	Euphorbiaceae	H	NE/NA	NI	P		+++				
Takipan	*Caryota rumphiana* Mart. var. *philippinensis* Becc.	Arecaceae	T	NE/NA	NI	N(?)					+++	
Talisai	*Terminalia catappa* L.	Combretaceae	T	NE/NA	NI	NI	++++	+++	+++			
Tikog	Fimbristylis dichotoma (L.) Vahl.	Cyperaceae	H	NE/NA	NI	P		+++				
Tridax	*Tridax procumbens*	Asteraceae	H	NE/NA	NI	P	+++					
Tubli	*Derris philippinensis* Merr.	Fabaceae	V	NE/NA	NI	N		++				
Tuhod manok	*Synedrella nodiflora* (L.) Gaertn.	Asteraceae	H	NE/NA	NI	NI		+++				
Uoko	*Mikania cordata* (Burm. f.) B.L. Rob.	Asteraceae	V	NE/NA	NI	P	++++	+++	+++			
Walis-walisan	*Sida acuta* Burm.f.	Malvaceae	S	NE/NA	NI	P(?)		+++				
Wild ampalaya	*Momordica charantia* L.	Cucurbitaceae	S	NE/NA	NI	P(?)						+++
Wild bougainvilla	*Bougainvillea* sp.	Nyctaginaceae	S	NE/NA	NI	P(?)			++			
Wild sampaguita	*Jasminium* sp.	Oleaceae	S	NE/NA	NI	N(?)		+++			+++	

Legend: Plant Type: T = tree; S = shrub; H = herb; V = vine
Threatened Status: NE/NA = not evaluated/not assessed; NI = no information
Distribution: N = native or endemic; P = pantropic; EN = Exotic (introduced) and Naturalized

Note:

Relative abundance (based on importance value computation and ocular inspection at the project site)	Key
Sparse	S / +
Uncommon	U / ++
Common	C / +++
Very common	V / ++++

1.5 Terrestrial Ecology - Fauna

The terrestrial fauna surveys for the coal fired power plant, which ran from August 5- 8, 2016 were conducted to determine the terrestrial wildlife organisms inhabiting within the proposed project area. Specifically, the survey intended:

- to study and enumerate terrestrial wildlife animals occurring within the study area;
- to compare the relative abundance of terrestrial wildlife animals among the study sites;
- to identify possible impacts of the proposed project to wildlife animals; and
- to provide mitigating measures for the conservation of terrestrial wildlife animals within the perimeter of the project.

Selection of the study sites was based on: 1) location of the main project area and boundary; 2) location of the two (2) affected barangays; and 3) areas with the highest probability that a substantial number of wildlife species would be observed. **Table EL-25** shows the sampling sites covered within the project area.

1.5.1 Methodology

Rapid assessment of wildlife was conducted to survey major vertebrate groups, namely, mammals, birds, reptiles and amphibians, within the project site. Designated stations and line transects for the survey are shown in **Figure EL-21**.

Ethnobiological interviews were also conducted to determine the presence of other terrestrial wildlife animals that were not recorded during the field surveys. This approach involved local people living in the site who were asked to describe what kind of wildlife species they have seen in the area. Information given by the local people would then support some data in the report that were not actually observed during the sampling period. Information such as local names, habitat type, and socio-economic importance were also noted.

The weight (using pesola spring scales), length, sex and age of all captured species were also noted in this study. Pesola is a precise and handy spring balance, with durable anodized aluminum tube and long scale of high resolution, used to determine the physical measurements of a wide variety of specimens (**Plate EL-9** to **Plate EL-11**).

Wildlife assessment is followed by an assessment of potential impacts that could arise due to the construction and operation of the project on terrestrial fauna. Based on the outcome of these assessments, measures to manage and mitigate potential adverse impacts are recommended.

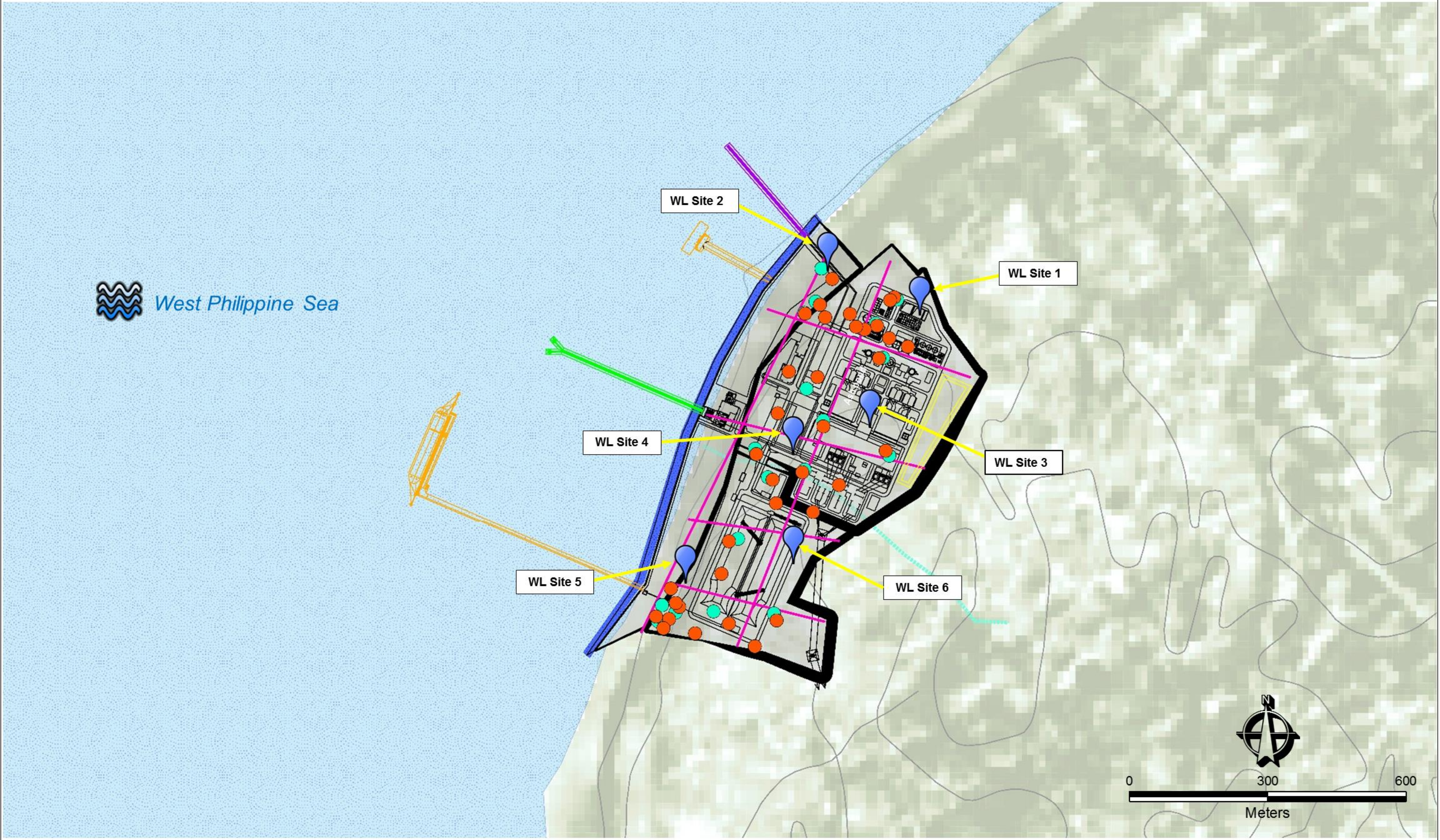


Figure EL-21 Wildlife Sampling Map	LEGEND: Live Traps Location; Mist Nets Location; Transect Line; Project Layout; Ash Pond; Foreshore Area; Jetty/ Temporary Jetty; Cooling Pipe; Outfall Pipe; Ground Depression	SCALE: 1:8,000 DATA INFORMATION/SOURCE: **Basemap and Boundary:** NAMRIA Topographic Bangar Sheet 3034-I **Project Boundary:** GLEDC 2016 **Created by:** Aperçu_AConjares	PAGE: 118
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT			aperçu CONSULTANTS INC.

Table EL-25
Wildlife Sampling Sites

Site ID	Coordinates	Barangay	Elevation	Site Description	Site Photos
Site 1	16°50'13.24"N 120°20'20.02"E	Nalvo Sur	Approximately 19 meters	Substantial portions of brushlands, especially mahagony (*Shorea sp.*) trees and grassland	
Site 2	16°50'17.18"N 120°20'12.93"E	Nalvo Sur	Approximately 7 meters	Near the beach where plant species have adapted to conditions of regular tide, wind and salinity fluctuations	
Site 3	16°50'6.10"N 120°20'17.30"E	Nalvo Sur	Approximately 27 meters	Substantial portions of grassland and brushlands; most observed plant species in the area is ipil-ipil (*Leucaena leucocephala*). Grasslands most common species, Hagonoi (*Chromolaena odorata*), Makahiyang lalae (*Mimosa invisa*) and Saluyot (*Corchorus olitoreus*)	

Table EL-23 continued

Site ID	Coordinates	Barangay	Elevation	Site Description	Site Photos
Site 4	16°50'4.19"N 120°20'10.82"E	Brgy. Carisquis	Approximately 17 meters	Numerous fig trees observed in the area and this is also near the abandoned poultry farm	
Site 5	16°49'53.03"N 120°20'1.86"E	Brgy. Carisquis	Approximately 8 meters	Near the beach thickets area; most common plants were talisai (*Terminalis catlappa*), Ipil-ipil (*Leucaena leucocephala*), kakauate (*Gliricidia sepium*) and aroma (*Acacia famesiana*)	
Site 6	16°49'56.52"N 120°20'10.57"E	Brgy. Carisquis	Approximately 27 meters	Brushland and grasslands area, few fig trees (*Ficus sp.*); grasslands species were Hagonoi (*Chromolaena odorata*); Alternanthera (*Alternathera sessilis*); Digitaria (*Digitaria cilaris*) and Ipil-ipil (*Leucaena leucocephala*)	

Herpetofauna

No standardized method was employed in the survey of amphibians and reptiles. Instead, numerous microhabitats for frogs and reptiles were examined intensively for the duration of the fieldwork. These microhabitats included tree holes, the forest floor, buttresses, decaying logs, leaf axils, epiphytes and tree ferns. Sampling was conducted from late afternoon until evening (**Plate EL-12**). The results and sampling locations for amphibians and reptiles are listed in **Table EL-26**. Additionally, frogs were surveyed and identified by their calls. Interviews with local guides were also conducted. Identification of amphibians and reptiles was based on Brown et al. (2000), Diesmos et al. (2000), Brown et al. (2012), and Brown et al. (2013). Population and threatened status were followed using IUCN 2000.

Table EL-26
Amphibians and Reptiles Sampling Sites

Stations/Sites	Northing	Easting		Northing	Easting
Transect 1	16°50'10.03"N	120°20'24.69"E	to	16°50'14.82"N	120°20'9.14"E
Transect 2	16°50'3.31"N	120°20'21.26"E	to	16°50'7.00"N	120°20'4.63"E
Transect 3	16°49'59.28"N	120°20'3.33"E	to	16°49'57.85"N	120°20'14.82"E
Transect 4	16°49'51.91"N	120°20'13.79"E	to	16°49'54.58"N	120°20'1.98"E
Transect 5	16°50'19.82"N	120°20'14.03"E	to	16°49'50.96"N	120°19'59.83"E
Transect 6	16°50'18.46"N	120°20'18.50"E	to	16°49'50.03"N	120°20'7.16"E

Avian Survey

The composition and distribution of avians were assessed using the transect survey (**Table EL-27**) and mist-netting (**Table EL-28**) methods. A standard 2-km route for each transect line involved regular pacing at a specific rate of 1 kilometer per hour (250 m for every 15 minutes). During the transect walk, the observers recorded the following information of the birds observed: species name, number of individuals, type of habitat and species association (single, pairs, flock, feeding groups or mixed flock. The transect surveys were done during the early morning (5:30-10:00 AM) and during the afternoon (3:00-6:30 PM). A sound recorder was also used to record bird calls and songs that were then identified up to species level, using birds' song and call archives online (i.e. xeno-canto.com).

Mist-nets were set up in strategic locations that involved either setting the nets singly or in series and operated for days (**Plate EL-13**). Specific sites included ridges, cliffs, clearings, and areas along streams, rivers or near bodies of water. Three (3) pieces of 12x24m mist nets were employed per station and each net had an average 36 mm mesh size. Nets were checked several times during the day. Captured birds were identified up to species level and basic biometric data were recorded. Nomenclature and classification were based on Kennedy et al. (2000). Population and threatened status were determined using the IUCN Red List 2000.

Table EL-27
Avifauna Sampling Sites – Bird Census

Stations/Sites	Northing	Easting		Northing	Easting
Transect 1	16°50'10.03"N	120°20'24.69"E	to	16°50'14.82"N	120°20'9.14"E
Transect 2	16°50'3.31"N	120°20'21.26"E	to	16°50'7.00"N	120°20'4.63"E
Transect 3	16°49'59.28"N	120°20'3.33"E	to	16°49'57.85"N	120°20'14.82"E
Transect 4	16°49'51.91"N	120°20'13.79"E	to	16°49'54.58"N	120°20'1.98"E
Transect 5	16°50'19.82"N	120°20'14.03"E	to	16°49'50.96"N	120°19'59.83"E
Transect 6	16°50'18.46"N	120°20'18.50"E	to	16°49'50.03"N	120°20'7.16"E

Table EL-28
Avifauna Sampling Sites – Mist Netting

Stations	Longitude	Latitude
Site 1	16°50'13.90"N	120°20'17.45"E
	16°50'15.68"N	120°20'19.05"E
	16°50'11.38"N	120°20'18.04"E
Site 2	16°50'15.45"N	120°20'12.83"E
	16°50'17.89"N	120°20'13.24"E
	16°50'14.61"N	120°20'11.98"E
Site 3	16°50'9.01"N	120°20'12.22"E
	16°50'6.70"N	120°20'13.54"E
	16°50'4.17"N	120°20'18.62"E
Site 4	16°50'4.55"N	120°20'8.36"E
	16°50'3.06"N	120°20'12.16"E
	16°50'2.47"N	120°20'9.35"E
Site 5	16°49'52.40"N	120°20'2.43"E
	16°49'52.94"N	120°20'1.39"E
	16°49'51.75"N	120°20'1.10"E
Site 6	16°49'57.90"N	120°20'7.14"E
	16°49'52.44"N	120°20'9.96"E
	16°49'52.53"N	120°20'5.34"E

Mammalian Survey

Two methods were used to survey volant and non-volant mammals. Identification was based on Heaney, Gonzalez and Alcala (1987) and Ingle and Heaney (1992). Population and threatened status were followed using the IUCN 2000.

Volant Mammals

The same mist-netting stations (**Table EL-28**) set up for the bird sampling were used to capture bats (3 pieces of 12x24m mist nets) (Gonzalez et al., 2003). Captured animals were carefully removed from the nets, identified and released back to the habitat. Basic information such as species name, number of individuals and type of habitat were recorded. Captured bats were identified up to species level.

Non- Volant Mammals

The use of live traps or box traps (**Plate EL-14**) is an effective means to capture small terrestrial mammals unharmed. Six (6) live traps with the same sizes were employed at each of the sites indicated in **Table EL-29**. Non-volant or ground dwelling mammals were surveyed using cage traps, baited with cooked coconut meat laced with peanut butter. Traps were placed on the ground near fallen logs, holes, and along possible runways such as root systems of trees or stumps. Traps were checked several times during the day. Captured mammals were identified up to species level.

Table EL-29
Non- Volant Mammals Sampling Sites (Live Traps)

Stations	Longitude	Latitude
Site 1	16°50'13.73"N	120°20'17.54"E
	16°50'15.84"N	120°20'18.83"E
	16°50'13.44"N	120°20'16.60"E
	16°50'12.83"N	120°20'18.48"E
	16°50'15.62"N	120°20'18.53"E
	16°50'12.22"N	120°20'19.92"E
Site 2	16°50'14.55"N	120°20'12.03"E
	16°50'15.22"N	120°20'13.16"E
	16°50'14.29"N	120°20'13.57"E
	16°50'17.13"N	120°20'14.07"E
	16°50'14.57"N	120°20'15.46"E
	16°50'13.64"N	120°20'15.94"E
Site 3	16°50'7.18"N	120°20'10.04"E
	16°50'6.26"N	120°20'13.55"E
	16°50'10.27"N	120°20'10.85"E
	16°50'11.33"N	120°20'17.74"E
	16°50'4.53"N	120°20'18.34"E
	16°50'9.89"N	120°20'13.04"E
Site 4	16°50'4.16"N	120°20'8.45"E
	16°50'2.29"N	120°20'9.72"E
	16°50'2.87"N	120°20'11.98"E
	16°50'0.56"N	120°20'10.01"E
	16°49'59.95"N	120°20'12.85"E
	16°50'1.96"N	120°20'14.80"E
Site 5	16°49'52.83"N	120°20'2.71"E
	16°49'53.12"N	120°20'2.44"E
	16°49'52.10"N	120°20'0.95"E
	16°49'51.93"N	120°20'1.95"E
	16°49'54.18"N	120°20'2.06"E
	16°49'51.25"N	120°20'1.53"E
Site 6	16°49'57.17"N	120°20'6.45"E
	16°49'55.31"N	120°20'5.90"E
	16°49'50.90"N	120°20'3.95"E
	16°49'51.64"N	120°20'6.53"E
	16°49'50.00"N	120°20'8.53"E
	16°49'51.93"N	120°20'10.17"E

Plate EL-9. Weighing bats and rats using a Pesola

Plate EL-10. Measuring the length of a rat species

Plate EL-11. Age identification of a bat species

Plate EL-12. Night time herpetofauna sampling

Plate EL-13. Setting up mist nets

Plate EL-14. Setting up live traps

Biodiversity Indices

Biodiversity indices that take into account both species richness and relative abundance of each species in the community were computed. Community diversity was calculated using the following indices:

Shannon-Weiner (H) Index:

$$D = \sum_{i=1}^{s} \frac{n_i(n_i - 1)}{N(N-1)}$$

n – number of individuals per species
N – total number of individuals of all species

Dominance (D) Index:

$$H = \sum_{i-1}^{s} p_i ln p_i$$

p_i - fraction of the entire population made up of species i
s – numbers of species encountered

Evenness (e) Index:

$$E = \frac{e^H}{S}$$

H – Shannon-Weiner Index
S – Numbers of species encountered

1.5.2 Regional Fauna in Northern Luzon

Northern Luzon is composed of mountain ranges and coastal areas occupying 63, 508 square kilometers, half of the Philippines' biggest island. At the central part of Northern Luzon is the Cordillera mountain range, which serves as headwaters for eight big rivers including the Agno River, the Abra River, the Cagayan River, and the Amburayan River. The foothills of the Cordillera mountain range connect with the lowlands of the Ilocos Region to the west and Cagayan Valley region to the west. At the southern part of Northern Luzon are the Caraballo Mountains found on the boundaries of southern Benguet, Pangasinan, and Nueva Vizcaya provinces. On the eastern portion of Northern Luzon lies the Sierra Madre Mountain range, the headwaters of six other major river systems. Being a part of the Luzon Island, the provinces of Ilocos Sur, La Union, western Pangasinan, Cagayan, Isabela and Quirino are lined with the coastal areas. On the east find the western part of the Pacific Ocean and on the west we find the China Sea (Bans-Veridiano, 2011).

Northern Luzon is a biodiversity hot spot where endemic birds, flora and fauna are found. Many terrestrial and inland water areas in the Cordillera and Cagayan Valley regions are deemed very high to extremely high in biological importance. Conservation priority areas for terrestrial and inland waters are extremely high urgent in Benguet while the rest of Cordillera and Cagayan Regions are very high to extremely high conservation priority sub-areas for plants (Bans-Veridiano, 2011).

In the trip report posted in the Wild Bird Club of the Philippines (WBCP) during a visit to Pangasinan in 2008, it was notably observed that more than 2,000 Philippine ducks (*Anas luzonica*) live in one of the reservoir project (San Roque Dam) in the area. In a trip report posted in the WBCP website, the eight member group composed of birders saw more than 40 bird species, nine (9) of them endemic during a three day tour (retrieved at Philippine Daily Inquirer (http://newsinfo.inquirer.net) on July 22, 2016).

The endemic species, aside from the Philippine duck, include the pygmy swiftlet (*Collocalia troglodytes*), blue-headed fantail (*Rhipidura cyaniceps*), the red- keeled flowerpecker (*Dicaeum australe*), the Philippine bulbul (*Hypsipetes philippinus*), the Philippine coucal (*Centropus viridis*), and the spotted buttonquail (*Turnix ocellata*) (retrieved at Philippine Daily Inquirer (http://newsinfo.inquirer.net) on July 22, 2016).

1.5.3 Project Site Species Composition

A total of 54 species of terrestrial wildlife were observed at six (6) sampling locations within the project site consisting of thirty- nine (39) birds, seven (7) mammals, four (4) species of reptiles (two of which were endemics) and four (4) species of amphibians (one is endemic).

Avifauna

A total of 39 birds were recorded in all study sites and transects within the area of the proposed project (**Table EL-30**). There were twenty-seven (27) non- endemic species and twelve (12) species endemic to the Philippines.

A total of three (3) bird species recorded were migrants. This included the Kentish Plover (*Charadrius alexandrines),* the Forest Wagtail (*Dendronathus indicus)* and the Brown Shrike (*Lanius cristatus).* Birds annually escape from the cold winter of the temperate regions to the warmth of the tropics to feed and breed. In the Philippines, the peak months for birds migrating to the South are usually from September to November, while those traveling North often do so between February and April. Experts say the number of migratory birds visiting the Philippines has declined (IUCN) due to hunting and land conversion. Land conversion into residential and agricultural areas is one of the reasons why migratory birds have looked to other areas for refuge[2].

Site 1

There were only four (4) of bird species observed in Site 1. Three (3) were endemic species, namely the Great-Eared Nightjar (*Lyncornis macrotis)* (**Plate EL-15**)*,* the Lowland White-eye (*Zosterops meyeni)* and the Golden Yellow White-eye (*Zosterops nigrorum*). There were only a few species observed at this site probably due to the lack of sources of food such as fig trees or fruit trees near the area. This is because the vegetation type observed were mainly Mahogany (*Swietenia mahagoni*) (**Plate EL-1**). Two (2) nests observed in this site indicate that it provides an ideal environment for nesting. The nest was too high to be accurately identified.The mahogany trees serve as their place of cover or shelter during inclement weather (sun, heat, wind and rain) and to protect them from natural predators. The most common predators of birds are other birds (such as the owl and the hawk) as well as other consumers of birds that include mammals like large cats and snakes.

A portion of the ash pond will cover Site 1. The ash pond will have a total area of 0.6 ha that will extend from Site 1 to Site 3.

Site 2

Among all the sampling sites, Site 2 had the least number of bird species with only one (1) resident bird species (**Figure EL-22**) observed the Pied Fantail (*Rhipidura nigritorquis*) (**Plate EL-16**). Site 2 is near the beach area where numerous invertebrates can be found. This could be the reason for the presence of the Pied Fantail in the area. The majority of the diet of fantails is composed of small insects and invertebrates. Majority of the species are found in rainforests, desserts and mangrove forests as well as in highly modified agricultural and urban environments (retrieved at Wikipedia.org on August 9, 2016).

No structures will be placed in Site 2. Nearby structures are the discharge pipe and the seawater tank that will be placed south and east of the site, respectively.

[2] Retrieved at denr.gov.ph on September 30, 2015

Plate EL-15. Great Eared Nightjar (*Lyncornis macrotis)*

Plate EL-16. Pied Fantail (*Rhipidura nigritorquis*)

Plate EL-17. White eared brown dove (*Phapitreton leucotis)*

Plate EL-18. Spotted Buttonquail (*Turnix ocellatus)*

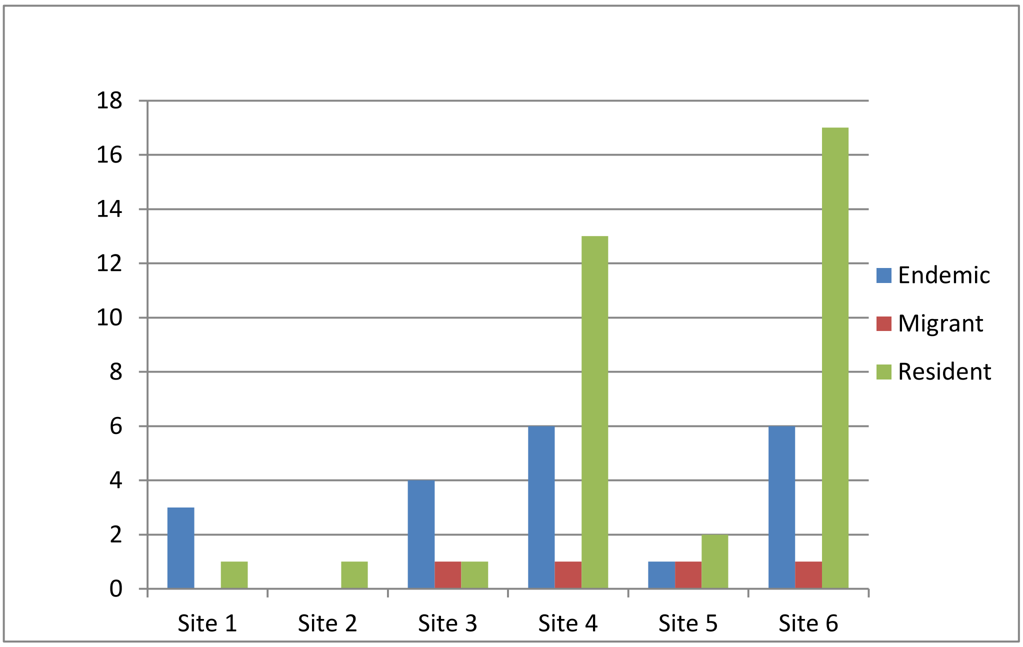


Figure EL-22. Distribution of Bird Species in each Study Sites

Site 3

Site 3 recorded 6 bird species, four (4) of which were endemic species that included the White-eared brown dove (*Phapitreton leucotis*) (**Plate EL-17**)*, the* Spotted Buttonquail (*Turnix ocellatus)* (**Plate EL-18**)*, the* Lowland White-eye (*Zosterops meyeni)* and the Golden Yellow White-eye (*Zosterops nigrorum*).

Major structures that will be placed in Site 3 include a portion of the ash pond, the stack, the electrostatic precipitators, the two boiler units, as well as the aeration basin.

Site 4

Site 4 had the second highest number of bird species with eighteen (18) species, most of which were resident species. The resident species identified in the site included, the Oriental Magpie-Robin (*Copsychus saularis*) (**Plate EL-19**), the White-collared kingfisher (*Todiramphus chloris)* **(Plate EL-20)***,* the Long-tailed shrike (*Lanius schach)* *(***Plate EL-21***), the* Yellow-vented Bulbul (*Pycnonotus goiavier)* **(Plate EL-22)** and the Pied Triller (*Lalage nigra)* (**Plate EL-23**).

Plate EL-19. Oriental Magpie-Robin (*Copsychus saularis*)

Plate EL-20. White-collared kingfisher (*Todiramphus chloris)*

Plate EL-21. Long tailed shrike (*Lanius schach)*

Plate EL-22. Yellow-vented Bulbul (*Pycnonotus goiavier)*

Site 4 is the proposed location of the steam turbine building, the transformer yard, and the dry and clean oil tank.

Plate EL-23. Pied Triller (*Lalage nigra)*

Site 5

Site 5, recorded only four (4) bird species, with one endemic species (White eared brown dove or *Phapitreton leucotis*) identified in this site. Three (3) migrant species were also identified in Site 5, these included the Kentish Plover (*Charadrius alexandrines) (***Plate EL-24**), the Hooded Pitta (*Pitta sordida)* (**Plate EL-25**), and the Eastern Reef Egret (*Egretta sacra) (***Plate EL-26**).

The conveyors will pass through Site 5. Aside from the conveyors, no other structures will be constructed in this site.

Plate EL-24. Kentish Plover (*Charadrius alexandrines)*

Plate EL-25. Hooded Pitta (*Pitta sordida)*

Plate EL-26. Eastern Reef Egret (*Egretta sacra*)

Site 6

Across all the sampling sites, Site 6 had the highest number of bird species with 22 bird species which included the Asian koel (*Eudynamys scolopaceus*)(**Plate EL-27**), *the* Philippine Tailorbird (*Orthotomus castaneiceps)* (**Plate EL-28***), the* Warbler (*Phylloscopus sp*.) (**Plate EL-29**) and the Citrine Canary Flycatcher (*Cucilicapa helianthea)* (**Plate EL-36**).

Plate EL-27. Asian koel (*Eudynamys scolopaceus*)

Plate EL-28. Philippine Tailorbird (*Orthotomus castaneiceps)*

Plate EL-29. Warbler (*Phylloscopus* sp.)
Note: This species died due to extreme exposure in an overnight heavy rainfall

Plate EL-30. Citrine Canary Flycatcher (*Cucilicapa helianthea)*

Site 6 is the proposed location of the coal stock piles and the crusher house.

Transects

Fewer bird species were observed during the conduct of the transect method. The highest number was five (5) species and this was observed in only one transect – Transect 3. These five species are composed of three residents – *Chalcopaps indica, Megalurus palustris, Pycnonotus qoiavier* **–** and two endemic bird species – *Orthotomus castaneiceps* and *Phapitreton leucotis.* Transect 2 followed with three (3) bird species recorded, all of which are resident bird species. These are the *Chalcopaps indica,* the *Pycnonotus qoiavier*, and the *Porzana fusca.* Transects 1 and 4 both have 2 bird species observed. These are *Oriolus chinensis* and *Rhipidura nigritorius* for Transect 1, both are resident in distribution, and *Orthotomus castaneiceps* and *Phapitreton leucotis* for Transect 4, both are endemic. One (1) bird species was recorded for Transect 6, *Orthotomus castaneiceps,* while none was recorded for Transect 5. The distribution of bird species on each transect are summarized in **Figure EL-23**.

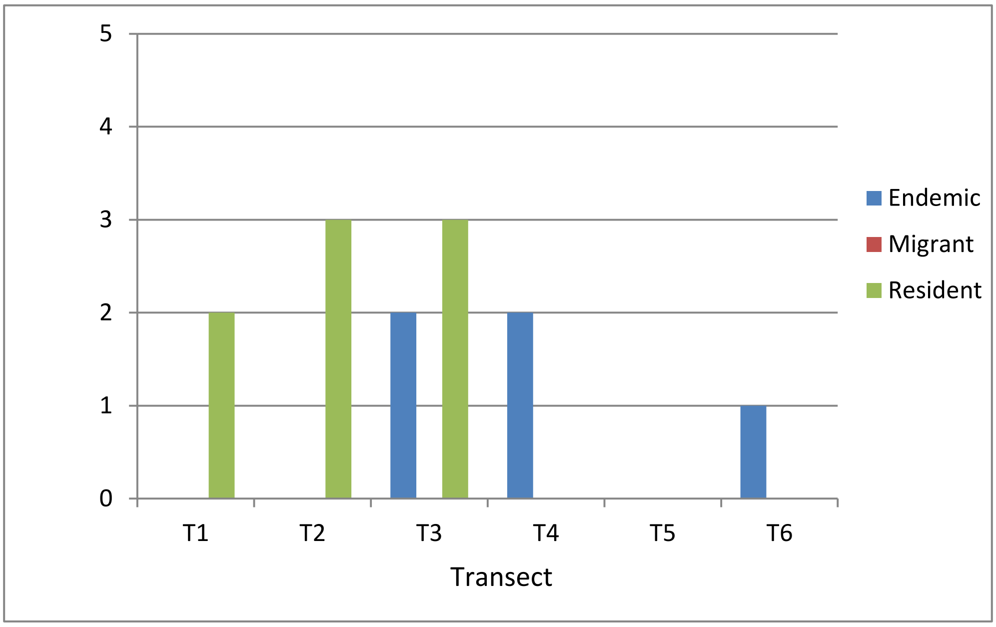


Figure EL-23. Distribution of Bird Species in each Transect

Avifauna

Of the observed avifauna population status, all of the 41 (100%) species recorded in the project site are of Least Concern (based on IUCN assessment) (**Figure EL-24**). These species are considered as widespread and abundant. Majority of the birds are resident species, meaning these birds are found in the Philippines and in other countries. They breed or are suspected of breeding in the Philippines, and normally live here throughout the year.

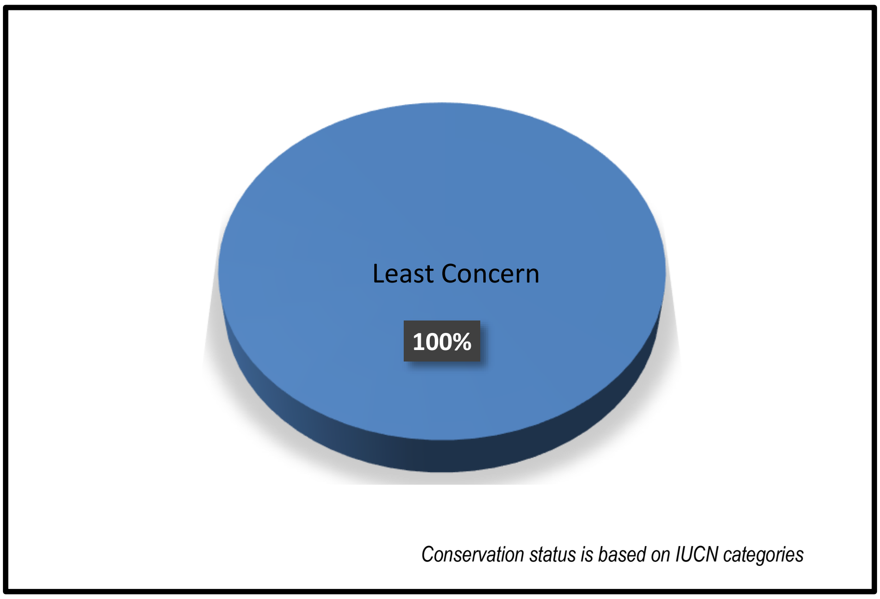


Figure EL-24. Population Status of Avifauna Species Recorded in the Site

Birds are highly mobile animals and are likely to be driven away during the clearing of vegetation and by construction noise. All of the birds found in the 6 study sites, however, are categorized as least concern under the IUCN listing and therefore the project will not impact any important species. Although their habitats within the project site will be removed as a result of the removal of vegetation, it is expected that the birds will relocate to adjacent habitats that will not be affected by construction activities and the ensuing noise generated. During the operation phase, a vegetation area that will eventually host the same species of avifauna impacted during the construction phase will be developed.

Birds are present throughout almost every habitat across the globe. Birds can provide a number of direct benefits to humans. Birds can help in nutrient cycling, which has been documented in many habitats by spreading activities through different habitats. Birds can move nutrients from one place to another, which is particularly relevant in places where plant growth is limited by nutrient availability. In agricultural systems, birds can also be beneficial through the regulation of pests. Birds are important scavengers in many ecosystems by removing the carcasses of dead animals. Another way that birds can provide regulating services is through promoting forest growth. This is important to humans because forests can sequester carbon and prevent it from going to atmosphere where it would contribute to climate change. Birds are able to perform this role through dispersing plant seeds during foraging. When they pick a seed or fruit from a plant and fly off with it, they end up transporting the seed to another place where it can germinate. This behavior is a major mechanism for seed dispersal in many plants and can increase the genetic diversity of plants in a particular area by spreading seeds. In some cases, animals can carry seeds more than 40 meters away from the source tree (retrieved at environemtalscience.org on August 21, 2016).

As for cultural services, bird watching can be used as to foster ecotourism as a source of income. Many nature centers and nonprofit environmental organizations create revenue by taking visitors on bird watching tours. These kinds of activities can also be used to introduce students and children to the outdoors in order to foster an appreciation for nature. Similarly, zoos often acquire rare birds and then use them as a heavily marketed feature attraction to increase traffic and visitor revenue. Birds also serve a number of cultural roles and factor heavily into religions across the globe. For example, eagles are considered sacred messengers that carry prayers to the spiritual world in many Native American religions (retrieved at environemtalscience.org on August 21, 2016). However, in the site, there were no species observed to be of cultural significance.

Table EL-30
Avifauna Species Composition in the Proposed Project Area

Scientific Name	Common Name	IUCN Status	CITES	DAO 2004-15/ PWA	Distribution	Economic Importance	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	T1	T2	T3	T4	T5	T6	Interview	Count
Actenoides lindsayi	Spotted Wood-Kingfisher	Least Concern	NA	NA	Endemic	Insect feeder				✓		✓								3
Artamus leucorhyncus	White-breasted woodswallow	Least Concern	NA	NA	Resident	Insect feeder						✓								2
Caprimulgus manillensis	Philippine Nightjar	Least Concern	NA	NA	Endemic	Insect feeder	✓													1
Centropus bengalensis	Lesser Coucal	Least Concern	NA	NA	Resident	Insect feeder				✓		✓								10
Centropus viridis	Philippine Coucal	Least Concern	NA	NA	Endemic	Insect feeder				✓		✓								8
Chalcophaps indica	Common Emerald Dove	Least Concern	NA	NA	Resident	Seed disperser						✓		✓	✓				✓	N/A
Charadrius alexandrinus	Kentish Plover	Least Concern	NA	NA	Migrant	No specific information					✓									5
Cinnyris jugularis	Olive-backed Sunbird	Least Concern	NA	NA	Resident	Insect and nectar feeder				✓		✓								1
Copsychus saularis	Oriental Magpie-Robin	Least Concern	NA	NA	Resident	The magpie robin is the national bird of Bangladesh (Wikipedia.com)				✓										3
Chrysocolaptes haematribon	Luzon flameback	Least Concern	NA	NA	Endemic	No specific information													✓	N/A
Dendronanthus indicus	Forest Wagtail	Least Concern	NA	NA	Migrant	No specific information				✓										2
Dicaeum australe	Red-keeled Flowerpecker	Least Concern	NA	NA	Endemic	No specific information				✓										3
Eudynamys scolopaceus	Asian koel	Least Concern	NA	NA	Resident	Popular in India as cage birds.						✓								1
Geopelia striata	Zebra dove	Least Concern	NA	NA	Resident	No specific information				✓		✓								1
Halcyon smyrnensis	White-throated Kingfisher	Least Concern	NA	NA	Resident	Medium sized generalist predators that feed on a wide variety of small creatures and help to keep various populations in check (animaldiversity.com)				✓										3
Hypotaenidia torquata	Barred Rail	Least Concern	NA	NA	Resident	No specific information				✓										1
Lalage nigra	Pied Triller	Least Concern	NA	NA	Resident	Natural pest control														
Lanius cristatus	Brown Shrike	Least Concern	NA	NA	Migrant	No specific information			✓			✓								2
Lanius schach	Long tailed shrike	Least Concern	NA	NA	Resident	No specific information				✓		✓								1
Megalurus palustris	Striated Grassbird	Least Concern	NA	NA	Resident	Insect feeder									✓					2
Orthotomus castaneiceps	Philippine Tailorbird	Least Concern	NA	NA	Endemic	Insect feeder									✓	✓		✓		1
Oriolus chinensis	Black-naped Oriole	Least Concern	NA	NA	Resident	No specific information							✓							1
Phapitreton leucotis	White eared brown dove	Least Concern	NA	NA	Endemic	Seed disperser					✓	✓			✓	✓				14
Pycnonotus urostictus	Yellow-wattled Bulbul	Least Concern	NA	NA	Endemic	No specific information			✓											1
Pycnonotus goiavier	Yellow-vented Bulbul	Least Concern	NA	NA	Resident	Seed dispersers				✓		✓		✓	✓					56
Porzana fusca	Ruddy-breasted Crake	Least Concern	NA	NA	Resident	Feeds aquatic insects and their larvae								✓						2
Rhipidura nigritorquis	Pied Fantail	Least Concern	NA	NA	Resident	Feeds on ground insects		✓		✓		✓	✓							9
Todiramphus chloris	White collared kingfisher	Least Concern	NA	NA	Resident	Feeds on coastal small creatures and help to keep various populations in check (animaldiversity.com)	✓		✓	✓		✓								3
Turnix ocellatus	Spotted Buttonquail	Least Concern	NA	NA	Endemic	Bred in captivity and found in aviaries (animaldiversity.org)			✓	✓		✓								6
Turnix suscitator	Barred Buttonquail	Least Concern	NA	NA	Resident	Bred in captivity and found in aviaries (animaldiversity.org)				✓	✓	✓								5
Zosterops meyeni	Lowland White-eye	Least Concern	NA	NA	Endemic	No specific information	✓		✓			✓								18
Zosterops nigrorum	Golden Yellow White-eye	Least Concern	NA	NA	Endemic	No specific information	✓		✓	✓										39
Pitta sordida	Hooded Pitta	Least Concern	NA	NA	Resident	Insect feeder and seed dispersal					✓									1
Egretta sacra	Eastern Reef Egret	Least Concern	NA	NA	Resident	No specific information						✓								1
Cyornis rufigastra	Magrove Blue Flycatcher	Least Concern	NA	NA	Resident	No specific information				✓										5
Orthotomus derbianus	Grey-backed Tailorbird	Least Concern	NA	NA	Endemic	No specific information				✓		✓								1
Megalurus timoriensis	Tawny Grassbird	Least Concern	NA	NA	Resident	No specific information						✓								2
Gallus gallus	Red Junglefowl	Least Concern	NA	NA	Resident	Used mainly for eggs and meat production, used for cock fighting or chicken competitions (animaldiversity.org)						✓								2

Table EL-30 continued

Scientific Name	Common Name	IUCN Status	CITES	DAO 2004-15/ PWA	Distribution	Economic Importance	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	T1	T2	T3	T4	T5	T6	Interview	Count
Culicicapa helianthea	Citrine Canary Flycatcher	Least Concern	NA	NA	Resident	No specific information						✓								1
Phylloscopus sp.	Warbler	Least Concern	NA	NA	Resident	No specific information						✓								1

Notes: Status is as follows:*IUCN Red List (IUCN = World Conservation Union; assesses conservation status of species on a global scale)

- Critically Endangered; considered to be facing an extremely conservation status in the wild
- Endangered: considered to be facing a high risk of extinction in the wild
- Vulnerable: considered to be facing a high risk of extinction in the wild
- lower risk, but is close to qualifying for or is likely to qualify for a threatened category in the near future
- lower risk, conservation dependent: taxa which are the focus of a continuing taxon-specific or habitat-specific conservation program targeted toward the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above within a period of five years
- Least Concern: widespread and abundant taxa are included this category
- Data deficient: there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status
- NA = Not Assessed

**CITES (Conservation on International Trade in Endangered Species of Wild Flora and Fauna): its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival. Not all endangered animals are traded, so not all species thought to be threatened would occur on this list. Conversely, species that may appear in Appendix I but be of "least concern" on the IUCN Red List.

- Appendix I = species considered threatened with extinction
- Appendix II – species that are not necessarily now threatened with extinction, but that may become so unless trade is closely controlled
- NA = Not assessed

***DAO 2004-15 (DENR Administrative Order 2004-15): provides a preliminary List of Threatened Wildlife, including their different categories, and the List of Other Wildlife Species, pursuant to RA No. 9147 or "Wildlife Conservation and Protection Act"

- Other Threatened Species = refers to a species that is not critically endangered, endangered, nor vulnerable but is under threat from adverse factors such as over collection throughout their range and is likely to move to the vulnerable category in the near future.

****IUCN Species Distribution (IUCN Red Distribution list)

- Endemic- species which is **only** found in a given range or location in the world or native to a particular region and can only be found in that one area
- Migratory- which perform cyclic movements between two distinct geographical areas, one which is usually the area in which they breed.
- Resident- living in one area throughout the year
- Indigenous/Native- naturally found in that region (they were not introduced) but they are also found naturally occurring in other regions around the world.
- Introduced- species living outside its native distributional range, which has arrived there by human activity, either deliberate or accidental.

*Other Threatened Species = refers to a species that is not critically endangered, endangered, nor vulnerable but is under threat from adverse factors such as over collection throughout their range and is likely to move to the vulnerable category in the near future.

Mammals

A total of seven (7) species of volant mammals were recorded in all sampling sites and two (2) from the surrounding community of the project site (**Table EL-31**). This comprised of three (3) species of bats and three (3) species of rats and a civet cat. The bats included the Common Rosette *(Roussettus amplexicaudatus)* (**Plate EL-31**), the Greater Musky Fruit Bat (*Ptenochirus jagori*) (**Plate EL-32**), the Lesser Short-nosed Fruit Bat (*Cynopterus brachyotis)* (**Plate EL-33**) and the Black-bearded Tomb bat (*Taphozous melanopogon*).

Site 4 had the highest number of captured bats with 17 bats while Site 3 had the least number of captured bats with only 5 individuals. The presence of more bats in Site 4 is probably due to the abundance of *Ficus* (**Plate EL-34**). This is a type of shrub and vine that are native throughout the tropics. The fruits of most figs are edible and are an important food source for wildlife. Additionally, there were minimal human disturbances in Site 4 when compared to Site 2, which is near human settlements/ resort establishments.

Plate- EL-31. Common Rosette *(Roussettus amplexicaudatus)*

Plate EL-32. Greater Musky Fruit Bat (*Ptenochirus jagori*)

Plate EL-33. Lesser short-nosed fruit bat (*Cynopterus brachyotis)*

Plate EL-34. *Ficus* species (Figs)

It is also notably observed that there were Black-bearded Tomb bats (*Taphozous melanopogon*) (**Plate EL-35**) inside the Luna Sport Complex about 4.49 km from the project site. This bat species inhabit a variety of areas, from rainforests to woodlands. They are often found in hilly forests near water but they may roost in many places including tombs, caverns, caves, rock crevices, sea cliffs and trees. They are also becoming common in urban areas, roosting in buildings and churches, the Luna Sports complex being a perfect example. The bats are very agile and are able to cling to sheer rock surfaces. This enables them to live in places where other bats are unable to. Also, they often roost in well-lit areas that other bats avoid. The tomb bats are gregarious and their relatively large colonies have been recorded with up to 4,000 individuals. Typically, adult males stay within their defined "territory" on the wall, and groups of females roost around them (Flannery, 1995; Lekagul, 1977; Nowak, 1997). The bats are insect-eating bats.

Ground dwelling mammals captured during the survey included the *Rattus everetti* (Philippine forest rat) (**Plate EL-36**), the *Rattus norvegicus* (Brown rat) (**Plate EL-37**) and the *Rattus tanezumi* (Oriental house rat) (**Plate EL-38**). The presence of the Palm Civet (*Paradoxurus hermaphroditus)* was recorded based on fecal materials (**Plate EL-39**) that were observed in Site 3. However, no Rubiaceae (a family of flowering coffee plants that serve as their food) was observed during the transect walk, although it does not mean that there were no coffee plants in the area.

Plate EL-35. Black-bearded Tomb bat (*Taphozous melanopogon*)

Plate EL-36. *Rattus everetti* (Philippine forest rat)

Plate EL-37. *Rattus norvegicus* (Brown rat)

Plate EL-38. *Rattus tanezumi* (Oriental house rat)

Plate EL-39. *Paradoxurus hermaphroditus* (Civet cat Scats)

Mammals

Of the observed mammal population, all of the 8 (100%) species recorded in the project site are of Least Concern (based on IUCN assessment) (**Figure EL-25)**. Two of the recorded species namely: the Brown rat (*Rattus norvegicus*) and the Oriental house rat (*Rattus tanezumi*) are considered as pests. In many places, rodents live in close association with human populations as well as with farm animals or pets. In other places, urban rodents provide a nexus between wildlife communities and humans, exposing humans to some zoonosis circulating in these natural ecosystems (Meerburg et al., 2009). Rodents are important competitors of humans for food, particularly through the pre-harvest damage they cause in agriculture areas (Stenseth et al., 2003).

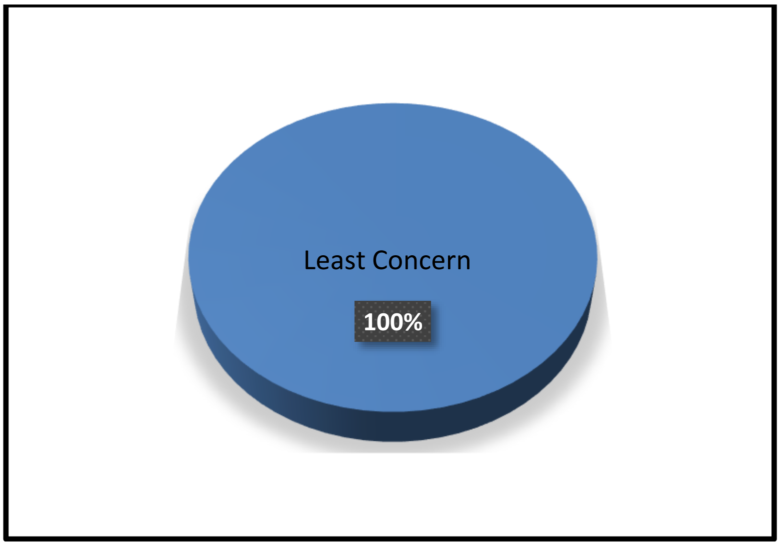


Figure EL-25. Population Status of Mammals Species Recorded in the Site

Similar to birds, mammals found in the project site are all of high abundance. All were also listed with least concern status, some of them even considered as pests. The removal of vegetation is thus expected to impact the mammals minimally. The civet cat will most likely move to areas outside of the project site where coffee plants are in greater abundance.

Table EL-31
Mammal Species Composition in the Proposed Project Area

Species	Common Name	IUCN Status	CITES	DAO 2004-15/PWA	Distribution	Economic Importance	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	T1	T2	T3	T4	T5	T6	Count
Cynopterus brachyotis	Lesser short-nosed fruit bat	Least Concern	NA	NA	Resident	Seed Disperser	✓		✓	✓	✓								28
Ptenochirus jagori	Greater Musky Fruit Bat	Least Concern	NA	NA	Resident	Seed Disperser	✓												4
Roussettus amplexicaudatus	Common rousettes	Least Concern	NA	NA	Resident	In the Philippines and Indochina it is subject to intense hunting at some cave roosts (IUCN).	✓			✓									2
Taphozous melanopogon	Black-bearded Tomb bat	Least Concern	NA	NA	Resident	In some countries, including Lao PDR and the Philippines, there is likely some localized hunting of this cave roosting species for food (IUCN).	This species was observed inside Luna's Sport Complex												
Mus musculus	House mouse	Least Concern	NA	NA	Resident	House mice are important prey items for many small predators (animadiversity.org)				✓									1
Rattus everetti	Philippine forest rat	Least Concern	NA	NA	Endemic	No specific information				✓		✓							8
Rattus norvegicus	Brown rat	Least Concern	NA	NA	Resident	Considered as agricultural and industrial pest					✓								1
Rattus tanezumi	Oriental house rat	Least Concern	NA	NA	Resident	Considered as agricultural and industrial pest	✓	✓	✓		✓	✓							21
Paradoxurus hermaphroditus	Common Palm Civet	Least Concern	NA	NA	Resident	Asian palm civet eat the seeds of many trees in its area, like palm trees. They are prime contributors to the dispersal of these seeds, since they tend to pass them in their feces several hundred meters from where the seeds were consumed. This also encourages the seeds to germinate, which helps forests regenerate (animaldiversity.org)	Scat was observed												

Notes: Status is as follows:*IUCN Red List (IUCN = World Conservation Union; assesses conservation status of species on a global scale)

- Critically Endangered; considered to be facing an extremely conservation status in the wild
- Endangered: considered to be facing a high risk of extinction in the wild
- Vulnerable: considered to be facing a high risk of extinction in the wild
- lower risk, but is close to qualifying for or is likely to qualify for a threatened category in the near future
- lower risk, conservation dependent: taxa which are the focus of a continuing taxon-specific or habitat-specific conservation program targeted toward the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above within a period of five years
- Least Concern: widespread and abundant taxa are included this category
- Data deficient: there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status
- NA = Not Assessed

**CITES (Conservation on International Trade in Endangered Species of Wild Flora and Fauna): its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival. Not all endangered animals are traded, so not all species thought to be threatened would occur on this list. Conversely, species that may appear in Appendix I but be of "least concern" on the IUCN Red List.

- Appendix I = species considered threatened with extinction
- Appendix II – species that are not necessarily now threatened with extinction, but that may become so unless trade is closely controlled
- NA = Not assessed

***DAO 2004-15 (DENR Administrative Order 2004-15): provides a preliminary List of Threatened Wildlife, including their different categories, and the List of Other Wildlife Species, pursuant to RA No. 9147 or "Wildlife Conservation and Protection Act"

- Other Threatened Species = refers to a species that is not critically endangered, endangered, nor vulnerable but is under threat from adverse factors such as over collection throughout their range and is likely to move to the vulnerable category in the near future.

****IUCN Species Distribution (IUCN Red Distribution list)

- Endemic- species which is **only** found in a given range or location in the world or native to a particular region and can only be found in that one area
- Migratory- which perform cyclic movements between two distinct geographical areas, one which is usually the area in which they breed.
- Resident- living in one area throughout the year
- Indigenous/Native- naturally found in that region (they were not introduced) but they are also found naturally occurring in other regions around the world.
- Introduced- species living outside its native distributional range, which has arrived there by human activity, either deliberate or accidental.

*Other Threatened Species = refers to a species that is not critically endangered, endangered, nor vulnerable but is under threat from adverse factors such as over collection throughout their range and is likely to move to the vulnerable category in the near future.

Herpetofauna (Reptiles and Amphibians)

A total of seven (7) species of reptiles (one of which is near threatened) and one (1) species of amphibian was recorded at the sampling sites (**Table EL-32**). Four (4) endemic reptiles namely: the Philippine Water Monitor lizard (*Varanus marmoratus*) (**Plate EL-40**), the Northern Philippine Cobra (*Naja philippinensis*), the Philippine pit viper (*Trimerusurus flavomaculatus*) and the Brown's mabuya (*Eutropis indeprensa*) (**Plate EL-41**) were recorded in Sites 1 and 2. Three (3) native species of reptiles were also observed, namely: the Paradise Tree snake (*Chrysopelaea paradasi*) (**Plate EL- 42**), the Reticulated python (*Python reticulatus*) and the Tokay gecko (*Gecko gecko*) (**Plate EL-43**).

One (1) native species of amphibian was recorded in Site 1 namely: the Banded bullfrog (*Kaloula pulchra*) (**Plate EL-44**). The presence of these amphibian species in Site 1 is due to its relatively wet and humid conditions. This species is most productive after storms or heavy rain (retrieved at amphibiancare.com on August 20, 2016), which occurred during the sampling period.

During the survey, the team also observed that there are man-made traps placed in the area (**Plate EL-45**). According to the local guides, people near the area placed this traps to capture or hunt "bayawak" or the Philippine Monitor Lizard (*Varanus marmoratus). The meat of monitor lizards is eaten by some local people in the area.*

Plate EL-40. Philippine Water Monitor Lizard (*Varanus marmoratus*)

Plate EL-41. Brown's mabuya (*Eutropis indeprensa*)

Plate EL-42. Paradise Tree Snake (*Chrysopelaea paradasi*)

Plate EL-43. Tokay gecko (*Gecko gecko*)

Table EL-32
Herpetofauna Species Composition in the Proposed Project Area

Species	Common Name	IUCN Status	CITES	DAO 2004-15/PWA	Distribution	Economic Importance	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	T1	T2	T3	T4	T5	T6	Interview	Count
Chrysopelaea paradisi	Paradise Tree Snake	Least Concern	NA	NA	Native	This species is collected in small numbers for the international pet trade, but not large scale (IUCN)	√													1
Kaloula pulchra	Banded bullfrog	Least Concern	NA	NA	Native	It is consumed in many places, and can sometimes be found in the international pet trade but at levels that are not considered to be a major threat (IUCN)	√													30
Varanus marmoratus	Philippine Water Monitor Lizard	Least Concern	NA	NA	Endemic	Heavily traded for the food and pet trade (capture of hatchlings and juveniles), this does not appear to be having a significant impact on the species population as a whole (IUCN).	√													1
Naja philippinensis	Northern Philippine Cobra	Near Threatened	NA	NA	Endemic	This snake is also collected and used for anti-venom production by the Research Institute for Tropical Medicine (RITM) (IUCN).													√	N/A
Python reticulatus	Reticulated Python	Data Deficient	NA	NA	Native	They are heavily sold for their skin and meat. Also tourist visiting these areas often buy materials made from these snakes (animaldiversity.org)													√	N/A
Trimerusurus flavomaculatus	Philippine pit viper	Least Concern	NA	NA	Endemic	Animals are collected for the pet trade and suffer from opportunistic persecution, and while it is unlikely that these constitute major threats to the species as a whole, certain subpopulations (such as that of the Bicol Peninsula) might be significantly impacted (IUCN).													√	N/A
Eutropis indeprensa	Brown's mabuya	Least Concern	NA	NA	Endemic	No specific information	√	√												8
Gecko gecko	Tokay gecko	Not evaluated	NA	NA	Native	Heavily traded for the food and pet trade			√	√		√								7

Notes: Status is as follows:*IUCN Red List (IUCN = World Conservation Union; assesses conservation status of species on a global scale)

- Critically Endangered; considered to be facing an extremely conservation status in the wild
- Endangered: considered to be facing a high risk of extinction in the wild
- Vulnerable: considered to be facing a high risk of extinction in the wild
- lower risk, but is close to qualifying for or is likely to qualify for a threatened category in the near future
- lower risk, conservation dependent: taxa which are the focus of a continuing taxon-specific or habitat-specific conservation program targeted toward the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above within a period of five years
- Least Concern: widespread and abundant taxa are included this category
- Data deficient: there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status
- NA = Not Assessed

**CITES (Conservation on International Trade in Endangered Species of Wild Flora and Fauna): its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival. Not all endangered animals are traded, so not all species thought to be threatened would occur on this list. Conversely, species that may appear in Appendix I but be of "least concern" on the IUCN Red List.

- Appendix I = species considered threatened with extinction
- Appendix II – species that are not necessarily now threatened with extinction, but that may become so unless trade is closely controlled
- NA = Not assessed

***DAO 2004-15 (DENR Administrative Order 2004-15): provides a preliminary List of Threatened Wildlife, including their different categories, and the List of Other Wildlife Species, pursuant to RA No. 9147 or "Wildlife Conservation and Protection Act"

- Other Threatened Species = refers to a species that is not critically endangered, endangered, nor vulnerable but is under threat from adverse factors such as over collection throughout their range and is likely to move to the vulnerable category in the near future.

****IUCN Species Distribution (IUCN Red Distribution list)

- Endemic- species which is only found in a given range or location in the world or native to a particular region and can only be found in that one area
- Migratory- which perform cyclic movements between two distinct geographical areas, one which is usually the area in which they breed.
- Resident- living in one area throughout the year
- Indigenous/Native- naturally found in that region (they were not introduced) but they are also found naturally occurring in other regions around the world.
- Introduced- species living outside its native distributional range, which has arrived there by human activity, either deliberate or accidental.

*Other Threatened Species = refers to a species that is not critically endangered, endangered, nor vulnerable but is under threat from adverse factors such as over collection throughout their range and is likely to move to the vulnerable category in the near future.

	
Plate EL-44. Banded bullfrog (*Kaloula pulchra*)	**Plate EL-45.** Man-made traps in the area

Herpetofauna (Amphibians and Reptiles)

Majority (62%) of the herpetofauna recorded in the area are classified as Least Concern under the IUCN Red List of Threatened Species (**Figure EL-26**). These species are considered as widespread and abundant. The Northern Philippine Cobra (*Naja philippinensis)*, locally known as ulupong, classified as Near Threatened under IUCN Red List, was incidentally sighted by the forester team near the beach area. This species is a highly venomous species of spitting cobra native to northern regions of the Philippine islands. It is often considered to be the most venomous of all the "true cobras" or all those species belonging to the genus *Naja.* Where it occurs in the northern Philippines, it is a significant cause of snakebites and fatalities.

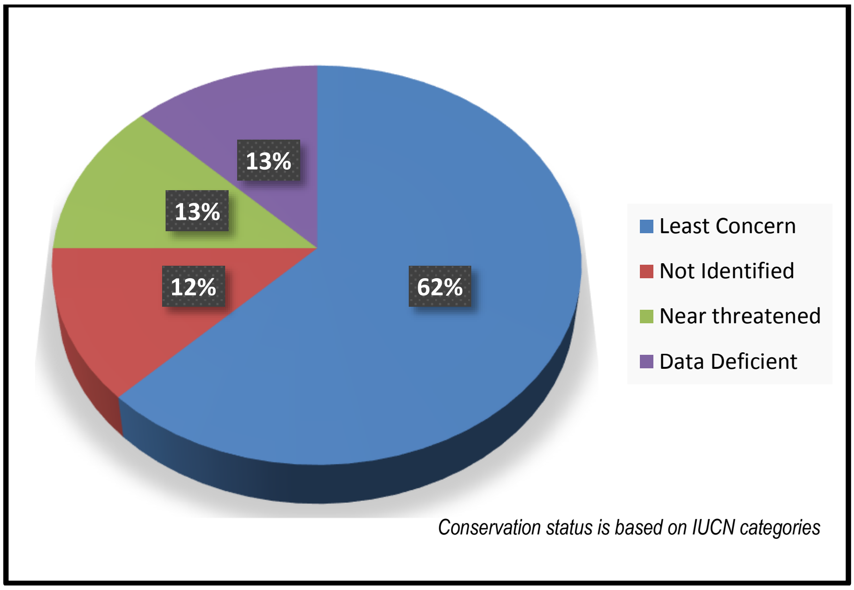
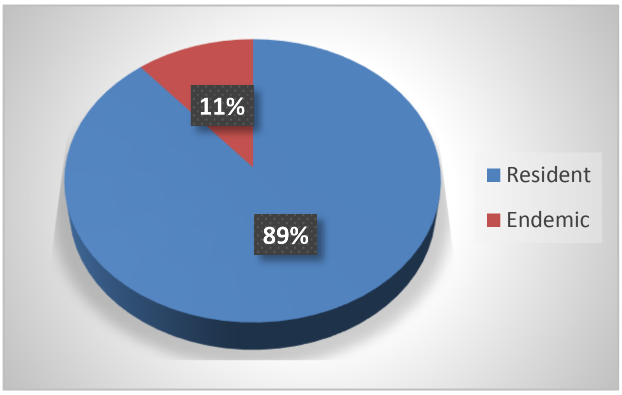


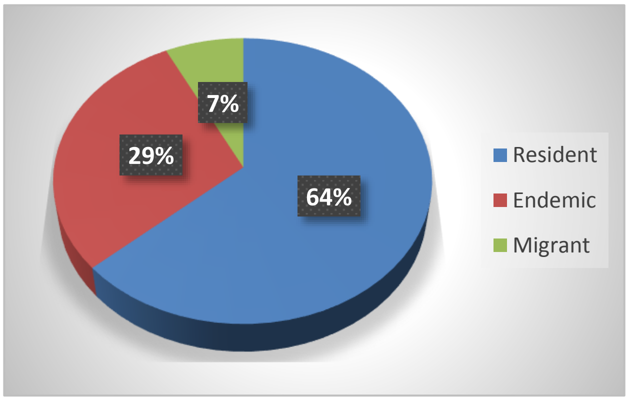
Figure EL-26. Population Status of Herpetofauna Species Recorded in the Site

Distribution Status

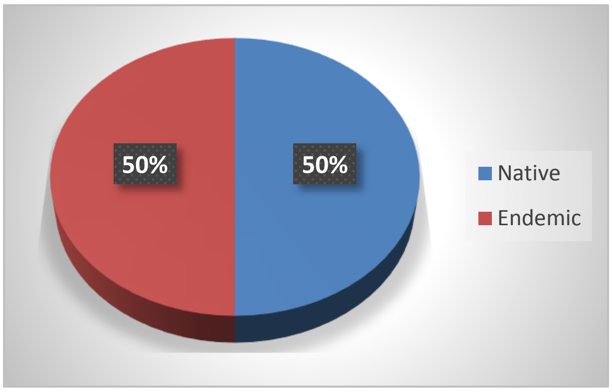
In terms of percentage population distribution of all wildlife species recorded in all sites, 59% (11% for mammals and 64% for birds) are residents, where 29% (11% for mammals, 29% for birds and 50% for amphibians and reptiles) are endemic. Migrant birds composed 5% (7% of all birds species), while native species (all herpetofauna) comprised 7% (50% of all herpetofauna) (**Figure EL-27**).



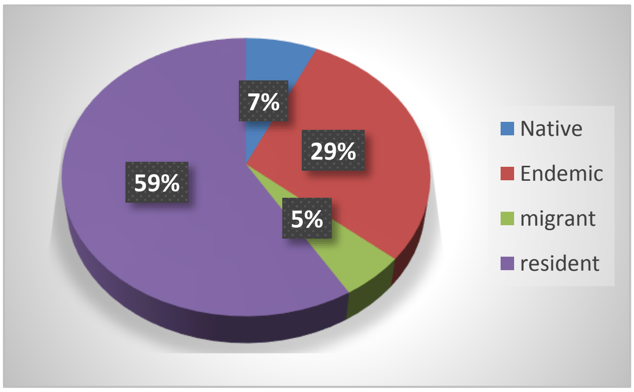
A. Distribution status of Mammals



B. Distribution status of Avifauna



C. Distribution status of Herpetofauna



D. Distribution status of overall wildlife fauna

Figure EL-27. Population Distribution of Wildlife Species Recorded in the Site

Summary of Endemicity/ Conservation Status

Of the observed wildlife population status (based on IUCN assessment), 94% (100% for birds, 100% for mammals and 62% for amphibians and reptiles) are of least concern, 2% (13% for amphibians and reptiles) are near threatened, while another 2% (13% for amphibians and reptiles) are not assessed due to data deficiency and 2% (12% for amphibians and reptiles) are not identified by IUCN (**Figure EL-28**).

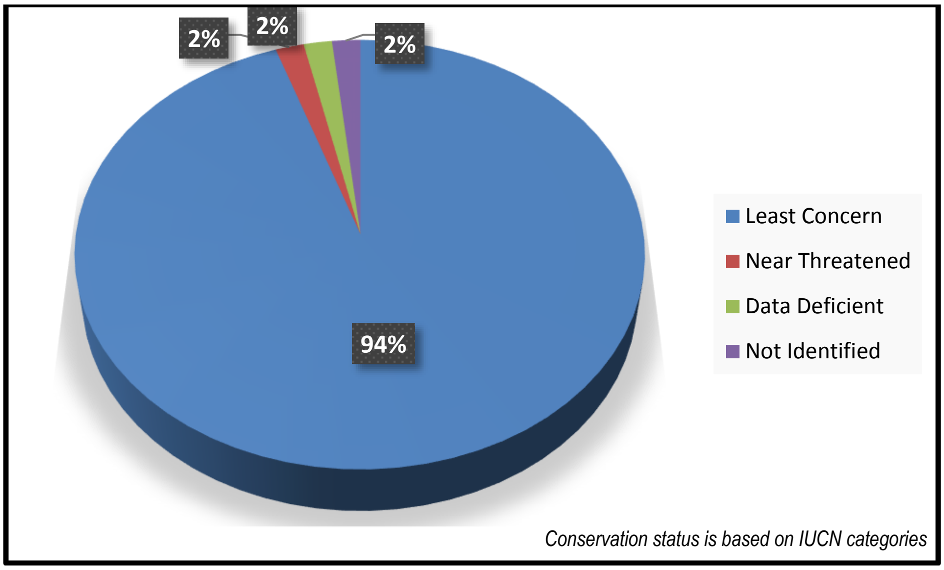


Figure EL-28. Population status of Wildlife species recorded in the site

Habitat Association of Recorded Species

The habitat association of wildlife species recorded concurs with the available habitat types. The surveyed sites consisted of a mosaic of non- forested areas (brushlands and residential areas) and forested areas (secondary growth forest). Most species (31 or 57%) recorded were those associated with forested and open areas while three (3) species (6%) were found in the beach areas (**Figure EL-29**). **Table EL-29** shows the summary of the habitat association and the ecological relationship of wildlife species in the habitat type.

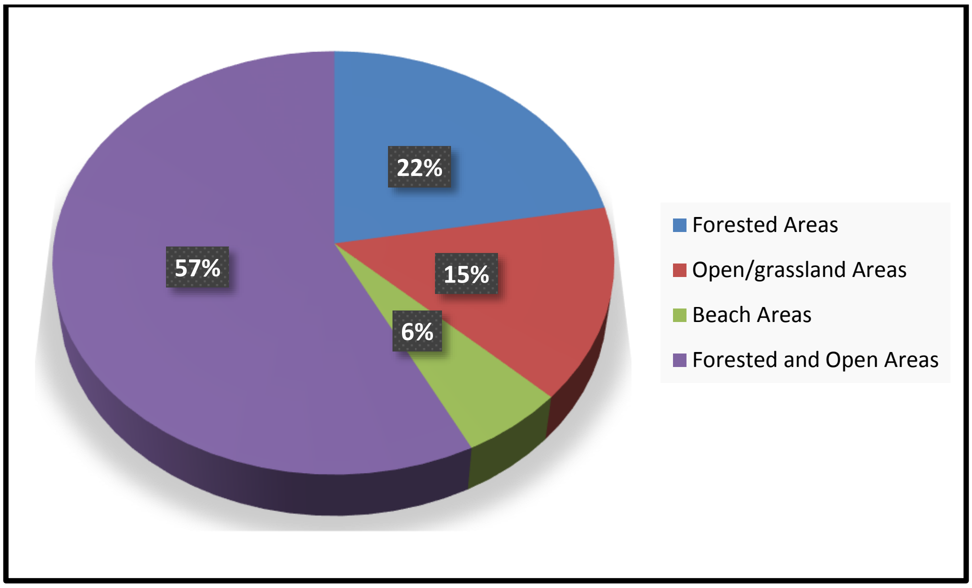


Figure EL-29. Habitat Association of Recorded Species

Table EL-33
Overall Ecology of Flora and Fauna

Sampling Sites	Coordinates/Elevation	Habitat type	Most Number of Individuals per Site			Biotic Components/Characteristics that Influence the Survival of the Species	Abiotic Components/ Characteristics that Influence the Survival of the Species	Ecological Relationships
			Mammals	Avifauna	Herpetofauna			
Site 1	16°50'13.24"N 120°20'20.02"E	Brushland; dominated by Mahogany trees(*Swietenia macrophylla*) with an importance value of 169.65	Lesser short-nosed fruit bat (*Cynopterus brachyotis)* with 25%	*Zosterops nigrorum (* Golden Yellow White-eye) with 6%	*Kaloula pulchra* (Banded bullfrog) with 64%	Biotic factors are living things that directly or indirectly affect organisms within an environment. This includes the organism themselves, other organisms, and interactions between living organisms. Other biotic factors include parasites, competition, disease and predation. Biotic factors are sorted into three groups: <u>Producers</u>: convert energy into food, some using photosynthesis such as fig trees (*Ficus* sp.) <u>Consumers</u>: rely upon producers for food such as Lesser short-nosed fruit bat (*Cynopterus brachyotis); Pycnonotus goiavier* (Yellow-vented Bulbul) and *Zosterops nigrorum (*Golden Yellow White-eye) <u>Decomposers</u>: breakdown chemicals from consumers and producers into simpler forms that used again (microfauna, crabs, flies, termites)	<u>Temperature</u>: Depends on intensity of sun's radiation, which depends on latitude and longitude <u>Availability of gases, water and ions</u> <u>Light penetration</u>: Decreases with depth. Affects availability of plants in water <u>Pressure variation</u>: Pressure varies with depth. Increased depth has increased pressure, Few organisms live at great depths <u>Availability and type of Substrate</u>: Different types of rocks, soils and sands and other materials from rocks. Vary in their mineral and nutrient levels <u>Strength of Natural Forces</u>: Tide, currents, waves may vary <u>Availability of Shelter and Space</u>: Not required for all organisms. Substrate, rocks, vegetation and coral reefs provide shelter. Space is important for animal requiring territory	The whole sampling site is composed of brushland, grasslands and beach thicket of shrubs and small trees bounded the western part of the proposed project site facing the West Philippine Sea. The plant species that were commonly observed in the sites were Mahogany trees (*Swietenia macrophylla*); talisai species (*Terminali cattappa*); ipil-ipil species (*Leucaena leucocephala*); fig tress (*Ficus* sp.) and pandakiki species (*Tabemaemontana pandcaqui*). The wildlife species with the most number of individuals per site are Lesser short-nosed fruit bat (*Cynopterus brachyotis);* Oriental House rat (*Rattus tanezumi*) and Philippine Forest rat (*Rattus everetti)* for mammals. For Avifauna the species with the most number of individuals recorded in each sites are Golden Yellow White-eye (*Zosterops nigrorum);* Pied Fantail (*Rhipidura nigritorquis);* Yellow-vented Bulbul (*Pycnonotus goiavier)* and Kentish Plover (*Charadrius alexandrines*). While for the herpetofauna, the species with the most number of individuals are Banded bullfrog (*Kaloula pulchra);* Brown's mabuya (*Eutropis indeprensa*) and Tokay gecko (*Gecko gecko).* The ecosystem structure observed in the project sites are controlled by a variety of biotic and abiotic factors that act alone and in combination. Almost all definitions of ecosystems refer in some manner to communities of organisms interacting with each other and with biogeochemical factors that collectively represent the environment. The totality of interactions includes species-species interactions such as competition, predation, commensalism and mutualisms (retrieved at cba.fc.ul.pt on September 2, 2016) and an interaction with abiotic variables found in ecosystems such as temperature, light, rain, wind etc. (retrieved at <u>www.study.com</u> on September 3, 2016). For a community or an ecosystem to survive, the correct interactions need to be in place. <u>Interacting</u> <u>species</u> have a tremendous influence on the size of each other's <u>populations</u>. The various mechanisms for these <u>biotic</u> influences are quite different from the way in which <u>abiotic</u> factors affect the size of populations. <u>Biotic</u> factors also regulate the size of populations more intensely. Finally, the influence of biotic interactions can occur at two different levels. <u>Interspecific</u> effects are direct interactions between species, one example of this are the snakes (*Naja philippinensis)* and monitor lizard (*Varanus sp.*) (predator species) that are in the same community and seek the same food resource (e.g. *Kaloula pulchra* (Banded bullfrog), and *Gecko gecko* (Tokay gecko). The <u>intraspecific</u> effects represent interactions of individuals within a single species; one example of this is the *Zosterops nigrorum (*Golden Yellow White-eye) (consumer) this species compete for fig trees (*Ficus* sp.) (producer) that was directly observed during the survey, the possible reason for this is due to limited source of fig trees in the site. Most species appear to be limited in at least part of their geographic range by abiotic factors, such as temperature, moisture availability, soil nutrients etc. No species is adapted to survive under all conditions found on the earth. All species have specific limits of tolerance to physical factors that directly affect their survival or reproductive success. The portion of the abiotic factor's range of variation which a species can survive and function in is commonly defined as the <u>tolerance range</u>. The level within the tolerance range at which a species or population can function most efficiently is termed the <u>optimum</u> (Retrieved at geography.net on September 3, 2016). If the environment have a low viscosity and buoyancy it is easy for the species to move through and be able to support themselves. Expected changes in temperature and
Site 2	16°50'17.18"N 120°20'12.93"E	Beach thicket area; dominated by talisai species (*Terminali cattappa*) with an importance value of 77.51%	*Rattus tanezumi* *(*Oriental house rat) with 15%	*Rhipidura nigritorquis* (Pied Fantail) with 1%	*Eutropis indeprensa* (Brown's mabuya) with 9%			
Site 3	16°50'6.10"N 120°20'17.30"E	-Brushland and grassland; brushland is being the dominant habitat type Dominated by ipil-ipil species (*Leucaena leucocephala*) with an importance value of 42.78%)	*Cynopterus brachyotis* *(*Lesser short-nosed fruit bat) with 10%	*Zosterops nigrorum (* Golden Yellow White-eye) with 5%	*Gecko gecko* (Tokay gecko) with 4%			
Site 4	16°50'4.19"N 120°20'10.82"E	-Brushland and grassland; brushland being the dominant habitat type Dominated by fig trees (*Ficus* sp.)	Lesser short-nosed fruit bat (*Cynopterus brachyotis)* with 12%	*Pycnonotus goiavier* (Yellow-vented Bulbul) with 9%	*Gecko gecko* (Tokay gecko) with 4%			
Site 5	16°49'53.03"N 120°20'1.86"E	Beach thicket area; dominated by pandakiki species (*Tabemaemontana pandcaqui*) with cumulative crown cover of 115	*Rattus tanezumi (*Oriental house rat) with 11%	*Charadrius alexandrinus* (Kentish Plover) with 2%	No records of Herpetofauna			
Site 6	16°49'56.52"N 120°20'10.57"E	Brushland and Grassland; brushland being the dominant habitat type Dominated by ipil-ipil species (*Leucaena leucocephala*) with an importance value of 59.31%	*Rattus everetti* *(*Philippine forest rat) with 6%	*Pycnonotus goiavier* (Yellow-vented Bulbul) with 5%	*Gecko gecko* (Tokay gecko) with 6%			

Table EL-33 continued

Sampling Sites	Coordinates/Elevation	Habitat type	Most Number of Individuals per Site			Biotic Components/Characteristics that Influence the Survival of the Species	Abiotic Components/ Characteristics that Influence the Survival of the Species	Ecological Relationships
			Mammals	Avifauna	Herpetofauna			
								soil moisture availability in the site may have a substantial effect on tree physiology and species distribution in an area. For plants, soil type is a major factor in deciding the type and variety of species growing in a particular area, presence of the species of plant in an area is correlated with the abundance of the wildlife species which is notably observed in the project site. The project site had a few fruit being trees which are positively correlated with the abundance of wildlife species in the site. Both abiotic and biotic factors determine both where an organism can live and how much a population can grow. A **limiting factor** is a factor that restricts the size of a population from reaching its full potential. The amount of food & water in a habitat is an example of a limiting factor. Other factors include **geographical space, predation, climate**, **competition** (for prey, food, mates) etc.

Adequacy of Sampling

Herpetofauna Transect Method

The Cumulative Species Effort Curve for the herpetofauna transect method suggests that for Sites 1, 3 and 6, the sampling effort was sufficient to record all species in the area. This suggests that further observation hours will not yield additional species. For Site 2, 4 and 5, however, data suggests that further sampling may yield additional species of amphibians or reptiles. **Figure EL-30** shows the Cumulative Species Effort Curve the Strip Transect Method for Herpetofauna.

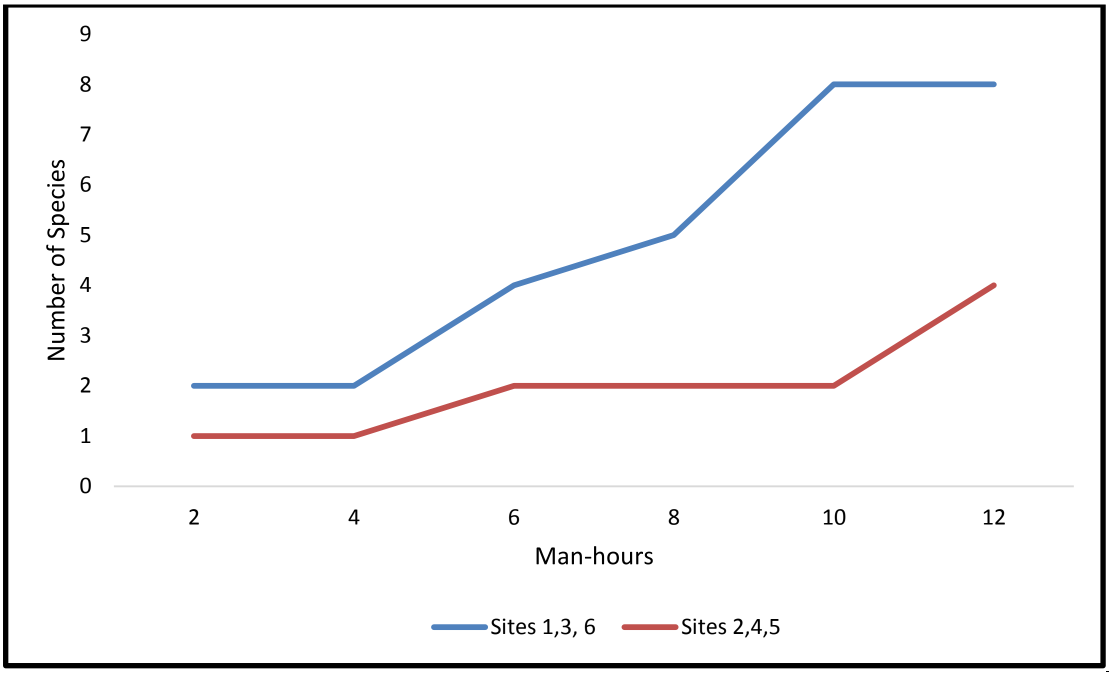


Figure EL-30. Cumulative Species Effort for the Herpetofauna Transect Method

Line Transect Method for Birds

The Cumulative Species Effort Curve for the Line Transect Method (**Figure EL-31**) of the three sites shows an increasing trend even after 12 hours of observation. This suggests that sampling was not enough to record all bird species and that further sampling may yield additional species. This, however, is normal given that birds are free to move around at great distances. The sites may be their nesting grounds or may only serve as foraging areas or flyways.

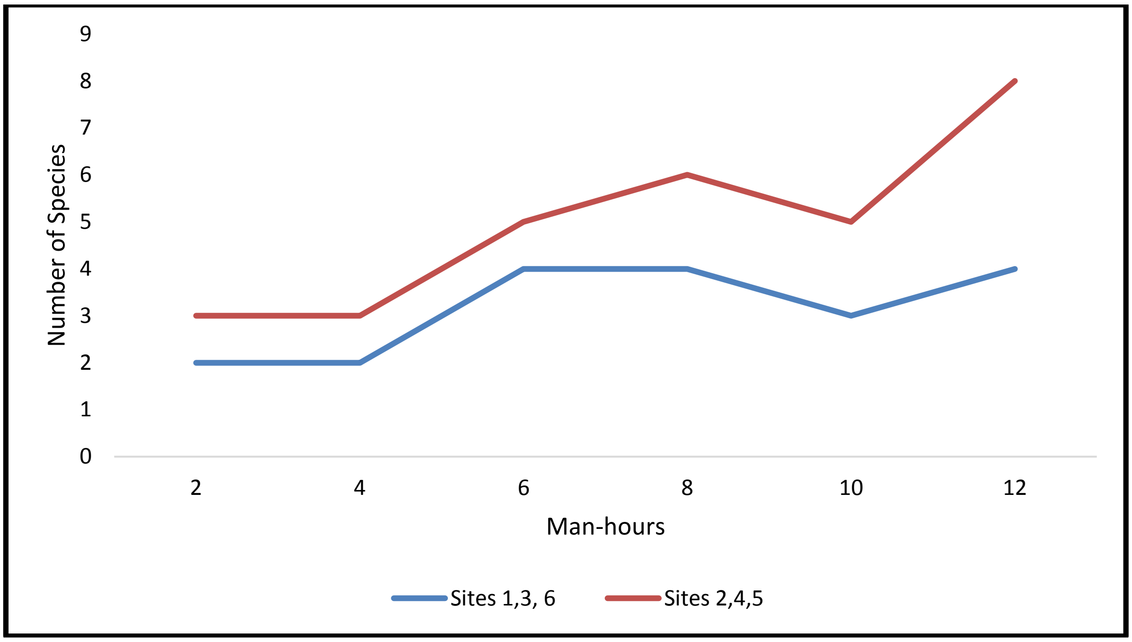


Figure EL-31. Cumulative Species Effort for the Line Transect Method for Birds

Bird Mist Netting

For the netting effort, the Cumulative Species Effort Curve (**Figure EL-32**) for Sites 3, 4, and 6 show an increasing and gradual leveling off. This suggests that sampling was sufficient to record all possible bird species in the area. For Sites 1 and 2, however, further sampling may yield additional species.

Figure EL-32. Cumulative Species Effort for Bird Mist Netting

Noteworthy Species

There are species present in the project area that are considered as noteworthy by virtue of several characteristics: (1) listed as globally threatened by IUCN, and (2) heavily exploited for food or pets. One species of reptile, the Northern Philippine Cobra (*Naja philippinensis*) is considered as nearly threatened; Philippine Water Monitor Lizard (*Varanus marmoratus*) and Tokay Gecko *(Gecko gecko*) are heavily hunted for food and for medicinal used.

Culturally Significant Fauna

There are no culturally significant fauna identified in the project site. Local people consider wildlife animals as a source of food and a substitute for chicken and pork meat. They hunt wildlife within their vicinity and nearby forest for food and not in any other traditional or cultural manner.

Biodiversity Parameters: Species Richness, Diversity Indices and Abundance

Among all the sites, Site 6 has the highest species richness and abundance followed by Site 4. Site 2 has the lowest species richness and abundance. The high diversity and abundance of species in Site 6 and 4 may be attributed to the relatively higher forest cover, humidity and solar exposure of the area compared to Sites 1, 3 and 5 (**Figure EL-33**).

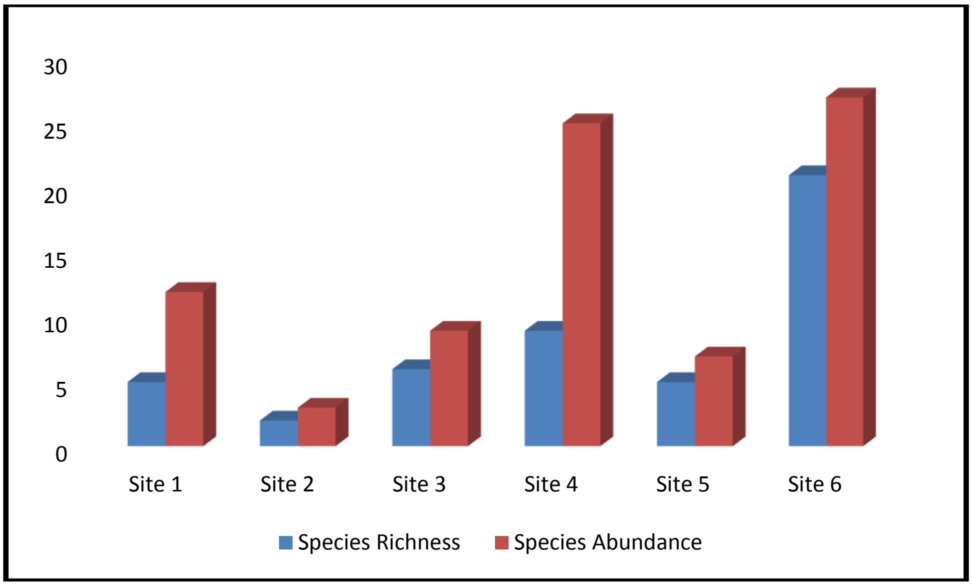


Figure EL-33. Wildlife Species Richness and Abundance Across all Sites

Alpha diversity indices for the entire area were computed using Paleontological Statistics (PaSt v. 3.0). **Table EL-34** summarizes the diversity indices of all wildlife groups for each site.

A total of 343 individuals from 54 wildlife species were found within the study area. The Shannon index of diversity reveals moderate to high diversity values for the study sites, with Site 6 being the most diverse. The dominance is not significantly high, suggesting that no one species dominates the area and that the distribution of the species is relatively even.

Table EL-34
Wildlife Diversity in the Proposed Project Area

Site Locations	Richness	Abundance	Dominance	Diversity	Evenness
Site 1	12	6	0.1848	3.9791	0.1129
Site 2	3	3	0.3580	2.1217	1.9312
Site 3	9	6	0.1681	3.5126	1.5986
Site 4	25	9	0.1175	5.3029	1.6474
Site 5	7	5	0.2108	3.4003	1.7473
Site 6	27	21	0.0469	6.3172	1.9167

Figure EL-34 shows the population sizes of individual wildlife species in the project area. Among 348 individuals of wildlife species observed, the Black-bearded tomb bat (*Taphozous melanopogon*) had the highest number of individuals recorded in the project area with a total number of 105 individuals followed by the Yellow-vented Bulbul (*Pycnonotus goaivier*) with 56 individuals, the Golden Yellow White-eye (*Zosterops nigrorum*) with 39 individuals. The Long tailed Shrike (*Lanius schach*) had the least number of species with 1. It indicates that *T. melanopogon* are more successful inhabitants and more stable among the other species in the project area. *T. melanopogon* is sometimes found in caves, however there was no caves seen in the project area, this species found roosting in the Sport Complex near the project area. *T. melanopogon* prefers light zone areas near entrances (Mackinnon et al., 1996). This species uses visual aid for orientation during day light hours, which is evident by their comparatively large eyes (Philipps, 1980). It was the most number of individuals found in the study site. It can be due to the availability of light penetrating establishment at the study site.

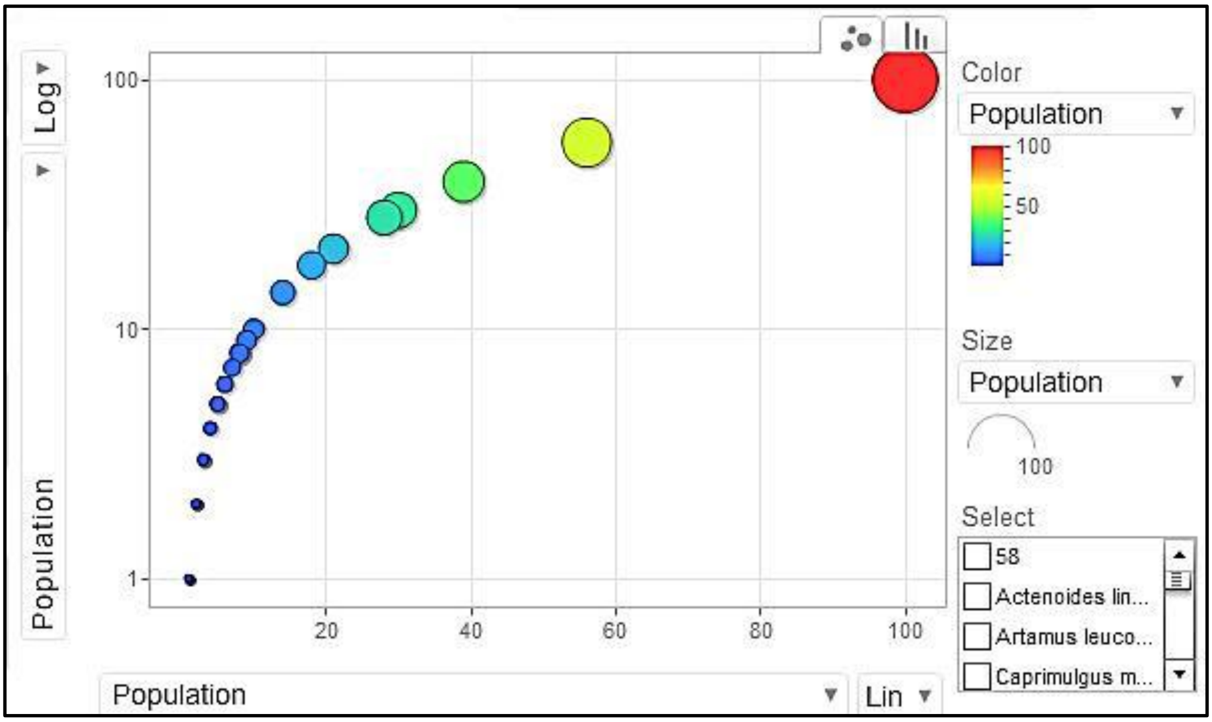


Figure EL-34. Population Sizes of Wildlife Species in the Project Area

Economic and Ecological Services of the Ecosystem

Ecosystem services are the benefits obtained from the environment that increase human well-being. Economic valuation is conducted by measuring the human welfare gains and losses that result from changes in the provision of ecosystem services. Around the world, small mammals act as pollinators, seed dispersers, support forest regeneration and maintain forest health, aerate soil and allow for increased plant diversity, control insects, provide food for people and other carnivores, provide fur and pelts, provide recreational opportunities in the form of hunting and wildlife viewing, and have an aesthetic value to many (retrieved at mjmerrick.wordpress.com on August 21, 2016).

Amphibians and reptiles represent a high proportion of global species diversity and include species that are widely distributed throughout the world and play a variety of roles that benefit humans. Within the amphibian and reptile groups, some species are important historical and current food sources for the inhabitants of rural areas in different parts of the world and are utilized to meet basic subsistence needs (Mittermeier et al. 1992; Thorbjarnarson et al. 2000). In many cultures, particularly those with limited or no access to primary medical services, animals have been used as medicinal sources and are integral to healing practices (Alves et al. 2007, 2009). Reptiles are among the most utilized animal groups in traditional folk medicine, and their role in the prevention and cure of disease has been reported in various socio-cultural contexts worldwide (Alves &Santana 2008). However, none of the roles described above are rendered by the amphibian and reptile species observed at the site.

Overall, wildlife species found in the project site will be affected during the construction phase. Impacts that may affect these species include disturbance and loss of habitat due to vegetation clearing in the area as well as construction noise. None of the species are threatened or vulnerable and therefore no loss of important local species will occur. Vegetation clearing and the movement of workers will be limited to designated areas only. GLEDC will ensure compliance with all regulations relevant to minimizing noise generated by construction activities/equipment to minimize noise-related disturbances to wildlife.

Wildlife access, on the other hand, will not be impeded. Development of the project facilities is near the coastal area where, according to the survey, only a small number of wildlife species were found. Impact on wildlife access will be mostly seen among animals with limited dispersal such as amphibians and reptiles. However, there were only 7 species of reptiles and 1 species of amphibian found in the project area. Birds and mammals, on the other hand, are a dispersed group of animals. In the presence of any disturbances during construction (e.i materials and equipment that may limit their area of movement), these animals will temporarily find a new place for their activities (e.i foraging, refuge) and will be back to normal as soon as reforestation and other efforts are implemented by the proponent after the construction phase.

1.5.4 Summary of Potential Impacts and Mitigation Measures for Terrestrial Fauna

Table EL-35
Summary of Impacts Related to Terrestrial Fauna

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
I. Construction Phase			
Impacts to wildlife due to habitat loss	Terrestrial fauna - Avifauna	Birds are highly mobile animals and are likely to be driven away during the clearing of vegetation and by construction noise. All of the birds found in the 6 study sites, however, are categorized as least concern under the IUCN listing and therefore the project will not impact any important species. Although their habitats within the project site	• During the operation phase, a vegetation area that will eventually host the same species of avifauna impacted during the

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
		will be removed as a result of the removal of vegetation, it is expected that the birds will relocate to adjacent habitats that will not be affected by construction activities and the ensuing noise generated	construction phase will be developed.
Impacts to wildlife due to habitat loss	Terrestrial fauna - Mammals	Similar to birds, mammals found in the project site are all of high abundance. All were also listed with least concern status, some of them even considered as pests. The removal of vegetation is thus expected to impact the mammals minimally. The civet cat will most likely move to areas outside of the project site where coffee plants are in greater abundance.	• No mitigation measures needed.
Disturbance and displacement of fauna	Terrestrial fauna	Overall, wildlife species found in the project site will be affected during the construction phase. Impacts that may affect these species include disturbance and loss of habitat due to vegetation clearing in the area as well as construction noise. None of the species are threatened or vulnerable and therefore no loss of important local species will occur. Impact on wildlife access will be mostly seen among animals with limited dispersal such as amphibians and reptiles. In the presence of any disturbances during construction, these animals will temporarily find a new place for their activities and will be back to normal as soon as reforestation and other efforts are implemented by the proponent after the construction phase.	• GLEDC will ensure compliance with all regulations relevant to minimizing noise generated by construction activities/equipment to minimize noise-related disturbances to wildlife. • Vegetation clearing and the movement of workers will be limited to designated areas only. • Wildlife access will not be impeded.

1.5.5 Monitoring Plan for Terrestrial Fauna

Restoration/rehabilitation of nearby forested areas will be carried out to ensure that alternative wildlife refuge will be available. Populations may recover over time and other wildlife species may be recruited in the area with the rehabilitation of nearby forested areas. Protection from hunters will be afforded to wildlife species once the boundaries of the area have been sealed. Monitoring wildlife species will take place before clearing, after clearing and then every three to six years during operation. Thereafter the schedule is to be reviewed based on results. GLEDC will provide financial support for enhanced ranger patrol operations.

Monitoring of noise will be carried out at construction sites and access roads as part of the regular monitoring activities.

2.0 Water Module

2.1 Hydrology/Hydrogeology

2.1.1 Methodology

2.1.1.1 Watershed Delineation

The watershed of Darigayos River and its sub-basins, where the proposed coal-fired power plant is to be located are delineated using the 1: 50,000-scale NAMRIA topographic map of Bangar and San Fernando La Union as well as the generated topographic map from the Shuttle Radar Topography Mission (SRTM) - Digital Elevation Model (DEM) as shown in **Figure EW-1** and **Figure EW-2**.

2.1.1.2 Rainfall and Streamflow Measurements

In this study, secondary rainfall and climatologic data of the relevant synoptic/rainfall stations are acquired from PAGASA while streamflow records are obtained from the publications of DPWH-BRS. The rainfall data and climatologic norms of Baguio, Dagupan, and Vigan synoptic stations are utilized to estimate the mean monthly rainfall and temperature at the study area. On the other hand, the stream flow records at Borobor, Maragayap, Baroro, Bauang, and Buaya stream gauging stations are employed to calibrate the model used in estimating the stream flows at the study area.

2.1.1.3 Spring and Well Point Inventory

Data gathering and field investigation were done to determine the existing water uses and consumption within the study area that includes the project site and adjacent areas that may be affected by the proposed power plant project. Spring and well point inventory, streamflow estimation and informal interviews with well owners and local residents were conducted on August 2 and 3, 2016.

The potential production of each well was estimated in the inventory. The flow measurements for springs and wells were carried out using the volumetric method.

It is noted that the surface water flow was relatively low at the time of observation based from the interviews and field investigations conducted in the study area. Stream flow measurements for open channels were estimated using the float method. The specific locations of all the stations in latitude-longitude coordinates were recorded using a GPS instrument.

2.1.1.4 Water Dependability Analysis

For the water dependability impact assessment of the project site, a water availability and dependability analysis was conducted. The study includes (1) rainfall estimation within the study area, (2) generation of monthly streamflows for Darigayos River, (3) calibration and validation of the generated monthly streamflows, and (4) generation of flow duration curves to determine the dependable flows of the river.

Rainfall estimation at the study area is done by utilizing the Baguio, Dagupan and Vigan synoptic stations. Although the project site is located along the coast and at low elevation like the Dagupan and Vigan stations, the watershed of Darigayos River emanates from the ridge separating Darigayos and Amburayan basins at a peak elevation of 255 meters. In this case, elevation was also considered in the rainfall estimation of the study area, hence the use of the Baguio station. Missing records are first estimated by normal-ratio method and then the inverse-distance method of interpolation is employed to generate the monthly rainfall estimates at the study area.

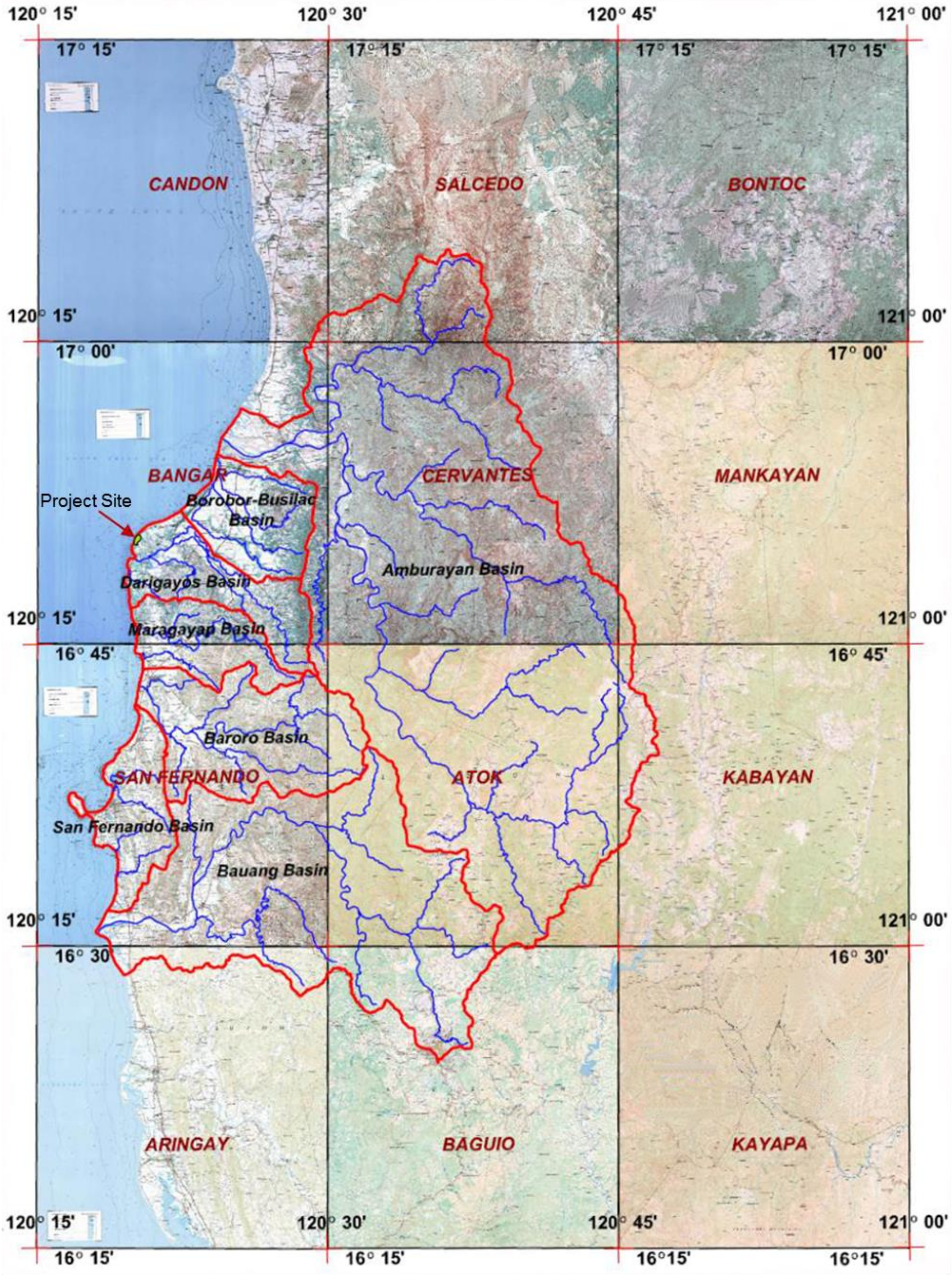


Figure EW-1. Configuration of Watersheds Surrounding the Project Site	**LEGEND:** Watershed Boundary Project Site Main Rivers and Tributaries	**SCALE: 1:80,000**
ENVIRONMENTAL IMPACT STATEMENT **2x335MW COAL-FIRED POWER PLANT PROJECT**	**DATA INFORMATION/SOURCE:** **Source Map: NAMRIA Topographic, 2016** **Modified By:** Aperçu_AConjares	aperçu CONSULTANTS INC. **PAGE: 153**

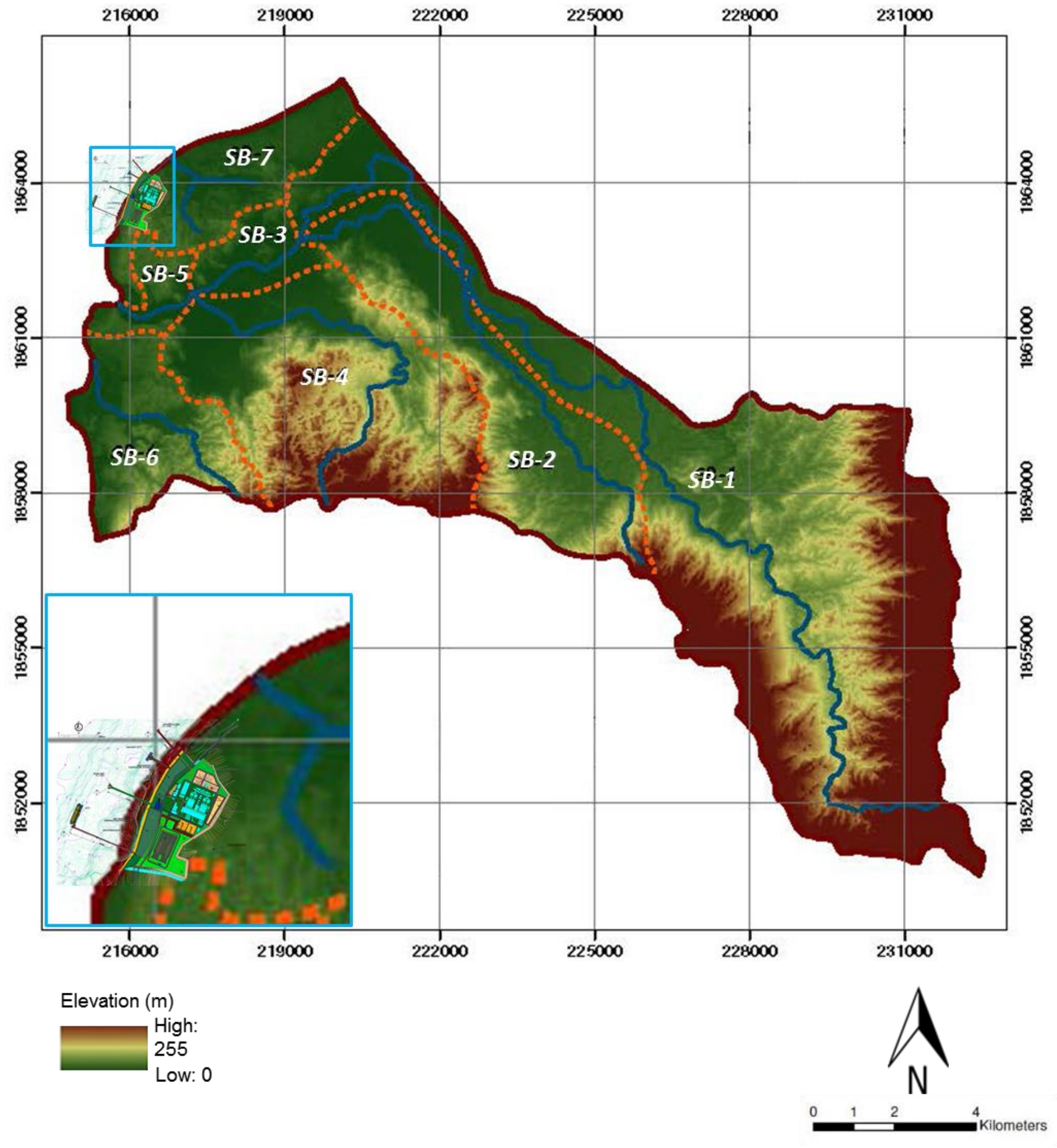


Figure EW-2. Basin and Sub-basin Delineations of Darigayos River and Proposed Site of Coal-Fired Power Plant

LEGEND:
Basin Boundary
Project Site
Sub-Basin Divide
Rivers/ Tributaries

SCALE: 1:50,000

ENVIRONMENTAL IMPACT STATEMENT
2x335MW COAL-FIRED POWER PLANT PROJECT

DATA INFORMATION/SOURCE:
Source Map: SRTM- DEM, 2016
Project Layout: GLEDC, 2017
Modified By: Aperçu_AConjares

aperçu CONSULTANTS INC

2.1.1.5 Water Balance Study

For the water balance impact assessment of the project site, water balance models were used to account and analyze the various components of the hydrologic cycle such as precipitation, evapotranspiration, groundwater recharge, and runoff. In this study, the Thornthwaite water balance model is utilized to estimate the amount of water that goes into the different hydrologic components of the study area.

The first input parameter in the model is the time series of estimated monthly rainfall in the area (referred to as P_{RAIN}). Direct runoff (*DRO*) is runoff from impervious surfaces or runoff resulting from infiltration-excess overflow and is computed as $DRO = P_{RAIN} \times drofrac$. The *drofrac* is the fraction of P_{RAIN} that becomes *DRO* and is usually based on previous water balance or is calibrated from observed rainfall and streamflows in the area. Direct runoff (*DRO*) is subtracted from P_{RAIN} to compute the amount of remaining precipitation (P_{REMAIN}).

Actual evapotranspiration (*AET*) is derived from potential evapotranspiration (*PET*), P_{REMAIN}, soil moisture storage (*ST*), and soil moisture storage withdrawal (*STW*). Monthly *PET* is estimated from mean monthly temperature (*T*) and is defined as the water loss from a large, homogenous, vegetation-covered area that never lacks water. Thus, *PET* represents the climatic demand for water relative to the available energy and is calculated in this water balance using the Hamon equation. The mean monthly temperature, number of days in month, mean monthly hours of daylight, and saturated water vapor are considered in this equation.

When P_{REMAIN} for a month is less than *PET*, then *AET* is equal to P_{REMAIN} plus the amount of soil moisture that can be withdrawn from storage in the soil. Soil moisture storage withdrawal linearly decreases with decreasing *ST* such that as soil becomes drier, water becomes more difficult to remove from the soil and less is available for *AET*. *STW* is computed as follows:

$$STW = ST_{i-1} - \left[abs(P_{REMAIN} - PET)x\left(\frac{ST_{i-1}}{STC}\right)\right]$$

Where ST_{i-1} is the soil moisture storage for the previous month and *STC* is the soil moisture storage capacity.

If the sum of P_{REMAIN} and *STW* is less than *PET*, then a water deficit is calculated as *PET-AET*. If P_{REMAIN} exceeds *PET*, then *AET* is equal to *PET* and the water in excess of *PET* replenishes *ST*. When *ST* is greater than *STC*, the excess water becomes surplus (*S*) and is eventually available for runoff.

Runoff (*RO*) is generated from *S* at a specified rate (*rfactor*). The *rfactor* parameter determines the fraction of surplus that becomes runoff in a month. The remaining surplus is carried over to the following month to compute total *S* for that month. Direct runoff (*DRO*) is added directly to the runoff generated from surplus (*RO*) to compute the total monthly runoff (RO_{TOTAL}).

2.1.1.6 Climate Change Analysis

Climate change analysis on rainfall and temperatures in 2020 and 2050 at the site was based on the paper "*Climate Change in the Philippines, 2011*" published by the PAGASA.

2.1.2 Drainage Morphology

2.1.2.1 Hydrological Setting and Drainage System

The proposed 2x335MW Coal-Fired Power Plant Project dwells within the boundary of Darigayos River basin, which is bordered by the Borobor-Busilac River basin in the north, the Maragayap River basin in the south, and the West Philippine Sea in the west. The two nearby major river basins are the Amburayan (1,290 sq. km.) and Bauang River basins (538 sq. km.), which are 13 km and 35 km away from the project site, respectively. **Figure EW-3** shows the configuration of the river basins around the proposed coal-fired power plant project.

The study area of the proposed Coal-Fired Power Plant Project in Luna, La Union, as per the hydrology module, will be composed of the proposed 41-hectare project area, the Darigayos River basin watershed and drainage

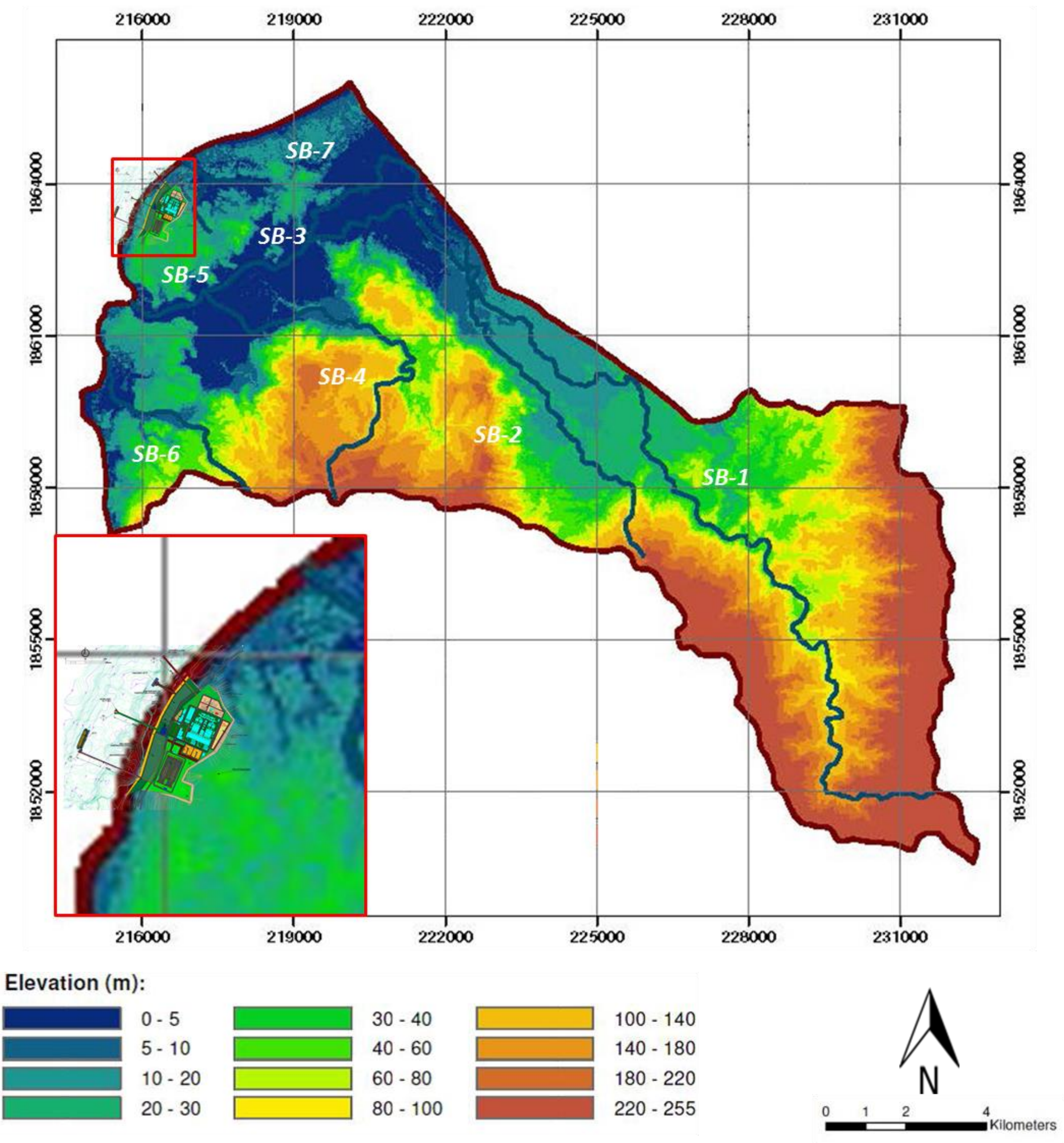


Figure EW-3. Generated Topographical Map of Darigayos River

ENVIRONMENTAL IMPACT STATEMENT
2x335MW COAL-FIRED POWER PLANT PROJECT

LEGEND:
Basin Boundary
Project Site
Rivers/ Tributaries

DATA INFORMATION/SOURCE:
Source Map: SRTM- DEM, 2016
Project Layout: GLEDC, 2017
Modified By: Aperçu_AConjares

SCALE: 1:50,000

aperçu CONSULTANTS INC.

system encompassing the project site. Darigayos River basin has a total catchment area of 103 sq. km. with 15.5 sq. km. of the area directly draining to the ocean. This includes the proposed 41-hectare power plant site. The project area is drained by an approximately 4-meter width ground depression originating from the project site and directly draining to the West Philippine Sea. On the other hand, the project site is around 2 km away from the Darigayos River, which has an approximate length of 28 km.

The original drainage morphology of the area will be altered when construction of the power plant commences. Earthworks such as grading, filling, and excavation will be done in the project site. Any affected portion of the ground depression, however, will be either re-aligned or installed with culvert pipes to make sure that any outflow will continue un-impeded and no flooding will occur in the area. Culvert pipe installation may seem the most practical and convenient option. Drainage system of the plant can be designed or directed towards the location of the ground depression. However, pending finalization of the power plant's overall design and layout including the drainage system, realignment will be considered an option.

Channel ditches and/or pipe drains will be provided to carry generated flows, around the area being developed, to the main storm water outfalls leading to the main river channel (ground depression) and/or directly to the West Philippine Sea. Before the existing drainage and ground depressions are backfilled, the proposed alignment and/or improvement of the main drainage system and storm water outfalls directly leading to the sea will already be constructed.

2.1.2.2 Watershed and Floodplain Delineation

Darigayos River basin is sub-divided into seven sub-basins that is comprised of 3 main river reaches (upstream, midstream, and downstream), 2 tributary rivers and 2 creeks that directly discharge to the sea. The river emanates from the ridge separating Darigayos and Amburayan basins at a peak elevation of 255 meters, which travels in a northwest direction before discharging to the West Philippine Sea. The project site, which is situated in sub-basin 7, is around 2 km away from the Darigayos River.

Based on the delineation, the topographic parameters that include the drainage area, main river length, stream slope and average overland flow slope are generated for each river sub-basin. The summary of the generated topographic parameters are presented in **Table EW-1**.

Table EW-1
Summary of Topographic Parameters for Darigayos River Sub-basins

Sub-Basin No.	Rivers/ Tributaries/ Creeks	SB Drainage Area (km^2)	Main Stream Length (m)	Main Stream (Slope)	Overland Flow Slope
SB-1	Darigayos River (Upstream)	47.818	24,818	0.0202	0.0898
SB-2	Tributary 1	15.212	12,368	0.0135	0.0661
SB-3	Darigayos River (Midstream)	2.986	2,539	0.0024	0.0115
SB-4	Tributary 2	20.014	9,471	0.0228	0.0454
SB-5	Darigayos River (Downstream)	2.169	1,702	0.0012	0.0243
SB-6	Creek 1	8.163	4,551	0.0198	0.0581
SB-7	Creek 2	7.346	1,864	0.0021	0.0106

As described in the land use section (**Section 1.1.2**), the project site is composed mainly of shrubs, wooded land and partly of natural grassland. The slope map of the study area generated using the STRM digital elevation is shown in **Figure EL-5** of the land module.

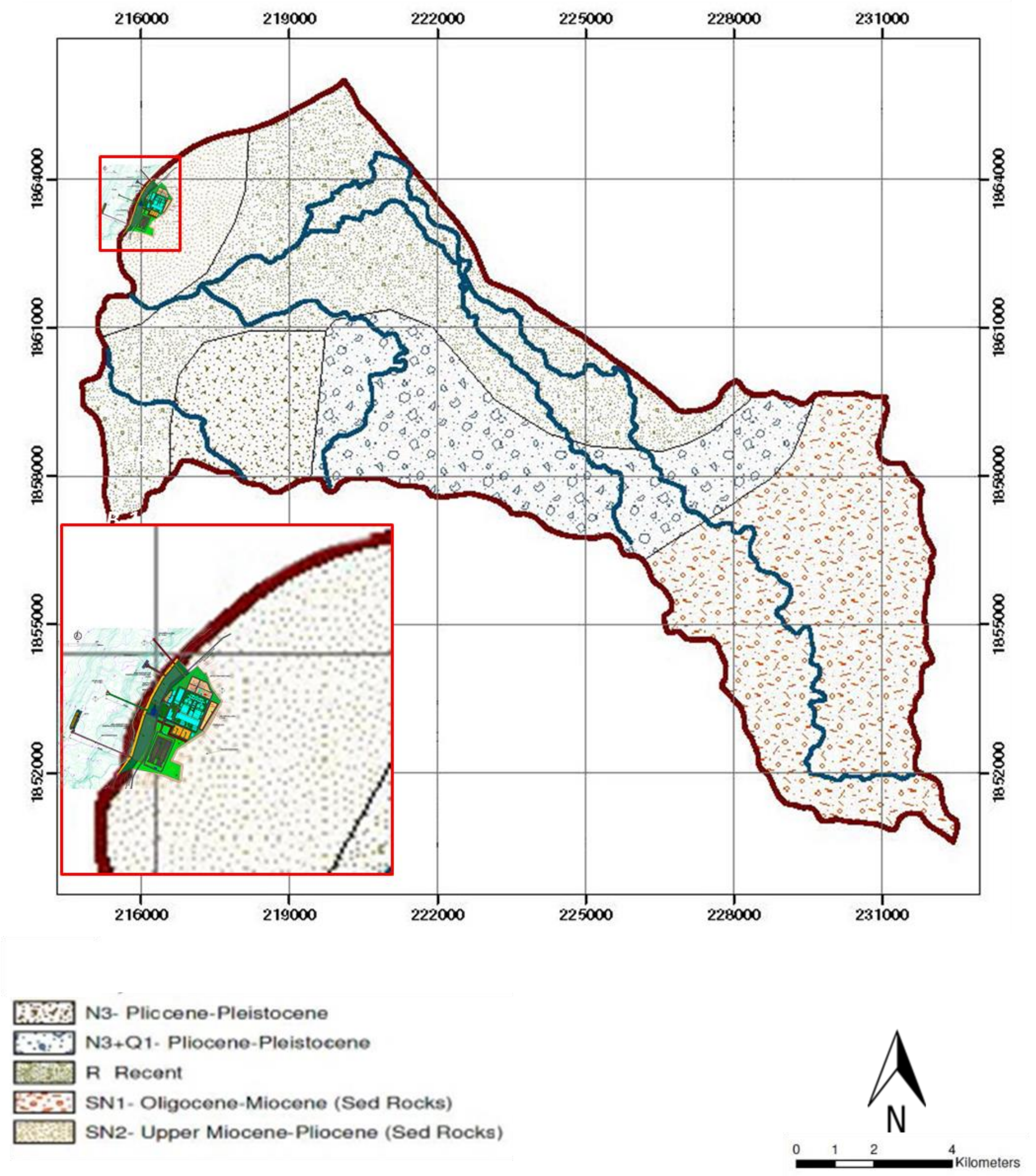


Figure EW-4. Geologic Map of Darigayos River	LEGEND: Basin Boundary; Project Site; Rivers/ Tributaries	SCALE: 1:50,000
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: **Source Map:** SRTM- DEM, 2016 **Project Layout:** GLEDC, 2017 **Modified By:** Aperçu_AConjares	aperçu CONSULTANTS INC. PAGE: 158

2.1.2.3 Hydrogeological Setting and Identification of Aquifer

The study area is situated in Bauang-Amburayan Basins (NWRB Framework Plan, 1983). The basin is largely an elevated coastal tract of raised coral and alluvium overlying older sediments. The eastern boundary of the plain is an escarpment, which has been caused partly by a fault and is partly the edge of extrusives. The hills and low mountains are gently folded sandstones and shales; a wide variety of metamorphic, dioritic and basic intrusive and volcanic rocks underline the higher mountains in the southeastern part of the basin. The geologic map of Northern Luzon is shown in **Figure EL-4** (Land Module) while the geologic map of the Darigayos river basin is shown in **Figure EW-4**.

The midstream and downstream portions of Darigayos River is a floodplain that is composed of recent alluvium that extends up to Amburayan River. On the other hand, around 4 km along the coast and 2 km inland overlies largely marine clastics overlain by extensive, locally transgressive pyroclastics and tuffaceous sedimentary rocks. This is where the project site is situated. Hence, the study area, as well as the project site, contains localized and less productive aquifers. This is depicted in **Figure EW-5**, which shows the groundwater availability map of northern Luzon and the study area.

2.1.3 Rainfall and Stream Flow Measurement

Table EW-2 summarizes the rainfall and streamflow data used for the study while **Figure EW-6** shows the location of these rainfall and stream gauging stations around the study area.

On the other hand, **Tables EW-3** to **EW-5** present the average monthly rainfall values as well as the statistical parameters for Baguio, Dagupan, and Vigan synoptic/rainfall stations, respectively. **Tables EW-6** to **EW-10** present the average monthly streamflow records as well as the statistical parameters for Borobor, Maragayap, Baroro, Bauang, and Buaya stream gauging stations, respectively.

Table EW-2
Summary of Rainfall and Streamflow Data Used for the Study

Station	Location	Agency	Latitude	Longitude	Period of Record		No. of Yrs of Record	No. of Yrs w/ Comp. Data	Data Used
					From	To			
Rainfall									
Bagio	Baguio City, Benguet	PAGASA	16º24'36"N	120º36'00"E	1974	2015	42	42	Monthly
Dagupan	Dagupan, Pangasinan	PAGASA	16º05'13"N	120º21'08"E	1974	2015	42	42	Monthly
Vigan	Sinai, Ilocos Sur	PAGASA	17º53'23"N	120º27'35"E	1974	2015	42	34	Monthly
Streamflow									
Borobor River	Rising, Luna, La Union	DPWH-BRS	16º51'51"N	120º24'48"E	1985	1988	4	2	Monthly
Maragayap River	Bacnotan, La Union	DPWH-BRS	16º45'20"N	120º20'22"E	1984	1991	8	6	Monthly
Baroro River	San Juan, La Union	DPWH-BRS	16º40'50"N	120º22'50"E	1984	1989	6	5	Monthly
Bauang River	Bauang, La Union	DPWH-BRS	16º31'26"N	120º20'48"E	1986	1989	4	2	Monthly
Buaya River	Sta. Cruz, Ilocos Sur	DPWH-BRS	17º06'00"N	120º27'48"E	1985	1988	4	3	Monthly

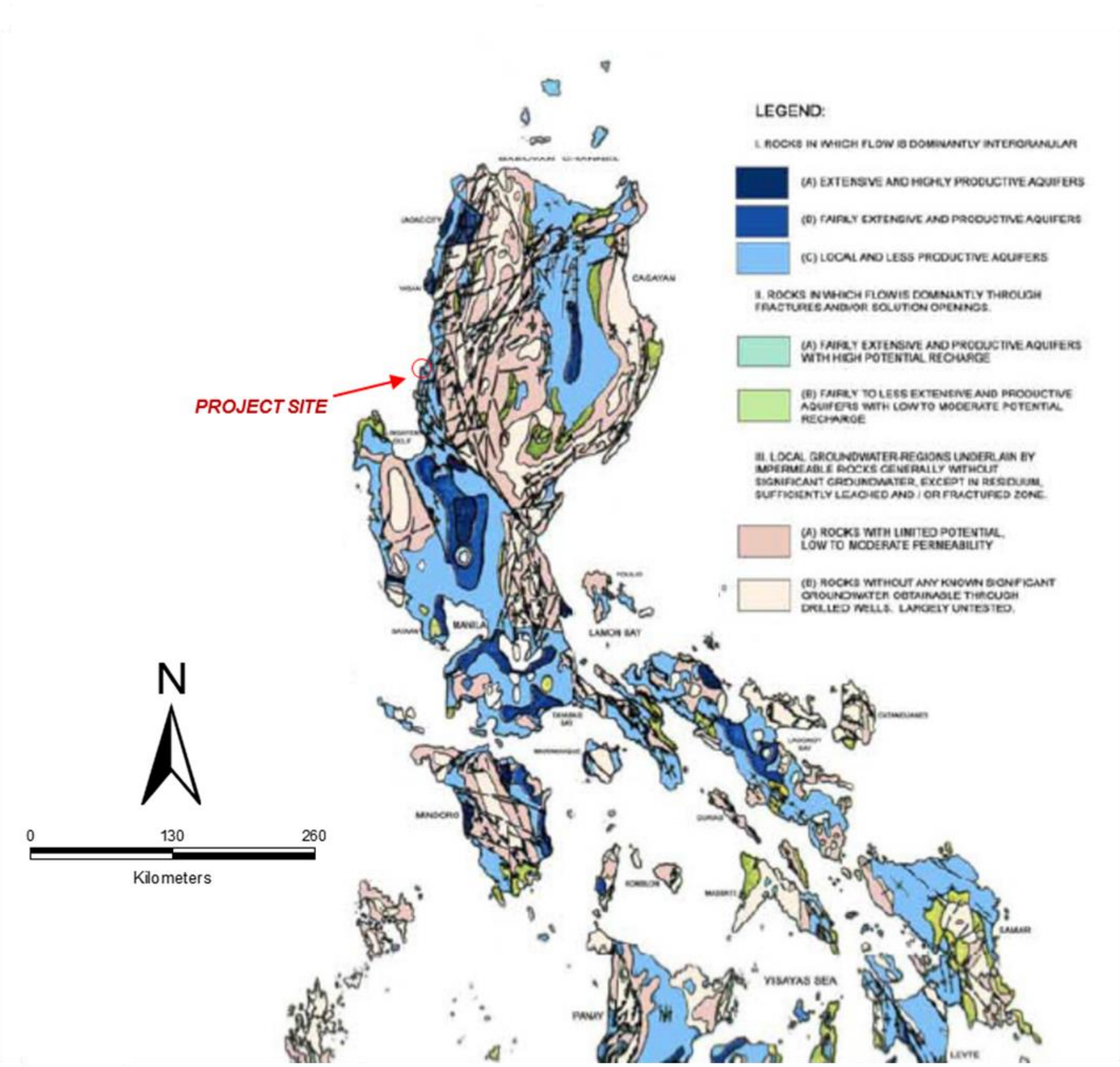


Figure EW-5. Groundwater Availability Map of the Project Site	LEGEND: Project Site	SCALE: As Above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: Source Map: NWRB, 2016 Modified By: Aperçu_AConjares	PAGE: 160

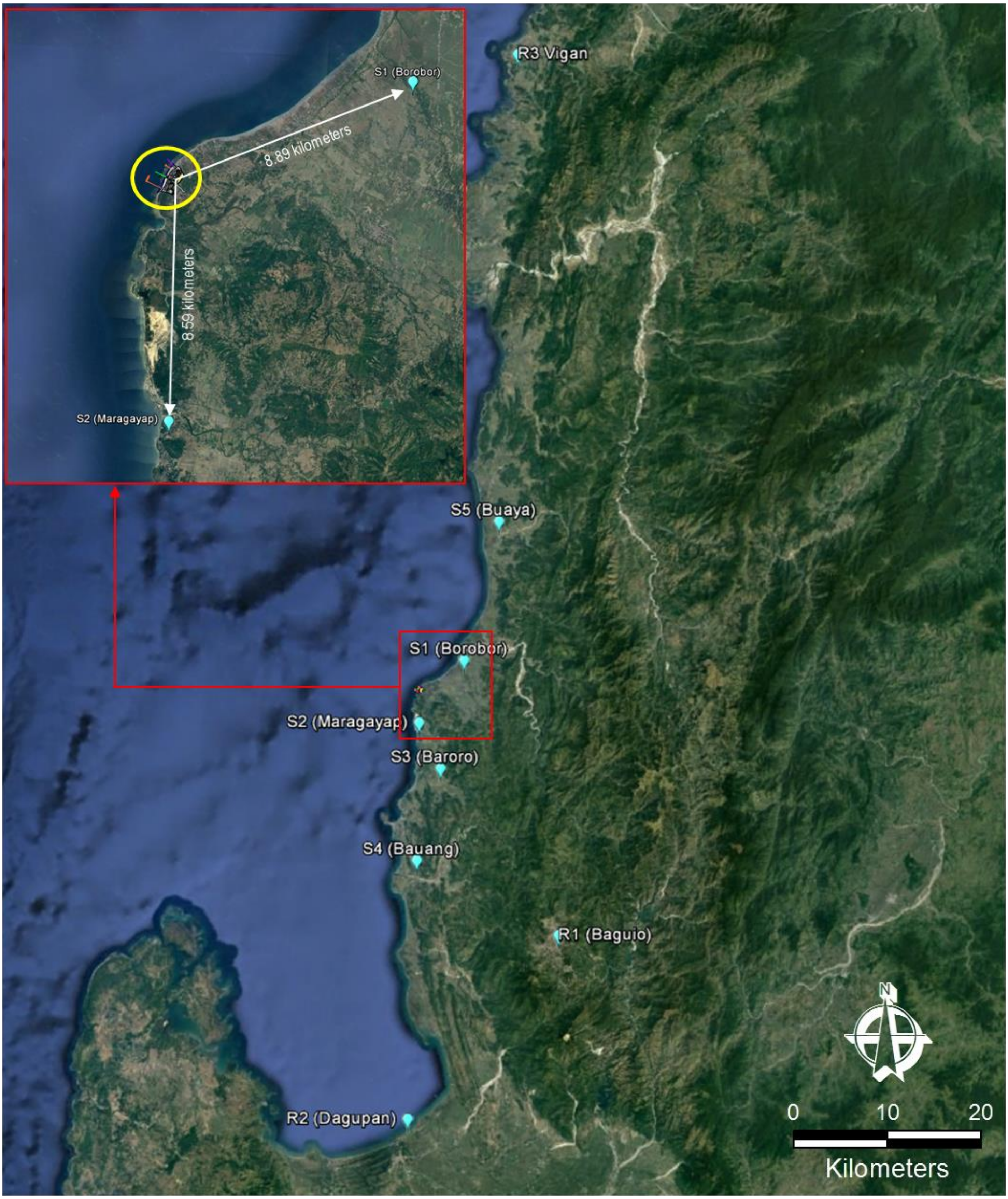


Figure EW-6. Location of PAGASA Synoptic/Rainfall Stations and DPWH-BRS River Gaging Stations

LEGEND: Rainfall Gauging and Streamflow Gauging Stations; Project Site

SCALE: 1: 600,000

ENVIRONMENTAL IMPACT STATEMENT
2x335MW COAL-FIRED POWER PLANT PROJECT

DATA INFORMATION/SOURCE:
Base Map: Google Earth Imagery, 2016
Imagery Date: 15 May 2017
Project Layout: GLEDC, 2017
Modified By: Aperçu_AConjares

aperçu CONSULTANTS INC.

Table EW-3
Summary of Monthly Rainfall Data for Baguio Synoptic Station

Proposed 2x335MW Coal-Fired Power Plant Project in Luna													
Monthly Rainfall in mm													
					Station No.:		100						
					Station Name:		Baguio City, Benguet						
	Latitude:		16°24'36"N					Elevation:			1,510.0 m		
	Longitude:		120°36'00"E					Operating Agency:			PAGASA		
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
1974	20.1	0.0	7.4	97.2	272.4	549.7	389.5	1487.5	332.4	2273.5	636.1	48.7	6114.5
1975	17.1	0.0	2.3	57.9	215.2	224.4	152.5	787.9	477.4	295.5	27.1	43.1	2300.8
1976	21.6	0.0	38.7	21.4	1304.5	1224.8	377.3	677.0	373.0	176.3	81.5	7.5	4303.6
1977	30.2	0.0	5.9	30.8	294.8	159.3	694.5	784.2	1281.4	148.8	186.6	0.0	3616.5
1978	0.0	0.0	5.8	64.6	265.9	431.4	613.4	1412.9	583.9	344.8	20.0	29.7	3772.4
1979	13.0	1.4	1.4	117.1	410.1	239.1	586.7	1078.4	250.2	206.2	20.7	48.1	2972.4
1980	1.0	1.9	16.8	4.8	1040.4	88.3	1323.3	237.6	562.2	210.8	885.0	35.4	4407.5
1981	38.6	2.8	0.0	263.2	248.2	629.5	465.2	1165.4	634.7	196.3	206.4	0.4	3850.7
1982	0.0	22.7	21.5	168.2	228.9	342.0	1146.8	921.4	443.6	238.2	123.8	47.3	3704.4
1983	40.4	15.4	10.4	0.0	95.6	202.9	279.3	933.0	391.7	176.4	72.2	0.8	2218.1
1984	10.6	0.0	54.8	209.5	525.6	442.4	286.1	1512.5	397.7	322.4	17.3	2.3	3781.2
1985	7.4	46.0	57.5	219.7	410.7	1540.7	189.5	1424.6	512.1	265.2	76.3	15.4	4765.1
1986	18.2	10.9	6.7	3.6	509.4	226.4	1495.7	1208.1	1030.2	146.6	41.5	17.9	4715.2
1987	0.0	0.0	8.2	29.4	234.5	381.6	304.6	814.7	413.9	503.5	9.5	27.7	2727.6
1988	14.6	36.9	0.1	119.5	306.4	546.5	928.6	240.7	312.1	451.0	23.4	3.4	2983.2
1989	50.2	64.3	113.0	51.2	334.5	343.5	1506.6	506.0	1539.0	355.1	106.5	0.2	4970.1
1990	0.0	0.0	6.9	15.7	346.9	1088.1	585.0	1599.9	861.5	109.5	51.5	8.5	4673.5
1991	0.0	10.4	10.6	125.6	124.0	177.8	586.4	677.2	593.8	1735.3	15.5	1.2	4057.8
1992	8.1	0.4	67.8	23.6	483.2	317.6	473.4	1403.8	1611.5	119.5	21.0	0.6	4530.5
1993	2.0	3.6	4.0	88.4	37.8	1024.3	410.9	431.9	492.0	584.6	172.4	25.7	3277.6
1994	23.1	5.0	94.6	103.5	353.4	193.1	1191.2	723.7	178.4	114.4	9.7	3.7	2993.8
1995	0.0	4.4	0.0	32.3	227.2	151.1	470.3	704.7	288.9	139.1	102.7	59.7	2180.4
1996	3.2	4.6	16.2	87.6	314.2	166.4	1494.5	816.5	356.6	240.7	340.4	0.4	3841.3
1997	2.2	0.5	24.6	89.1	388.5	218.0	287.1	1200.0	209.0	106.0	88.3	0.0	2613.3
1998	0.0	0.0	14.4	44.1	307.1	82.7	290.8	291.9	1031.8	1569.3	85.2	89.5	3806.8
1999	5.7	0.1	121.1	245.5	293.8	541.3	724.3	1279.3	694.5	732.5	99.5	44.5	4782.1
2000	3.6	106.9	151.7	178.7	470.6	249.4	1385.7	697.3	640.6	917.6	51.4	63.6	4917.1
2001	14.6	39.5	289.8	76.0	291.0	451.4	1642.0	274.0	842.2	97.0	61.6	23.2	4102.3
2002	5.0	2.0	0.6	71.2	264.4	411.0	1883.4	525.6	301.5	224.8	67.3	10.0	3766.8
2003	0.0	25.4	4.8	46.8	662.7	792.4	721.3	1089.4	303.2	179.7	60.4	4.4	3890.5
2004	17.0	128.6	0.0	37.8	428.6	1400.7	445.4	1432.9	225.6	42.4	114.5	154.9	4428.4
2005	0.2	0.0	54.6	32.0	291.0	425.7	292.4	690.2	644.6	256.6	55.2	68.0	2810.5
2006	160.6	8.8	38.4	29.6	266.5	188.2	1769.8	735.8	207.6	316.0	72.4	43.2	3836.9
2007	0.0	0.6	31.8	25.4	308.6	368.4	218.8	1201.6	393.8	410.3	444.8	21.6	3425.7
2008	24.0	97.0	78.7	149.8	839.7	307.0	681.2	1869.5	760.4	178.0	82.6	0.0	5067.9
2009	7.2	64.5	82.9	407.3	398.5	810.0	758.4	1087.7	516.9	1981.8	22.2	0.0	6137.4
2010	0.0	0.0	15.3	148.6	242.6	254.0	543.7	536.6	296.8	920.1	226.4	47.4	3231.5
2011	96.0	13.8	93.4	11.9	462.5	529.1	427.5	1096.3	619.7	332.4	81.6	67.4	3831.6
2012	17.5	80.8	151.9	72.6	187.7	659.0	1020.0	2200.7	288.3	72.4	57.8	10.8	4819.5
2013	11.4	26.8	63.6	70.3	338.7	232.8	368.2	1220.4	590.1	240.0	53.5	23.6	3239.4
2014	0.0	0.0	5.9	126.3	213.0	401.7	444.2	531.9	985.4	107.1	39.2	9.5	2864.2
2015	11.3	7.3	57.1	121.8	245.5	282.5	1493.9	1031.6	263.6	1212.2	8.0	167.1	4901.9
	Period of Record:		**1974-2015**										
	Monthly Rainfall in mm												
n	42	42	42	42	42	42	42	42	42	42	42	42	42
Mean	16.6	19.8	43.6	93.3	368.7	459.4	746.4	965.3	565.1	458.3	119.5	30.4	3886.5
Max	160.6	128.6	289.8	407.3	1304.5	1540.7	1883.4	2200.7	1611.5	2273.5	885.0	167.1	6137.4
Min	0.0	0.0	0.0	0.0	37.8	82.7	152.5	237.6	178.4	42.4	8.0	0.0	2180.4
StDv	29.0	32.6	57.6	83.9	233.2	349.3	493.3	448.0	343.0	536.7	171.5	37.9	951.1

Table EW-4
Summary of Monthly Rainfall Data for Dagupan Synoptic Station

Proposed 2x335MW Coal-Fired Power Plant Project in Luna

Monthly Rainfall in mm

Station No.: 200
Station Name: Dagupan City, Pangasinan
Latitude: 16º05'13"N | Elevation: 2.0 m
Longitude: 120º21'08"E | Operating Agency: PAGASA

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1974	3.3	0.0	0.0	60.6	256.3	576.2	339.4	1259.9	125.6	568.5	149.1	3.8	3342.7
1975	4.7	0.0	33.0	54.6	261.7	174.0	216.1	443.5	279.8	197.8	18.8	10.7	1694.7
1976	15.5	21.9	19.1	263.5	578.0	591.1	333.2	381.7	498.5	68.5	0.0	0.0	2771.0
1977	53.3	0.0	11.2	70.3	101.3	176.3	302.0	524.3	552.6	31.5	247.7	0.0	2070.5
1978	0.0	0.0	0.0	45.6	141.5	356.8	495.8	1068.2	308.8	204.4	77.3	1.0	2699.4
1979	0.0	0.0	0.0	76.1	441.2	125.1	304.6	699.6	224.5	216.0	5.8	3.1	2096.0
1980	1.0	3.3	24.1	5.5	205.0	232.5	703.7	162.2	381.0	221.7	156.4	4.2	2100.6
1981	0.7	4.4	0.0	40.1	114.6	534.5	417.5	702.8	187.8	133.8	206.4	1.4	2344.0
1982	0.0	0.8	1.1	163.5	178.9	249.1	695.2	532.9	158.8	86.8	2.0	47.1	2116.2
1983	13.1	0.2	2.0	0.4	61.3	97.5	141.9	742.1	222.9	110.8	37.2	7.2	1436.6
1984	8.2	0.0	31.4	94.2	137.7	287.3	223.8	1067.4	158.9	328.5	6.8	1.0	2345.2
1985	0.0	3.2	20.2	99.5	135.9	739.8	154.6	680.7	386.4	189.4	39.6	0.8	2450.1
1986	21.7	28.4	13.0	0.0	202.8	116.5	905.2	646.0	536.6	51.3	64.8	16.3	2602.6
1987	0.0	0.0	11.0	7.6	61.6	232.6	319.6	250.0	241.8	157.8	14.4	3.0	1299.4
1988	3.0	33.4	0.0	78.2	285.0	304.2	654.6	444.0	372.6	252.6	23.8	0.0	2451.4
1989	14.2	8.4	101.2	18.2	155.4	247.3	619.0	448.6	531.0	241.0	53.8	0.6	2438.7
1990	0.0	0.0	0.0	0.0	184.1	1040.7	496.3	855.5	462.5	132.5	8.8	25.4	3105.8
1991	0.0	7.6	44.8	76.6	113.6	179.3	462.9	492.7	366.2	295.6	4.0	0.0	2043.3
1992	15.6	0.0	0.0	15.6	189.2	496.2	571.1	717.7	791.8	41.2	4.4	0.0	2842.8
1993	0.0	4.2	6.4	61.8	52.7	392.9	309.0	264.9	376.7	353.9	86.3	7.5	1916.3
1994	15.1	13.4	1.0	25.2	51.2	202.1	918.3	203.2	326.2	70.4	0.0	2.0	1828.1
1995	0.0	0.0	0.6	4.0	248.5	216.0	523.0	407.0	308.9	82.1	30.0	24.9	1845.0
1996	5.2	0.0	3.4	49.1	141.0	62.4	665.7	538.9	442.7	130.9	106.8	0.0	2146.1
1997	6.0	0.0	11.6	91.5	335.6	231.8	322.5	846.6	333.3	83.5	8.6	0.0	2271.0
1998	0.0	0.0	0.0	53.0	184.6	83.4	111.8	188.3	1063.7	527.6	107.2	41.0	2360.5
1999	0.0	0.0	80.4	58.9	150.3	418.3	742.9	1070.8	276.9	349.1	52.0	14.7	2944.3
2000	1.0	37.0	77.4	39.3	318.1	210.1	1191.7	548.9	320.7	492.1	17.0	44.7	3298.4
2001	0.0	36.5	131.1	94.6	106.5	383.6	605.7	328.6	328.2	21.2	4.8	1.3	2042.1
2002	0.0	21.1	0.0	5.2	310.6	221.3	1289.2	216.9	329.3	266.6	14.7	51.6	2726.5
2003	0.4	0.0	15.4	13.2	939.3	539.0	347.7	1030.2	391.1	139.0	47.0	0.0	3462.3
2004	0.0	88.5	12.2	3.8	332.4	616.4	261.4	1184.0	111.7	37.6	72.5	93.6	2814.1
2005	3.8	0.0	5.3	38.5	177.5	279.7	187.8	332.7	324.8	163.3	88.6	21.5	1623.5
2006	79.8	0.0	18.9	42.6	53.9	165.7	792.7	546.7	274.1	212.8	105.2	13.3	2305.7
2007	6.6	4.0	10.5	64.2	134.1	241.9	237.4	709.9	197.4	142.6	194.8	1.2	1944.6
2008	5.0	27.0	47.4	86.2	426.3	208.1	319.3	615.3	371.2	35.9	28.7	0.0	2170.4
2009	0.8	0.0	26.1	221.7	285.9	547.0	488.5	394.0	531.9	807.2	3.0	0.0	3306.1
2010	0.2	1.0	0.0	94.1	122.0	278.2	265.2	489.8	164.2	582.2	199.5	4.2	2200.6
2011	1.0	12.0	5.6	48.6	309.7	747.2	403.3	826.9	419.3	167.7	101.7	25.0	3068.0
2012	4.6	19.5	58.0	44.6	240.1	684.8	640.4	994.6	386.7	49.6	2.3	4.6	3129.8
2013	9.2	1.2	71.5	108.8	170.4	135.5	235.2	1135.0	552.2	134.9	13.6	19.7	2587.2
2014	0.0	-1.0	1.6	185.0	227.2	441.8	604.3	451.7	870.0	143.1	1.6	23.4	2949.2
2015	3.0	0.0	19.2	59.6	56.4	246.1	1087.9	352.8	435.3	361.2	0.0	136.4	2757.9
	Period of Record:	**1974-2015**											
	Monthly Rainfall in mm												
n	42	42	42	42	42	42	42	42	42	42	42	42	42
Mean	7.0	9.0	21.8	63.4	218.6	340.7	491.4	611.8	379.2	211.5	57.3	15.6	2427.4
Max	79.8	88.5	131.1	263.5	939.3	1040.7	1289.2	1259.9	1063.7	807.2	247.7	136.4	3462.3
Min	0.0	-1.0	0.0	0.0	51.2	62.4	111.8	162.2	111.7	21.2	0.0	0.0	1299.4
StDv	14.9	16.9	30.7	58.2	161.9	215.9	282.4	297.9	192.2	174.2	66.3	27.0	535.0

Table EW-5
Summary of Monthly Rainfall Data for Sinait/Vigan Synoptic Station

Proposed 2x335MW Coal-Fired Power Plant Project in Luna													
Monthly Rainfall in mm													
					Station No.:		300						
					Station Name:			Sinait, Ilocos Sur (former Vigan Station)					
Latitude:		17°53'23"N						Elevation:			58.1 m		
Longitude:		120°27'35"E						Operating Agency:			PAGASA		
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
1974	0.0	0.0	0.0	3.6	309.5	616.1	149.0	1374.4	329.8	535.7	80.0	15.5	3413.6
1975	23.8	1.0	0.8	9.1	70.1	464.1	219.6	0.0	89.8	143.2	4.9	2.1	1028.5
1976	0.0	0.0	0.0	0.0	339.5	290.9	206.1	355.5	121.5	93.3	0.0	1.5	1408.3
1977	2.0	2.5	0.0	0.0	82.4	219.9	815.9	798.5	781.7	4.3	28.3	0.0	2735.5
1978													
1979	0.0	2.3	15.2	55.6	314.7	260.9	582.9	643.6	132.0	44.3	3.3	15.9	2070.7
1980													
1981	3.6	0.0	0.0	1.7	278.7	450.5	555.7	1028.9	341.6	55.5	40.5	0.0	2756.7
1982													
1983	0.1	36.7	1.1	4.6	16.8	416.0	179.3	991.7	460.2	64.2	4.3	0.0	2175.0
1984	0.0	0.0	1.2	35.0	193.8	324.6	192.5	1049.4	120.5	53.9	18.3	0.0	1989.2
1985	0.0	0.0	0.0	1.2	113.2	1157.7	250.1	1194.6	280.8	300.5	12.3	0.0	3310.4
1986	0.0	0.0	0.0	7.1	593.6	329.4	679.1	1140.0	748.7	98.1	5.6	0.7	3602.3
1987	0.0	0.0	0.0	0.0	0.0	375.7	382.8	231.2	324.1	343.7	3.8	5.4	1666.7
1988	2.6	11.2	0.0	10.9	302.5	754.0	640.2	255.4	340.1	105.0	5.0	0.0	2426.9
1989	0.0	2.4	3.9	0.0	34.7	156.3	636.2	478.7	615.1	79.7	1.2	0.0	2008.2
1990													
1991	0.0	0.0	0.0	0.0	40.9	243.3	551.5	665.9	405.0	322.2	33.4	0.0	2262.2
1992	2.8	1.5	0.0	147.4	380.7	89.9	181.5	704.1	746.5	6.8	0.7	0.0	2261.9
1993	0.0	0.0	0.2	0.4	46.0	183.6	511.4	476.6	441.7	88.2	6.2	9.3	1763.6
1994	2.7	0.0	0.2	8.2	100.7	225.5	1060.5	394.5	287.5	50.7	0.0	0.0	2130.5
1995	0.0	0.0	0.0	0.0	160.9	170.0	838.9	360.4	193.4	188.2	11.2	4.0	1927.0
1996	0.0	0.0	0.0	8.2	96.4	254.3	1089.1	551.4	375.8	88.7	271.6	0.0	2735.5
1997	0.0	0.0	0.0	0.0	219.4	278.5	228.4	506.1	85.2	27.4	19.4	1.0	1365.4
1998	0.6	0.0	0.0	0.0	283.1	100.1	180.4	442.3	649.0	269.6	211.8	2.2	2139.1
1999	8.2	0.0	59.3	11.4	109.1	435.1	482.8	625.8	243.1	288.5	5.7	4.4	2273.4
2000	0.0	3.0	0.8	9.6	254.2	175.4	838.8	475.6	249.1	293.3	2.5	3.5	2306.4
2001	0.0	8.6	58.6	7.0	282.7	207.0		298.5	646.0	11.4	4.4	3.6	
2002	0.0	24.2	25.8	6.2	292.7	279.2	897.0	190.8	117.2	123.5	4.0	0.0	1960.6
2003	8.2	0.0	0.0	6.2	422.9	342.2	246.5	590.8	305.0	23.2	19.6	0.0	1964.6
2004	0.0	7.8	0.0	0.0	180.1	358.4	247.5	1032.1		17.7	11.8	14.2	
2005	0.0	0.0	0.3	13.0	59.7	438.1	280.9	425.3	482.2	119.5	1.5	3.8	1824.3
2006	67.4	0.0	0.0	0.0	140.0	202.2	860.4	298.9	486.7	10.3	54.3	3.1	2123.3
2007	0.6	0.0	6.4	0.0	224.0	146.2	124.1	1094.8	208.2	69.7	236.3	0.0	2110.3
2008	0.2	4.0	0.0	9.8	61.6	27.0	874.8	1028.9	517.3	27.6	47.8	0.0	2599.0
2009	0.0	0.0	0.0	189.5	277.6	315.0	1092.9	235.3	543.6	901.0	3.2	0.0	3558.1
2010	0.0	0.0	0.0	10.4	258.1	242.8	170.0	472.0	390.5		18.3	0.0	
2011	2.0	11.6	0.0	0.0	76.9	576.4	286.2	658.0	450.5	47.4	16.2	16.5	2141.7
2012	2.0	0.5	6.0	9.3	233.9	647.6	624.9	1038.2	192.4	29.3	0.2	8.7	2793.0
2013	7.7	0.0	0.3	36.0	115.3	285.1	259.6	1137.8	411.7	124.7	31.7	51.6	2461.5
2014	0.0	1.7		0.0	23.0	563.6		520.6	661.6	29.0	0.0	1.9	
2015	0.3	0.3	0.2	3.5	17.4	46.5	1009.1	587.0	98.8	248.2	0.0	20.6	2031.9
	Period of Record:		**1974-2015**										
	Monthly Rainfall in mm												
n	38	38	37	38	38	38	36	38	37	37	38	38	34
Mean	3.5	3.1	4.9	15.9	184.4	332.9	511.9	640.9	375.0	144.0	32.1	5.0	2274.3
Max	67.4	36.7	59.3	189.5	593.6	1157.7	1092.9	1374.4	781.7	901.0	271.6	51.6	3602.3
Min	0.0	0.0	0.0	0.0	0.0	27.0	124.1	0.0	85.2	4.3	0.0	0.0	1028.5
StDv	11.5	7.4	14.0	38.5	135.0	216.5	315.9	339.7	202.5	176.9	64.5	9.6	590.8

Table EW-6
Summary of Monthly Streamflow Data for Borobor River Gauging Station

Proposed 2x335MW Coal-Fired Power Plant Project in Luna													
Monthly Mean Flow in LPS													
					River:				Borobor				
					Station Name:				Rising, Luna, La Union				
	Latitude:		16°51’51”N					Catchment Area:			169.0 km^2		
	Longitude:		120°24’48”E					Operating Agency:			DPWH-BRS		
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
1985							4441	38107	8719	2191	3122		
1986	2681	3585	3035	1902	3876	4580	40588	14332	44082	1534	408	318	10077
1987						372	1555	15049	5207	4088	4655	3897	
1988	2631	1639	1048	1312	2117	11061	19679	8228	3006	7926	2182	3649	5353
	Period of Record:		**1985-1988**										
	Monthly Flow in LPS												
n	2	2	2	2	2	3	4	4	4	4	4	3	2
Total	5312	5224	4083	3214	5993	16013	66263	75716	61014	15739	10367	7864	15450
Mean	2656	2612	2042	1607	2997	5338	16566	18929	15254	3935	2592	2621	7725
Max	2681	3585	3035	1902	3876	11061	40588	38107	44082	7926	4655	3897	10077
Min	2631	1639	1048	1312	2117	372	1555	8228	3006	1534	408	318	5373
	Monthly Runoff in mm												
	42.1	37.4	32.4	24.6	47.5	81.9	262.5	300.0	233.9	62.4	39.8	41.5	
	Monthly Runoff Volume in 1,000,000 m^3												
	7.1	6.3	5.5	4.2	8.0	13.8	44.4	50.7	39.5	10.5	6.7	7.0	
	Annual Values:			**Mean Flow**		**Runoff Depth**		**Runoff Volume**		**Max M. Flow**		**Min. M. Flow**	
				7725 LPS		1206.0 mm		203.8x10^4 m^3		44082 LPS		318 LPS	

Table EW-7
Summary of Monthly Streamflow Data for Maragayap River Gauging Station

Proposed 2x335MW Coal-Fired Power Plant Project in Luna													
Monthly Mean Flow in LPS													
					River:				Maragayap				
					Station Name:				St. Rita, Bacnotan, La Union				
	Latitude:		16°45’20”N					Catchment Area:			63.0 km^2		
	Longitude:		120°20’22”E					Operating Agency:			DPWH-BRS		
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
1984	91		52	26	210	1546	882	18885	2723	674	472	359	2356
1985	291	286	304	209	345	19743	3940	15652	4082	1153	804		4255
1986	501	415	305	304	3242	2361	34429	9359	30221	1828	1043		7637
1987	655	584	571	471	42	784	2128	1739	3790	6646	296	136	1519
1988	421	485	302	471	1371	16541	20241	3535	710	1973	607	184	3903
1989	118	90	70	56	838	586	18683	4969					
1990					590	15340	3839	5328	31281	2679	2318	921	
1991	286	182	106	80	50		4847	10896	6761	21793	2868	709	4416
	Period of Record:		**1984-1991**										
	Monthly Flow in LPS												
n	7	6	7	7	8	7	8	8	7	7	7	5	6
Total	2363	2042	1710	1617	7070	56901	88989	70363	79568	36746	8408	2309	24087
Mean	338	340	244	231	884	8129	11124	8795	11367	5249	1201	462	4015
Max	655	584	571	471	3242	19743	34429	18885	31281	21793	2868	921	7637
Min	91	90	52	26	50	586	882	1739	710	674	296	136	1519
	Monthly Runoff in mm												
	14.4	13.1	10.4	9.5	37.6	334.4	472.9	373.9	467.7	223.2	49.4	19.6	
	Monthly Runoff Volume in 1,000,000 m^3												
	0.9	0.8	0.7	0.6	2.4	21.1	29.8	23.6	29.5	14.1	3.1	1.2	
	Annual Values:			**Mean Flow**		**Runoff Depth**		**Runoff Volume**		**Max M. Flow**		**Min. M. Flow**	
				4015 LPS		2026.1 mm		127.6 x 10^6 m^3		34429 LPS		26 LPS	

Table EW-8
Summary of Monthly Streamflow Data for Baroro River Gauging Station

Proposed 2x335MW Coal-Fired Power Plant Project in Luna

Monthly Mean Flow in LPS

	River:	Baroro	
	Station Name:	Cabaruan, San Juan, La Union	
Latitude:	16º40'50"N	Catchment Area:	129.0 km^2
Longitude:	120º22'50"E	Operating Agency:	DPWH-BRS

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1984	517		422	480	1890	3622	1573	11009	3587	5661	3041	1868	3061
1985	1039	736	914	1190	2943	19315	1477	17641	16028	6195	3588		6461
1986	1246	1267	1172	1299	3706	5809	15645	18376	15856	4506	2451	1807	6095
1987	760	580	578	588	686	3191	4568	3903	6480	4920	1719		2543
1988	889	1698	925	1464	2323	12108	11568	8444	3261	4558	1362	772	4114
1989	782		941	797	819	2766	22300	12714					
	Period of Record:		**1984-1989**										
	Monthly Flow in LPS												
n	6	4	6	6	6	6	6	6	5	5	5	3	5
Total	5233	4281	4952	5818	12367	46811	57131	72087	45212	25840	12161	4447	22274
Mean	872	1070	825	970	2061	7802	9522	12015	9042	5168	2432	1482	4455
Max	1246	1698	1172	1464	3706	19315	22300	18376	16028	6195	3588	1868	6461
Min	517	580	422	480	686	2766	1477	3903	3261	4506	1362	772	2543
	Monthly Runoff in mm												
	18.1	20.1	17.1	19.5	42.8	156.8	197.7	249.5	181.7	107.3	48.9	308	
	Monthly Runoff Volume in 1,000,000 m^3												
	2.3	2.6	2.2	2.5	5.5	20.2	25.5	32.2	23.4	13.8	6.3	4.0	
	Annual Values:			**Mean Flow**		**Runoff Depth**		**Runoff Volume**		**Max M. Flow**		**Min. M. Flow**	
				4455 LPS		1090.2 mm		140.6 x 10^6 m^3		22300 LPS		422 LPS	

Table EW-9
Summary of Monthly Streamflow Data for Bauang River Gauging Station

Proposed 2x335MW Coal-Fired Power Plant Project in Luna													
Monthly Mean Flow in LPS													
				River:				Bauang					
				Station Name:				Acao, Bauang, La Union					
Latitude:	16°31'26"N							Catchment Area:		511.0 km²			
Longitude:	120°20'48"E							Operating Agency:		DPWH-BRS			
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
1986											14936	7144	
1987	3628	3275	2558	1675	5209	10218	33779	65269	122707	89441	13431	10384	30131
1988	5863	4536	1358	2577	8090	71485	224232	114495	25249	33554	13145	6775	42613
1989	6113	2637	5336	3687	10721	37762							
	Period of Record:	**1986-1989**											
	Monthly Flow in LPS												
n	3	3	3	3	3	3	2	2	2	2	3	3	2
Total	15604	10448	9252	7939	24020	119465	258011	179764	147956	122995	41512	24303	72744
Mean	5201	3483	3084	2646	8007	39822	129006	89882	73978	61498	13837	8101	36372
Max	6113	4536	5336	3687	10721	71485	224232	114495	122707	89441	14936	10384	42613
Min	3628	2637	1358	1675	5209	10218	33779	65269	25249	33554	13145	6775	30131
	Monthly Runoff in mm												
	27.3	16.5	16.2	13.4	42.0	202.0	676.2	471.1	375.2	322.3	70.2	42.5	
	Monthly Runoff Volume in 1,000,000 m³												
	13.9	8.4	8.3	6.9	21.4	103.2	345.5	240.7	191.8	164.7	35.9	21.7	
	Annual Values:			**Mean Flow**		**Runoff Depth**		**Runoff Volume**		**Max M. Flow**		**Min. M. Flow**	
				36372 LPS		2274.8 mm		1162.4 x 10⁶ m³		224232 LPS		1358 LPS	

Table EW-10
Summary of Monthly Streamflow Data for Buaya River Gauging Station

Proposed 2x335MW Coal-Fired Power Plant Project in Luna													
Monthly Mean Flow in LPS													
					River:				Buaya				
					Station Name:				Saoat, Sta. Cruz, Ilocos Sur				
	Latitude:	17°06'00"N						Catchment Area:			195.0 km^2		
	Longitude:	120°27'48"E						Operating Agency:			DPWH-BRS		
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
1985								40079	193575	101927	18067	3043	
1986	2512	2455	1820	458	14309	10600	272030	101805	108273	5578	1362	588	43483
1987	300	115	195	251	126	749	5117	18118	77702	46573	6842	1435	13127
1988	1197	1026	808	696	8456	47260	96501	51188	22507	10045	2354	1143	20265
	Period of Record:		**1985-1988**										
	Monthly Flow in LPS												
n	3	3	3	3	3	3	3	4	4	4	4	4	3
Total	4009	3596	2823	1405	22893	58609	373648	211190	402057	164123	28625	6209	76875
Mean	1336	1199	941	468	7631	19536	124549	52798	100514	41031	7156	1552	25625
Max	2512	2455	1820	696	14309	47260	272030	101805	193575	101927	18067	3043	43483
Min	300	115	195	251	126	749	5117	18118	22507	5578	1362	588	13127
	Monthly Runoff in mm												
	18.4	14.9	12.9	6.2	104.8	259.7	1710.7	725.2	1336.1	563.6	95.1	21.3	
	Monthly Runoff Volume in 1,000,000 m^3												
	3.6	2.9	2.5	1.2	20.4	50.6	333.6	141.4	260.5	109.9	18.5	4.2	
	Annual Values:				**Mean Flow**	**Runoff Depth**		**Runoff Volume**		**Max M. Flow**		**Min. M. Flow**	
					25625 LPS	4868.9 mm		949.4 x 10^6 m^3		272030 LPS		115 LPS	

Rainfall events may increase chances of sedimentation. Sedimentation can be caused by increased runoff volume due to less infiltration in the project area since earthworks will be conducted as part of the project construction. This may lead to a change in the depth. Silt traps will be provided to avoid construction sediments from getting into the ground depression, which will also be improved to accommodate the increase in runoff volume and avoid channel overflows.

2.1.3.1 PAGASA Climate Change Projections

The projected seasonal temperature increase, seasonal rainfall change and frequency of extreme events in 2020 and 2050 under the medium-range emission scenario for Region I are based on the PAGASA's Climate Change in the Philippines published on February 2011 and presented in **Table EW-11**.

The summary of climate change projection for the normal and extreme values of temperature and rainfall for the study area (La Union Province) are summarized in **Table EW-12**. **According to the publication, there is a projected increase in temperature of around 1.0°C in 2020 and around 2.0°C in 2050 for almost all quarters. This will mean an increase in the evapotranspiration amount in the water balance that may further affect (decrease) the amount of runoff and groundwater recharge in the area.**

For the average rainfall, there will be a slight decrease and increase in the DJF and MAM quarters while a large increase is expected for the two other quarters in the year 2020. On the other hand, in the year 2050, rainfall in the DJF and MAM quarters are expected to diminish while during JJA and SON quarters rainfall will be augmented. All in all, there is a slight reduction of rainfall (around 20mm per month) in dry months and large increase of rainfall (around 150mm per month) in wet months. The annual average rainfall for 2020 and 2050 relative to the baseline condition is projected to increase.

For possible drought occurrences, there is an observed decrease in the number of dry days in the study area in the periods of 2020 and 2050. The projection for Dagupan, Pangasinan was adopted for southern La Union (as suggested and indicated in the Table) where the proposed power plant is located. The

projected significant decrease in the number of dry days will decrease the probability of drought occurrences in the area.

Furthermore, PAGASA predicts a significant increase in the number of days with rainfall greater than 300mm in Dagupan, Pangasinan as well as in the study area (southern La Union) in the periods of 2020 and 2050. The increase in the number of days with extreme precipitation will increase the frequency of flooding events in the area. Thus, mitigation measures that will be done in the area will include channel and drainage improvements within the project site using design peak flows.

Table EW-11
PAGASA Climate Change Projection for Region I

Table 11a: Seasonal temperature increases in 2020 and 2050 under medium-range emission scenario in provinces in Region 1												
Region 1	Observed Baseline (1971-2000)				Change in 2020 (2006-2015)				Change in 2050 (2036-2065)			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
Ilocos Norte	25.3	28.1	28.3	27.4	0.8	1.0	0.8	0.9	2.1	2.2	1.7	1.8
Ilocos Sur	23.1	25.7	25.4	24.8	0.9	1.1	0.8	1.0	2.0	2.1	1.6	1.8
La Union	20.5	22.9	22.8	22.2	0.9	1.1	0.7	1.0	2.0	2.1	1.6	1.8
Pangasinan	25.0	27.4	26.9	26.4	0.9	1.1	0.9	1.0	2.2	2.2	1.8	2.0

Table 11b: Seasonal rainfall change in 2020 and 2050 under medium-range emission scenario in provinces in Region 1												
Region 1	Observed Baseline (1971-2000)				Change in 2020 (2006-2015)				Change in 2050 (2036-2065)			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
Ilocos Norte	49.8	185.5	1106.4	595.4	4.4	-3.1	18.0	5.8	-18.8	-31.3	20.9	4.7
Ilocos Sur	17.5	288.8	1575.4	672.9	-4.6	-2.0	36.3	23.0	-0.1	-27.6	58.1	33.3
La Union	14.7	395.6	1852.3	837.8	-0.4	4.5	43.1	30.0	-1.1	-24.6	72.5	39.0
Pangasinan	19.4	298.0	1608.9	707.8	54.3	-6.0	6.1	5.9	1.1	-11.2	22.9	11.9

Table 11c: Total frequency of extreme events in 2020 and 2050 under medium-range emission scenario in provinces in Region 1										
Provinces	Stations	No. of Days w/ T_{max} >35°C			No. of Dry Days			No. of Days w/ Rainfall >300mm		
		OBS (1971-2000)	2020	2050	OBS	2020	2050	OBS	2020	2050
Ilocos Norte	Laoag	801	1677	3157	9015	7391	7425	4	19	10
Ilocos Sur	Vigan	110	130	627	8728	8105	7939	1	17	6
Pangasinan	Dagupan	1280	2265	3728	8303	6443	6419	2	13	20

Note: For northern La Union, use values of Vigan
For southern La Union, use values of Dagupan

Table EW-12
Summary of PAGASA Climate Change Projection for Normal and Extreme Values of Temperature and Rainfall for La Union Province

NORMS								
Year/Mo	Temperature (°C)				Rainfall (mm)			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
Base	20.5	22.9	22.8	22.0	14.7	395.6	1,852.3	837.8
2020	21.4	24.0	23.5	23.0	14.6	413.4	2,650.6	1,089.1
2050	22.5	25.0	24.4	23.8	14.5	298.3	3,195.2	1,164.5

EXTREMES			
Year/Station	No. of Days w/ T_{max} >35°C	No. of Dry Days	No. of Days w/ Rainfall >200mm
	Pangasinan	Pangasinan	Pangasinan
Base	1280	8,303	2
2020	2265	6,443	13
2050	3278	6,419	20

Applying the quarterly percentile changes on the estimated monthly rainfall at the project area, the projected values of average monthly rainfall for 2020 and 2050 are obtained. Using these rainfall values as well as the projected monthly temperature values, the water balance model is re-run to obtain the projected impact of the climate change on the water balance at the study area for the periods of 2020 and 2050. **Table EW-13** presents the projected impact of climate change on evapotranspiration, runoff, and groundwater recharge for 2020 and 2050 at the project site based on PAGASA climate change projection.

Table EW-13
Projected Impact of Climate Change on Evapotranspiration, Runoff, and Groundwater Recharge Based on PAGASA Climate Change Projection at the Project Site

Month	Evapotranspiration (mm)			Direct Runoff (mm)			GW Recharge (mm)		
	Present	2020	2050	Present	2020	2050	Present	2020	2050
Jan	88.6	93.6	98.9	143.1	141.4	140.8	39.9	35.4	33.8
Feb	83.9	88.0	92.8	91.5	89.5	89.5	22.3	19.5	18.6
Mar	96.0	99.2	104.0	66.8	63.8	63.2	13.0	10.8	9.4
Apr	91.6	89.2	90.0	48.0	45.1	44.2	10.6	9.5	8.9
May	104.0	102.6	103.5	61.3	59.3	59.0	10.7	8.7	7.5
Jun	120.1	124.5	129.1	75.5	76.7	77.8	12.6	8.8	6.2
Jul	125.1	130.8	137.1	79.5	80.8	82.2	22.5	17.6	13.7
Aug	121.3	125.4	129.4	62.2	62.2	62.1	8.8	5.4	3.4
Sep	111.9	117.9	123.9	76.8	79.9	82.0	33.2	24.5	17.0
Oct	106.8	112.9	119.4	66.6	70.4	75.3	197.5	184.7	169.0
Nov	94.5	100.0	105.7	91.9	90.1	88.7	268.4	263.7	255.3
Dec	88.8	93.9	99.3	128.3	127.1	125.0	249.3	243.2	240.9
Annual	***1232.5***	***1278.0***	***1333.0***	***991.6***	***986.3***	***989.8***	***888.7***	***831.7***	***783.9***

Based on the simulation results, there will be significant increase in the amount of actual evapotranspiration and significant decrease in the amount of groundwater recharge in the study area for the periods of 2020 and 2050 due to climate change projection. On the other hand, only minimal change in the amount of runoff is expected in the study area for the periods of 2020 and 2050.

2.1.3.2 Flood and Drought Occurrences

PAGASA data indicates that there were a total of 39 tropical cyclones that traversed the La Union province from 1948 to 2013. Eight (8) of these were tropical depressions, 12 were tropical storms while 19 were fully developed typhoons. From the informal interviews conducted with the old members of the local community, it was said that flooding occurs almost yearly at the low lying barangays of Baroro-Busilac River, especially in Barangays Rimus 1 to Rimus 5. The recent remarkable typhoon that hit the area was Typhoon Lando, which occurred in October 2015.

Based on the historical records, the typhoon frequency in the area is estimated to be one every 3 to 4 years. The frequency of a storm or rainfall event in any area has a corresponding precipitation value where the maximum flow can be computed. In this study, the flood discharges in the project site were computed for various frequencies or return periods using the rational method. The rainfall-intensity duration frequency (RIDF) data of PAGASA at the Dagupan synoptic station and the hydrologic properties of the project area were utilized in the computations. The Dagupan station was employed in the computation because of the similarity in rainfall pattern since both are coastal areas.

Table EW-14 presents the RIDF data for Dagupan synoptic station.

Table EW-14
Rainfall Intensity- Duration Frequency (RIDF) Data for Dagupan City, Pangasinan
(Based on 48 years of record)

Computed Extreme Values (in mm) of Precipitation									
Return Period (yrs)	10 mins	20 mins	30 mins	60 mins	2 hrs	3 hrs	6 hrs	12 hrs	24 hrs
2	23.9	34.3	42.3	55.4	77.6	93.0	121.2	148.3	175.8
5	33.9	47.4	58.8	77.3	109.1	131.3	170.8	209.0	246.7
10	40.5	56.1	69.7	91.9	129.9	156.6	203.6	249.2	293.6
15	44.3	61.0	75.9	100.1	141.6	170.9	222.1	271.9	320.1
20	46.9	64.4	80.2	105.8	149.8	180.9	235.1	287.8	338.6
25	48.9	67.1	83.5	110.2	156.2	188.7	245.1	300.0	352.9
50	55.1	75.2	93.8	123.8	175.7	212.4	275.8	337.7	396.8
100	61.2	83.3	103.9	137.3	195.0	236.0	306.3	375.1	440.5
Equivalent Average Intensity (in mm/hr) of Computed Extreme Values									
Return Period (yrs)	10 mins	20 mins	30 mins	60 mins	2 hrs	3 hrs	6 hrs	12 hrs	24 hrs
2	143.7	102.8	84.7	55.4	38.8	31.0	20.2	12.4	7.3
5	203.6	142.2	117.6	77.3	54.5	43.8	28.5	17.4	10.3
10	243.2	168.3	139.5	91.9	64.9	52.2	33.9	20.8	12.2
15	265.6	183.0	151.8	100.1	70.8	57.0	37.0	22.7	13.3
20	281.2	193.3	160.4	105.8	74.9	60.3	39.2	24.0	14.1
25	293.3	201.2	167.0	110.2	78.1	62.9	40.8	25.0	14.7
50	331.5	225.7	187.5	123.8	87.8	70.8	46.0	28.1	16.5
100	367.4	250.0	207.8	137.3	97.5	78.7	51.1	31.3	18.4

Source: Hydrometeorological Data Applications Section (HDAS), Hydro-Meteorology Branch, PAGASA

Peak runoff computation was done for the ground depression within the project site for various design floods of 10-year, 25-year, 50-year and 100-year return period using the rational method. The topographic parameters generated for the project site were utilized together with some land-use and soil parameters of the area to define the basin characteristics. The time of concentration was computed using Kirpich Formula while the RIDF data for Dagupan synoptic station was utilized to get the peak rainfall for various return periods. The computed design flood flows for 10-year, 25-year, 50-year and 100-year return periods are 36.9 m^3/s, 44.5 m^3/s, 50.2 m^3/s, and 55.8 m^3/s respectively.

The historical average monthly rainfall in the study area is shown in **Figure EW-7**. For drought occurrences, based on the Modified Coronas Climate Classification System, the study area falls under the Type I climate zone which means that the area has two pronounced seasons, dry from November to April and wet during the rest of the year. Due to this, the area is susceptible to long dry spells wherein there is almost no or very minimal rainfall from November to April. The recent drought that hit the study area was the El Niño phenomenon in 2015.

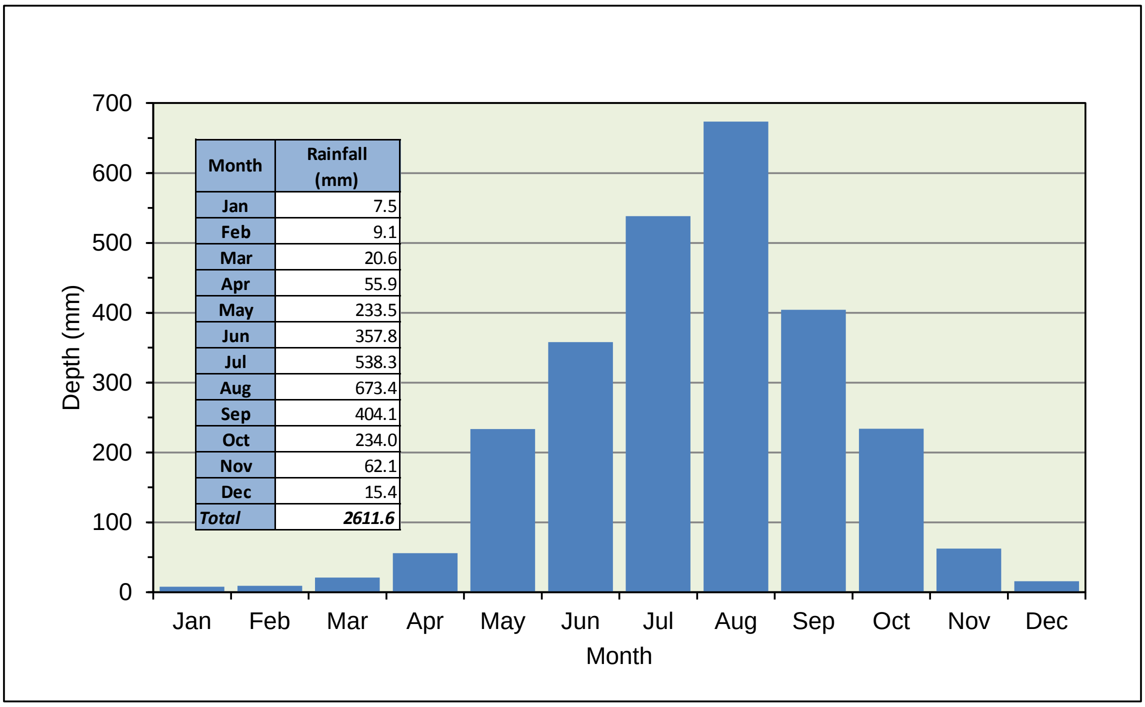


Figure EW-7. Historical Average Monthly Rainfall at the Study Area

During the construction of the project, surface runoff may increase because of increased paved surfaces within the construction area and decreased infiltration rate, both of which may induce flooding in the project area.

This can be prevented by improving the channel of the ground depression thereby increasing its capacity to contain runoff and preventing the site and nearby areas from flooding. The computed design peak flows will be used as basis in designing the channel improvement. The internal drainage system of the plant complex will be designed such that some of the storm water drainage outflow can be directed toward the sea so that the additional surface runoff will not impact on the peak flood discharge and water level of the original drainage.

2.1.4 Spring and Well Point Inventory

From the well point inventory and streamflow measurements, a total of seven (7) groundwater (GW) stations and 7 surface water (SW) stations were inventoried. All the seven (7) groundwater stations inventoried are located outside the project site since there are no existing wells within the project area. On the other hand, only one surface water station was inventoried within the project site, which is a ground depression that drains the project area to the sea. The rest of the SW stations are in the vicinity of the project site, which are located along Darigayos River, Busilac-Borobor River, and the Amburayan River.

From the well point inventory, low productivity of aquifer and some cases of saltwater intrusion were manifested around the study area.

Table EW-15 provides a summary listing of the inventory while **Annex C** presents the photo highlights of the inventory. The location of the groundwater (GW) and surface water (SW) observation stations are presented in **Figure EW-8**.

Table EW-15
Summary List of Springs, Wells, and River Inventory within and around the Study Area

Station No.	Owner	Owner-Specific	Latitude	Longitude	Well Type	Estimated/ Flow (m^3/s)	Remarks
GW1	Communal	Church	16°51'13.64"N	120°22'36.19"E	Well, Hand-pump	5,082 lpd	Drinking water, said to be miraculous or have healing power
GW2	Communal	Barangay	16°49'12.60"N	120°20'10.61"E	Well, Hand-pump	57,600 lpd	Safe for drinking, not main purpose
GW3	Communal	School	16°49'59.10"N	120°21'42.68"E	Well, Hand-pump	Not measured	Unable to measure prod, water is salty, school near river and prone to flooding
GW4	Private	Household	16°49'47.52"N	120°20'37.41"E	Well, Hand-pump	22,544 lpd	Can be used for drinking, but household source drinking from water company
GW5	Private	Household	16°49'30.22"N	120°19'59.66"E	Well, Hand-pump	37,181 lpd	Near the sea. Can be used for drinking. Brgy Darigayos
GW6	Private	Hotel	16°50'20.45"N	120°20'18.54"E	Well, Motor pump (Piped)	Not measured	Near the sea. Can be used for drinking. Brgy Darigayos
GW7	Private	Tourist Spot	16°50'49.98"N	120°21'6.15"E	Well, Motor pump (Piped)	Not measured	Near the sea. Can be used for drinking. Brgy Darigayos. Bahay na Bato
SW1	Government	Busilac BR	16°53'45.68"N	120°24'26.36"E	River	0.251	Busilac River along bridge. Low flow during time of observation
SW2	Government	Amburayan BR	16°54'42.13"N	120°27'46.33"E	River	0.811	Amburayan River along bridge. Relative high flow during time of observation
SW3	Government	Borobor BR	16°51'14.96"N	120°25'14.94"E	River	0.714	Borobor River along bridge. 10 minutes after short but high rainfall event during time of observation
SW4	Government	Darigayos BR	16°49'5.55"N	120°20'9.56"E	River	0.32	Darigayos River along bridge. 30 minutes after rainfall event, low flow during time of observation.
SW5	Government	Brgy Magsiping	16°49'46.17"N	120°21'58.62"E	River	0.14	Along bridge in Brgy Magsiping. 15 meters width. Low flow during time of observation. Debris from cleared fish cages observed.
SW6	Government	Darigayos R	16°49'32.06"N	120°22'36.19"E	River	0.133	Along bridge. 15 meters width. Low flow during time of observation
SW7	Private	Project Site Ground Depression	16°50'3.90"N	120°22'36.19"E	Ground Depression	Dry	Around 4 meter width ground depression draining the project area directly to the sea

Figure EW-8. Location of Groundwater and Surface Water Inventory within and around the Project Area	**LEGEND:** Inventory Stations Project Site	**SCALE: 1: 24,000**
ENVIRONMENTAL IMPACT STATEMENT **2x335MW COAL-FIRED POWER PLANT PROJECT**	**DATA INFORMATION/SOURCE:** **Base Map:** Google Earth Imagery, 2016 **Imagery Date:** 15 May 2017 **Project Layout:** GLEDC, 2017 **Modified By:** Aperçu_AConjares	aperçu CONSULTANTS INC. **PAGE: 174**

2.1.4.1 Current and Major Water Users

Based on the existing records of the National Water Resources Board (NWRB) as of January 2015, only 18 water permits are issued within the Darigayos River basin. These consist of 13 surface water and 5 groundwater permits totaling 369.1 liters per second (lps) and 2.3lps for surface water and groundwater use, respectively. **Table EW-16** summarizes the location, source type, coordinates, granted flow, purpose, and date of application of all grantees.

Table EW-16
NWRB's Summary of Existing Water Permits within Darigayos River Basin

No.	Grantee	Location	Source	Type	Latitude	Longitude	Flow (lps)	Purpose	Date App
1	Uballes	Masupa, Balaoan	Masupa Ck	SW	16º48'09"N	120º24'56"E	4.0	Irrigation	11/28/79
2	Aquino	Paraoirn, Balaoan	Daraoan Creek	SW	16º47'56"N	120º20'40"E	2.1	Irrigation	11/28/79
3	Nacis	Paraoirn, Balaoan	Daracan Ck	SW	16º47'55"N	120º20'43"E	0.3	Irrigation	11/28/79
4	Alfredo Narido	Paraoirn, Balaoan	Daraoan Creek	SW	16º47'53"N	120º20'50"E	0.3	Irrigation	11/28/79
5	Alejandro Nituka	Paraoirn, Balaoan	Daraoan Creek	SW	16º47'42"N	120º20'50"E	0.5	Irrigation	11/28/79
6	Bongalan	Paraoirn, Balaoan	Daraoan Ck	SW	16º47'30"N	120º21'02"E	0.5	Irrigation	11/28/79
7	J. Sibayan	Paraoirn, Balaoan	Daracan Ck	SW	16º47'32"N	120º21'00"E	1.5	Irrigation	11/28/79
8	Macis	Paraoirn, Balaoan	Daragan Ck	SW	16º47'28"N	120º21'08"E	0.7	Irrigation	11/28/79
9	Bangalan	Paraoirn, Balaoan	Daraoan Ck	SW	16º47'49"N	120º20'45"E	0.5	Irrigation	12/28/79
10	Callagen Rwa C	42 Callagen, Luna	Callagen Sp.	GW	16º49'58"N	120º23'07"E	0.5	Domestic	10/16/81
11	Tallagan, Rwa O	Tallagan, Luna	Tallagan S.	GW	16º50'05"N	120º22'57"E	0.5	Domestic	04/16/82
12	V. Ancheta	Tallaban, Luna	Tara-Tara Sp.	GW	16º50'08"N	120º22'12"E	0.1	Domestic	03/16/84
13	Timpuyog IA	Pitpitan, Luna	Ukkalong Ck.	SW	16º47'51"N	120º21'20"E	8.0	Irrigation	11/29/85
14	Balaoan Irrig's Assn, Inc.	Lit-Tac, Santol	Maloyo River	SW	16º46'52"N	120º26'35"E	300.0	Irrigation	09/26/88
15	Cabalitocan Dam #1 I.A.I.	Cabalitocan, Luna	Ukkalong Creek	SW	16º48'17"N	120º21'10"E	14.7	Irrigation	05/29/90
16	Bolong Agri-Mgt Corp.	Paraoirs, Balaoan	Deepwell	GW	16º48'16"N	120º20'00"E	0.8	Irrigation	05/29/90
17	Namnama I.S.I.	Cabalitocan, Luna	Nagsiping Creek	SW	16º48'25"N	120º20'59"E	36.0	Irrigation	07/10/90
18	Holcim Philippines, Inc.	Quirino, Bacnotan	Deepwell	GW	16º47'27"N	120º20'07"E	0.5	Industrial	01/26/10

All of the water permits for surface water are for irrigation purposes while most groundwater permits are for domestic and industrial uses. The latest permit issued within the basin boundary was on January 2010, which was granted to Holcim Philippines Inc.

Given the 18 water permits, no grantee falls within the proposed 41-hectare coal-fired power plant site. Most permits are located along the Darigayos River, tributaries, creeks, and within the floodplains of Luna and Balaoan, La Union. **Figure EW-9** shows the locations of NWRB groundwater and surface water permits within the Darigayos River Basin.

Depletion in water resources or competition in water use is not expected during the construction and operation phases of the proposed project since all NWRB water grantees are located outside the project site and because the power plant's freshwater demands, during both phases, are proposed to be supplied by a water service provider. The large cooling water requirement during operation, on the other hand, will be taken from the sea.

Moreover, the project is located downstream of the Darigayos River and along the coastal area. Therefore, tapping either groundwater or surface water source will not compete with existing water users who are all located upstream of the project site.

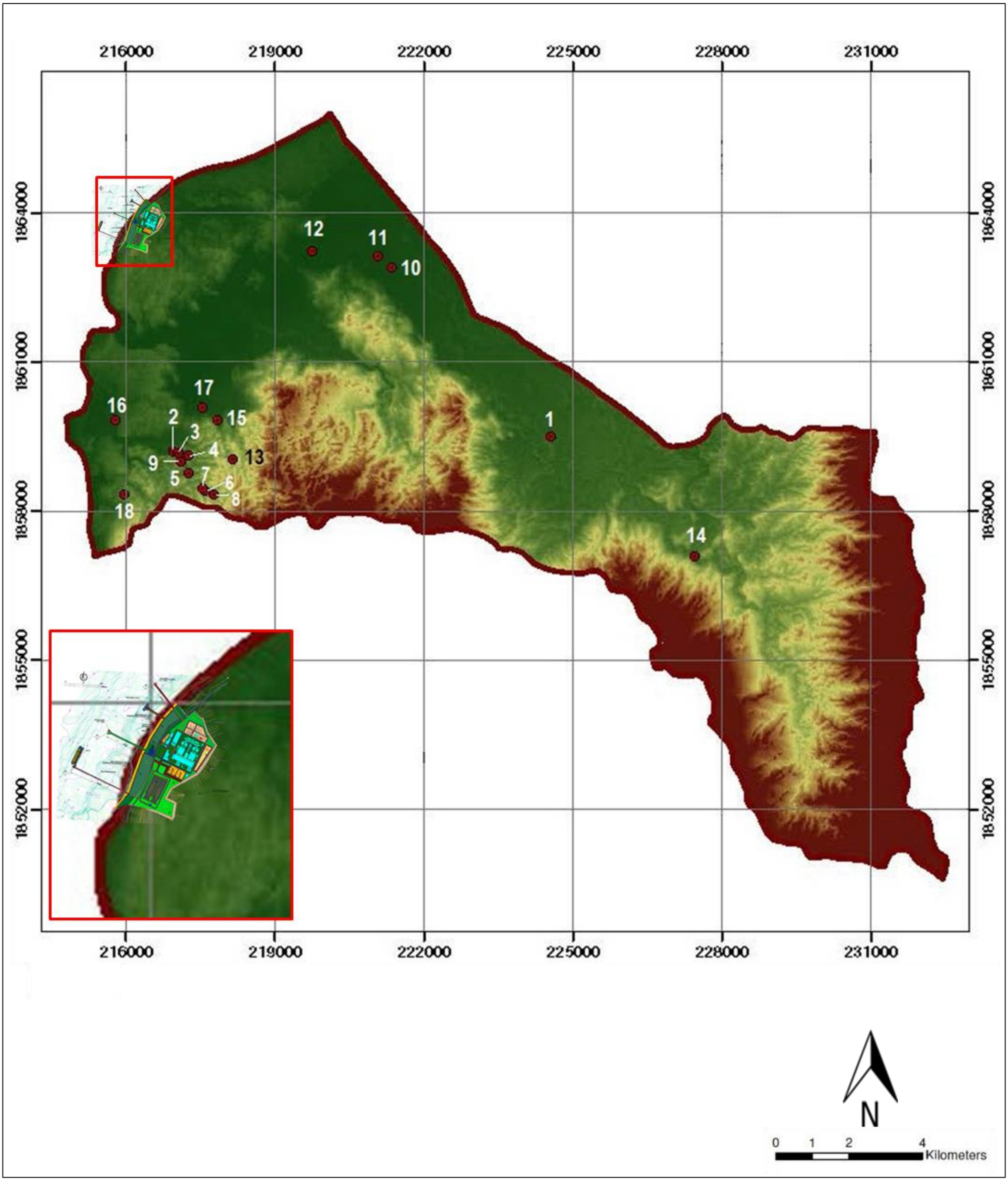


Figure EW-9. Locations of NWRB Groundwater and Surface water Permits within the Darigayos River Basin	LEGEND: Basin Boundary Project Site Existing NWRB Permits	SCALE: 1:50,000
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: **Source Map:** SRTM- DEM, 2016 **Project Layout:** GLEDC, 2017 **Modified By:** Aperçu_AConjares	aperçu CONSULTANTS INC. PAGE: 176

2.1.5 Water Availability and Dependability Analysis

Table EW-17 presents the estimated monthly rainfall at the study area from which streamflow estimates are generated for Darigayos River that has a catchment area of 86sq.km and which is the nearest river point (at about 2 km) to the project site. Generated values were then calibrated and validated from the available gauged streamflows near the river. In this study, the nearest gauged rivers are the Borobor River (169 sq. km), Maragayap River (63 sq. km), and Baroro River (129 sq. km) which are 9km, 8km, and 17km away, respectively, from the project site. These 3 stations are utilized to estimate and calibrate the monthly river flows generated from the computed monthly rainfall for the study area. **Tables EW-18** presents the generated monthly streamflows for Darigayos River.

Table EW-17
Estimated Monthly Rainfall at Darigayos River Basin

Proposed 2x335MW Coal-Fired Power Plant Project in Luna													
Monthly Rainfall in mm													
				Station No.:		LUN-400							
				Station Name:		Darigayos Basin-Luna Power Plant							
	Latitude:		16°49'00"N				Elevation:			N/A			
	Longitude:		120°22'00"E				Operating Agency:			None (Generated)			
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
1974	5.0	0.0	1.1	50.8	273.2	582.9	295.6	1326.1	212.9	823.7	205.8	13.9	3791.0
1975	11.8	0.3	19.5	42.8	202.6	260.3	207.2	376.8	259.0	198.2	16.4	13.4	1608.3
1976	12.2	12.6	17.0	154.7	626.0	608.0	305.6	420.3	377.0	91.9	12.6	1.6	2639.5
1977	25.8	0.7	7.3	45.2	126.2	185.5	501.9	638.8	727.5	42.3	178.9	0.0	2480.1
1978	0.0	0.0	1.4	47.1	161.5	351.2	491.3	1079.8	353.2	224.0	58.9	7.7	2776.1
1979	2.0	0.8	4.3	76.9	402.1	179.5	423.6	743.1	203.4	168.0	7.4	13.5	2224.6
1980	0.9	2.8	20.8	5.0	387.3	183.7	803.2	169.4	398.8	204.8	316.8	11.2	2504.7
1981	7.4	3.0	0.0	64.3	179.7	526.5	462.3	862.7	298.6	122.3	161.5	0.9	2689.2
1982	0.0	5.9	5.8	154.0	179.0	254.7	755.9	589.4	215.2	116.6	30.4	44.1	2351.0
1983	13.8	12.4	3.1	1.5	54.6	200.0	173.3	839.2	313.3	108.3	33.7	4.3	1757.5
1984	6.4	0.0	26.8	96.0	213.0	321.4	225.0	1131.5	185.5	253.2	11.5	0.9	2471.2
1985	1.1	9.0	20.5	91.5	172.3	977.0	185.9	935.0	377.3	231.2	37.9	2.8	3041.5
1986	15.3	18.0	8.5	2.5	356.1	191.1	935.5	866.8	670.5	78.7	45.2	12.3	3200.5
1987	0.0	0.0	7.6	8.9	71.7	294.4	334.4	332.4	290.7	261.7	10.8	7.5	1620.1
1988	4.7	27.9	0.0	66.4	293.1	463.5	693.1	361.5	354.4	243.4	18.6	0.5	2527.1
1989	15.9	15.4	76.7	18.4	150.5	237.6	761.1	465.6	709.9	215.0	47.7	0.4	2714.2
1990	0.0	0.0	1.6	3.7	210.3	984.5	485.0	904.3	526.0	118.5	18.2	19.8	3271.9
1991	0.0	6.0	27.4	63.5	95.5	196.4	506.0	568.2	412.0	525.8	13.7	0.2	2414.7
1992	11.0	0.5	10.5	52.5	286.6	358.6	450.5	820.3	906.5	44.0	6.0	0.1	2947.1
1993	0.3	3.0	4.4	49.3	48.6	434.0	379.6	348.1	412.2	317.7	78.0	10.8	2086.0
1994	13.0	8.5	15.3	32.7	111.4	207.0	999.1	335.6	292.8	71.9	1.5	1.7	2090.5
1995	0.0	0.7	0.3	7.3	221.5	193.5	600.3	440.5	274.5	119.6	36.2	24.6	1919.0
1996	3.5	0.7	4.5	44.0	155.8	130.5	908.7	585.3	411.6	136.5	187.6	0.1	2568.5
1997	3.8	0.1	10.5	66.4	312.3	242.3	291.5	809.2	246.9	71.8	23.9	0.3	2079.0
1998	0.2	0.0	2.2	37.3	230.2	87.8	158.1	273.1	946.5	619.1	132.1	38.0	2524.6
1999	3.1	0.0	81.0	74.9	161.4	441.9	514.5	982.6	332.4	392.1	46.8	16.5	3047.2
2000	1.1	38.6	68.2	52.8	324.4	206.8	1126.2	552.0	351.0	504.4	18.4	36.5	3280.4
2001	2.3	29.4	136.1	68.0	182.8	346.3	809.1	312.0	493.8	30.3	13.5	5.3	2428.9
2002	0.8	19.0	7.1	15.7	298.6	266.4	1275.1	257.6	267.6	221.4	19.9	31.2	2680.4
2003	2.4	3.9	9.6	16.5	756.7	525.0	378.2	920.4	354.2	114.0	41.7	0.7	3123.3
2004	2.6	72.9	7.0	8.0	306.1	668.0	286.1	1181.4	131.1	33.0	62.6	81.6	2840.4
2005	2.2	0.0	11.6	30.6	163.2	345.2	229.2	413.1	416.9	165.9	59.9	23.9	1861.7
2006	8.9	1.4	16.8	29.1	110.1	179.1	962.4	508.9	321.3	174.0	86.3	15.2	2413.5
2007	4.0	2.4	12.7	40.8	185.5	235.6	203.9	890.2	230.7	164.3	244.8	4.0	2218.9
2008	6.6	31.6	39.4	75.4	391.6	174.4	525.7	921.5	471.0	55.7	42.2	0.0	2735.1
2009	1.6	10.0	27.8	241.7	301.1	524.9	693.9	458.5	532.7	1014.5	6.0	0.0	3812.7
2010	0.1	0.6	2.4	79.9	177.5	264.9	282.6	492.2	246.0	623.6	154.6	9.8	2334.2
2011	16.0	12.2	17.7	29.8	270.3	667.2	375.4	822.9	458.8	160.6	75.4	29.3	2935.6

2012	5.9	23.9	58.5	39.4	230.3	670.7	695.0	1193.2	318.9	47.6	10.3	6.7	3300.4
2013	9.1	4.8	51.0	83.1	181.6	191.1	262.4	1149.0	520.0	148.4	24.7	28.9	2654.1
2014	0.0	0.5	2.5	125.8	170.0	468.6	527.7	482.8	831.5	106.6	7.0	15.4	2738.4
2015	3.6	1.2	19.9	54.0	75.1	197.7	1129.4	521.3	317.6	462.4	1.2	109.8	2893.2
Period of Record:	1974-2015												
Monthly Rainfall in mm													
n	42	42	42	42	42	42	42	42	42	42	42	42	42
Mean	5.3	9.1	20.6	55.9	233.5	357.8	538.3	673.4	404.1	234.0	62.1	15.4	2609.4
Max	25.8	72.9	136.1	241.7	756.7	984.5	1275.1	1326.1	946.5	1014.5	316.8	109.8	3812.7
Min	0.0	0.0	0.0	1.5	48.6	87.8	158.1	169.4	131.1	30.3	1.2	0.0	1608.3
StDv	6.0	14.3	27.6	47.2	138.9	213.7	296.0	303.9	192.1	218.7	74.0	22.0	513.8

Table EW-18
Generated Monthly Streamflows for Darigayos River Basin

Proposed 2x335MW Coal-Fired Power Plant Project in Luna
Monthly Mean Flow in LPS

River: Darigayos River
Station Name: Darigayos River, Luna, La Union
Latitude: N/A — Elevation: 86.0 km^2
Longitude: N/A — Operating Agency: None

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1974	647	114	73	511	1555	10279	5487	19398	5158	14669	4943	937	5314
1975	1330	140	604	432	1156	4604	3854	5527	6268	2549	425	906	2400
1976	1370	1211	532	1527	3553	10721	5672	6163	9108	1659	334	186	3503
1977	3739	175	252	456	723	3288	9298	9355	17544	778	4302	88	4167
1978	145	114	82	474	923	6203	9102	15799	8535	4008	1439	558	3949
1979	346	184	166	766	2285	3182	7852	10879	4929	3012	210	912	2894
1980	236	358	641	63	2202	3256	14864	2496	9633	3667	7592	772	3815
1981	888	375	42	643	1026	9287	8566	12627	7221	2200	3887	143	3909
1982	145	328	209	1520	1022	4505	13990	8634	5213	2099	759	2780	3459
1983	1531	1194	131	28	317	3543	3228	12284	7575	1951	837	351	2748
1984	788	114	814	953	1214	5679	4183	16555	4499	4527	308	143	3315
1985	256	898	633	909	984	17212	3461	13684	9225	4136	938	259	4374
1986	1681	1682	287	38	2025	3386	17307	12687	16172	1425	1112	839	4887
1987	145	114	261	101	414	5204	6204	4878	7031	4678	291	546	2489
1988	617	2544	42	663	1668	8179	12830	5303	8564	4353	477	119	3780
1989	1742	1455	2252	194	861	4204	14086	6825	17120	3848	1171	113	4489
1990	145	114	88	50	1199	17344	8986	13235	12694	2132	468	1297	4813
1991	145	637	831	635	549	3480	9374	8324	9950	9373	360	101	3647
1992	1250	157	344	527	1631	6333	8348	12008	21852	808	177	94	4461
1993	175	375	169	496	283	7660	7039	5108	9955	5674	1894	748	3298
1994	1450	854	483	334	639	3666	18482	4925	7081	1304	69	192	3290
1995	145	175	50	85	1263	3429	11116	6458	6641	2152	897	1590	2833
1996	497	175	171	444	891	2320	16812	8574	9933	2452	4509	94	3906
1997	527	123	344	663	1777	4287	5411	11845	5976	1302	604	107	2747
1998	165	114	105	379	1312	1569	2947	4012	22815	11032	3185	2408	4170
1999	457	114	2376	746	922	7799	9531	14379	8034	6996	1150	1096	4467
2000	256	3476	2007	530	1845	3663	20830	8087	8482	8993	472	2316	5080
2001	376	2675	3965	679	1043	6117	14973	4580	11919	564	356	412	3972
2002	226	1769	246	167	1699	4711	23581	3785	6475	3962	508	1993	4093
2003	386	454	318	175	4294	9260	7013	13470	8559	2052	1028	131	3928
2004	406	6464	243	92	1742	11776	5312	17284	3189	612	1527	5069	4476
2005	366	114	376	313	932	6097	4261	6057	10068	2975	1463	1547	2881
2006	9080	236	526	298	632	3175	17804	7457	7767	3119	2094	1016	4434
2007	547	323	408	413	1059	4169	3793	13029	5586	2947	5874	333	3207
2008	808	2866	1177	751	2226	3093	9738	13486	11370	1016	1040	88	3972
2009	306	985	843	2378	1713	9259	12845	6721	12855	18061	177	88	5519
2010	155	166	111	795	1013	4685	5247	7213	5955	11112	3722	687	3405
2011	1752	1177	552	305	1539	11762	6961	12046	11077	2881	1832	1877	4480

Table EW-18 continued

Proposed 2x335MW Coal-Fired Power Plant Project in Luna													
Monthly Mean Flow in LPS													
				River:		Darigayos River							
				Station Name:		Darigayos River, Luna, La Union							
Latitude:		N/A						Elevation:			86.0 km^2		
Longitude:		N/A						Operating Agency:			None		
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2012	738	2196	1728	399	1312	11824	12865	17456	7709	872	279	497	4823
2013	1059	532	1512	827	1037	3386	4874	16811	12550	2664	623	1853	3977
2014	145	157	114	1244	971	8268	9775	7076	20047	1921	200	1028	4246
2015	507	218	615	542	434	3503	20889	7638	7678	8246	62	6791	4760
Period of Record: 1974-2015													
Monthly Flow in LPS													
n	42	42	42	42	42	42	42	42	42	42	42	42	42
Total	37676	37945	26725	23545	55886	265367	418789	414158	409904	175778	63593	43109	164373
Mean	897	903	636	561	1331	6318	9971	9861	9760	4185	1514	1026	3914
Max	9080	6464	3965	2378	4294	17344	23581	19398	22815	18061	7592	6791	5519
Min	145	114	42	28	283	1569	2947	2496	3189	564	62	88	2400
Monthly Runoff in mm													
	31.0	28.2	22.0	18.8	46.0	211.6	345.0	341.2	326.8	144.8	50.7	35.5	
Monthly Runoff Volume in 1,000,000 m^3													
	2.4	2.2	1.7	1.5	3.6	16.4	26.7	26.4	25.3	11.2	3.9	2.7	
	Annual Values:			Mean Flow		Runoff Depth		Runoff Volume		Max M. Flow		Min. M. Flow	
				3914 LPS		1601.9 mm		124.0 x 10^6 m^3		23581 LPS		28 LPS	

From the generated 42 years of monthly stream flows, Darigayos River depicts an average flow of 3,914 liters per second, which ranges from a monthly minimum of 28 liters per second to a monthly maximum of 23,581 liters per second. On the other hand, the project site, which is drained by an approximately 4-m width ground depression, has an average flow of 19.9 liters per second and a monthly maximum flow of 120.5 liters per second. The minimum flow is zero since the ground depression is often dry during periods of no rainfall.

Also from the generated streamflows, flow duration analysis was undertaken for Darigayos River to determine the dependable streamflows of the nearest river to the project site. The flow duration curve of a river indicates the exceedance probability or also called the dependability of a specific streamflow magnitude. For flow diversions, the 80% exceedance probability or the flow that is available 80% of the time throughout the year is regarded by the NWRB as the dependable flow at the point of diversion. Also, 10% of the dependable flow is considered as the minimum environmental flow. A flow at least equal to the minimum environmental flow has to be released all the time to the downstream reach of the diversion point for ecological sustainability. **Figure EW-10** exhibits the flow duration curve of Darigayos River at a point nearest to the project site.

Based from the generated flow duration curve of Darigayos River, the 80% dependable flow is estimated at 356 liters per second. Subtracting the minimum environmental flow (10% of the dependable flow), the net dependable flow of the river is *320 liters per second* at possible point of diversion.

Referring to the surface water permitees of NWRB (**Table EW-16**), there are 5 major water users of Darigayos River that amount to 305.1 liters per second. The largest user is the Balaoan Irrigators Association, Inc. with a granted permit of 300lps. Given the net dependable flow of 320lps and the existing water permits of 305.1lps of Darigayos River, 14.9lps may be applied for river diversion should the Proponent decide to use river water. On the other hand, the ground depression draining the project site has no dependable flow since it is a ground depression in which flow is only observed during considerable rainfall events.

The project is not expected to cause reduction in volumetric flow since it will not use the Darigayos River as a water source. The project's freshwater requirements are to be provided by either a local water supplier or an in-house desalination plant.

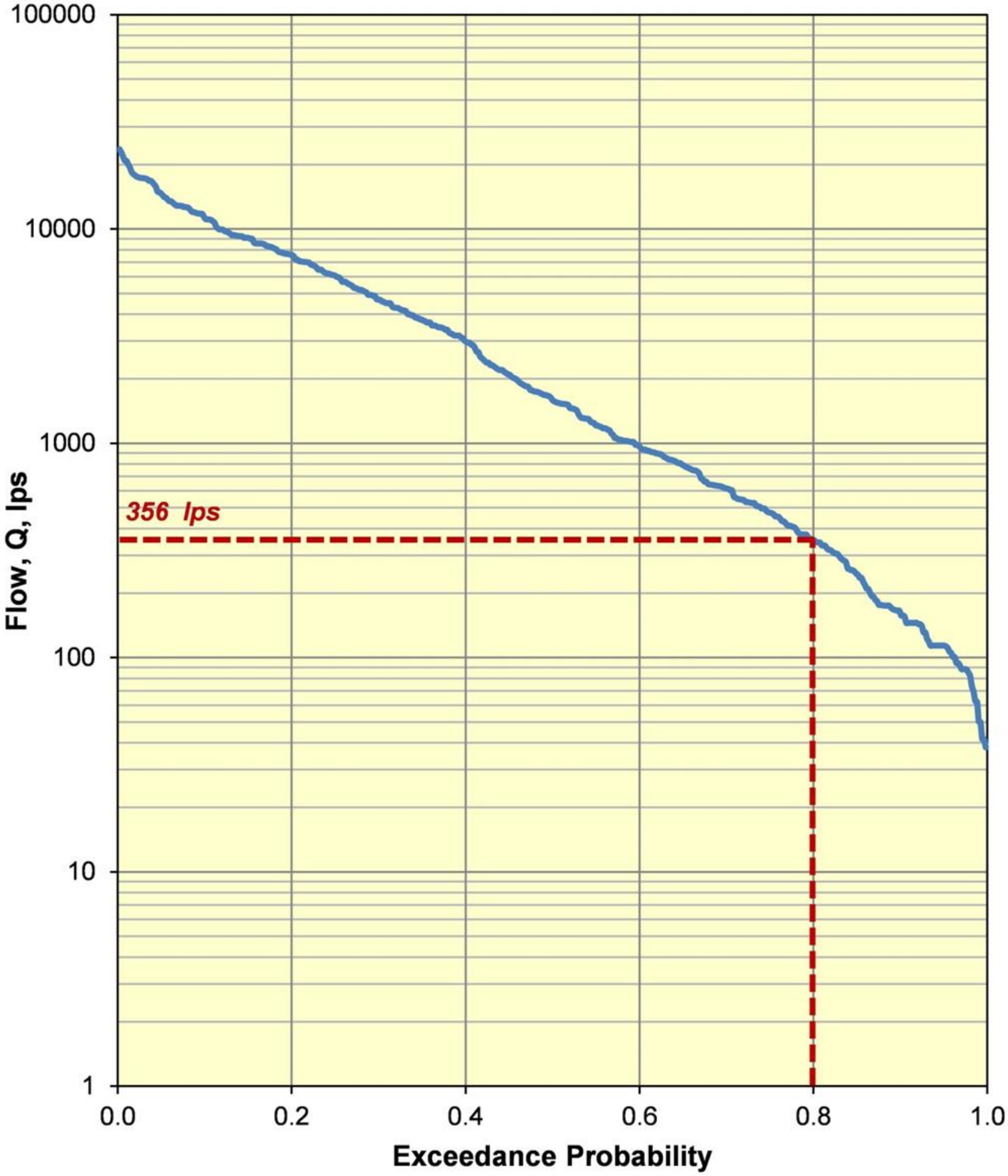


Figure EW-10. Generated Flow Duration Curve for Darigayos River based from the Estimated Streamflows of the Basin

LEGEND:

Flow Duration Curve

SCALE: Not to Scale

ENVIRONMENTAL IMPACT STATEMENT
2x335MW COAL-FIRED POWER PLANT PROJECT

DATA INFORMATION/SOURCE:

Data and Graph Generated By: Aperçu_AConjares

aperçu CONSULTANTS INC.

2.1.6 Water Balance Study

The results of the water balance simulation are the time slots of the computed equivalent water depths (in millimeters) of various components of the hydrologic cycle. The summary results are presented in time series plots as shown in **Figure EW-11**.

The monthly averages of rainfall, actual evapotranspiration, runoff, change in soil moisture storage and surplus or groundwater recharge from the 42-year water balance simulation are computed and presented in **Table EW-19** and **Figure EW-12**.

Table EW-19
Summary of Monthly Averages of Rainfall, Evapotranspiration, Runoff, Change in Soil Moisture Storage and Groundwater Recharge from the Water Balance Simulation

Month	Rainfall (mm)	Actual Evapo-Transpiration (mm)	Runoff (mm)	Δ Soil Moist. Storage (mm)	Groundwater Recharge (mm)
Jan	5.3	33.4	10.5	-26.9	0.0
Feb	9.1	21.7	6.4	-15.8	0.0
Mar	20.6	24.2	8.5	-10.8	0.0
Apr	55.9	40.4	20.1	-4.1	0.0
May	233.5	114.2	79.3	31.0	6.5
Jun	357.8	128.5	108.4	58.0	46.1
Jul	538.3	128.8	135.6	59.8	161.3
Aug	673.4	119.8	160.9	22.4	295.5
Sep	404.1	108.6	169.1	2.6	151.5
Oct	234.0	103.2	125.7	-20.9	69.8
Nov	62.1	83.7	64.8	-49.3	5.9
Dec	15.4	56.0	25.0	-46.0	0.0
Total	**2609.4**	**962.6**	**914.2**	**0.0**	**736.5**

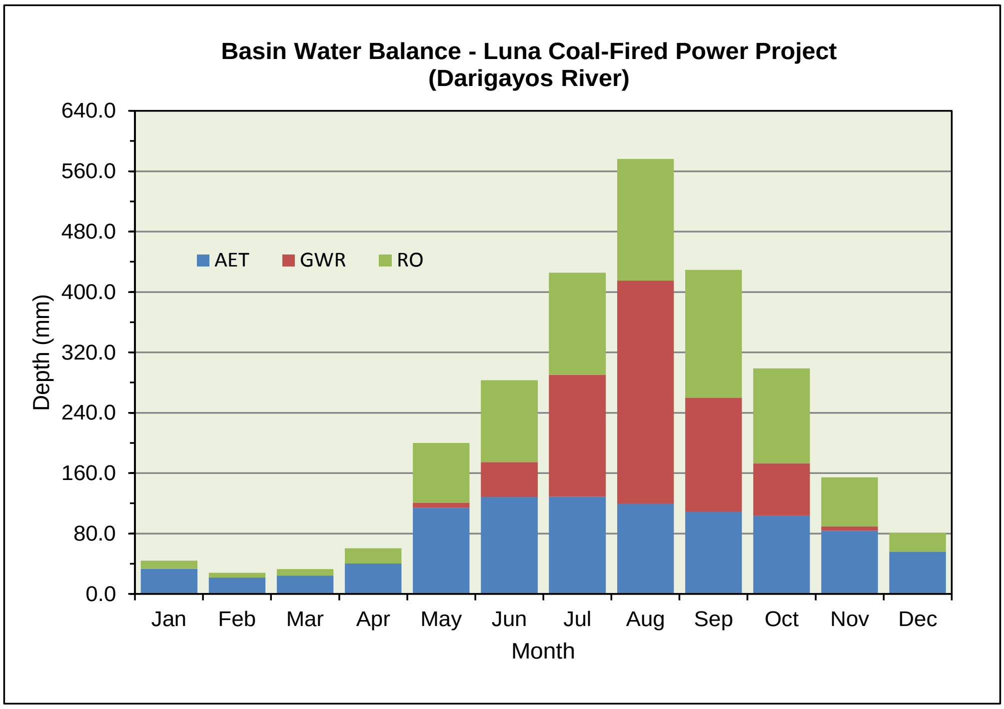


Figure EW-12. Monthly and Annual Water Balance of Darigayos River Basin

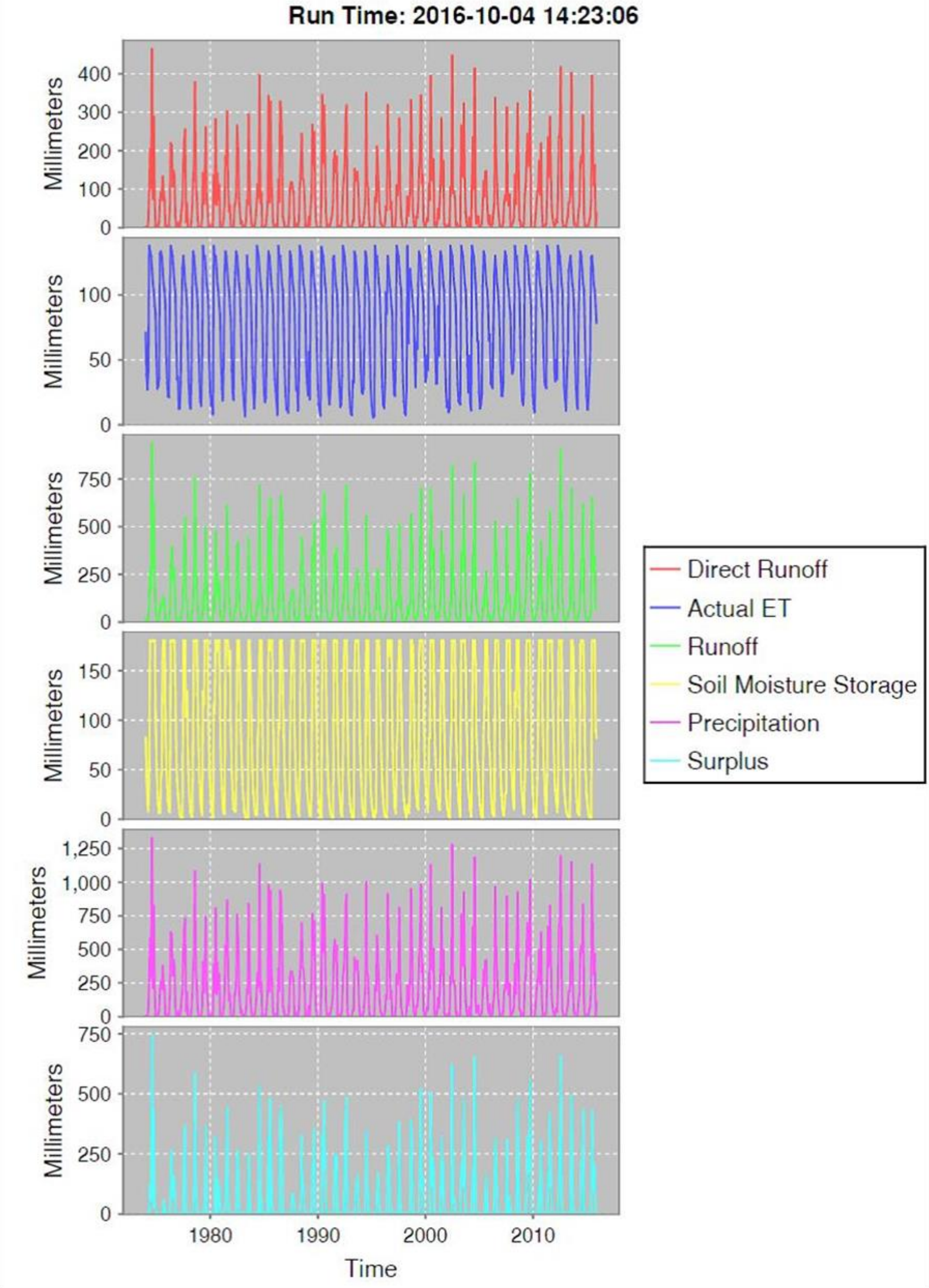


Figure EW-11. Time Series Plots of the Hydrologic Components	**LEGEND: (As Above)**	**SCALE: Not to Scale**
ENVIRONMENTAL IMPACT STATEMENT **2x335MW COAL-FIRED POWER PLANT PROJECT**	**DATA INFORMATION/SOURCE:** **Generated From:** Thornwaite Monthly Water Balance Program, 2016 **Generated By:** Aperçu_AConjares	aperçu CONSULTANTS INC. **PAGE: 182**

Simulations indicate that the annual groundwater recharge at Darigayos River basin is *736.5mm* or 28.2% of its mean annual rainfall. Considering the project area of 40 hectares, this groundwater recharge is translated to an average daily volume of around 827m³ per day over the area. However, this water amount may not be available for use since recharge occurs only during the rainy season and based on the hydrogeology of the area, the project site is situated in an area categorized as "less productive aquifer" that is not capable of containing and yielding considerable amounts of water. Wells have to be drilled in the area and pump tests carried out, to determine the actual possible yield of the underlying aquifer should its use be considered. Hence, groundwater is not being considered as a source of freshwater during the construction nor during the operation phases of the project.

Another available option to meet the freshwater requirement is to use the streamflow of Darigayos River, which has an available flow of 14.9lps, after subtracting the existing water permits in the area that use 305.1lps, from the computed net dependable flow of 320lps. However, the proposed diversion point is located around 2km away from the project site and the elevation is even lower than the average project site elevation, which means conveyance will not be achieved merely by gravity. Any reduction in volumetric flow will have a minimal impact since the computed available flow already considered all the water users in the area and no other water users are located downstream of the possible diversion point. Nevertheless, the project proponent is not considering the Darigayos River for sourcing its water requirements.

During the operation phase, a significant amount of water will be required by the power plant for cooling. This volume of water is to be taken from the sea and eventually discharged back to the sea thus, producing no impact on the availability of freshwater in the area during this stage.

A desalination plant facility and a potable water treatment plant facility will be integrated in the plant design thus supplying the freshwater requirement for the operation of the project. Supply from a local water service provider will also be considered. Consequently, there is no predicted impact on the freshwater availability during operation.

2.1.7 Summary of Potential Impacts and Mitigation Measures for Hydrology/ Hydrogeology

The Environmental Management Plan is summarized in **Tables EW-20**. Based on the assessment of the project impacts and concerns on hydrology and water resources, there will be minimal impacts due to the project. The possible impact on the surface water due to the water supply for cooling water requirement of the power plant is eliminated by the use of seawater for cooling. On the other hand, the possible significant impact due to flooding is also mitigated by the provision of a properly designed drainage system that will discharge storm water directly to the sea as well as the channel improvement of the ground depression draining the project site so as to increase the discharge capacity of the main drain in the study area.

Table EW-20
Summary of Environmental Management Plan

Project Phase/ *(Project Activity which will Likely Impact the Environmental Component)*	Environmental Component Likely to be Affected	Potential Impact	Options for Prevention or Mitigation or Enhancement
I. CONSTRUCTION PHASE			
Change in drainage morphology	Surface water	Earthworks such as grading, filling, and excavation will be done in the project site. These may affect the ground	• Any affected portion of the depression will be re-aligned to make sure that outflow will continue un-impeded and no flooding will occur in the area. • Channel ditches and/or pipe drains will be provided to carry generated flows, around the area being developed, to the main storm water outfalls leading to the

Project Phase/ ***(Project Activity which will Likely Impact the Environmental Component)***	**Environmental Component Likely to be Affected**	**Potential Impact**	**Options for Prevention or Mitigation or Enhancement**
		depression within the project site.	main river channel (ground depression) and/or directly to the West Philippine Sea. • Before the existing drainage and ground depressions are backfilled, the proposed alignment and/or improvement of the main drainage system and storm water outfalls directly leading to the sea will already be constructed.
II. OPERATION PHASE			
Use of water for cooling purposes	Seawater	Extraction of significant amount of water Thermal discharge	• Apply for necessary extraction permit • Application of once-through cooling system with discharge back to the sea • Ensure temperature of discharge water is within DENR standards
Use of water for other plant requirements during operation	Surface water and groundwater	Minimal	• No groundwater extraction • Use of water service providers • Installation of a desalination plant

Monitoring for the hydrology section during the construction phase will include physical inspections of the area of the ground depression during rain events, as well as checking of any ponded areas or flooded areas and drainage systems within the project site. The same inspection for after rain events will also be done during the operation phase.

2.2 Oceanography

2.2.1 Methodology

2.2.1.1 Tidal Observation

An automatic water level logger was set up at a location near GLEDC's proposed project site from 2:00 PM of March 18 to 10:00 AM of March 19, 2017 (submerged about one meter below the surface) to automatically record the fluctuations in water level every five (5) minutes. **Figure EW-13** shows the raw data of the tidal pattern, as well as the ambient water temperature, observed and recorded over a 20-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.

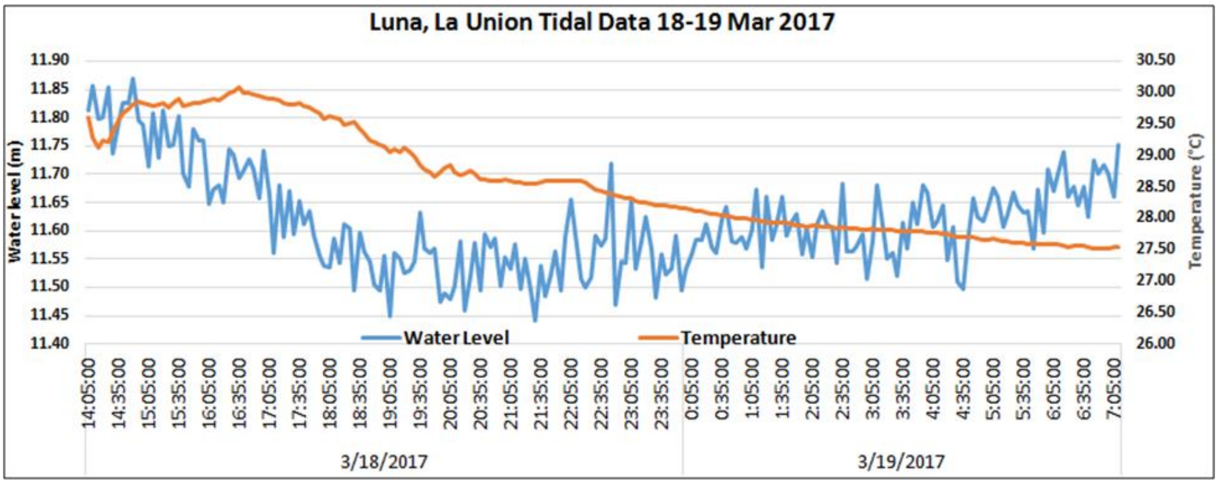


Figure EW-13. Tidal fluctuation and water temperature recorded during the observation period

The tidal water level of the nearest gauging station, i.e. San Fernando Bay Tidal Gauging Station, located south of the project, was used. **Table EW-21** below summarizes the amplitudes and phases of the major tidal constituents for the said station. 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 as the area experiencing mixed primarily semidiurnal tides (i.e., two highs and two lows in a given day).

Table EW-21
Summary of Tidal Constituent for San Fernando Tidal Station

Tidal Constituent	Amplitude	Phase
Semi-diurnal Species		
M2 (principal lunar)	235.2602	0.076661
S2 (principal solar)	243.2496	1.501665
N2 (elliptical lunar)	325.9039	0.154274
K2 (declination lunar-solar)	41.60406	0.456918
Diurnal Species		
K1 (declination lunar-solar)	331.5544	0.595932
O1 (principal lunar)	265.2945	0.198195
P1 (principal solar)	185.9075	0.337926
Q1 (elliptical solar)	248.0925	0.055467

2.2.1.2 Wind Pattern

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 2.62 meters per second generally coming from the west direction.

Table EW-22
Summary of Wind Influence Observed from the Three 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	1,862,528.29	215,322.72	16°49'43.35"N	120°19'43.59"E	WNW	1.7	2.6	2.15
02	1,863,140.61	215,485.38	16°50' 3.33" N	120°19'48.80"E	WNW	2.6	2.9	2.75
03	1,863,897.36	216,003.05	16°50'28.15"N	120°20' 5.93"E	W	2.6	3.3	2.95

2.2.1.3 Surface and Sub-surface Water Movement

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 0.36m/s generally towards the East.

Table EW-23
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	1,862,528.29	215,322.72	16°49'43.35"N	120°19'43.59"E	NE	0.44	0.48	0.46
02	1,863,140.61	215,485.38	16°50' 3.33" N	120°19'48.80"E	NE	0.26	0.32	0.29
03	1,863,897.36	216,003.05	16°50'28.15"N	120°20' 5.93"E	E	0.30	0.36	0.33

Sub-surface currents were observed in three areas (**Figure EW-14**). A drifter was assembled using a floating styrofoam 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 in open waters, the position of the drifter is recorded automatically using the GPS at each 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 GIS software (**Figure EW-14**).

Based on drift current observations, the average subsurface current is about 0.315 meters per second flowing in easterly and southeasterly directions.

Table EW-24
Summary of Sub-Surface Flow Trajectories observed from the Three Stations

Track	Time Stamp		Time Lapsed	End Position		End Position		Distance	Speed	Dir
	Start	End	(secs)	N	E	N	E	(m)	(m/s)	
01	3/18/2017 10:34	3/18/201 7 10:51	240	1,862,566.0	215,310.0	1,862,576.0	215,353.0	68.41	0.285	E
02	3/18/2017 11:11	3/18/201 7 11:31	675	1,863,137.0	215,507.0	1,862,946.0	215,559.0	234.73	0.348	SSE
03	3/18/2017 11:42	3/18/201 7 11:53	185	1,863,879.0	216,004.0	1,863,873.0	216,036.0	57.52	0.311	E

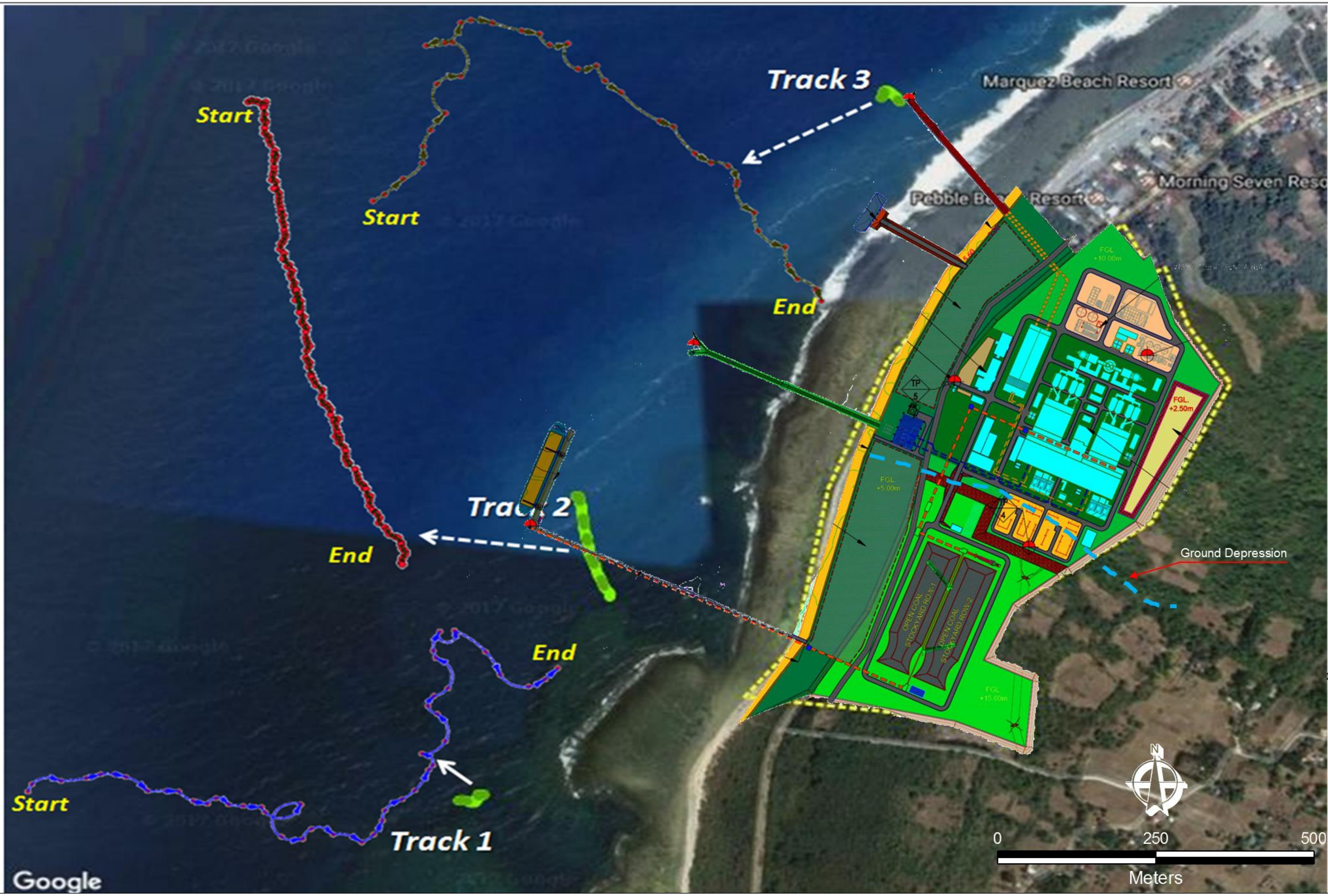


Figure EW-14 Sub-Surface Flow Trajectories Observed from the Three Location using a Drifter	LEGEND: As labelled above	SCALE: 1: 6,000	PAGE: 187
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	*Note: the actual trajectories are the green lines while blow-up of the trajectories are inserted for better visualization*	DATA INFORMATION/SOURCE: **Base Map:** Google Earth Imagery, 2016 **Imagery Date:** 15 May 2017 **Project Layout:** GLEDC, 2017 **Created By:** Aperçu_AConjares	aperçu CONSULTANTS INC.

2.2.1.4 Bathymetry

The bathymetric survey was conducted within a 120-hectare extent of the coastal area fronting the proposed project site. To develop a bathymetric map within the project vicinity, a survey was done with a Garmin echo-sounder installed on the boat, collecting depth information every 2 second interval. **Figure EW-15** shows the spatial distribution of the depth data collected.

Figure EW-16 depicts the bathymetry of the area fronting the project site and includes the locations of the survey control points. The shore and water line has an elevation of 7 meters above sea level, with the mean sea level at a depth of zero-meter depth.

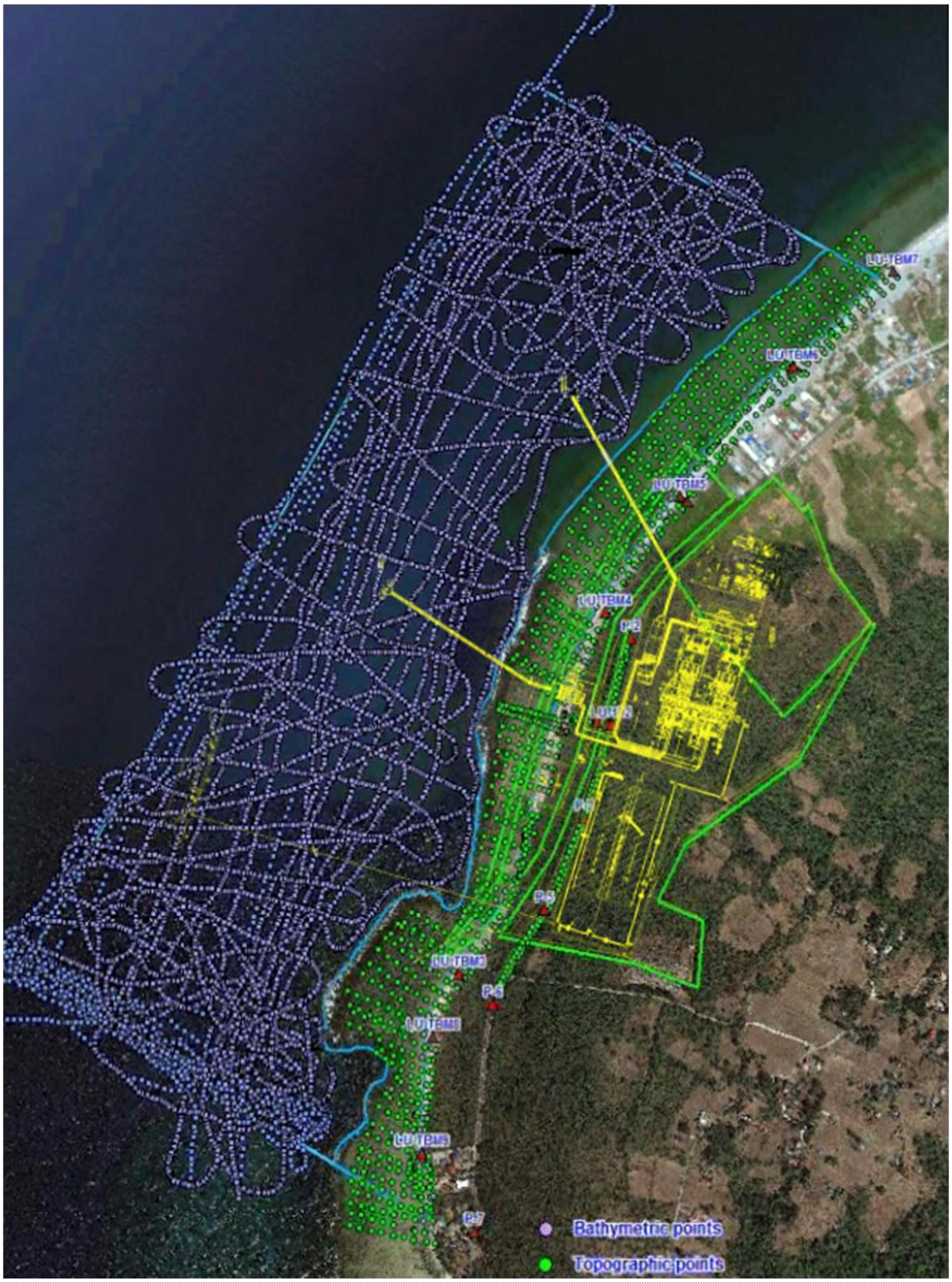


Figure EW-15. Spatial Distribution of Bathymetric Data

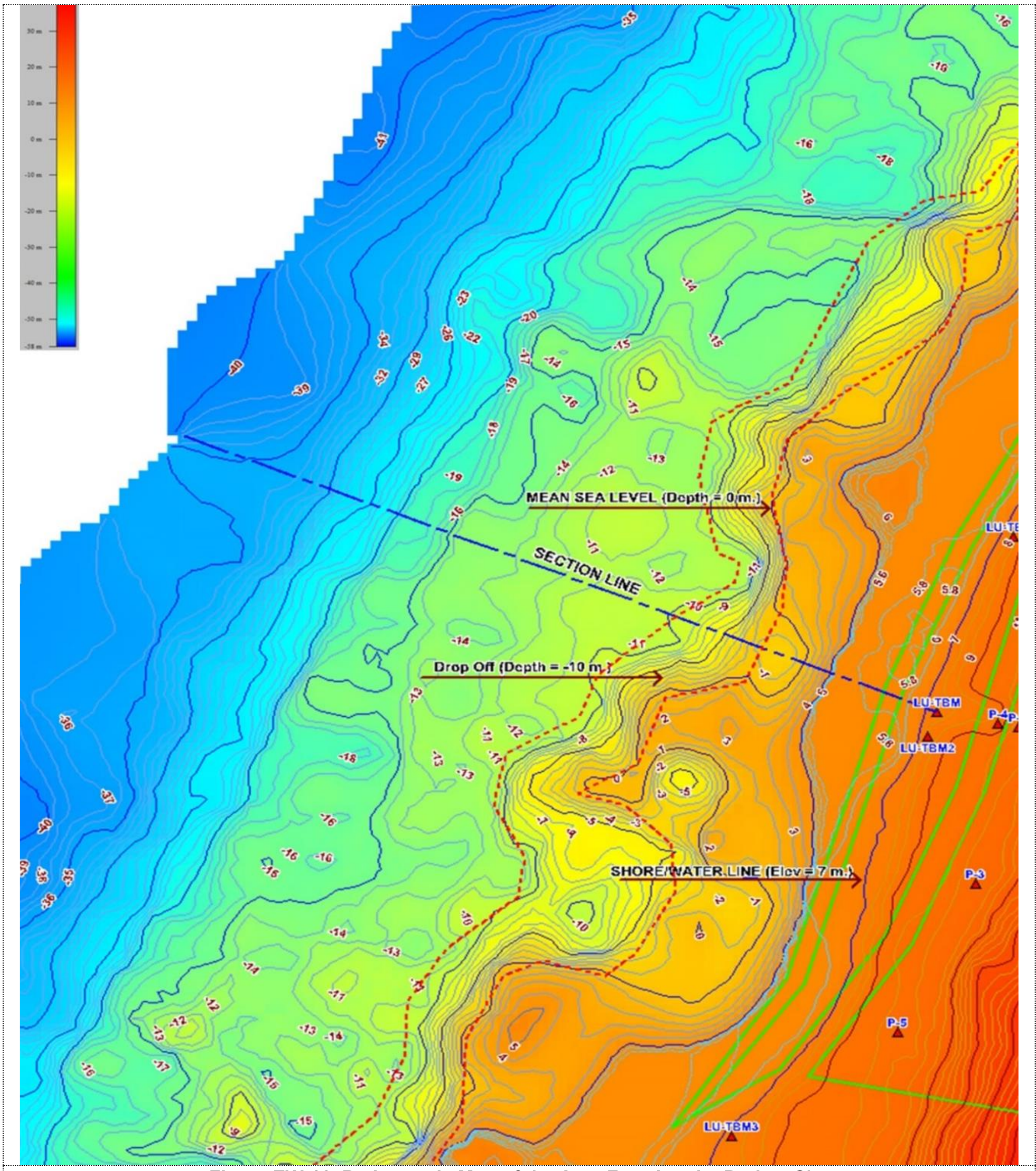


Figure EW-16. Bathymetric Map of the Area Fronting the Project Site

2.2.1.5 Particle Tracking Model Setup and Modelling Scenarios

Background

In this oceanographic assessment study, numerical modelling is employed to assess the potential impact on the water quality from an unspecified pollutant discharge on the harbour waters for different wind speeds and directions, as well as different tidal conditions (spring and neap tides) for the proposed installation.

The main objective of the modelling was to determine the effect on the flow and water quality in the project area and to determine specifically potential hotspot areas as a result of an accidental spillage of an unspecified pollutant.

An example of this would be polluted storm water (or solid particulates during construction works) discharging in the coastal area of the proposed development.

The assessment of pollution impacts has been conducted by predicting the dispersion and fate of the pollutant, of which the particle tracking model Delft3D-PART was used to simulate pollutant dispersion. The model simulates the dispersion of pollutant by discharging particles at specified discharge rates and locations. Every particle represents a specific pollutant mass. Resulting concentrations of pollutants are defined by the relative number of particles present in a certain area at a certain time.

Because the actual composition of the pollutants is not known, the representative pollution load used in this model setup is based on the bottom sediment that may be disturbed during excavation and dredging works during the construction of the intake, outfall, jetty and other appurtenant coastal structures. Typical mechanical dredging equipment used for such works include grab dredge (i.e., clam shell) and backhoe dredge. The action of these dredgers causes a lot of water turbidity (muddying up the waters with disturbed materials).

In determining the amount of pollution (suspended sediment) loadings for consideration in this study, a 2% rate of sediment loss from the dredgers was assumed. For a typical backhoe dredging equipment with a bucket capacity of 5 cubic meters and assuming it is operated 30 cycles per hour, the volume of dredged material is about 150 m^3/hr. Local borehole or sediment grab samples were not available at the time of this study therefore, a dry sediment density of 800 kg/m^3 was applied for the dredge material. Applying the 2% loss rate and assumed sediment density, the rate of fine sediment released at the immediate vicinity of the dredging sites is about 0.67 kg/s. For model input, this suspended sediment loading is assumed equivalent to a conservative constant release rate of some 0.80 liter per second with a mean concentration of 834 kilograms per cubic meters (or 834,000 mg/L). The very low discharge is considered to ensure that no additional increase of flow velocities near the discharge point is generated.

Finally, to cover higher than normal pollution loads, it is assumed that during construction, about four (4) units of backhoe/dredgers are used thus, these four sources of pollution with individual source loads of 0.67 kg/s each are strategically placed in the model which is within the coastal seafront of the proposed power plant. Moreover, as construction works are normally conducted during daytime, it is assumed that daily releases of sediment occurred for a 12-hour period starting at 6:00 AM ending at 6:00 PM, which were then fed into the model.

The hydrodynamic data necessary for the analysis of the dispersion of pollutants were generated with the detailed hydrodynamic model set-up as discussed in the preceding sections.

Model Setup for Particle Tracking Simulation

This section assesses the water quality transport and simple water quality processes by means of a particle tracking method. In particular, dispersal, dilution and accumulation patterns of an unspecified pollutant (say particulate matter dispersed during construction or polluted storm water runoff during project operation, for example) released within the immediate vicinity of the project area as it is transported by the ambient current circulations were investigated.

The model considers the release of 80,000 particles in four locations just offshore of the 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 particles 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 particles in the assumed discharge points within the coastal stretch of the plant were simulated for 26 days in the model, to allow buildup of the far field particle concentrations over many tidal cycles. The releases in a given day were assumed to start at 6:00 in the morning and ends at 6:00

in the afternoon, as it is unusual for non-stop offshore excavation works of piers and intake and outfall structure. Results were examined over a spring and neap cycle using tidal data from March 2017.

The results of the model runs are shown in the next succeeding figures. Some of the results of the 26-day simulation of particles 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.

Model Setup for Hydrodynamic Simulations

The Deltares' Delft3D models were employed for the assessment. The water quality module simulates transport and simple water quality processes by means of a particle tracking method using the flow data from the hydrodynamic module. The tracks are followed in two dimensions over time, whereby a dynamic concentration distribution is obtained by calculating the mass of particles in the model grid cells.

The processes are assumed to be deterministic except for a random displacement of the particle at each time step. The particle tracking method is based on random-walk method since the simulated behaviour is stochastic and the number of particles is limited. Particle tracking allows water quality processes to be described in a detailed spatial pattern, resolving sub-grid concentration distributions.

Basically, the hydrodynamic model setup consists of refined grids, distributed in a way to resolve the high resolution required in the coast and narrow channels, while providing enough coverage far offshore of West Philippine Sea. Grid sizes ranged from 250 m down to 100 m, covering about 50 km offshore from the Project area. The resolution in the vicinity of the La Union project area is enhanced using the small grid size of about 40 m.

The transport of substances was dependent on the results of the hydrodynamic model and were used as inputs for the particle tracking model to assess the impact of an accidental release of an unspecified pollutant during the construction and operational phases of the project.

The models were run for the following simulation periods: March 5-31, 2017. 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.

For the model scenarios, a conservative pollutant, i.e. without the incorporation of decay factor, was assumed to discharge continuously from 6:00 AM to 6:00 PM daily for 26 days, at the vicinity of the proposed power plant at an assumed rate of 0.67 kg/s per source for four (4) sources. Tidal and wind driven currents then conveyed the pollutants and diluted the pollutants to the surrounding coastal waters.

Hydrodynamic Modelling Scenarios

To help quantify the effect of coastal circulation and pollutant dispersion in the study area, the hydrodynamic model was used to simulate the effect of the representative tidal events occurring from March 01 to 31, 2017. The first 5 days of the simulation was used to ensure that the model reached its steady state thus preventing the effect of numerical oscillations as a result of the initial conditions of the model run. The particle tracking simulation started from the 5th March to 31st March 2017, 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: San Fernando and Port Salomangue, 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 in **Figure EW-17** from which it can be deduced that the model (in black line) under-predicts high tides and over-predicts the low 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 was aggregated into a 30-minute interval to eliminate 'noises' also shown as a green 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.

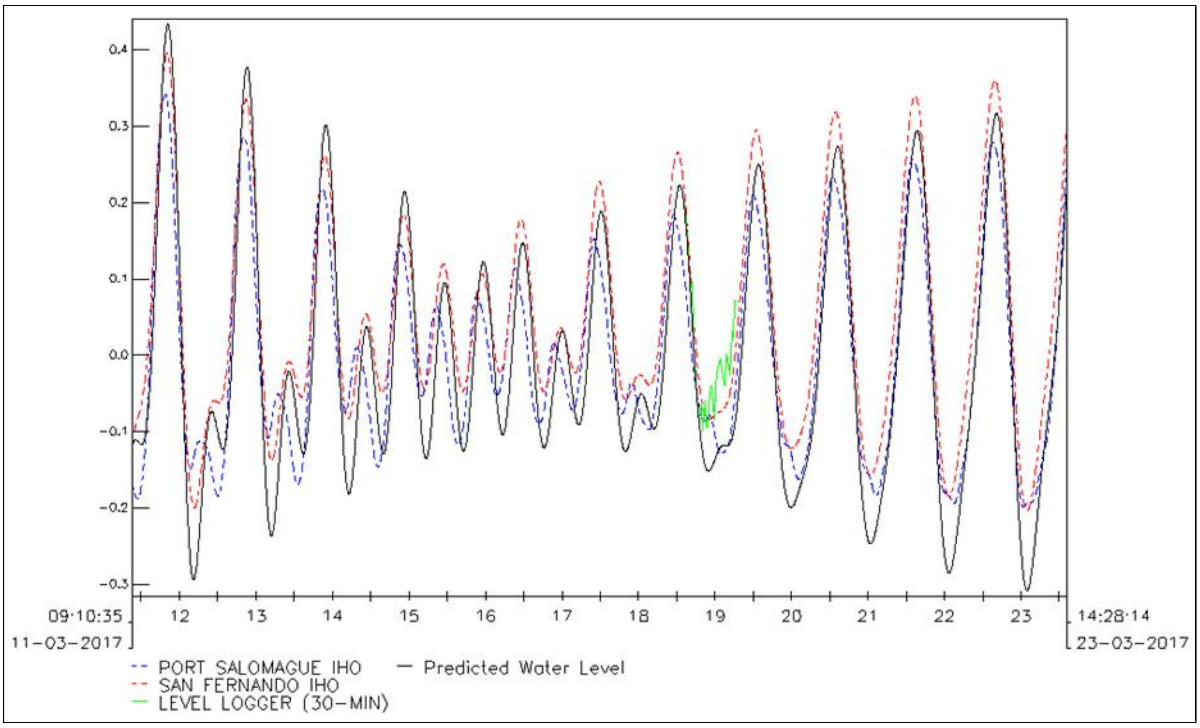


Figure EW-17. Comparison of water levels in the area: Predicted tides at Port Salomangue and San Fernando Stations derived from tidal harmonics, observed water level using a data logger and predicted water levels using the model

One of the critical inputs of the hydrodynamic model is the bathymetry (or bottom configuration of the sea bed). Hence, a bathymetric survey was conducted to complement the available, but somewhat coarse NAMRIA topographic map, as well as the previous surveys made. The sites chosen for the survey were mainly the immediate areas that were outside of the coverage of previous bathymetric survey. Depth data was extracted from the published NAMRIA topographic map of the whole area for sites that were outside the coverage of previous bathymetric surveys. After appropriate post-processing, these three (3) datasets were merged, interpolated at every computational grid cell and then eventually used in the setup of the hydrodynamic model for the project area.

2.2.2 Hydrodynamic Modelling Results

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.

2.2.2.1 Habagat (Southwest) Wind Scenario

Figures EW-18 and **EW-19** 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 the West Philippine Sea, depth-averaged currents during high tidal event, are geared towards the south flowing into the project area and then veer westward offshore of Santiago Island with the residual flow entering Lingayen Gulf. The modelled flow magnitudes in the project area is quite moderate, with flow velocities in the range of 0.02 to 0.060 m/s while flow velocity fields in the range of about 0.05 m/s are likewise predicted by the model near the coast and to more than 0.10 m/s far offshore. Far south of the project, weak circular gyres are also predicted to form near the shore with velocities in the range of 2 to 5 cm/s.

During tidal ebbing, the flow velocity field far offshore is directed to flow towards the project area, with significantly higher flow magnitudes in the range of more than 10 cm/s is predicted to occur north of Santiago Island, and of the out flowing current exiting Lingayen Gulf. Likewise, higher flow magnitudes are expected near the coast, with speeds of more than 8 cm/s is predicted headings towards the northeast.

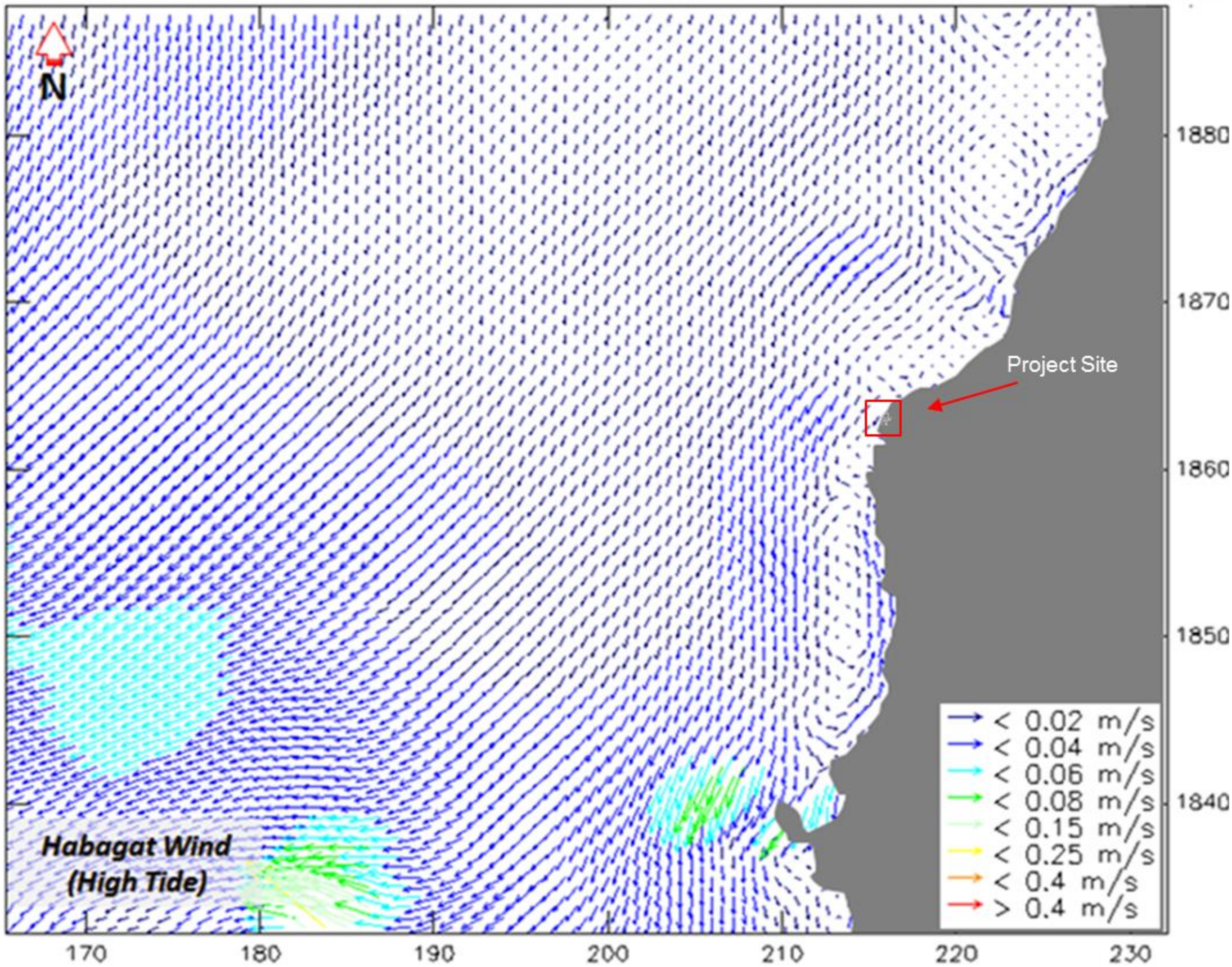


Figure EW-18. Predicted Currents in the Project Area during Tidal Flooding (Habagat Wind Condition)	LEGEND: As Above	SCALE: 1:80,000
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: **Software Used:** Delt3D- PART **Project Layout:** GLEDC, 2017 **Generated By:** Aperçu_AConjares	aperçu CONSULTANTS INC.

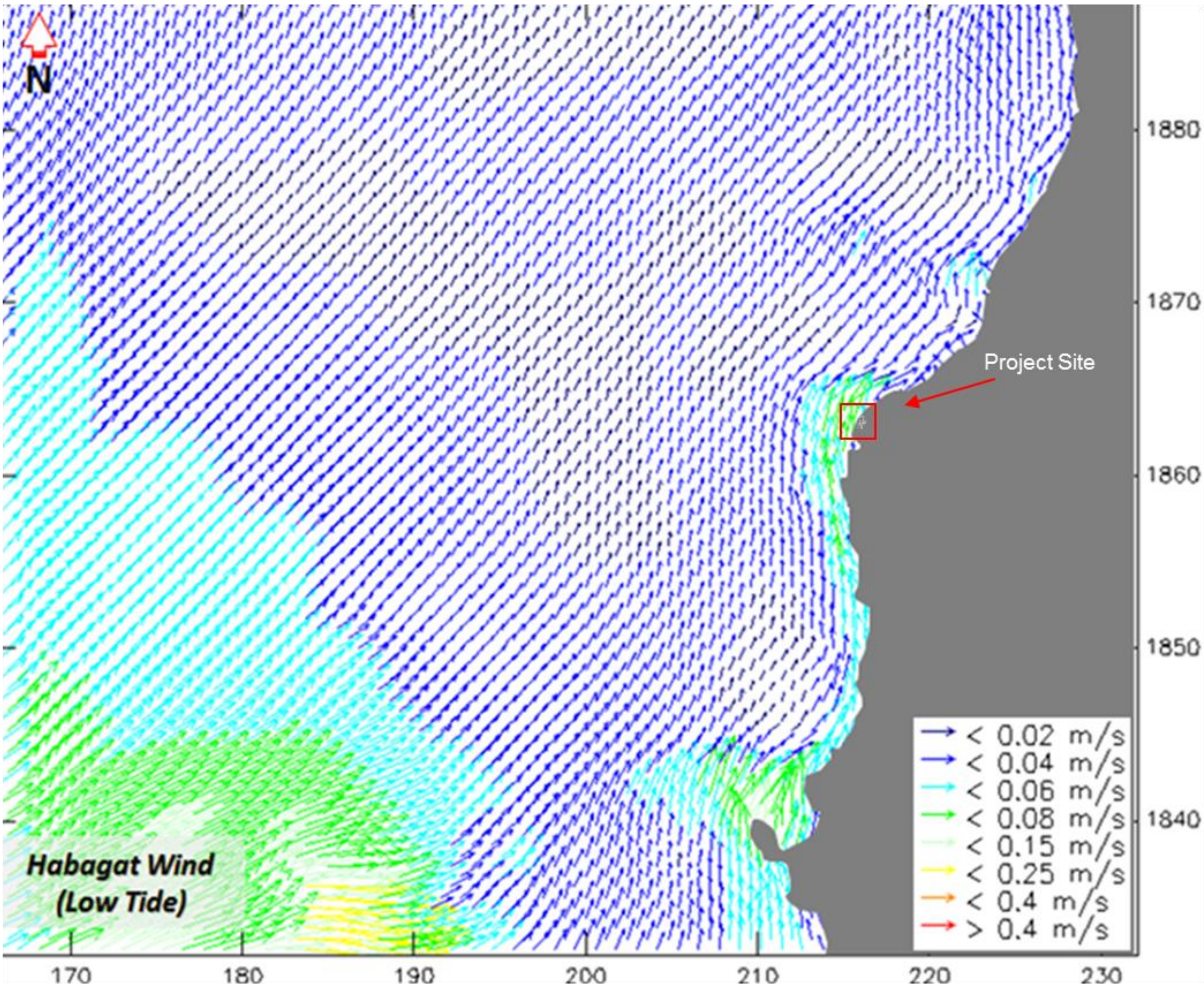


Figure EW-19. Predicted Currents in the Area during Tidal Event (Habagat Wind Condition)	LEGEND: As Above	SCALE: 1:80,000
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	**DATA INFORMATION/SOURCE:** **Software Used:** Delt3D- PART **Project Layout:** GLEDC, 2017 **Generated By:** Aperçu_AConjares	aperçu CONSULTANTS INC. PAGE 195

2.2.2.2 Amihan (Northeast) Wind Scenario

Under amihan wind conditions scenario, with a wind velocity input of $4ms^{-1}$ and blowing from the northern direction, the model results revealed similar southward flow direction during tidal floodings, with alongshore currents running parallel to the configuration of the coast and into the project area until it enters Lingayen Gulf with residual currents flowing westward and out into West Philippine Sea. During tidal flooding, flow velocity fields are in the range of 4 to 8cm/s near the coastline, which is somewhat higher than when the prevailing winds is from the southwest (habagat) (**Figure EW-20**).

During tidal ebbing, the model predicts a similar trend wherein flow rushes out into the project area coming from open sea off Santiago Island and merges with the out flowing waters from Lingayen Gulf, which generates weak gyres near the coast (**Figure EW-21**).

From examination of the predicted currents in the project area during these two wind conditions, it follows that the tidal conditions dictate the direction of the current, although wind shear 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 southwesterly winds. The low tidal event induces current speeds reaching a maximum of about 0.1 m/s while the currents during tidal flooding were generally weaker, reaching a maximum of ~ 0.07 m/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 the landmass in Bolinao, except in the area near Santiago Island where the flow is predicted to be more than 0.15 m/s for both amihan and habagat wind conditions for a wind speed of 4 m/s. For higher wind magnitudes, it is expected that high flow velocities would occur, but for pollution dispersal prediction, low magnitude winds are preferred since it offers less mixing and can be considered the worst case scenario where conservative results are expected.

2.2.3 Particle Tracking Simulation Results

2.2.3.1 Habagat (Southwesterly) Wind Condition

This scenario incorporated the influence of wind on coastal current circulation and particle 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 dredged operation and the release of the particles, the patch of particles is relatively small and the mixing of the particles is caused by small-scale turbulence effects only. However, after some time, the 'cloud' of particles will have spread sufficiently such that larger-scale eddies and circulations will contribute to the mixing effect.

It can be seen in **Figures EW-22** to **EW-30** that after a couple of hours, the released particles spread farther from the release point towards the north-eastern part of the project area for a prevailing south-westerly wind field in effect. Very limited particles released near the site drifted southwards even during changes in the direction of the tides as the proposed project area is at the convex bend of the coast where exposure to wind drag is most pronounced. Thus, significant amounts were transported towards the area northwest of the project, though the spreading did not reach the mouth of Amburayan River further up north. The model predicts that the spreading of particles reaches about 5 km northwest, though the concentration is very minimal at less than 3 mg/L (denoted as 0.003 kg/m^3 in the legend).

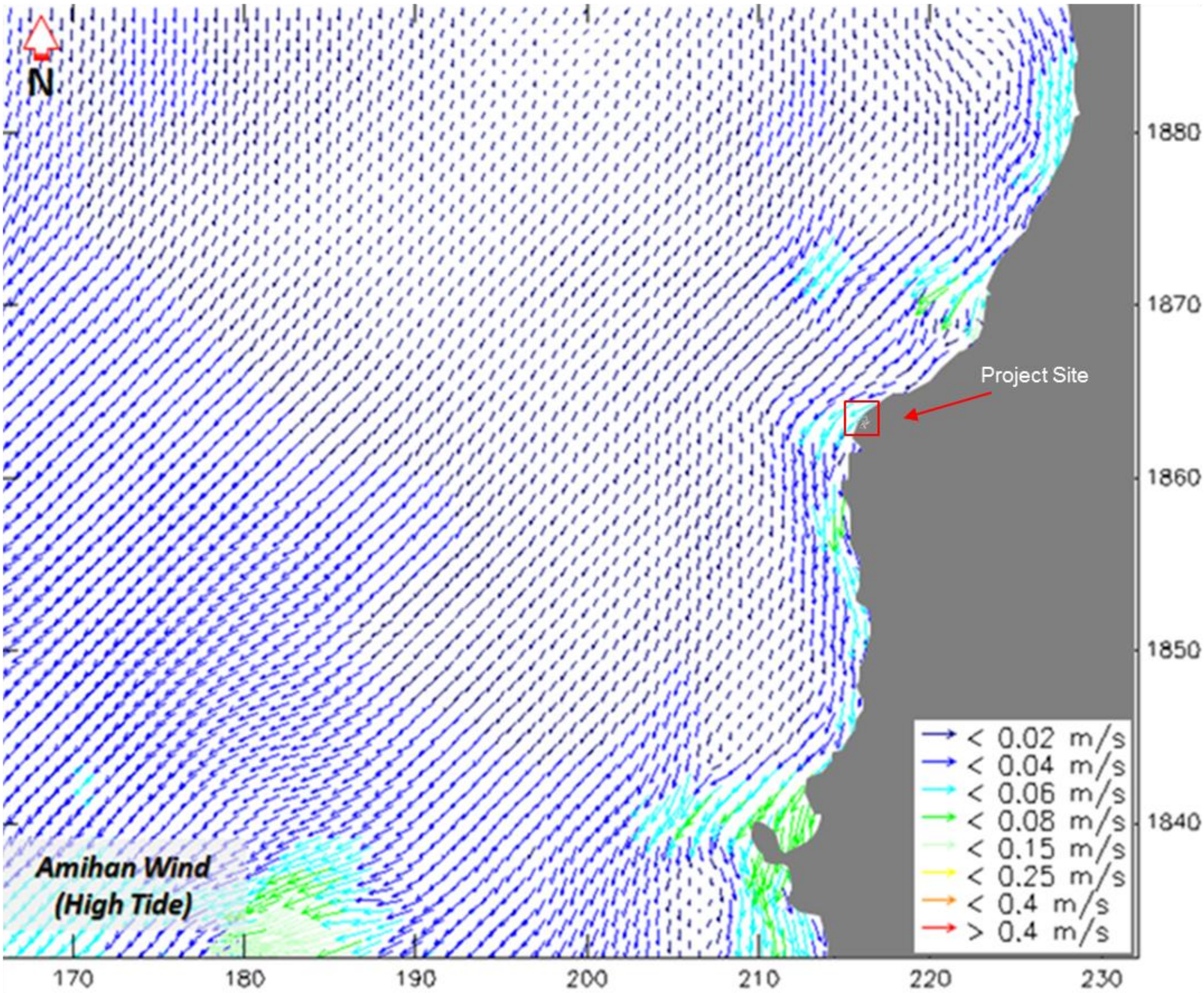


Figure EW-20. Predicted Currents in the Project Area during High Tidal Event (amihan wind condition - wind speed of 4m/s blowing from the northeast).	**LEGEND:** As Above	**SCALE:** 1:80,000
ENVIRONMENTAL IMPACT STATEMENT **2x335MW COAL-FIRED POWER PLANT PROJECT**	**DATA INFORMATION/SOURCE:** **Software Used:** Delt3D- PART **Project Layout:** GLEDC, 2017 **Generated By:** Aperçu_AConjares	aperçu CONSULTANTS INC.

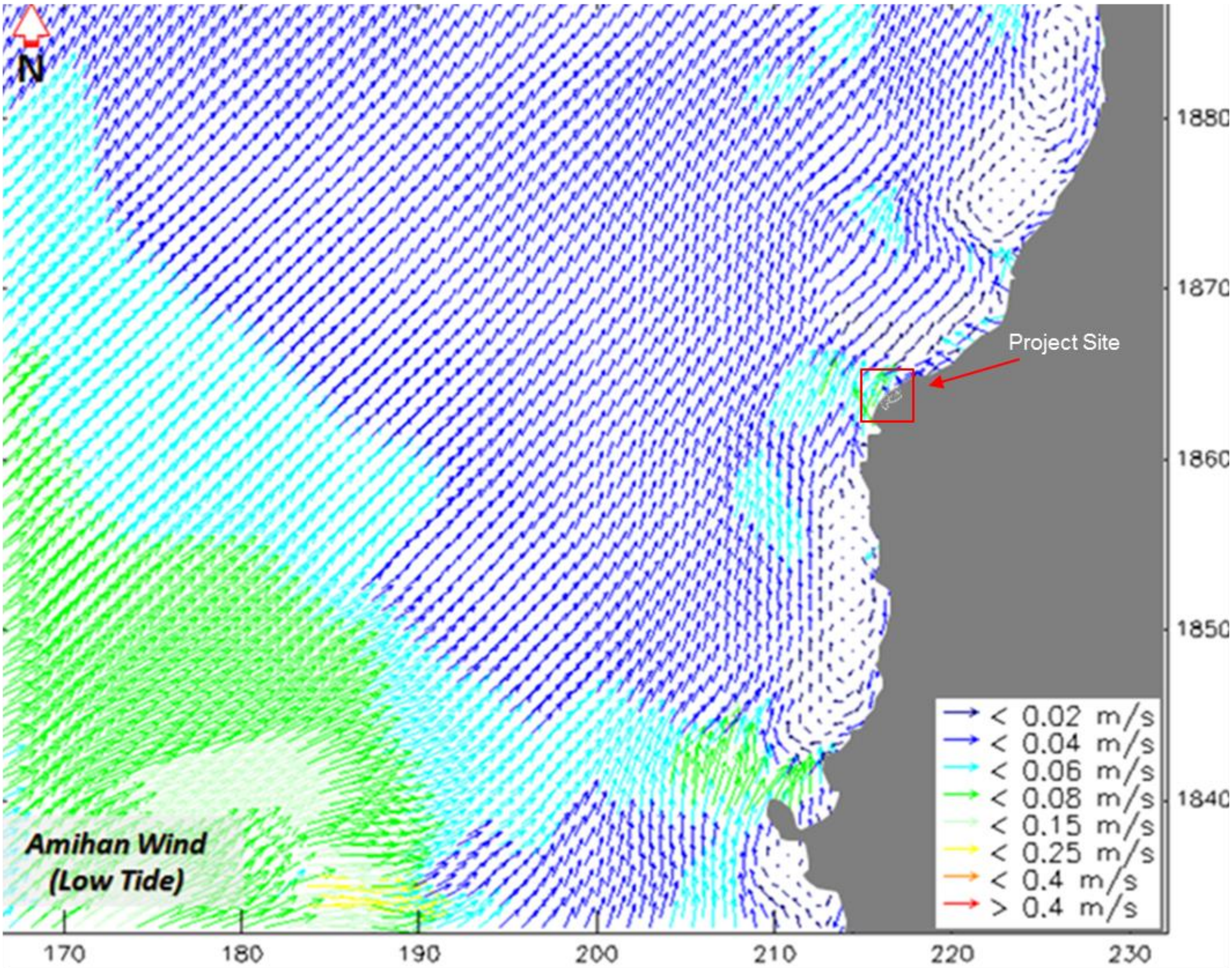


Figure EW-21. Predicted Currents in the Project Area during High Tidal Event (amihan wind condition).	**LEGEND:** As Above	**SCALE: 1:80,000**
ENVIRONMENTAL IMPACT STATEMENT **2x335MW COAL-FIRED POWER PLANT PROJECT**	**DATA INFORMATION/SOURCE:** **Software Used:** Delt3D- PART **Project Layout:** GLEDC, 2017 **Generated By:** Aperçu_AConjares	aperçu CONSULTANTS INC. **PAGE 198**

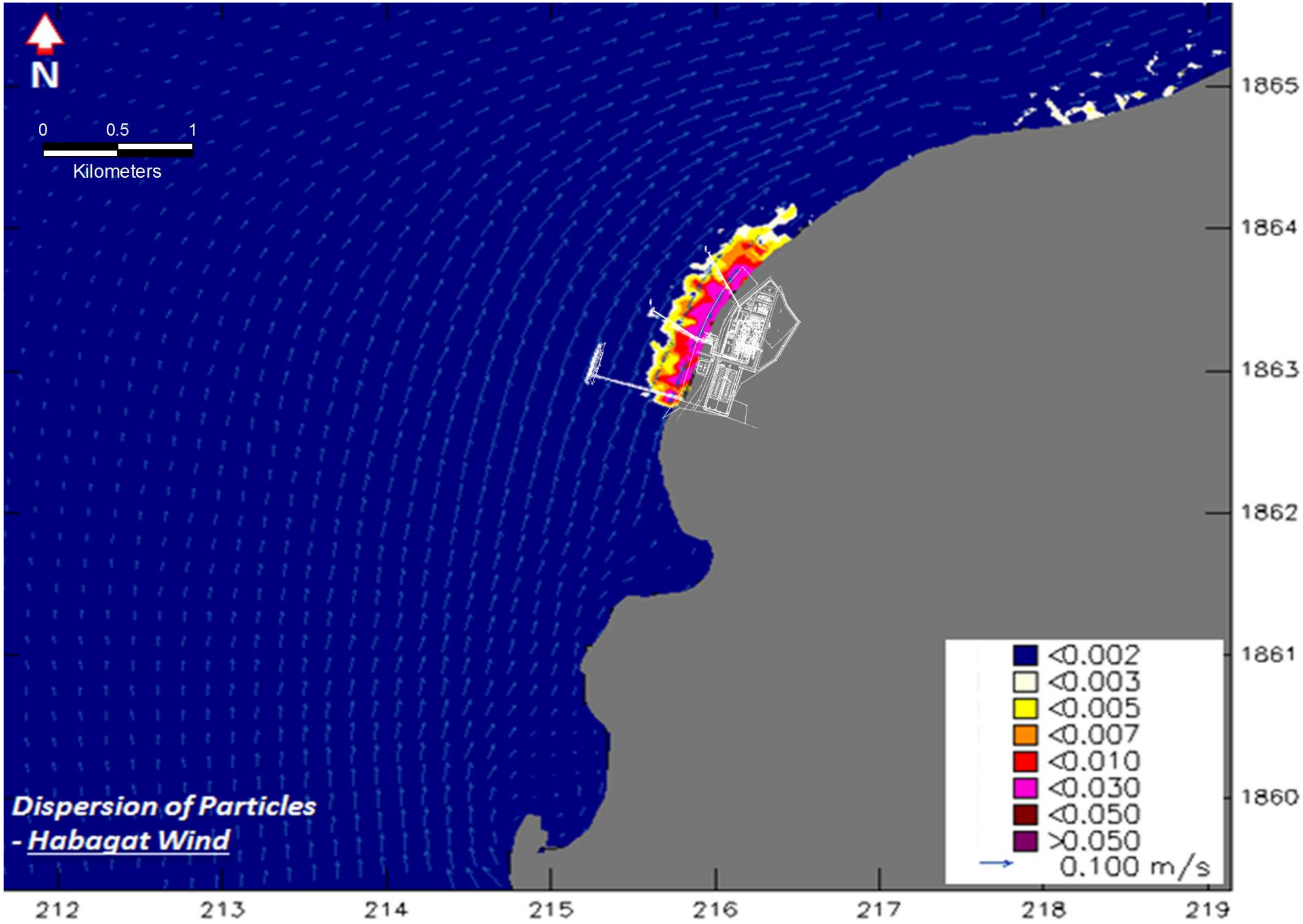


Figure EW-22 Predicted Transport of Particles after 2-hours Continuous Release on Day 1 (Habagat Wind Condition)

ENVIRONMENTAL IMPACT STATEMENT
2x335MW COAL-FIRED POWER PLANT PROJECT

LEGEND: As labelled above

Note: The black dots in the figure represent low concentration particles

SCALE: 1: 25,000

DATA INFORMATION/SOURCE:
Software Used: Delt3D- PART
Project Layout: GLEDC, 2017
Generated By: Aperçu_AConjares

aperçu CONSULTANTS INC.

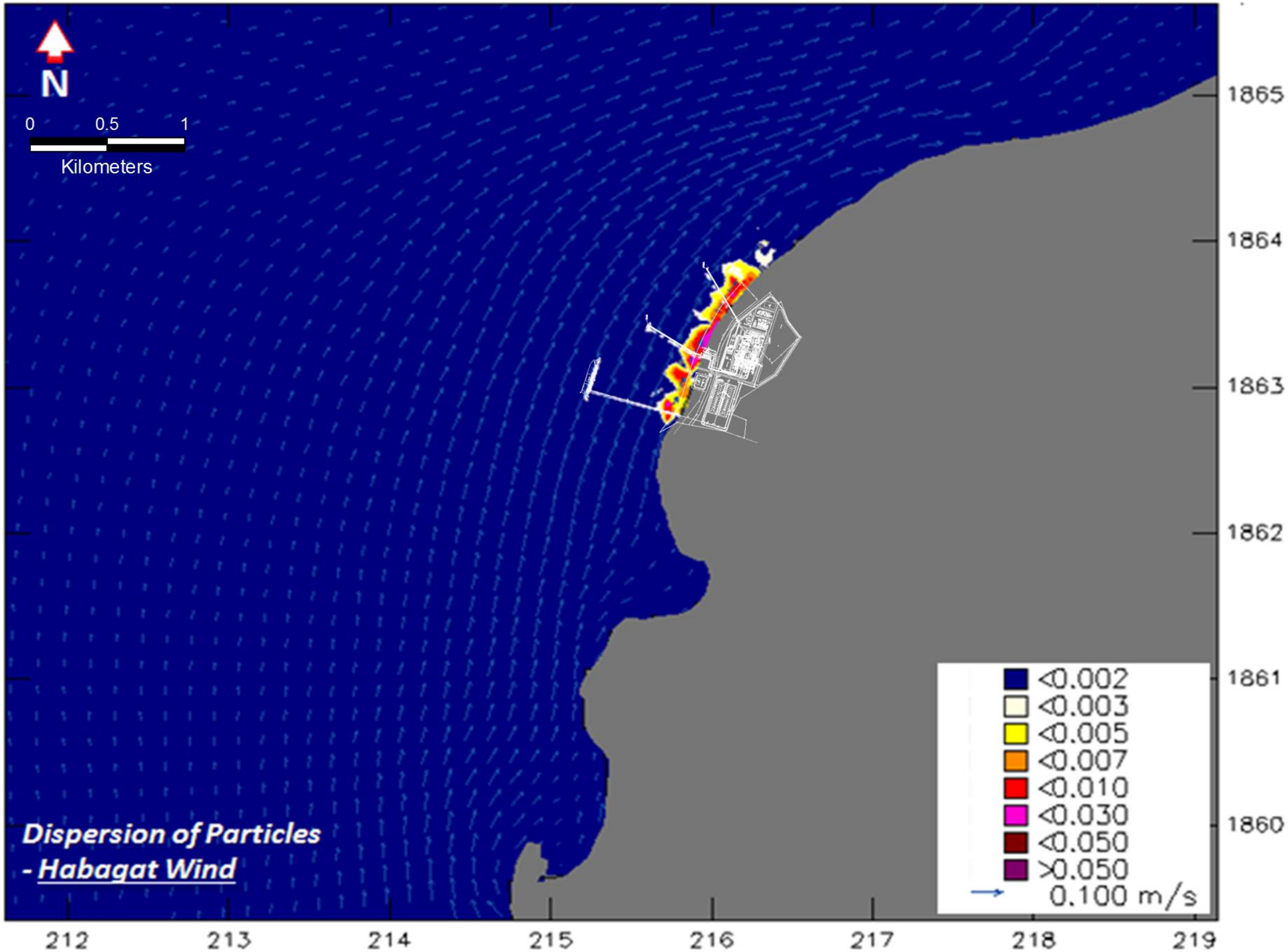


Figure EW-23 Predicted Transport of Particles after 4-hours Continuous Release on Day 5 (Habagat Wind Condition)

ENVIRONMENTAL IMPACT STATEMENT
2x335MW COAL-FIRED POWER PLANT PROJECT

LEGEND: As labelled above

Note: The black dots in the figure represent low concentration particles

SCALE: 1: 25,000

DATA INFORMATION/SOURCE:
Software Used: Delt3D- PART
Project Layout: GLEDC, 2017
Generated By: Aperçu_AConjares

aperçu CONSULTANTS INC.

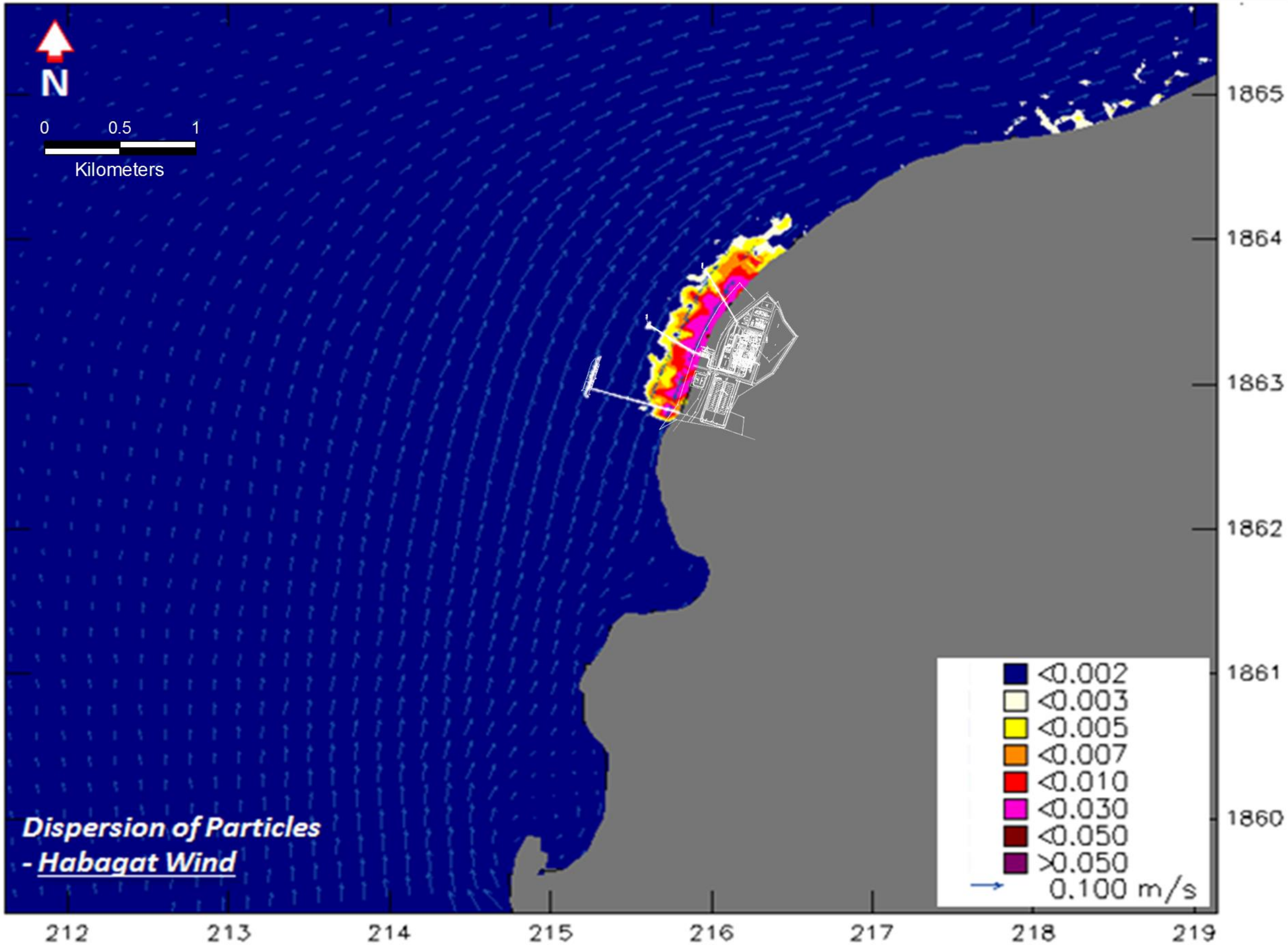


Figure EW-24 Predicted Transport of Particles after 6-hours Continuous Release on Day 8 (Habagat Wind Condition)	LEGEND: As labelled above	SCALE: 1: 25,000	PAGE 201
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	*Note: The black dots in the figure represent low concentration particles*	**DATA INFORMATION/SOURCE:** **Software Used:** Delt3D- PART **Project Layout:** GLEDC, 2017 **Generated By:** Aperçu_AConjares	aperçu CONSULTANTS INC.

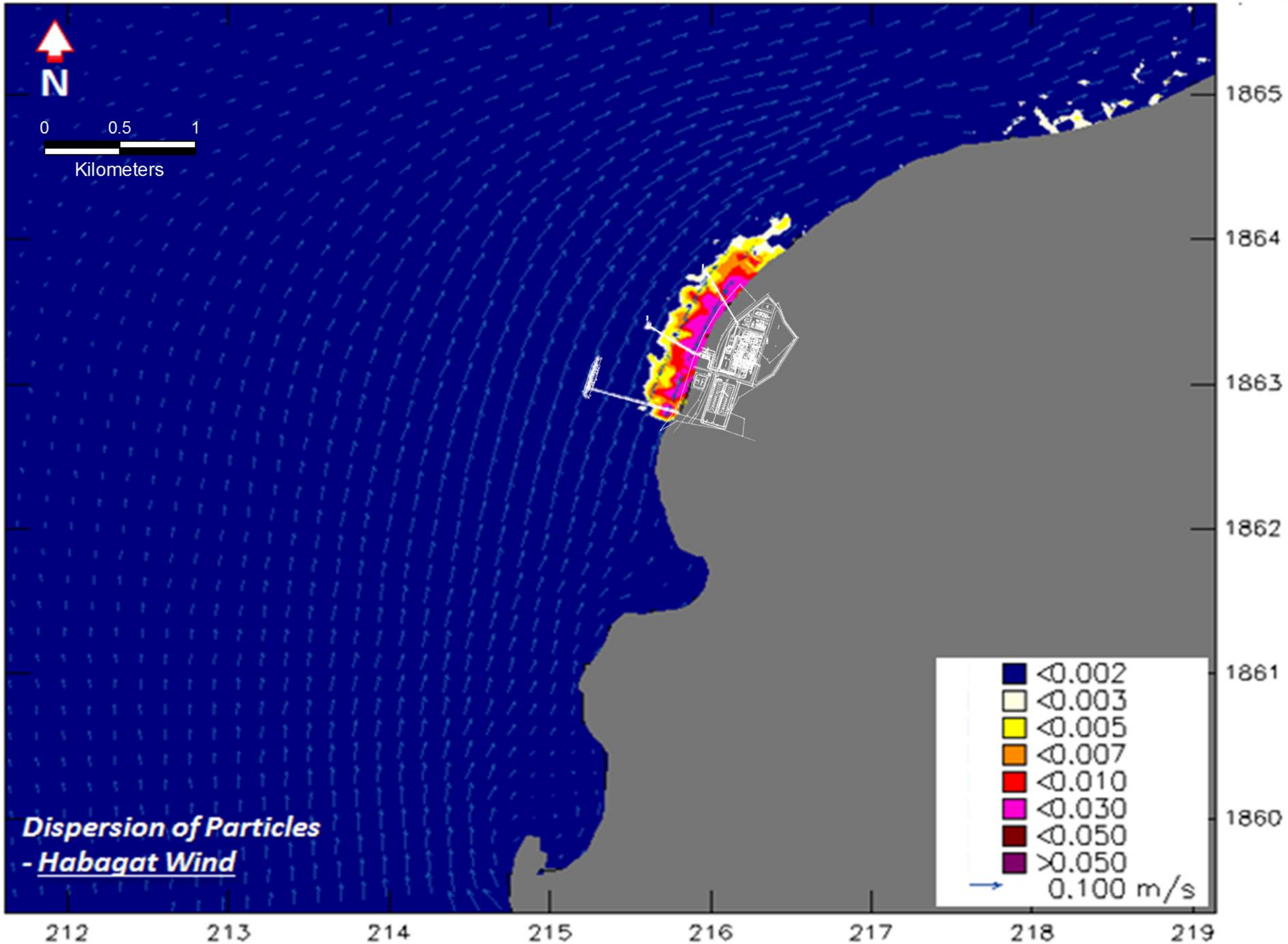


Figure EW-25 Predicted Transport of Particles after 8-hours Continuous Release on Day 11 (Habagat Wind Condition)	**LEGEND: As labelled above** *Note: The black dots in the figure represent low concentration particles*	**SCALE: 1: 25,000**	**PAGE 202**
ENVIRONMENTAL IMPACT STATEMENT **2x335MW COAL-FIRED POWER PLANT PROJECT**		**DATA INFORMATION/SOURCE:** **Software Used:** Delt3D- PART **Project Layout:** GLEDC, 2017 **Generated By:** Aperçu_AConjares	aperçu CONSULTANTS INC.

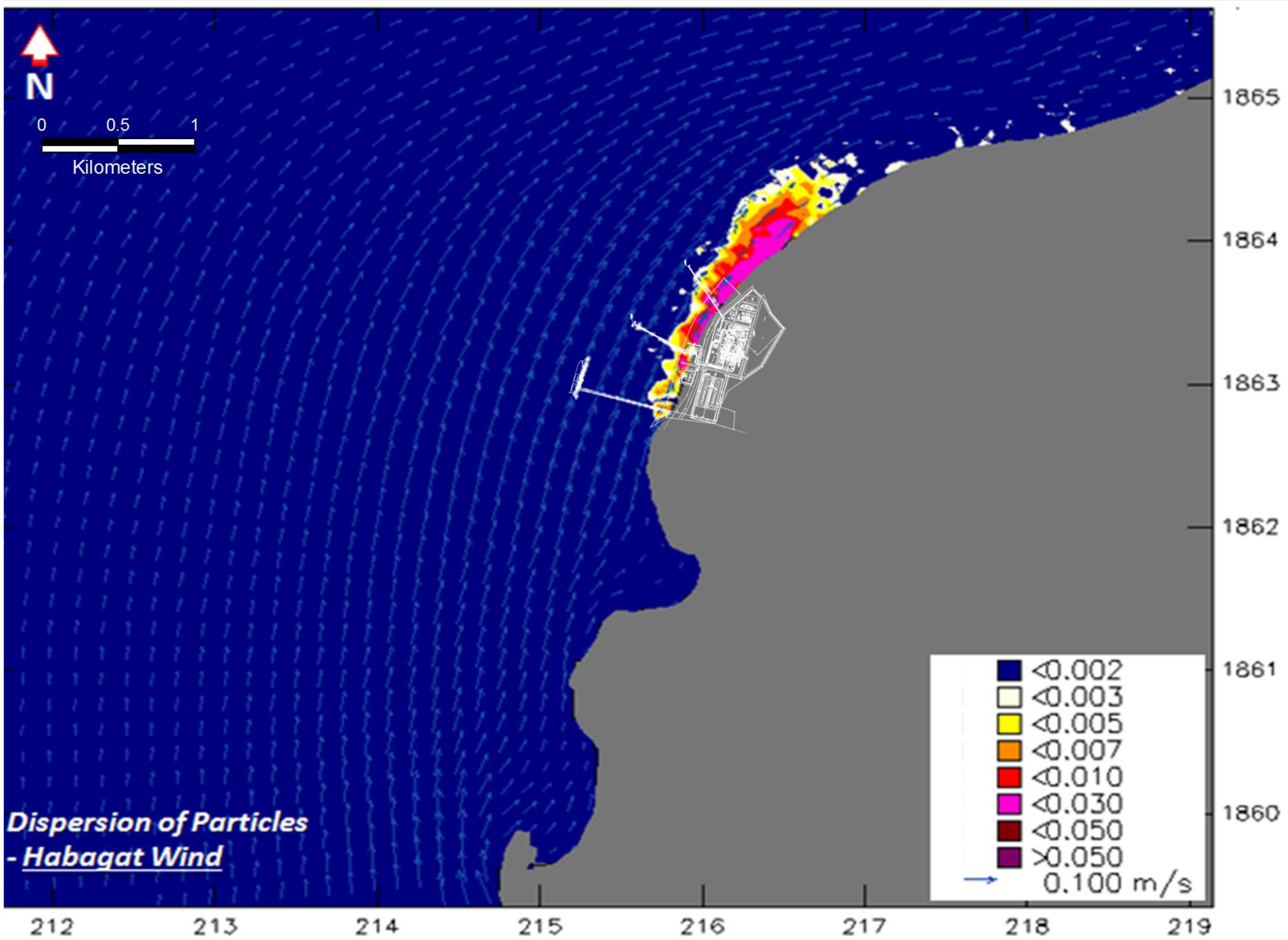


Figure EW-26 Predicted Transport of Particles after 10-hours Continuous Release on Day 15 (Habagat Wind Condition)	**LEGEND: As labelled above** *Note: The black dots in the figure represent low concentration particles*	**SCALE: 1: 25,000**	**PAGE 203**
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT		**DATA INFORMATION/SOURCE:** **Software Used:** Delt3D- PART **Project Layout:** GLEDC, 2017 **Generated By:** Aperçu_AConjares	aperçu CONSULTANTS INC.

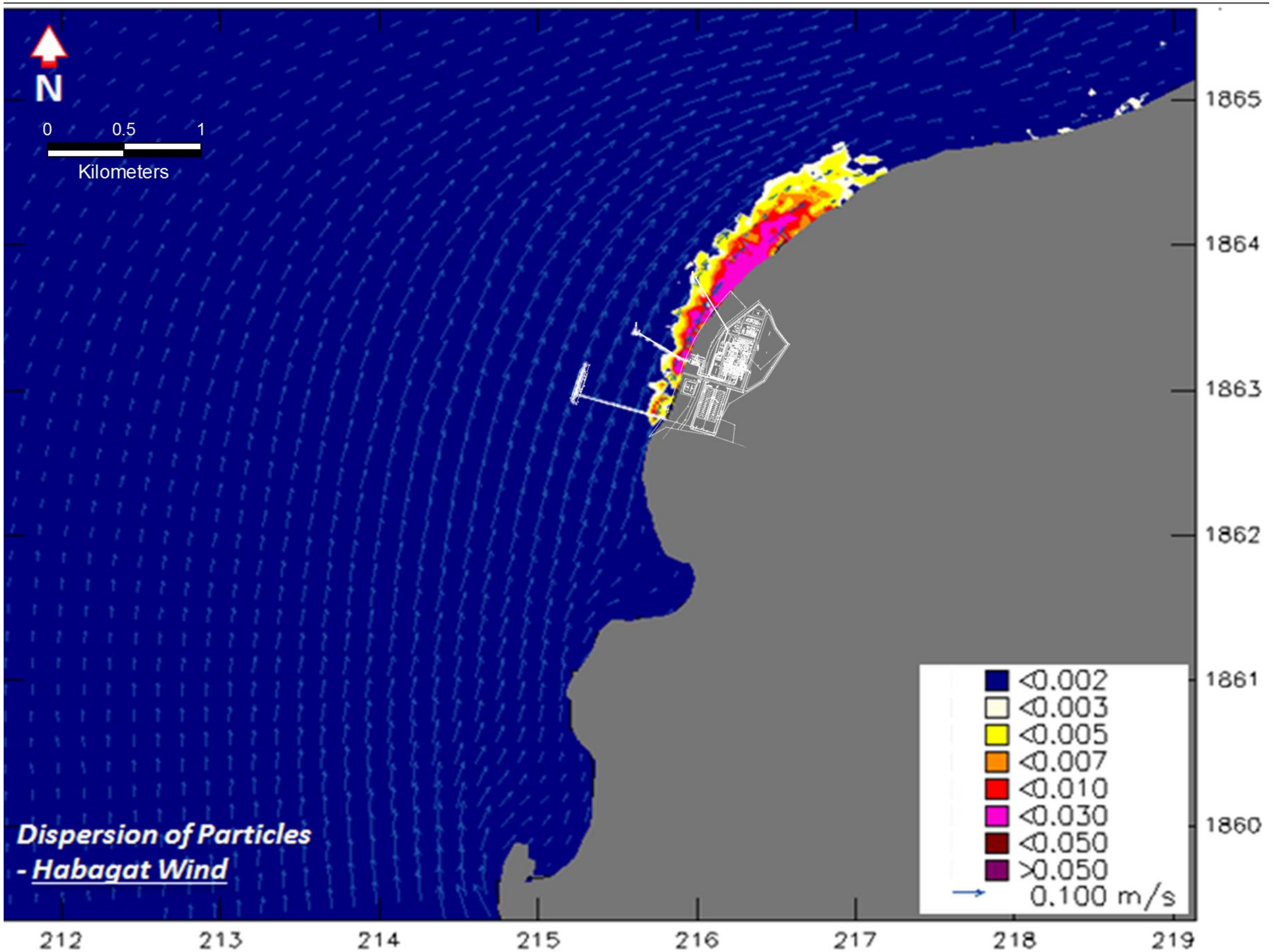


Figure EW-27 Predicted Transport of Particles after 12-hours Continuous Release on Day 18 (Habagat Wind Condition)

ENVIRONMENTAL IMPACT STATEMENT
2x335MW COAL-FIRED POWER PLANT PROJECT

LEGEND: As labelled above

Note: The black dots in the figure represent low concentration particles

SCALE: 1: 25,000

DATA INFORMATION/SOURCE:
Software Used: Delt3D- PART
Project Layout: GLEDC, 2017
Generated By: Aperçu_AConjares

aperçu CONSULTANTS INC.

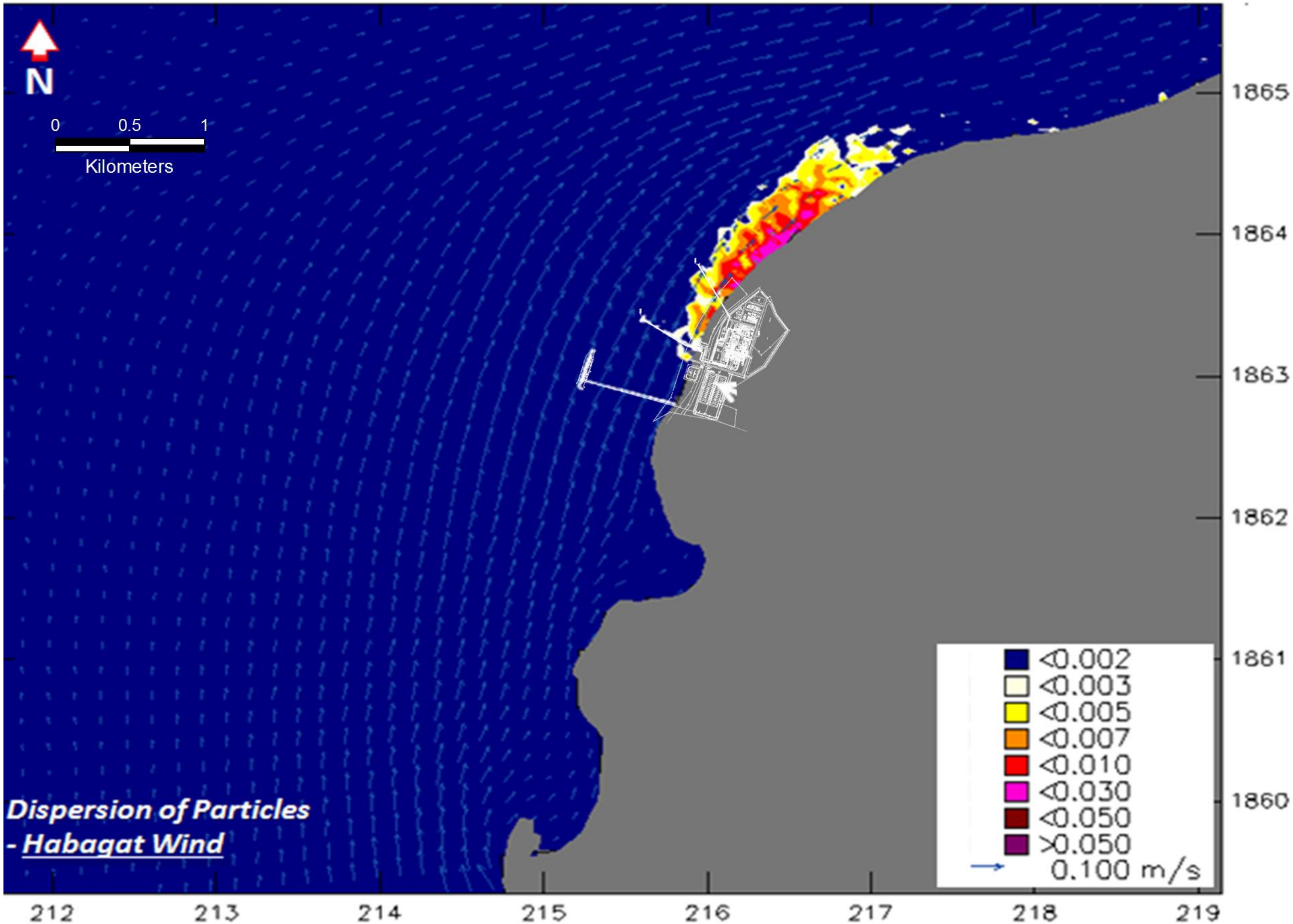


Figure EW-28 Predicted Transport of Particles 2-hours After the End of the 12-hours Continuous Release on Day 18 (Habagat Wind Condition)	**LEGEND:** As labelled above *Note: The black dots in the figure represent low concentration particles*	**SCALE:** 1: 25,000 **DATA INFORMATION/SOURCE:** **Software Used:** Delt3D- PART **Project Layout:** GLEDC, 2017 **Generated By:** Aperçu_AConjares	**PAGE 205** aperçu CONSULTANTS INC.
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT			

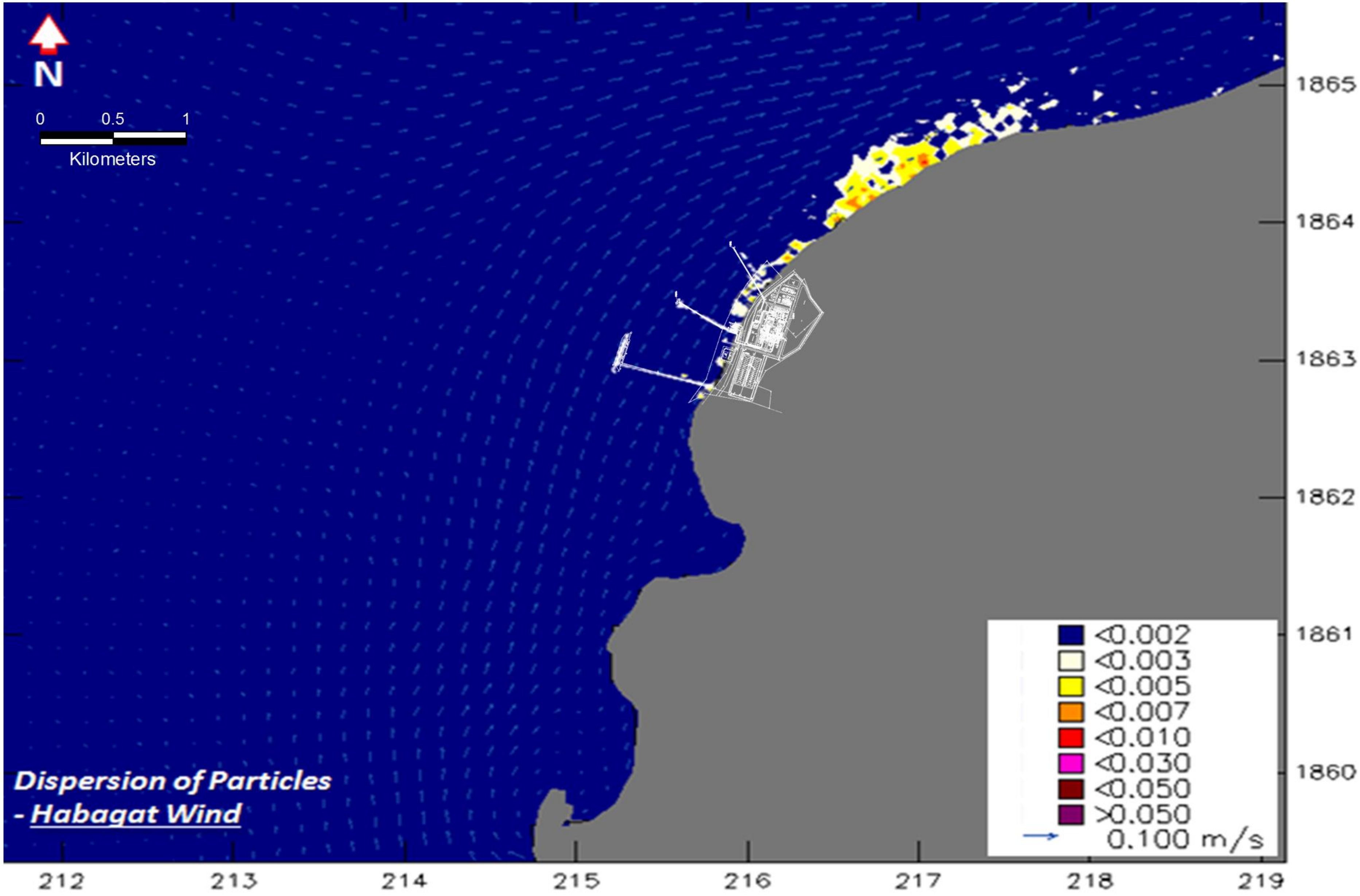


Figure EW-29 Predicted Transport of Particles 6-hours After the End of the 12-hours Continuous Release on Day 26 (Habagat Wind Condition)

ENVIRONMENTAL IMPACT STATEMENT
2x335MW COAL-FIRED POWER PLANT PROJECT

LEGEND: As labelled above

Note: The black dots in the figure represent low concentration particles

SCALE: 1: 25,000

DATA INFORMATION/SOURCE:
Software Used: Delt3D- PART
Project Layout: GLEDC, 2017
Generated By: Aperçu_AConjares

aperçu CONSULTANTS INC.

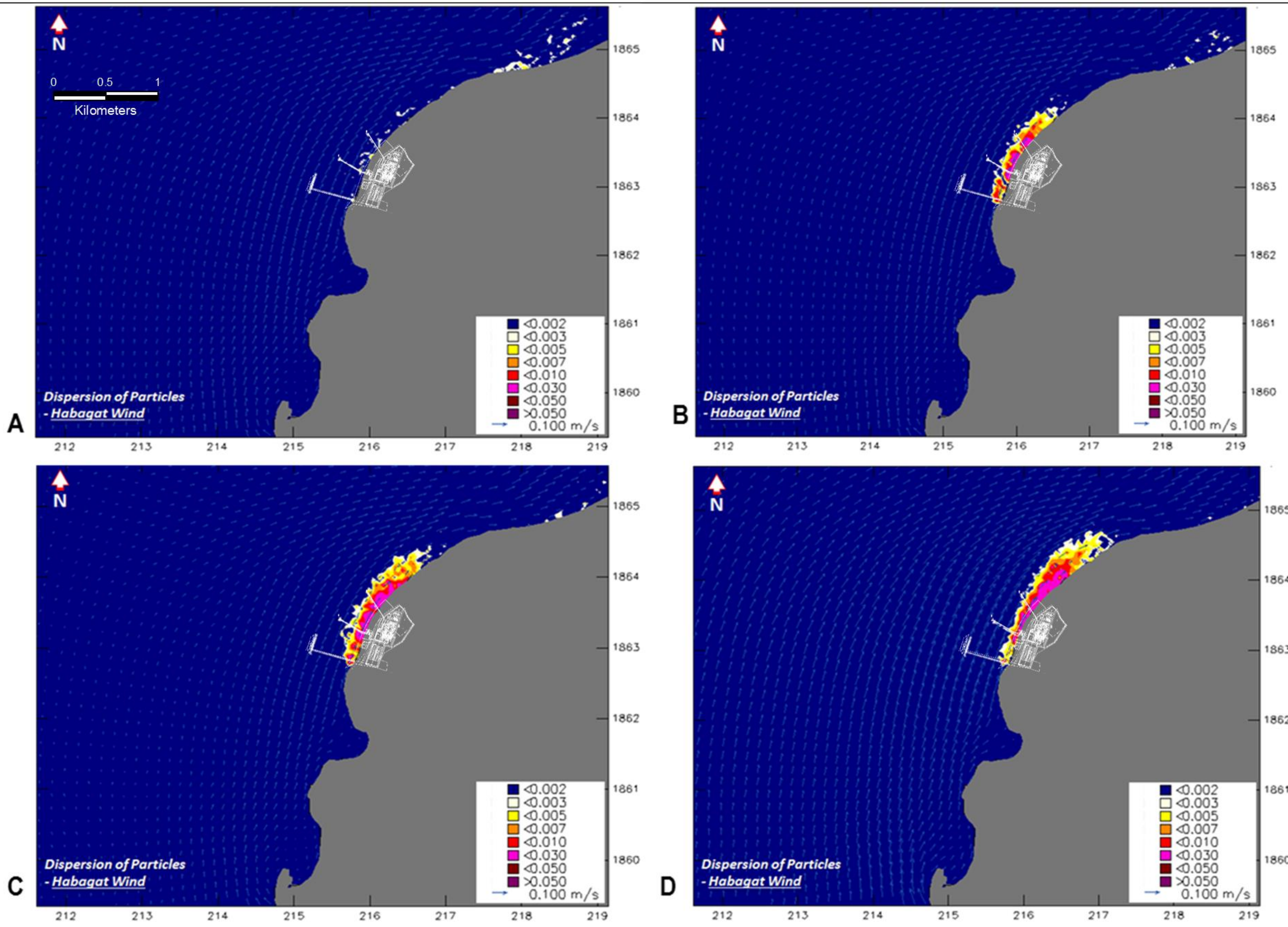


Figure EW-30 Predicted Transport of Particles for Day 2: (A) just before start, (B) 4-hours after, (C) 8-hours after, (D) after 12 hours of continuous releases)

ENVIRONMENTAL IMPACT STATEMENT
2x335MW COAL-FIRED POWER PLANT PROJECT

LEGEND: As labelled above

Note: The black dots in the figure represent low concentration particles

SCALE: 1:25,000

DATA INFORMATION/SOURCE:
Software Used: Delt3D-PART
Project Layout: GLEDC, 2017
Generated By: Aperçu_AConjares

Also, due to habagat wind, a significant amount of released particles from the power plant area move north-eastward and are dispersed within a few hundred meters from the project area. The area where most of the particles 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.

In the series of figures presented (figures same to the previous stated), the legend refers to the resulting levels of concentration, in kilograms per cubic meter, of the unspecified pollutant.

2.2.3.2 Amihan (Northeasterly) Wind Condition

This scenario incorporated the influence of amihan winds on coastal current circulation and particle transport and movement in the study area. A uniform wind forcing (northeasterly wind, ranging from 10 to 45 degrees from the north, with a speed of $4ms^{-1}$), 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 power plant area.

Similar to habagat wind scenario results, at the start of the simulation, the unspecified pollutant dispersed initially in a radial pattern and after a few hours started to scatter southwards following the topography of the coast. Because of the prevailing alongshore currents and weak circular eddies formed due to high flow velocities far offshore as the water moves into and out of Lingayen Gulf due to interaction of tides from the open sea, majority of the pollutant dispersed towards the southern portion. During periods of slack tides however, portions of released particles flow towards the northern part in the absence of, or weak formation of circular eddies (**Figure EW-31** to **EW-38**).

Figure EW-39 shows an example of the typical progression of particles for a single day of operation considering 12-hours of continuous release from four (4) individual sources.

2.2.3.3 Calm Wind Conditions

One potential combination of oceanographic and meteorological conditions that may produce low dispersion of the particle plume is a period of low ambient current, which would correspond to the period of lowest transport and mixing potential, thereby allowing the plume to sustain its release concentration under normal conditions. Thus, this scenario specifies low wind speed conditions 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 1m/s is used with random wind directions.

The results of the model simulation using calm wind speed are shown in **Figures EW-40** to **EW-46**. The predicted currents were tidal induced as surface wind-driven turbulence and the flow component were obliterated from the model forcing due to the low speeds 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 particle 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 particles with a very low concentration (less than $0.002kg{\cdot}m^{-3}$ shown in the legend of the figures or less than $2mg{\cdot}L^{-1}$) veered towards the north-eastern direction of the adjacent coast with much of the particles appeared to remain and concentrate adjacent to the discharge location and veered towards the south during periods of high and slack tides. These are then swept further to the north during transition and low tidal events due to reversal of the current and the influence of the resulting formation of weak circular eddies near adjacent coast.

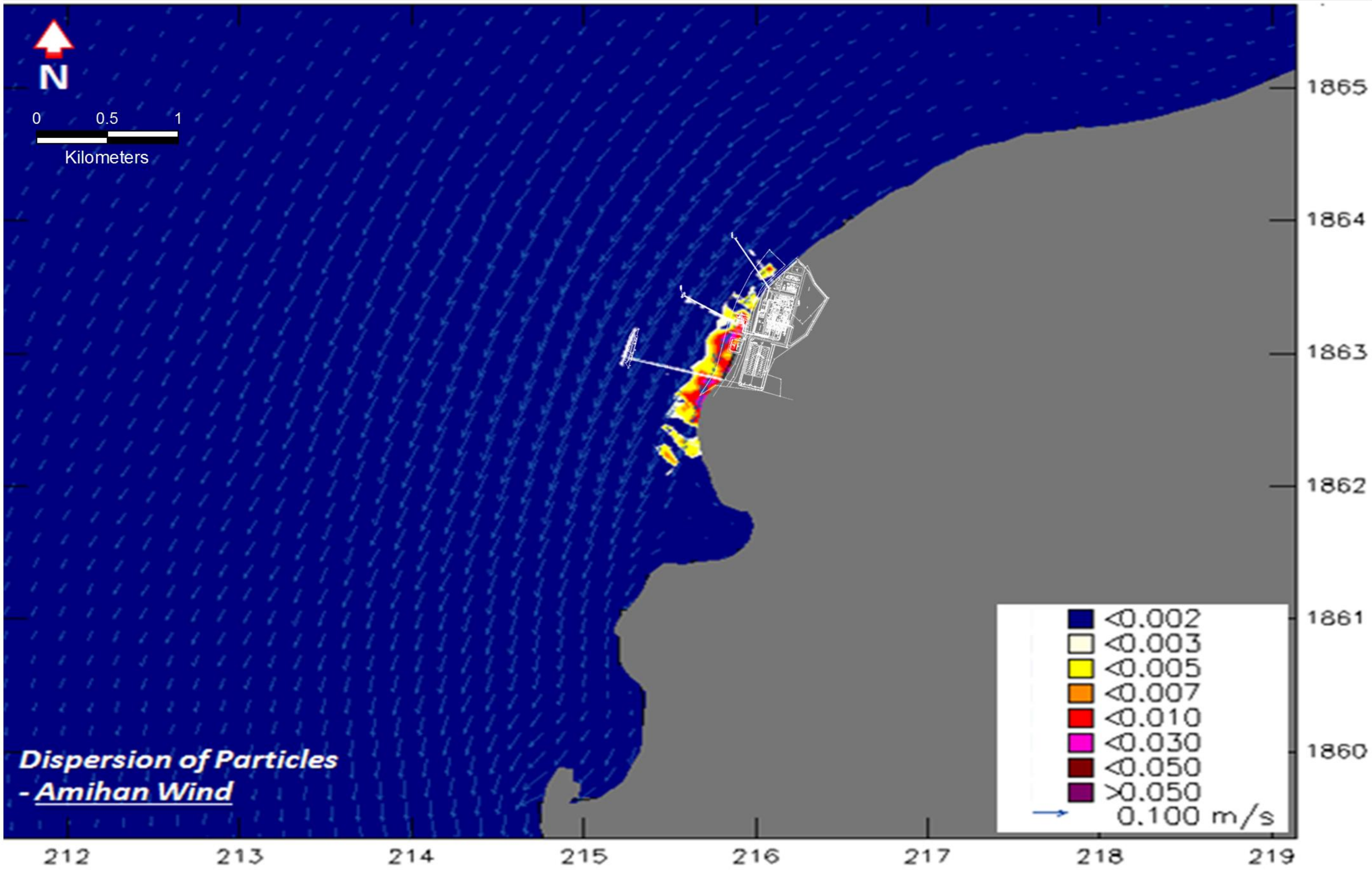


Figure EW-31 Predicted Transport of Particles after 2-hours of Continuous Release for Day 1 (Amihan Wind Condition)

ENVIRONMENTAL IMPACT STATEMENT
2x335MW COAL-FIRED POWER PLANT PROJECT

LEGEND: As labelled above

Note: The black dots in the figure represent low concentration particles

SCALE: 1: 25,000

DATA INFORMATION/SOURCE:
Software Used: Delt3D- PART
Project Layout: GLEDC, 2017
Generated By: Aperçu_AConjares

aperçu CONSULTANTS INC.

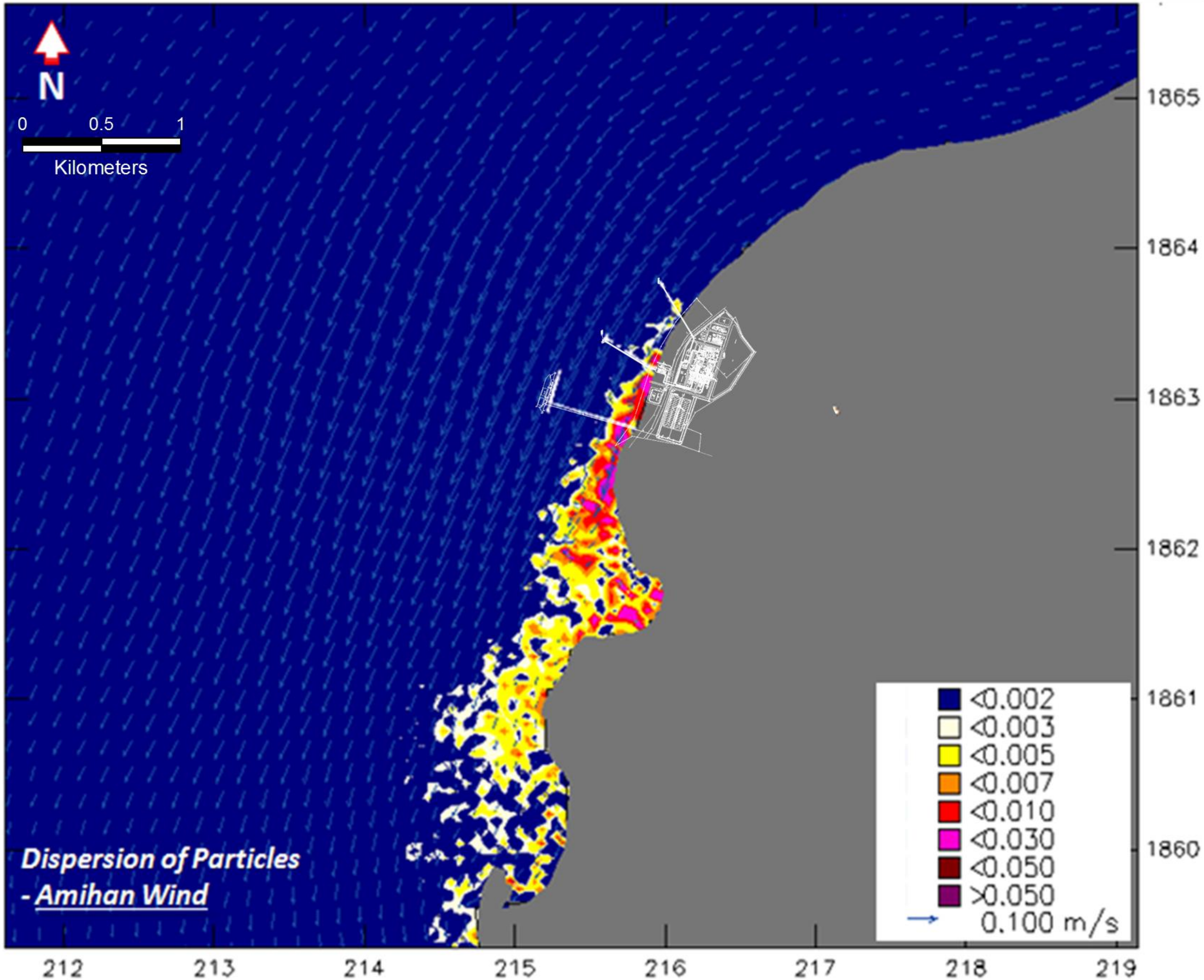


Figure EW-32 Predicted Transport of Particles after 4-hours of Continuous Release for Day 6 (Amihan Wind Condition) **ENVIRONMENTAL IMPACT STATEMENT** **2x335MW COAL-FIRED POWER PLANT PROJECT**	**LEGEND: As labelled above** *Note: The black dots in the figure represent low concentration particles*	**SCALE: 1: 25,000** **DATA INFORMATION/SOURCE:** **Software Used:** Delt3D- PART **Project Layout:** GLEDC, 2017 **Generated By:** Aperçu_AConjares	**PAGE 210** aperçu CONSULTANTS INC.

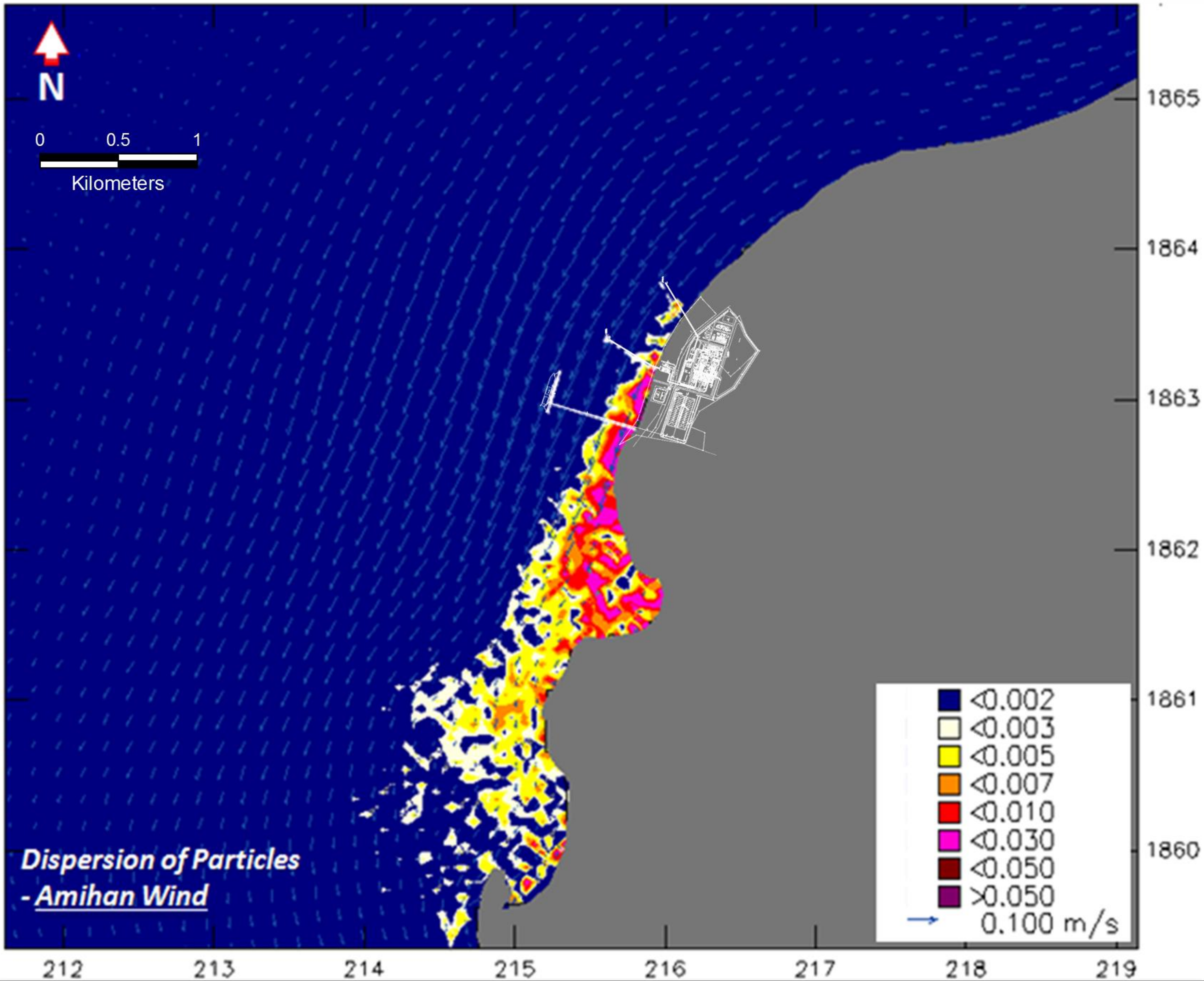


Figure EW-33 Predicted Transport of Particles after 6-hours of Continuous Release for Day 9 (Amihan Wind Condition)

ENVIRONMENTAL IMPACT STATEMENT
2x335MW COAL-FIRED POWER PLANT PROJECT

LEGEND: As labelled above

Note: The black dots in the figure represent low concentration particles

SCALE: 1: 25,000

DATA INFORMATION/SOURCE:
Software Used: Delt3D- PART
Project Layout: GLEDC, 2017
Generated By: Aperçu_AConjares

aperçu CONSULTANTS INC.

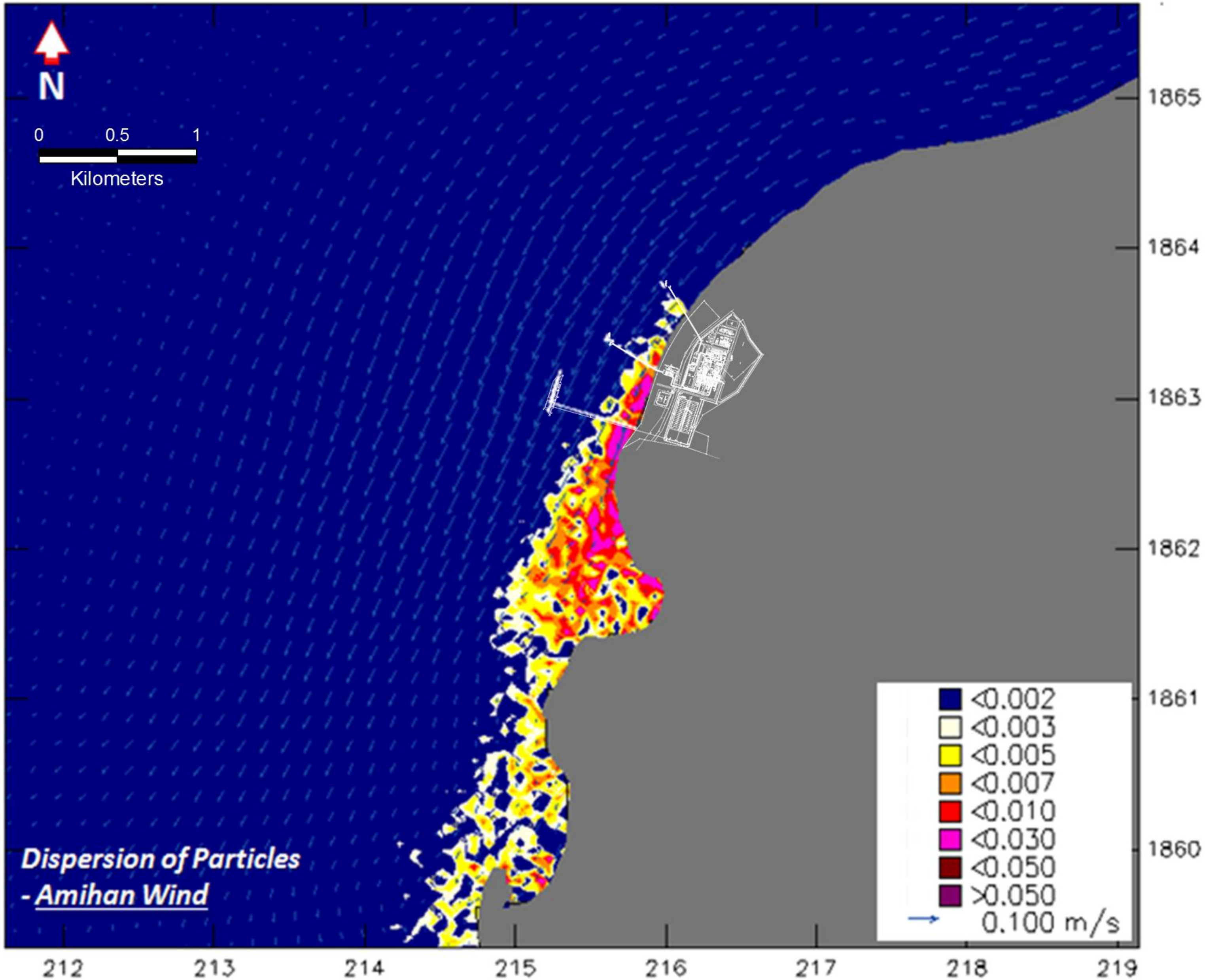


Figure EW-34 Predicted Transport of Particles after 8-hours of Continuous Release for Day 12 (Amihan Wind Condition)

ENVIRONMENTAL IMPACT STATEMENT
2x335MW COAL-FIRED POWER PLANT PROJECT

LEGEND: As labelled above

Note: The black dots in the figure represent low concentration particles

SCALE: 1:25,000

DATA INFORMATION/SOURCE:
Software Used: Delt3D-PART
Project Layout: GLEDC, 2017
Generated By: Aperçu_AConjares

aperçu CONSULTANTS INC.

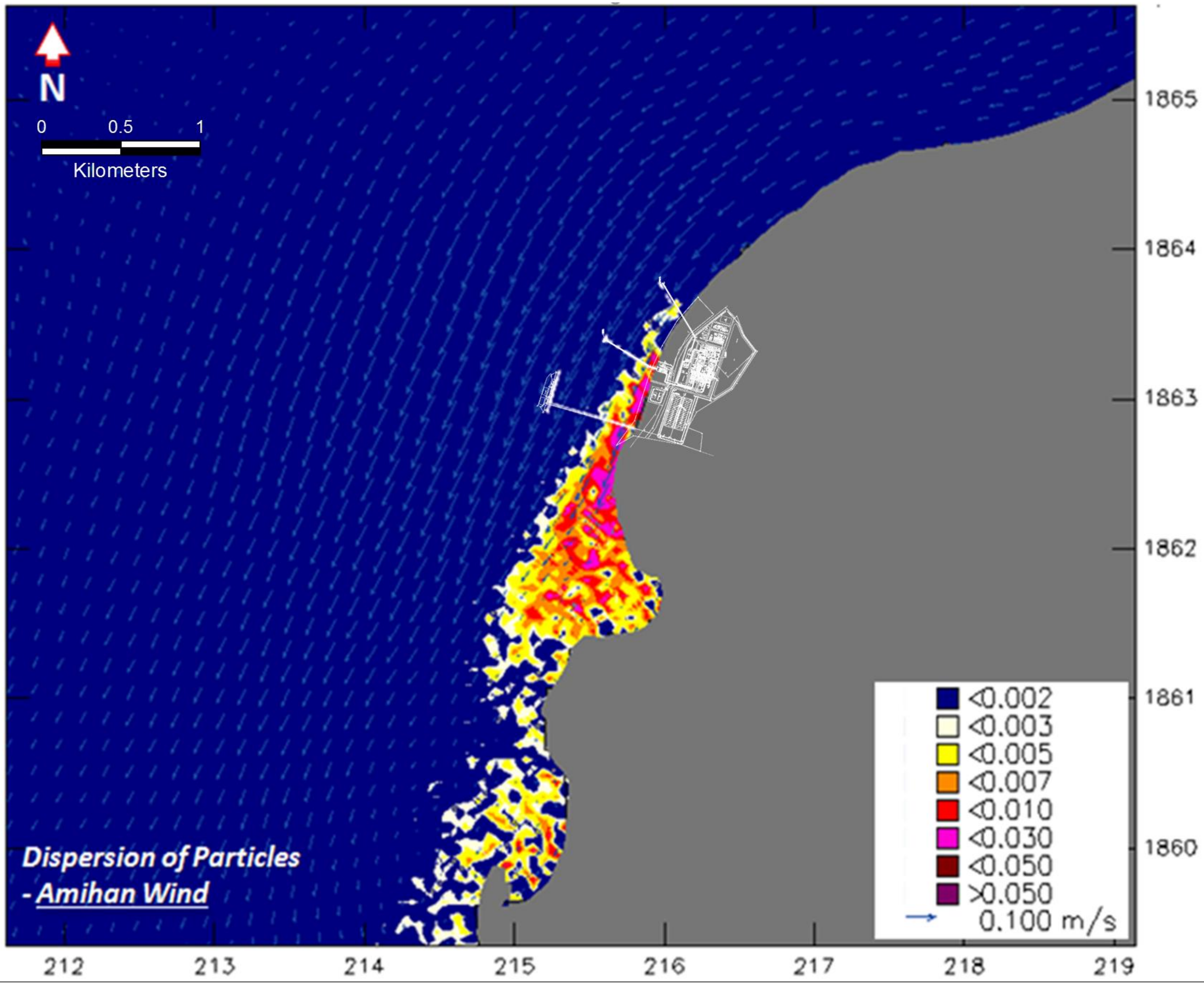


Figure EW-35 Predicted Transport of Particles after 10-hours of Continuous Release for Day 16 (Amihan Wind Condition)	LEGEND: As labelled above *Note: The black dots in the figure represent low concentration particles*	SCALE: 1: 25,000 **DATA INFORMATION/SOURCE:** **Software Used:** Delt3D- PART **Project Layout:** GLEDC, 2017 **Generated By:** Aperçu_AConjares	PAGE 213
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT			aperçu CONSULTANTS INC.

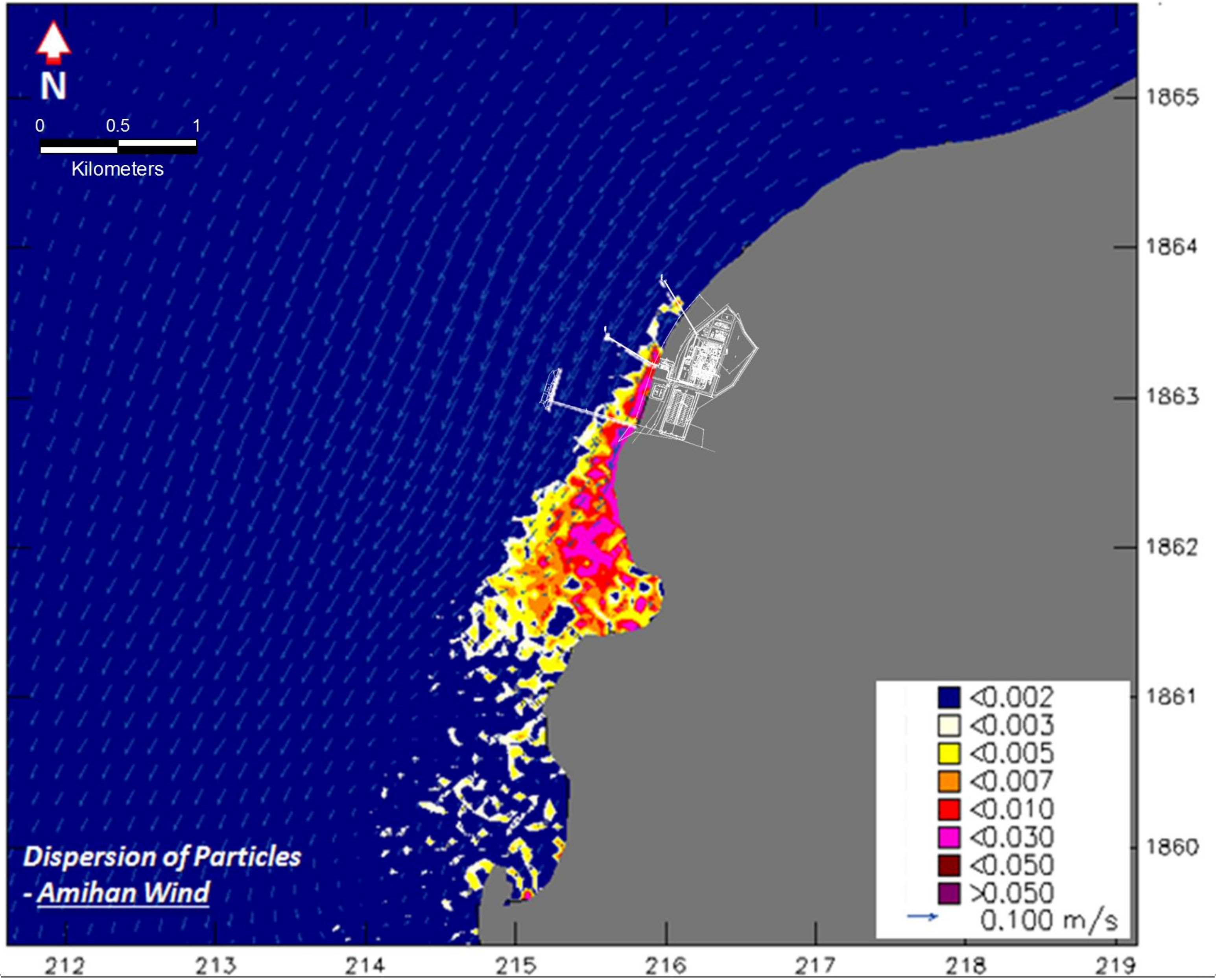


Figure EW-36 Predicted Transport of Particles after 12-hours of Continuous Release for Day 19 (Amihan Wind Condition)	LEGEND: As labelled above *Note: The black dots in the figure represent low concentration particles*	SCALE: 1: 25,000 **DATA INFORMATION/SOURCE:** **Software Used:** Delt3D- PART **Project Layout:** GLEDC, 2017 **Generated By:** Aperçu_AConjares	**PAGE 214**
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT			aperçu CONSULTANTS INC.

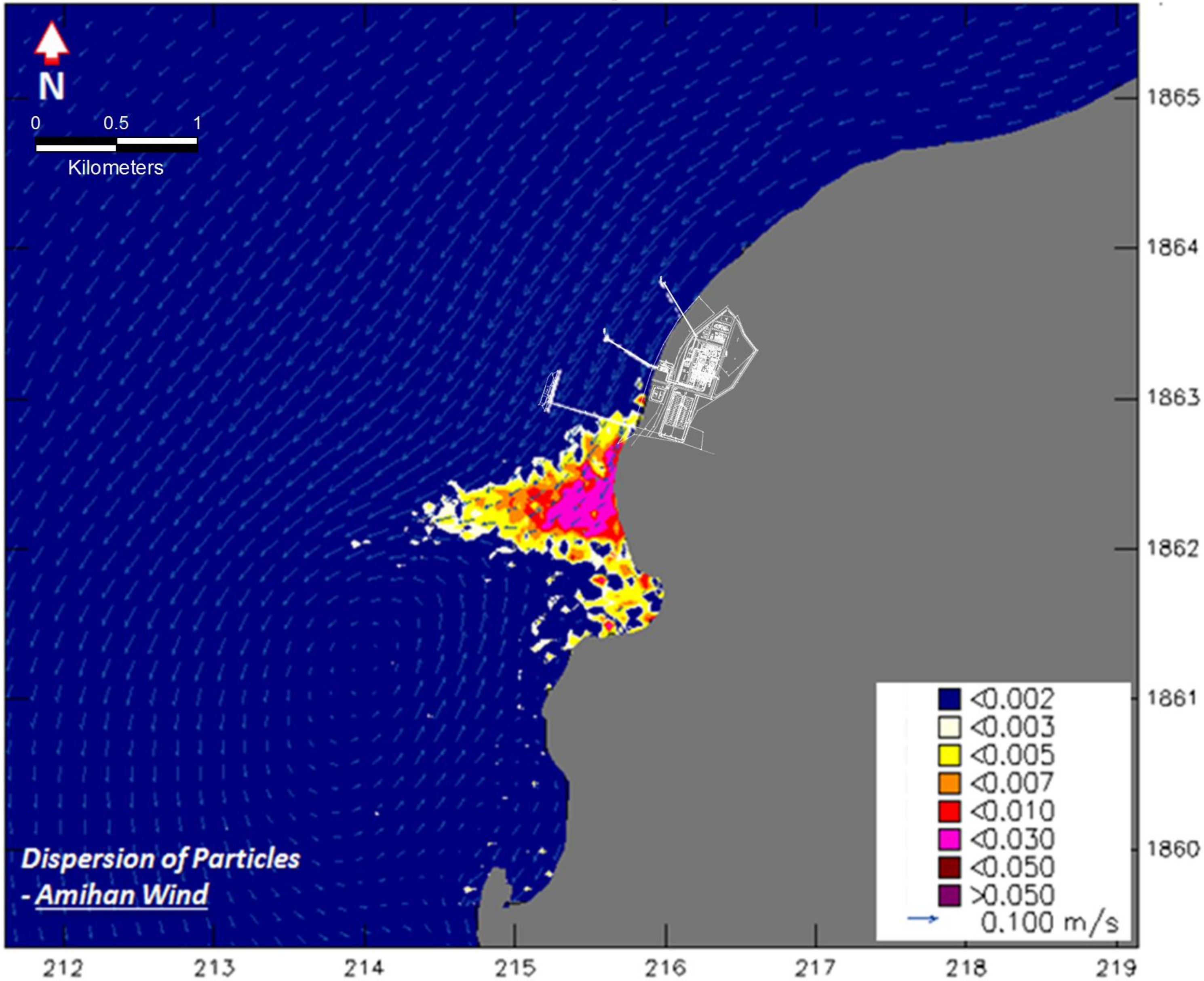


Figure EW-37 Predicted Transport of Particles 2 hours after the end of 12-hours Continuous Release for Day 22 (Amihan Wind Condition)	**LEGEND: As labelled above** *Note: The black dots in the figure represent low concentration particles*	**SCALE: 1: 25,000** **DATA INFORMATION/SOURCE:** **Software Used:** Delt3D- PART **Project Layout:** GLEDC, 2017 **Generated By:** Aperçu_AConjares	**PAGE 215**
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT			aperçu CONSULTANTS INC.

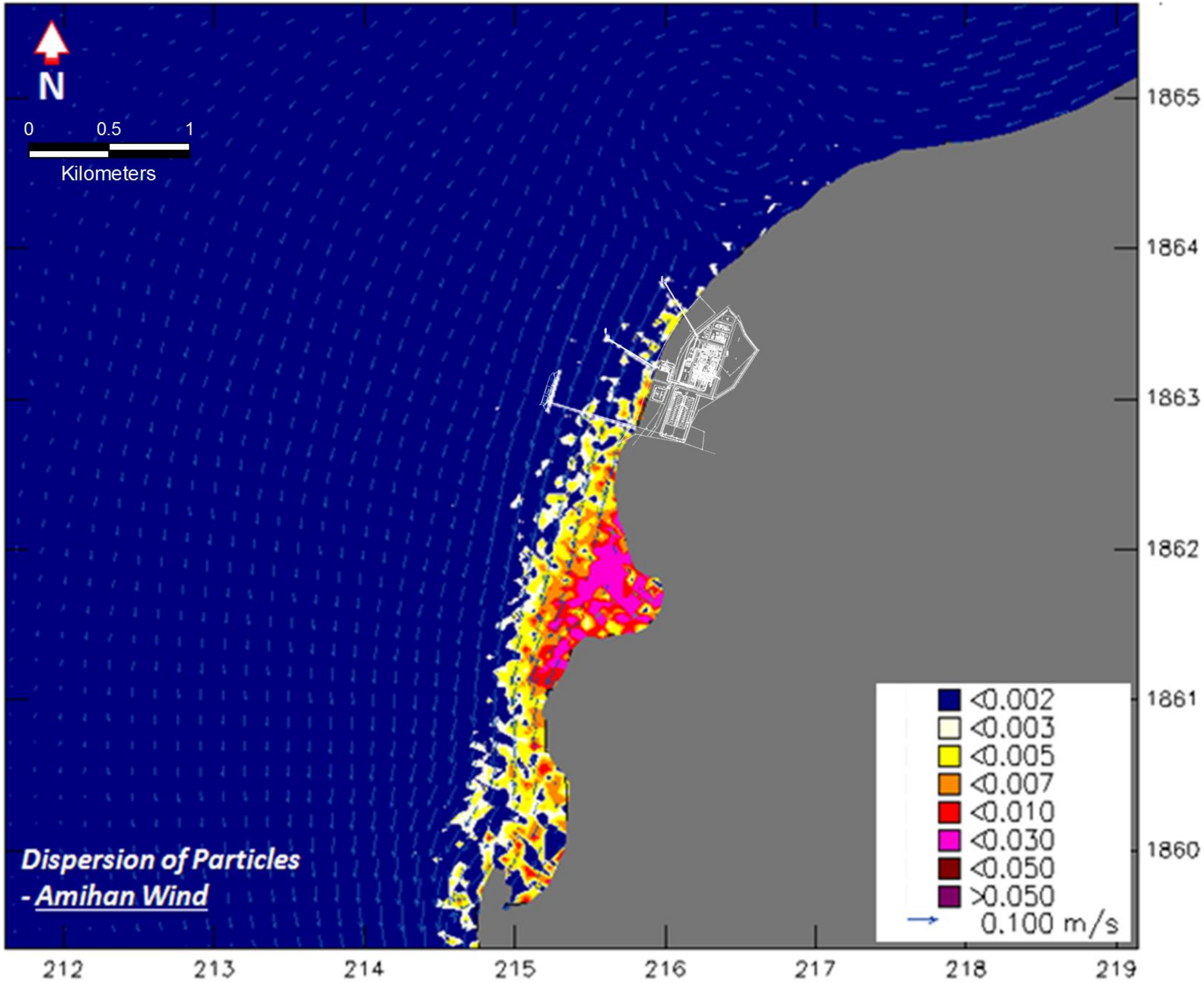


Figure EW-38 Predicted Transport of Particles after 6-hours after the end of 12 hours Continuous Release for Day 26 (Amihan Wind Condition)	**LEGEND:** As labelled above *Note: The black dots in the figure represent low concentration particles*	**SCALE:** 1: 25,000	**PAGE 216**
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT		**DATA INFORMATION/SOURCE:** **Software Used:** Delt3D- PART **Project Layout:** GLEDC, 2017 **Generated By:** Aperçu_AConjares	aperçu CONSULTANTS INC.

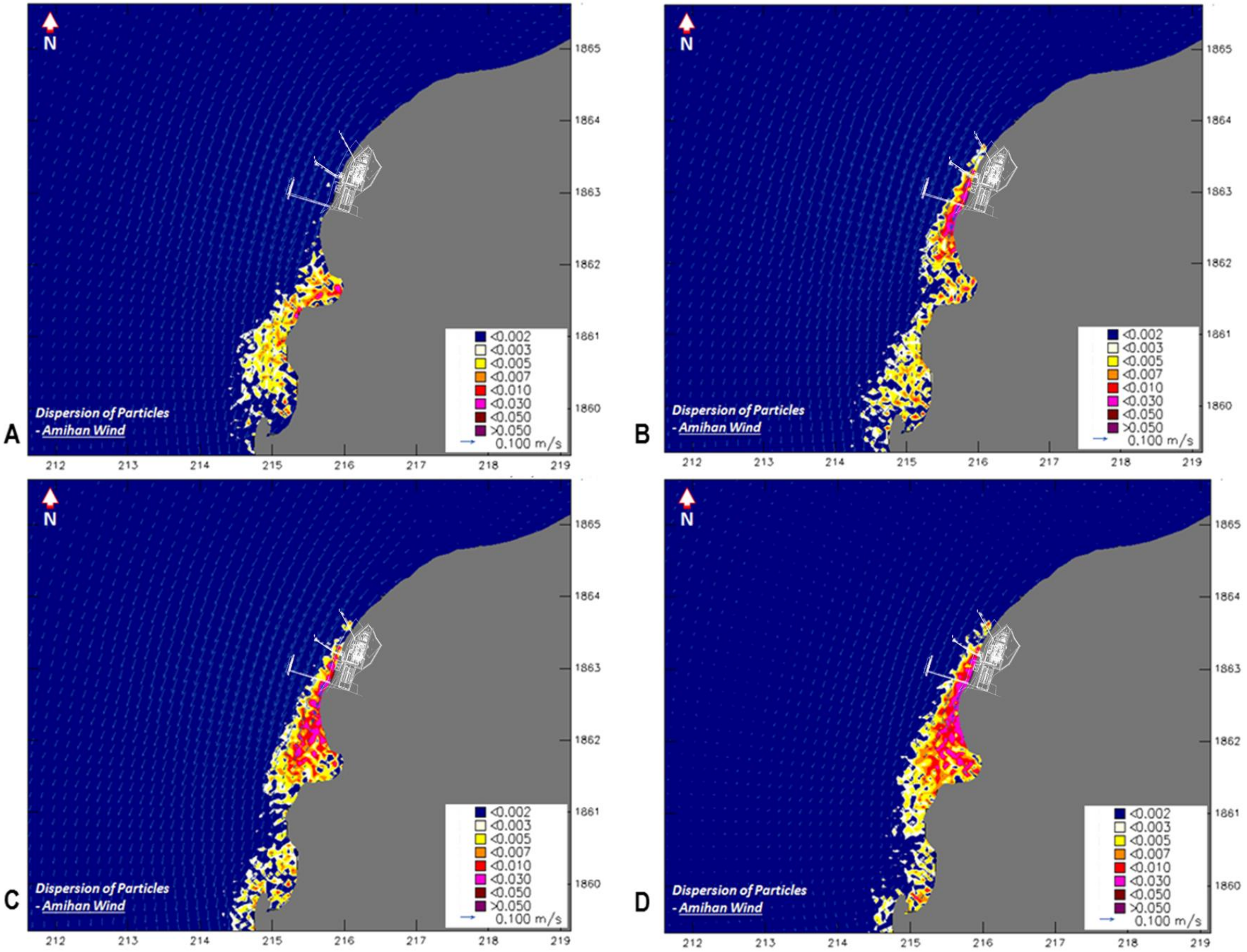


Figure EW-39 Predicted Transport of Particles for Day 2: (A) just before start, (B) 4 hours after, (C) 8 hours after, and (D) after 12 hours of continuous releases.

ENVIRONMENTAL IMPACT STATEMENT
2x335MW COAL-FIRED POWER PLANT PROJECT

LEGEND: As labelled above

Note: The black dots in the figure represent low concentration particles

SCALE: 1: 25,000

DATA INFORMATION/SOURCE:
Software Used: Delt3D- PART
Project Layout: GLEDC, 2017
Generated By: Aperçu_AConjares

aperçu CONSULTANTS INC.

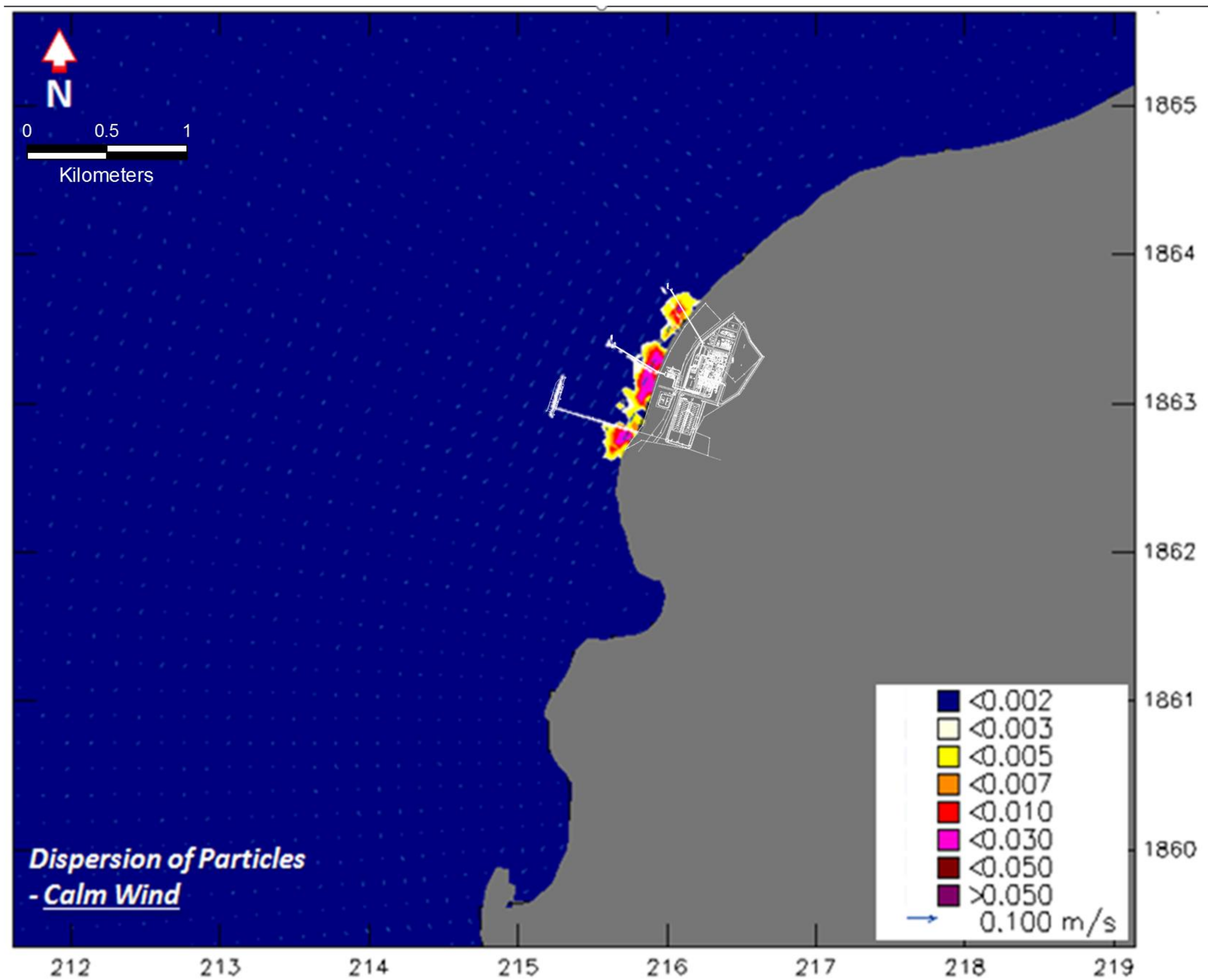


Figure EW-40 Predicted Transport of Particles after 2-hours of Continuous Release for Day 1 (Calm Wind Condition)

ENVIRONMENTAL IMPACT STATEMENT
2x335MW COAL-FIRED POWER PLANT PROJECT

LEGEND: As labelled above
Note: The black dots in the figure represent low concentration particles

SCALE: 1: 25,000

DATA INFORMATION/SOURCE:
Software Used: Delt3D- PART
Project Layout: GLEDC, 2017
Generated By: Aperçu_AConjares

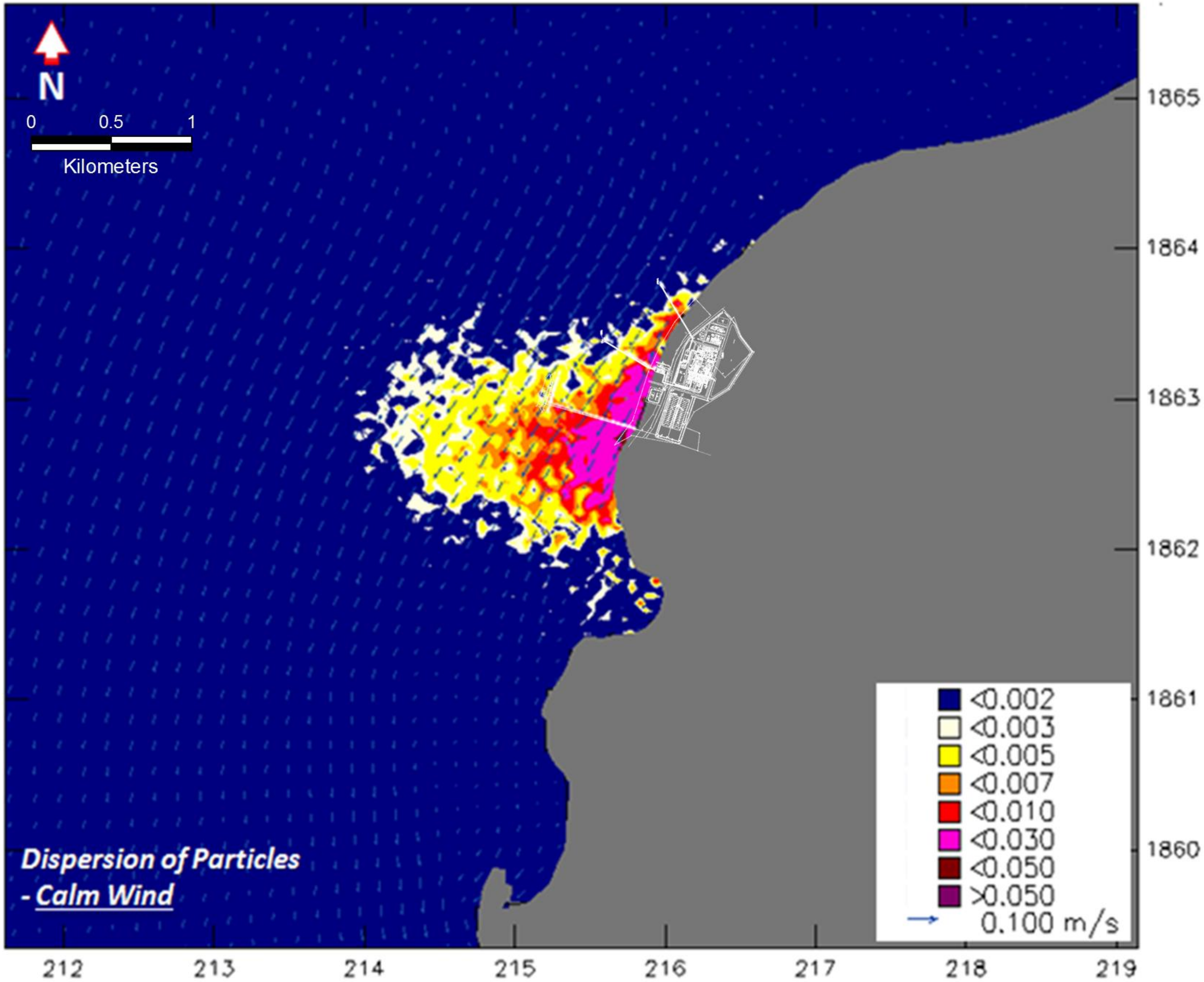


Figure EW-41 Predicted Transport of Particles after 4-hours of Continuous Release for Day 5 (Calm Wind Condition)	**LEGEND: As labelled above** *Note: The black dots in the figure represent low concentration particles*	**SCALE: 1: 25,000**	**PAGE 219**
ENVIRONMENTAL IMPACT STATEMENT **2x335MW COAL-FIRED POWER PLANT PROJECT**		**DATA INFORMATION/SOURCE:** **Software Used:** Delt3D- PART **Project Layout:** GLEDC, 2017 **Generated By:** Aperçu_AConjares	aperçu CONSULTANTS INC.

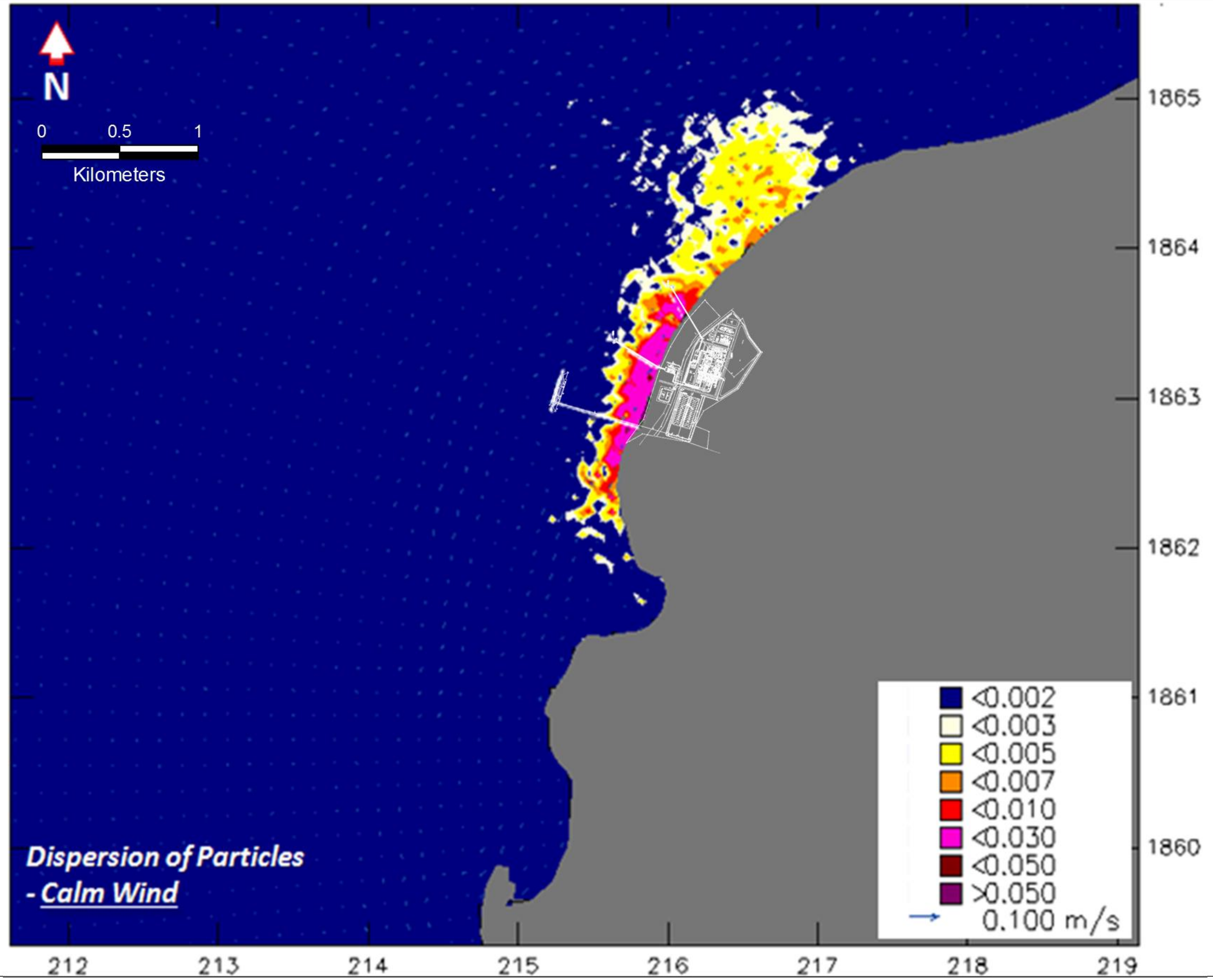


Figure EW-42 Predicted Transport of Particles after 6-hours of Continuous Release for Day 9 (Calm Wind Condition)

LEGEND: As labelled above

Note: The black dots in the figure represent low concentration particles

SCALE: 1: 25,000

PAGE 220

ENVIRONMENTAL IMPACT STATEMENT
2x335MW COAL-FIRED POWER PLANT PROJECT

DATA INFORMATION/SOURCE:
Software Used: Delt3D- PART
Project Layout: GLEDC, 2017
Generated By: Aperçu_AConjares

aperçu CONSULTANTS INC

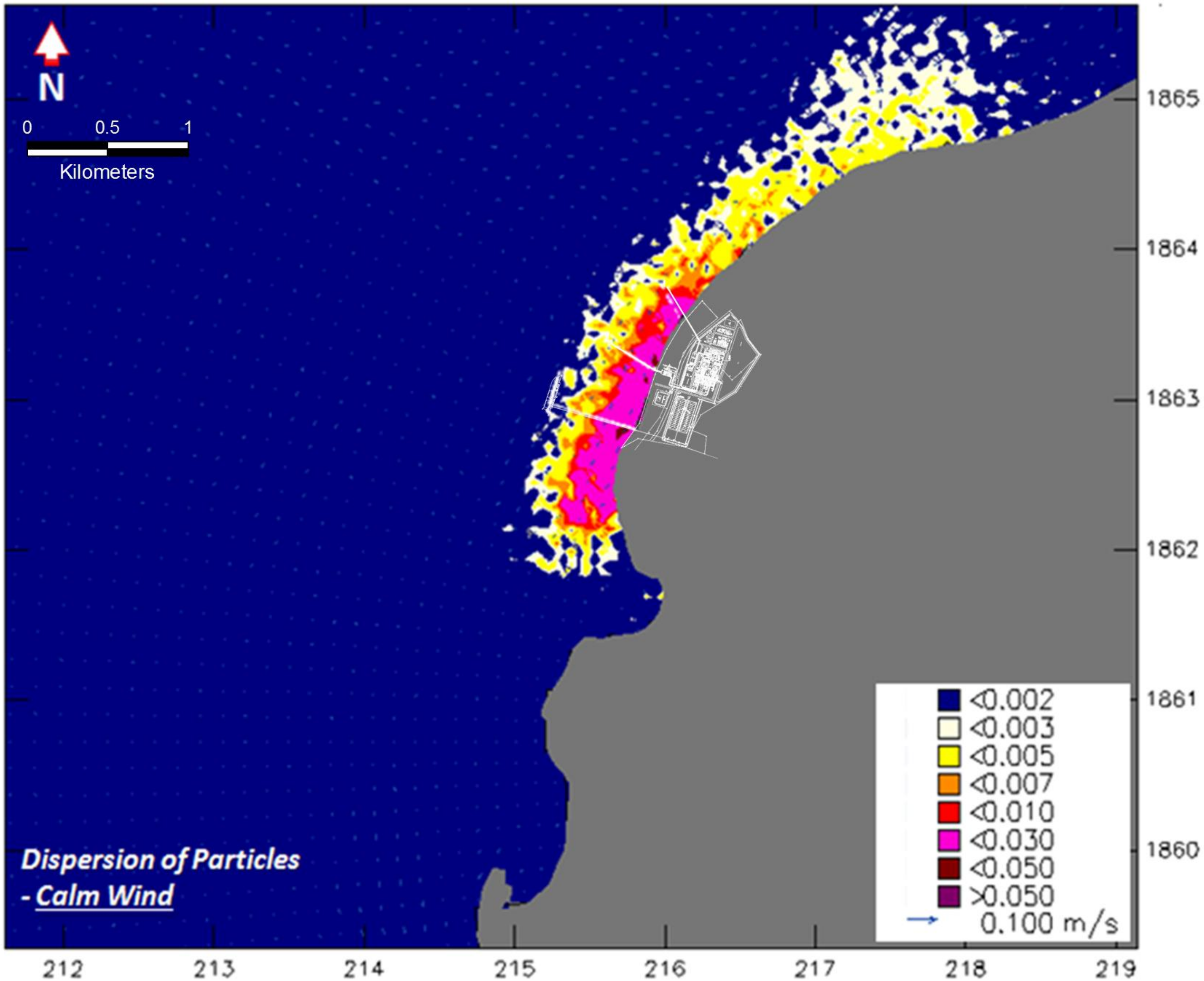


Figure EW-43 Predicted Transport of Particles after 8-hours of Continuous Release for Day 14 (Calm Wind Condition)	**LEGEND: As labelled above** *Note: The black dots in the figure represent low concentration particles*	**SCALE: 1: 25,000**	**PAGE 221**
ENVIRONMENTAL IMPACT STATEMENT **2x335MW COAL-FIRED POWER PLANT PROJECT**		**DATA INFORMATION/SOURCE:** **Software Used:** Delt3D- PART **Project Layout:** GLEDC, 2017 **Generated By:** Aperçu_AConjares	aperçu CONSULTANTS INC.

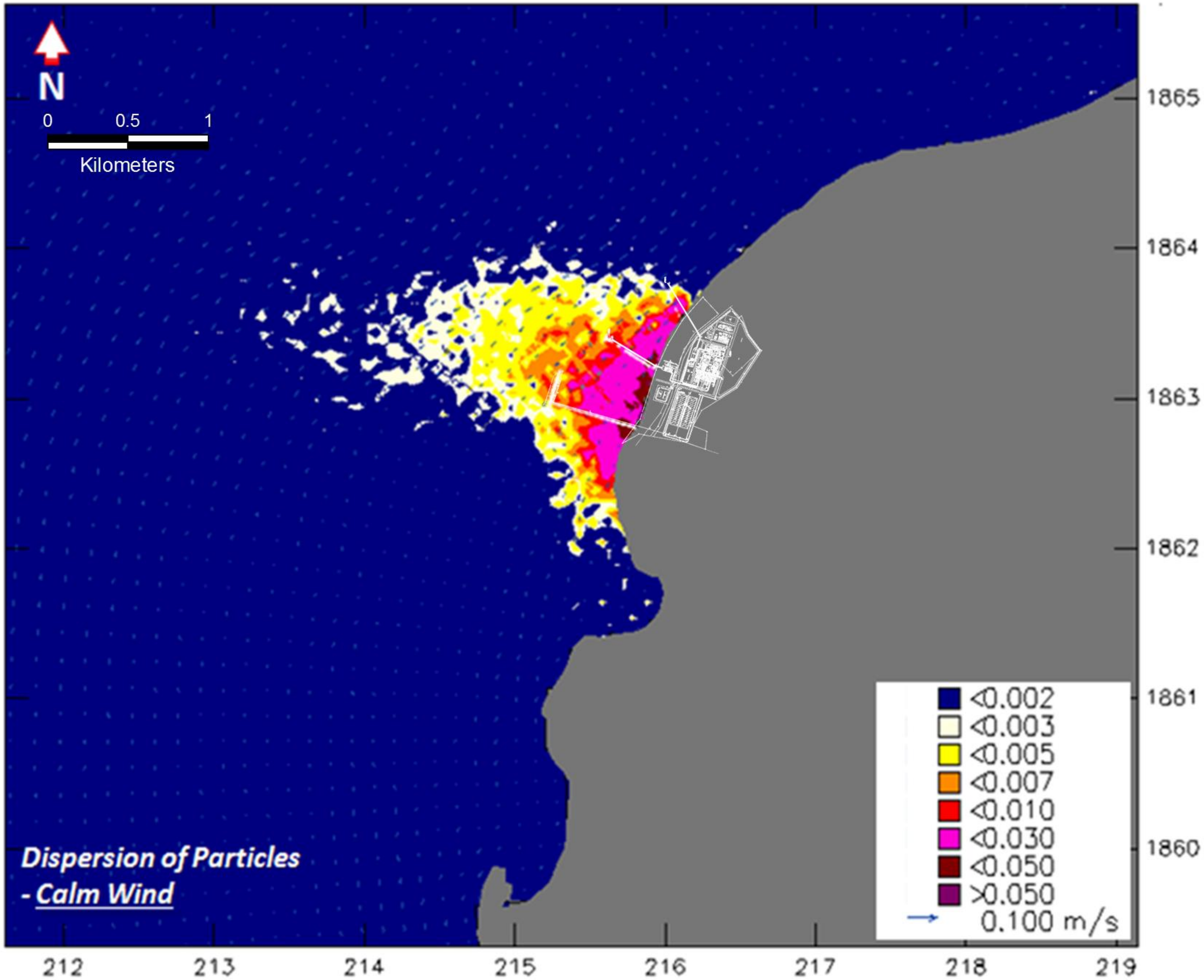


Figure EW-44 Predicted Transport of Particles after 10-hours of Continuous Release for Day 19 (Calm Wind Condition)

ENVIRONMENTAL IMPACT STATEMENT
2x335MW COAL-FIRED POWER PLANT PROJECT

LEGEND: As labelled above

Note: The black dots in the figure represent low concentration particles

SCALE: 1: 25,000

DATA INFORMATION/SOURCE:
Software Used: Delt3D- PART
Project Layout: GLEDC, 2017
Generated By: Aperçu_AConjares

aperçu CONSULTANTS INC.

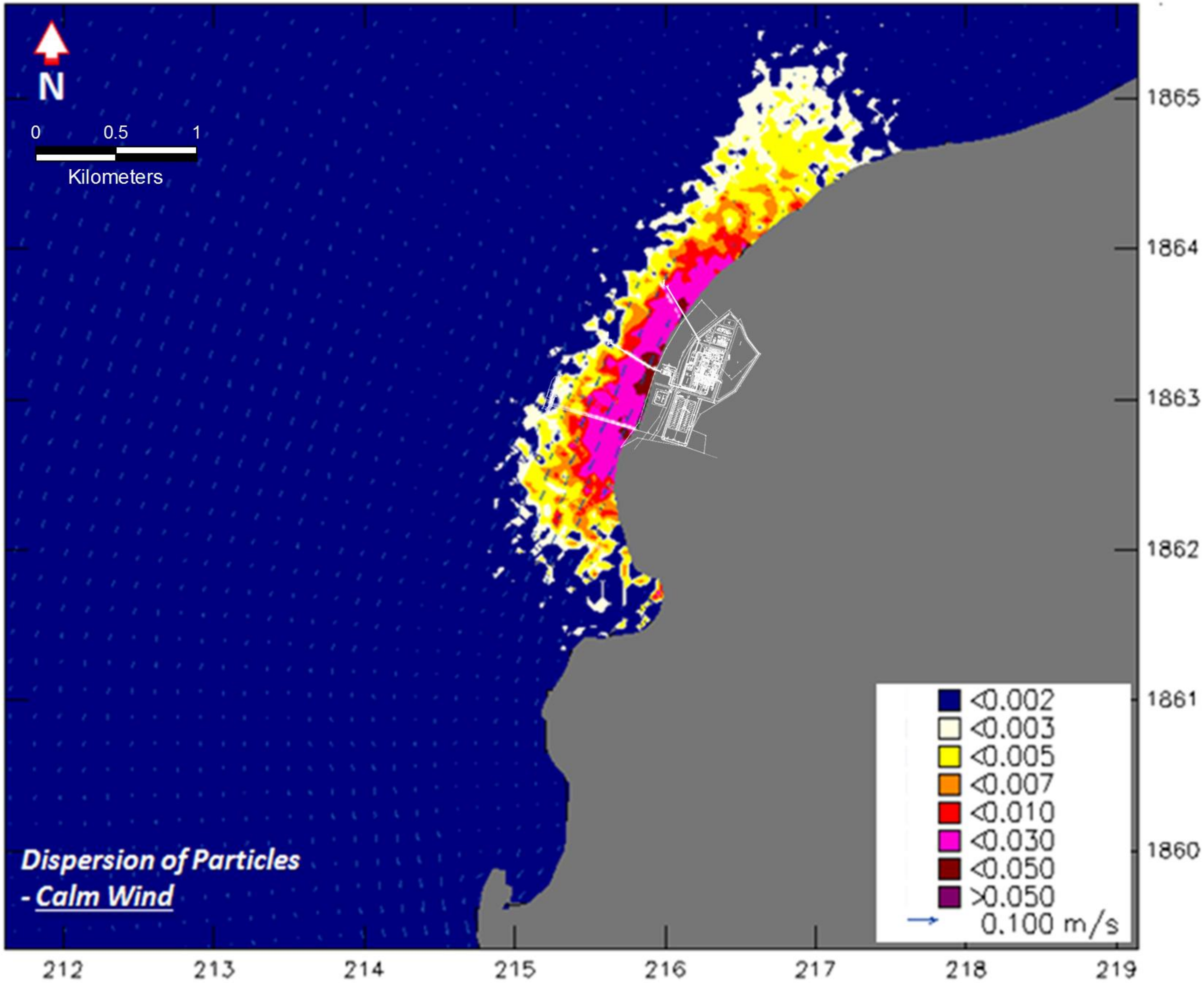


Figure EW-45 Predicted Transport of Particles after the end of 12-hours continuous release for Day 23 (Calm Wind Condition)	**LEGEND: As labelled above** *Note: The black dots in the figure represent low concentration particles*	**SCALE: 1:25,000**	**PAGE 223**
ENVIRONMENTAL IMPACT STATEMENT **2x335MW COAL-FIRED POWER PLANT PROJECT**		**DATA INFORMATION/SOURCE:** **Software Used:** Delt3D-PART **Project Layout:** GLEDC, 2017 **Generated By:** Aperçu_AConjares	aperçu CONSULTANTS INC.

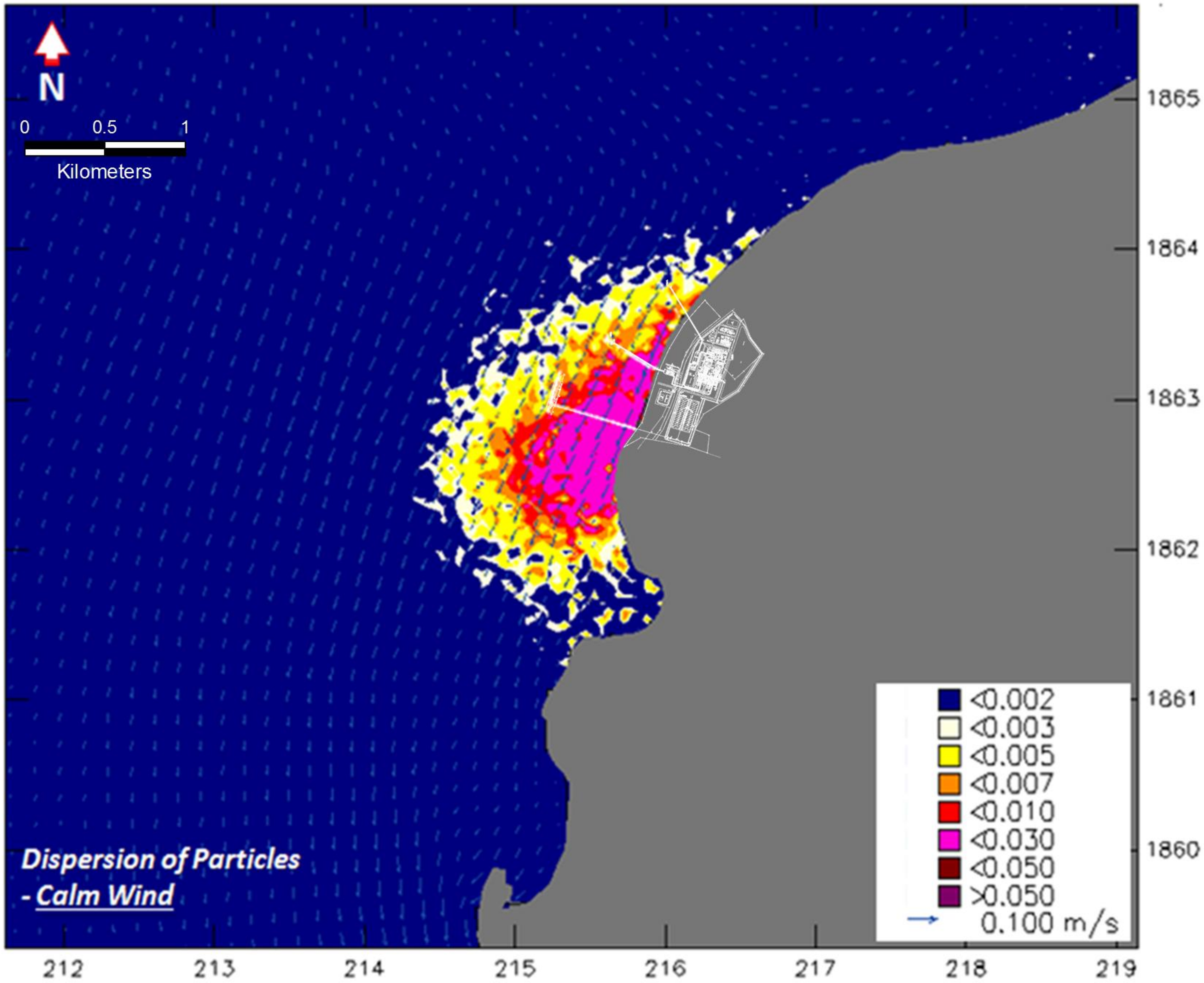


Figure EW-46 Predicted Transport of Particles 6-hours after the end of 12-hours of Continuous Release for Day 26 (Calm Wind Condition)	**LEGEND:** As labelled above *Note: The black dots in the figure represent low concentration particles*	**SCALE:** 1: 25,000	**PAGE 224**
ENVIRONMENTAL IMPACT STATEMENT **2x335MW COAL-FIRED POWER PLANT PROJECT**		**DATA INFORMATION/SOURCE:** **Software Used:** Delt3D- PART **Project Layout:** GLEDC, 2017 **Generated By:** Aperçu_AConjares	aperçu CONSULTANTS INC.

Notice also the presence of some scattered particles of low concentrations at the coastal area a few kilometers northeast of the project. This is also due to the resulting weak flow velocities in the area brought by the 'sheltering' effect of the concave area of the coast.

Figure EW-47 shows an example of the typical progression of particles for a single day of operation considering 12-hours of continuous release from four (4) individual sources.

2.2.4 Impact Assessment

The numerical modeling study investigated the circulation and transport features of the coastal environments with scenario analysis on the possible impacts of an accidental release of unspecified pollutant in the area of the proposed power plant in Luna, La Union. 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, evaporation and direct rainfall were not incorporated); uniform wind field condition, 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, the particle tracking model simulations to investigate pollutant transport patterns in the study area conservatively assumed pollutant particle as a conservative constituent. Extreme scenario simulations thru calm wind condition were also undertaken to consider the effects of tidal oscillations to obliterate the effects of wind-driven turbulence on pollutant transport.

From the results of the scenario analyses, the model results revealed that the particle dispersion fluctuates depending on the rise and fall of the tides. Higher pollutant concentration is predicted to be consistent with low tidal level event.

Likewise, the scenario simulations revealed pollutant particles released in the immediate vicinity of the project area were not transported far offshore in the direction towards the open sea. The natural convex configuration of the coast of the project area exposes it to the open sea, especially during periods of flood and ebb tides where the current run parallel to the coast, appeared to prevent the cross-shore transport of pollutant in the area further offshore.

In summary, based on the hydrodynamic and particle tracking modeling results, pollutant particles transported away from the coastal zone are minimal. In case of accidental spillage of particulate matter or pollutant in the project area, most of the particles released are dispersed mainly towards the northeast and small portions move south of the project area. Also, the simulations of 12-hours continuous release of particles over 26 days revealed that the concentration of pollutants become minimal a few hours after such a release, maintaining a marginal increase in pollutant concentrations during the 12-hour period and then starts to diffuse to minimal levels a few hours after the end of the 12-hour release. This is mainly due to the efficient transport and mixing processes in the area. The critical situation is during calm wind conditions, with predicted concentrations nearest the point sources of particles reaching more than 50 mg/L, but generally is less than said concentration once the spreading reaches a few tens of meters away from these sources. In the area of the intake and outfall points, the concentration of pollutants is less than 10 mg/L.

Nevertheless, even if the model results revealed marginal increases in suspended sediment, proper mitigating measures such as silt curtains will be employed to ensure the confinement of the suspended material in case of accidental spillage during the construction of coastal structures.

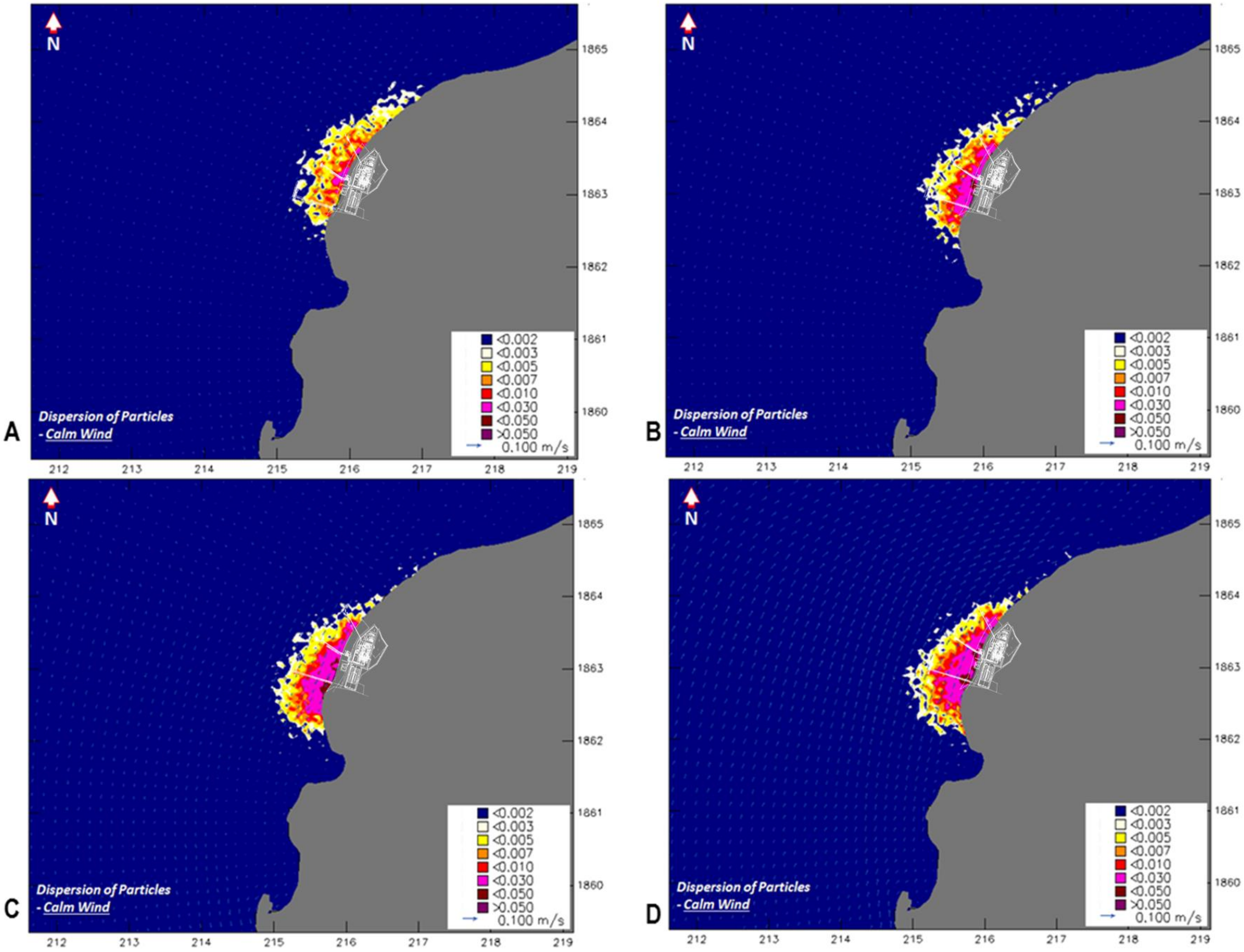


Figure EW-47 Predicted Transport of Particles for Day 2: (A) just before start, (B) 4 Hours after, (C) 8 hours after, and (D) after 12 hours of continuous releases.

ENVIRONMENTAL IMPACT STATEMENT
2x335MW COAL-FIRED POWER PLANT PROJECT

LEGEND: As labelled above

Note: The black dots in the figure represent low concentration particles

SCALE: Not Drawn to Scale

DATA INFORMATION/SOURCE:
Software Used: Delt3D- PART
Project Layout: GLEDC, 2017
Generated By: Aperçu_AConjares

aperçu CONSULTANTS INC.

2.2.4.1 Changes in Circulation Patterns

Due to Construction of Jetty

To assess the potential impact of piers on the hampering the flow movement within the project area, and considering that the detailed design of the pier columns is yet to be available to warrant detailed formulations in the model, the bed roughness term (a measure of the resistance of the flow to the sea bottom) in the location of the jetty was modified into the model inputs. This was made possible by changing the bed friction at the jetty's site, which is computed according to the Chezy formulation (Chezy's coefficient C from 65 to 30, the lower the value means the higher the resistance to flow).

Based on the simulations conducted, the changes in flow magnitudes for both high tides and low tides were checked by taking the difference of the results for 'with pier' and the 'present condition' scenarios. The next two figures show the differences in flow magnitude. Values with a positive value means an increase while a negative value denotes reduced flow velocities.

Figures EW-48 and EW-49 indicates that in both high and low tidal events, there is a decrease in flow magnitudes of more than 0.004 m/s near the shore of the project and increase of less than 0.002 m/s far offshore. Nevertheless, the reduction in flow magnitudes is less than 1 cm/s which is deemed insignificant to affect the prevailing water movement in the area.

Due to Sea Level Rise

To assess the impact of sea level rise on the prevailing circulation patterns in the project site, the tidal harmonics used in the model boundary, specifically each tidal amplitude for each tidal constituents were increased by 10%. In effect, the vertical displacement of the sea level as a function of astronomical argument based on the present condition was increased by 10% to simulate increased sea levels.

Based on the simulations conducted, the changes in flow magnitudes for both high tides and low tides were checked by taking the difference of the results for 'with sea level rise' and the 'present condition' scenarios. Figures EW-50 and EW-51 show the differences in flow magnitude values with a positive value meaning an increase and a negative value denoting reduced flow velocities. It appears that during high tide, there is an increase of more than 0.004 m/s in the project site and increase of less than 0.002 m/s far offshore. During low tidal event, the change in flow magnitudes is quite insignificant with less than 0.003 m/s increase near the project site and a decrease of less than 0.001 m/s far offshore. Near Santiago Island farther southwest of the project area, there is an increase and decrease of about 0.004 m/s for high and low tidal events, respectively due to the assumed 10% sea level rise.

Also, due to the minimal reclamation works and changes in coastal configuration in the proposed area, no significant effects/changes on the general current flow patterns of the coast is expected, based on the results of the hydrodynamic modeling study conducted. Simulation results demonstrated that hydrodynamics in the said area are partly influenced by the tidal current flowing in and out of Lingayen Gulf as well as the influence of the rather significant flow velocities north of Santiago Island and off Bolinao coast.

Therefore, based on these model results, it appears that the impact of climate change (sea level rise) and of the changes in coastal configurations on the disruption of circulation patterns in the area is deemed not significant.

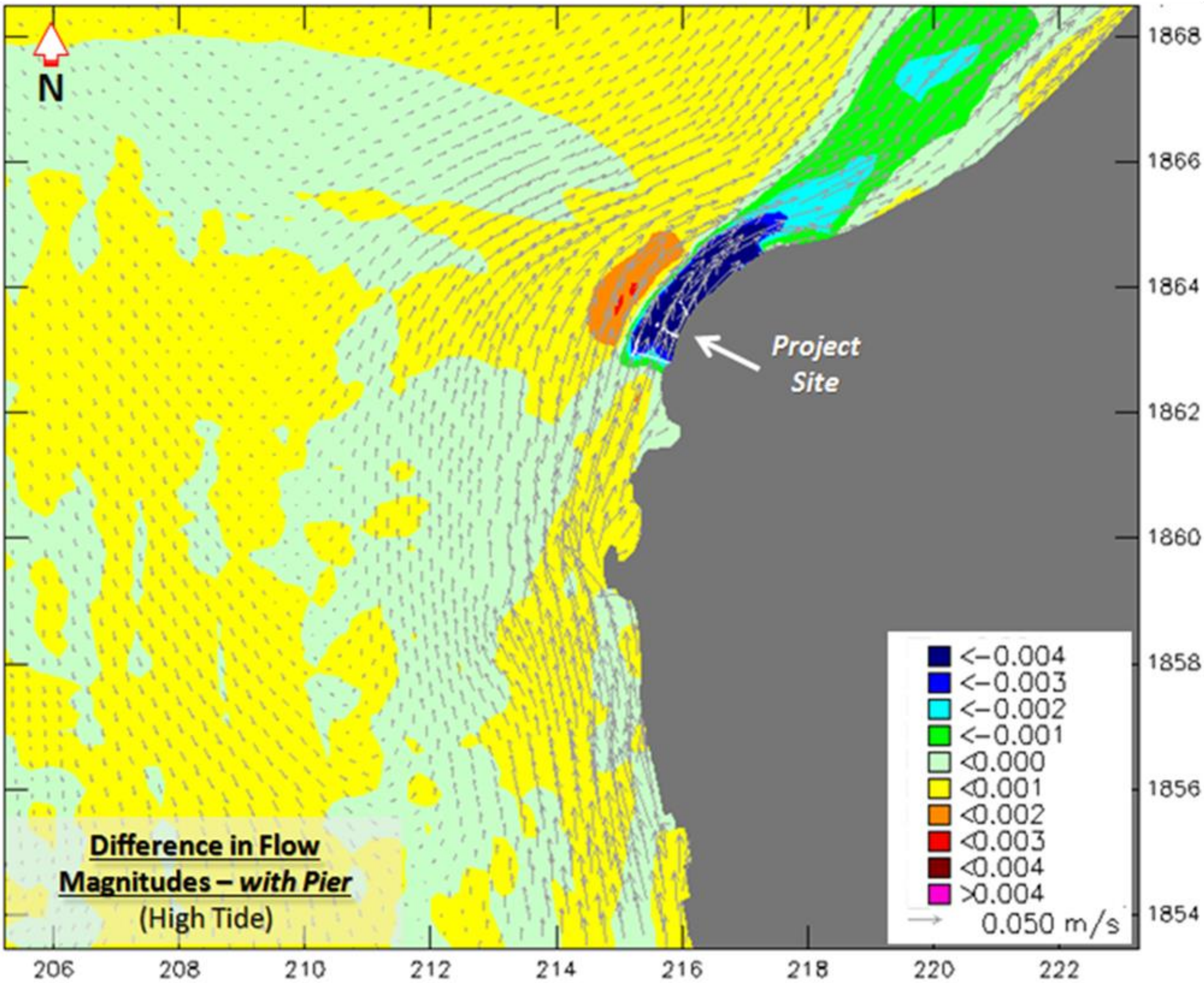


Figure EW-48. Predicted changes in flow magnitudes due to effects of the proposed jetty in the project area (high tidal event)	**LEGEND: As Above**	**SCALE: As Above**
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	**DATA INFORMATION/SOURCE:** **Software used:** Delft3D-PART **Created by**: Aperçu Constultants, Inc._RRP (2017)	aperçu CONSULTANTS INC. **PAGE 228**

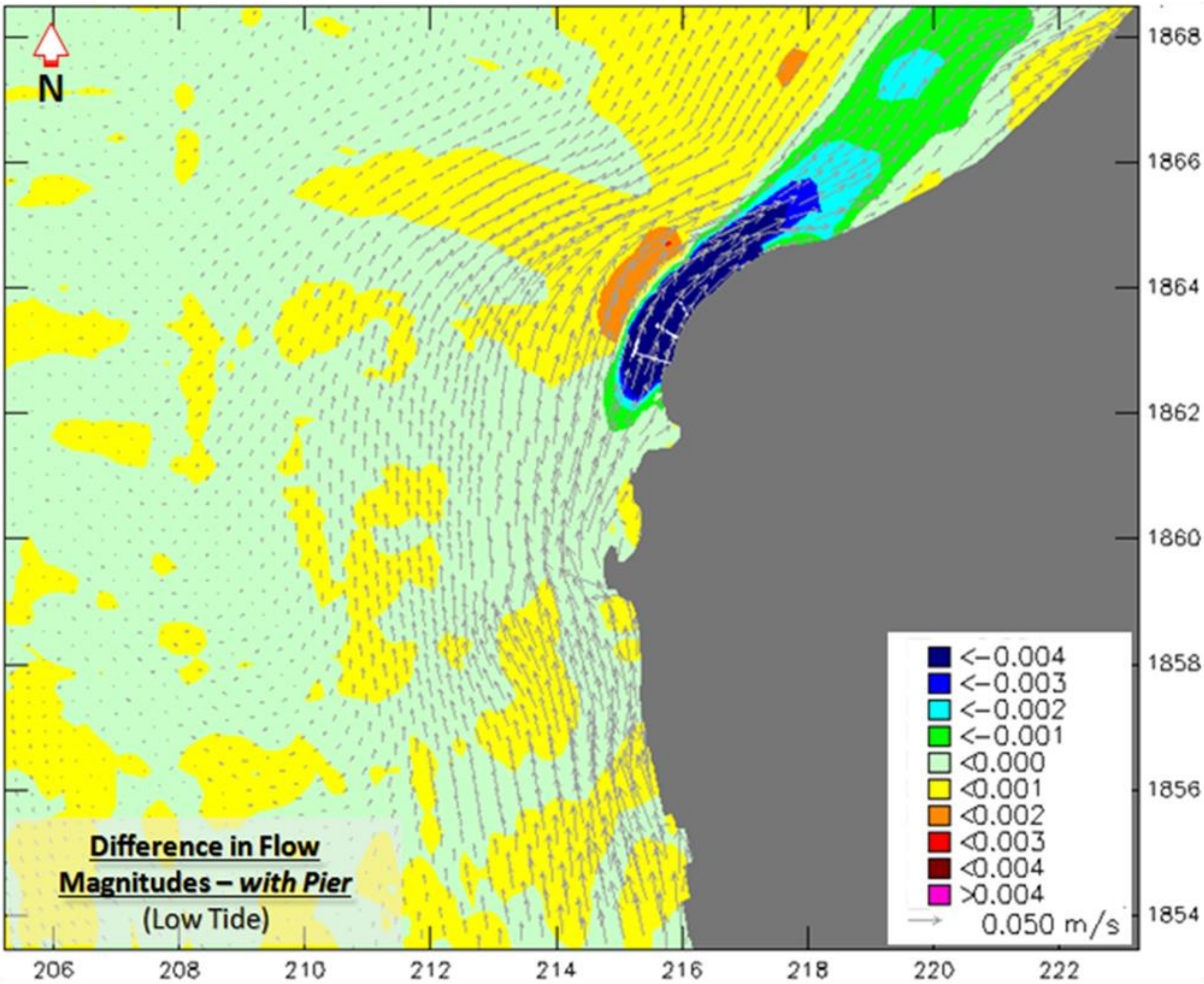


Figure EW-49. Predicted changes in flow magnitudes due to effects of the proposed pier in the project area (low tidal event)	**LEGEND: As Above**	**SCALE: As Above**
ENVIRONMENTAL IMPACT STATEMENT **2x335MW COAL-FIRED POWER PLANT PROJECT**	**DATA INFORMATION/SOURCE:** **Software used:** Delft3D-PART **Created by**: Aperçu Constultants, Inc._RRP (2017)	aperçu CONSULTANTS INC **PAGE 229**

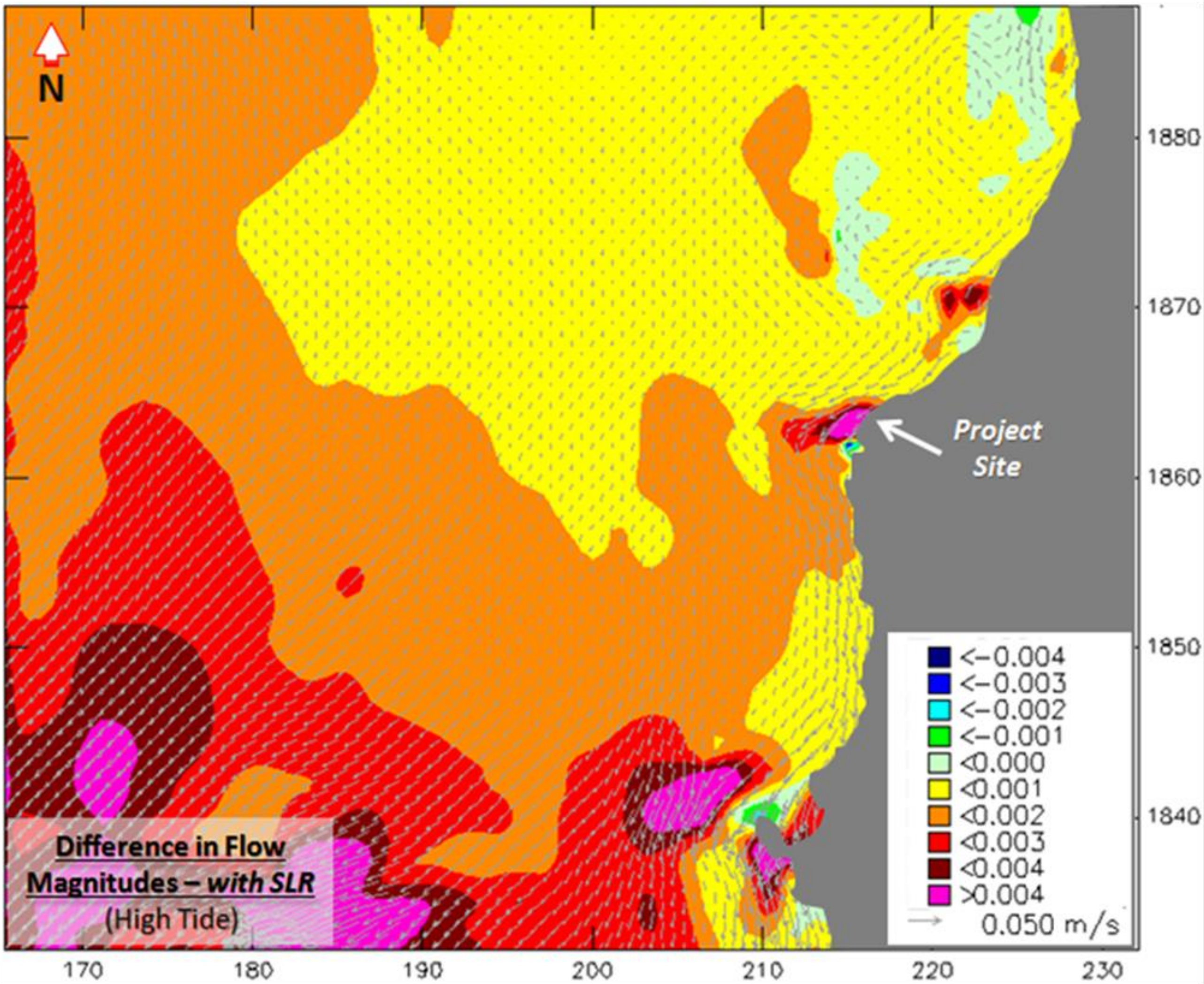


Figure EW-50. Predicted changes in flow magnitudes due to a 10% increase in sea level from the present condition (high tidal event)	LEGEND: As Above	SCALE: As Above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	**DATA INFORMATION/SOURCE:** **Software used:** Delft3D-PART **Created by**: Aperçu Constultants, Inc._RRP (2017)	PAGE 230

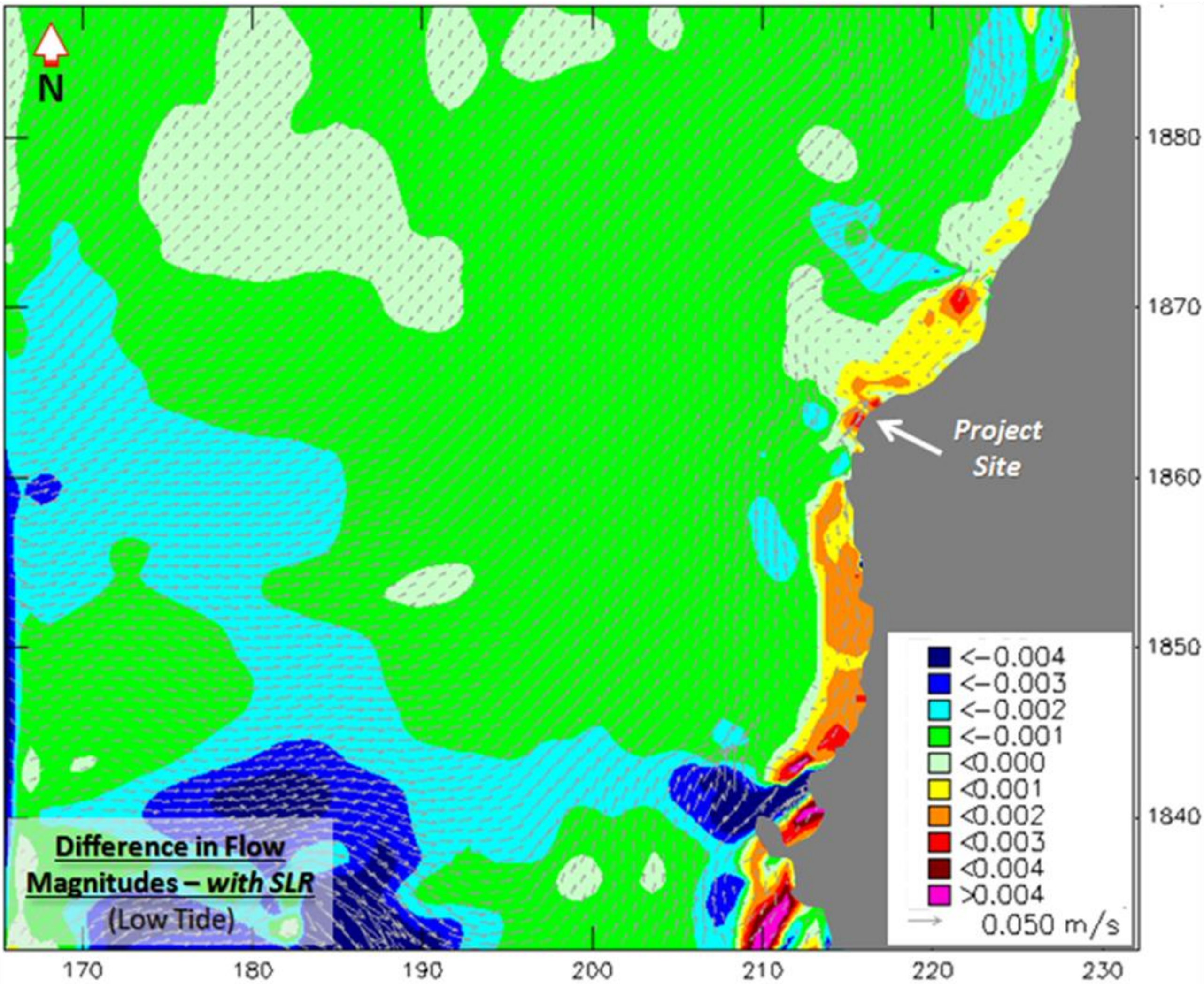


Figure EW-51. Predicted changes in flow magnitudes due to 10% increase in sea level from the present condition (low tidal event)	LEGEND: As Above	SCALE: As Above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: **Software used:** Delft3D-PART **Created by**: Aperçu Constultants, Inc._RRP (2017)	

2.2.4.2 Changes in Coastal Bathymetry

No reclamation works will be conducted in the area, with limited excavations for foundation works and pipe laying of the intake, outfall and other appurtenant structures. It is thus expected that no significant changes on the bathymetry in the area will occur. Thus, the small modification of the coastal topography once the project is realized may not significantly alter the existing hydrodynamic patterns in the area.

However, the area may be affected by sediment deposition coming from the nearby Darigayos River especially during the rainy months were occurrence of sediment-laden flows may not be unusual. Depending on the sediment run-off from the watershed of said river system, changes in bathymetry may or may not be significant.

2.2.5 Summary of Potential Impacts to Oceanography and Mitigation Measures

Table EW-25 summarizes the potential impacts and proposed mitigation related to Oceanography.

Table EW-25
Summary of Potential Impacts to Oceanography during Construction and Operation

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
I. Construction Phase			
Change/disruption in water circulation pattern	Coastal flow patterns	In both high and low tidal events, there is a decrease in flow magnitudes of more than 0.004 m/s near the shore of the project and increase of less than 0.002 m/s far offshore. Nevertheless, the reduction in flow magnitudes is less than 1 cm/s which is deemed insignificant to affect the prevailing water movement in the area.	No mitigation measures needed
Change in bathymetry	Coastal bathymetry	No reclamation works will be conducted in the area, with limited excavations for foundation works and pipe-laying of the intake, outfall and other appurtenant structures. No significant changes on the bathymetry in the area will occur. The small modification of the coastal topography once the project is realized may not significantly alter the existing hydrodynamic patterns in the area. However, the area may be affected by sediment deposition coming from the nearby Darigayos River during the rainy months where occurrence of sediment-laden flows may not be unusual. Depending on the sediment run-off from the watershed of said river system, changes in bathymetry may or may not be significant.	No mitigation measures needed
II. Operation Phase			
Degradation of coastal water quality	Coastal resources	Based on the hydrodynamic and particle tracking modelling results, pollutant particles transported away from the coastal zone are minimal.	Silt curtains will be employed to ensure the confinement of the suspended

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
			material in case of accidental spillage during the construction of coastal structures.
Change/disruption in water circulation pattern	Coastal flow patterns	No significant effects/changes on the general current flow patterns of the coast are expected based on the results of the hydrodynamic modelling study conducted.	No mitigation measures needed

2.3 Water Quality

2.3.1 Methodology

2.3.1.1 Physico-Chemical Characterization

The water quality baseline conditions of the proposed project site were determined through the collection of groundwater, surface/freshwater and marine water samples from stations established in the direct and indirect impact areas of the project on August 22, 2016.

Pre-cleaned sample containers from the laboratory were brought to the site and prior to the collection of water samples (except the sterilized bottles for total coliform) were rinsed thoroughly with water from the sampling location, and the rinsing water thrown downstream of the sampling location. *In situ* measurements of temperature, dissolved oxygen (DO) and salinity were taken by using the YSI 550A DO meter.

A total of ten (10) water quality stations were established - three (3) stations for groundwater (deep wells), three (3) stations for surface water, and four (4) stations for marine water. The coordinates and descriptions of the sampling stations are provided in **Table EW-26** and **Figure EW-52**. Coordinates of the stations were determined using a handheld Garmin III + Global Positioning System (GPS).

Water samples were taken at 0.2m from the surface. Proper water sampling protocols were followed to avoid cross contamination during collection. Samples were stored in a cooler packed with ice and then transported and delivered to the DENR accredited laboratory for analysis (CRL Laboratory). The laboratory analysis certificates are attached as **Annex B**.

The ground depression within the proposed project area was dry and had no flow during both the wet and dry seasons and thus, no water quality samples were collected.

The characterization is followed by an assessment of potential impacts that could arise due to the construction and operation of the project on groundwater, fresh water, and marine water quality. Based on the outcome of these assessments, measures to manage and mitigate potential adverse impacts are recommended.

Table EW-26
Locations of the Water Quality Sampling Stations

Station ID	Coordinates	Elevation	Site Description
GW1	16°50'20.80"N 120°20'19.00"E	Approx. 9m	Within Pebble Beach Resort, Brgy. Nalvo Sur, north of the project site. Near the proposed power block.
GW2	16°49'34.40"N 120°19'58.40"E	Approx. 11m	Near Coral Beach, Brgy. Darigayos, 500m south of project site
GW3	16°49'42.50"N 120°20'17.00"E	Approx. 30m	200m southeast of the project site, near the barangay road of Carisquis
FW1	16°49'6.91"N 120°20'6.02"E	Approx. 8m	Downstream, near the river mouth of Darigayos River, approx. 1.3km south of the project site
FW2	16°49'8.90"N 120°20'30.00"E	Approx. 5m	Midstream, along Darigayos River, approx. 1.6km south of the project site
FW3	16°49'22.04"N 120°21'1.82"E	Approx. 7m	Upstream, along Darigayos River, approx. 2km southeast of the project site
MW1	16°50'23.82"N 120°19'56.22"E	0m	Located in the proposed outfall
MW2	16°50'17.46"N 120°19'49.39"E	0m	Located in the proposed intake
MW3	16°50'11.13"N 120°19'52.13"E	0m	Located in the proposed jetty
MW4	16°49'45.27"N 120°19'38.42"E	0m	Control Station located near the shore of Brgy. Darigayos

Note: WGS84 coordinate system was used

2.3.1.2 Thermal Plume Modeling

The proposed 2x335MW Coal-Fired Power Plant will be using seawater as cooling water. The area is exposed to the southwest monsoon and will typically experience the warmest temperatures as well as wettest conditions during this season. On the other hand, the northeast monsoon will bring in cool and calm conditions.

This section describes modeling studies undertaken to determine the potential characteristics (e.g. extent and magnitude) of the thermal discharge released from a proposed submarine discharge pipe. This thermal discharge is seawater derived from the surrounding sea that has been used as a coolant for the power plant. The objective was to get an estimate of the boundaries of the temperature compliance monitoring points, which is defined as the water surface area where the surface temperature increases due to the thermal discharge and exceeds the ambient water temperature by 3 degrees Celsius, a limit specified by the DENR.

A thermal discharge model of the proposed project was simulated using CORMIX software (www.cormix.info). CORMIX is a software analysis and modeling system used for the analysis, prediction and design of discharges into water bodies. It also includes modules for modeling the discharge and mixing characteristics of a submarine discharge pipe for single and multiport diffusers. The design used was that of a single port discharge pipe, as specified by the Proponent's engineers.

Model parameters used to setup the model (**Table EW-27**) were based on actual design parameters, but were adapted to fit constraints set by CORMIX. Ambient parameters such as temperature, wind and current velocities were based on previously collected field data.

The ambient temperature used was 28°C derived from measurements at the site (**Figure EW-53**) and shown in **Table EW-28**.

The modeling is followed by an assessment of potential impacts of the thermal plume on thermal plume distribution in the area.

Figure EW-52. Water Quality Sampling Stations	**LEGEND:** Project Site; Intermittent Creek; Marine Water SS; Groundwater SS; Freshwater SS	**SCALE: As above**
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	**DATA INFORMATION/SOURCE:** **Bathymetric contour lines: actual field survey (Sept. 29 to October 2, 2016)**	aperçu CONSULTANTS INC

Table EW-27
Parameters Used for CORMIX Model Runs

Parameter	Value
Cross-section	unbounded
Average depth	15 m
Depth at discharge	12 m
Discharge port height	0 m
Wind velocity	2.6 ms^{-1}
Surface density	1021.32 kgm^{-3}
Bottom density	1021.32 kgm^{-3}
Diffuser type	Single Port Discharge pipe
Nearest bank	right
Distance from nearest bank	280 m
Diameter of discharge pipe	3.9 m
Discharge flow rate	33.33 m^3s^{-1} (120,000 m^3hr^{-1})
Vertical discharge angle	0 deg
Horizontal discharge angle	65 deg
Discharge density	1017.03 kgm^{-3}
Ambient temperature	28°C
Average ambient current (measured through fieldwork)	0.4ms^{-1}
Excess temperature (difference between ambient and discharge)	6.8^{0}C
Water quality standard (safe limit of surface temperature)	3^{0}C

Table EW-28
Temperature Readings during Field Survey

Station ID	Surface			At Depth			Depth
	1st	2nd	3rd	1st	2nd	3rd	
MW1	28.7	28.7	28.7	28.9	28.9	28.9	9
MW2	28.7	28.7	28.7	28.9	28.9	28.9	10
MW3	28.5	28.6	28.6	28.9	28.9	28.9	10
MW4	28.5	28.6	28.6	28.9	28.9	28.9	6
MW5	28.7	28.7	28.7	28.9	28.9	28.9	7
MW6	28.6	28.6	28.6	28.9	28.9	28.9	10

Figure EW-53. Sampling Stations for temperature	LEGEND: Project Site Sampling Stations	SCALE: As above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: Basemap: Google Earth Imagery Created by: Apercu Consultants_CV_2017	apercu CONSULTANTS INC. PAGE 237

Model scenarios were based on different magnitudes of ambient current velocities. The summary of the different scenarios are shown in **Table EW-29**.

Table EW-29
Summary of Model Scenarios

Scenario	Current Speed (ms^{-1})
1	0.2
2	0.4
3	0.6

2.3.2 Groundwater Quality

The three (3) groundwater quality stations sampled within the project area were deep wells are used for the domestic needs of the residents. Results of the groundwater analysis are compared with the Philippine National Standards for Drinking Water (**Table EW-30**). Only pH, heavy metals, Oil and Grease, and TSS parameters have standard values indicated in DAO 2016-08. Results of other parameters such as DO, BOD, TDS, and total coliform will be discussed with no comparison to the standards.

Table EW-30
Groundwater Quality Baseline Results

Parameters	Station ID			DAO 2016-08	PNSDW Standard
	GW1	GW2	GW3		
Physico-chemical Parameters					
Temperature (°C)	28	31	31	-	-
DO (mg/L)	6.7	7.7	4.5	-	-
pH	7.5	7.3	7.3	6.5-8.5	6.5-8.5
BOD_5 (mg/L)	1	<1	<1	-	-
Oil and Grease (mg/L)	0.4	0.7	0.7	1	-
Total Suspended Solids (mg/L)	10	<2.5	24	65	-
Total Dissolved Solids (mg/L)	914	1,550	409	-	500
Heavy metal Parameters					
Cr^{+6}, mg/L	< 0.003	< 0.003	< 0.003	0.01	0.05
As, mg/L	0.001	0.002	0.002	0.01	0.05
Cd, mg/L	< 0.003	< 0.003	< 0.003	0.003	0.003
Pb, mg/L	< 0.0001	< 0.0001	< 0.0001	0.01	0.01
Hg, mg/L	< 0.0002	< 0.0002	< 0.0002	0.001	0.001
Bacteriological Parameters					
Total Coliform, MPN/100 ml	> 23	> 23	> 23	-	<1.1
Time of Sampling	11:20am	11:31am	11:40am	-	
Date of Sampling	22-Aug-16	22-Aug-16	22-Aug-16	-	

Temperature

Of the three stations, Station GW1 had the lowest recorded temperature at 28°C while Stations GW 2 and GW3 both had the highest temperature with 31°C.

pH

All stations tested for pH were within the prescribed range. The pH levels of the groundwater stations are compliant to the PNSDW standards.

Dissolved Oxygen and Biochemical Oxygen Demand

Dissolved Oxygen levels for all surveyed stations ranged from 4.5 to 7.7 mg/L. While results for BOD analyses were found to be 1mg/L and below the detection limit.

Oil and Grease

All surveyed ground/spring water samples analyzed for oil and grease resulted in values below the detection limit and prescribed standard of 1.0mg/L, with values ranging from 0.4-07 mg/L.

Total Suspended Solids

The highest value for total suspended solids was recorded at Station GW3 with 24mg/L while the lowest value was at Station GW2 with less than 2.5 mg/L, well below the standard.

Total Dissolved Solids

Station GW2 had the highest value for total dissolved solids at 1,550mg/L while the lowest value recorded in Station GW3 at 409 mg/L.

Heavy Metals

Heavy metals in all the groundwater samples were well within the limits of the PNSDW.

Total Coliform

Total coliform in all groundwater samples exceeded the limit by more than 13 MPN/ml.

Groundwater quality may be affected during both construction and operation phases. Water may be polluted if effluents from the project construction and operation will not be managed. Contamination during project construction can originate from used oil or spillage of fuel from construction equipment. Wastes from project development may also reach groundwater and cause degradation of water quality. During the operation phase, leakage of chemicals and also leachate of the ash pond can pollute the groundwater resources.

To mitigate these impacts, equipment, machinery and trucks will be maintained in perfect condition and free of oil leaks. Repair and maintenance of machinery and vehicles will be done in a designated maintenance area that is cemented and provided with proper drainage and oil absorbing material. Ecological solid waste management plans will be established and strictly implemented within the construction site. On-site toilets and facilities at work areas will also be provided.

Mitigation measures during the operation phase include:

- **Lining of the ash pond with clay and HDPE lining to prevent leachate**
- **Establish drainage systems for the areas around the coal yard, equipped with siltation ponds**
- **Maintain designated cemented areas for vehicle maintenance and repair, equipment maintenance and repair; and diesel fuel storage.**

2.3.3 Freshwater Quality

Table EW-31 presents water quality analyses of the collected river water samples, which are compared to the standard values prescribed in DAO 2016-08 for Class C waters under the Clean Water Act (CWA). This standard was chosen due to the intended beneficial uses of the river as classified by DAO 2016-08; including boating, fishing, agriculture, and irrigation. The Darigayos River is approximately 2km away from the project site. Although it is unlikely to be affected by the project due to its distance from the site, the river was included in the study since it fell within the initially identified 2km impact radius of the air dispersion model. Majority of the surface water parameters analyzed were within the prescribed values of the DENR standards. **Table EW-31** tabulates the results and values in red font indicate exceedances to the standard. For the freshwater quality impa

Table EW-31
Surface/Fresh Water Quality Baseline Results

Parameters	Station ID			DAO 2016-08
	FW1	FW2	FW3	
Physico-chemical Parameters				
Temperature (°C)	31.8	31.6	31.5	25-31
DO (mg/L)	6.7	7.5	6.1	5.0 minimum
pH	7.8	7.8	7.8	6.5 - 9
BOD_5 (mg/L)	1	1	1	7
Oil and Grease (mg/L)	0.7	0.6	0.7	2
Total Suspended Solids (mg/L)	42	60	7.5	80
Total Dissolved Solids (mg/L)	3,390	1,640	8,210	-
Heavy metal Parameters				
Cr^{+6}, mg/L	< 0.003	< 0.003	< 0.003	0.01
As, mg/L	< 0.01	< 0.01	< 0.01	0.02
Cd, mg/L	< 0.003	< 0.003	< 0.003	0.005
Pb, mg/L	< 0.05	< 0.05	< 0.05	0.05
Hg, mg/L	< 0.0002	< 0.0002	< 0.0002	0.002
Bacteriological Parameters				
Total Coliform, MPN/100 ml	2,400	11, 000	17, 000	5,000
Time of Sampling	10:06am	10:29am	11:01am	-
Date of Sampling	22-Aug-16	22-Aug-16	22-Aug-16	-

Temperature

Temperature values ranged from 31.5°C (Station FW3) to 31.8°C (Station FW1), which are slightly above the limit prescribed in DAO 16-08. These values are acceptable as long as any increase in temperature will only be up to 10% and is not detrimental to human health and the environment.

pH

The pH values of the water from all 3 stations were well within the CWA standards.

Dissolved Oxygen and Biochemical Oxygen Demand

Dissolved oxygen levels ranged from 6.1 to 7.5 mg/L, well above the minimum value of 5mg/L. The BOD levels were way below the maximum amounts allowed under the CWA standards.

Oil and Grease

Oil and grease levels for all stations complied to the DENR prescribed limits with the samples exhibiting have low concentrations of oil and grease ranging from 0.6 to 0.7 mg/L.

Total Suspended Solids

TSS values ranged from 7.5 mg/L (Station FW3) to 60 mg/L (Station FW2), all of which were compliant with the DENR standard values of 80 mg/L.

Total Dissolved Solids

Station FW3 recorded the highest value of total dissolved solids at 8,210mg/L while Station FW2 had the lowest value at 1,640 mg/L.

Heavy Metals

All the fresh water stations had heavy metal concentrations that were well within the limits of DENR standards.

Total Coliform

Two of the surface water stations exceeded the prescribed limits of the DAO 2016-08 with coliform concentrations of 17,000 MPN/100ml in Station FW3 and 11,000 MPN/100ml in Station FW2 with. The results imply contamination with fecal matter that may have been contained in the run-off during precipitation. Site observations in Stations FW2 and FW3 noted the presence of pigs and cows.

Due to its distance from the project site, Darigayos River water quality will not be affected by project activities during the construction and operation phases.

2.3.4 Marine Water Quality

Table EW-32 presents the results of the physico-chemical analysis of marine water samples, which are assessed against the standard values prescribed in DAO 2016-08 for Class SC waters under the Clean Water Act (CWA). This standard was chosen due to the intended beneficial uses of the marine water as classified by DAO 2016-08; including boating, fishing, or similar activities.

Temperature

Temperature values ranged from 29°C (Station MW 1, 2 and 4) to 30°C (Station MW 3). There were minimal differences in the water temperature of the stations.

pH

The pH values of all marine water stations tended to be basic, with values ranging from 8.2 to 8.4.

Dissolved Oxygen

Most of the dissolved oxygen levels were above the minimum value of 5mg/L. BOD levels of all stations are within the prescribed DENR standards.

Oil and Grease

Results of the analysis show that the oil and grease levels for all stations are compliant to the DENR prescribed limits. All of the samples have low concentrations of oil and grease (0.4 mg/L).

Table EW-32
Coastal/Marine Water Quality Baseline Results

Parameters	Station ID				DAO 2016-08
	MW1	MW2	MW3	MW4	
Physico-chemical Parameters					
Temperature (°C)	29	29	30	29	25-31
DO (mg/L)	6.5	7.0	7.2	6.0	Minimum of 5.0
pH	8.4	8.4	8.3	8.2	6.5 – 8.5
BOD_5 (mg/L)	1	< 1	1	1	-
Oil and Grease (mg/L)	0.4	0.4	0.4	0.4	3
Total Suspended Solids (mg/L)	< 2.5	4.0	4.3	3.0	80
Total Dissolved Solids (mg/L)	28,500	27, 900	28, 900	29, 800	-
Sulfate (mg/L)	2,110	2,090	2,290	2,200	275
Ammonia (mg/L)	<0.003	<0.003	<0.003	<0.003	0.05
Chloride (mg/L)	20,300	21,000	21,200	21,200	-
Boron (mg/L)	3.1	2.3	2.7	2.5	5
Nitrate (mg/L)	<0.02	<0.02	<0.02	<0.02	10
Phosphate (mg/L)	<0.006	<0.006	<0.006	<0.006	0.5
Heavy metal Parameters					
Cr^{+6}, mg/L	< 0.0003	< 0.0003	< 0.0002	< 0.0003	0.05
As, mg/L	< 0.01	< 0.01	< 0.01	< 0.01	0.02
Cd, mg/L	< 0.006	< 0.006	< 0.006	< 0.006	0.005
Pb, mg/L	< 0.05	< 0.05	< 0.05	< 0.05	0.05
Hg, mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	0.002
Bacteriological Parameters					
Total Coliform, MPN/100 ml	< 1.8	< 1.8	< 1.8	< 1.8	5000
Time of Sampling	10:18am	10:30am	10:37am	10:48am	-
Date of Sampling	22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	-

Total Suspended Solids

TSS values ranged from <2.5 mg/L in Station MW1 to 4.3 mg/L in Station MW3.

Total Dissolved Solids

Station MW4 recorded the highest value for total dissolved solids at 29,800mg/L while Station MW2 had the lowest value at 27,900 mg/L. These results indicate that TDS baseline levels in the project area are already high.

Sulfate

Sulfate levels ranged from 2,090 (MW2) to 2,290 (MW3), all exceedingly high levels and way above the standard of 275 mg/L. These results indicate a very high level of sulfate in the project area. Probable causes of high sulfate levels include agricultural and urban runoff. A ground depression (**Figure EW-52)** feeds into the marine water sample sites. Household and agricultural waste, byproducts, and runoff in close proximity to this stream could account for the high levels of sulfate recorded.

Ammonia

Ammonia levels remained consistent across all stations at <0.003 mg/L, well below the standard of 0.05 mg/L.

Chloride

Chloride levels ranged from 20,300 mg/L (MW1) to 21,200 mg/L (MW3, MW4).

Boron

Boron levels ranged from 2.3 mg/L (MW2) to 3.1 mg/L (MW1), well below the standard of 5 mg/L.

Nitrate

Nitrate levels were consistent at <0.02 mg/L, well below the standard of 10mg/L.

Phosphate

Phosphate levels were consistent at <0.006 mg/L, well below the standard of 0.5 mg/L.

Copper

Copper levels ranged from <0.004 mg/L (MW1, MW2) to 0.006 mg/L (MW3, MW4), well below the standard of 0.02 mg/L/

Nickel

Nickel levels ranged from <0.004 mg/L (MW1) to 0.006 mg/L (MW2), all well below the standard of 0.06 mg/L.

Zinc

Zinc levels ranged from 0.03 mg/L (MW1) to <0.004 mg/L (MW1, MW2, MW3), all well below the standard of 0.8 mg/L.

Heavy Metals

Concentrations of the heavy metals hexavalent chromium, arsenic, cadmium, lead and were well within the limits of the CWA.

Total Coliform

Total coliform values in all marine stations were very low and below the 1.8 MPN/100ml detection limit.

Results indicate that marine water quality in the project site is within the prescribed DENR standards for Class SC waters for most of the parameters. **Water quality, however, may be affected during project construction, from various activities such as excavation, drilling, land clearing, and the construction of coastal structures (e.g. jetty, intake and outfall pipes). These activities may result in sedimentation in the coastal waters fronting the site, especially during the rainy season. The sediments carried in run-off may increase suspended solids in the water column thereby increasing turbidity.**

A Sedimentation and Erosion Control Plan, such as provision of devices to retain sediments and materials that may find its way to the sea, will be created and implemented. Stockpiles of excavated soils will be stabilized to minimize occurrence of erosion. Excess soil will be disposed to prevent storm water from carrying the particles into the coastal water.

Silt curtains will be used around the construction site for coastal structures and wave deflection structures will be installed on the shore to prevent beach erosion and to retain sediments on shore.

During the operation phase, marine water quality may be degraded by:

- **Effluent discharge**
- **Thermal discharge**

- **Effluents or bilge from delivery vessels**
- **Oil and coal spills, also from delivery vessels**

GLEDC will install sewage and wastewater treatment facilities to ensure that effluents from the various processes of the plant are treated to meet CWA effluent guidelines upon discharge. Cooling water will also be discharged to meet the 3-degree limit under the Clean Water Act. Contracts with coal suppliers will include provisions to ensure that delivery vessels employ best practice coal unloading procedures and vessel cleaning procedures.

2.3.5 Thermal Plume Modeling Results

The thermal discharge is modeled as a buoyant plume which rises to the sea surface from the submarine discharge pipe. At the surface, a uniform ambient cross current deflects the buoyant jet, while the temperature of the discharge gradually decreases due to buoyant spreading motions and passive diffusion caused by the ambient water. The temperature compliance monitoring point area decreases with increased ambient velocity, as these conditions increase mixing for the surface layer (**Figures EW-54** to **EW-56**). The thermal plume does not greatly vary between flood and ebb conditions.

Estimates of the temperature compliance monitoring point were computed as the product of the distance traveled along the x and y axis of the plume when it reached the 3^0C water quality standard limit specified in the model. The estimates are shown in **Table EW-33** for a 0.2, 0.4, and 0.6ms^{-1} ambient velocity. Note that the temperature compliance monitoring point decreases drastically with increasing ambient velocities.

Table EW-33
Estimates of Temperature Compliance Monitoring Points for Each Scenario

Current Speed (ms^{-1})	Flood Conditions			Ebb Conditions		
	X axis (m)	Y (m)	TCMP (m^2)	X axis (m)	Y (m)	TCMP (m^2)
0.2	18.40	31.29	576	23.52	28.56	672
0.4	16.20	22.89	371	15.31	25.90	397
0.6	14.71	17.88	263	8.46	24.52	207

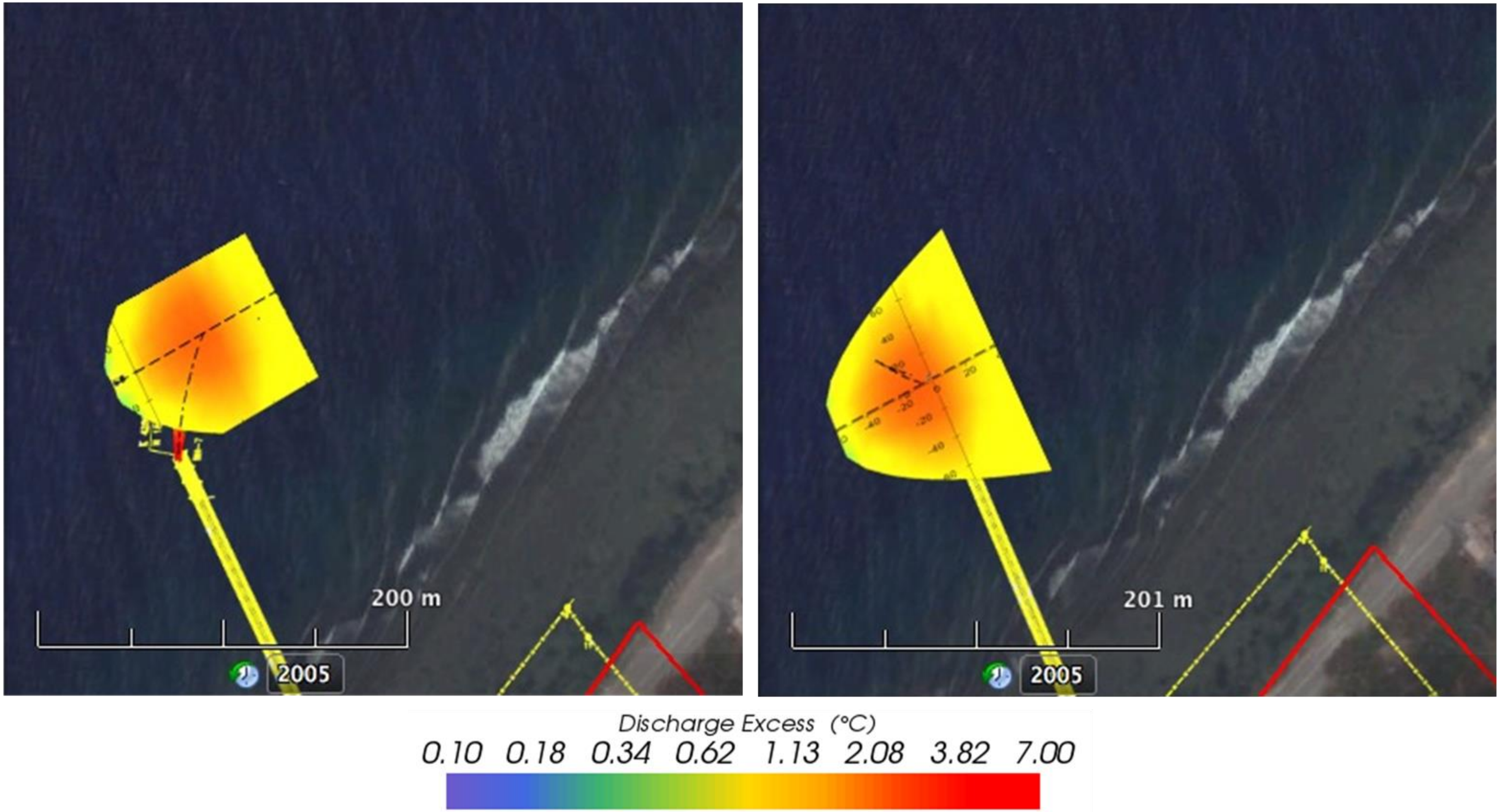


Figure EW-54 Temperature Compliance Monitoring Point for 0.2ms^{-1} Scenario during Flood (left) and Ebb (right) Conditions	LEGEND: As labelled above	SCALE: As above	DATA INFORMATION/SOURCE: Software used: CORMIX Generated by: Apercu Consultants_CV_2017	PAGE 245
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT				aperçu CONSULTANTS INC.

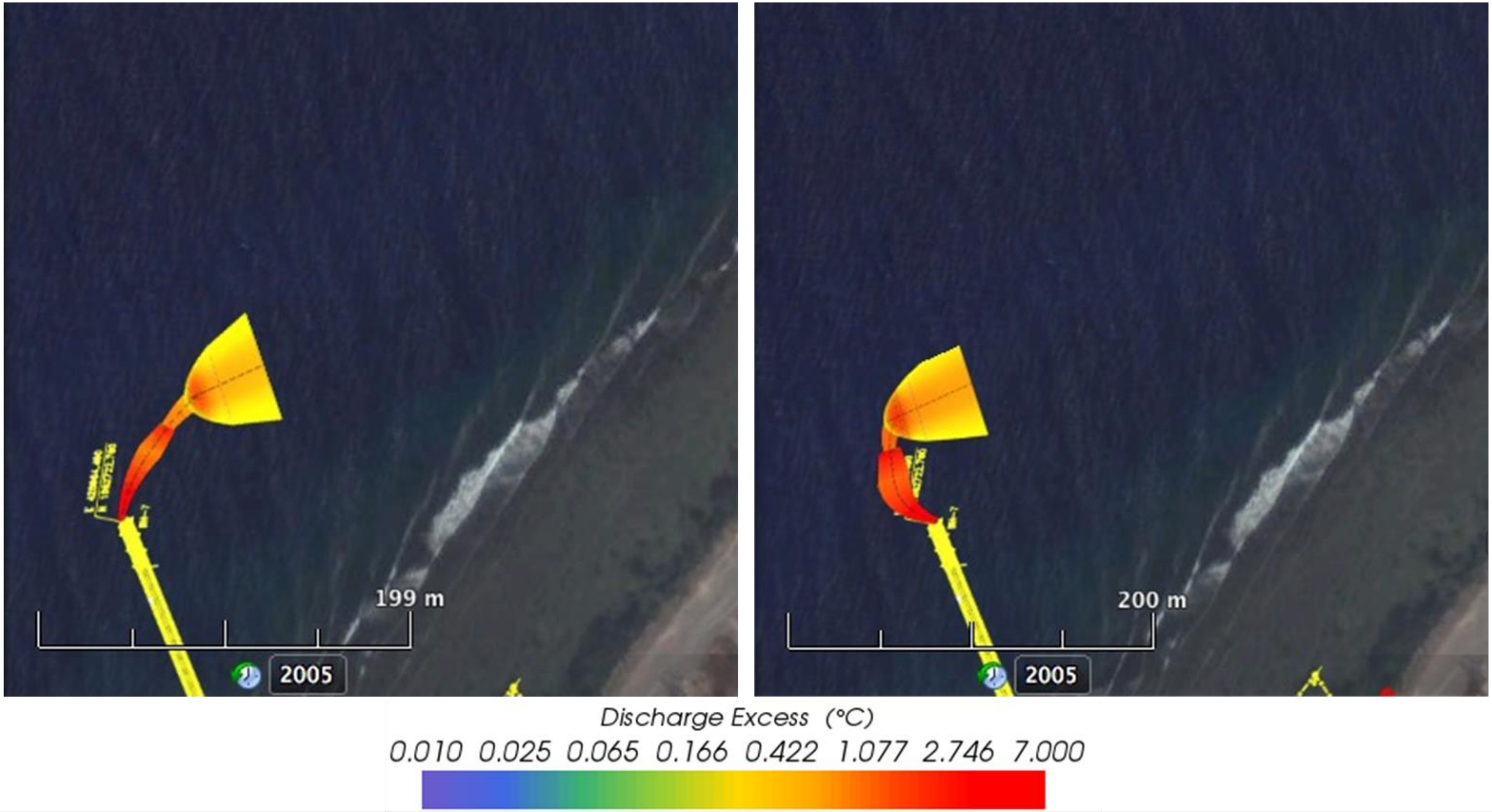


Figure EW-55 **Temperature Compliance Monitoring Point for 0.4ms^{-1} Scenario during Flood (left) and Ebb (right) Conditions**	**LEGEND:** As labelled above	**SCALE:** As above	**DATA INFORMATION/SOURCE:** Software used: CORMIX Generated by: Apercu Consultants_CV_2017	**PAGE 246**
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT				aperçu CONSULTANTS INC.

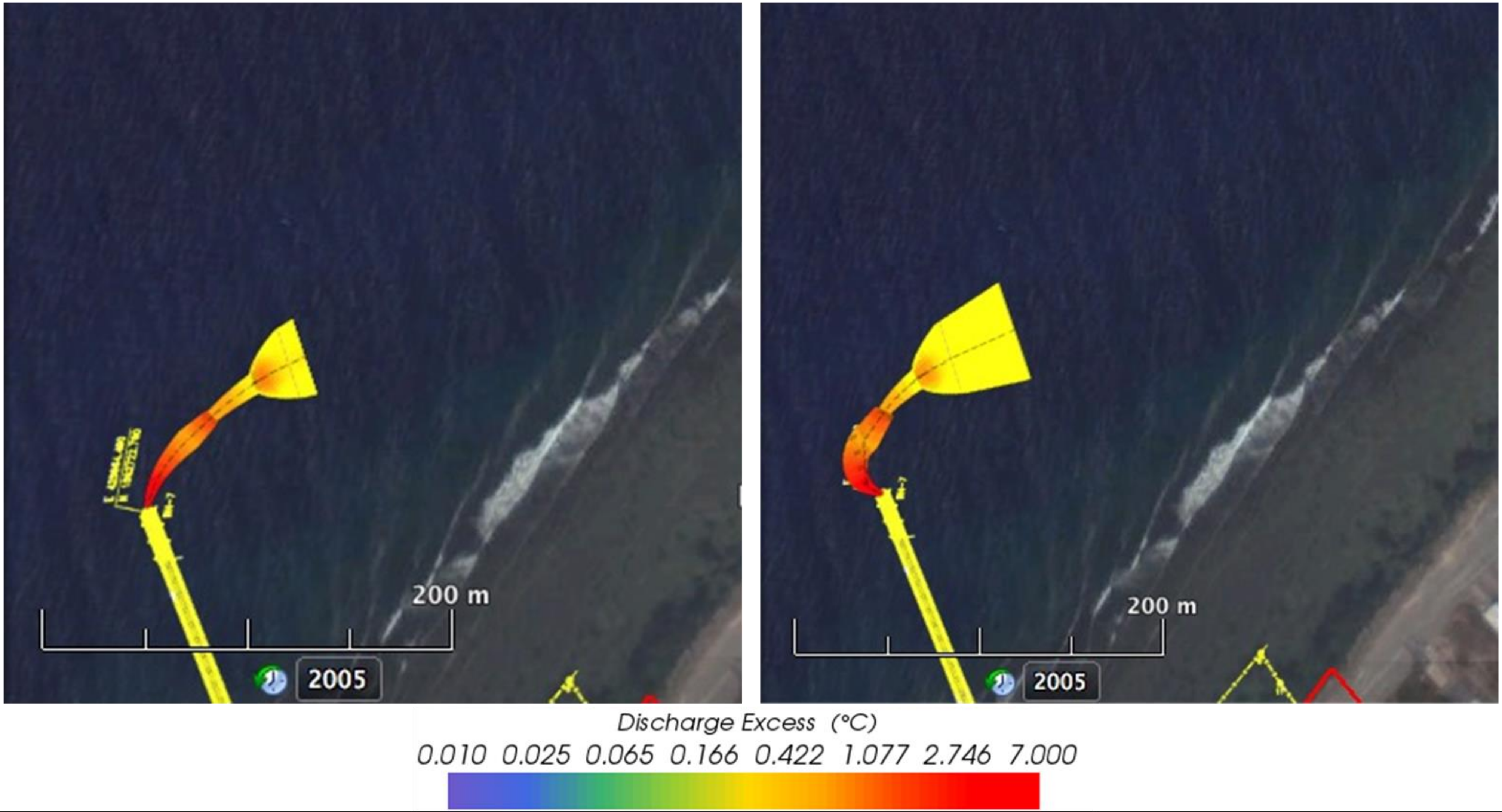


Figure EW-56 **Temperature Compliance Monitoring Point for 0.6ms^{-1} Scenario during Flood (left) and Ebb (right) Conditions**	**LEGEND:** As labelled above	**SCALE:** As above	**DATA INFORMATION/SOURCE:** Software used: CORMIX Generated by: Apercu Consultants_CV_2017	**PAGE 247**
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT				apercu CONSULTANTS INC.

In general, thermal plume dispersion can influence current movements and consequently, the thermal plume distribution in the area. Thermal effluent may also cause back-eddies (Langford, 1990).

The design of the project's discharge system, however, promotes rapid and efficient mixing involving the whole water column. The buoyant (warmer) discharge eventually re-establishes stratification and spreads horizontally at the surface layer. The temperature compliance monitoring point decreases significantly with increasing ambient velocity because mixing of the thermal discharge is enhanced by strong ambient velocities. Thus, the effluent will not cause significant impact on water circulation pattern. The computed TCMP do not reach the marine resources in the coastal area fronting the project site.

2.3.6 Summary of Potential Impacts to Water Quality and Mitigation Measures

Table EW-34 summarizes the potential impacts and proposed mitigation related to Water Quality.

Table EW-34
Summary of Potential Impacts to Water Quality during Construction and Operation

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
I. Construction Phase			
Deterioration of water quality	Groundwater	Water may be polluted if effluents from the project construction and operation will not be managed. Contamination during project construction can originate from used oil or spillage of fuel from construction equipment. Wastes from project development may also reach groundwater and cause degradation of water quality.	• Equipment, machinery and trucks will be maintained in perfect condition and free of oil leaks. Repair and maintenance of machinery and vehicles will be done in a designated maintenance area that is cemented and provided with proper drainage and oil absorbing material. Ecological solid waste management plans will be established and strictly implemented within the construction site. On-site toilets and facilities at work areas will also be provided.
Deterioration of water quality	Freshwater	Due to its distance from the project site, Darigayos River water quality will not be affected by project activities during the construction phase.	• No mitigation measures needed.
Deterioration of water quality	Marine water	Water quality, however, may be affected during project construction, from various activities such as excavation, drilling, land clearing, and the construction of coastal structures (e.g. jetty, intake and outfall pipes). These activities may result in sedimentation in the coastal waters fronting the site, especially during the rainy	• A Sedimentation and Erosion Control Plan, such as provision of devices to retain sediments and materials that may find its way to the sea, will be created and implemented. • Stockpiles of excavated soils will be stabilized to minimize occurrence of erosion.

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
		season. The sediments carried in run-off may increase suspended solids in the water column thereby increasing turbidity.	• Excess soil will be disposed to prevent storm water from carrying the particles into the coastal water. • Silt curtains will be used around the construction site for coastal structures and wave deflection structures will be installed on the shore to prevent beach erosion and to retain sediments on shore.
II. Operation Phase			
Deterioration of water quality	Groundwater	Leakage of chemicals and also leachate of the ash pond can pollute the groundwater resources.	• Lining of the ash pond with clay and HDPE lining to prevent leachate. • Establish drainage systems for the areas around the coal yard, equipped with siltation ponds. • Maintain designated cemented areas for vehicle maintenance and repair, equipment maintenance and repair; and diesel fuel storage.
Deterioration of water quality	Freshwater	Due to its distance from the project site, Darigayos River water quality will not be affected by project activities during the operation phase.	• No mitigation measures needed.
Deterioration of water quality	Marine water	Marine water quality may be degraded by effluent discharge, thermal discharge, effluents, bilge, and coil and oil spills from delivery vessels.	• GLEDC will install sewage and wastewater treatment facilities to ensure that effluents from the various processes of the plant are treated to meet CWA effluent guidelines upon discharge. • Cooling water will also be discharged to meet the 3 degree limit under the Clean Water Act. • Contracts with coal suppliers will include provisions to ensure that delivery vessels employ best practice coal unloading procedures and vessel cleaning procedures.

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
Change in water circulation	Marine water circulation, thermal plume distribution	The effluent will not cause significant impacts on the water circulation pattern.	• No mitigation measures needed.

2.3.7 Water Quality Monitoring Plan

The water quality monitoring plan includes provisions to cover the activities that will cover the West Philippine Sea fronting the project, Darigayos River and the nearest available groundwater source. The parameters for water quality monitoring will include pH, BOD_5, COD, temperature, oil and grease, dissolved oxygen, suspended solids, heavy metals (Hg, Cd, As, Cr and Pb), total coliform, zinc, copper, nickel, ammonia, phosphate, nitrate, chloride, boron, and sulfate. Quarterly monitoring of the sampling stations established for the baseline study will be undertaken. **Figure EW-57** presents the recommended monitoring stations for water quality.

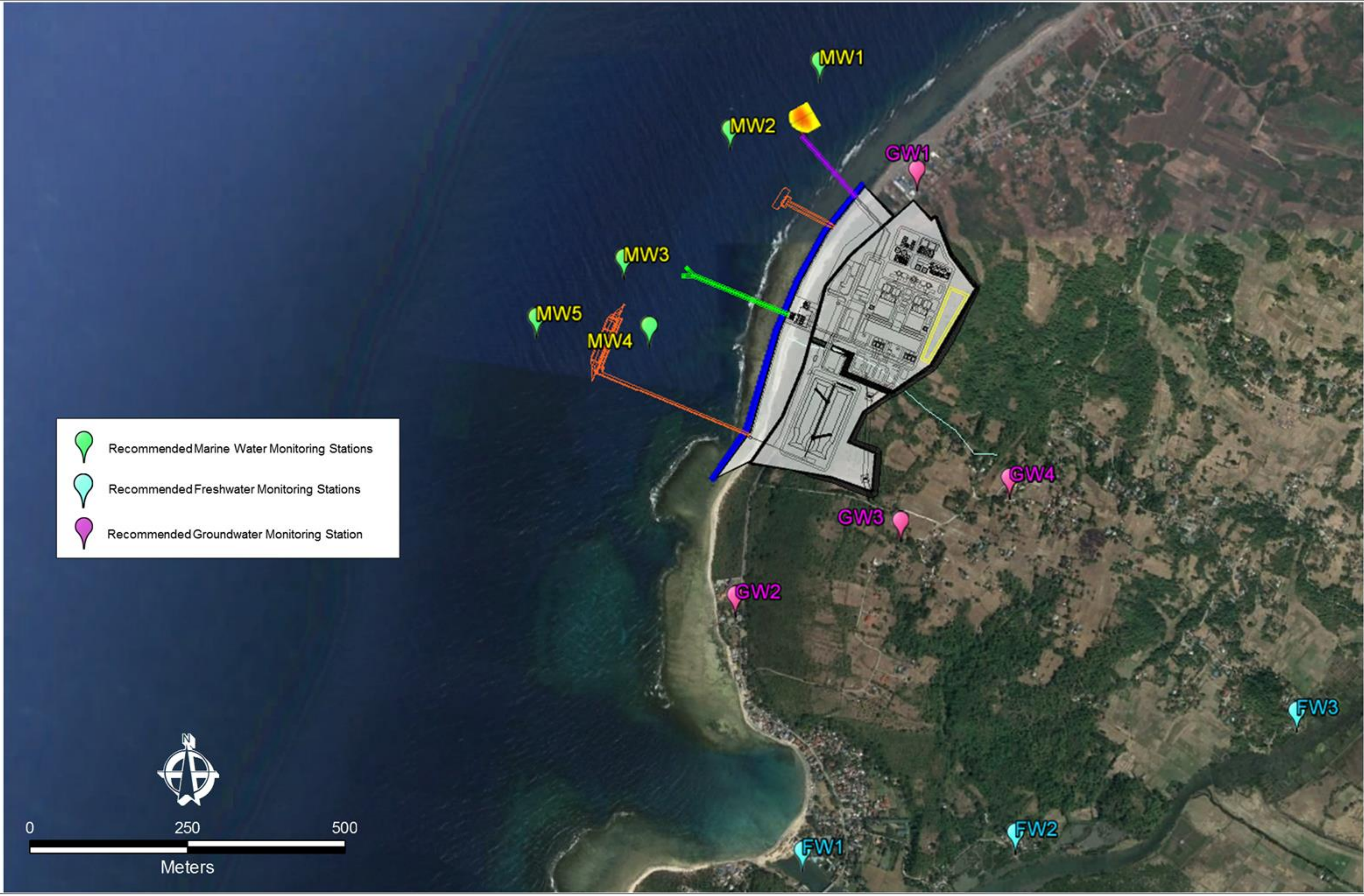


Figure EW-57 Recommended Sampling Points for Water Quality	LEGEND: Project Layout; Ash Pond; Jetty/ Temporary Jetty; Cooling Pipe; Outfall Pipe; Foreshore Area; Ground Depression; Thermal Plume Discharge	**SCALE:** 1:6,000 **DATA INFORMATION/SOURCE:** **Basemap:** GOOGLE EARTH IMAGERY, 2017 **Project Boundary:** GLEDC, 2016 **Boundaries:** NAMRIA BOUNDARY, 2016 **Imagery Date:** DECEMBER 1, 2016 **Created by:** APERCU CONSULTANTS, INC (2017)	**PAGE:** 251 aperçu CONSULTANTS INC
ENVIRONMENTAL IMPACT STATEMENT **2x335MW COAL-FIRED POWER PLANT PROJECT**			

2.4 Freshwater Ecology

This section describes the physical characteristics and biological communities in Darigayos River, which is within the 2km radius initially identified impact area for the project site. The objective of the freshwater ecology survey was to provide information on the baseline conditions of the river even though no potential impacts are expected during the construction and operation of the project since it is 2km away and water from the river will not be used by the project. The baseline survey involved the assessment of *in-situ* water quality and aquatic communities, which include plankton, macrophytes, benthic organisms and fishes. Fisheries data and other general uses of the river were obtained from interviews with locals in the area and from secondary data.

The characterization is followed by an assessment of potential impacts that could arise due to the construction and operation of the project on freshwater ecology. Based on the outcome of these assessments, measures to manage and mitigate potential adverse impacts are recommended.

The depression within the project site was not included in the sampling since there was no water flow during the survey. The depression is dry most of the time and flow is observed only during considerable rainfall events.

2.4.1 Methodology

Sampling Locations

Three (3) freshwater ecology stations were established at Darigayos River. The coordinates of these sampling stations were determined using a GPS and their relative locations are presented in **Table EW-35** and **Figure EW-58**.

Table EW-35
Freshwater Ecology Sampling Stations

Station ID	Coordinates	Elevation	Site Description
FWE1	16°49'6.91"N 120°20'6.02"E	Approx. 8m	Downstream, near the river mouth of Darigayos River, approx. 1.3km south of the project site
FWE2	16°49'8.90"N 120°20'30.00"E	Approx. 5m	Midstream, along Darigayos River, approx. 1.6km south of the project site
FWE3	16°49'22.04"N 120°21'1.82"E	Approx. 7m	Upstream, along Darigayos River, approx. 2km southeast of the project site

Note: WGS84 coordinate system was used

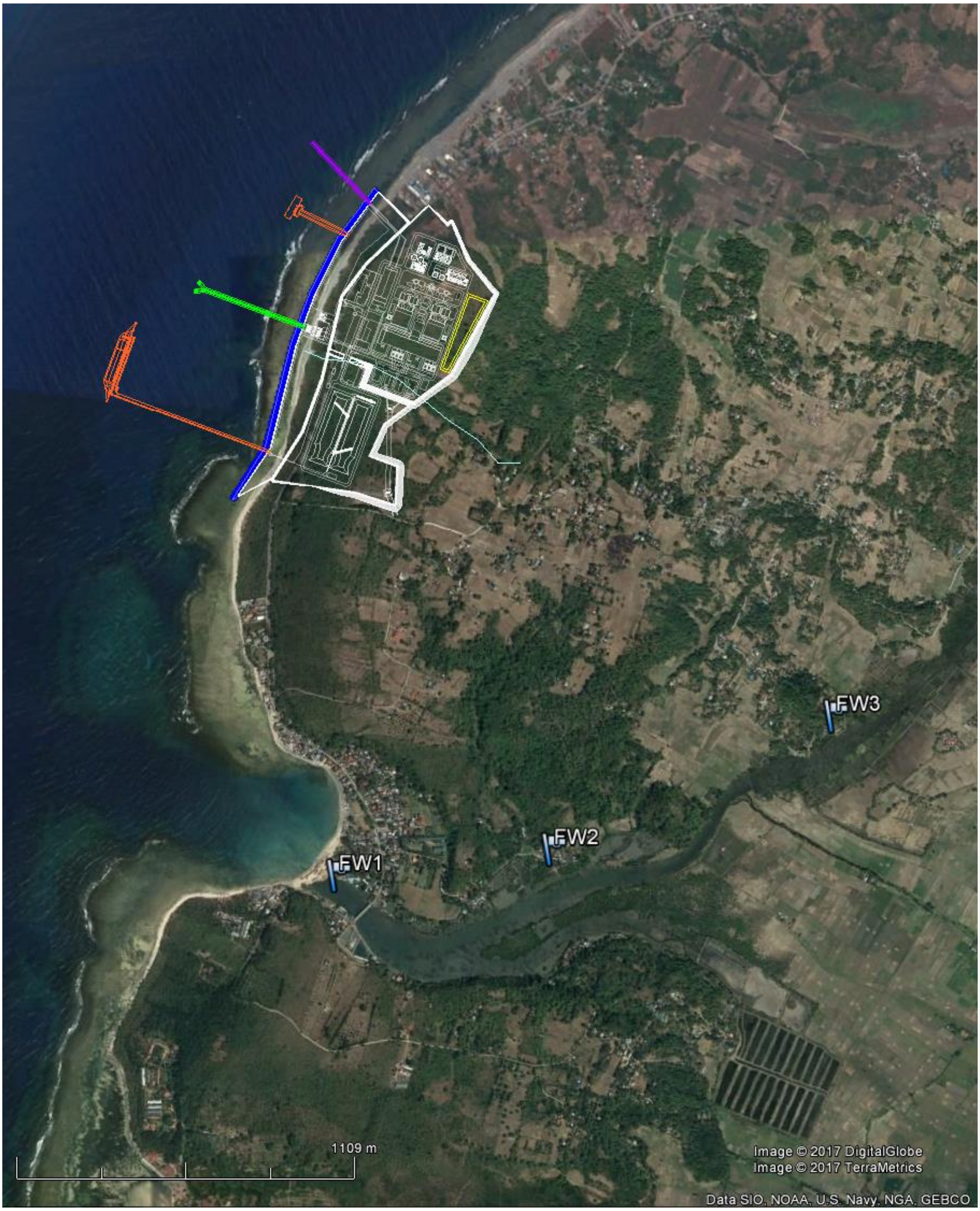


Figure EW-58. Freshwater Ecology Survey Stations	LEGEND: Project Site Survey Station	SCALE: As Above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: **Basemap:** GOOGLE EARTH IMAGERY **Created by:** APERCU CONSULTANTS, INC (2016)	aperçu CONSULTANTS INC PAGE 253

2.4.1.1 Plankton

Plankton sampling was conducted in the three (3) stations with open canopies and moderate water velocity (*between 10 and 60 cm/sec*). Two replicate samples were collected from each station. Plankton samples were obtained by passing a bucketful of water (10L) through a plankton net with a mesh size of 64µ and a mouth diameter of 0.3m until a 500mL sample was collected. Samples were then transferred to properly labeled plastic containers and treated by adding 1mL of formaldehyde solution. These were then brought to the UPLB laboratory for processing and further analysis. Plankton enumeration was done using a Sedgewick counting chamber observed under a binocular microscope. Plankton were identified to the lowest possible taxa using taxonomic keys such as those of Mamaril et al. (1986), Segers (200;2007) and Bellinger and Sigee (2010).

2.4.1.2 Macrobenthos

Benthic organisms were collected in the same stations established for plankton sampling. Sediment samples were collected from two replicate zones for each station. Samples were collected from five placements at each replicate zone using a trowel over within an estimated area of $1m^2$. The sediments were carefully placed inside sealed plastic bags and preserved with 5% formaldehyde. Samples were likewise brought to the UPLB laboratory for further processing.

In the laboratory, sediment samples were passed through a 1mm mesh-sized sieve and all animals retained were identified to the lowest taxa using taxonomic keys, illustration guides and checklist such as those of *Haynes* (2001) and *Gapud and Raros* (1986). Their abundances were recorded and expressed as number of animals/ $0.08m^2$. Methods of macrobenthos collection, preservation, and processing generally followed Barbour *et al.* (1999).

2.4.1.3 Fish

Fisheries data were obtained through key informant interviews with fisher folk who were present at the sampling station. The questions asked included:

- What are the fishes often caught in the river;
- What species are being bred inside the fish pens; and,
- What are the species that you think is abundant in the river.

2.4.1.4 Macrophytes

The samples of the macrophytes and vegetation found in all stations were collected for identification at the species level.

2.4.2 General Description of the Study Area

Darigayos River is generally broad with upstream and in-stream sections mainly comprised of silt with coarse pebbles and sand, and a significant amount of leaf litter, especially at the upstream section. Turbid waters were observed at the three (3) stations. The river has open to partially open canopies with only about 5-10% of the channel covered with overhanging vegetation. The downstream section is wide and open with little vegetation observed on the banks, which were covered with coarse sand (or smaller particle sizes). River flow was generally minimal, with recorded flows of 0.2 m/s in all three stations.

2.4.2.1 Economic and Ecological Services of the Ecosystem and River Use

The primary use of the river is for fishing and aquaculture, as evidenced by the number of fish pens present in the area. The major species being cultivated in the fish pens were tilapia, biya, bangus and hipon. Locals also indicated that they often caught the said fishes in the river. Occasionally, the river also serves as transportation route for some of the locals who traverse the river using a bamboo raft called “balsa”.

2.4.2.2 Classification of the Water Body

Darigayos River is considered a Class C Fresh Surface Waters in accordance with the values from the DENR Administrative Order No. 34 Series of 1990 under the Clean Water Act. Under this category, Class C waters' beneficial uses include fishery water for the propagation and growth of fish and other aquatic resources and recreational activities.

2.4.3 Habitat Assessment

The upstream stations (Stations FWE2 and FWE3) of Darigayos River had sub-optimal conditions of 50-75% in terms of basin land cover while Station FWE1 had 25-50% natural land cover. In terms of riparian width, the three stations had optimal conditions since the width was more than 18 meters wide. In terms of riparian structure and composition, Station FWE1 lacked vegetation cover while Stations FWE2 and FWE3 were dominated by non-native plants like mangroves, which were transplanted to the area. Stations FWE2 and FWE3 are channelized due to the fish pens and mangrove growth while Station FWE1 can be described as having undergone historic channelization due to the existence of establishments, river banks and roads that are built close to the river.

Station FWE1 is embedded predominately by sand and coarse pebbles while Stations FWE2 and FWE3 are embedded by silt. The river bed for Stations FWE2 and FWE3 is considered in poor condition since it is embedded by silt while Station FWE1 has suboptimal conditions due to the coarse pebbles and sand. Rocky and sandy river beds with presence of aquatic plants are considered ideal. Water in the three (3) stations was turbid but the river bottom was visible in shallow riffle sections. **Table EW-36** shows the overall habitat condition scores and while the habitat assessment form used during the survey is provided in **Annex D.**

Table EW-36
Habitat Condition Scores of the Freshwater Ecology Stations

Habitat Parameter	FWE1	FWE2	FWE3
Basin Land Cover	10	15	15
Riparian structure and composition	5	10	10
Channel alteration	10	15	15
Embeddedness	15	5	5
Benthic Silt Cover	20	5	5
Water Appearance	10	10	10
Habitat Conditions	**Suboptimal**	**Marginal**	**Marginal**

2.4.4 Characterization of the Biotic Components

2.4.4.1 Overall Plankton Composition

The plankton communities combined from the three (3) stations is comprised of twenty-eight (28) taxa representing four Phyla. Bacillariophytes (diatoms) largely dominated the community representing 69% of the total count. Dinophytes come second in terms of abundance, representing 20% of the total count. Chlorophytes represented 8% of the total count while zooplankton represented the remaining 3% of the plankton population.

Bacillariophytes dominated with the most number of species in all three (3) stations. *Chaetoceros* (**Plate EW-5**), *Pleurosigma* (**Plate EW-6**) and *Melosira* (**Plate EW-7**) has the most number of cells/L in Stations FWE1, FWE2 and FWE3, respectively. *Bulbochaete* was present only at Station FWE2 while *Scenedesmus* (**Plate EW-8**) was present at both Stations FWE1 and FWE3.

Phylum Dinophyta was represented by 4 taxa with *Peridinium* (**Plate EW-9**) being the most abundant and *Ornithacercus* (**Plate EW-10**) being the least.

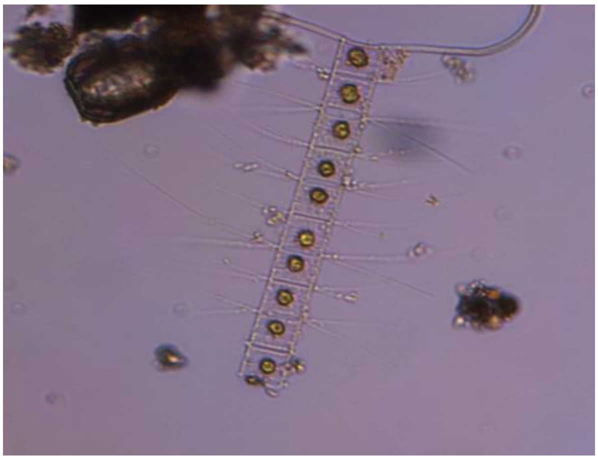


Plate EW-5. _Chaetoceros_

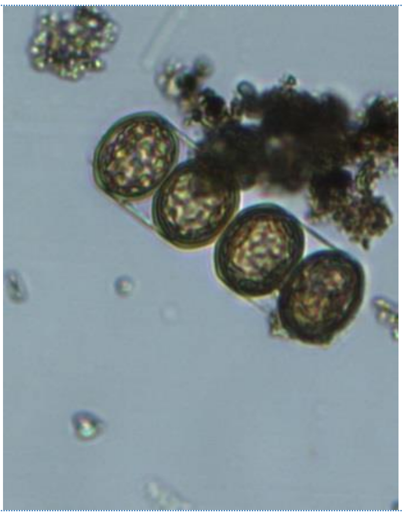


Plate EW-6. _Pleurosigma_

Plate EW-7. _Melosira_

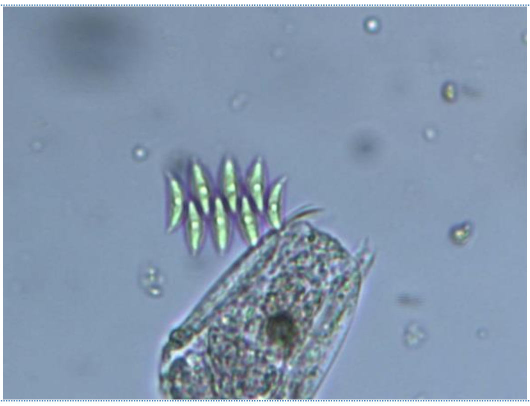


Plate EW-8. _Scenedesmus_

Plate EW-9. _Peridinium_

Plate EW-10. _Ornithocercus_

Plate EW-11. *Bivalve veliger*

Plate EW-12. *Gastropod veliger*

The zooplankton representatives had the least number of, most of which are found in Station FWE2.

Table EW-37 shows the number of taxa, densities, overall abundances and relative abundances of the identified plankton species.

Table EW-37
Taxa, Mean Density and Relative Abundance of Plankton (no. of cells/L) in Three Station

Taxon	Station 1	Station 2	Station 3	Abundance	
				Overall	Relative
Bacillariophytes					
Amphora	72	0	0	72	0.005623
Asterionella	378	0	0	378	0.029520
Bellorochea	225	0	0	225	0.0175713
Campylodiscus	99	200	100	399	0.031160
Chaetoceros	1,557	0	0	1557	0.121593
Coscinodiscus	729	266	220	1215	0.094884
Eunotia	0	0	20	20	0.001561
Melosira	252	485	350	1087	0.084888
Navicula	216	0	150	366	0.028582
Odontella mobiliensis	54	105	0	159	0.012417
Odetella aurita	108	0	0	108	0.008434
Pleurosigma	342	1,359	140	1841	0.143771
Rhabdonema	36	0	0	36	0.002811
Rhizosolenia	153	0	0	153	0.011948
Surirella	135	200	330	665	0.051933
Thalassionema	702	0	0	702	0.054822
Bacillariophytes					
Amphora	72	0	0	72	0.005623
Asterionella	378	0	0	378	0.029520
Bellorochea	225	0	0	225	0.0175713
Campylodiscus	99	200	100	399	0.031160
Chaetoceros	1,557	0	0	1557	0.121593
Coscinodiscus	729	266	220	1215	0.094884
Eunotia	0	0	20	20	0.001561
Melosira	252	485	350	1087	0.084888
Navicula	216	0	150	366	0.028582
Odontella mobiliensis	54	105	0	159	0.012417
Odetella aurita	108	0	0	108	0.008434
Pleurosigma	342	1,359	140	1841	0.143771

Taxon	Station 1	Station 2	Station 3	Abundance	
				Overall	Relative
Rhabdonema	36	0	0	36	0.002811
Rhizosolenia	153	0	0	153	0.011948
Surirella	135	200	330	665	0.051933
Thalassionema	702	0	0	702	0.054822
Chlorophytes					
Bulbochaete	0	114	0	114	0.008903
Coelastrum	0	0	210	70	0.016400
Dictyosphaerium	0	0	130	130	0.010152
Pandorina	0	0	190	190	0.014838
Scenedesmus	162	0	250	412	0.032174
Dinophytes					
Diplopsalis	216	0	0	216	0.016868
Ornithacercus	27	0	0	27	0.002109
Peridinium	90	266	1,850	2206	0.172276
Protoperidinium	108	0	0	108	0.008434
Zooplankton					
Bivalve veliger	9	95	0	104	0.008122
Gastropod veliger	0	10	0	10	0.000781
Copepod Nauplius	9	86	0	95	0.007419
Grand Total	**5679**	**3186**	**3940**	**12805**	
Mean Density	**258**	**289**	**328**		
SD	**341.718**	**359.467**	**467.33**		
No. of Taxa	**22**	**11**	**12**		

Abundance per Station

In Station FWE1, eighty-six percent (86%) of the overall composition were made up of Bacillariophytes, while the remaining 14% were composed of Dinophytes. Bacillarophytes also dominated in Station FWE2 comprising eighty-two (82%) of the total composition. Dinophytes dominated with a forty-seven percent (47%) of the total composition in Station FWE3 while the Bacillarophytes comprised thirty-three percent (33%) and Chlorophytes comprising twenty percent (20%). Zooplanktons were not observed in the FWE3 Station. Bacillarophytes are unicellular organisms that are important components of phytoplankton and serve primary sources of food for zooplankton in both marine and freshwater habitats. Most diatoms are planktonic, but some are bottom dwellers or grow on other algae plants. The large number of Bacillarophytes observed in the three stations is due to the fact that this said phytoplankton is the most common in the entire algal group. The percentage abundance graphs of all stations are presented in **Figures EW-59** to **EW-61**.

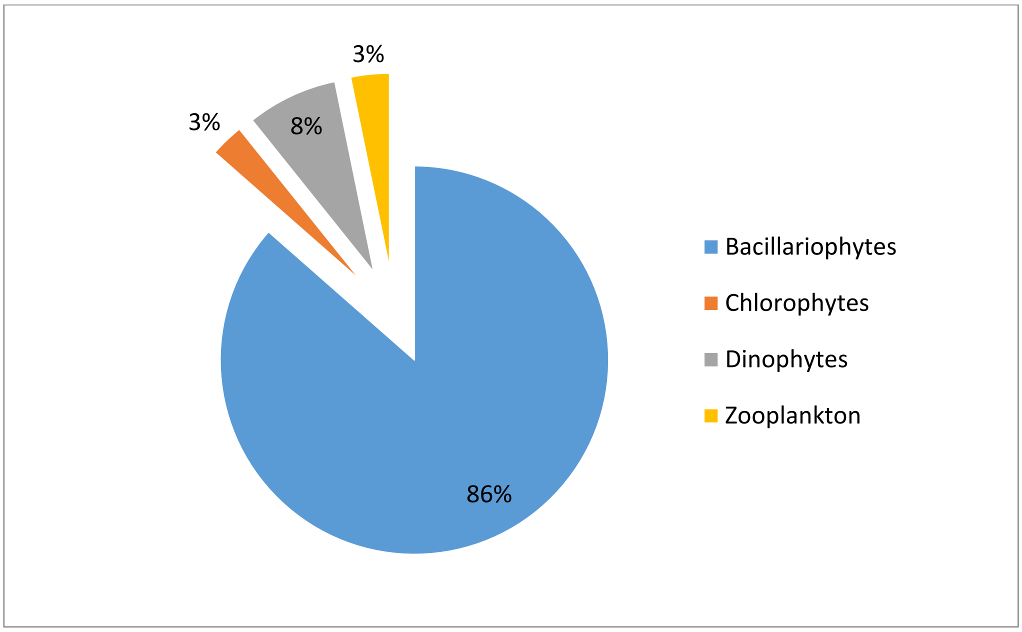


Figure EW-59. Percentage Abundance of Plankton in Station FWE1

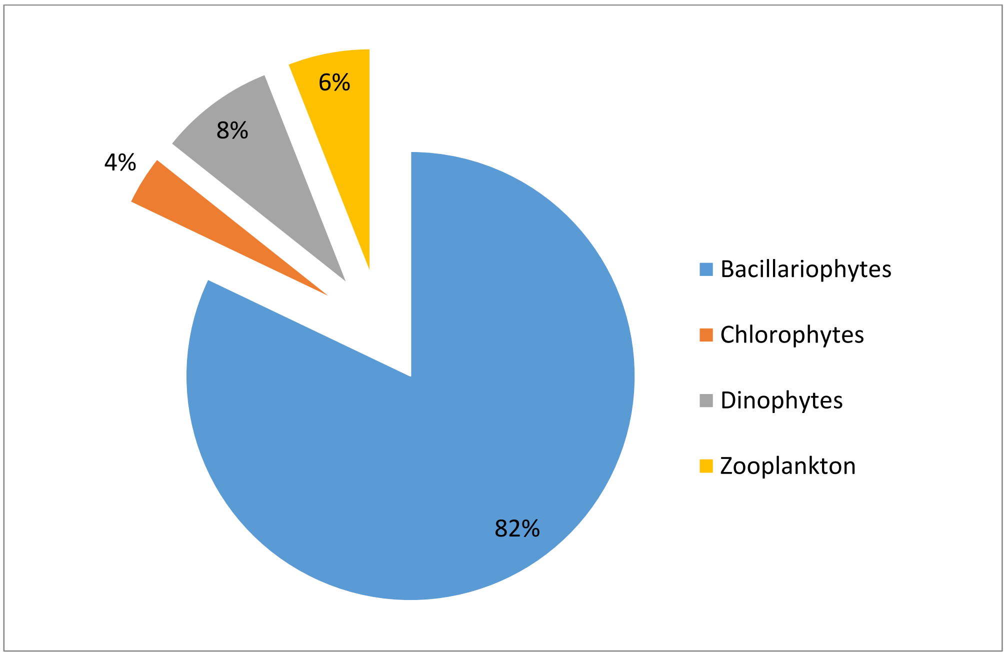


Figure EW-60. Percentage Abundance of Plankton in Station FWE2

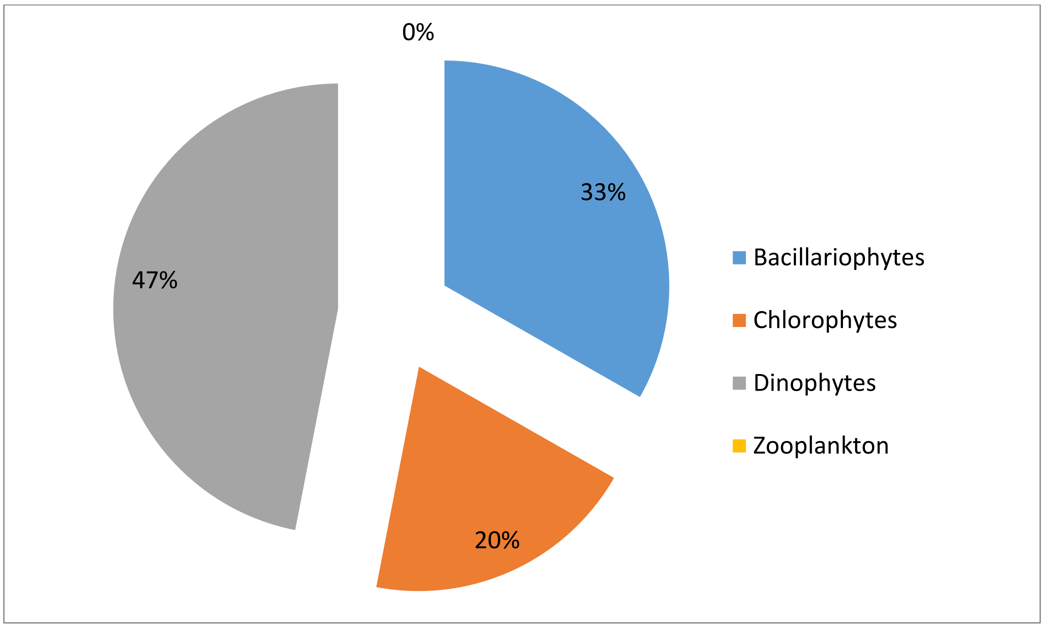


Figure EW-61. Percentage Abundance of Plankton in Station FWE3

The abundance of the various Chlorophyta in the 3 stations is shown in **Figure EW-62.** Among the members of the phylum Bacillariophyta, *Pleurosigma* is the most abundant in all stations, with density recorded at 1,841 cell/L, followed by *Chaetoceros* at 1,557 cell/L. It can be noted that diatoms have fewer occurrences in Station FWE3 compared to Stations FWE1 and FWE2. *Eunotia,* which has the lowest density at 20 cell/L, was observed in Station FWE3. Under the phylum Chlorophyta (**Figure EW-63**), *Scenedesmus* is the most abundant comprising 39% of the total population while *Dictyosphaerium* is the least comprising 12% of the population. Under Phylum Dinophyta (**Figure EW-64**), the most abundant taxon is the *Peridinium* comprising 86% of the total population. The remaining 14% is comprised of individuals from *Ornithocercus, Protoperidinium,* and *Diplopsalis.* Among the zooplankton (**Figure EW-65**), *Bivalve veliger* dominated the population (50%) and *Copepod naupilus* (45%). The remaining 5% is comprised by *Gastropod veliger.*

The community of plankton will not be affected by the proposed project.

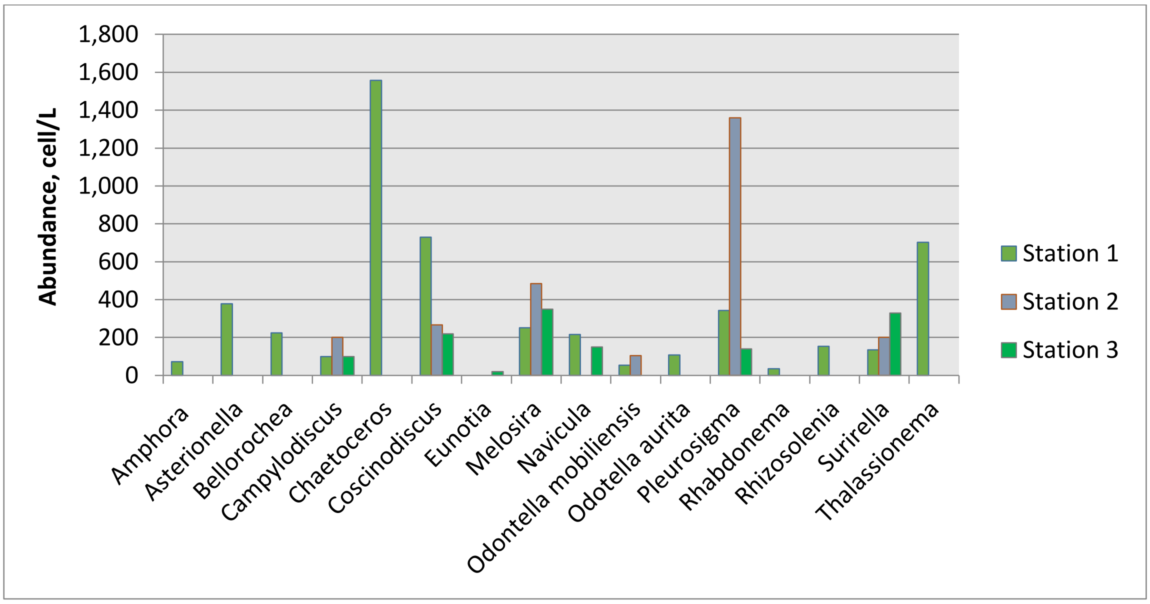


Figure EW-62. Abundance of Taxa per Station under the Phylum Bacillariophyta

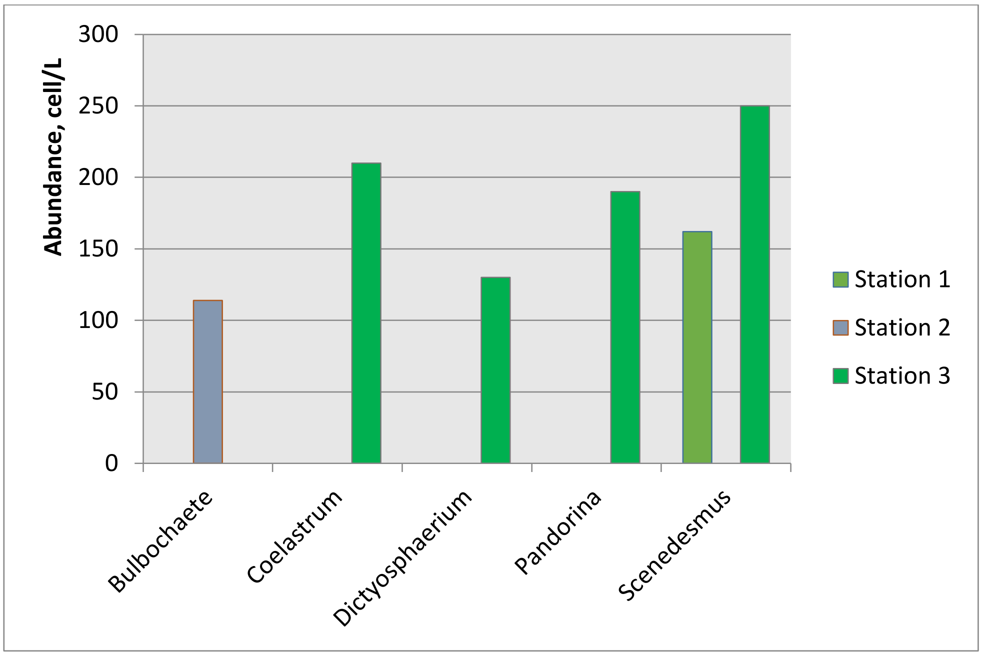


Figure EW-63. Abundance of Taxa per Station under the Phylum Chlorophyta

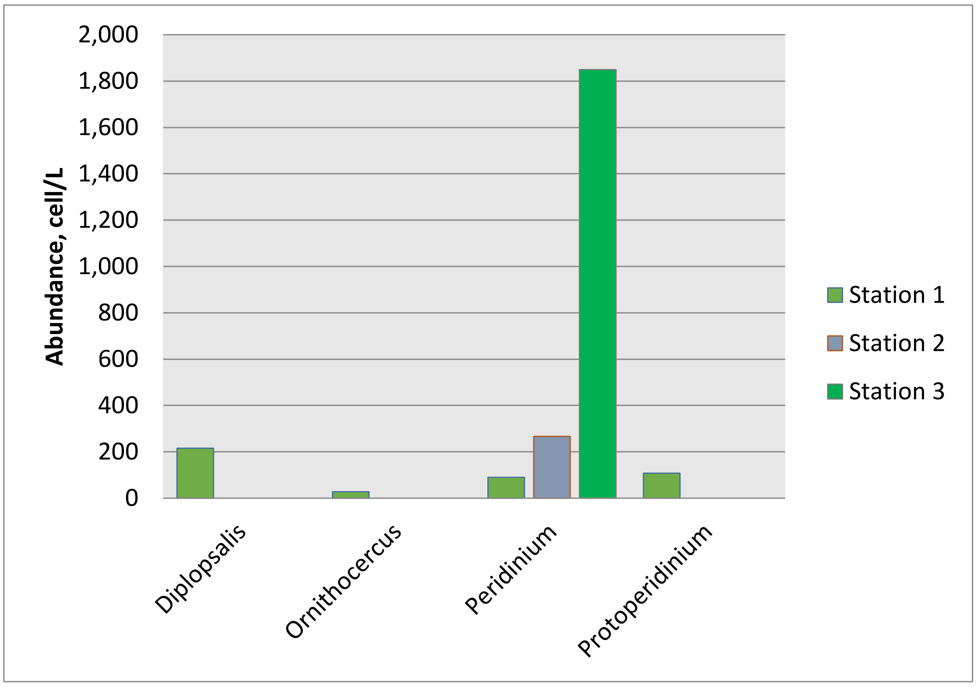


Figure EW-64. Abundance of Taxa per Station under the Phylum Dinophyta

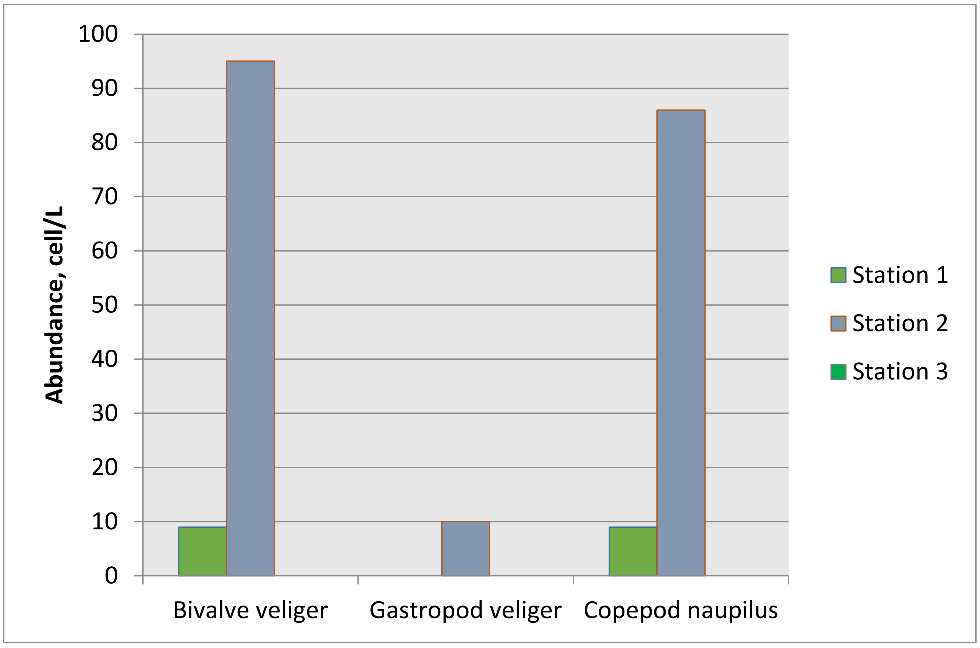


Figure EW-65. Abundance of Taxa per Station under the Division of Zooplankton

2.4.4.2 Macrobenthos

A total of thirteen (13) macrobenthos family representing two (2) animal phyla were recorded at three (3) stations in Darigayos River (**Figure EW-66**). The total number of taxa per station was combined according to their taxonomic families (**Figure EW-67**). In Station FWE-1, two (2) taxa were observed. In Stations FWE-2 and FWE-3, eleven (11) taxa were observed. This indicates a high species richness and diversity for the two stations. Overall, the macrobenthos community in the Darigayos River is dominated by phylum Mollusca (84%), and a smaller portion of the population is comprised by Arthropoda (16%).

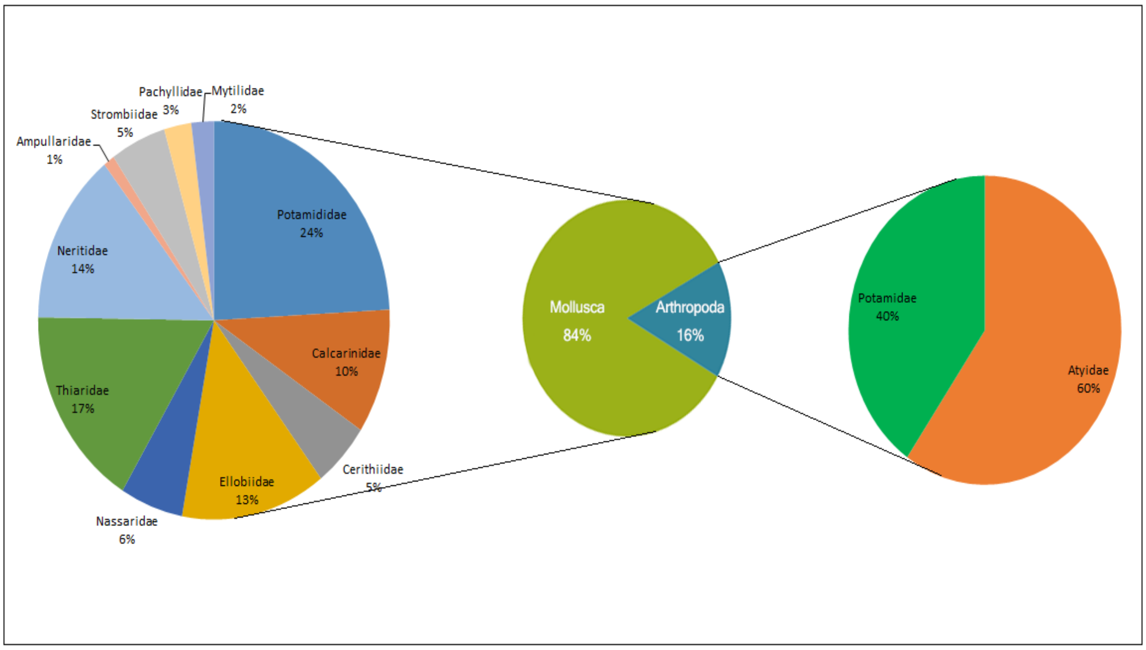


Figure EW-66. Composition of Macrobenthos by Phylum and divided into Families

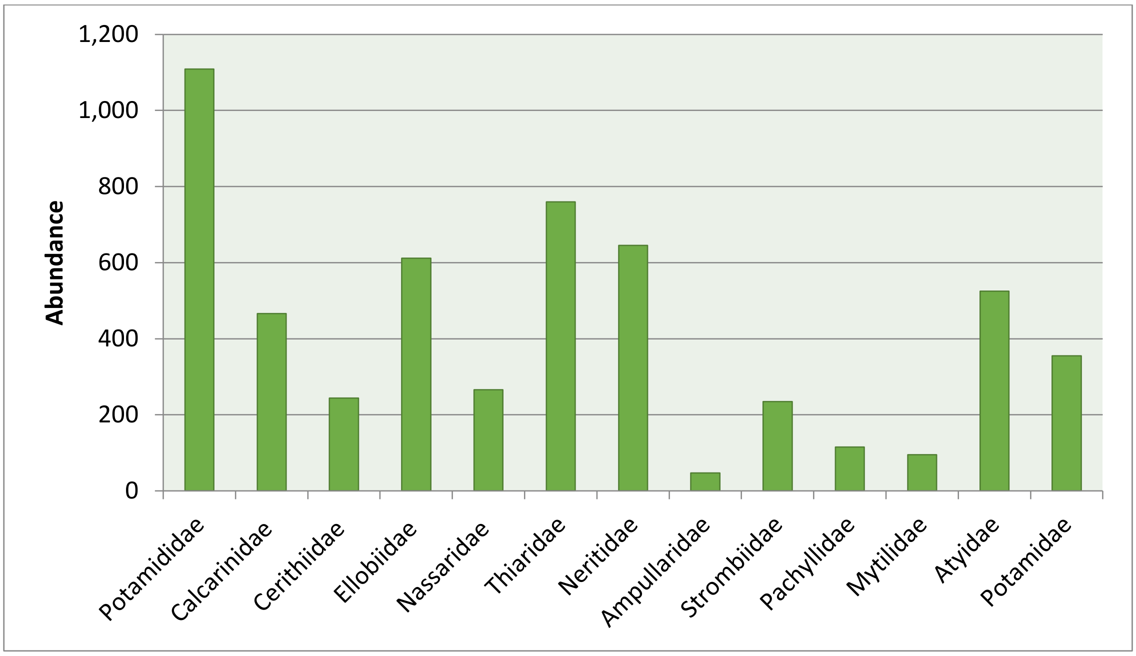


Figure EW-67. Composition of Macrobenthos by Phylum and divided into Families

Eleven (11) of the families observed belong to phylum Mollusca. The most abundant of which is Potamididae (**Plate EW-13**) comprising 24% of the population, while the least is family Ampullaridae (**Plate EW-14**) at 1%. Only two families were observed in Station FWE-1, where Calcarinidae is more abundant than Cerithiidae.
The two other families, which are under phylum Arthropoda, are Atyidae (**Plate EW-15**) and Potamidae (**Plate EW-16**). The Atyidae or the Freshwater shrimps dominated the total count for Arthropoda scoring 60% of the total count while the remaining 40% is comprised of Potamidae also known as Freshwater Crabs.

Among the three stations in Darigayos River, Station FWE-1 has the lowest species diversity with only two (2) species found, belonging to the families Calcarinidae (466 ind) and Cerithiidae (244 ind). In the study of Cedeño et al., some organisms, especially the mollusk and crustaceans, that live in freshwater cannot easily adapt and thrive in an area with high salinity and temperature. This explains the low species diversity in Station FWE1. The first station has the closest proximity to the sea and has high salinity. While the other two stations, FWE2 and FWE3, are 772m and 1,736m away from the first station, respectively. This means that only the macrobenthos in Station FWE1 can survive in water with high salinity.

Stations FWE-2 and FWE-3 have more diverse species since the area is close to mangrove plots and has shallow water. The abundance of macrobenthos can be associated with the overwhelming numbers of mangroves and the silt in mud that makes up the river bed which is an extremely favorable condition for the organisms.

Plate EW-13. Potamidae (Freshwater Crab)

Plate EW-14. Ampullaridae (*Pomacea canaliculata*)

Plate EW-15. Atyidae (Freshwater Shrimp)

Plate EW-16. Potamididae

Plate EW-17. Thiaridae *(Melanoides*)

Table EW-38 shows the mean density and the relative abundance of each family according to each stations. The mean density of Station FWE-1 is 344 ind/m^2, 305 ind/m^2 for Station FWE-2 and 157 ind/m^2 for Station FWE-3. This shows that despite the low species diversity in Station FWE1, high abundance is still observed primarily because of the environmental composition of the area.

Table EW-38
Mean Density and Relative Abundance of Macrobenthos (ind/m^2) in Three Stations

Taxon	Station 1	Station 2	Station 3	Abundance	
				Overall	Relative
Potamididae	0	643	466	1109	0.202816
Calcarinidae	466	0	0	466	0.085223
Cerithiidae	222	0	22	244	0.044623
Ellobiidae	0	404	208	612	0.111924
Nassaridae	0	266	0	266	0.048647
Thiaridae	0	559	195	754	0.137893
Neritidae	0	482	163	645	0.117959
Ampullaridae	0	0	47	47	0.008595
Strombiidae	0	57	178	235	0.042977
Pachyllidae	0	45	70	115	0.021031
Mytilidae	0	39	56	95	0.017374
Atyidae	0	281	244	525	0.096013
Potamidae	0	274	81	355	0.064923
Grand Total	**688**	**3,050**	**1,730**	**5,468**	
Mean Density	**344**	**305**	**157**		
SD	**172.5**	**230.5**	**130.16**		
No. of Taxa	**2**	**10**	**11**		

In terms of abundance (**Figure EW-68**), it shows that Potamididae dominated Stations FWE2 and FWE3 while Calcarinidae dominated Station FWE-1. Potamididae is also the most abundant macrobenthos in all stations (**Plate EW-13**).

The abundance of macrobenthos in the three stations was combined according to its family classification to produce the overall abundance of the Darigayos River. The most abundant species belongs to the family Potamididae (**Plate EW-13**) that makes up 20% of the overall population of the macrobenthos surveyed (1,109 individuals). Next is the Thiaridae (754 ind.) and Neritidae (645 ind.) making up the 14% and 12% of the overall population, respectively. The remaining 54% is made up of the rest of the population surveyed with Ampullaridae (**Plate EW-14**) having the lowest number of individuals observed (47ind/m^2) (**Table EW-35**).

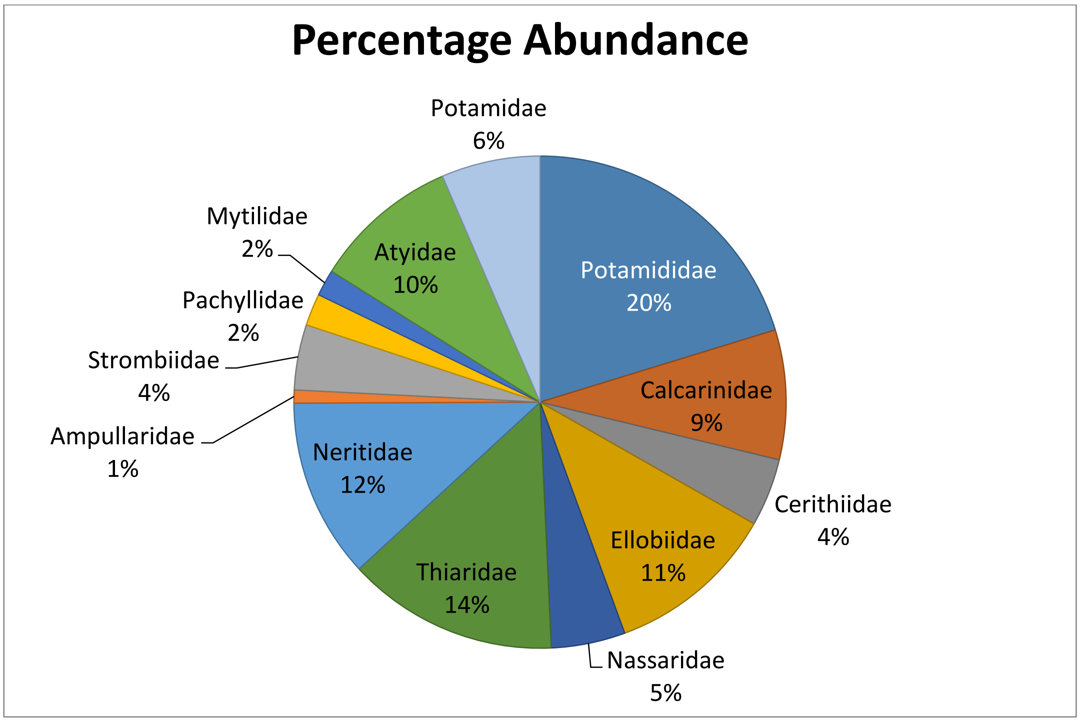


Figure EW-68. Percentage Abundance of Macrobenthos

There are no foreseen impacts on the macrobenthos community in Darigayos River since the project will not use the river water or discharge any effluent into the river.

2.4.4.3 Fish

The fish community in Darigayos River was identified by interviewing the locals residing near the said river. Some of them own a fish pen, which can be observed in the river, for fish propagation. Locals said that the most common fishes like biya, bangus, tilapia and hito can be caught in the river (**Table EW-39**).

Table EW-39
Fishes Caught in Darigayos River

Local Name	Common Name	Scientific Name
Biya	Speckled goby	*Redigobius sp.*
Bangus	Milkfish	*Chanos chanos*
Tilapia	Nile Tilapia	*Oreochromis niloticus*
Hito	Catfish	*Clarias batrachus*

There are no foreseen impacts on the fish community in Darigayos River since the project will not use the river water or discharge any effluent into the river.

2.4.4.4 Macrophytes

The macrophytes that can be observed from the three (3) stations vary from aquatic to weeds and shrubs (**Table EW-37**). In Station FWE-1, where the substrate composition is mostly made up of large rocks, beach pebbles and sand, the dominant species that thrive in the area is the *Leucaena leucocephala.* Seedlings and adult trees of the species can be observed within its vicinity. Another tree observed in the area is the *Terminalia catappa*. Shrubs are mostly composed of *Lantanna camara* and *Acalypha sp*.

In Station FWE-2, *bakawan* can be observed surrounding the area together with some *nipa*. The mangroves that inhabit the area are found to be *Avicenia sp.* and *Rhizophora sp*. According to the Luna Tourism Officer, the mangroves were transplanted in the area to help the fisher folks to make their fish catch steady and also for their greening program. Some shrubs are also present such as *Gliricidia sepium*, *Melanolepis*, *Stachytarpheta* and *Phylanthus.*

In Station FWE-3, the number of Fimbrystilis is observed to increase upon nearing the site, together with the *Ceriops sp.* and *kulasi*. Some *Tamarindus sp.* trees were also observed in the area.

Plates EW-18 to **EW-29** show the macrophytes observed in Darigayos River.

Plate EW-18. Station FWE1 - *Leucaena leucocephala*

Plate EW-19. Station 1 - *Lantanna camara*

Plate EW-20. Station 1 - *Acalypha sp.*

Plate EW-21. Station 1 - *Terminalia catappa*

Plate EW-22. Station 2 - *Avicennia sp.*

Plate EW-23. Station 2 **-** *Gliricidia sepium*

Plate EW-24. Station 2 - *Nypa fruticans*

Plate EW-25. Station 2 - *Rhizophora sp.*

Plate EW-26. Station 3 - *Ceriops sp.*

Plate EW-27. Station 3 - *Fimbrystilis sp.*

Plate EW-28. Station 3 **-** *Kulasi*

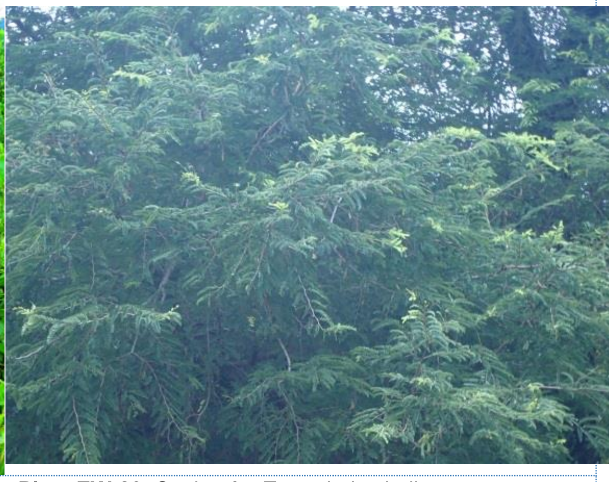


Plate EW-29. Station 3 **-** *Tamarindus indica*

There are no foreseen impacts on the vegetation in Darigayos River since the project will not use the river water or discharge any effluent into the river.

2.4.5 Overall Ecology of the Darigayos River

The Darigayos River is rich and has a significant economic impact in barangay Darigayos. The river serves as the primary source of income, food and leisure. Plenty of fish pens can be observed along the stretch of Darigayos River containing mostly tilapia, biya, hito, sugpo and bangus.

Plankton communities are relatively abundant in the river. This indicates that fishes and other species that feed on plankton are likely to survive without an external factor affecting the cycle of nutrients within the river.

In terms of macroinvertebrates, Station FWE-1 is the least diverse given that only two (2) species were found. The vegetation in Station FWE-1 is composed of shrubs, weeds and some other trees like *Terminalia catappa* and *Leucaena leucocephala*. On the other hand, Stations FWE-2 and FWE-3 have almost the same communities and composition. The macroinvertebrate that dominantly live in the area is the Potamididae. The difference on the macroinvertebrates composition on each station is due to the difference in salinity levels. High salinity or chloride in the water causes the shells of freshwater macrobenthos to corrode and is likely the reason why only a few species of macrobenthos inhabit the area.

The macrobenthos community propagating in Stations FWE-2 and FWE-3 can be attributed to the rich population of macrophytes providing suitable environment. In Station FWE-1, on the other hand, the two types of macroinvertebrate propagating in the area are due to environmental composition such as water quality and river bed composition.

The proposed project in Barangay Carisquis and Nalvo Sur is two kilometers away from the Darigayos River and impacts is very unlikely due to the distance.

2.4.6 Summary of Potential Impacts and Mitigation Measures Related to Freshwater Ecology

Table EW-40 summarizes the potential impacts and proposed mitigation related to freshwater ecology.

Table EW-40
Summary of Potential Impacts Related to Freshwater Ecology during Construction and Operation

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
II. Operation Phase			
Threat to existence and/or loss of species (Freshwater)	Darigayos River ecology	There are no foreseen impacts on the vegetation in Darigayos River since the project will not use the river water or discharge any effluent into the river.	• No mitigation measures needed.

2.4.7 Monitoring Plan for Freshwater Ecology

There is no proposed monitoring for the Darigayos River since the water body is two (2) kilometers away from the project site and will not be impacted either during the construction or operation phases of the project.

2.5 Marine Ecology

2.5.1 Methodology

An assessment of the primary coastal habitats and resources around the project site was undertaken from 22-24 July 2016 along Barangays Carisquis and Nalvo Sur, Municipality of Luna, La Union Province.

The survey methods employed follow standard marine resource survey techniques prescribed by English *et al.* (1994) and modified in accordance with *in-situ* conditions following rapid appraisal techniques for coastal resources. In the coral reef, more focused assessments were done by undertaking underwater surveys, systematic snorkelling and spot dives to more closely determine reef and fish distribution patterns in the slope area where higher live coral cover was discerned. Key informants were interviewed to determine marine capture fisheries conditions. Sampling stations were also designated in areas pointed by key respondents as shellfish collection areas to determine the presence of macro-invertebrates.

The baseline survey is focused on assessing the presence, distribution and diversity of principal coastal resources - (i) corals, (ii) reef-associated fish communities, (iii) seagrass communities, (iv) plankton, (v) benthic macro-invertebrates; and, (ii) fishing practices and productivity. Mangroves do not occur in the coastline of the power plant project site.

The survey and profiling covered a linear expanse of coastal waters covering more than 3.5 kilometers, including coastal waters past the boundaries of the project site. Observations from manta tow pathways covered a breadth of approximately 50 to 70 meters of shallow coastal seas following the reef flat and crest isobath. A total of twenty (20) manta tow observation stations, three (3) line intercept stations for detailed coral reef assessment, three (3) fish visual census stations, four (4) seagrass survey stations, two (2) sampling stations for economically-important macro-invertebrates (apart from LIT stations which were also sampled opportunistically for macro-invertebrates), six (6) zooplankton-phytoplankton sampling stations, and five (5) stations were surveyed for soft-bottom communities. A map showing the consolidated location of all survey stations is presented in **Figure EW-69**. Details of the survey methods for each components are discussed in the succeeding sections.

The characterization is followed by an assessment of potential impacts that could arise due to the construction and operation of the project on marine ecology. Based on the outcome of these assessments, measures to manage and mitigate potential adverse impacts are recommended.

2.5.1.1 Corals

Two (2) survey methods were employed to determine spatial distribution and abundance of live coral cover.

Manta Tow Survey Method

Manta tow surveys (**Plate EW-30**) were conducted in continuous stations in order to determine benthic conditions over a long stretch of seabed across the coastal waters covering the 2 barangays. Manta tow is a useful method for generating a general profile of the benthic resources because it permits observation of the condition, distribution and abundance of benthic habitats in a continuous stretch of the coastal environment. Estimates of percentage distribution of coral reefs and associated benthos observed within the tow stations are recorded in accordance with standard categories to document distribution of coral life forms. The collective picture generated can show a fairly accurate description of the overall state of the coastal area under study. The manta tow surveys also enable the identification of the location of seagrass meadows, if present in the area. In areas where significant coral reefs occur, results from a manta tow survey are used to pinpoint the locations of ideal stations where more detailed underwater coral reef characterization employing line transects are undertaken.

A total of twenty (20) manta tow survey stations were investigated covering a stretch of more than 3.5 kilometers of shallow coastal waters fronting the project site's coastline (**Figure EW-69**). The survey pathway included stations outside of the project site boundary in the south and north to determine the extent of the fringing reef.

Plate EW-30. Team member on Manta tow survey in project site coastal waters; 23 July 2016

Line Intercept Transect (LIT) Method

The manta tow surveys revealed that coral reefs in the slope portion of the reef hosted higher coral cover than the reef flat. To document diversity in more detail, transect lines were laid out inside each of the three sampling stations established on the reef slope in order to more precisely estimate the relative abundance of living and non-living resources. The survey protocol involved the laying out of 50-m transects parallel to the shoreline and following the reef contour (**Figure EW-70**, **Plate EW-31**). Data generated from line-intercept method for coral reef assessment provides more rigid data sets on percentage of live coral cover as well as species distribution that can be ultimately used for comparative evaluation if the same survey stations are monitored in the future. The categories utilized for classifying coral cover follow standard ratings used for live coral distribution, i.e., *76-100%*

live coral cover = Excellent; 51-75% coverage live coral cover = Good, 26-50% coverage live coral cover = Fair, and 0-25% coverage live coral cover = Poor coral cover (Gomez, et al.,1981). The coordinates of the three LIT stations are shown in **Table EW-41.** The surveys in these stations were supplemented by spot dives to augment information on the extent of coral cover and record other relevant information.

Plate EW-31. A diver undertaking line intercept transect survey, Luna, La Union (Jly 2016)

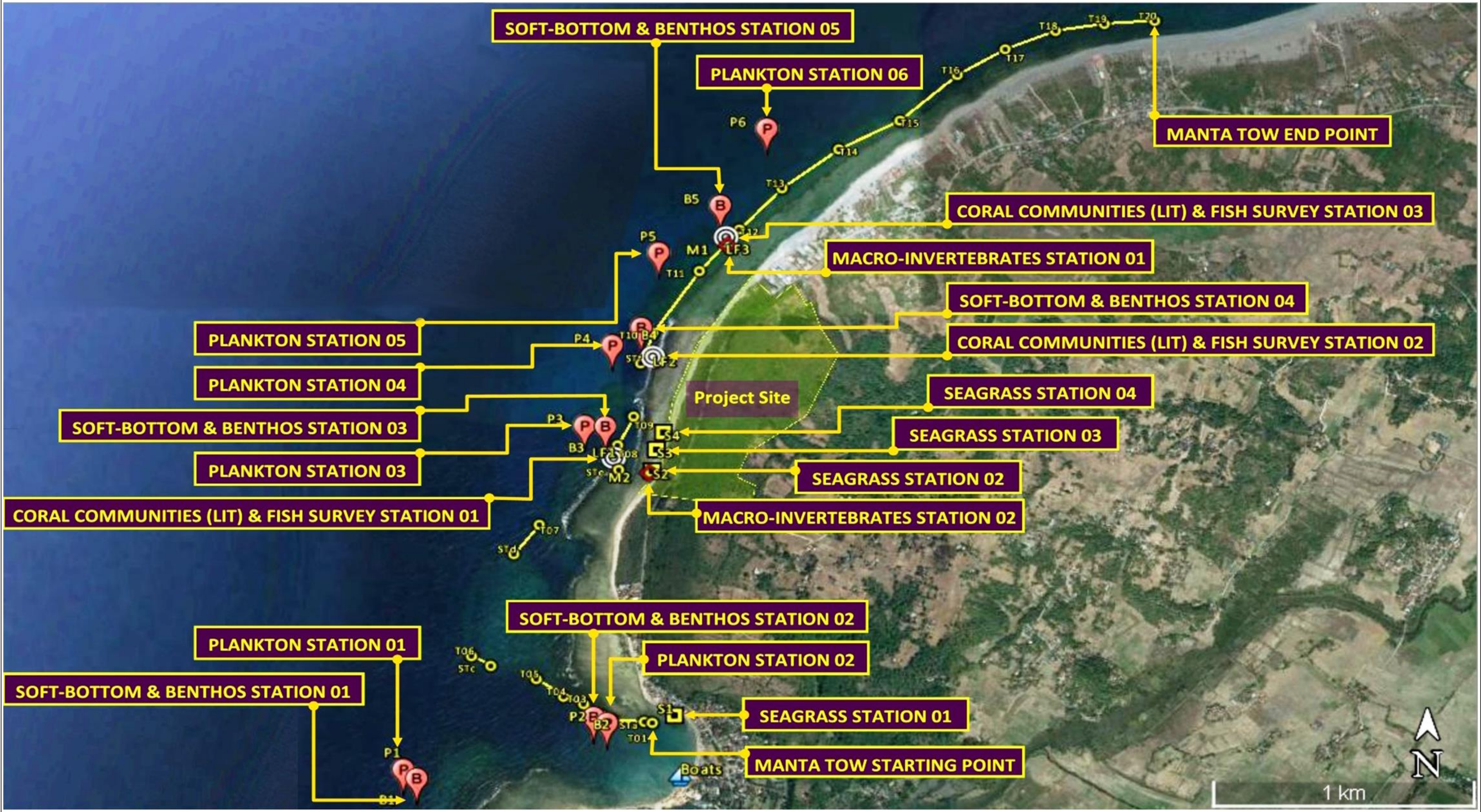


Figure EW-69. Consolidated Map Showing All Marine Ecology Survey Stations ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	LEGEND: Plankton Stations Soft-bottom & Benthos Stations Coral Communities (lit) & Fish Survey Stations Sea grass Stations Macro-invertebrates Stations Manta-tow (Coral & Substrate Profiling) Points	SCALE: AS ABOVE	DATA INFORMATION/SOURCE: **Basemap:** GOOGLE EARTH IMAGERY **Created by:** APERCU CONSULTANTS, INC (2016)	PAGE 273 aperçu CONSULTANTS INC.

Figure EW-70. **Manta Tow Stations Surveyed**	**LEGEND:**	**SCALE:**	**DATA INFORMATION/SOURCE:**	**PAGE 274**
ENVIRONMENTAL IMPACT STATEMENT **2x335MW COAL-FIRED POWER PLANT PROJECT**	Project Site Manta tow station	**AS ABOVE**	**Basemap:** GOOGLE EARTH IMAGERY **Created by:** APERCU CONSULTANTS, INC (2016)	aperçu CONSULTANTS INC.

Table EW-41
Coordinates of LIT Stations Surveyed for Coral Communities, Luna, La Union

WP Code	Latitude	Longitude	Remarks
LIT01	16°49'55.74" N	120°19'55.49" E	Approx 0.18 km with a bearing of 320.96° from SSW corner of project site; Near projected offshore reference boundary between Brgy. Carisquis and project site.
LIT02	16°50'9.67" N	120°20'0.60" E	Approx 0.46 km with a bearing of 18.65° from LIT01; Almost at the center of the projected offshore reference boundary of the site.
LIT03	16°50'26.23" N	120°20'10.21" E	Approx 0.58 km with a bearing of 28.23° from LIT02

2.5.1.2 Reef-associated Fish Assemblages

The three-line intercept stations were also used to account for fish communities associated with coral reefs using the standard fish visual census (FVC) method. The conduct of FVC is designed to document a fairly accurate picture of demersal fish species richness, abundance and biomass of fish assemblages associated with benthic habitats. In this case high values for these principal variables can indicate the overall ecological condition of a reef area and can give a glimpse of ecosystem function and diversity. Fish biomass was calculated using the formula:

$$W = aL^b$$

Where W = weight (g)
a = condition factor (Pauly 1993)
L = estimated length (cm)
b = exponent (b<1)

Specific constants *a* and *b* are referenced from Kulbicki et al (1993) and FISHBASE (2000).

Collectively, the results of the coral reef assessments and FVC surveys are used as reference points for comparative monitoring of changes in spatial distribution and diversity of benthic life forms in periodic environmental impact monitoring. Fish visual census is used to estimate the variety, numbers and sizes of fishes along a 10-meter belt following a 50-meter transect laid over representative coral reef stations. FVC surveys document mostly demersal, reef-associated species of fish that normally indicate the robustness of a coral reef ecosystem. In healthy reefs, the fish species diversity may include both commercially important fish (e.g., Groupers, Snappers) and reef-dependent species of fish such as Angelfishes and Butterfly fishes. The estimation of fish biomass in the stations surveyed can subsequently be used to extrapolate the average fisheries productivity of the broader coastal area under normal circumstances, especially in view of the fact that demersal fish can supply about 30 percent of total food fish production in a locality. This productivity value is in fact one of the most important merits in protecting coral reefs in the area.

Fish species encountered in the FVC transects are categorized as target, major or indicator species based on categories recommended in *FishBase* (2004). Target species are economically important food fish that are normally sought by fishers for trade or for food. In reef areas, such demersal species may include high value groupers (*Ephinephalidae*), snappers (*Lutjanidae*), jacks (*Carangidae*) and some species of surgeons (*Acanthuridae*). Fish that belong to the major fish category are considered to be ecologically important because they occupy unique niches and sometimes symbiotic relationships in the coral reef ecosystem. Many of these species are represented by members of the damselfishes (*Pomacentridae*) and wrasses (*Labridae*). Indicator species are coral-feeders whose presence, variety and abundance in a reef area may give an indication of the robustness and diversity of corals present in the reef. These are mostly comprised of the magnificently-colored

Butterflyfishes (*Chaetodontidae*), species of Angelfishes and the lone damsel species popularly known as *Moorish Idol*.

The FVC station coordinates are shown in **Table EW-42** as follows:

Table EW-42
Fish Visual Census (FVC) Survey Stations, Luna, La Union (July 2016)

WP Code	Latitude	Longitude	Remarks
FVC01	16°49'55.74" N	120°19'55.49" E	Approx 0.18 km with a bearing of 320.96° from SSW corner of project site; Near projected offshore reference boundary between Brgy. Carisquis and project site
FVC02	16°50'9.67" N	120°20'0.60" E	Approx 0.46 km with a bearing of 18.65° from LIT01; Almost at the center of the projected offshore reference boundary of the site
FVC03	16°50'26.23" N	120°20'10.21" E	Approx 0.58 km with a bearing of 28.23° from LIT02

2.5.1.3 Seagrass and Associated Macro-algae

The manta tow survey paths revealed the occurrence of seagrass meadows in the shallow tidal flats near the southern border of the power plant site and in a more extensive bed outside of the site near Barangay Darigayos. Three stations were surveyed in front of the project site and a forth station was surveyed in Barangay Darigayos for comparison (**Table EW-43** and **Figure EW-71**).

Assessment of the composition and density of the seagrass beds were undertaken employing the standard transect-quadrat method prescribed in English et al. (1997). Opportunistic surveys of macro-algae occurring alongside the seagrass transects were also documented.

Table EW-43
Seagrass (SGR) Survey Stations, Luna, La Union (July 2016)

WP Code	Latitude	Longitude	Remarks
SGR01	16°49'20.68" N	120°20'3.62" E	Approx 1.06 km traversing south along the coastline from SSW corner of project site; Along the northern part of the cove across Brgy Darigayos.
SGR02	16°49'54.16" N	120°20'0.67" E	Approx 103.99 m with a bearing of 27.91° from SSW corner of the project site; across the project site boundary
SGR03	16°49'57.07" N	120°20'1.21" E	Approx 92.49 m with a bearing of 6.60° from SGR02; across the project site boundary
SGR04	16°49'59.45" N	120°20'2.15" E	Approx 82.32 m with a bearing of 23.22° from SGR03; across the project site boundary

Figure EW-71. . Line Intercept Stations on the Fringing Coral Reef

ENVIRONMENTAL IMPACT STATEMENT
2x335MW COAL-FIRED POWER PLANT PROJECT

LEGEND:
Project Site
Line intercept station

SCALE:
AS ABOVE

DATA INFORMATION/SOURCE:
Basemap: GOOGLE EARTH IMAGERY
Created by: APERCU CONSULTANTS, INC (2016)

aperçu CONSULTANTS INC

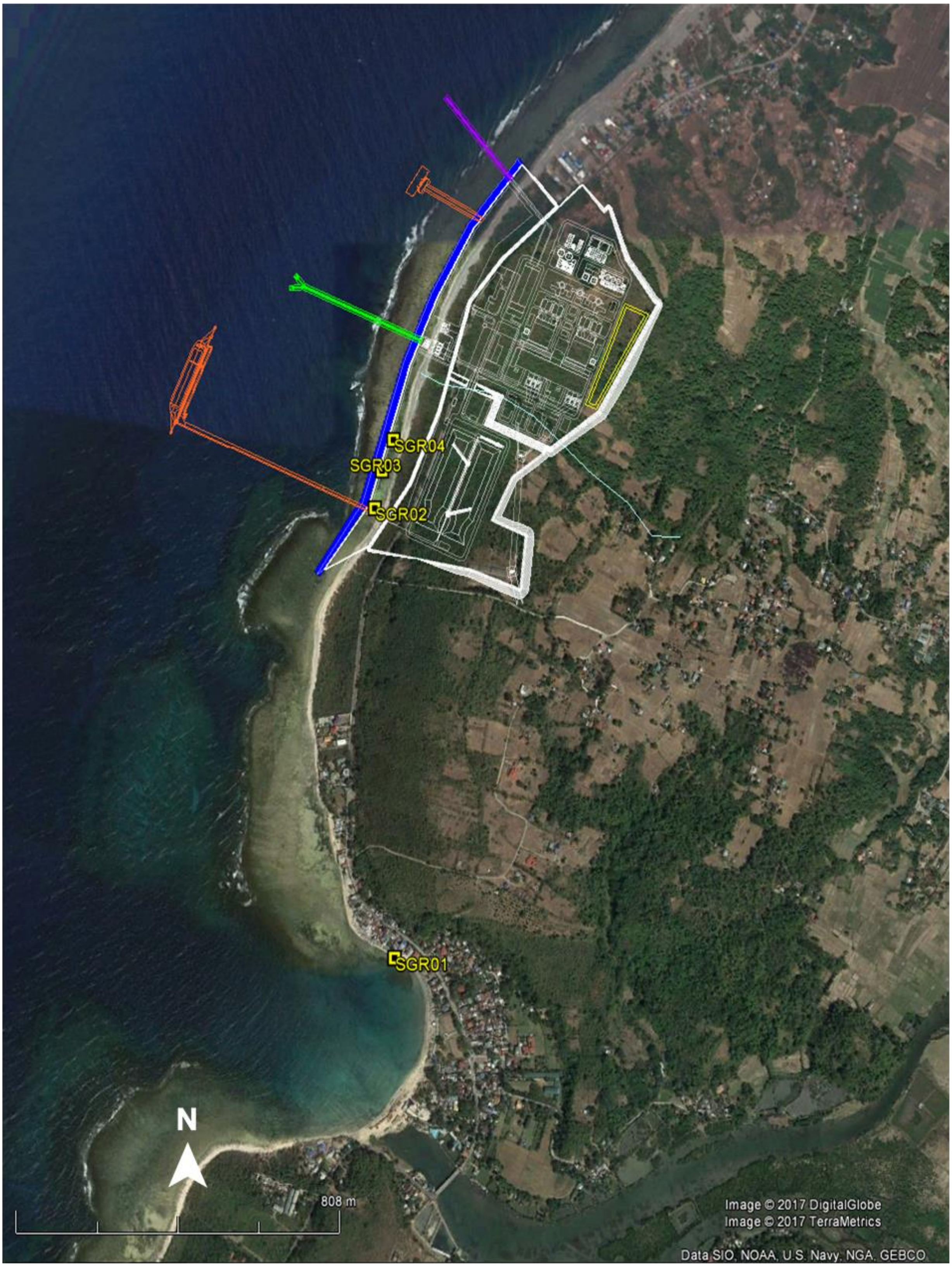


Figure EW-72. Survey Stations for Seagrass Communities	LEGEND: Project Site Survey Stations	SCALE: As Above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: **Basemap:** GOOGLE EARTH IMAGERY **Created by:** APERCU CONSULTANTS, INC (2016)	aperçu CONSULTANTS INC PAGE 278

2.5.1.4 Commercially-Important Macro-Invertebrates

Many bivalves and univalves are collected during gleaning activities for food and trade by the coastal residents of Luna. Macro-invertebrates, like bivalve mollusks, can be good indicators of site – specific disturbances in the marine benthic environment since they are sessile organisms and their sedentary nature allows effective analyses of pollutants and effects of benthic disturbance. The presence of macro-benthos in the sediment is therefore a suitable biological indicator of the fertility of the bottom sediment, on the one hand, and the unsuitability of benthic substrates for the viable existence macro-invertebrate populations on the other. Most of the benthic organisms in a particular coastal area play important ecological roles in the marine food chain, particularly as prey for many species of fish and crustaceans that are permanently reside or are transients in the bottom of the sea.

Investigation on the presence of benthic macro-invertebrates was done through actual specimen collection, opportunistic surveys and observations along a 5-meter belt corridor with the two coral line intercept transects as the belt midpoint. Opportunistic surveys were done through actual specimen collection in shellfish gleaning areas observed by the survey team (coordinates shown in **Table EW-44** and **Figure EW-73**). Cataloguing of macro-invertebrates encountered was also done in three LIT stations.

Table EW-44
Coordinates of Macro-invertebrate Sampling Stations, Luna, La Union

WP Code	Latitude	Longitude	Remarks
MAC1	16°50'25.15" N	120°20'10.43" E	Approx 0.16 km with a bearing of 322.33° from NNW corner of project site
MAC2	16°49'53.69" N	120°20'0.17" E	Approx 0.08 km with a bearing of 19.95° from SSW corner of project site

2.5.1.5 Plankton and Soft Bottom Communities

Species composition, abundance and density of phytoplankton and zooplankton communities were determined using a plankton net that was vertically lowered and then towed from sub-surface depths. For the zooplankton abundance or density, each sample was sieved through 60μm mesh sieves. One to two ml aliquots from known sample volume served as subsamples. Organisms were identified and counted with a binocular-dissecting microscope, expressed as number of organisms per cubic meter. For phytoplankton density, samples were sieved through a 20μm mesh sieve and were diluted with a known volume of filtered seawater. Two aliquots were drawn from the sample and were allowed to settle in a Sedgewick-rafter chamber. At least 3-4 horizontal strips were randomly counted. Cell density was expressed in number of cells per cubic meter. Shannon-Weaver Diversity/Evenness Indices and bio-assessment metrics were then derived from the results of the sampling.

Identification of phytoplankton species that can become harmful algal blooms that can potentially cause paralytic shellfish poisoning was also undertaken. Algal blooms normally indicate hyper-nutrient levels in the sea that are sometimes triggered by problems of anthropogenic origin. Sampling stations were strategically chosen so that the stations were evenly distributed throughout the length of the power plant's coastline. Six (6) plankton sampling stations were established for the survey.

Soft bottom fauna were also catalogued in five (5) stations employing a grab sampler. The coordinates of plankton and soft-bottom sampling stations are listed in **Table EW-45** and **EW-46**, respectively, and depicted in **Figures EW-74** and **EW-75** below.

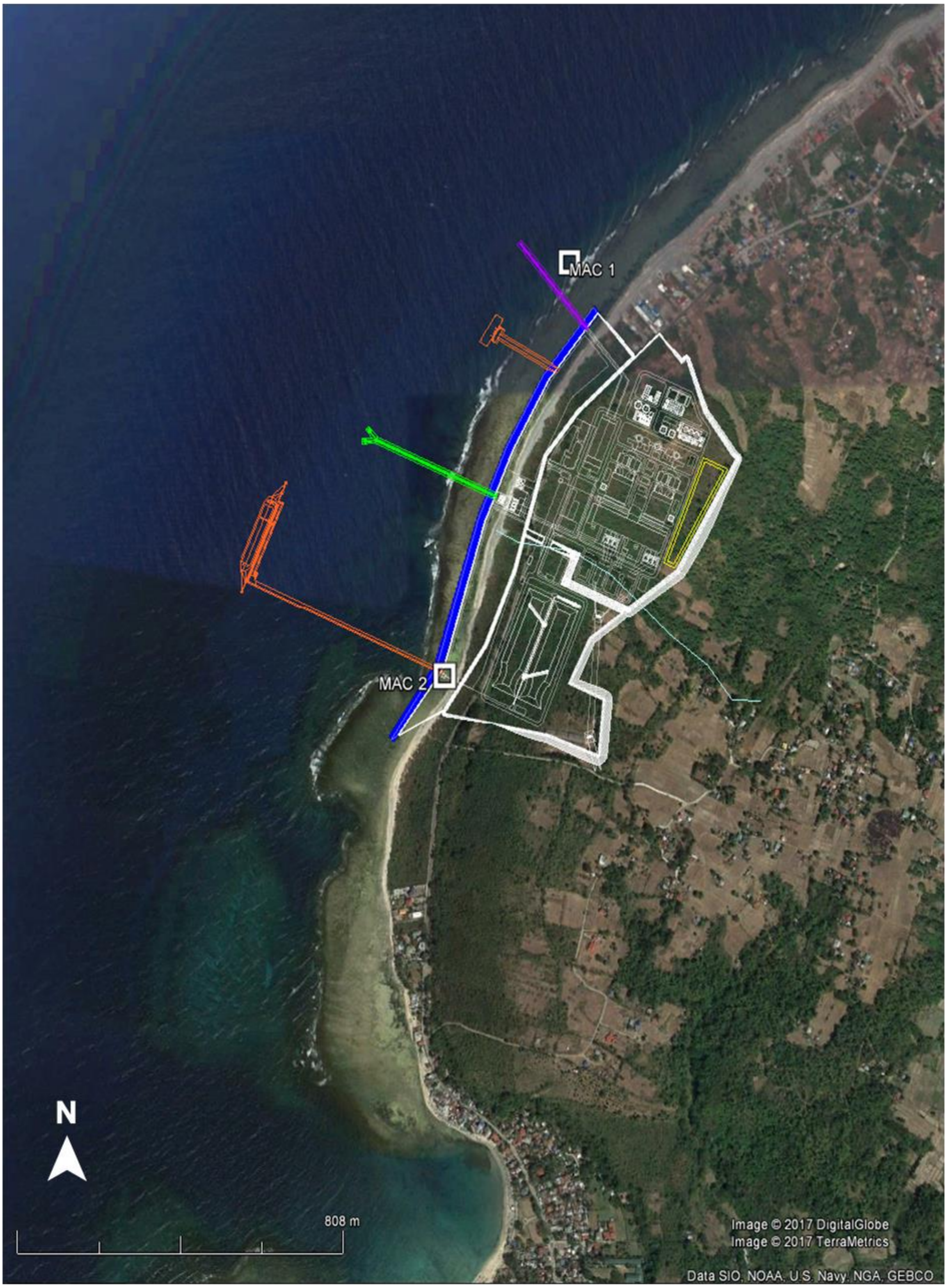


Figure EW-73. Sampling Stations for Collection of Commercially-Important Macro-Invertebrates (Gleaning Stations)	LEGEND: Project Site Sampling Stations	SCALE: As Above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: **Basemap:** GOOGLE EARTH IMAGERY **Created by:** APERCU CONSULTANTS, INC (2016)	aperçu CONSULTANTS INC. PAGE 280

Table EW-45
Plankton Sampling Stations, Luna, La Union (July 2016)

WP Code	Latitude	Longitude	Remarks
PLKT01	16°49'9.56" N	120°19'28.16" E	Approx 1.57 km with a bearing of 215.19° from SSW corner of project site.
PLKT02	16°49'15.89" N	120°19'54.68" E	Approx 0.81 km with a bearing of 75.96° from PLKT01.
PLKT03	16°49'56.64" N	120°19'51.64" E	Approx 1.27 km with a bearing of 355.58° from PLKT02.
PLKT04	16°50'7.75" N	120°19'55.25" E	Approx 0.36 km with a bearing of 16.70° from PLKT03.
PLKT05	16°50'20.56" N	120°20'1.32" E	Approx 0.43 km with a bearing of 24.05° from PLKT04.
PLKT06	16°50'37.82" N	120°20'15.56" E	Approx 0.68 km with a bearing of 37.92° from PLKT05.

Table EW-46
Sampling stations for Soft-bottom Communities, Luna, La Union (July 2016)

WP Code	Latitude	Longitude	Remarks
SBBN01	16°49'8.31" N	120°19'29.93" E	Approx 1.57 km with a bearing of 213.20° from SSW corner of project site.
SBBN02	16°49'16.68" N	120°19'52.94" E	Approx 0.73 km with a bearing of 69.11° from SBBN01.
SBBN03	16°49'56.52" N	120°19'54.36" E	Approx 1.23 km with a bearing of 01.95° from SBBN02.
SBBN04	16°50'10.15" N	120°19'59.06" E	Approx 0.45 km with a bearing of 17.30° from SBBN03.
SBBN05	16°50'27.12" N	120°20'9.43" E	Approx 0.60 km with a bearing of 29.83° from SBBN04.

2.5.1.6 Mangroves

Mangroves do not occur in the coastline of the two Barangays surveyed. Information from key informants indicated that small patches of mangroves exist inside the Darigayos River, 1.5 kilometers from the southern border of the power plant. A rapid ocular inspection of the mangrove patches was undertaken but the remote distance of the mangrove trees from the project site, its smallness in area and growth, and intermittent occurrence no longer required the conduct of an assessment.

2.5.1.7 Fisheries

A rapid appraisal was undertaken through key informant interviews to determine: (i) presence of fishing activities in the study area and dominant fishing gears used, (ii) dominant catch composition, (iii) estimated catch rates; and, (iv) issues affecting fisheries. In the coastal waters fronting the MPSLs, fishers conducting actual fishing operations were interviewed. The presence of coral reefs and deep waters adjoining San Fernando Bay signifies that the fisheries of the area is comprised of both pelagic and demersal fishing operations; with the latter dominated by hook and line operations in reef areas. The shallow, reef-fringed coastal waters are fished for sustenance fisheries employing small-scale fishing gears. Under the Fisheries Code of the Philippines, the use of commercial fishing boats and gears is prohibited inside municipal waters.

Secondary data were obtained from the Local Government Unit of Luna, from the Bureau of Fisheries and Aquatic Resources Region 01, and other institutions in the area to augment the primary data gathered.

2.5.1.8 Marine Wildlife

The status of megafauna in Luna, La Union was determined by conducting household interviews to randomly selected 44 fisherfolk using a pre-tested survey questionnaire. Questions that were asked from the respondents include the mega fauna frequently seen, activities when megafauna are seen, areas where megafauna regularly occurs, their presence throughout the year, among others. The respondents were also asked to compare the number of seen megafauna before and at the present (2016).

Figure EW-74. Sampling Stations for Phytoplankton and Zooplankton	LEGEND: Project Site Sampling Stations	SCALE: As Above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: **Basemap:** GOOGLE EARTH IMAGERY **Created by:** APERCU CONSULTANTS, INC (2016)	aperçu CONSULTANTS INC PAGE 282

Figure EW-75. Sampling Stations for Soft-Bottom Ecosystems and Benthic Communities	LEGEND: Project Site; Survey Stations	SCALE: As Above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: **Basemap:** GOOGLE EARTH IMAGERY **Created by:** APERCU CONSULTANTS, INC (2016)	aperçu CONSULTANTS INC

2.5.2 General Description of the Study Area

The near-shore waters in the two barangays surveyed are characterized by shallow waters over a relatively broad reef flat extending 60 to 150 meters from the shoreline. A fringing reef hugs the entire coastline of the project site, running to about 3.5 kilometers. The reef flat is irregularly shaped in the southern boundary of the project site, with significant indentions near the boundary in the south. In contrast, the reef flat is wider in the northern portion, extending 100 to 150 meters from the shoreline in most areas. The shelf abruptly drops to deep waters past the reef slope, dropping from 12 to 22 fathoms in most portions. The offshore waters are influenced by strong waves during the northeast monsoon. According to a Barangay Captain, bigger waves are experienced in Carisquis than in Nalvo Sur. Deep waters, about 10 kilometers from the shoreline, are known to be pathways for large pelagic fishes moving toward offshore shoals in the West Philippine Sea, consisting mainly of tunas. During ebb tides, the strong currents from the Darigayos River also sweep through the coral colonies in a northeasterly direction (Northeast monsoon) such that sediments emanating from the river are flushed out towards the coral reefs in Barangay Carisquis. The coastline of the two barangays is dominated by a mixture of sand, fine coral rubble and pebbles, and supports a modest tourism industry.

In contrast to the fringing reef that is consistent along the coastline, there are no mangrove stands in Barangays Nalvo Sur and Carisquis. Seagrass communities occur only in intermittent patches in Barangay Carisquis, mostly towards the southern boundary of the project site, and disappear throughout the rest of the coastline going north. It is evident that over the last few decades, the coastal habitats in the coastal impact area of the power plant project site have been subjected to various forms of stresses and pressures that have altogether eroded portions of the reefs, which are now colonized by macro-algae. The reef flat has been mostly damaged throughout the fringing reef but the reef slope hosts more diverse coral cover with vivid evidence of old growths and recruitment. However, coral re-growth in the reef flat appears slow, perhaps deterred by periodic strong currents and big waves. Moreover, coral bleaching of recent occurrence, perhaps during the 2016 El Niño episode, has occurred in many patches of the reef, both on the reef flat and on the slope.

2.5.3 Existing Marine Ecology

2.5.3.1 Corals – Reef Flat

Broad area manta tow observations supplemented by systematic snorkeling revealed that fringing coral reefs are found in the entire coastline. Corals were recorded in all 20 pathways observed, with live coral cover ranging from 5% to 10% on the reef flat (*category: Poor)*. Corals on the reef slope had relatively higher live coral cover, ranging from 24 to 29% as revealed in the line intercept surveys (discussed in section **2.5.3.2**).

Out of the 20 manta tow pathway observations, seven stations revealed 10% live coral cover, and only one station hosted live coral cover (LHC) of about 20%. This station (STe-T08: N 16.832680°, E 120.332250°; **Table EW-47**) is located just above the midpoint in the project's boundary in the coastline and hosted a higher coral cover due to the presence of coral recruits of the fire coral *Millepora sp*. The rest of the coral substrate in the entire length of the reef flat facing the project site was composed of dead corals with algae, ranging from 70 to 80% of the benthic substrate. The reef flat in the area of the project's boundary with Barangay Darigayos was observed to host patches of live hard coral cover reaching 15% LHC near the boundary. In contrast, reefs in the NE portion towards Nalvo Sur were more degraded. These reefs run about 2 kilometers towards the end of the fringing reef, dominated by dead corals with algae and only 5% live coral cover on the shallow shelf and 24% live coral cover on the slope, 50 to 80 meters from the shoreline. In this portion of the project's coastline, the reef flat and shelf is broader. The benthic composition of stations outside the project boundary to the north were comprised mostly of rocks, sand and coral rubble, while the stations to the south in the jurisdiction of Barangay Darigayos hosted a better coral profile of 25 % LHC in three stations but also hosted the lowest coral cover of 3% in another three stations inside Darigayos Cove.

Overall, the coral cover on the reef flat (**Plate EW-32a, b and c**) fronting the project site was categorized as *poor.* **Average Live Coral Cover** for the whole survey route was **8%**, **Dead Corals** overgrown with algae comprise

62%, and **abiotics** cover **30%**. Dead corals in the inner portions of the reef flat have been extensively colonized by macro-algae consisting of *Sargassum* sp. and *Padina* sp. Recruits were mostly found in the deeper portions of the reef flat, where crevices and canals cut through the reef towards the slope. More robust coral colonies, due to the presence of a greater number of recruits, were found in the SW portion of the survey area, particularly in the boundary of the project site in Barangay Carisquis. The reef is dominated by the fire coral *Millepora* sp., recruits of massive *Porites* spp. and encrusting coral varieties, all of which appear to be connected to the reefs in Barangay Darigayos that are actually in a better state (**Table EW-43**, **Figures EW-76** and **EW-77**).

Plate EW-32A The reef flat in front of the project site hosts little live coral cover, averaging 10% throughout the entire length of the reef.

Plate EW-32B Dead corals have been colonized by macro-algae

Plate EW-32C) The reef flat has been cleared of coral rubble, presumably by strong monsoon waves sweeping the sea floor during northeast monsoon

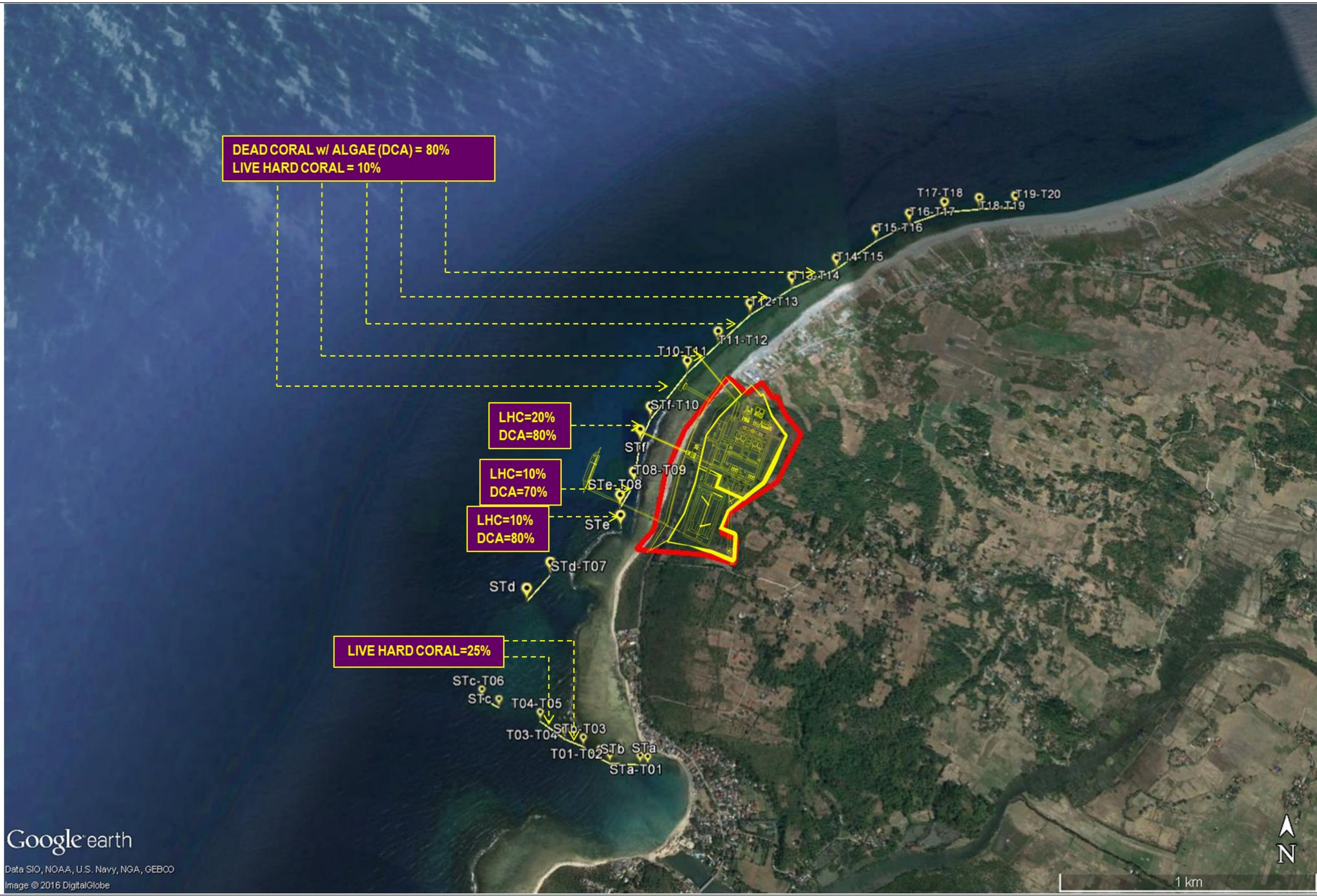


Figure EW-76. Live Hard Coral Coverage in Selected Manta Tow Stations	LEGEND:	SCALE:	DATA INFORMATION/SOURCE:	PAGE 286
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	Project Site Manta tow station	AS ABOVE	**Basemap:** GOOGLE EARTH IMAGERY **Created by:** APERCU CONSULTANTS, INC (2016)	aperçu CONSULTANTS INC.

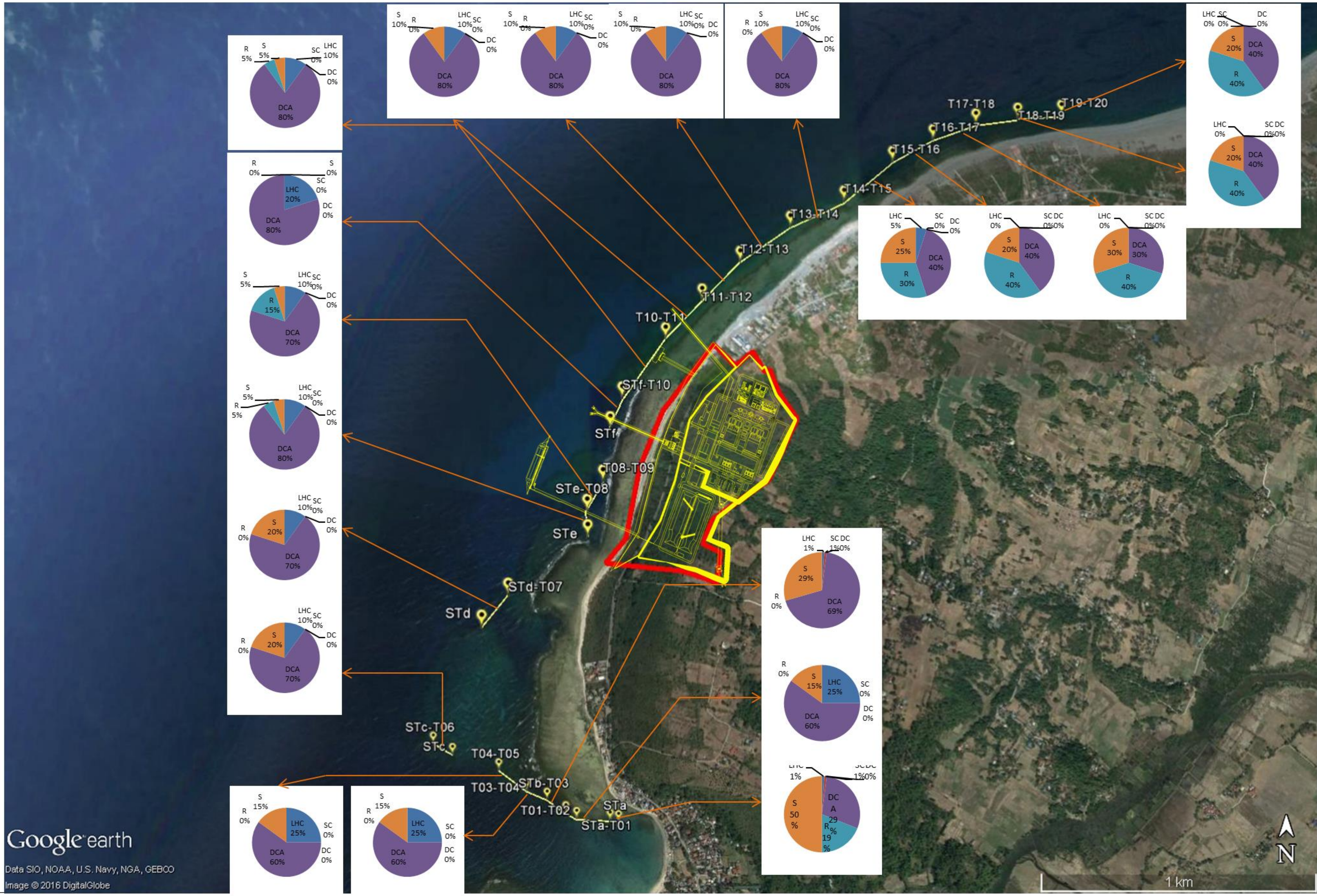


Figure EW-77. Coral Substrate Distribution (Pie Graphs) of the 20 Manta Tow Stations	LEGEND:	SCALE:	DATA INFORMATION/SOURCE:	PAGE 287
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	Project Site Manta tow station	AS ABOVE	**Basemap:** GOOGLE EARTH IMAGERY **Created by:** APERCU CONSULTANTS, INC (2016)	

Table EW-47
Summary of Results of Manta Tow Surveys in 20 Stations, Luna, La Union (July 2016)

Manta Tow Results for Coral and Substrate Survey		
Site Name:	Offshore GLEDC Project Site across Bgy Darigayos, Carisquis, and Nalbo Sur, Luna, La Union	Observers:
Time / Date:	0852H-1105H / 23 July 2015	Rene Villegas
Tow Speed:	3.0 kmh (ave)	Benjamin Francisco
Visibility:	Approx. 6m	Michael Francisco
Weather:	Sunny	
Wave:	Smooth with Very Low-Amplitude Crests	
Current:	None	
Tide:	Rising then lowering (0.87m to 0.93m)	
Water Temp:	Approx. 29°C-30°C	
Wind:	Beaufort Scale #1	
Cloud Cover:	Patches of Cirrocumulus and Altocumulus Clouds	

Tow Coverage	Location [DecDeg]	LHC	SC	DC	DCA	R	S	Remarks
STa	N 16.822110° E 120.333530°	-	-	-	-	-	-	1st Start across west coast of Bgy Darigayos (with settlements)
STa-T01	N 16.822150° E 120.333240°	1	1	0	29	19	50	Live corals are less than 3%
T01-T02	N 16.822210° E 120.332080°	1	1	0	59	19	20	Reef Slope; live corals < 3%; presence of Striped Barracuda, *Sphyraena* sp. ("tursilyo")
STb	N 16.822390° E 120.331700°	-	-	-	-	-	-	2nd Start [adjusted from reef deviation] across Bgy Darigayos
STb-T03	N 16.822820° E 120.331040°	1	1	0	70	0	30	Reef Flat; live corals < 3%; presence of Yellow-striped Trevally, *Selaroides* sp. ("salay-salay")
T03-T04	N 16.823100° E 120.330310°	25	0	0	60	0	15	Reef flat; among few areas with relatively higher live coral cover
T04-T05	N 16.823770° E 120.329320°	25	0	0	60	0	15	Reef flat; presence of rabbitfish ("barangan"), sea cucumbers (10), & blue sea star *Linckia* sp.
STc	N 16.824270° E 120.327670°	-	-	-	-	-	-	3rd Start [adjusted from reef deviation] across Bgy Darigayos
STc-T06	N 16.824640° E 120.326970°	10	0	0	70	0	20	Profuse algal growth on dead coral exoskeletons
STd	N 16.828520° E 120.328490°	-	-	-	-	-	-	4th Start [adjusted from reef deviation] across Bgy Darigayos
STd-T07	N 16.829640° E 120.329410°	10	0	0	70	0	20	Profuse algal growth on dead coral exoskeletons
STe	N 16.831740° E 120.332290°	-	-	-	-	-	-	5th Start [adjusted from reef deviation] across Bgy Carisquis, near Proj Boundary (Lower)
STe-T08	N 16.832680° E 120.332250°	10	0	0	80	5	5	Tow Segment within Proj Site; chains of Sea Salps (tunicates) & Millepora (fire coral)
T08-T09	N 16.833780° E 120.332830°	10	0	0	70	15	5	High DCA and coral rubble
STf	N 16.835820° E 120.333080°	-	-	-	-	-	-	6th Start [adjusted from reef deviation] across Project Site
STf-T10	N 16.836990° E 120.333530°	20	0	0	80	0	0	Coral species generally *Millepora* sp. (fire corals)
T10-T11	N 16.839370° E 120.335220°	10	0	0	80	5	5	Near Proj Boundary (upper) under Bgy Nalbo
T11-T12	N 16.840970° E 120.336680°	10	0	0	80	0	10	Presence of approx 20 adults Moorish Idol fish
T12-T13	N 16.842560° E 120.338240°	10	0	0	80	0	10	High DCA with profuse algal growth
T13-T14	N 16.844070° E 120.340320°	10	0	0	80	0	10	High DCA with profuse algal growth
T14-T15	N 16.845180° E 120.342560°	10	0	0	80	0	10	High DCA with profuse algal growth
T15-T16	N 16.846950°	5	0	0	40	30	25	Edge of pebbles and coral rubble accretion on

Tow Coverage	Location [DecDeg]	LHC	SC	DC	DCA	R	S	Remarks
	E 120.344670°							shoreline
T16-T17	N 16.847950° E 120.346430°	0	0	0	40	40	20	Profuse and thick algal growth
T17-T18	N 16.848660° E 120.348280°	0	0	0	30	40	30	Dominated by rubble and sandy substrate
T18-T19	N 16.848930° E 120.350070°	0	0	0	40	40	20	Near and past edge of SAT image of possible reef; thick algal growth
T19-T20	N 16.849048° E 120.351917°	0	0	0	40	40	20	End of tow series
Average Reef and Substrate Composition		**8**	**0**	**0**	**62**	**13**	**17**	

- Tow area coverage are expressed in Decimal Degrees notation in reference to WGS84 Map Datum
- Reef and Substrate composition are expressed in (%) and described as follows:
  Live hard coral (LHC) - coverage of stony or hard corals on the bottom or part of the bottom
  Live soft coral - (SC) - coverage of soft corals attached to the bottom
  Dead coral (DC) - recently dead coral still attached and recognizable at the bottom in original upright position, color usually white with no living tissue
  Dead coral with algae (DCA) - corallites still visible, skeletal structure can still be seen but algae dominate the structure (often appears greenish to brownish)
  Coral rubble/rock (CR) - loose broken fragments of stony corals, consolidated hard bottom or large blocks of hard reef materials not attached or easily moved around
  Sand/silt (S)

2.5.3.2 Corals – Reef Slope

The three LIT stations for recording of detailed coral cover and benthic life form assessment were laid out on the reef slope in order to account for coral cover in the area. The reef slope runs throughout the entire fringing reef, broken only in abrupt indentions in the southern boundary of the project site in Barangay Carisquis (**Plate EW-33**).

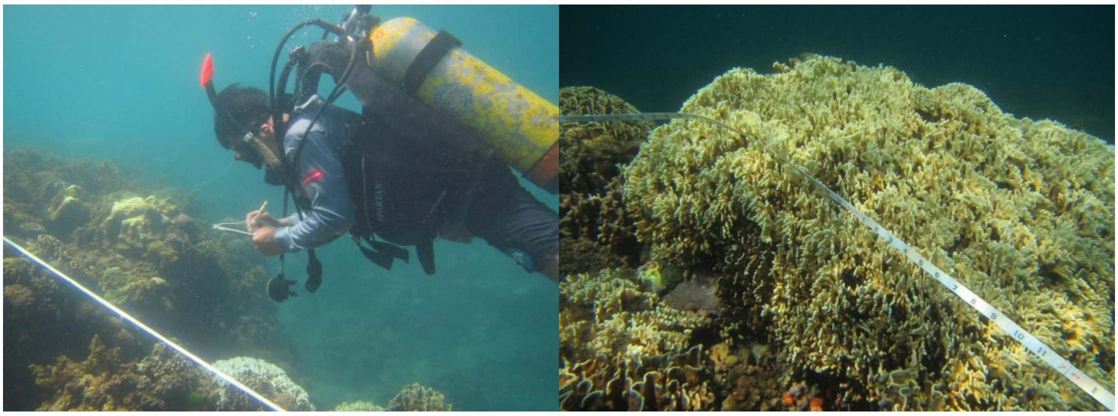


Plate EW-33. Underwater survey with scuba using the line intercept method. The line transect is laid out on the slope of the fringing reef fronting the power plant site.

Across the three stations, the average live coral cover was documented at 26.52%, with the fire coral *Millepora* sp. dominating coral cover and accounting for 45% of all live corals in the survey pathways. This was followed by the massive varieties of *Porites* sp. which were recorded to comprise 20% of live coral life forms across the three stations. Dead coral colonized with algae comprised 45.25%, followed by sponges, which comprised 19.6% of the surveyed pathways (**Table EW-48** and **Figure EW-78**). Under the standard categories employed for coral reef assessment, this ratio is classified as *Fair.*

Table EW-48
Average Percentage Cover of the Different Lifeform Categories Across Three (3) LIT Transects Luna, La Union (July 2016)

Lifeform	Categories	Code	Average Percentage Cover (in %)
	Branching	ACB	1.33
	Digitate	ACD	2.73
Acropora	*Encrusting*	ACE	0.33
Non-Acropora	*Encrusting*	CE	4.87
	Massive	CM	5.33
	Mushroom coral	CMR	0.13
	Millepora	CME	11.80
Average Percent Live Hard Coral (LHC) Cover			**26.52 – Fair Condition**
Dead Coral		DC	3.33
Dead Coral with Algae		DCA	45.25
Other Fauna	*Soft coral*	SC	0.47
	Sponge	SP	19.60
Abiotic	*Sand*	S	0.20
	Rubble	R	0.47
	Water	WA	3.53
	Rock	RCK	0.54

Status Category: Poor = 0 - 24.9; Fair = 25 - 49.9%; Good = 50 - 74.9%; Excellent = 75 - 100% (Gomez et al. 1981)

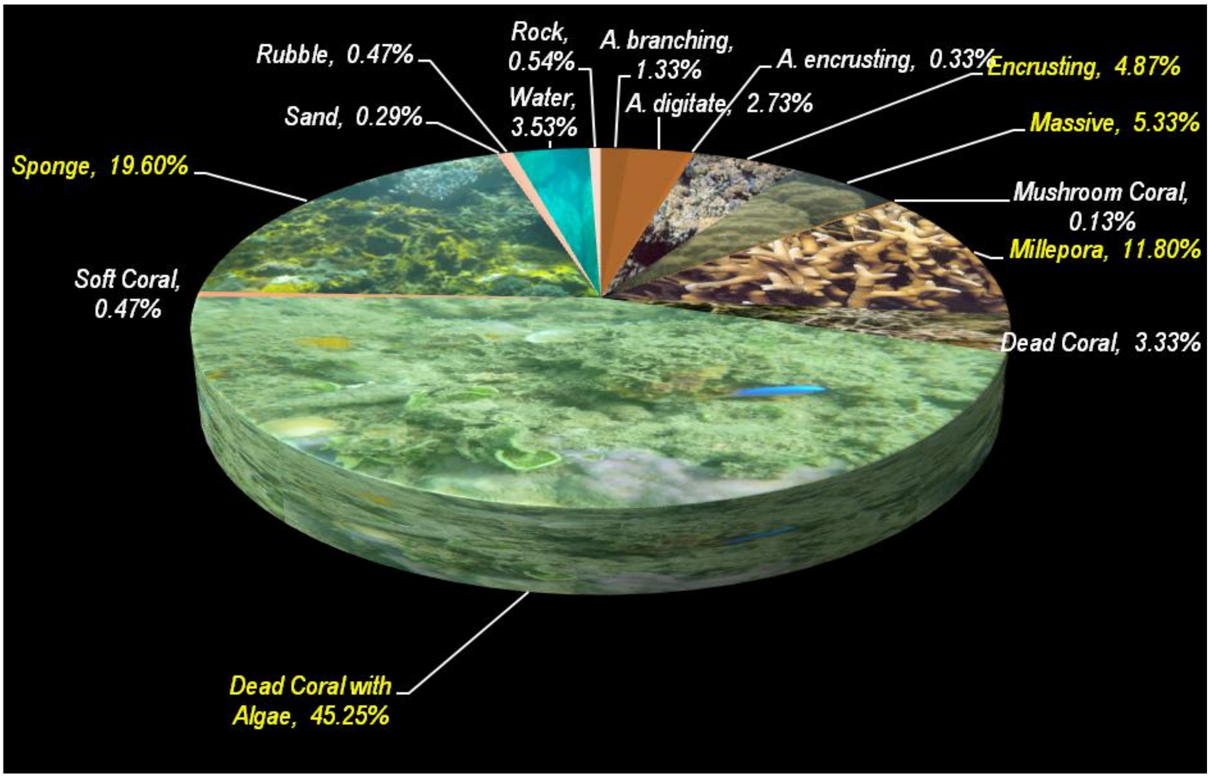


Figure EW-78. Average live coral cover, dead coral with algae, other fauna (OT) and abiotic components across three (3) LIT transects (Observers: Victor L. Pantaleon and Ronald T. Pocon).

It is worthwhile to mention that bleached corals were ubiquitous in all the LIT stations surveyed, with most of the bleaching occurring on *Millepora* sp. and small branching corals (**Plate EW-34**). It is evident that the coral bleaching occurred in the 2016 El Niño episode.

Plate EW-34. Bleached coral colonies ('white corals') were encountered in many sections of the coral reef slope.

On a per station basis, Station 1, located in the southern boundary of the project site with Barangay Carisquis, hosted the highest coral cover in the reef slope with 29% live coral cover, 49% of which are *Millepora* species (Category: *Fair*). Digitate, encrusting and massive corals were distributed at 2.8%, 7.4% and 3%, respectively. Dead corals and dead corals with algae combined, accounted for 66.8% of the benthic coral life forms (**Table EW-49**). In this area, the reef is cut by massive indentions and some portions of the coastal shelf have a short reef flat and crest. Corals were observed on the deeper parts of the slope.

Station 3, located past the northern boundary of the project in Nalvo Sur, hosted a live coral cover of 26.4% (Category: *Fair*). Beyond this area, the reef began to be dominated by rocks and dead corals. The presence of a significant colony of sponge was, however, noted in this station, accounting for 58.8% of the benthic pathway surveyed while dead corals and dead coral with algae consisted 13.2%. In this area, massive corals were more dense, representing 9.6% of all coral life forms encountered along the transect.

Station 2, which was laid out in the middle of the coastline fronting the project site, hosted the lowest live coral cover, averaging 24.2% (category: *Poor*). In this area, the reef flat is wide, about 100 meters from the shoreline, and the slope is abrupt and cut by crevices. Dead corals were catalogued as highest in Station 2, averaging 66 % across the survey corridor, in fact the highest level of DC/DCA in the reef slope surveyed. However, coral species are more diverse in this portion of the reef, with more numerous branching, digitate and massive corals than in the other two stations. The branching corals are mostly represented by young recruits but the *Millepora* and massive varieties included "old growth" colonies.

The overall result of the assessments indicates that the slope of the fringing reef in the two Barangays surveyed in Luna, La Unions hosts a diverse array of coral colonies that appear to be undisturbed at the moment and recruitment of coral planulae is happening, indicating that recovery of the reef is taking place. In the reef flat which has been severely impaired, the presence of coral recruits observed along the survey pathways reveals natural restoration. The reef slope evidently functions as effective sources of propagules in this regard.

A map showing the coral cover in the three LIT stations is provided in **Figure EW-79** while a comparison of percent cover is provided in **Table EW-49** and depicted in **Figure EW-80**. There were 27 species of corals catalogued across three LIT stations, listed in **Table EW-50**.

Table EW-49
Comparison of Percent Cover of Major Lifeforms Obtained from Three Coral Line Intercept Stations Luna, La Union (July 2016)

Lifeform Categories		Code	Distribution per Transect *(in %)*		
			1	2	3
	Branching	ACB	1.20	2.40	0.40
	Digitate	ACD	2.80	2.80	2.60
Acropora	*Encrusting*	ACE	0.60	0.40	
Non-Acropora	*Encrusting*	CE	7.40	2.40	4.80
	Massive	CM	3.00	3.40	9.60
	Mushroom Coral	CMR	0.40		
	Millepora Coral	CME	13.60	12.80	9.00
Average Percent LHC Cover			**29.00 (Fair)**	**24.20 (Poor)**	**26.40 (Fair)**
Dead Coral		*DC*	7.10	1.80	1.20
Dead Coral with Algae		*DCA*	59.70	64.20	12.00
	Soft Coral	*SC*	0.80		0.60
Other Fauna	*Sponge*	*SP*			58.80
Abiotic	*Sand*	*S*		0.60	
	Rubble	*R*	1.40		
	Rock	*RCK*		0.60	1.00
	Water	*WA*	2.00	8.60	

Status Category: Poor = 0 - 24.9; Fair = 25 - 49.9%; Good = 50 - 74.9%; Excellent = 75 - 100% (Gomez et al. 1981)

Table EW-50
Species of Corals in Three LIT Stations observed, Luna, La Union (July 2016)

Massive	Branching	Encrusting, Millepora & Other
Porites sp.	*Acropora palifera*	*Montipora cactus*
Porites lutea	*Montipora digita*	*Lobophyllia costata*
Lobophyllia hemprichii	*Seriatopora hystrix*	*Millepora* sp.
Leptoria sp.	*Montipora cactus*	*Montipora floweri*
Porites murrayensis	*Montipora stellata*	*Anthelia* sp. *(soft coral)*
	Acropora formosa (staghorn)	*Porites lichen*
	Acropora robusta	*Montipora cebuensi*
	Acropora cylindrica	*Fungia granulosa*
	Porites nigrescens	*Montipora confusca*
	Acropora plana	*Pavona cactus*
		Monipora capricornis
		Cycloseris sp.

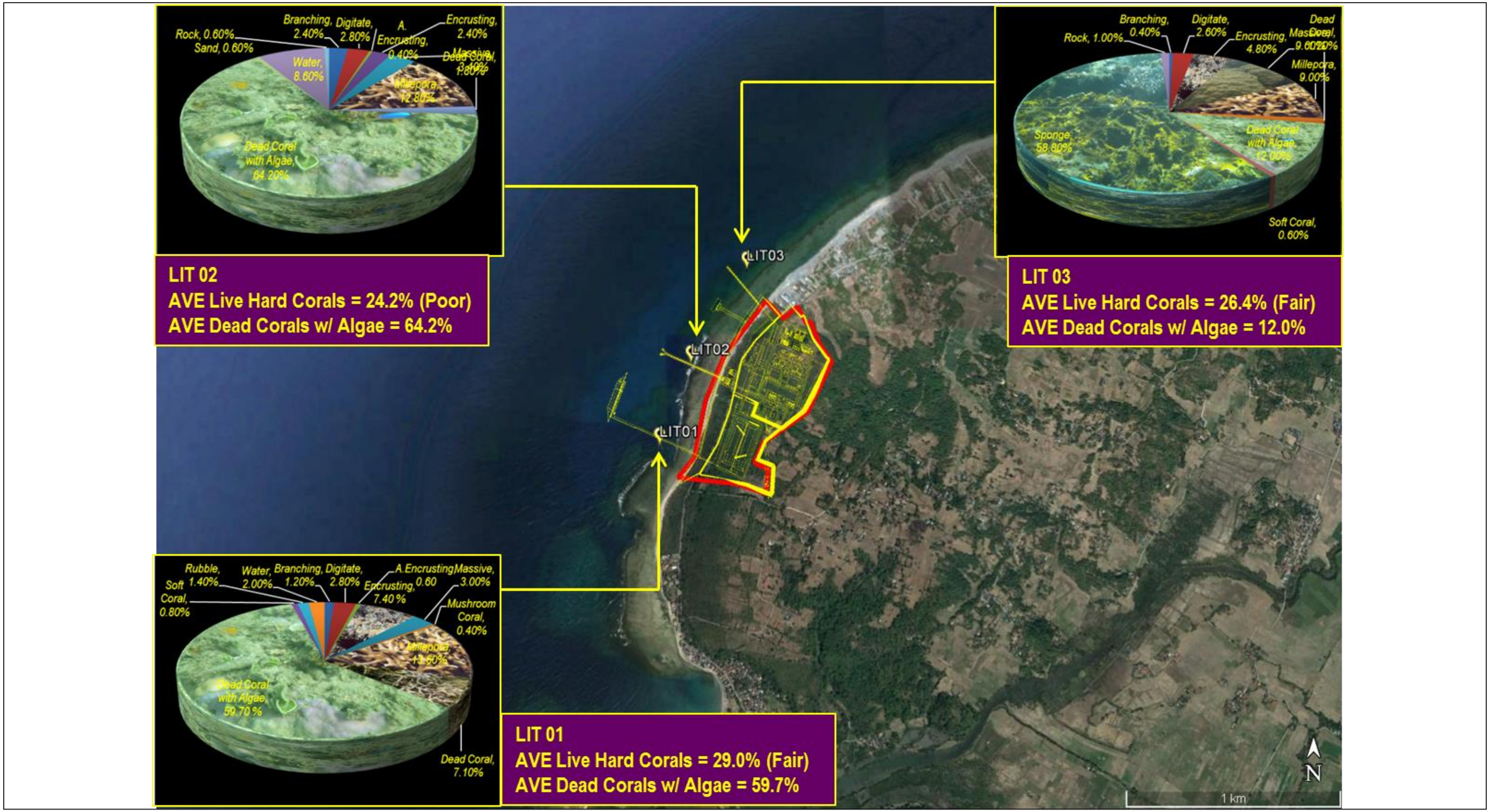
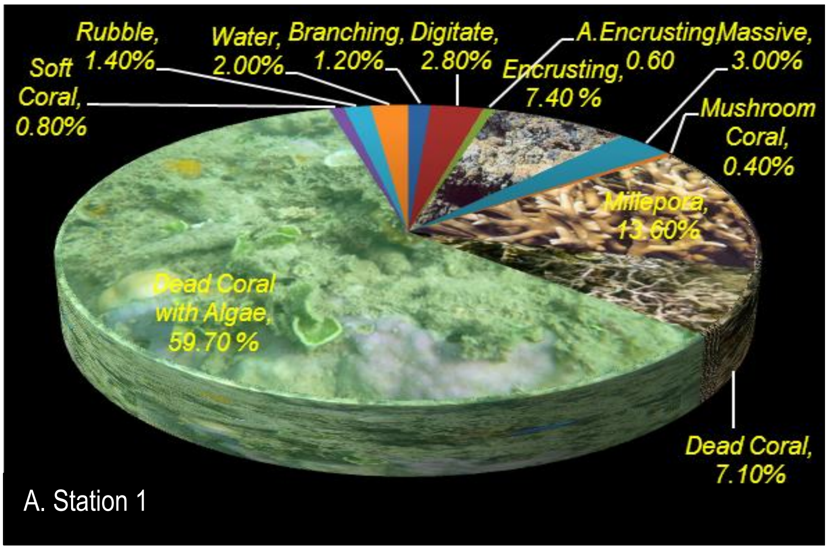
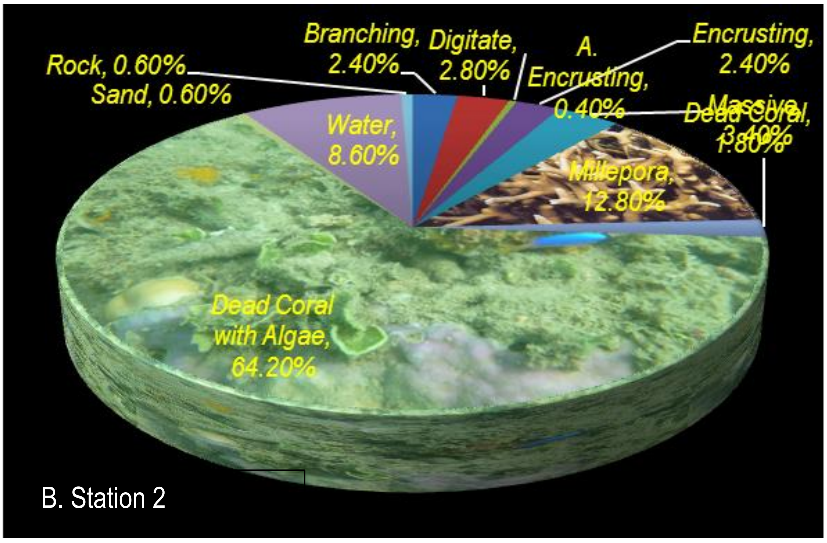


Figure EW-79. Percentage Coral Cover in Three LIT Stations	LEGEND:	SCALE:	DATA INFORMATION/SOURCE:	PAGE 293
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	Project Site Line intercept station	AS ABOVE	**Basemap:** GOOGLE EARTH IMAGERY **Created by:** APERCU CONSULTANTS, INC (2016)	aperçu CONSULTANTS INC





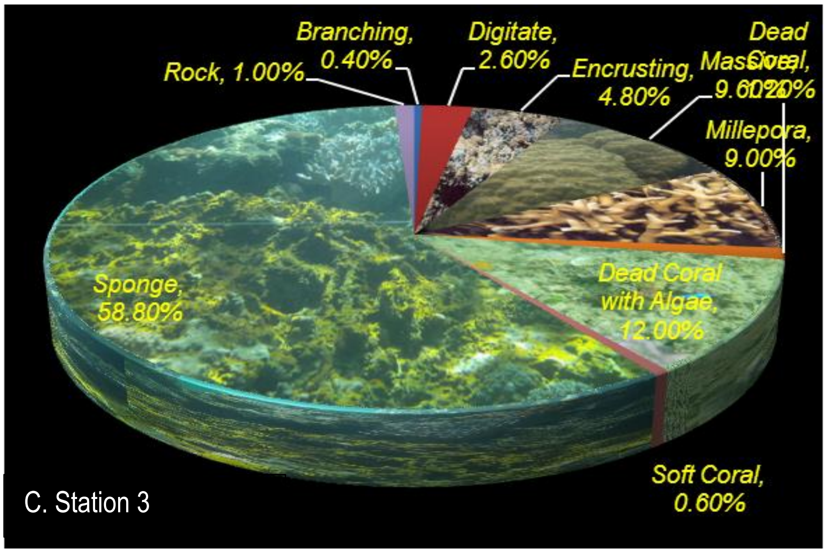


Figure EW-80. Percentages of coral cover and abiotic components in LIT Stations: A: Station 1, B: Station 2, and C: Station 3

The primary threats to the corals in the project site during the construction phases are: 1) loss of coral cover, 2) increased turbidity, and 3) water quality degradation. These may occur when structures like the intake pipe, the outfall pipe, and the jetty undergo construction.

To avoid potential loss of coral cover, the design of the outfall and intake pipe will consider the least disturbance to coral reef patches by selecting the most suitable pathways in the least coral-encrusted areas of the sea. For the position of the discharge, two options may be considered - (i) located past the slope of the coral colony in the area of LIT Station 2 or manta tow station T10-T11 (estimated at 150 meters from the mean tidal mark) (ii) or in the northern extreme boundary of the project site where rocks become the dominant substrate. Additionally, the pipe should not reach the coral slope. If the outfall pipe will be positioned to extend past the reef slope, it is estimated that a breadth of about 10-15 meters of coral-encrusted portion of the slope will be in the direct path and corals may be dislodged during pipe laying activities.

Depending on its length, the jetty pylons may pass through the reef slope and the most ideal site would be just above the mid-point of the length of the coastline in the project site. In this manner, the jetty's ship bays/berthing docks will be located way beyond the coral reef slope. A separate detailed survey of the presence and configuration of the reef ledge and drop off will be undertaken in order to factor this into the design of the jetty and to ensure the least number of coral heads are impacted.

If corals will be unavoidably removed to accommodate project coastal structures, some of the branching coral fragments will be transplanted to undisturbed locations employing the most recent technological practices to ensure survival and re-growth. An area of translocation with formed substrate, clear water, and no freshwater intrusion will be identified and demarcated as a special management area in close coordination with the local BFAR office.

The deterioration of water quality will be induced by increasing turbidity as sediments get sequestered in the water column or get stirred up by strong wave action as well as by construction activities on the coast. Increased turbidity may lead to coral polyp suffocation.

Based on observations of DCA values across all three coral stations, silt pollution in the project site and contiguous coastal environs is occurring but these have not reached extreme proportions to cause widespread coral polyp mortality or suffocation. Additional sediment loads is most likely to occur during the construction of the coastal structures (e.g. jetty, intake pipe, and outfall). To reduce the potential damage to corals, the dispersion of sediments resulting from construction activities will be minimized using silt booms/curtains and silt reduction devices installed in areas before the coral slope. Additionally, activities will be conducted during calm weather or between tidal cycles to prevent the spread of suspended sediments.

Human habitation is expected to increase within the proposed site during the construction phase, which could lead to degraded water quality from waste generated by the increased population. Domestic garbage, particularly non-biodegradable waste is expected to increase in the area. Wastewater discharge and sewage runoff, particularly in periods of rain, can all lead to eutrophication of nearby waters. Increased boat traffic may also contribute as a source of oil pollution. In order to mitigate these impacts, proper soil and waste management plans will be implemented.

One of the potential threats during the operation phase is increased coral bleaching which can be brought about by thermal discharges. The current surveys indicate that coral bleaching is present in the area. To prevent bleaching caused by the project's thermal discharges, the outfall will located away from coral areas, at sufficient depth to induce mixing and the temperature of the discharge will be within DENR requirements.

Another threat during the operation phase is increased boat/vessel traffic delivering coal to the site, which may be sources of bilge water and potential leaks and spillages. GLEDC will ensure that the marine vessels will comply with the requirements of Presidential Decree No. 979 or the Marine Pollution Decree of 1976 by prohibiting the following acts:

a. ***discharge, dump or suffer, permit the discharge of oil, noxious gaseous and liquid substances and other harmful substances from or out of any ship, vessel, barge, or any other floating craft, or other man-made structures at sea, by any method, means or manner, into or upon the territorial and inland navigable waters of the Philippines;***

b. ***throw, discharge or deposit, dump, or cause suffer or procure to be thrown, discharged, or deposited either from or out of any ship, barge, or other floating craft of vessel of any kind, or from the shore, wharf, manufacturing establishment, or mill of any kind, any refuse matter of any kind or description whatever other than that flowing from streets and sewers and passing therefrom in a liquid state into tributary of any navigable water from which the same shall float or be washed into such navigable water; and***

c. ***deposit or cause, suffer or procure to be deposited material of any kind in any place on the bank of any navigable water or on the bank of any tributary of any navigable water, where the same shall be liable to be washed into such navigable water, either by ordinary or high tides, or by storms or floods, or otherwise, whereby navigation shall or may be impeded or obstructed or increased the level of pollution of such water (Presidential Decree no. 979).***

In addition to the above measures, GLEDC will help protect the coral colony in the middle area by supporting efforts to prevent the use of destructive fishing practices in the area. Focal conservation areas where reproductive processes can occur unimpeded will be established with the help of the Fisheries and Aquatic Resource Management Council of Luna.

2.5.3.3 Reef-associated Fish Assemblages

Fish visual census (FVC) was undertaken in the same stations where line intercept transects for coral communities and substrate was laid out (**Figure EW-81**).

A total of 4804 reef-associated fish individuals were counted in all three FVC stations, consisting of 21 species representing 13 families (**Table EW-51**). Target fishes dominated the population with 15 species, indicator species consisted only of four (4) species while 'other' species comprised 2 species across all stations (**Figure EW-79**). Of the target species seen, nine (9) are popular species for hook and line fisheries. The highest fish abundance were encountered in Stations 1 and 3 where schools of fusiliers (*Dalagang Bukid*) and oxeye scad (*Salay-salay*) were encountered as they entered the FVC belts. Altogether, these fishes numbered a total of about 4200 individuals accounting for about 87% of abundance in the stations surveyed. The redbelly yellow-tailed fusilier *Caseo cuning* and the blue-and-gold fusilier *Caseo caerulaurea* dominated the schools of fishes, numbering an estimated 2800 individuals. The huge number of fusiliers hovering over the reef is suspected to be forming a spawning aggregate of mature individuals. Both species are primary targets of municipal fisheries and is important for fish-food supply. On the other hand, the oxeye scad (*Selar boops*) numbered 1400 individuals and consisted of mature fishes as well (**Figure EW-82**). This species is a primary species for dried fish production.

Without the fusiliers and scads, the fish profile in the three stations surveyed would have been *extremely poor* at only 604 individuals for 18 species. The small rabbitfish (*Siganus spinus*) dominated the net population with 300 individuals found in Station 3 where many scads and fusiliers were also encountered. The spinefoot rabbitfish is an important species sought by the local community for production of fish paste. It appears that the siganid population in this northern section of the project site, past its boundary in Barangay Nalvo Sur, is comprised of mature individuals grazing on macro-algae. After the rabbitfish, damselfishes were the most numerous, with 140 individuals in Stations 2 and 3. Again, minus the rabbitfish school, the fish population was altogether, not remarkable.

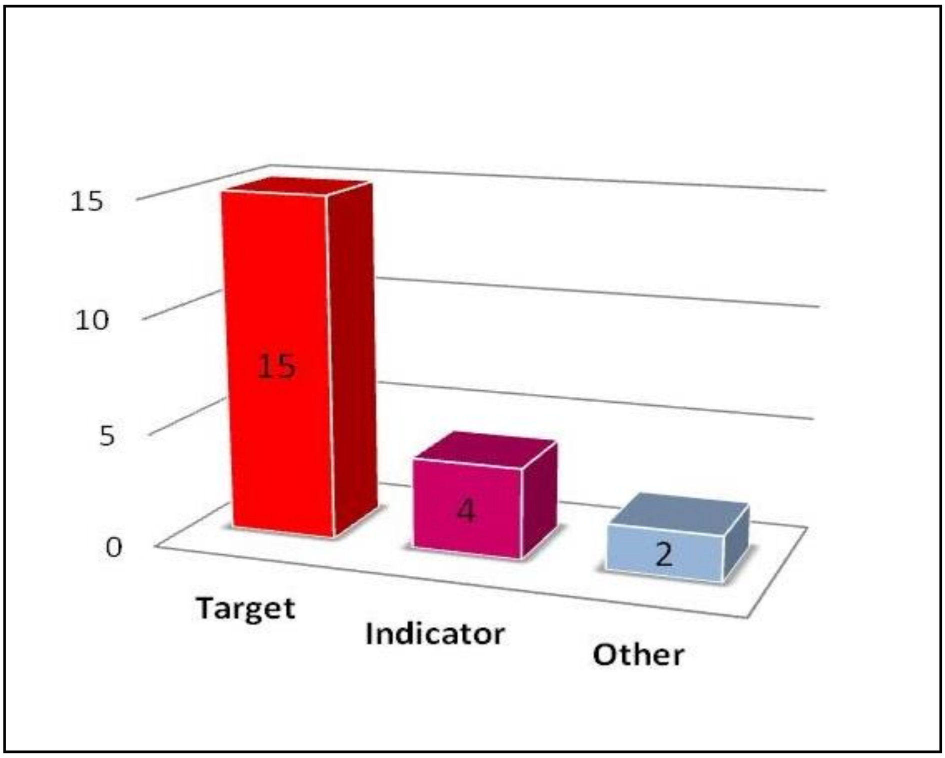


Figure EW-81. Fish species richness and abundance per fish family in three FVC stations, Luna, La Union on July 2016

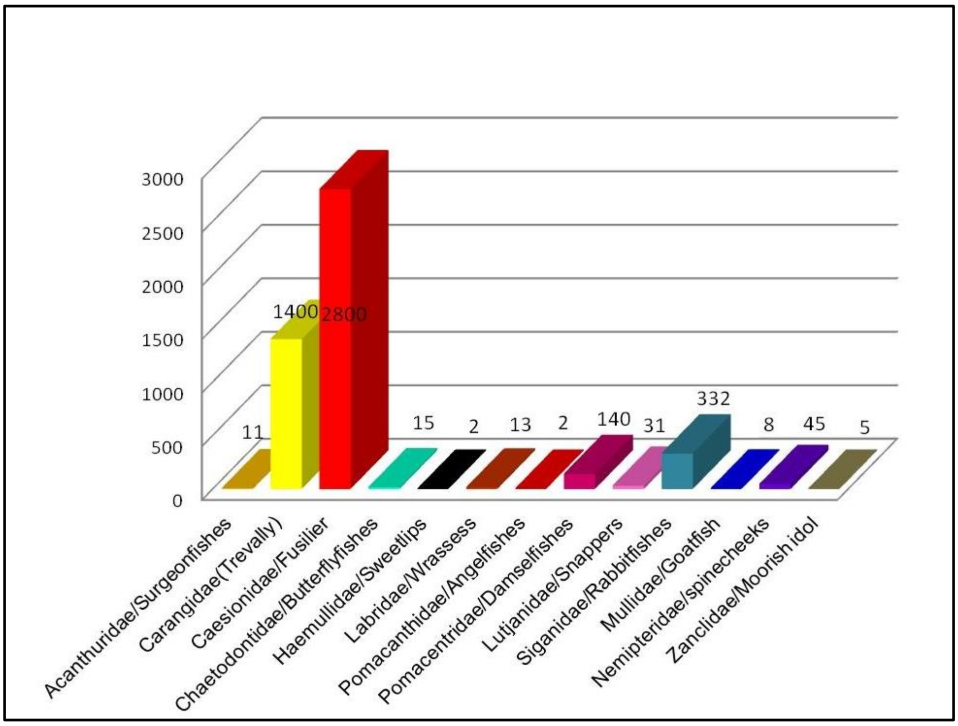


Figure EW-82. Species richness in three FVC stations, Luna, La Union; July 2016

Table EW-51
Fish Abundance Data Form

Site Name: Barangays Carisquis and Nalvo Norte		Municipality & Province: Luna, La Union
Date: July 23-24, 2016		Observers: Victor L. Pantaleon and Ronald T. Pocon
Time: 8:02 A.M.		Depth(m): 2 – 6; reef slope
Coordinates	Station 1: 16.83215^0 N, 120.33208^0 E	
	Station 2: 16.83602^0 N, 120.33350^0 E	
	Station 3: 16.84062^0 N, 120.33617^0 E	

Family	English Name	Scientific Name	Common Name	Station 1		Station 2		Station 3		Total # of individuals
				# of ind	Size *(cm)*	# of ind	Size *(cm)*	# of ind	Size *(cm)*	
Acanthuridae	Surgeonfishes	*Acanthurus lineatus*	Lined surgeonfish			5	15	6	15	11
Chaetodontidae	Butterflyfishes	*Chaetodon auriga*	Threadfin butterflyfish	10	8					10
Chaetodontidae	Butterflyfishes	*Chaetodon trifacialis*	Chevron butterflyfish	5	7					5
Caesionidae	Fusilier	*Caseo cuning*	Redbelly yellow-tailed Fusilier	300	20			350	13	650
Caesionidae	Fusilier	*Caseo caerulaurea*	Blue-and-Gold Fusilier	1500	17	150		500	16	2150
Carangidae	Trevallies	*Selar boops*	Oxeye scad	400	12			1000	15	1400
Haemullidae	Sweetlips	*Plectorhincus lessoni*	Lesson's thicklip	2	25					2
Labridae	Wrasses	*Choerodon anchorago*	Orange-dotted tuskfish			4	16			4
Labridae	Wrasses	*Cheilinus trilobatus*	Tripletail wrasse			2	25			2
Labridae	Wrasses	*Cheilinus fasciatus*	Redbreasted wrasse					2	25	2
Labridae	Wrasses	*Labroides dimidiatus*	Bluestreak cleaner wrasse					5	4	5
Lutjanidae	Snappers	*Lutjanus decussatus*	Checkered snapper	30	15					30
Lutjanidae	Snappers	*Lutjanus lunulatus*	Lunartail snapper	1	40					1
Mullidae	Goatfish	*Parupeneus barbarinus*	Dash & Dot Goatfish	8	5					8
Nemipteridae	Spinecheeks	*Scolopsis lineata*	Striped monocle bream	20	10	25	8			45
Pomacentridae	Damselfishes	*Abudefduf sexfasciatus*	Scissortail Sergeant			80	7			80
Pomacentridae	Damselfishes	*Abudefduf sexfasciatus*	Scissortail Sergeant			60	9			60
Pomacanthidae	Angelfishes	*Pomacanthus semicirculatus*	Semicircle angelfish	2	15					2
Siganidae	Rabbitfishes	*Siganus gutatus*	Orange-spotted Spinefoot					7	30	7
Siganidae	Rabbitfishes	*Siganus spinus*	Little spinefoot			20	7	300	5	320
Siganidae	Rabbitfishes	*Siganus vulpinus*	Foxface rabbitfish			5	6			5
Zanclidae	Moorish idol	*Zanclus cornutus*	Moorish idol	5	7					5
Total # of individuals per transect ($500m^2$)				***2,283***		***351***		***2,170***		***4,804***
Richness Species Richness										
Total number of fish families										***13***
Total number of target species▪										***15***
Total number of indicators										***4***
Total number of other species										***2***
Total number of species										***21***

The overall assessment of the demersal fish profile of the area in front of project site is poor, with species richness comprised of 11 fish families (without the fusiliers and scads that will ultimately move out to open waters), dominated by juveniles. The low species richness and density on the reef flats and slope indicates declining fisheries productivity and this is manifested in the presence of mostly juvenile fishes and the low numbers of food fish species. The factors that contribute to this low fisheries profile could primarily be recruitment overfishing and the loss of coral habitats in the past. The narrow slope of the fringing reef also limits the spatial capacity for fish abundance. Anecdotal accounts from fishers in the area also confirm the absence of long-lived demersal fish species in the near shore waters. There were no significant populations of groupers and emperors encountered on the reef slope. No sea turtles were seen either except for the presence of 'Gray Drummer Chubs' (*Kyphosus bigibbus*) in the deeper slope, the survey did not encounter any significant population of mature spawning aggregations of high value food fish.

The fish biomass was recorded at 5 kg for food fish, owing to the huge number of fusiliers and scads. In contrast, fish biomass for indicator and 'other' species were computed at 0.005 and 1.05 kg., respectively shown in **Figure EW-83** as follows:

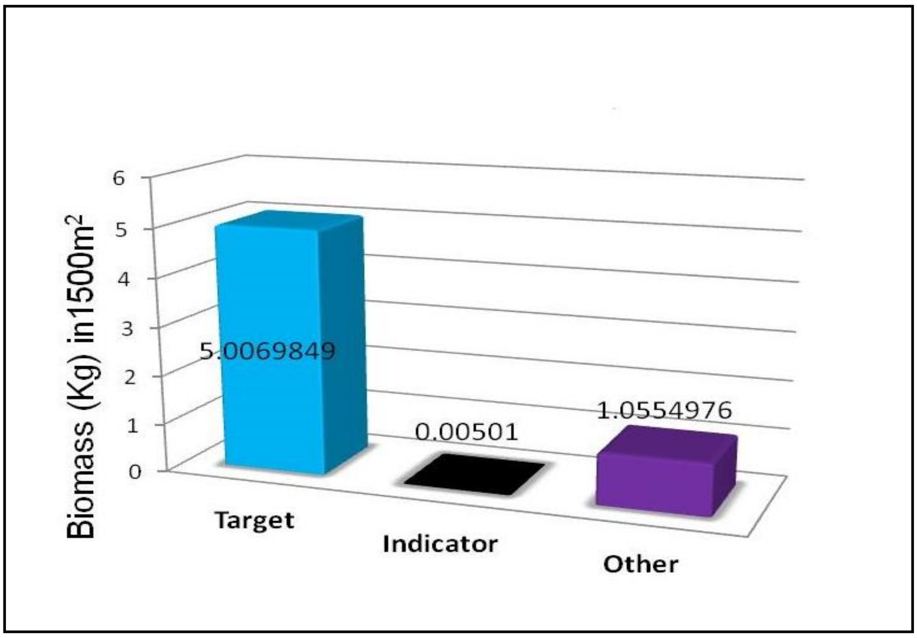


Figure EW-83. Fish biomass of target, indicator and 'other' species of fish counted in three FVC stations Luna, La Union.

The low species richness and density of demersal fishes will further decrease if the thriving coral reefs in the area will be affected, since these corals serve as their habitat, refuge and food source. The location and orientation of the project's coastal structures will be constructed taking into consideration the path of least disturbance to corals.

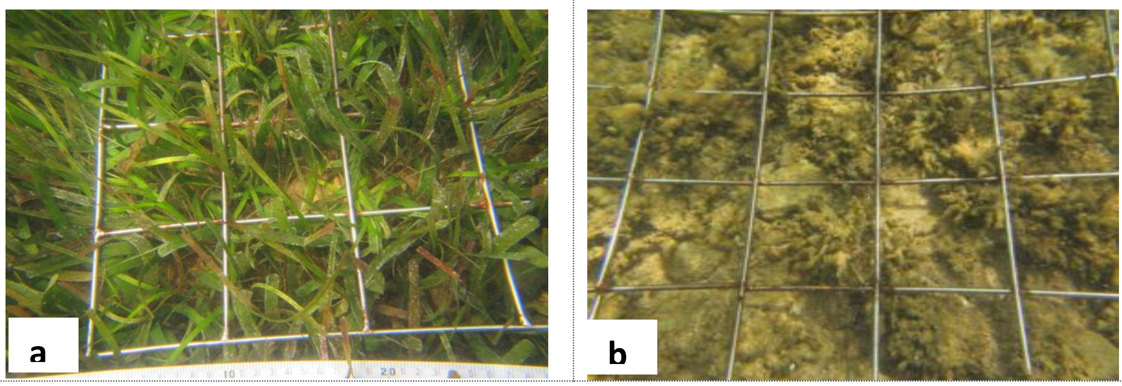
During the operation phase, the jetty structure is expected to serve as a fish aggregating device. The jetty columns serve as suitable substrates for the colonization of corals and its associated biota. Over time, the assemblage attracts various fish, and the submerged sections of the jetty develop into a stable marine community that can be a source of recruitment and propagules for nearby reefs.

The issue of overfishing, which is assessed to be occurring in the area, will be difficult to address unless alternative and supplementary sources of income for coastal communities can be enabled. Intensifying eco-tourism, with inclusive benefits, can be a major vehicle to achieve improvements in rural income over time. The Proponent will support efforts to improve habitats, fish production, and prevent the use of destructive fishing practices. Focal conservation areas where reproductive processes can occur

unimpeded will be established with the help of the Fisheries and Aquatic Resource Management Council of Luna.

2.5.3.4 Seagrass Resources

Three stations were surveyed for seagrass communities employing ten quadrates per station (**Figure EW-72**). The first station is located in the cove of Barangay Darigayos where the most dense seagrass beds were observed during manta tow surveys (**Plates 35a** and **b**). Three contiguous stations were laid out near the southern boundary of the project site in Barangay Carisquis. These three stations host intermittent seagrass beds interspersed with sandy substrate and rocks located in the shallow flat about 20 meters from the rocky coastline. Drawing from the results of the broad area manta tow surveys, it appears that this is the only site within the coastal impact area of the project where seagrass occurs. The seagrass meadows occupy the inner tidal flat, consisting of scattered patches measuring less than one hectare in aggregate. Results from the four quadrats evaluated reveal four (4) seagrass species present in the study area, dominated by *Cymodocea rotundata (ribbon seagrass)*. The other species consist of *Thalassia hemprichii* (Sickle seagrass), *Syringodium isoetifolium* (tube seagrass) and *Enhaulus acoroides* (eel seagrass) (**Figure EW-84** and **Table EW-52**). The seagrass beds are frequently used by fishers in Bgy. Carisquis to harvest benthic and epibenthic invertebrates, particularly the Almond Arkshell (*Barbatia amigdalumtostum*). This bivalve thrives extensively in rocks and dead corals along the southern portion of plant site and is being collected by gleaners either for food or trade. The capture of rabbitfishes is also frequent in the meadows with the use of scoop nets.



Plates EW-35a & 35b. Dense seagrass in one quadrat (left) and dead corals with algae and rocks in another quadrat (right) Luna, La Union; July 2016.

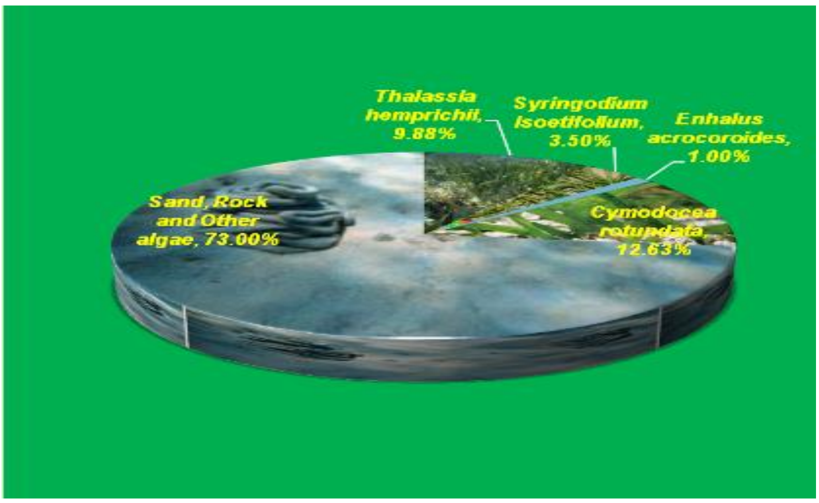


Figure EW-84. Species of seagrass and percentage distribution across four survey transects Luna, La Union.

Table EW-52
Summary of Results of Seagrass Assessment in Four (4) Survey Stations
Luna, La Union (July 2016)

Transect No.:	Location/ Geographic Coordinates		Quadrant No.:	Seagrass Distribution by species *(in % of total)*				Total Reading (in %)	Remarks
	Latitude	Longitude		*Thalassia hemprichii*	*Syringodium isoetifolium*	*Enhalus acoroides*	*Cymodocea rotundata*		
1	N 16.82241^0	E 120.33434^0	1	80				100	20% Sandy mud
			2	60			10	100	30% Sandy mud
			3	40			10	100	10% Rock and 40% Sandy mud
			4	40		10	20	100	30% Sandy mud
			5	30			40	100	30% Sandy mud
			6	35			25	100	40% Sandy mud
			7	25			5	100	70% Sandy mud
			8			30	10	100	40% Sandy mud and 20 Rubble
			9				10	100	90% Sandy mud
			10	10			30	100	60% Sandy mud
2	N 16.83171^0	E 120.33352^0	1				5	100	95% Rock
			2					100	100% Rock
			3	5			95	100	5% Sand
			4	5			85	100	5% Sand and 5 %Rock
			5					100	30% Turf algae and 70% Rock
			6					100	40% Turf algae, 20% Sand and 40% Rock
			7					100	100% Rock
			8					100	60% Sand, 30% Turf algae and 10% Rock
			9					100	50% Turf algae, 40% Rock, 5% Sponge and 5% Sand
			10					100	100% Rock
3	N 16.83252^0	E 120.33367^0	1	10	5		75	100	10% Sand
			2	15	5		70	100	10% Rock
			3					100	100% Rock
			4					100	80% Turf algae and 20% Rock
			5					100	40% Turf algae and 60% Rock
			6					100	40% Turf algae and 60% Rock

Table EW-52 continued

Transect No.:	Location/ Geographic Coordinates		Quadrant No.:	Seagrass Distribution by species *(in % of total)*				Total Reading *(in %)*	Remarks
	Latitude	Longitude		*Thalassia hemprichii*	*Syringodium isoetifolium*	*Enhalus acoroides*	*Cymodocea rotundata*		
			7					100	90% Turf algae and 10% Rock
			8					100	60% Sargassum, 10% Sand and 30% Rock
			9					100	15% Sargassum, 5% Sponge and 80% Rock
			10					100	40% Sargassum and 60% Rock
4	N 16.83318^0	E 120.33393^0	1	40	50			100	10% Sand
			2					100	10% Sand and 90% Rock
			3		80		10	100	10% Sand
			4				5	100	20% Sand and 75% Rock
			5					100	60% Sand, 10% Turf algae and 30 Rock
			6					100	10% Sand, 40% Turf algae and 50 Rock
			7					100	30% Sand, 10% Turf algae and 60 Rock
			8					100	100% Sand
			9					100	10% Sand and 90% Turf algae
			10					100	10% Sand, 80% Turf algae and 10 Rock
Average percent distribution by species				***9.88***	***3.50***	***1.00***	***12.63***	***100***	*73 % Sand, Rock and other algae.*

On a per station basis, Station 1 which is located outside of the project site's boundary, hosted profuse seagrass with 52% of the quadrat populated with three species of seagrass dominated by *Thalassia hemprichii.* The three contiguous seagrass stations investigated contained an average of 17.33 % seagrass consisting of three species. Sand, rocks and other macro-algae dominated the seabed along the surveys pathways (**Figure EW-85**). Although sparsely distributed in intermittent patches, the seagrass beds were growing profusely with no signs of disturbance. Although gleaning for shellfish and small rabbitfish are being undertaken in the area frequently, it is apparent that local fishers are not using active gears that can scrape or damage the seagrass and rocks around the beds.

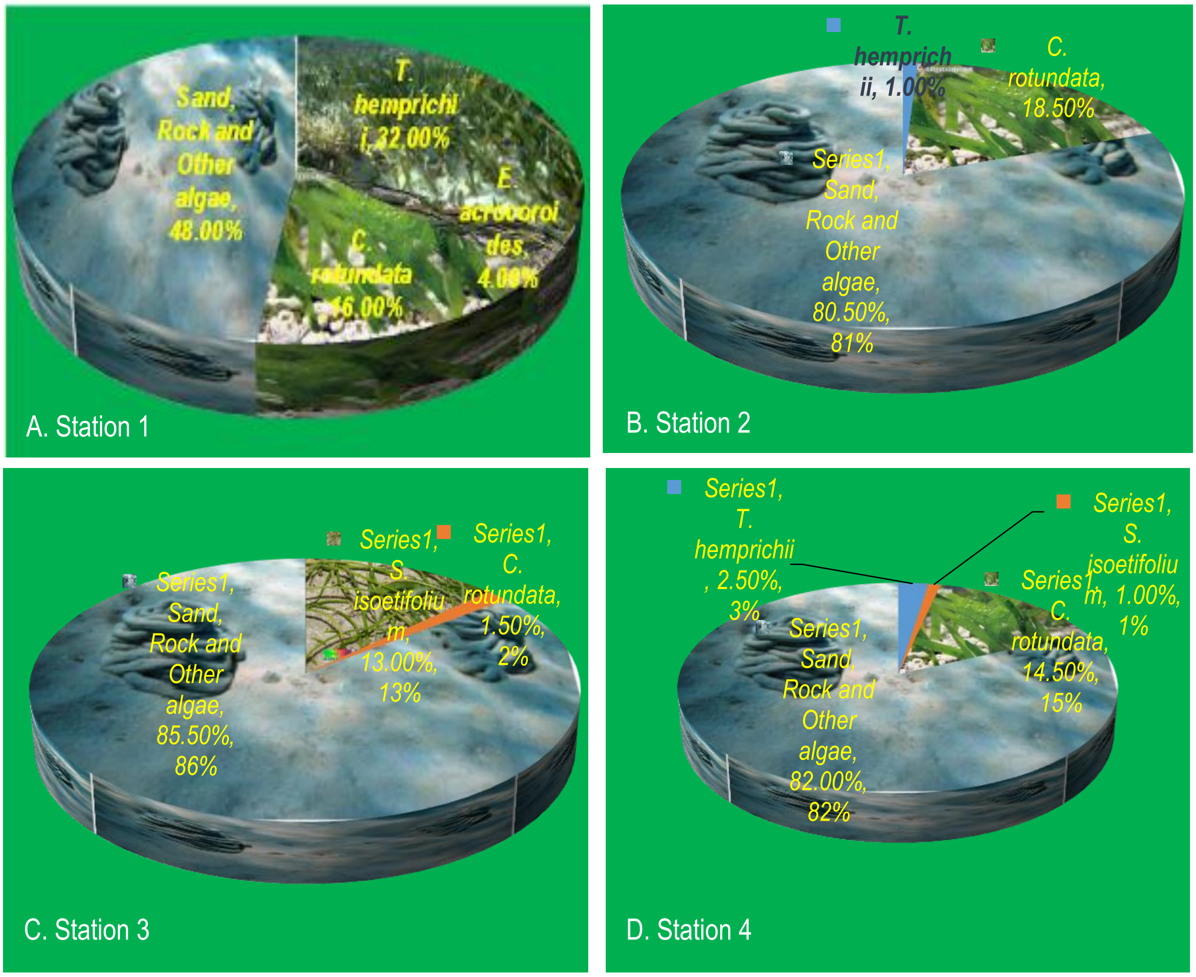


Figure EW-85. Seagrass distribution by species in four transects surveyed, Luna, La Union; July 2016: Top left to right – Stations 1 and 2; Bottom left to right – Stations 3 and 4.

The growth of seagrass meadows in the shallow portions of the sea in the southern boundary of the project site can be affected if sediment intrusion becomes extreme and the benthic substrate is blanketed by loose silt. This may occur during the construction of the project's coastal structures. The mitigating measures to prevent increased turbidity and sedimentation (e.g use of silt curtains; scheduling of coastal activities, etc.) discussed for corals are applicable for the seagrass beds.

Shipboard wastes during the operation phase and domestic wastes both during the construction and operation phases may result in degradation of water quality and cause die-out of some algae species. A solid waste management plan incorporating the tenets of reuse, recycle and reduce will be develop and implemented. All drainage water will be filtered through a series of settling ponds and filtering devices. Collaboration with the municipal government will also be undertaken to enable adoption of clean practices and domestic waste management. Policy of no shipboard waste disposal will be enforced.

Pollution causes euthrophication or the loss of oxygen through excessive algal blooms which in turn causes the seagrass and algal communities to wilt over long periods of exposure to such anoxic conditions. The densities of plankton groups observed in the coastal area within the vicinity of the project site, however, do not indicate proportions that can cause the occurrence of HABs.

With roots firmly embedded in sandy substrate, seagrasses are the true plants of the sea and their resilience in tolerating a wide range of stresses in the marine environment is manifested in their perennial presence even in silted waters. Seagrass meadows provide shelter to many species of fish and invertebrates and the diversity of the seagrass beds in an area can be a contributing factor to the recruitment of rabbitfishes, seahorses, sea cucumber, some species of shrimps, and the settlement of mollusks, small cephalopods, crustaceans and associated epiphytes. Dense seagrass meadows can create a barrier that subsequently decreases water currents while the seagrass roots and rhizomes can help stabilize the seabed by sequestering and fastening sediments and silt onto the bottom substrate. Because of this, it is of primary importance that the seagrass meadows in the southern boundary of the project site should be conserved and monitoring of their condition would be a valuable element of environmental management. To assist in maintaining the seagrass beds in the area, investigations on the propagation of seagrass communities in the reef flat will be undertaken during the operation phase.

2.5.3.5 Commercially-important Macro-invertebrates

Macro-invertebrate surveys were undertaken through opportunistic observations and observations within the 5-meter belt of the coral line-intercept transects. The investigation focused on macro-invertebrates of significant economic value to local fishers, in order to assess whether these organisms are susceptible to any disturbance of anthropogenic origin. Qualitative sampling was conducted by means of scuba diving in two LIT stations and in two other stations – one of which was located in the seagrass meadow (Station Mac 1) and another on the rocky-sandy shoreline in the northern boundary of the project site (Station Mac 1; **Figure EW-73**). **Table EW-53** shows the list of macro-invertebrates found in the areas surveyed.

Table EW-53
List of Macro-invertebrates Encountered in Survey Stations, Luna, La Union

Species Name	Common Name	Habitat	Group
Barbatia amigdalumtostum	Almond Arkshell	Rocks	Gastropod
Trochus niloticus	Top shell	Coral reef	Gastropod
Conus sp 1	Conus shell	Coral reef	Gastropod
Turbo setosus	Rough turban	Coral reef	Gastropod
Conus marmoreus	Conus shell	Coral reef	Gastropod
Scapharca globosa	Globose arkshell	Sandy substrate	Bivalve
Codakia tigerina	Pacific tiger lucine	Sandy substrate in coral reef	Bivalve
Turbo sp	Turban shell	Inter-tidal areas	Gastropod
Tectarius sp	Perwinkle	rocks	Gastropod
Litoria sp	Perwinkle	sand	Gastropod
Cypraea sp	Cowrie	corals	Gastropod
Linkia sp	Sea star	Coral reef	Echinoderm
Stylissamassa sp.	Sponge	Coral reef	Poriferan
	Sponge2	Coral reef	Poriferan
Palythoa sp	Zoanthids	Coral reef	Zoanthid
Diadema sp	Sea urchin	corals	Echinoderm
Lambis	Spider shell	Sand-seagrass	Gastropod

Few species of macro-invertebrates (**Plates EW-36a, b** and **c**) were found in all stations surveyed except in the rocky-seagrass area where around eight (8) kilos of the arkshell (*Barbatia amigdalumtostum)* were collected by four gleaners at the time of the survey. A total of 16 species were found in opportunistic surveys, of which nine (9) species were noted to have commercial importance and/or considered edible based on "*FAO Species Identification Guide for Fishery Purposes".* These include the spider shell, lucine shells and periwinkles.

However, specimens collected consisted of solitary individuals and no aggregations were found, except for the almond arkshell which were distributed over a wide area in the rocky and seagrass beds.

On another note, the reefs were completely devoid of species of the *Tridacna* family which are, under normal circumstances, present in corals.

36a Conus shells

36b Almond arkshell

36c Turban shell

Plates EW-32a-b-c. Some species of significant macro-invertebrates found in the survey area.

These populations of macro-invertebrates can be affected by alterations in the inter-tidal shoreline. These alterations include conversion or establishment of coastal structures for the project and small boat dockings, both of which can lead to loss of habitats for mollusks.

Additionally, if contaminated by land-based pollutants, the population of bivalves and other shellfish such as the edible arkshell can be impacted resulting in a decrease in the population.

To prevent any significant effect on the macro-invertebrates, no additional structures apart from the intake and outfall pipes and the jetty will be constructed on shore. Alterations in the land-sea interface will be kept to a minimum. No permanent structures will be built in sensitive areas where bivalves are assessed to reproduce and all temporary structures will be removed immediately. Also, a focal conservation zone in the inter-tidal area with adequate tidal movement and replenishment will be declared. Human traffic will be restricted and managed to ensure very little disturbance to natural processes.

2.5.3.6 Plankton

Plankton samples were collected using 20 µm and 60 µm nets for phytoplankton and zooplankton, respectively. A total of 6 stations were selected with Stations 1, 2 and 6 representing control sites and Stations 2, 3 and 4 as potential impact sites (**Figure EW-74**). Two samples were collected from each station and were immediately preserved in Lugol's solution for phytoplankton and 10% formalin for zooplankton. These were brought to the laboratory for sorting and identification.

Phytoplankton

The phytoplankton assemblage collected off the coast of Luna, La Union was typical of tropical coastal waters. Generally, plankton group belonging to class *Bacillariophyceae* (2,555,232 cells/m^3) was the most dominant, accounting for 49-96% of the community, followed by class *Cyanophyceae* (633,046 cells/m^3) at 3-61 %, class *Dinophyceae* (68,616 cells/m^3) at 1-3% and class *Dictyochaphyceae* at 2 % (**Figure EW-86**, **Table EW-54**). Station 6, a control station located in front of Nalvo Norte had the highest total cell density. The small centric chain-forming diatom belonging to genus *Chaetoceros* (**Plate EW-37a**) was the most common and abundant genera which constituted 44%, followed by a pennate chain-forming diatom *Pseudonitzschia* (**Figure EW-86**) which constituted 22% (**Table EW-50**). The marine cyanobacteria of the genus *Trichodesmium* (**Plate EW-37c**) also had a significant contribution to phytoplankton community particularly in Stations 3, 4, and 5 (38-61%) off the coast of Brgy. Carisquis where the proposed project site is located (**Figure EW-86**). The lowest phytoplankton concentration was found in Station 3. The highest number of species was found in Station 2, off the coast of Brgy. Darigayos while the lowest was observed in Station 1 just outside the small embayment off the coast of Brgy. Darigayos. This is expected since higher number of phytoplankton species tend to be generally observed in coastal embayments rather than in open water, where they are more affected by water currents and waves.

Table EW-54
Phytoplankton Composition and Abundance (cells/m³) in Six Stations
Luna, La Union (July 2016)

Taxa	Stations						Grand	Imp
	1	2	3	4	5	6	Total	Val
Bacillariophyceae	301,031	769,076	90,037	227,985	121,491	1,045,611	2,555,232	78.29
Asterionella			786	33,364	8,257	14,154	56,561	1.73
Bacillaria			786				786	0.02
Campylodiscus					2,949		2,949	0.09
Chaetoceros	101,102	312,306	74,310	136,488	27,129	769,097	1,420,432	43.52
Coscinodiscus	107,926	3,539	1,573			13,649	126,686	3.88
Guinardia		1,180					1,180	0.04
Hemiaulus		5,750		5,561			11,311	0.35
Leptocylindrus		55,732					55,732	1.71
Licmophora	8,846	2,654					11,500	0.35
Munuera		1,769					1,769	0.05
Odontella				1,011			1,011	0.03
Proboscia		2,212	786	2,528	1,769	2,528	9,822	0.30
Pseudonitzschia	70,771	360,934	5,504	19,715	64,284	182,489	703,698	21.56
Rhizosolenia	5,308	23,001	3,932	29,320	17,103	55,606	134,269	4.11
Thalasionema			2,359			8,088	10,447	0.32
Thalassiosira	7,077						7,077	0.22
Dinophyceae	**7,077**	**11,943**	**3,932**	**7,583**	**11,795**	**26,287**	**68,616**	**2.10**
Ceratium furca					1,769		1,769	0.05
Ceratium fusus		1,769	1,966		1,180		4,915	0.15
Ceratium macroceros		885					885	0.03
Ceratium teres				2,022			2,022	0.06
Ceratium trichoceros		885				2,022	2,907	0.09
Ceratium tripos					590		590	0.02
Ceratocorys					2,949		2,949	0.09
Diplosalis	3,539	1,327	1,180		3,539	12,132	21,716	0.67
Ornithocercus		2,212					2,212	0.07
Podolompas				1,011			1,011	0.03
Protoperdinium oblongum		3,096		2,528		12,132	17,756	0.54
Protoperdinium pentagonum	3,539				1,769		5,308	0.16
Protoperidinium oceanicum		1,769	786	2,022			4,578	0.14
Cyanophyceae	**97,311**	**20,789**	**90,823**	**141,543**	**208,776**	**73,804**	**633,046**	**19.39**
Trichodesmium	97,311	20,789	90,823	141,543	208,776	73,804	633,046	19.39
Dictyochapheceae	**7,077**						**7,077**	**0.22**
Dityocha	7,077						7,077	0.22
Grand Total	**412,496**	**801,808**	**184,792**	**377,111**	**342,062**	**1,145,702**	**3,263,971**	**100.00**
Mean Abundance	**41,250**	**44,545**	**15,399**	**31,426**	**26,312**	**104,155**		
Richness (S)	**10**	**18**	**12**	**12**	**13**	**11**		
Diversity (H')	**1.70**	**1.32**	**1.17**	**1.52**	**1.30**	**1.15**		
Evenness (J')	**0.74**	**0.46**	**0.47**	**0.61**	**0.51**	**0.48**		

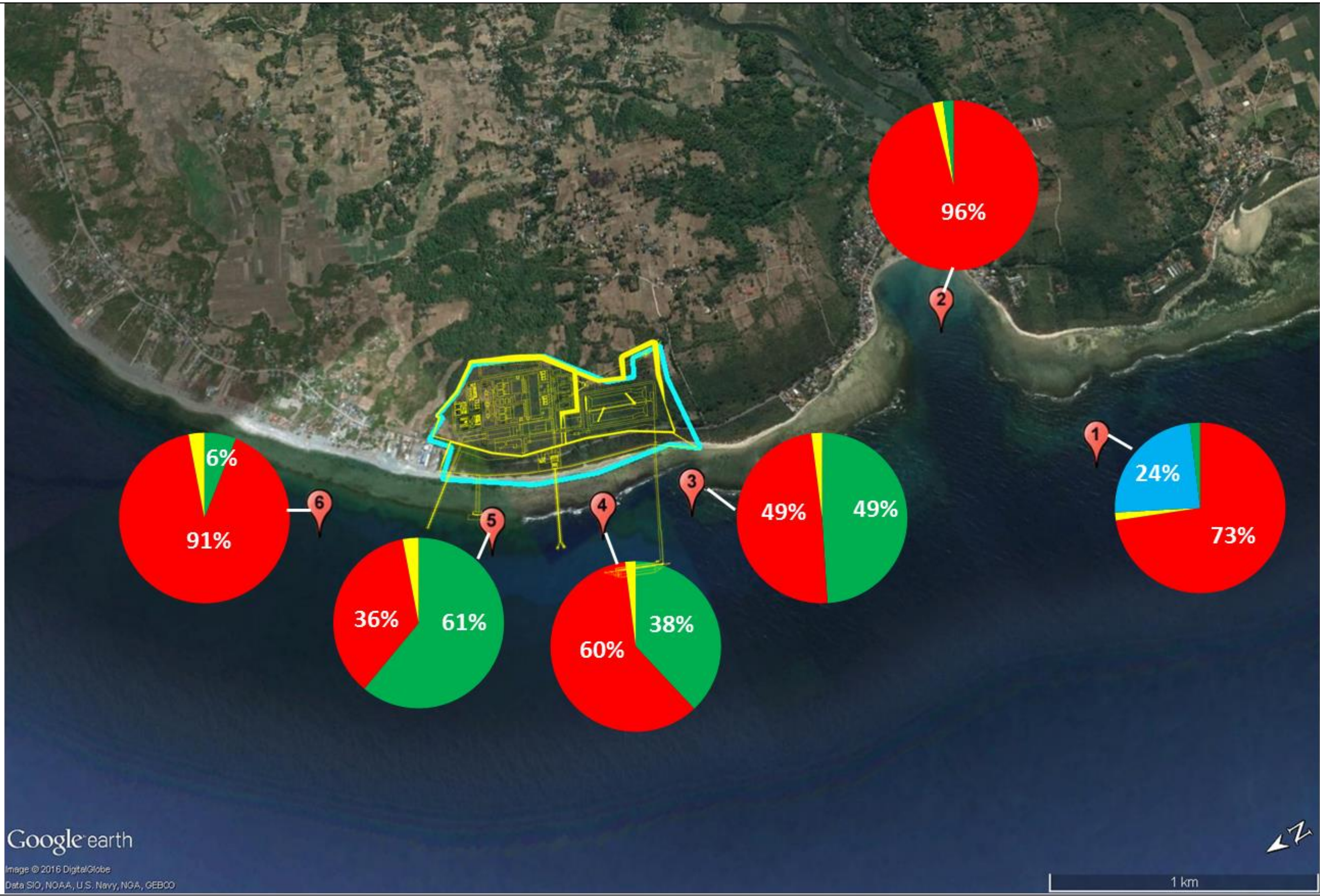
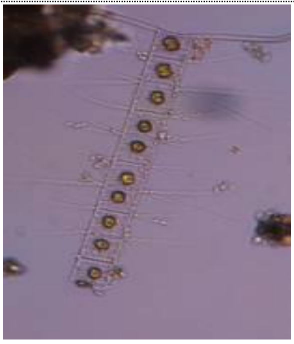


Figure EW-86. Percentage Composition of Major Phytoplankton Groups in Six Sampling Stations	LEGEND: Bacillariophyceae Dinophyceae Cyanophyceae Sillicoflagellate Project Site	**SCALE:** As above	**DATA INFORMATION/SOURCE:** **Basemap:** GOOGLE EARTH IMAGERY **Created by:** APERCU CONSULTANTS, INC (2016)	**PAGE 307**
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT				aperçu CONSULTANTS INC

Table EW-55
Phytoplankton Composition and Abundance (cells/m³) in Six Stations
Luna, La Union (July 2016)

Taxa	Stations						Grand	Imp
	1	2	3	4	5	6	Total	Val
Bacillariophyceae	301,031	769,076	90,037	227,985	121,491	1,045,611	2,555,232	78.29
Asterionella			786	33,364	8,257	14,154	56,561	1.73
Bacillaria			786				786	0.02
Campylodiscus					2,949		2,949	0.09
Chaetoceros	101,102	312,306	74,310	136,488	27,129	769,097	1,420,432	43.52
Coscinodiscus	107,926	3,539	1,573			13,649	126,686	3.88
Guinardia		1,180					1,180	0.04
Hemiaulus		5,750		5,561			11,311	0.35
Leptocylindrus		55,732					55,732	1.71
Licmophora	8,846	2,654					11,500	0.35
Munuera		1,769					1,769	0.05
Odontella				1,011			1,011	0.03
Proboscia		2,212	786	2,528	1,769	2,528	9,822	0.30
Pseudonitzschia	70,771	360,934	5,504	19,715	64,284	182,489	703,698	21.56
Rhizosolenia	5,308	23,001	3,932	29,320	17,103	55,606	134,269	4.11
Thalasionema			2,359			8,088	10,447	0.32
Thalassiosira	7,077						7,077	0.22
Dinophyceae	**7,077**	**11,943**	**3,932**	**7,583**	**11,795**	**26,287**	**68,616**	**2.10**
Ceratium furca					1,769		1,769	0.05
Ceratium fusus		1,769	1,966		1,180		4,915	0.15
Ceratium macroceros		885					885	0.03
Ceratium teres				2,022			2,022	0.06
Ceratium trichoceros		885				2,022	2,907	0.09
Ceratium tripos					590		590	0.02
Ceratocorys					2,949		2,949	0.09
Diplosalis	3,539	1,327	1,180		3,539	12,132	21,716	0.67
Ornithocercus		2,212					2,212	0.07
Podolompas				1,011			1,011	0.03
Protoperdinium oblongum		3,096		2,528		12,132	17,756	0.54
Protoperdinium pentagonum	3,539				1,769		5,308	0.16
Protoperidinium oceanicum		1,769	786	2,022			4,578	0.14
Cyanophyceae	**97,311**	**20,789**	**90,823**	**141,543**	**208,776**	**73,804**	**633,046**	**19.39**
Trichodesmium	97,311	20,789	90,823	141,543	208,776	73,804	633,046	19.39
Dictyochapheceae	**7,077**						**7,077**	**0.22**
Dityocha	7,077						7,077	0.22
Grand Total	**412,496**	**801,808**	**184,792**	**377,111**	**342,062**	**1,145,702**	**3,263,971**	**100.00**
Mean Abundance	**41,250**	**44,545**	**15,399**	**31,426**	**26,312**	**104,155**		
Richness (S)	**10**	**18**	**12**	**12**	**13**	**11**		
Diversity (H')	**1.70**	**1.32**	**1.17**	**1.52**	**1.30**	**1.15**		
Evenness (J')	**0.74**	**0.46**	**0.47**	**0.61**	**0.51**	**0.48**		



37a *Chaetoceros*

37b *Pseudonitzscia*

37c *Trichodesmium*

Plates EW-33a-b-c. Photomicrograph of common and most abundance phytoplankton species in Luna, La Union during the July 22, 2016 sampling

The potentially harmful species observed during the survey is *Pseudoniztschia* spp. Some species belonging to this genus are reported to produce domoic acid, a toxin associated with amnesic shellfish poisoning (FAO, 2000). However, exact species identification of this species was a limitation as it requires observation under a more powerful microscope i.e Scanning Electron Microscope and special sample preparation. However, the risk could be very low and can be even ruled out since cell densities observed in stations where shellfish (notably benthic dwelling Arkshells) were collected by locals was relatively low and there were no anecdotal accounts indicate no experience of this type of poisoning according to some local respondents.

Shannon index of diversity (H') is low ranging from 1.15 to 1.70 with the highest value measured in station 1 while the lowest was observed in station 3 and 5. This diversity measurement is considered low based on the Wilhm criteria (1975) classifying the diversity index <3.0 as low diversity and community stability. In addition, species abundance in station 1 (control station) is more even as indicated by high Pielou's index of evenness (I') as compared to all the other stations. The overall impression of the phytoplankton community in Luna, La Union during this sampling is poor as indicated on the low diversity measurement and species richness.

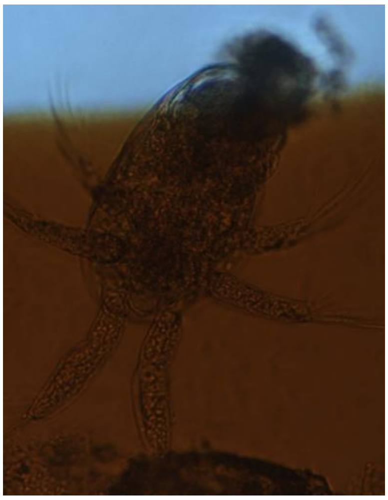
Zooplankton

A total of 12 zooplankton groups (adult and larval forms) were identified (**Table EW-56**) from the six stations along the coast of Luna, La Union. Zooplankton observed consisted of larval form accounting for 60-92% and adult forms only constituting 8-40% of the community (**Figure EW-85**). *Nauplius* copepodite stage (**Plate EW-38a**) at 16,218ind/m^3 were the most abundant larval forms of zooplankton accounting for 66% of the zooplankton community (**Table EW-56**). A large portion of the adult zooplankton were calanoid copepod (Plate EW-34b) at 2,389ind/m^3 comprising 10%. Most of the zooplankton quantified were seen in water samples taken from Station 5 (Nalvo Norte) while fewer zooplankton were encountered towards the offshore Station 3 (Barangay Carisquis). Other important groups like bivalve veliger (**Plate EW-38c**) were only observed at very low abundance (101 individuals/ m^3) in station 4 (Brgy. Carisquis), which coincides with the source of the bivalves (Arkshells) collected by locals in the area. No fish larvae were observed during the sampling period. There were no rare or endemic zooplankton species found in the area and majority of the groups are common and cosmopolitan in distribution. The mean estimates of abundance ranged from 330 to 1911 individuals/m^3 among stations.

Generally, the zooplankton abundance ranging from 101-6723ind/m^3 were relatively low compared to other tropical areas where zooplankton concentration could range from 14,396 to 58,949 ind/m^3 like in Singapore straight (Tham et al., 1990). The index of species diversity (H') was also low ranging from 0.67 to 2.06 across all the stations. Moreover, index of evenness (I') slightly varied from 0.34 to 0.84. Species richness (S) was low with only 3-5 zooplankton taxa recorded across all stations. Similar to phytoplankton, these indices indicate that zooplankton communities in the area were low Wilhm criteria (1975) classifying the diversity index <3.0 as low diversity and community stability. The photomicrographs of the planktons are presented in **Plates EW-38a, b** and **c.**

Table EW-56
Zooplankton Composition and Abundance (ind/m^3) in Six Stations in the Coastal Waters
Luna, La Union (July 22, 2016)

Taxa	Stations						Grand Total	Imp Value
	1	2	3	4	5	6		
Adult form	**265**	**1,180**	**202**	**708**	**1,769**	**708**	**4,832**	**19.70**
Calanoid copepod		354					354	1.44
Cyclopoid copepod	265	236		472	708	708	2,389	9.74
Harpacticoid copepod		472	202		1,062		1,736	7.08
Larvacean		118		236			354	1.44
Larval form	**3,096**	**2,123**	**2,224**	**3,404**	**7,785**	**1,062**	**19,694**	**80.30**
Balanus nauplius		236					236	0.96
Bivalve veliger				101			101	0.41
Echinoderm larvae		236	303				539	2.20
Egg		236					236	0.96
Flatworms			303		708		1,011	4.12
Nauplius and copepodite	2,654	1,062	1,415	3,303	6,723	1,062	16,218	66.13
Polychaete trocophore	265	118			354		737	3.01
Pteropod veliger	177	236	202				615	2.51
Grand Total	**3,362**	**3,303**	**2,426**	**4,111**	**9,554**	**1,769**	**24,526**	**100.00**
Mean Abundance	**840**	**330**	**485**	**1,028**	**1,911**	**885**		
Richness (S)	**4**	**10**	**5**	**4**	**5**	**2**		
Diversity (H')	**0.74**	**2.06**	**1.25**	**0.68**	**1.00**	**0.67**		
Evenness (I')	**0.36**	**0.84**	**0.61**	**0.34**	**0.48**	**0.48**		



38a *Nauplius* Copepod

38b *Calanoid* Copepod

38c Veliger Bivalve

Plate EW-38a-b-c. Photomicrograph of common and most zooplankton group in Luna, La Union during the July 22, 2016 sampling.

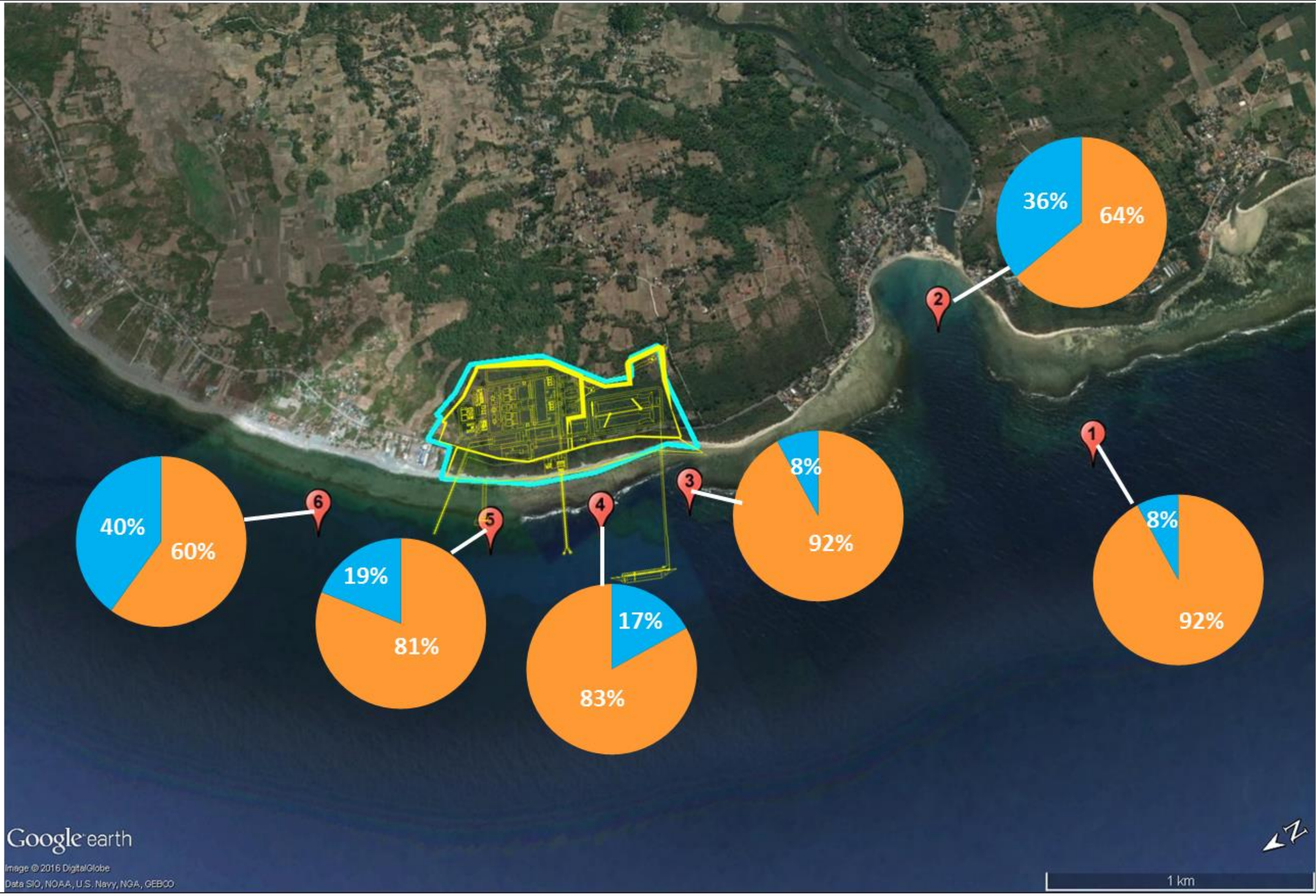


Figure EW-87. Percentage Composition of Zooplankton Forms in Six Sampling Stations	**LEGEND:** Adult forms Larval forms Project site	**SCALE:** As above	**DATA INFORMATION/SOURCE:** **Basemap:** GOOGLE EARTH IMAGERY **Created by:** APERCU CONSULTANTS, INC (2016)	**PAGE 311**
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT				aperçu CONSULTANTS INC

Thermal discharge from power plant operations may have a negative effect on phytoplankton and primary productivity which have been shown to decrease in varying percentages due to thermal effluents of power plants (2. 34% Fox and Moyer 1983), (60% Servais and Bellen 1989) and (36% Martinez-Arroyo et al 1999). Similarly, phytoplankton (including the potentially harmful diatom *Pseudonitschia* off the coast of project site in Luna, La Union) may be negatively affected by the water intake (through entrainment) and by the thermal discharge from the outfall because of increased temperature.

Thermal discharge impacts on plankton will be mitigated by locating the discharge pipe in deeper waters which will allow adequate mixing with ambient water and where plankton concentration is lower.

It is important to note that the phytoplankton community in front of project site has low abundance, richness and diversity so impact will be minimal. Also, these communities replenish themselves from phytoplankton communities beyond the project site through the current system and tidal forcing in the area.

Various wastes from land as well as from activities on the shore may result in degradation of marine water quality which can trigger algal blooms and may cause paralytic shellfish poisoning that may pose health hazards to consumers. Implementation of proper solid waste management practices by all personnel involved during the construction as well as operation phases will mitigate potential water quality degradation impacts. Collaboration with the municipal government to enable adoption of clean practices and domestic waste management will also be undertaken to ensure wastes are properly disposed of and preventing them from reaching the sea.

Except for the presence of the potentially toxic *Pseudoniztschia spp,* the plankton survey revealed that the coastal waters in the study areas are free from large volumes of toxic algal species; the proliferation of plankton species that are known to trigger harmful algal blooms are almost nil and currently does not pose a risk capable of enhancing algal blooms. The plankton community in the area appears to remain stable. However, algal blooms are a natural phenomenon and can be influenced by a number of factors, including cultural eutrophication and hyper-nutrient loading from domestic wastes, aquaculture, unusual climatological conditions and transport of dinoflagellates through ballast waters, and transfer of shellfish stocks, among others. Harmful algal blooms (HAB) occur in some locations because of entirely natural reasons, while other HAB events occur as a result of human activities. Records show that the occurrence of HABs in the Philippines has been associated with the onset of the southwest monsoon but there has been very little evidence attributing warm thermal plumes as a primary and sudden trigger of HABs. In many cases, increased nutrient loading through sediment transport has been observed to be a more likely pathway for occurrence of HABs in coastal areas if the suspended organic matter (OM) causes hyper-nutrient levels and eutrophication. The pollution of coastal waters, as well as occurrence of excessive sedimentation are believed to stimulate bursts in populations of microscopic and macroscopic algae as various pollution-supplied substances fertilize the water column and bottom substrate and provide the nutrients that trigger algal bloom proportions. Because of this, harmful or toxic algal species become more abundant and more noticeable. Currently, the densities of plankton groups observed in the coastal area within the vicinity of the project site do not indicate proportions that can cause the occurrence of HABs. Nevertheless, constant monitoring of the cell counts of bio-toxin carrying species needs to be undertaken.

2.5.3.7 Fisheries

The rapid appraisal consisted mainly of key informant interviews with fishers to determine: (i) location of fishing grounds and fishing gears used, (ii) catch composition, (iii) catch rates; and, (iv) issues affecting fisheries.

Of the 14 coastal Barangays in Luna, only 10% of fishers reside in Barangays Nalvo Sur and Carisquis. The municipal fisheries profile lists 38 fishing boats based in Nalvo Sur and Carisquis, of which only 14 are motorized. Fishers in the two project Barangays who do not have motorized boats capable of fishing offshore work as crew members of the larger boats based in Barangay. Darigayos, under a catch sharing agreement. The major fishing village is Barangay Darigayos where 350 fishers and 223 fishing boats are based. The annual fish production in the municipality in 2015 was recorded at 836.25 MT, of which only 8.6 %, or 72 MT, were supplied by fishers in the two project Barangays. Hook and line fishing gears are used for offshore fishing while surface gill nets are used in near shore waters to catch small pelagic such as scads and mackerels. The deep sea waters off the coast of the project site are favored fishing grounds for pelagic fisheries consisting of large species of tuna and tuna-like species. According to the key informants, the fishing grounds are located "25 miles" offshore, with boat trips lasting 3 hours. Target species are large pelagic such as Tuna, Marlins, Spanish Mackerel, Dolphinfish and large barracudas (**Table EW-57**). The common catch rate ranges from 10 to 50 kilograms. A catch of only 2 pieces of large tuna or Spanish mackerel would bring enough income to fishers as the landed price is P 150/kg. Fishing trips last between 6 to 8 hours.

Table EW-57
List of Commonly Caught Fish Species Offshore Waters
Barangays Nalvo Sur and Carisquis, Luna, La Union

English Name	Local Common Name (Navotas terminology)	Scientific Name
Spanish mackerel	Tanguinge	*Scomberomorus commerson*
Barracuda	Torcillo	*Sphyraena jello*
Siganids	Samaral	*Siganus spp*
Skipkack Tuna	Golyasan	*Katsuwonus pelamis*
Oxeye scad	Matang baka	*Selar boops*
Orange spotted surgeonfish		*Acanthurus olivaceus*
Wrasse	Molmol	*Labridae*
Emperors	Bisugo	*Lethrinus spp*
Rainbow runner	Salmon	*Elagatis bipinulatus*
Frigate mackerel	Tulingan	*Auxis thazard*
Short bodied mackerel	Hasa-hasa	*Rastrelliger brachysoma*
Roundscad	Galungong	*Decapterus macrosoma*
Japanese mackerel	Alumahan	*Scomber australasicus*
Yellow striped scads	Salay-salay	*Selaroides leptolepis*

In spite of the fringing reef in front of the project site, no fishing boats for catching demersal species were observed during the time of the survey. However, some five spear fishers working on bamboo rafts were observed in two days. These spear fishers would normally target demersal species but an investigation of their catch composition revealed the absence of groupers, emperors or snappers. The main catch consisted of less valuable species – surgeonfishes and parrotfish. The fish visual census conducted during the survey also did not encounter such species. Anecdotal accounts reveal that the the catch rate is low, at less than 2 kg per fisher per day for demersal species consisting mostly of juvenile sizes.

Small fishing boats use nets to catch small pelagic species in nearshore waters, with fishing grounds located about 1 to 2 kilometers offshore. The catch is comprised of mackerels, Matang-baka, Salay-salay, flying fish and small barracudas (**Plate EW-39**). At the time of the survey, the sizes of scads and mackerels landed in the barangay consisted of mature sizes.

Plate EW-39. Catch composition of small-scale fishing in waters off the coast of Barangays Nalvo Sur and Carisquis.

Fishers in Carisquis and Darigayos claim that catch rates have dwindled, allegedly due to migrant fishers using large nets and strong lights in previous years but also admit that illegal fishing methods are still being used in offshore fishing grounds and shoals. The manta tow surveys however, revealed that there are no recent damages to corals caused by dynamite blasts, bottom trawls or cyanide use.

The Office of the Municipal Agriculturist has listed the following as the major issues confronting fisheries management in Luna:

(i) Illegal fishing;
(ii) "Fish kills";
(iii) Absence of a municipal fisheries ordinance; and
(iv) Lack of alternative livelihoods.

Fisheries in the impact areas can be affected by any damage to the coral reef. Noise pollution may also pose an impact on fish population structure as some species will seek to avoid noisy areas. As a result, loss of fisheries productivity and reduced species diversity may occur. Marine pollution will also lead to decrease fish populations.

Issues on overfishing and practice of illegal fishing methods are not expected from the Proponent but from the locals in the municipality themselves as most people in the area depend on fisheries as a means of livelihood. Although this is the case, the Proponent will still participate and support efforts to improve habitats, fish production, and prevent the use any destructive fishing practices. Mitigation measures to avoid damage to coral reefs will also be implemented. Noise reduction measures and waste management in all phases of the project will be adopted, maintained, and implemented forcefully.

Yields from small-scale fisheries, as well as size and species composition, are deteriorating but the harvest from artisanal set nets still supply important fish food for coastal households. Gleaning for edible shellfish, especially the almond arkshell is being undertaken in the inter-tidal seagrass areas in the southern boundary of the project site and protection of the ecological components that support long term health of the bivalves need to be considered, including the prevention of over-harvesting by local fishers. Along this line, it is evident that the further use of illegal fishing practices, as well as the issue of increasing siltation discharged from the Darigayos River, are major issues that needs to be addressed. Any improvement over time needs to be comparatively evaluated through consistent coral reef monitoring, fish and macro-invertebrate visual census to determine coral mortality and reduction of species diversity as a result of anthropogenic sediment intrusion.

Municipal Fishery Profile

The Municipal Fisheries profile of Luna, La Union is presented in **Table EW-58**. There are about 230 motorized fishing bancas (16 horse power), 142 non-motorized bancas while fishing gears include the Hook and Line, Gill net, Daklis and Trap nets which are used by 942 fisherfolk in catching fisheries resource in the municipal waters of Luna. In January –April 2016, the fisherfolks in the municipality harvested 33.05 MT of fish species (tuna, palapal, durado, tanguigui, susay, pusit & flying fish) with an average fish catch of 2.46MT per banca. Darigayos has the highest contribution to fisheries production (512.34 MT) in Luna, La Union, followed by Nalvo Sur (52.27 MT) and with the lowest in barangay Victoria (7.41 MT). The fishing season in the municipality is from the month of September to May and the major fish landing area is in Darigayos Cove (Municipal Fisheries Profile of Luna, 2016). The approximate fishing ground of fisher folks in the municipality is shown in **Figure EW-88.**

Table EW-58
Fisheries Profile in the Municipality of Luna

Municipal Water Areas	No. of Motorized Fishing Banca	No. of Non-motorized Fishing Banca	Fishing Method/ Fishing Gear Used	Annual Production (MT)	Average Catch/Banca (Kg)	Species Commonly Caught	No. of Municipal Fishermen
Darigayos	175	48	Hook & Line, Gillnet, Daklis, Trap Net	512.34	2.30	Tuna Species, Palapal, Durado, Tangguigui, Susay, Pusit & Flying fish	349
Rimos 1	2	8	same	24.86	2.48	same	100
Rimos 2	1	8	same	22.31	2.47	same	51
Rimos 3	6	15	same	37.05	2.48	same	20
Rimos 4	15	10	same	29.8	2.48	same	20
Rimos 5	6	10	same	40.0	2.30	same	16
Victoria	-	1	same	7.41	2.47	same	75
Sto. Domingo Norte	1	8	same	22.31	2.47	same	60
Sto Domingo Sur	3	3	same	15.06	2.60	same	60
Magallanes	-	5	same	12.15	2.47	same	15
Nalvo Norte	5	10	same	37.45	2.49	same	80
Nalvo Sur	6	16	same	52.27	2.48	same	73
Carisquis	8	-	same	20.04	2.50	ame	23
Total	**230**	**142**	**-**	**833.05**	**2.46**	**-**	**942**

The fishing ground of fisherfolks in Luna, La Union is approximately 10 to 11 kilometers from the shoreline of the Municipality and about 15 to 16 kilometers from the shore of Candon, Ilocos, Sur (**Figure EW-86**). In addition, only few of the fisherfolks went fishing outside the Municipal waters of Luna, only those that have fishing boat 3 gross tonnages and above or commercial fisher folks most are fishing within the municipal waters.

Aquaculture is one of the major sources of livelihood in Luna, La Union. There are about 32.564 hectares of fishponds used for brackish water aquaculture of Bangus, Malaga, Sugpo, Kapiged, and Mullet in barangay Darigayos, Pila, Mamay, Pitpitac, and Bungro. This livelihood created 64 job employments and contributed 91,296 MT to aquaculture production in the province (**Table EW-59**) (Municipal Fisheries Profile of Luna, 2016).

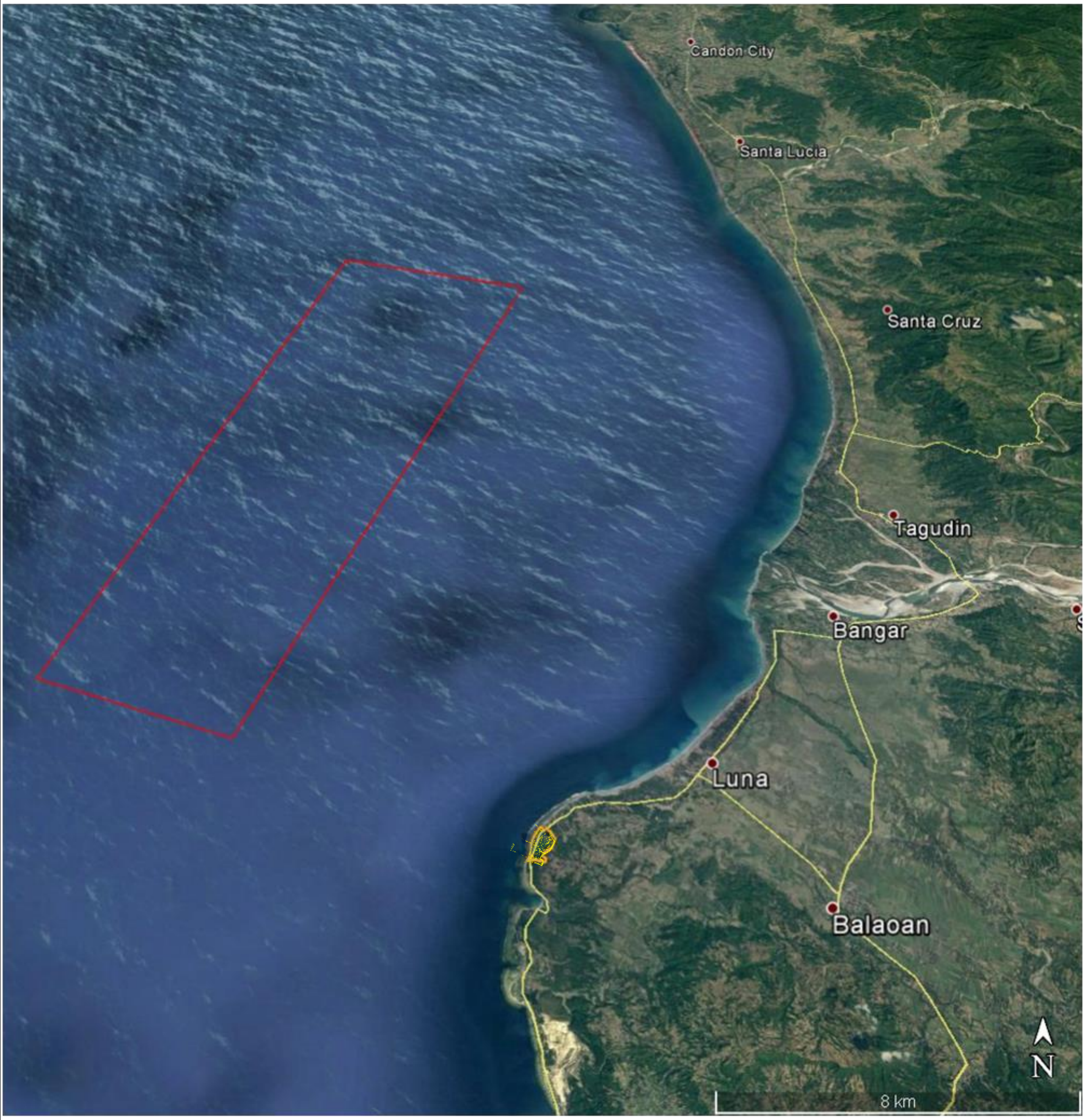


Figure EW-88. Approximate Fishing Ground of Fisher Folks in Luna, La Union	**LEGEND:** Project Site Fishing ground	**SCALE:** As Above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	**DATA INFORMATION/SOURCE:** **Basemap:** GOOGLE EARTH IMAGERY **Created by:** APERCU CONSULTANTS, INC (2016)	aperçu consultants inc **PAGE 316**

Table EW-59
Brackish Water Fishponds in the Municipality of Luna

Location	Species Cultured (Common Name)	Area (has.)	No. of Operators	Annual Production (MT)	Employment	
					Male	Female
Darigayos	Bangus, Malaga, Sugpo, Kapiged, Mullet	9.120	12	25,541.00	11	1
Pila	Bangus, Malaga, Sugpo, Kapiged, Mullet	3.004	21	8,523.00	21	-
Mamay	Bangus, Malaga, Sugpo, Kapiged, Mullet	2.625	20	7,350.00	20	-
Pitpitac	Bangus, Malaga, Sugpo, Kapiged, Mullet	17.250	5	48,300.00	5	-
Bungro	Bangus, Malaga, Sugpo, Kapiged, Mullet	0.565	6	1,582.00	5	1
Total	**-**	**32.564**	**64**	**91,296.00**	**62**	**2**

For the freshwater aquaculture, there are about 1.7905 hectares of fishponds used for the culture of tilapia in Barangays Barrientos, Bungro, Cabalitocan, Magsiping, Nalvo Norte, Napaset, Oaqui No. 1, Pila, Sto. Domingo Norte, Sucoc Sur, Nagrebcan and Buselbusel. This endeavour created 38 job employments and contributed 6.2505 MT to the fisheries production of La Union Province (**Table EW-60)** (Municipal Fisheries Profile of Luna, 2016).

Table EW-60
Freshwater Fishponds Aquaculture in the Municipality of Luna

Barangay	Species Cultured (Common Name)	Area (has.)	No. of Operators	Annual Production (MT)
Barrientos	Tilapia	0.0250	1	0.3750
Bungro	Tilapia	0.0600	2	0.9000
Cabalitocan	Tilapia	0.4250	11	0.6375
Magsiping	Tilapia	0.1800	7	0.2700
Nalvo Norte	Tilapia	0.0250	1	0.3750
Napaset	Tilapia	0.0305	2	0.4555
Oaqui No. 1	Tilapia	0.0500	2	0.7500
Pila	Tilapia	0.0250	1	0.3750
Sto. Domingo Norte	Tilapia	0.7750	6	1.1625
Sucoc Sur	Tilapia	0.0200	1	0.3000
Nagrebcan	Tilapia	0.1500	3	0.2750
Buselbusel	Tilapia	0.0250	1	0.3750
Total	**-**	**1.7905**	**38**	**6.2505**

Fish pens are also used in the culture of tilapia and bangus in Barangays Darigayos, Pila, Mamay, Pitpitac, and Bungro. There are 1.234 hectares used for fish pen culture operated by 77 fisherfolks which contributed 3.095MT to fisheries production of the province for the period of January – April 2016 (**Table EW-61**) (Municipal Fisheries Profile of Luna, 2016).

Other aquaculture activities in the municipality are the culture of oysters, seaweeds, sea urchin and mussels in Barangays Darigayos and Pitpitac which have a production area of 1.5 hectares and a production of 1.5 MT for the period of January – April, 2016. Bangus fry are also collected in barangay Darigayos and Rimos 1 – 5. There are about 50 collectors engaged in the gathering of fry. In January – April 2016, 2,500 million of fry were collected.

Payao – a fish aggregating device, is also used in Darigayos waters with species caught like tuna, palapal, durado, and susay. The payao contributed an estimated 8MT to fisheries production of the province of La Union for the period of January – April 2016 (Municipal Fisheries Profile of Luna, 2016).

Table EW-61
Fish Pens in the Municipality of Luna

Barangay	Species Cultured (Common Name)	Area (has.)	No. of Operators	Annual Production (MT)	Employment	
					Male	Female
Darigayos	Tilapia & Bangus	0.575	21	1.4375	20	1
Pila	Tilapia & Bangus	0.3004	29	0.75	27	2
Pitpitac	Tilapia & Bangus	0.173	15	0.4325	12	3
Mamay	Tilapia & Bangus	0.165	10	0.4125	10	
Bungro	Tilapia & Bangus	0.025	2	0.0625	1	1
Total	**-**	**1.2384**	**77**	**3.095**	**70**	**7**

There are 7 communal waters in the municipality namely Darigayos River, Nalvo Creek, Barobor River, Mangcappi Creek, Pillaoc CIS, Bungro-Sucoc Sur Irrigation, Carisquis SWIP which have a total area of 16.05 hectares. There are estimated 415 fishermen fishing in the communal waters and contributed an estimated 18.15MT to fisheries production of the province of La Union for the period of January – April, 2016. The communal waters have a 4.50 hectares potential for fish cage culture (**Table EW-62**).

Table EW-62
Communal Waters (SWIP, Rivers, Lakes, SFR, Marshes, Lagoons) in the Municipality of Luna

Name of Rivers, SWIP, etc.	Location	Total Area	No. of Fishermen	Estimated Production (MT)	Potential Area for Fish Cage
Darigayos River	Darigayos, Pila, Mamay, Pitpitac, Bungro	5.00	150	5.5	1
Nalvo Creek	Nalvo Norte	2.00	50	2.2	1
Barobor River	Rimos # 1-5 & Oaqui #1-4	3.00	65	3.3	1
Mangcappi Creek	Magsiping	3.00	45	3.3	1.5
Pillaoc CIS	Cabalitocan	2.00	40	2.2	-
Bungro-Sucoc Sur Irrigation	Bungro & Sucoc Sur	1.00	45	1.1	-
Carisquis SWIP	Carisquis	0.05	20	0.55	-
Total	**-**	**16.05**	**415**	**18.15**	**4.50**

Fishing Gear

Fisher folks in the municipality of Luna use a variety of fishing gears in their activities. These are hook and line, gill net, daklis, and trap net. Hook and line method is used by fishers for off shore fishing either through simple hand line, multiple hand line, bottom set long line, drift long line, or troll line. Daklis is a collaborative effort performed by a number of fishers depending on the size of the seine net. Fishers who perform this method deploy seine nets from the shore, also referred as beach seine. Gill nets are also used by fishers for near shore waters opting to catch small pelagic fishes.

Catch Composition

Catch composition in the municipality include tuna species, palapal, durado, tangguigui, susay, pusit & Flying fish. Key informants in Darigayos also cited marlin, spanish mackerel, dolphin fish, and large barracudas.

Catch per Unit Effort

The fisheries production in Darigayos, Luna in year 2015 is presented in **Figure EW-89**. The graph implies fluctuating fisheries production throughout 2015. A total of 3,828.75kg of fish was caught in the Ilocos Coast and landed in Darigayos, Luna. The highest fisheries production was observed during the month of May (1,112.40 kg) followed by the month of January (622.20kg) and February (464.80kg) with the lowest during the month of June 2015 (49.15kg). The month of May is the hottest month in Luna which is very favorable for fishing. The fisherfolk used fishing gears such as floating hook and line, floating handline, and scoop net to catch fish in Ilocos Coast.

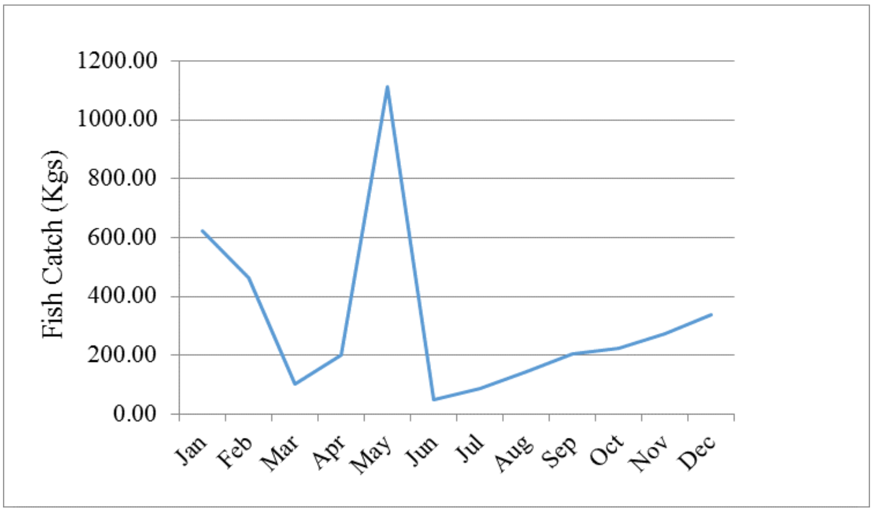


Figure EW-89. Fisheries Production in Darigayos, Luna, La Union in year 2015

In January –April 2016, a harvest amounting to 33.05MT of various fish species with an average fish catch of 2.46MT per banca and average CPUE of 25.63 kg/day/banca was recorded (**Figure EW-90**).

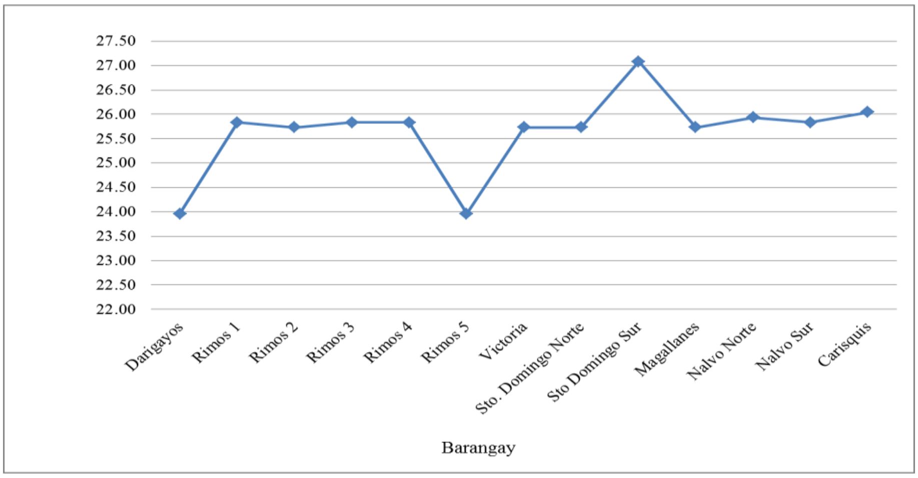


Figure EW-89. Catch Per Unit Effort in Luna, La Union (January – April, 2016)

The catch per unit effort (CPUE) of fisherfolk from January – April 2016 in the coastal barangays of Luna, La Union is presented in **Figure EW-90**. The average CPUE of fisherfolk in Luna, La Union is 25.63 kg/day/banca having a range of 23.96kg/day/banca to 27.08kg/day/banca with the highest CPUE in barangay Sto. Domingo Sur and the lowest in barangay Darigayos. However, although fisherfolk from barangay Darigayos had the lowest CPUE, they had the highest contribution of 512.34MT to the municipal fisheries production, since more fisherfolk and fishing bancas operated in the area.

There are millions of tiny fish eggs, larvae, and very young fish essentially adrift in the water, and hence extremely vulnerable of being entrained by the power plant cooling water intake system. These small animals are often killed by the passage through a plant´s cooling system. In certain species, reports document up to 60% mortality in a given year´s newborn fish stock due to power plants. Adult fish are also trapped and pinned to intake screens by the force of the suction.

To counter act these impacts, GLEDC will install physical barriers that prevent fish from entering the intake structure, such as stationary screens. Traveling screens that move above the intake structure are equipped with flushing structures to free the fish. Then collection systems such as baskets gather the fish and transport them to a recovery pond, where canals enable them to return to their habitat. Diversion systems direct fish away from the intake structure and include angled screens or louver systems that alter flow direction and velocity. Behavioral deterrents involving light or sound are also effective and will be considered as options for mitigating fish entrainment.

2.5.3.8 Mangroves

Data from the municipal fisheries profile indicate that only 4 hectares of mangrove stands occur in Luna, La Union.

There are no mangrove trees in the coastline of Nalvo Sur and Carisquis where the power plant project is located. The relatively proximal mangrove clumps of isolated patches are found upstream from the outflow of the Darigayos River (**Plate EW-40**), which is approximately 2.5 kilometers form the project site's boundary in Barangay Carisquis passing by the coast and the river outflow. A small patch of mangroves appear at a distance of 200 meters from the river mouth consisting mostly of *Nipa fruticans* and *Rhizopora apiculata*. Thereafter mangroves appear again about 1.5 kilometers inside the river, lined up in the river bank and dominated by *Nipa* mixed with *Avicennia sp*. There are small patches of mangrove reforestation projects but these are in small areas along the river bank where some 200 fish pens are also situated. The pens and cages are utilized for the culture of "malaga" (rabbitfishes), Pompano, milkfish and prawn fry. The Darigayos River is also an area for the collection of oysters, milkfish fry, mullet, siganids and gobies.

Plate EW-40. Clumps of the mangrove associate *Nipa fruticans* line up the Darigayos River, approximately 1.5 kilometers from the river mouth. Numerous fish pens and cages are operated in the river.

2.5.3.9 Marine Wildlife

Marine megafauna are amongst the most charismatic animals on the planet and engender a high degree of public interest in their biology and conservation, making them useful ambassadors for the whole marine environment. These animals play a significant role in the lateral transport of mineral nutrients in the marine environment through their movement, between the time they consume the nutrient and the time they release it through elimination and decomposition after death. Their roles had been realized 12,500 years ago when megafaunal extinctions occurred and have reduced 98% lateral diffusion of mineral nutrients like phosphorus in the ocean. The availability of phosphorus limits productivity of the ocean and the decrease in its transport from West Philippine Sea and from floodplains to other areas (i.e. Babuyan Channel in the North) is believed to pose a negative impact to the marine ecosystem.

While marine megafauna such as sharks, rays, marine mammals and turtles are widely distributed in oceans around the world, these animals potentially encounter numerous anthropogenic influences. Their populations are usually the first to be reduced by human pressures in the marine environment (i.e. dredging, mining and extraction of minerals) as they are long-lived and have low reproductive rates.

This section presents baseline data and information of megafauna gathered in Luna, La Union through primary and secondary data collection. The impacts of the proposed coal-fired power plant project to these marine megafaunas in Luna, La Union were also assessed. Possible impacts of the power plant to megafauna during the construction and operation phase of the project could be noise pollution, water pollution, fish kills, turbidity/sedimentation, and vessel traffic. The mitigating measures are also discussed to minimize the impacts of the proposed power plant to marine mega faunas.

Species Composition

Respondent fisherfolks in Brgy. Darigayos observed the presence of different megafauna such as dugong, sea turtles, whales, dolphins, whaleshark, sharks and seabirds in the marine waters (**Figure EW-91**). They have frequently seen these megafauna species throughout 2015 with the highest incidence of occurrence during the month of December.

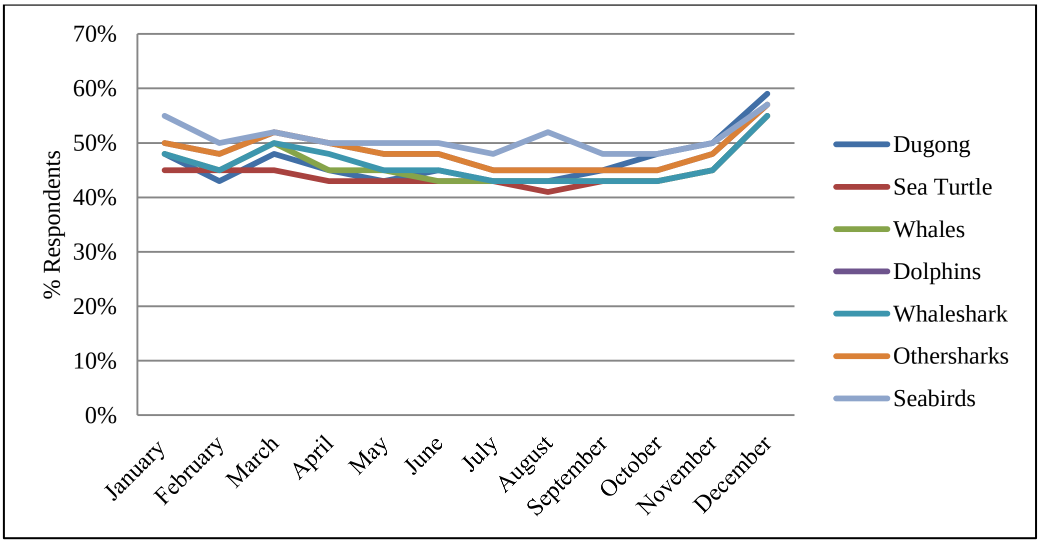


Figure EW-91. Percent Respondents who witnessed Marine Megafauna in 2015

Seabirds are the most observed megafauna in the area with a high incidence of occurrence during the month of December, and a low incidence during the months of July, September, and October. According to the respondents, the seabirds occur from hundreds to thousands in numbers in rivers and farms in the area.

Sharks and dolphins are the second most frequent megafauna species occurring in Darigayos. Respondent fisherfolk observed sharks frequently during month of December while they are hardly seen during months of August – October. Similarly, dolphins were frequently observed during month of December and were observed less during months from July to October.

Other megafauna observed during the month of December in order of decreasing frequency included the dugong, the whale shark, and the sea turtles. **Table EW-63** summarizes the months of high and low occurrences of each megafauna cited by the respondents to occur in the marine waters of Brgy. Darigayos.

Table EW-63
Months of High and Low Occurrences of Megafaunas Cited by the Respondents to be Occurring in the Vicinity of the Project Site

Megafauna	Month(s) of High Occurrences	Month(s) of Low Occurrences
Seabirds	December	July, September, October
Sharks	December	August to October
Dolphins	December	July to October
Dugongs	December	February, May, July, August
Whaleshark	December	July to October
Whales	December	June to October
Sea turtles	December	August

Megafauna were observed by the respondents mostly during navigation aboard a boat, fishing – where animals are found to inhabit the fishing grounds of fisherfolks, some were trapped in fishing gears, hunted by fisher folks, or dead ashore, among others (**Figure EW-92**).

Species of sea turtles contribute to marine and coastal food webs and transport nutrients within the oceans (Bouchard and Bjorndal 2000). The species of sea turtle observed in La Union are *Chelonia mydas*, *Eretmochelys imbricata*, *Lepidochelys olivacea* (**Table EW-64**). All of these species are categorized under the IUCN Red List of threatened species. These were seen in San Fernando City, Rosario, San Juan, Dagupan and Luna, La Union. In particular, the *Eretmochelys imbricata* has been found to inhabit the marine waters of Darigayos, Luna. These sea turtles are usually trapped in fishing nets according to reports from BFAR – Region 1.

Table EW-64
Sea Turtle Species Observed in Luna, La Union

English Name	Local Name	Scientific Name	Family	Remarks
Green Turtle	Pawikan	*Chelonia mydas*	Cheloniidae	IUCN Red List of Threatened Species
Hawksbill Turtle	Kasikasan	*Eretmochelys imbricata*	Cheloniidae	IUCN Red List of Threatened Species
Olive Ridley and Pacific Ridley	Pagong	*Lepidochelys olivacea*	Cheloniidae	IUCN Red List of Threatened Species

The perception of the fisherfolk on the observed megafauna is a qualitative assessment that may determine the abundance and availability of the megafauna. The present abundance of megafauna in Darigayos, Luna this year 2016 was compared by the fisherfolk to its abundance in year 2015. Results show that majority of the fisherfolk perceived all the megafauna species to be less abundant at present compared before (**Table EW-65**). Dugong is perceived to have the highest decline in abundance among the megafauna at present compared to last year.

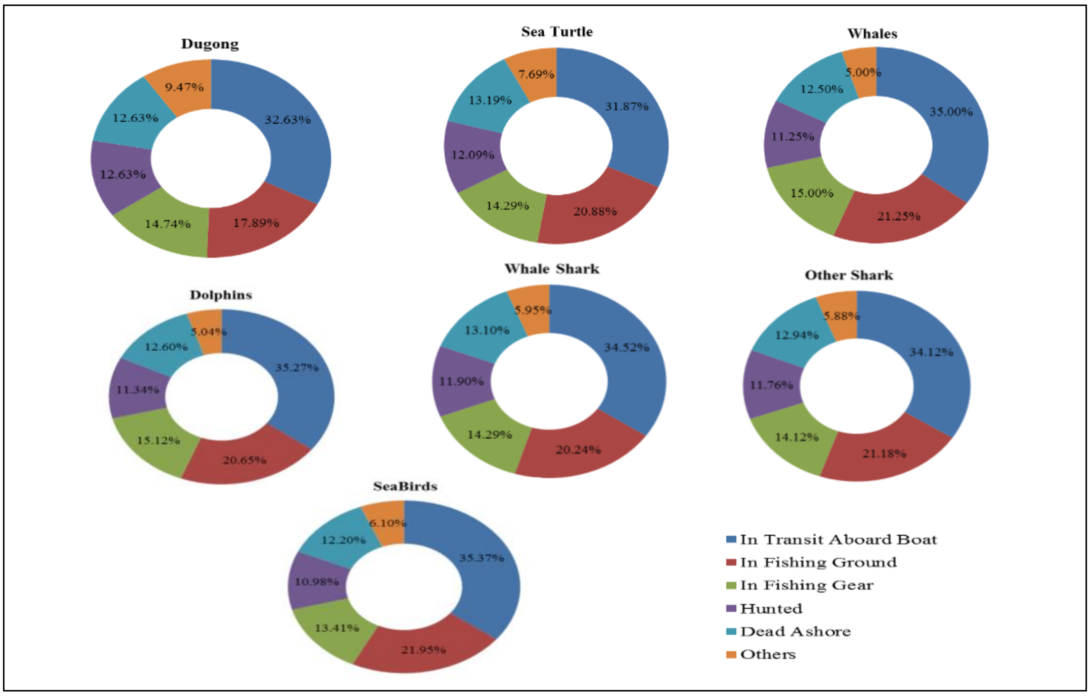


Figure EW-92. Activities of fisherfolks at the time megafauna were observed

Table EW-65
Comparison of Present Abundance of Megafauna in La Union According to Fisherfolks

Megafauna	Fisherfolk (N=44)			
	Less (%)	Same (%)	More (%)	Don't Know (%)
Dugong	68.53	6.29	3.15	22.03
Sea Turtle	55.17	6.90	20.69	17.24
Whales	57.14	7.14	14.29	21.43
Dolphins	64.29	7.14	14.29	14.29
Whale Sharks	57.14	7.14	14.29	21.43
Other Sharks	37.21	6.98	13.95	41.86
Seabirds	60.71	10.71	10.71	17.86

Potential impacts to the marine wildlife cited in the municipality include noise pollution from pile driving activities for the jetty construction, increased boat traffic and the collective noise from nearshore construction activities. Marine mammals, particularly cetaceans like dolphins and whales, are acoustically reliant animals that utilize sound for detecting prey, navigating, and communicating. Activities that generate very high sound pressure levels can cause auditory injuries to marine mammals such as temporary threshold shift (TTS) or permanent threshold shift (PTS) (Lucke et al., 2009; Mooney et al., 2009; Todd et al., 2015), other types of physical injury and, in some circumstances, lead to the death of the receiver (Southall, et al. 2007). The extent to which auditory loss occurs depends on the intensity and frequency of the sound, duration of exposure, and the health of the organism.

Robinson et al. (2011) as cited by Todd et al. (2015) measured six trailer suction hopper dredgers (TSHDs) and found that sound levels below 500 Hz were in line with those noise expected for a cargo ship travelling at modest speeds (8–16 kn). This can cause long term changes in distribution of marine mammals. For instance, Bryant et al. (1984) reported that grey whales (*Eschrichtius robustus*) in lagoon of Baja California were almost absent completely from the lagoon during the many years of intense shipping activity and returned only once shipping had ceased. Thus, shipping itself is potentially a major cause for disturbance in cetaceans (Rolland et al., 2012; Todd et al., 2015).

Collision with vessels maybe a source of anthropogenic mortality for dolphins, dugongs, sea turtles, whales, whale sharks, and other sharks. Whales and large whales, particularly right whales, are vulnerable to injury and mortality from ship strikes during the shipping of construction materials and the delivery of coal. Ship strike injuries to whales take two forms: (1) propeller wounds characterized by external gashes or severed tail stocks; and (2) blunt trauma injuries indicated by fractured skulls, jaws, and vertebrae, and massive bruises that sometimes lack external expression (Laist et al., 2001). Collisions with smaller vessels may result in propeller wounds or no apparent injury, depending on the severity of the incident.

To manage the impact of noise on marine mammals, and to prevent vessel collisions, a marine mammal observer will be assigned to record the presence of marine mammals within the field view of a pair of binoculars. This is to be done from the location of the noise source, for example the area where the pile driving activity is to be done. During the operation phase, such observations will also be done a day or two prior to the arrival of delivery vessels, especially during the month of December when most marine mammals have been sighted in the area.

The site clearing, filling, excavation and other earth-moving and land development activities may generate silted runoff that ultimately end up in marine waters which can result in increased turbidity and creation of sediment plumes. Turbidity can interfere with the ability of sea turtles and whales to forage effectively by obscuring visual detection or dispersing potential prey. On the other hand, marine mammals often inhabit turbid environments and many utilize sophisticated sonar systems to sense the environment around them (Au *et al.*, 2000). Although sediment plumes are short lived lasting a maximum of four to five tidal cycles in general (Hitchcock and Bell, 2004), and are confined mainly to an area of a few hundred meters from the point of discharge (Hitchcock and Bell, 2004), these animals have some level of tolerance in turbid conditions to be able to feed.

Indirect impacts on marine mammals from coal-fired power plant stem from changes to their physical environment, or to their prey. Physical characteristics, such as sediment particle size and suspended sediment concentrations can be altered by sedimentation but changes also occur naturally, as a result of disturbance events such as tides, waves, and storms. Consequently, small changes are unlikely to have a substantial effect on the marine ecosystem, and can even increase biodiversity, but large-scale repeated alterations have the potential to affect the entire food-web, right up to megafauna.

Mitigating measures include the installation of settling ponds to trap sediment load before it drains into the marine waters and the use of silt curtains around the construction areas in the marine environment to prevent sediment dispersion over large areas.

2.5.4 Summary of Potential Impacts and Mitigation Measures Related to Marine Ecology

The outfall pipe head is positioned about 500 meters from the shoreline. The fringing coral reef hugging the shores of Barangay Nalvo Sur extend to about 200 meters from the shoreline with the slope about 250 meters away in 8 to 10 meters of water. The coral crest in this region hosts poor coral cover, averaging 10% LHC live coral cover running northeast towards Barangay Nalvo Norte in diminishing proportions (**Figure EW-93**). However, a narrow patch of corals about 300 meters below the outfall head hosts live coral cover of about 26% LHC (marine ecology baseline assessment LIT results, 2016; **Figure EW-94**) dominated by massive *Porites spp* and the fire coral *Millepora sp*. Along the shoreline, corals disappear about 1 kilometer from the outfall pipe.

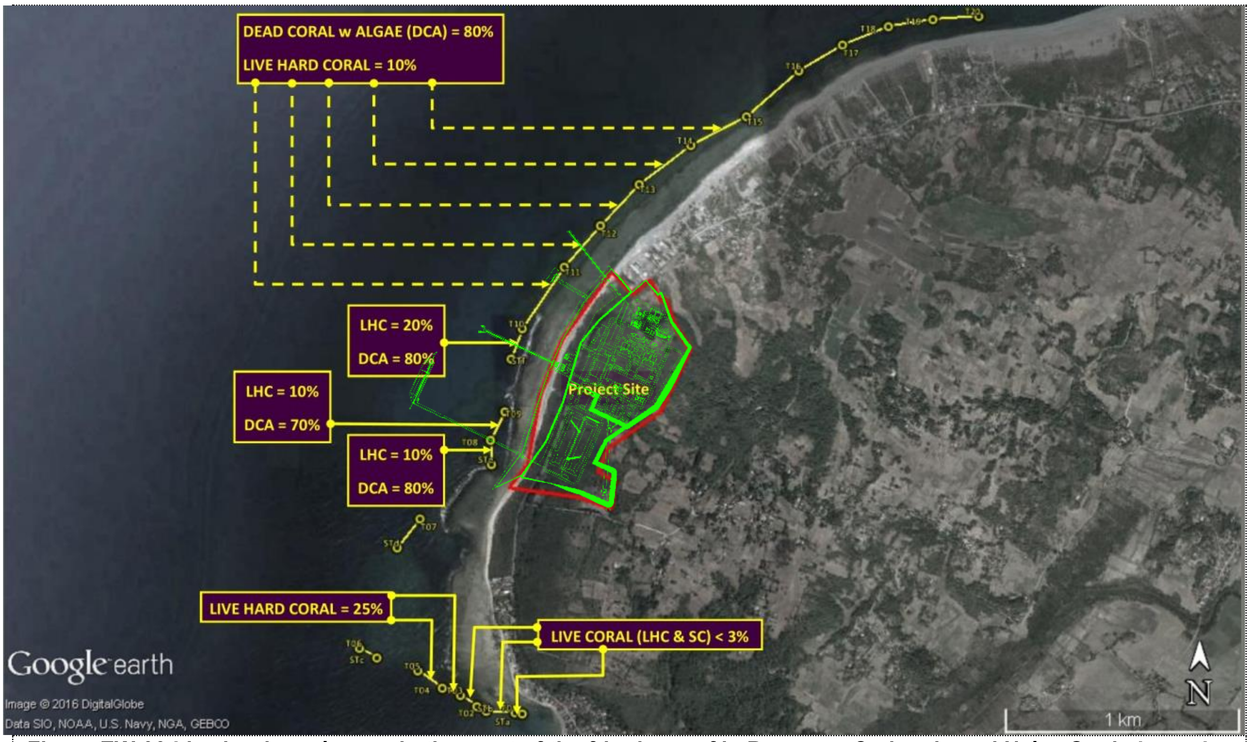


Figure EW-93 Live hard coral cover in the crest of the fringing reef in Barangay Carisquis and Nalvo Sur in Luna, La Union resulting from manta tow observations in July 2016 reveal poor coral cover averaging 10% LHC in the area where the outfall pipe will be positioned.

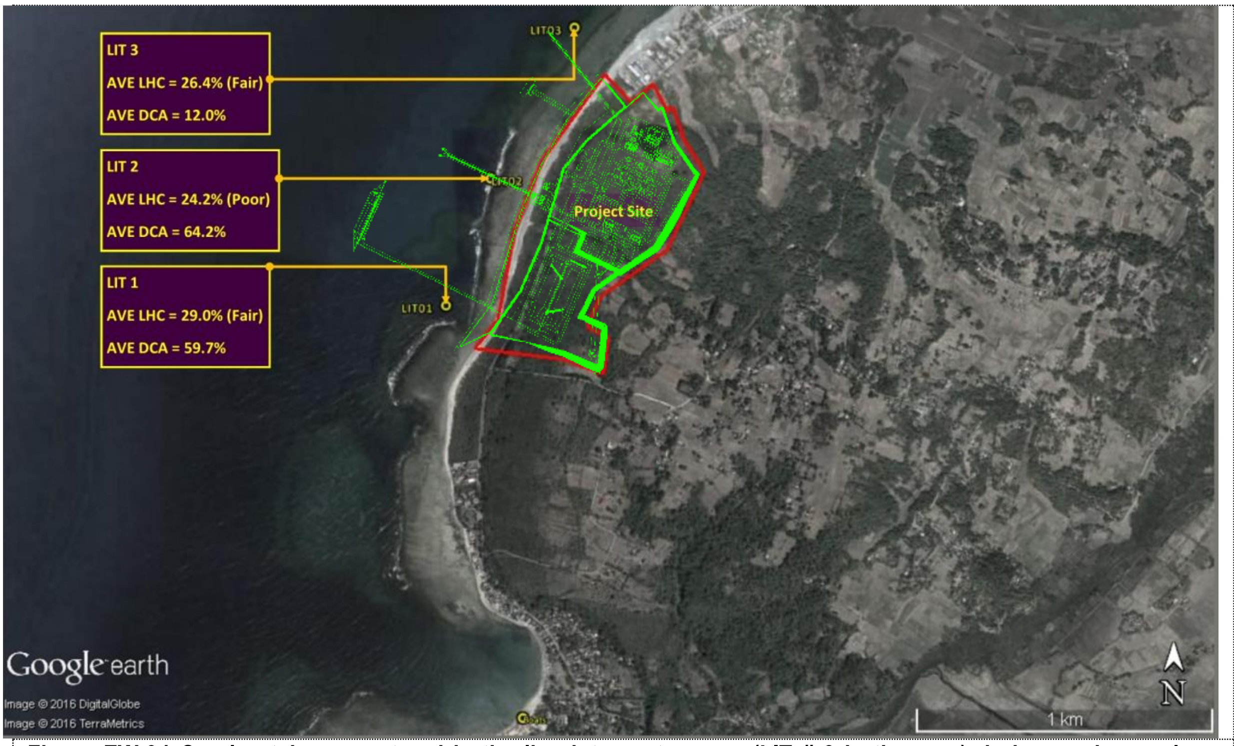


Figure EW-94 Coral patch encountered in the line intercept survey (LIT # 3 in the map) during marine ecology baseline assessment in 2016 indicate 26% LHC in a narrow strip of coral colonies along the reef slope 600 meters south of the outfall head.

The outfall head would be more than 300 meters away from the slope and corals in this area are unlikely to be affected by the thermal plume unless in extremely strong southerly winds during the interface between the SW and NE monsoon, occurring mostly in the months of May and June. In this scenario, 'clouds' of thermal plumes carried on a southerly direction will most likely swathe into the coral slope. Corals have a low range of tolerance for high seawater temperatures and an increase of more than 3 degrees Celsius will result to bleaching of coral polyps. Already in a poor state, coral bleaching can be irreversible.

During the NE monsoon, the thermal plumes are anticipated to be carried by wind-driven currents towards the southern portion of the reef where there are deeper waters in the vicinity of the bend/indention in the reef slope. During the SW monsoon, heated water will be dispersed towards the North, also in deeper waters and where the fringing reef is short and sparse. Unusually high seawater temperatures, particularly during El Niño episodes, can also disturb fish feeding behavior, spawning events and larval development. However, since thermal plumes are localized, fish communities easily move away from the affected area. Moreover, the baseline survey in 2016 did not encounter any significant population of mature spawning aggregations of high value foodfish in the area of the outfall pipe. In addition, no fish larvae were observed in six zooplankton sampling stations conducted in 2016.

Coral-associated sessile macro invertebrates can be susceptible. However, the important macro-invertebrate found during the baseline assessment - the gastropod *Barbatia amigdalumtostum (*Almond Arkshell) inhabits shallow rocky inter-tidal flats along the coastline and will not be affected by thermal plumes.

There are no seagrass meadows in the general area of the outfall pipe.

Particle dispersal modeling indicates that columns of suspended particles carried by southwest monsoon currents will deviate from the coral flat and slope due to the curve in the fringing reef and shoreline. Granting that the monsoon winds are strong, sediment plumes are likely to be carried on an easterly direction towards Barangay Nalvo Norte where the shelf is dominated by rocks and muddy-sandy substrate. It appears however, that the southern portion of the fringing reef, in the area of the proposed project jetty will be the initially prone to sediment settlement during lethargic currents. The corals in this region were catalogued to be dominated by dead corals with algae (70-80%) and only 10% LHC was observed in the reef flat. The reef slope in this area, which hosted 26% LHC, is located in deep waters and is unlikely to be suffocated by sediment in view of the abrupt inclination.

Table EW-66 summarizes the potential impacts and proposed mitigation related to marine ecology.

Table EW-66
Summary of Potential Impacts Related to Marine Ecology during Construction and Operation

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
I. Construction Phase			
Threat to existence and/or loss of species (Marine water)	Marine ecology - coral reefs	The primary threats to the corals in the project site during the construction phases are: 1) loss of coral cover, 2) increased turbidity, and 3) water quality degradation. These may occur when structures like the intake pipe, the outfall pipe, and the jetty undergo construction.	• To avoid potential loss of coral cover, the design of the outfall and intake pipe will consider the least disturbance to coral reef patches • The most ideal site for the jetty pylons would be just above the mid-point of the length of the coastline in the project site. The jetty's ship bays/berthing docks will be located way beyond the coral reef slope. A separate detailed survey of the presence and configuration of the reef ledge and drop off will be

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
			undertaken in order to factor this into the design of the jetty. • If corals will be unavoidably removed to accommodate project coastal structures, some of the branching coral fragments will be transplanted to undisturbed locations employing the most recent technological practices to ensure survival and re-growth. An area of translocation with formed substrate, clear water, and no freshwater intrusion will be identified and demarcated as a special management area in close coordination with the local BFAR office. • The dispersion of sediments resulting from construction activities will be minimized using silt booms/curtains and silt reduction devices installed in areas before the coral slope. Additionally, activities will be conducted during calm weather or between tidal cycles to prevent the spread of suspended sediments. • Proper soil and waste management plans will be implemented.
Threat to existence and/or loss of species (Marine water)	Marine ecology - seagrass	The growth of seagrass meadows in the shallow portions of the sea in the southern boundary of the project site can be affected if sediment intrusion becomes extreme and the benthic substrate is blanketed by loose silt.	• The dispersion of sediments resulting from construction activities will be minimized using silt booms/curtains and silt reduction devices installed. Additionally, activities will be conducted during calm weather or between tidal cycles to prevent the spread of suspended sediments.
Threat to existence and/or loss of species (Marine water)	Marine ecology - macro-invertebrates	Populations of macro-invertebrates can be affected by alterations in the inter-tidal shoreline. These alterations include conversion or establishment of coastal structures for the project and small boat dockings, both of which can lead to loss of habitats for mollusks. Additionally, if contaminated by land-based pollutants, the population of bivalves and other shellfish such	• No additional structures apart from the intake and outfall pipes and the jetty will be constructed on shore. Alterations in the land-sea interface will be kept to a minimum. No permanent structures will be built in sensitive areas where bivalves are assessed to reproduce and all temporary structures will be removed immediately. Also, a focal conservation zone in the inter-tidal area with adequate

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
		as the edible arkshell can be impacted resulting in a decrease in the population.	tidal movement and replenishment will be declared. Human traffic will be restricted and managed to ensure very little disturbance to natural processes.
		Potential impacts to marine wildlife include noise pollution from pile driving activities for the jetty construction, increased boat traffic and the collective noise from nearshore construction activities. Marine mammals are acoustically reliant animals. Activities that generate very high sound pressure levels can cause auditory injuries, other types of physical injury and death. Collision with vessels maybe a source of anthropogenic mortality for megafauna. Whales are vulnerable to injury and mortality from ship strikes during the shipping of construction materials and the delivery of coal. Indirect impacts on marine mammals from coal-fired power plant stem from changes to their physical environment, or to their prey. Physical characteristics, such as sediment particle size and suspended sediment concentrations can be altered by sedimentation. Small changes are unlikely to have a substantial effect on the marine ecosystem, and can even increase biodiversity, but large-scale repeated alterations have the potential to affect the entire food-web, right up to megafauna.	• A marine mammal observer will be assigned to record the presence of marine mammals within the field view of a pair of binoculars. This is to be done from the location of the noise source. During the operation phase, such observations will also be done a day or two prior to the arrival of delivery vessels, especially during the month of December when most marine mammals have been sighted in the area. • Installation of settling ponds to trap sediment load before it drains into the marine waters and the use of silt curtains around the construction areas in the marine environment to prevent sediment dispersion over large areas.
II. Operation Phase			
Threat to existence and/or loss of species (Marine water)	Marine ecology - coral reefs	One of the potential threats during the operation phase is increased coral bleaching which can be brought about by thermal discharges. The current surveys indicate that coral bleaching is present in the area. Another threat is increased boat/vessel traffic delivering coal to the site, which	• The outfall will be located away from coral areas at sufficient depth to induce mixing and the temperature of the discharge will be within DENR requirements. • Ensure that the marine vessels will comply with the requirements of Presidential Decree No. 979 or the Marine Pollution Decree of

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
		may be sources of bilge water and potential leaks and spillages.	1976. • GLEDC will help protect the coral colony in the middle area by supporting efforts to prevent the use of destructive fishing practices in the area. Focal conservation areas where reproductive processes can occur unimpeded will be established with the help of the Fisheries and Aquatic Resource Management Council of Luna.
Threat to existence and/or loss of species (Marine water)	Marine ecology - reef-associated fish assemblages	The low species richness and density of demersal fishes will further decrease if the thriving coral reefs in the area will be affected, since these corals serve as their habitat, refuge and food source. The location and orientation of the project's coastal structures will be constructed taking into consideration the path of least disturbance to corals.	• The jetty structure is expected to serve as a fish aggregating device. The jetty columns serve as suitable substrates for the colonization of corals and its associated biota. Over time, the assemblage attracts various fish, and the submerged sections of the jetty develop into a stable marine community that can be a source of recruitment and propagules for nearby reefs. • The Proponent will support efforts to improve habitats, fish production, and prevent the use of destructive fishing practices. Focal conservation areas where reproductive processes can occur unimpeded will be established with the help of the Fisheries and Aquatic Resource Management Council of Luna.
Threat to existence and/or loss of species (Marine water)	Marine ecology - seagrass	Shipboard wastes during the operation phase and domestic wastes both during the construction and operation phases may result in degradation of water quality and cause die-out of some algae species.	• A solid waste management plan incorporating the tenets of reuse, recycle and reduce will be developed and implemented. • All drainage water will be filtered through a series of settling ponds and filtering devices. • Collaboration with the municipal government will also be undertaken to enable adoption of clean practices and domestic waste management. • Policy of no shipboard waste disposal will be enforced.
Threat to existence and/or loss of species (Marine water)	Marine ecology - plankton	Thermal discharge from power plant operations may have a negative effect on phytoplankton and primary Similarly, phytoplankton may be negatively affected by the water intake	• Thermal discharge impacts on plankton will be mitigated by locating the discharge pipe in deeper waters which will allow adequate mixing with ambient water and where plankton

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
		(through entrainment) and by the thermal discharge from the outfall because of increased temperature. The phytoplankton community in front of project site has low abundance, richness and diversity so impact will be minimal. Various wastes from land as well as from activities on the shore may result in degradation of marine water quality which can trigger algal blooms and may cause paralytic shellfish poisoning that may pose health hazards to consumers.	concentration is lower. • Implementation of proper solid waste management practices by all personnel involved during the construction as well as operation phases will mitigate potential water quality degradation impacts. • Collaboration with the municipal government to enable adoption of clean practices and domestic waste management will also be undertaken to ensure wastes are properly disposed of and preventing them from reaching the sea.
Threat to existence and/or loss of species (Marine water)	Marine ecology - fisheries	Fisheries in the impact areas can be affected by any damage to the coral reef. Noise pollution may also pose an impact on fish population structure as some species will seek to avoid noisy areas. As a result, loss of fisheries productivity and reduced species diversity may occur. Marine pollution will also lead to decrease fish populations. There are millions of tiny fish eggs, larvae, and very young fish essentially adrift in the water, and hence extremely vulnerable of being entrained by the power plant cooling water intake system. These small animals are often killed by the passage through a plant´s cooling system.	• Mitigation measures to avoid damage to coral reefs will also be implemented. Noise reduction measures and waste management in all phases of the project will be adopted, maintained, and implemented forcefully. • The Proponent will participate and support efforts to improve habitats, fish production, and prevent the use any destructive fishing practices. • Installation of physical barriers that prevent fish from entering the intake structure, such as stationary screens. Traveling screens that move above the intake structure are equipped with flushing structures to free the fish. Then collection systems such as baskets gather the fish and transport them to a recovery pond, where canals enable them to return to their habitat. Diversion systems direct fish away from the intake structure and include angled screens or louver systems that alter flow direction and velocity. Behavioral deterrents involving light or sound are also effective and will be considered as options for mitigating fish entrainment.

3.0 Air

3.1 Methodology

3.1.1 Assessment of Existing Conditions

3.1.1.1 Meteorology

Data from the PAGASA stations in Dagupan City, Pangasinan and Sinait, Ilocos Sur were used in the absence of onsite meteorological data. The said PAGASA stations are about 83 kilometers south and 119km north of the project site, respectively (**Figure EA-1**). The meteorological conditions at the project site were described using the following secondary data:

- Climate map of the Philippines (**Figure EA-4**);
- Climatological normals from 1981 to 2010 (**Table EA-2** and **Table EA-3**);
- Annual windrose at the Dagupan City Station from 1971 to 2000 (**Figure EA-13**);
- Climatological extremes as of 2015 (**Table EA-4** and **Table EA-5**); and
- Tropical cyclone maps (**Figure EA-5** and **Figure EA-6**).

3.1.1.2 Ambient Air Quality

The existing ambient air conditions were described by measuring the levels of criteria pollutants (SO_2, NO_2, TSP, and PM10) and trace metals (As, Cd, Cr^{+6}, Pb, Hg) at fixed locations at the project site vicinities (**Figure EA-2**). These locations, namely USAFIL National Park, Coral Beach Resort, Carisquis Barangay Hall, Mercedes Sports Complex, House of Nazareno, and Nalvo Sur Barangay Hall, were selected because they can be potential receptors of the power plant emissions. The coordinates and elevation of the sampling sites are summarized in **Table EA-1**.

Methods for sampling and analysis conformed to methods prescribed in Sec. 1(b) Rule VII Part II of the Clean Air Act IRR. The resulting ambient air concentrations were compared with the National Ambient Air Quality Guidelines Values (NAAQGV), Rule VII, Part II and the National Ambient Air Quality Standards for Source Specific Air Pollutants from Industrial Sources/Operations Section 1 Rule XXVI Part VII of the Clean Air Act IRR for indicative air quality.

Table EA-1
Ambient Air Quality Sampling Stations

Station ID	Description	Latitude	Longitude	Elevation (m)
AQ1	USAFIL National Park	16°49'15.51" N	120°20'8.38" E	7
AQ2	Coral Beach Resort	16°49'35.60" N	120°19'57.58" E	9
AQ3	Carisquis-Barangay Hall	16°49'47.91" N	120°20'34.19" E	31
AQ4	Nalvo Sur – Mercedes Sports Complex	16°50'24.69" N	120°20'27.81" E	12
AQ5	Mansyon – House of Nazareno	16°50'42.02" N	120°20'53.69" E	6
AQ6	Nalvo Sur – Barangay Hall	16°50'1.49" N	120°20'56.27" E	18

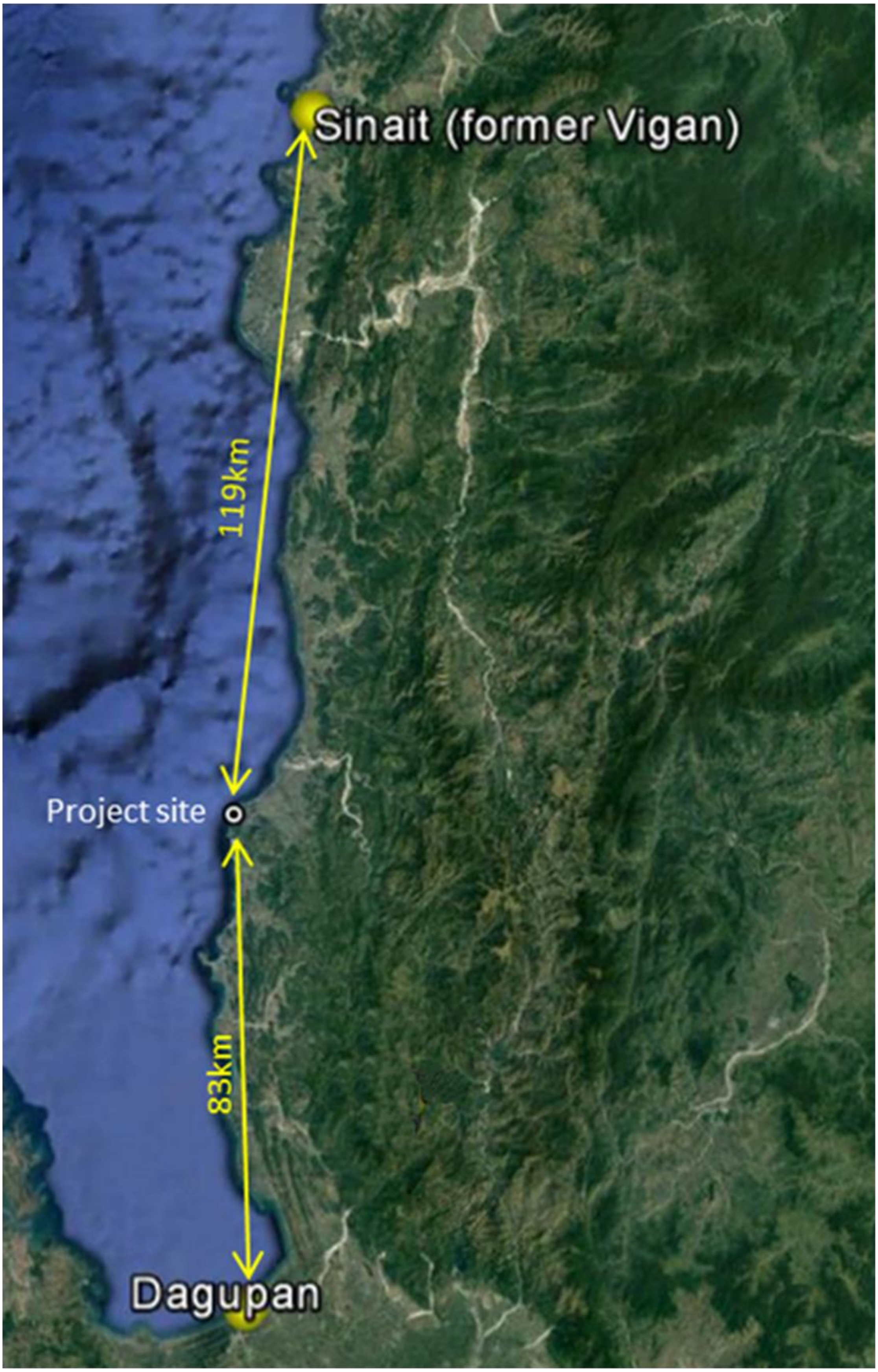


Figure EA-1. Location of PAGASA Stations Near the Project Site	LEGEND: Project Site PAGASA Stations	SCALE: As above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: Base map: Google Earth Imagery Created by: Apercu Consultants_JACH (2017)	aperçu

Table EA-2
Climatological Normals at the PAGASA Station in Dagupan City, Pangasinan (1981-2010)

Month	Rainfall Amount (mm)	No. of RD	Temperature						Vapor Pressure (mbs)	Relative Humidity (%)	Wind		Cloud Amount (okta)	No. Days w/	
			Max (°C)	Min (°C)	Mean (°C)	Dry Bulb (°C)	Wet Bulb (°C)	Dew Point (°C)			DIR (16pt)	SPD (mps)		TSTM	LTNG
January	6.7	1	30.8	20.7	25.8	25.7	23	21.9	26.2	79	S	2	4	0	0
February	10.7	1	31.8	21.2	26.5	26.4	23.5	22.4	26.9	78	S	3	3	0	0
March	22.2	2	33.2	22.6	27.9	27.6	24.5	23.4	28.6	77	S	3	3	1	1
April	60.4	5	34.7	24.4	29.5	29.1	25.8	24.7	30.9	77	S	3	4	5	6
May	209.8	10	34.1	24.8	29.4	29.1	26.2	25.3	32	79	S	3	5	14	17
June	337.9	17	33.1	24.7	28.9	28.4	26.1	25.3	32.2	83	S	2	6	17	15
July	499.6	21	32	24.4	28.2	27.8	25.9	25.3	32.1	86	SE	2	6	17	15
August	581.3	22	31.3	24.3	27.8	27.4	25.7	25.1	31.8	87	SE	2	7	14	12
September	368.4	20	31.6	24.2	27.9	27.6	25.7	25	31.7	86	SE	2	6	14	14
October	215.9	11	31.9	24	27.9	27.8	25.6	24.8	31.3	84	S	2	5	8	9
November	53.9	5	31.8	23	27.4	27.3	24.9	24.1	29.8	82	S	2	4	2	2
December	14.1	2	30.9	21.4	26.2	26.2	23.6	22.6	27.3	80	S	2	4	1	1
Annual	**2,380.9**	**119**	**32.3**	**23.3**	**27.8**	**27.5**	**25.1**	**24.2**	**30.1**	**82**	**S**	**2**	**5**	**93**	**92**

Source: PAGASA; RD – rainy days DIR - direction; SPD- wind speed in meters per second; TSTM – thunderstorm; LTNG - lightning

Table EA-3
Climatological Normals at the PAGASA Station in Sinait, Ilocos Sur (1981-2010)

Month	Rainfall Amount (mm)	No. of RD	Temperature						Vapor Pressure (mbs)	Relative Humidity (%)	Wind		Cloud Amount (okta)	No. Days w/	
			Max (°C)	Min (°C)	Mean (°C)	Dry Bulb (°C)	Wet Bulb (°C)	Dew Point (°C)			DIR (16pt)	SPD (mps)		TSTM	LTNG
January	3.5	1	30.4	21.1	25.8	25.7	22	20.5	23.9	72	N	3	3	0	0
February	3.9	1	30.9	21.6	26.2	26.1	22.4	20.9	24.5	73	N	2	2	0	0
March	5.4	1	32	23.1	27.6	27.4	23.7	22.3	26.7	73	N	2	2	0	0
April	16.1	2	33.3	24.5	28.9	28.8	25.1	23.8	29.3	74	N	2	2	3	4
May	194.5	10	33.2	24.8	29	28.9	25.7	24.6	30.8	77	S	2	4	12	12
June	321.8	16	32	24.3	28.2	28.3	25.7	24.8	31.2	81	S	2	5	15	13
July	536.3	20	31.3	23.9	27.6	27.7	25.5	24.7	31.1	84	S	2	5	15	11
August	630.3	21	30.6	23.7	27.2	27.4	25.3	24.6	30.8	84	S	3	6	11	9
September	382.6	16	31	23.7	27.4	27.6	25.3	24.5	30.6	83	S	2	5	10	9
October	143.8	8	31.5	23.4	27.5	27.7	24.9	23.9	29.5	80	N	2	4	5	5
November	36.3	3	31.5	23	27.3	27.4	24.2	23	28	77	N	2	3	1	1
December	2.9	1	30.8	21.8	26.3	26.3	22.5	21	24.6	72	N	3	3	0	0
Annual	**2,277.4**	**100**	**31.6**	**23.3**	**27.4**	**27.4**	**24.4**	**23.2**	**28.4**	**78**	**N**	**2**	**4**	**72**	**64**

Source: PAGASA; RD – rainy days DIR - direction; SPD- wind speed in meters per second; TSTM – thunderstorm; LTNG - lightning

Table EA-4
Climatological Extremes at the PAGASA Station in Dagupan City, Pangasinan (2016)

Month	Temperature (°C)				Greatest Daily Rainfall (mm)		Highest Wind (mps)			Sea Level Pressure (mbs)			
	High	Date	Low	Date	Amount	Date	Spd	Dir	Date	High	Date	Low	Date
January	36.0	01-14-1989	14.3	01-08-1907	78.0	01-25-2006	18	S	01-24-2000	1022.2	01-18-1959	1001.3	01-01-1950
February	37.0	02-25-1927	16.3	02-07-1971	64.8	02-19-2009	18	NNW	02-11-1993	1022.0	02-01-1962	1003.2	02-07-2000
March	38.7	03-24-1921	16.7	03-05-1971	71.9	03-29-1938	19	NNW	03-20-1981	1020.8	03-30-1958	1002.0	03-13-1949
April	39.9	04-12-1915	19.7	04-01-1973	195.0	04-18-1998	23	SE	04-21-1979	1019.0	04-07-1968	999.4	04-21-1956
May	39.6	05-12-1924	19.0	05-25-2004	722.6	05-27-2003	35	E	05-17-2008	1015.5	05-12-1960	986.9	05-23-1976
June	38.7	06-05-1987	20.2	06-30-1978	306.0	06-21-1990	27	SE	06-22-2008	1016.0	06-06-1966	987.3	06-29-1964
July	38.2	07-07-1915	20.4	07-14-1911	376.8	07-08-1986	33	W	07-04-2001	1016.7	07-05-1951	984.6	07-22-2003
August	36.4	08-10-1906	19.0	08-03-1999	342.0	08-22-2003	35	SSE	08-24-1982	1016.0	08-18-1963	991.2	08-24-1982
September	36.6	09-21-1983	20.5	09-06-1984	374.3	09-14-2014	30	ESE	09-18-1998	1016.2	09-01-1971	985.7	09-14-1998
October	37.2	10-22-1990	19.5	10-26-1990	443.5	10-08-2009	56	WNW	10-11-1974	1017.7	10-27-1968	978.3	10-26-1978
November	36.9	11-20-2000	17.2	11-13-1905	229.1	11-17-1935	41	NNW	11-24-1981	1019.3	11-04-1958	983.4	11-24-1981
December	36.9	12-30-1978	15.2	12-14-1988	69.4	12-04-1936	27	N	12-02-2004	1021.0	12-08-1960	989.0	12-02-2004
Annual	**39.9**	**04-12-1915**	**14.3**	**01-08-1907**	**722.6**	**05-27-2003**	**56**	**WNW**	**10-11-1974**	**1022.2**	**01-18-1959**	**978.3**	**10-26-1978**
Period of Records	1903 - 2016				1903 - 2016		1966 - 2016			1949 - 2016			

Source: PAGASA

Table EA-5
Climatological Extremes at the PAGASA Station in Sinait, Ilocos Sur (2016)

Month	Temperature (°C)				Greatest Daily Rainfall (mm)		Highest Wind (mps)			Sea Level Pressure (mbs)			
	High	Date	Low	Date	Amount	Date	Spd	Dir	Date	High	Date	Low	Date
January	35.6	01-21-1967	13.5	01-04-1986	38.8	01-13-1929	20	N	01-19-2000	1022.8	01-18-1959	997.9	01-30-1990
February	35.7	02-21-2013	14.0	02-10-1986	36.7	02-16-1983	19	NNE	02-10-1988	1022.6	02-01-1962	1004.6	02-28-1972
March	36.9	03-25-2000	16.0	03-02-1911	82.5	03-31-1960	20	N	03-09-1998	1022.8	03-30-1958	1004.9	03-29-1994
April	38.8	04-28-1994	19.3	04-14-2015	139.6	04-13-1992	26	NNW	04-08-1967	1019.8	04-05-1998	998.4	04-08-1967
May	38.2	05-05-1951	19.6	05-22-1984	237.7	05-09-1913	25	S	05-21-1996	1016.2	05-07-1959	989.4	05-23-1976
June	38.2	06-02-1987	16.8	06-22-1984	382.2	06-04-1974	36	SSE	06-15-1971	1016.2	06-06-1966	986.5	06-26-1993
July	35.4	07-04-1921	17.8	07-03-1984	594.1	07-18-1920	60	SSW	07-09-1986	1016.4	07-16-1965	976.0	07-13-1965
August	36.9	08-13-1987	17.0	08-30-1984	529.6	08-30-1968	34	SSE	08-14-1971	1015.7	08-12-1958	977.5	08-07-1964
September	35.1	09-24-1938	19.0	09-02-1986	393.3	09-03-1913	44	SSW	09-28-1968	1018.5	09-20-1987	985.1	09-14-2014
October	35.8	10-06-1972	17.2	10-21-1994	263.9	10-04-2009	42	W	10-24-1987	1017.8	10-30-1961	963.0	10-10-1971
November	36.7	11-03-1921	15.4	11-20-1984	295.7	11-24-1938	20	N	11-01-1993	1020.2	11-24-1957	984.8	12-17-1953
December	35.5	12-09-2003	14.5	12-09-1986	99.0	12-16-1970	20	NNW	12-10-1967	1021.5	12-07-1960	992.0	12-12-1949
Annual	**38.8**	**04-28-1994**	**13.5**	**01-04-1986**	**594.1**	**07-18-1920**	**60**	**SSW**	**07-09-1986**	**1022.8**	**01-18-1959**	**963.0**	**10-10-1971**
Period of Records	1903 - 2016				1903 - 2016		1965 - 2016			1949 - 2016			

Source: PAGASA

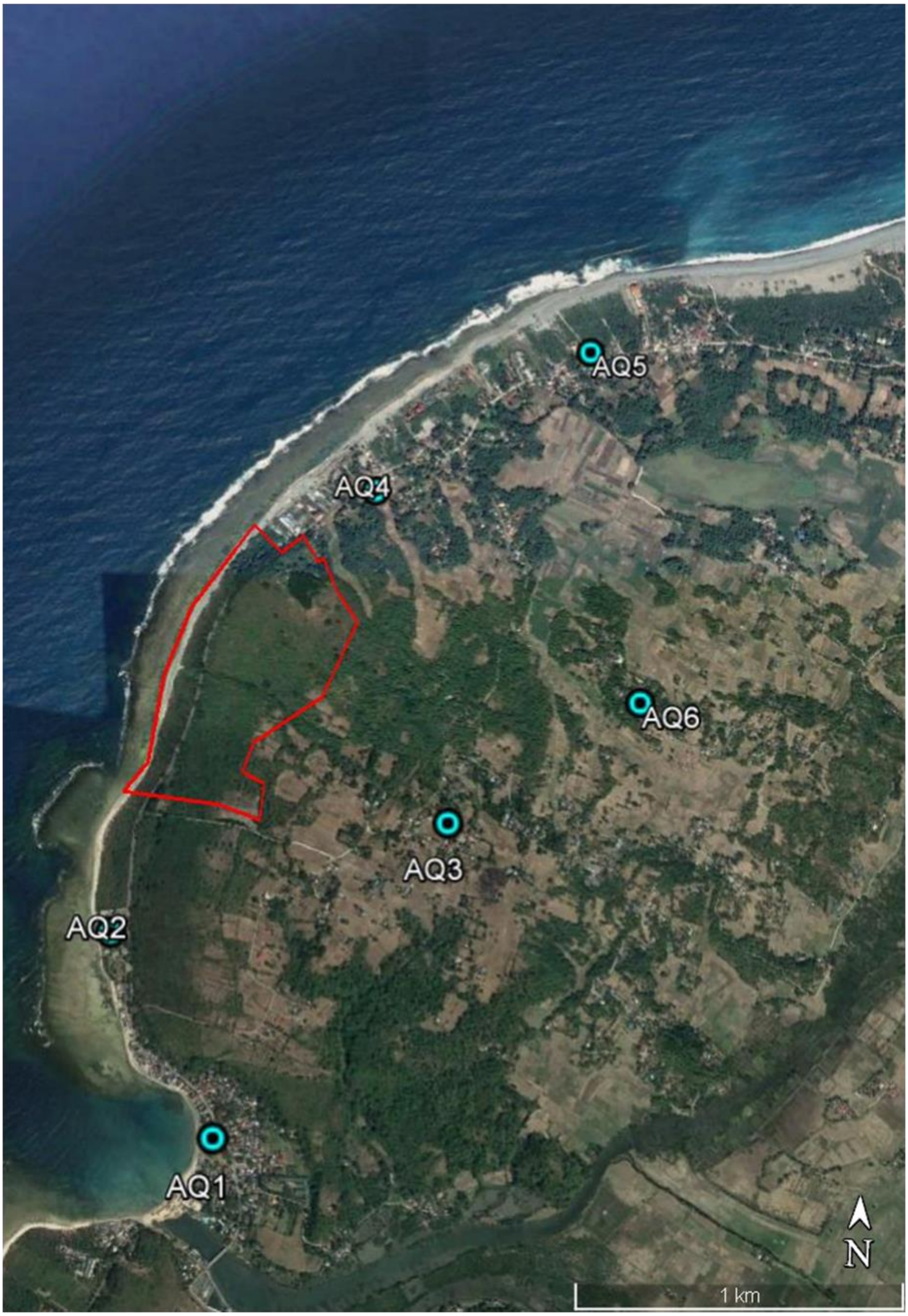


Figure EA-2. Ambient Air Sampling Stations	LEGEND: Project Site Sampling Station	SCALE: As above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: Base map: Google Map Imagery Created by: Apercu Consultants_JACH (2017)	PAGE 337

3.1.1.3 Noise

The existing sound profile at the project site was determined by taking sound measurements at the ambient air quality stations using a sound meter for 24 hours at five minute intervals. The resulting records were processed to determine the noise descriptors defined in **Table EA-6**.

Table EA-6
Noise Descriptors Used in Describing the Existing Sonic Profile at the Site

Noise Descriptor	Description
L10	Noise level exceeded 10% of the time of the measurement period. For example, a L10 of 75 dBA means that over a period of one hour, the noise greater than 75dBA was recorded for six minutes or one minute over a period of 10 minutes.
L50	Noise level exceeded 50% of the time. It is statistically the midpoint of the noise readings representing the median of the fluctuating noise levels.
L90	Noise level exceeded 95% of the time and represents the background levels.
Lmax	Highest recorded sound level
Lmin	Lowest recorded sound level

3.1.2 Impact Assessment

3.1.2.1 Climate Change Projections

Climate change projections on rainfall and temperatures in 2020 and 2050 at the site were based on the paper "*Climate Change in the Philippines, 2011*" published by the PAGASA. The projections were based on the Dagupan City Station normal data (nearest to the project site) using the medium-range emission scenario (A1B) defined by the IPCC as:

> *A1: The A1 storyline and scenario family describe a future world of very rapid economic growth, a global population that peaks mid-century and declines thereafter, and a rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family is further developed into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil-intensive (A1FI), non-fossil energy sources (A1T), or balanced across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies).*

The PAGASA projections showed annual mean temperature increases of 0.98°C and 2.05°C in 2020 and 2050 respectively. The projected increase may affect the buoyancy flux of the stack plume rise due to a decreased difference between the stack exit and ambient temperatures.

In addition to possible increase in pollutant deposition, the predicted rainfall increase from June to February may also contribute to possible flooding.

3.1.2.2 GHG Emissions

The descriptions of the three categories of GHG accounting are described below[1]:

a. Scope 1 (also referred to as Direct GHG) - emissions from sources that are owned or controlled by the organization, such as:
   - Stationary Combustion: from the combustion of fossil fuels (e.g. natural gas, fuel oil, propane, etc.) for comfort heating or other industrial applications
   - Mobile Combustion: from the combustion of fossil fuels (e.g. gasoline, diesel) used in the operation of vehicles or other forms of mobile transportation
   - Process Emissions: emissions released during the manufacturing process in specific industry sectors (e.g. cement, iron and steel, ammonia)
   - Fugitive Emissions: unintentional release of GHG from sources including refrigerant systems and natural gas distribution

b. Scope 2 (Indirect GHG) - emissions from the consumption of purchased electricity, steam, or other sources of energy (e.g. chilled water) generated upstream from the organization.

c. Scope 3 (Other Indirect GHG) - emissions that are a consequence of the operations of an organization, but are not directly owned or controlled by the organization. Examples includes employee commuting, business travel, third-party distribution and logistics, production of purchased goods, emissions from the use of sold products, and several more.

The carbon dioxide (CO_2) emission of the proposed power plant was estimated using the Tier 1 method of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The Tier 1 approach uses two inputs: the amount of fuel combusted and the appropriate CO_2 emission factor (natural gas in this case). The CO_2 emissions were calculated by the equation:

$$GHG_i\ emissions = coal\ consumption\ (TJ) x GHG_i\ emission\ factor\ (\frac{kg}{TJ})$$

The default IPCC CO_2 emission factor for coal used was 96,100 kg CO_2/TJ. It was assumed that the power plant will be operating at full capacity (670MW) for 8,760 hours a year with an annual coal consumption of 2,006,040MT (114.5 MT/h/boiler) as the worst-case scenario.

Due to limited information at the EIA stage of the project, the GHG emission was only made for the two coal-fired boilers (Scope 1 – stationary combustion). It is recommended that a more detailed GHG accounting be done after the detailed engineering design phase and during operation.

3.1.2.3 Air Dispersion Modeling

The focus of the ambient air quality impact assessment is the resulting levels of the pollutants from the power plant stack emissions during operation. The following were done to assess ambient air quality impacts:

1. Predicted the maximum ground-level concentrations (GLC) of criteria pollutants (SO_2, NO_2, TSP, PM10, CO) and trace metals (As, Cd, Cr^{+6}, Pb, Hg);
2. Determined the incremental impact of pollutants;
3. Identified air pollution hotspots; and
4. Identified mitigating measures to minimize the potential impacts on ambient air quality.

The EMB Air Dispersion Modeling Guidelines (EMB Memorandum Circular 2008-003) was used in the ambient air quality impact assessment. The guidelines prescribe a tiered approach following USEPA methods in assessing

[1]http://www.icomplisustainability.com/index.php/ask-the-expert/ghg-management/item/63-what-are-the-differences-between-scope-1-2-and-3-greenhouse-gas-emissions/63-what-are-the-differences-between-scope-1-2-and-3-greenhouse-gas-emissions

contaminant concentrations against CAA air quality standards. A fundamental assumption of the tiered approach to model selection is that the simpler modeling techniques always yielded more conservative results (higher estimates). The Tier 4 approach was adopted for predicting the pollutant GLCs. The detailed air dispersion modeling procedure is presented in **Annex E**.

3.1.2.4 Noise Modeling

The noise impacts during construction and operation were predicted using the ISO 9613-2 procedures for calculating attenuation of sound propagated outdoors. The equations used in calculating the equivalent continuous A-weighted downwind sound pressure levels (SPL) are:

$$L_{fT}(DW) = L_W + D_C - A \quad \text{(Eq. 1)}$$

$$A = A_{div} + A_{atm} + A_{gr} + A_{bar} + A_{misc} \quad \text{(Eq. 2)}$$

$$A_{div} = \left[20\log\left(\frac{d}{d_o}\right) + 11\right] \quad \text{(Eq. 3)}$$

$$A_{atm} = \frac{\alpha d}{1000} \quad \text{(Eq. 4)}$$

$$A_{gr} = 4.8 - \left(\frac{2h_m}{r_2}\right)\left(17 + \frac{300}{r_2}\right) \quad \text{(Eq. 5)}$$

$$L_{AT}(DW) = 10\log\left\{\sum_{i=1}^{n}\left[\sum_{j=1}^{8} 10^{0.1[L_{fT}(ij)+A_f(j)]}\right]\right\} \quad \text{(Eq. 6)}$$

where

$L_{fT}(DW)$ - equivalent continuous octave-band SPL at a receiver location, dB

L_W - octave-band SPL produced by the point sound source, dB

D_C - directivity correction, dB

A - octave-band attenuation, dB

A_{div} - attenuation due to geometrical divergence

A_{atm} - attenuation due to atmospheric absorption

α - atmospheric attenuation coefficient octave-band at the mid-band frequency, dB/km

h_m - mean height of the propagation path, meters

r_2- distance between the source and receiving node, meters

A_{gr} - attenuation due to ground effects

A_{bar} - attenuation due to a barrier

A_{misc} - attenuation due to miscellaneous effects

$L_{AT}(DW)$ - equivalent continuous A-weighted downwind SPL at a receiver location, dBA

d - distance from the source to receiver, meters

d_0 - reference distance

A_f - standard A-weighting

n - the number of contributions *i*

j - index indicating the eight standard octave-band mid-band frequencies from 63 Hz to 8 kHz

The following assumptions were made to determine the worst-case noise impact:

a. Sound point sources propagated omnidirectional sound into free space (*Dc=0*);

b. Attenuation was only due to spherical spreading in the free field, atmospheric effect, ground attenuation only (A_{bar} and A_{misc} were ignored); and
c. The total SPL were distributed along the perimeter of the project site.

Sound Modeling Domain

The model domain was 4km by 4 km rectangle with a 50-meter resolution resulting to 6,561 computational nodes, i.e., intersections where sound levels were calculated. **Figure EA-3** shows the model domain and sound points. Terrain inside the domain was assumed to be simple as the worst-case, i.e., all sources and receptors lie on the same elevation.

Sound Sources

Construction Phase

Due to the limited information on the project construction activities, typical equipment and machines and their corresponding sound-pressure levels (SPL), presented in **Table EA-7,** were assumed to be used simultaneously during the entire construction phase and is continuously emitting sounds. The SPLs of the equipment were added and placed at the perimeter of the site to depict worse-case conditions.

Table EA-7
Sound Levels Used during the Construction Phase

Equipment	SPL, dB(A)	Equipment	SPL, dB(A)
Jackhammer	104	Laborers	90
Chipping gun	93	Power shovel	88
Air compressor	96	Shop work	95
Bulldozer	89	Power shovel	88
Lejeune gun	89	Rubber tired crane, <35 ton	81
Backhoe	86	Truck-mounted crane	79
Forklift	85	Tower crane	74
Hand hammer	85	Dozer	102
Welding torch	84	Paver	90
Chopsaw	80	Front-end loader	90
Truck	78	Roller	98
Heavy-duty bulldozer	99	Heavy equipment	90
Vibrating road roller	97	Gravel plant	102
Crawler crane <35 ton	94	Crane	99
Total SPL			**110**

Source: Neitzel, R., N. Seixas, M. Yost, and J. Camp., 1998; SPL – sound *pressure level*

Figure EA-3. Noise Model Domain and Sound Sources	LEGEND: As above	SCALE: As above	DATA INFORMATION/SOURCE: Base map: Google Map Imagery Created by: Apercu Consultants_JACH (2017)	PAGE 342
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT				

Operation Phase

The main sources of potential noise during the operation phase are the boilers, steam turbines, boiler feed pumps, air compressors, and ancillaries with typical sound levels shown in **Table EA-8**. Similar to the construction phase simulations, the sound levels of each component were added and placed at points within the project site to represent worst-case conditions.

Table EA-8
Sound Levels during the Operation Phase

Equipment	SPL, dB(A)
Boiler #1	103.6
Boiler #2	103.6
Steam turbine #1	110.2
Steam turbine #2	110.2
Transformer	87.3
Boiler feed pump, pumps	107.7
- Main/aux oil pumps	98.8
- Chemical injection system	86.8
- Condensate pump	100.1
- Oil pump	98.7
- Other	89.8
- Vacuum pumps	100.2
- Cooling water pump	99.6
Air compressor (instruments)	114.3
Air compressor (service)	109.5
- General operations (materials handling)	105.8
- General operations (Coal crushing and screening)	102.1
- General operations (Conveyors)	67.1
- General operations (Fans)	111.6
Total SPL	**120.0**

Source: Noise Assessment for the Proposed Coal-fired Power Station in the Erongo Region, Namibia; SPL – sound pressure level

3.2 Meteorology

Climate

The proposed project site is under the Type I climate based on the Modified Coronas Classification of the Philippine Climate (**Figure EA-4**). A Type I climate is characterized by two distinct seasons: dry from November to April and wet for the rest of year.

Tropical Cyclones

In general, cyclone frequency in the country is highest from June to December. These tropical cyclones are associated with the occurrence of low pressures areas (LPA) normally originating over the North Western Pacific Ocean side of the Philippine Area of Responsibility (PAR) and generally moving northwestward. Tropical cyclones also originate in the West Philippine Sea, at the western part of the country, having unusual motions, and quite rare with 52 occurrences in 50 years (*Perez*, 2001). The PAGASA categorizes these cyclones as tropical depressions (TD) when wind speeds are up to 63 kph; as a tropical storm (TS) when wind speeds are from 64 to117 kph; and as a tropical typhoon (TY) when wind speeds are over 117 kph.

From 1948-1993 (period of 46 years) PAGASA determined an annual average of 20 tropical cyclones in the PAR, nine of these making landfall. Overall, PAGASA had tracked 917 cyclones within the PAR, with 415 (45.3%) crossing the archipelago and 120 (22.5%) considered disastrous.

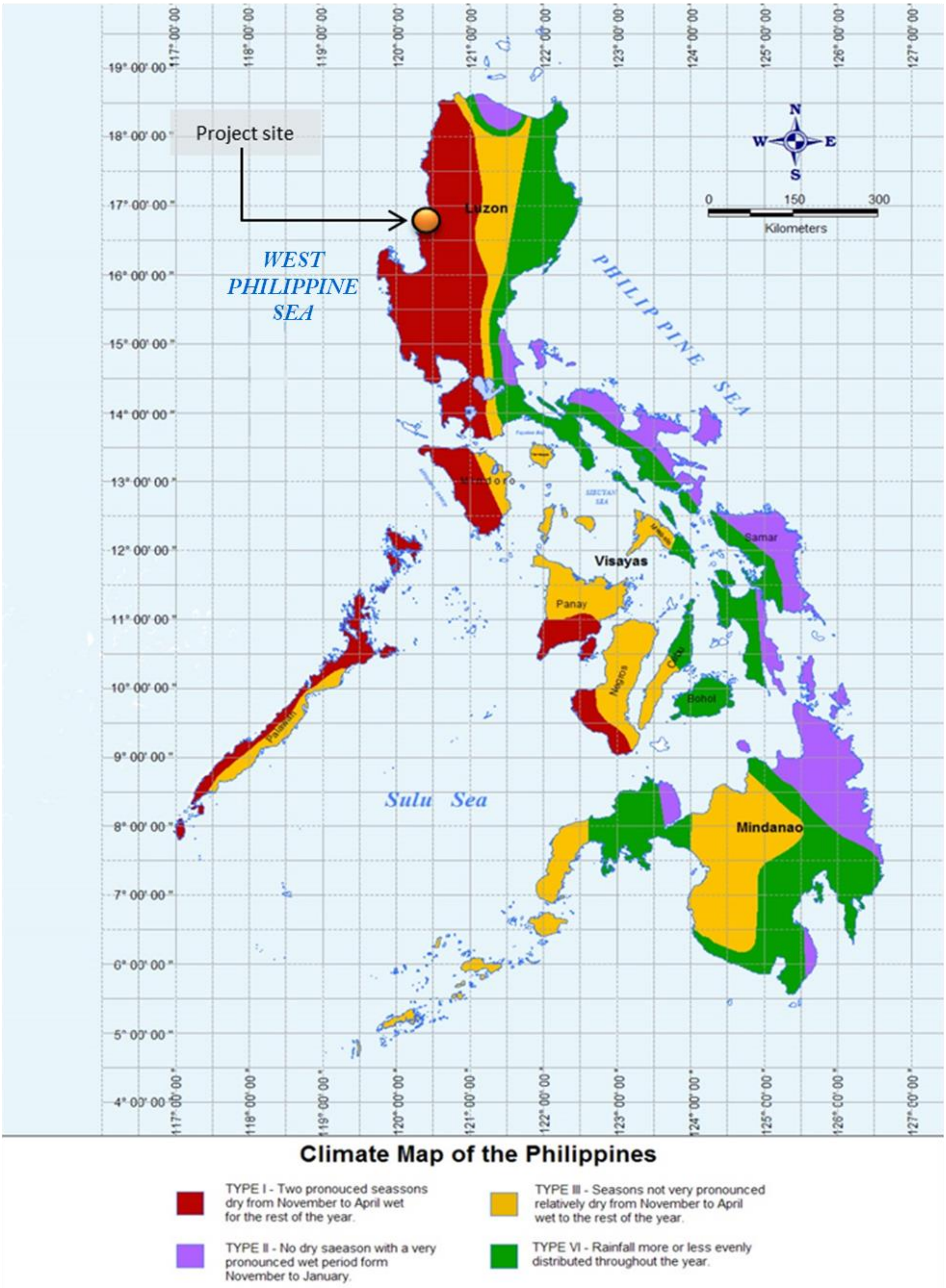


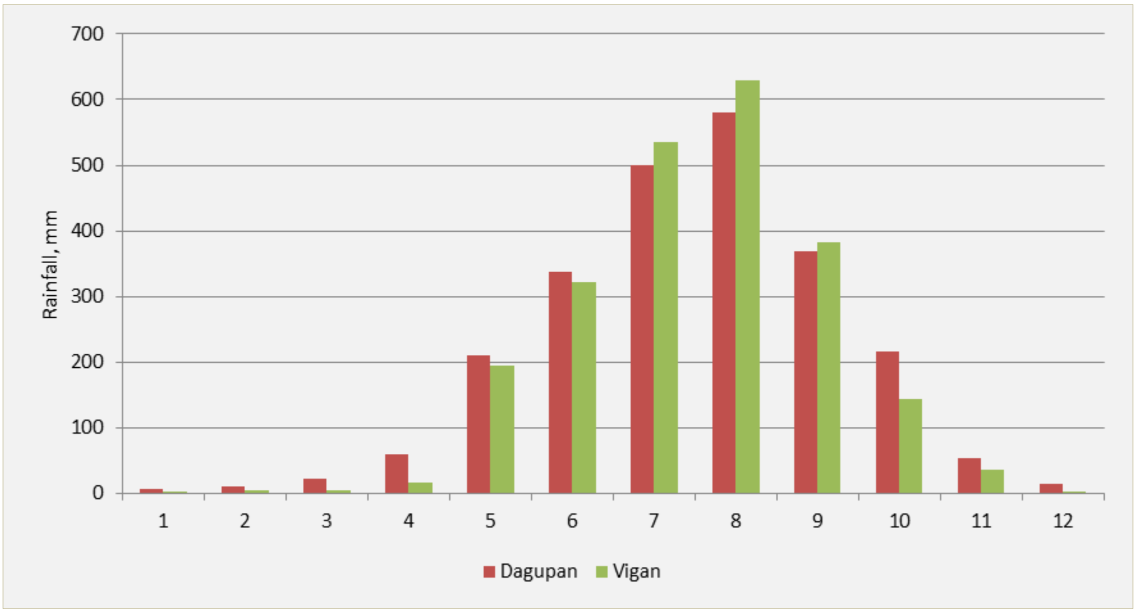
Figure EA-4. Climate Map of the Philippines	LEGEND: As above	SCALE: As above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: PAGASA (retrieved: January 2017)	aperçu PAGE 344

The project site is located in an area with a very high typhoon risk, with a frequency of two cyclones per year (Figure EA-5).The PAGASA recorded a total of 39 tropical cyclones crossing the province of La Union from 1948 to 2013 (Figure EA-6) with July and October as the months having the highest frequency.

Rainfall

The site may experience an annual rainfall of **2,277.4**mm to **2,380.9**mm with the maximum and minimum monthly rainfall occurring in August and January respectively (**Figure EA-7**). Rainfall generally starts in May, peaks in August, and declines thereafter. The number of rainy days in a year may range from 100 to 119.

Figure EA-7. Potential monthly rainfall at the project site



The mean annual rainfall and the number of rainy days in the country have increased since 1960. The country also experienced variability in the onset of the rainy season. The trend has been toward decreasing rainfall over Luzon and parts of Mindanao and increasing rainfall over the central western part of the country (*Anglo*, 2006).

The PAGASA predictions for the medium-range scenario showed both decreases and increases in rainfall from the observed baseline. The site may experience an increase in rainfall from June to February and a decrease from March to May in 2020 and 2050 (Figure EA-8). It may also experience the highest rainfall in June, July, and August in 2020 and 2050 with an annual rainfall of 1,707 to 2,098 mm (Table EA-9).

The highest increase from the baseline was projected for 2020 in the months from December to February, with an increase of 54.3%; and in the months of June, July, and August with an increase of 11.9 percent in 2050 (Table EA-9).

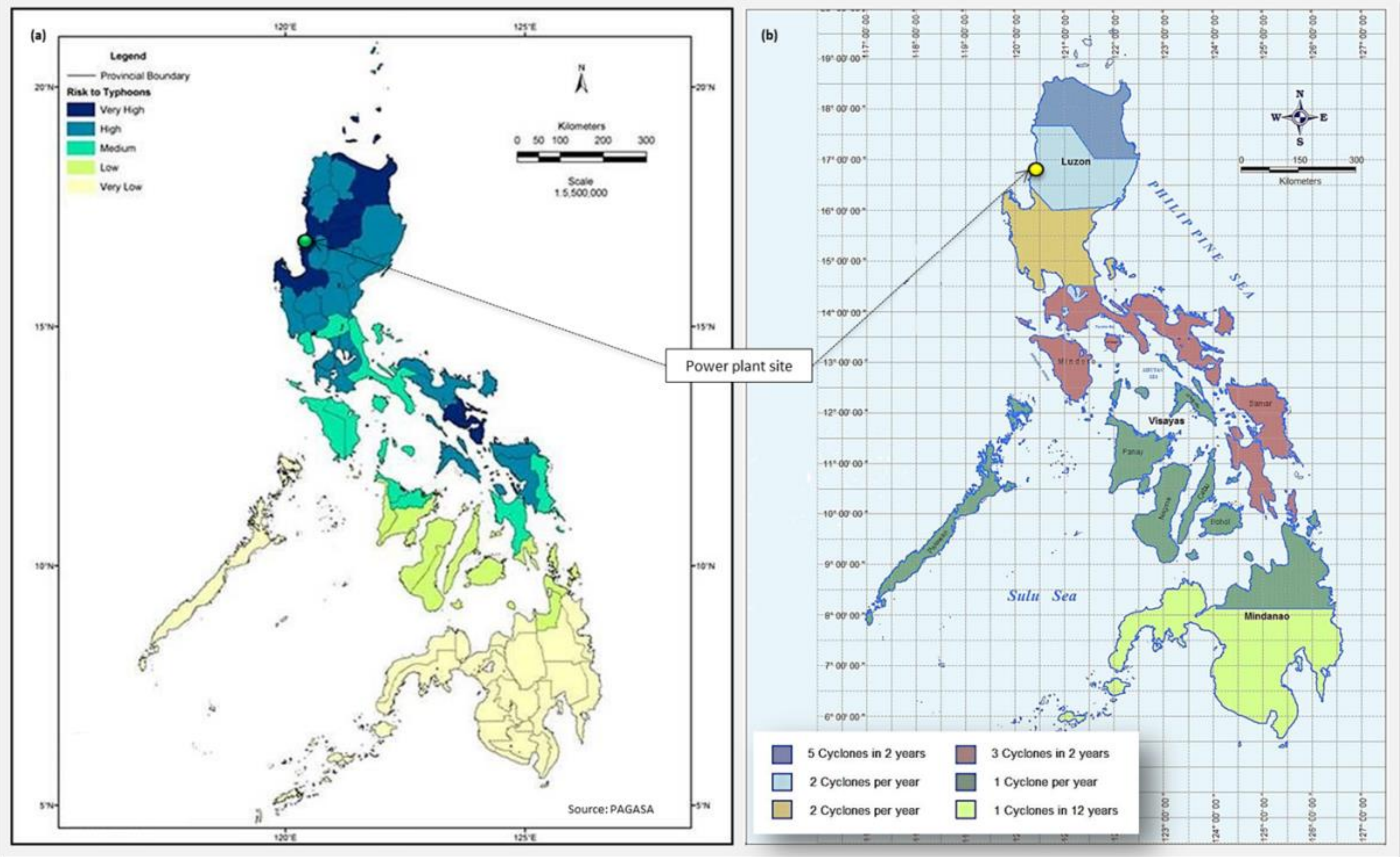
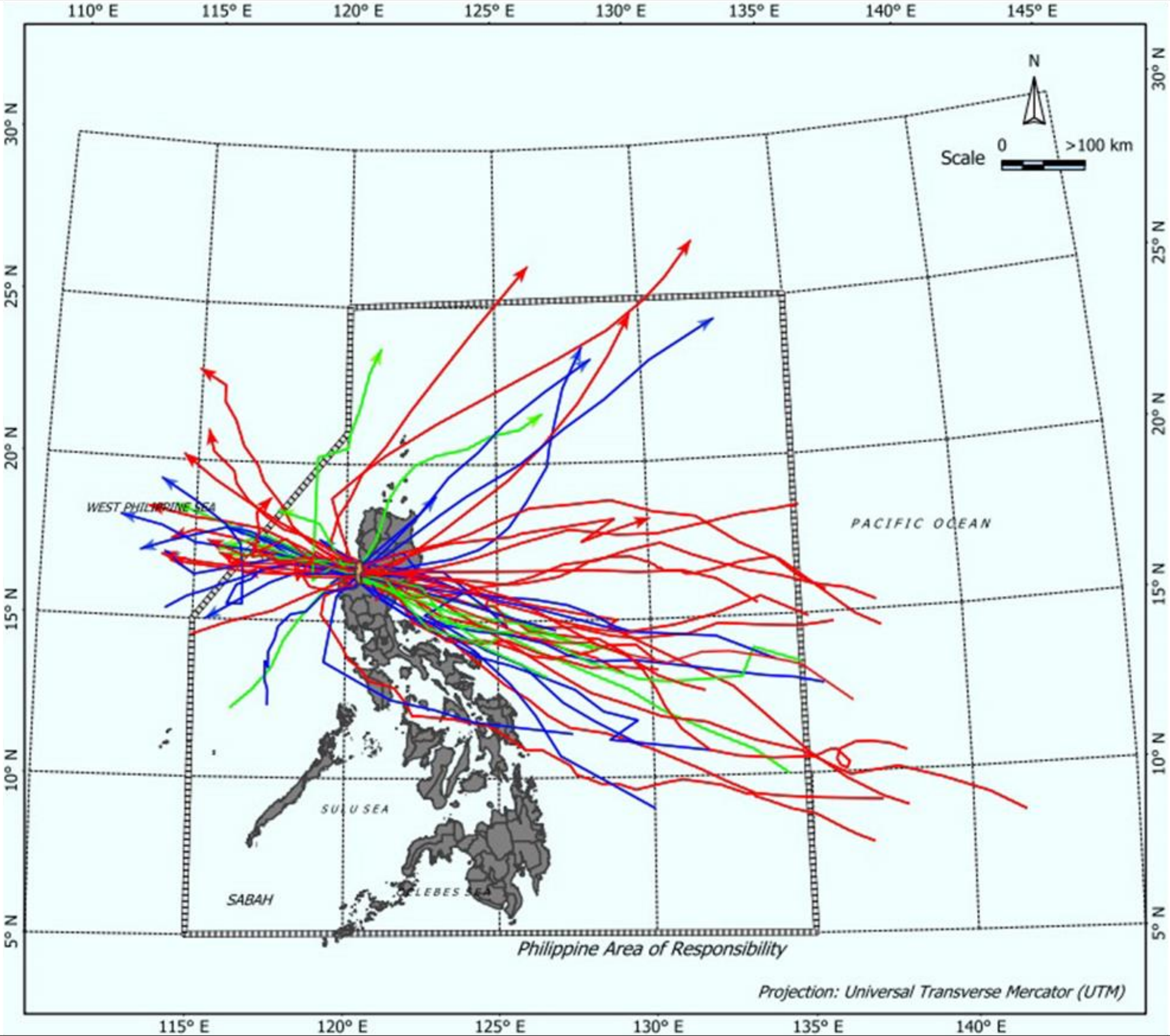


Figure EA-5. Typhoon Risks (a) and Cyclone Frequency (b) Maps of the Philippines	LEGEND: As above	SCALE: As above	DATA INFORMATION/SOURCE: Basemap: NAMRIA Data source: Joint Typhoon Warning Center, National Statistics Office, UNDP, PAGASA (retrieved: January 2017)	PAGE 346
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT				aperçu CONSULTANTS INC.



Monthly Frequency of Tropical Cyclones

MONTH	NUMBER
JAN	0
FEB	0
MAR	0
APR	0
MAY	6
JUN	3
JUL	7
AUG	4
SEP	6
OCT	9
NOV	3
DEC	1
TOTAL	39

LEGEND:

Line symbol

- Tropical Depression
- Tropical Storm
- Typhoon

Areas

- La Union

Figure EA-6. Tracks of Tropical Cyclones which Crossed La Union (1948-2013)	LEGEND: As above	SCALE: As above	DATA INFORMATION/SOURCE: Basemap: NAMRIA Data source: Joint Typhoon Warning Center, National Statistics Office, UNDP, PAGASA (retrieved: January 2017)	PAGE 347
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT				aperçu CONSULTANTS INC.

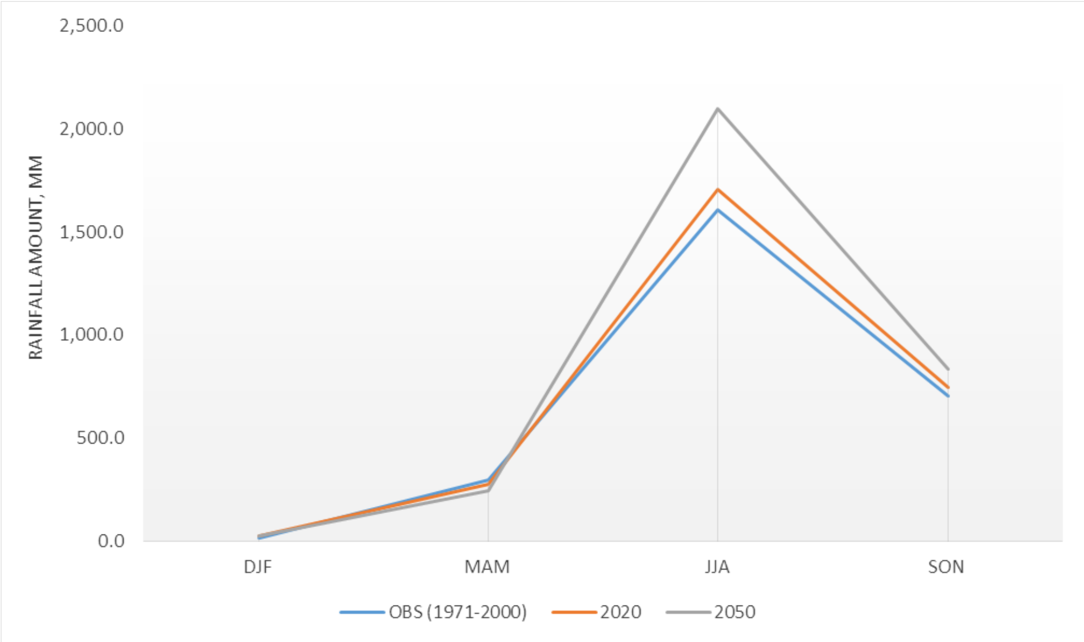


Figure EA-8. Graph of projected quarterly rainfall at the site

Table EA-9
Potential Mean Rainfall Projections at the Site

Quarter	Projected Change (%)		Temperature (°C)		
	2020	2050	1971-2000	2020	2050
DJF	54.3	1.1	19.4	29.9	30.3
MAM	-6	-11.2	298.0	280.1	248.7
JJA	6.1	22.9	1,608.9	1,707.0	2,098.0
SON	5.9	11.9	707.8	749.6	838.8
Annual Mean Rainfall			**2,634.1**	**2,766.7**	**3,215.7**

Source: derived from the report "*Climate Change in the Philippines*", PAGASA; *medium-range emission scenario projection.
Notes: DJF – Dec, Jan, Feb; MAM – Mar, Apr, May; JJA – Jun, Jul, Aug; SON- Sep, Oct, Nov

Surface Temperature

The mean temperatures at the site may range from a minimum of 25.8°C in January to a maximum of 29.5°C in April (**Figure EA-9**) resulting to a normal seasonal mean temperature difference of about 3.7 degrees. The mean temperatures then decreases and somewhat stabilizes from July to October then further declines to reach the minimum in January.

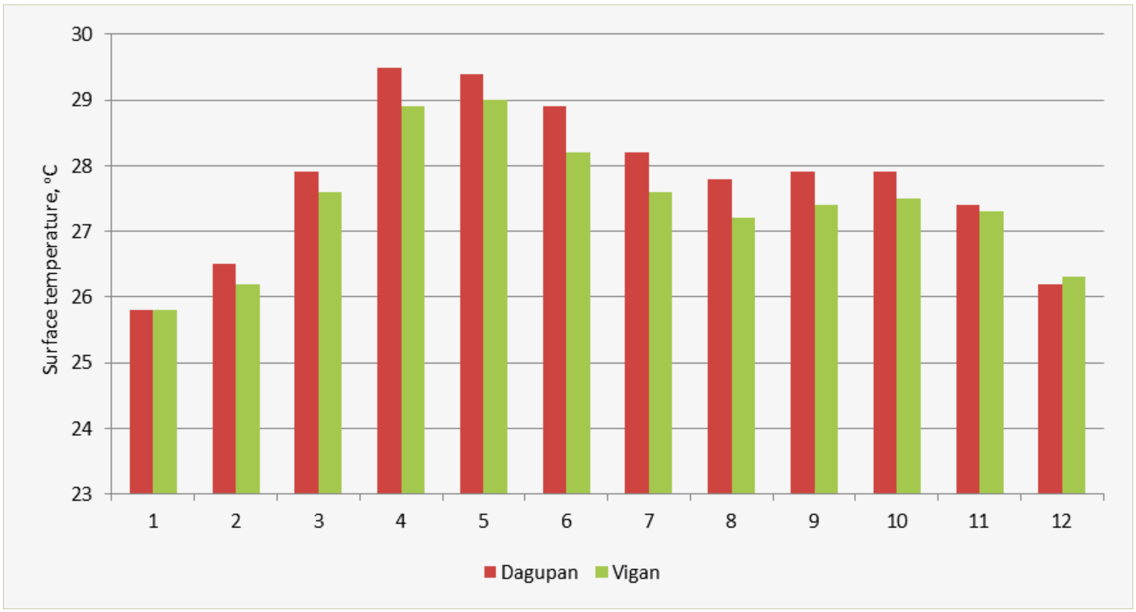


Figure EA-9. Potential monthly average temperatures at the project site

Since 1971 the country in general has experienced an increase in mean, maximum, and minimum temperatures by 0.14°C per decade (*IPCC*, 2007). *Tibig* (2004) and *Manton* et al. (2001) support this finding by showing departures from the annual mean, maximum, and minimum temperatures in recent years of 0.61°C, 0.34°C, and 0.89°C, respectively, from the 1961–1990 normal values (*ADB*, 2009).

The PAGASA projections for the province of Pangasinan under the medium-range scenario showed surface temperature increases in 2020 and 2050 from the observed baseline (Figure EA-10). With these projections, the site may experience mean surface temperatures of 25.9°C to 28.5°C and 27.2°C to 29.6°C in 2020 and 2050 respectively (Table EA-10). The projections result to annual mean temperature increases of 0.98°C and 2.05°C in 2020 and 2050, respectively.

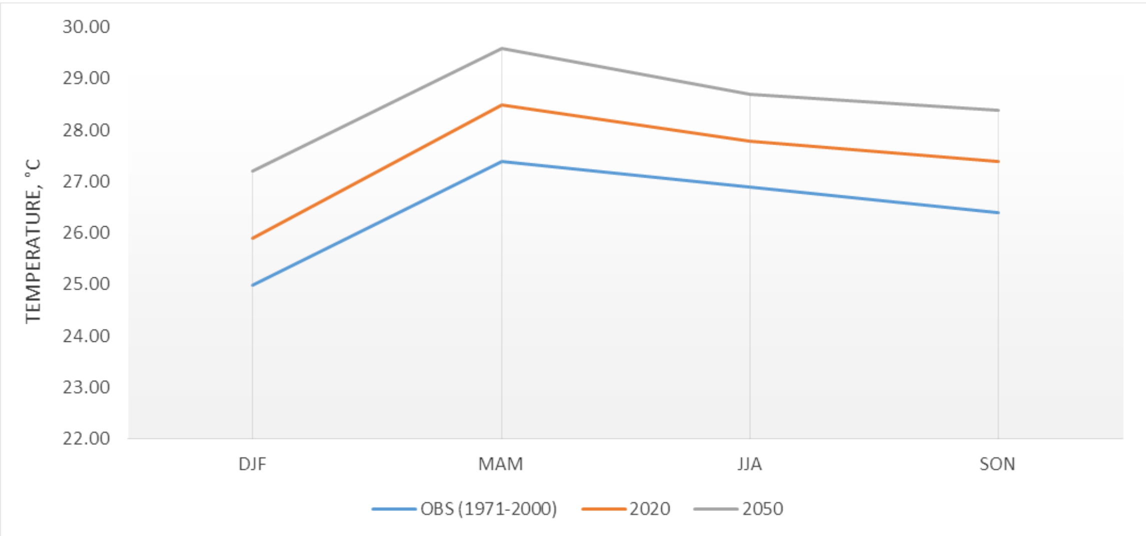


Figure EA.10 Graph of potential projected quarterly temperatures at the site

Table EA-10
Potential Mean Temperature Projections at the Site

Quarter	Projected Change (%)		Temperature (°C)		
	2020	2050	1971-2000	2020	2050
DJF	0.9	2.2	2.5	25.9	27.2
MAM	1.1	2.2	27.4	28.5	29.6
JJA	0.9	1.8	26.9	27.8	28.7
SON	1	2	26.4	27.4	28.4
Annual Mean Temperature			**26.425**	**27.4**	**28.475**

Source: derived from the report "*Climate Change in the Philippines*", PAGASA; *medium-range emission scenario projection
Notes: DJF – Dec, Jan, Feb; MAM – Mar, Apr, May; JJA – Jun, Jul, Aug; SON- Sep, Oct, Nov

Relative Humidity

Relative humidity is expressed in percentage of water vapor present in air using psychrometric charts with the dry- and wet-bulb temperatures as input. The project site may experience a mean relative humidity range of 72% to 87% with July to September as the most humid months (**Figure EA-11**).

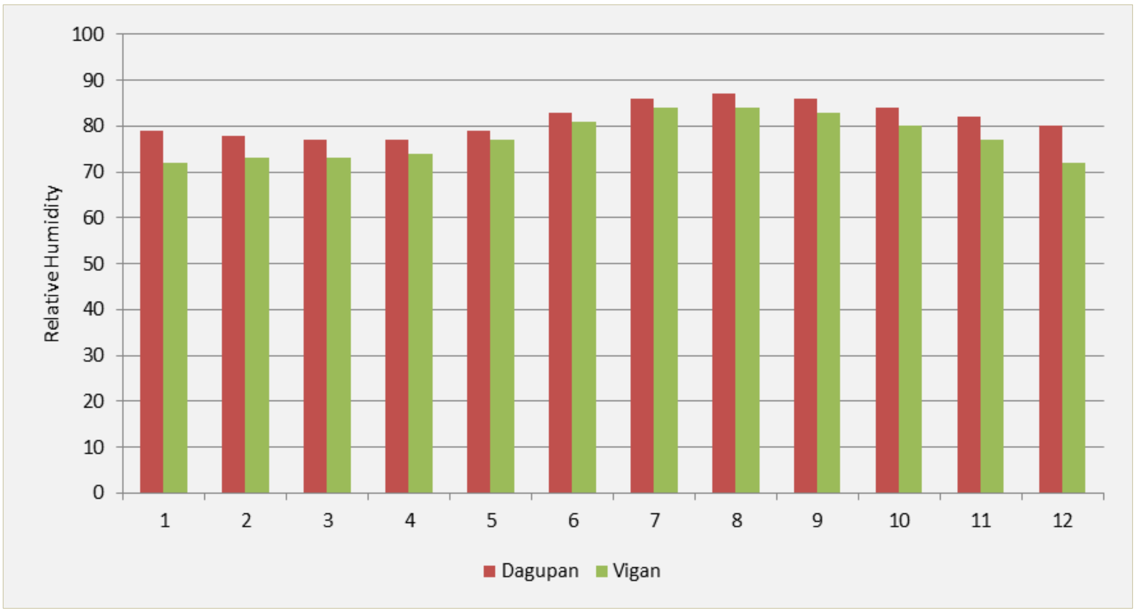


Figure EA-11. Potential monthly relative humidity at the project site

Cloudiness

Cloud cover is important in determining atmospheric stability (dispersion of air pollutants) because it controls insolation, i.e., amount of sunlight reaching land. Cloud cover is inversely proportional to insolation, i.e., more clouds, less insolation therefore less heating of the earth's surface. The monthly cloud cover at the project site may range from three to seven okta. The project area may be generally cloudy from June to October (**Figure EA-12**).

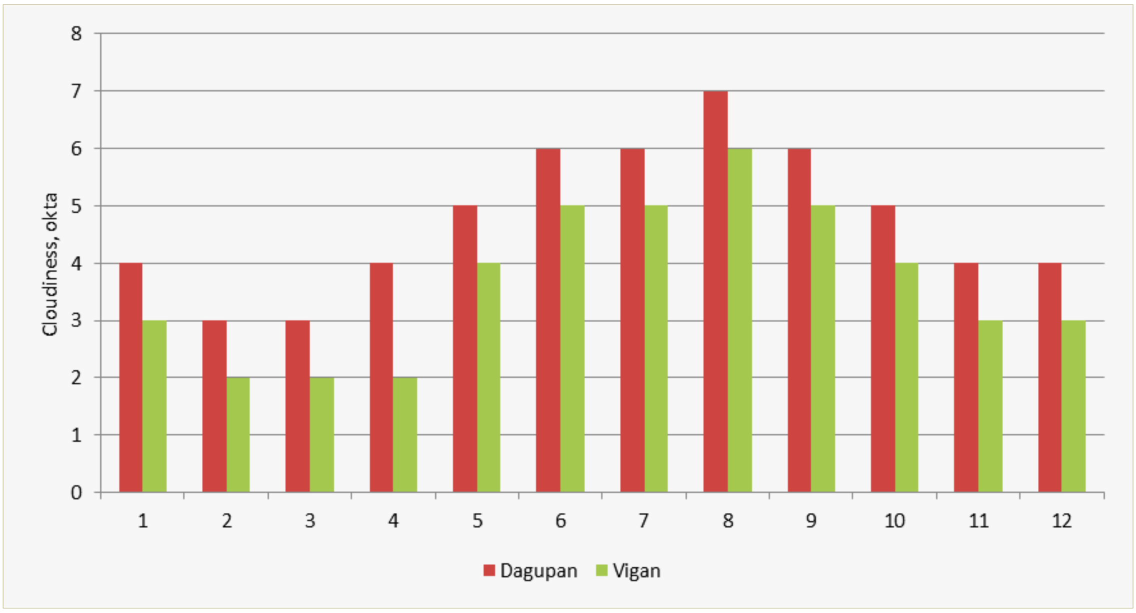


Figure EA-12. Potential monthly cloud-cover at the project site

Surface Winds

A windrose diagram (**Figure EA-13**) is a graphical representation that depicts a bivariate frequency distribution table of wind speed and wind direction using sixteen compass directions. The dominant wind speed at the site may range from one to four meters per second at the south-southeast, south, and north-northwest directions (**Table EA-11**).

Table EA-11
Annual Wind Frequency (1981-2010) at Dagupan PAGASA Station

Wind Direction	Wind Speed Class (mps)					Total
	1-4	5-8	8-12	13-16	>16	
N	7.7	0.6	0.0	0.0	0.0	8.3
NNE	0.3	0.0	0.0	0.0	0.0	0.3
NE	0.3	0.0	0.0	0.0	0.0	0.3
ENE	0.1	0.0	0.0	0.0	0.0	0.1
E	0.2	0.0	0.0	0.0	0.0	0.2
ESE	0.8	0.1	0.0	0.0	0.0	0.9
SE	18.2	1.1	0.0	0.0	0.0	19.3
SSE	18.0	0.7	0.0	0.0	0.0	18.7
S	14.8	0.6	0.0	0.0	0.0	15.4
SSW	0.3	0.0	0.0	0.0	0.0	0.3
SW	0.5	0.0	0.0	0.0	0.0	0.5
WSW	0.2	0.0	0.0	0.0	0.0	0.2
W	0.8	0.1	0.0	0.0	0.0	0.9
WNW	0.7	0.1	0.0	0.0	0.0	0.8
NW	9.1	0.8	0.0	0.0	0.0	9.9
NNW	21.6	2.1	0.1	0.0	0.0	23.8
Total	93.6	6.2	0.1	0.0	0.0	100
Average WS		**2.7**	**mps**			

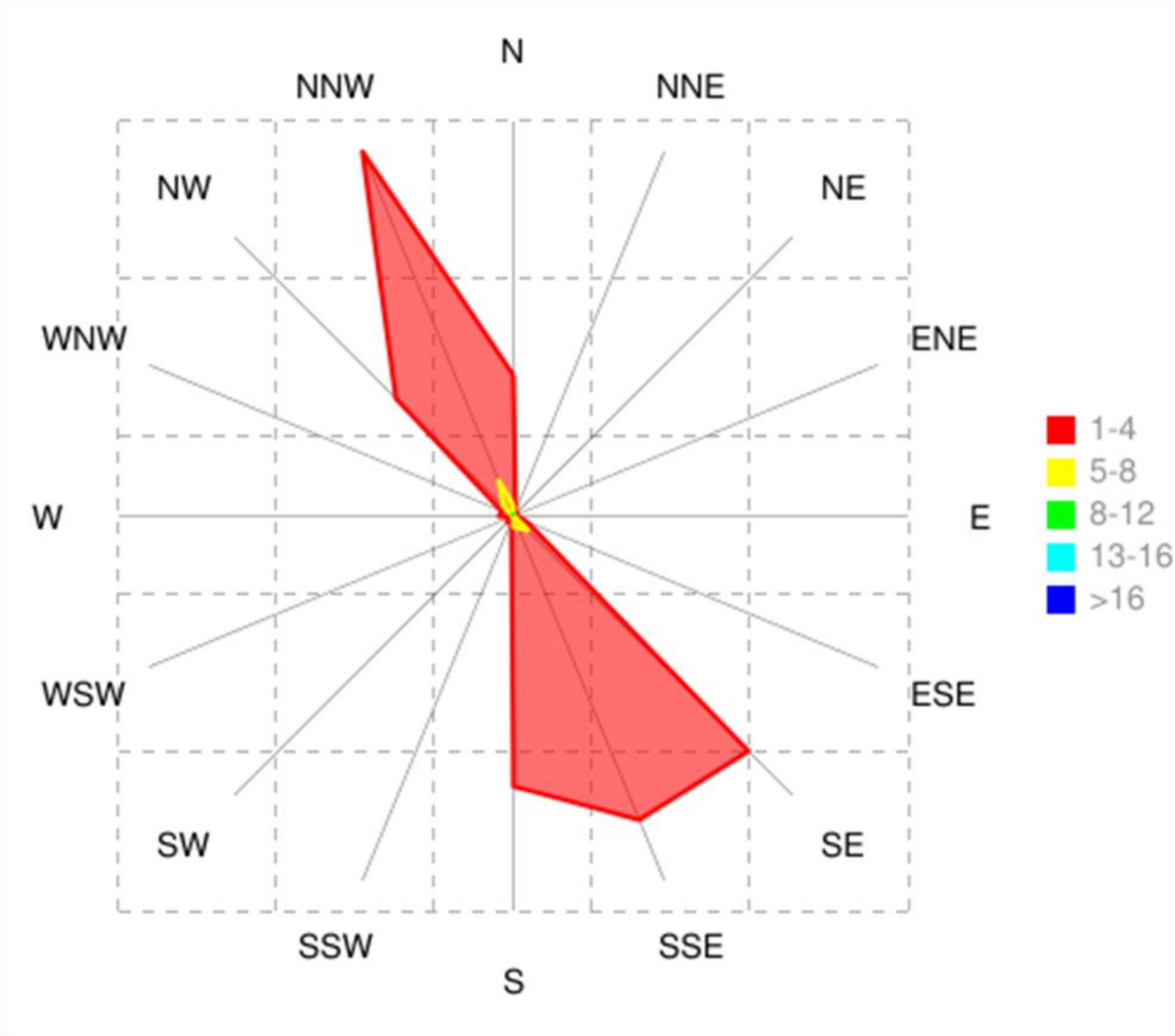


Figure EA-13. Annual Windrose Diagram (1971-2000) at Dagupan PAGASA Station	LEGEND: As above	SCALE: Not drawn to scale
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: Data Source: PAGASA (retrieved: January 2017) Diagram generated using: Enviroware (2017)	aperçu

Greenhouse Gas (GHG) Emissions

The estimated annual CO_2 emission of the power plant is 3,981,971 metric tons as the worst-case scenario and a normalized CO_2 emission of 750g-CO_2/kWh assuming full capacity output of 670MW operating 8,760 hours a year (**Table EA-12**).

Table EA-12
Predicted Worst-case setting Emissions of the Project

Greenhouse Gas	Unit	Projected Emissions
CO_2	MT/yr	3,954,197
CH_4	MT/yr	8,641
N_2O	MT/yr	19,133
Total CO_2-e	MT/yr	3,981,971
Normalized CO_2-e		
Capacity, MW		670
Operation	hr/yr	8,760
Normalized GHG	gCO_2/kwh	750.41

Comparing the worst-case CO_2 emission with various estimates showed that the project's contribution to global GHG levels in 2020 is less than 0.05 percent (orange cell in Table EA-13). Locally, project CO_2 emissions are estimated to contribute about four percent to the country's energy sector GHG budget in 2020 (green cell in Table EA-13).

Table EA-13
Annual CO_2 Contribution of the Proposed Coal-fired Power Plant

CO_2 Projections	Gg CO_2/yr	% Contribution
Global levels	9,042,000	0.044%
2020[1]		
Country energy sector		
SNC 2020	100,402	3.938%
ALGAS 2020	429,963	0.919%

Sectoral Trends in Global Energy Use and Greenhouse Gas Emissions, Climate Protection Division, Office of Air and Radiation, U.S. Environmental Protection Agency, 2006; SNC - Second National Communication on Climate Change (Philippines)

3.3 Ambient Air

This section presents the existing ambient air quality at the site vis-à-vis applicable Clean Air Act (CAA) ambient air quality standards and guideline values (**Table EA-14**). Air dispersion modeling was also done to predict the incremental impacts of power plant emissions on the ambient air quality.

Table EA-14
National Ambient Air Quality Standards and Guideline Values

Pollutant	AT	Unit	Value	Source	Analytic Method
Criteria pollutants					
TSP	1h	μg/ncm	300	CAA NAAQSSSAPIS/O	Gravimetric
	24h	μg/ncm	230	CAA NAAQGV	
	Annual	μg/ncm	90	CAA NAAQGV	
PM-10	1 hr	μg/ncm	200		Gravimetric
	24 hr	μg/ncm	150		
Sulfur Dioxide	1h	μg/ncm	340	CAA NAAQSSSAPIS/O	Colorimetric-Pararosaline
	24h	μg/ncm	180	CAA NAAQGV	
	Annual	μg/ncm	80	CAA NAAQGV	
Nitrogen Dioxide	1h	μg/ncm	260	CAA NAAQSSSAPIS/O	Griess-Saltzman
	24h	μg/ncm	150	CAA NAAQGV	
Carbon monoxide	1h	mg/ncm	35	CAA NAAQGV	NDIR
	8h	mg/ncm	10	CAA NAAQGV	
Trace metals					
Arsenic (As)	30min	mg/ncm	0.02	CAA NAAQSSSAPIS/O	*Atomic Absorption Spectrophotometry*
Cadmium (Cd)	30min	mg/ncm	0.01	CAA NAAQSSSAPIS/O	
Chromium (Cr+6)	-	-	-	-	
Lead (Pb)	30min	μg/ncm	20	CAA NAAQSSSAPIS/O	
Mercury (Hg)	-	-	-	-	

Source: Implementing Rules and Regulations of the Clean Air Act
AT – averaging time; CAA – Clean Air Act; NAAQSSSAPIS/O - National Ambient Air Quality Standards for Source Specific Air Pollutants from Industrial Sources/Operations; NAAQGV - National Ambient Air Quality Guideline Values

3.3.1 Baseline Conditions and Modeling Results

3.3.1.1 Sources of Air Emissions

The major sources of air residuals within the model domain are a) gaseous and particulate emissions from the vehicles passing through the national highway and roads, b) emissions from households, e.g., cooking, (c) and fugitive particulates and gases from agricultural areas (**Figure EA-14**). There is also a large emission source from the Holcim Cement plant and quarry about 7 kilometers south of the proposed site.

3.3.1.2 Air Pollutant Levels

The sampling results showed that concentrations of criteria and trace metal pollutants at all stations and averaging times were very low compared to their corresponding CAA standards and guideline values (**Table EA-15**).

Table EA-15
Existing Pollutant Concentrations at the Project Site

Pollutant	Unit	Averaging Time	Station						CAA
			AQ1	AQ2	AQ3	AQ4	AQ5	AQ6	
Criteria Pollutant									
TSP	ug/ncm	24h	0.4	0.5	0.4	0.8	0.7	0.8	230
PM10	ug/ncm	24h	0.3	0.3	0.3	0.5	0.6	0.6	150
SO_2	ug/ncm	24h	<4	<4	<4	<4	<4	<4	180
NO_2	ug/ncm	24h	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	150
Trace Metal Pollutant									
As	mg/ncm	30min	ND	ND	ND	ND	ND	ND	0.02
Cd	mg/ncm	30min	ND	ND	ND	ND	ND	ND	0.01
Cr	ug/ncm	30min	ND	ND	ND	ND	ND	ND	ns
Pb	ug/ncm	30min	ND	ND	ND	ND	ND	ND	20
Hg	ug/ncm	24h	ND	ND	ND	ND	ND	ND	ns

ND – no detection (below the method detection limit); ns – no standard or guideline value; CAA – DENR

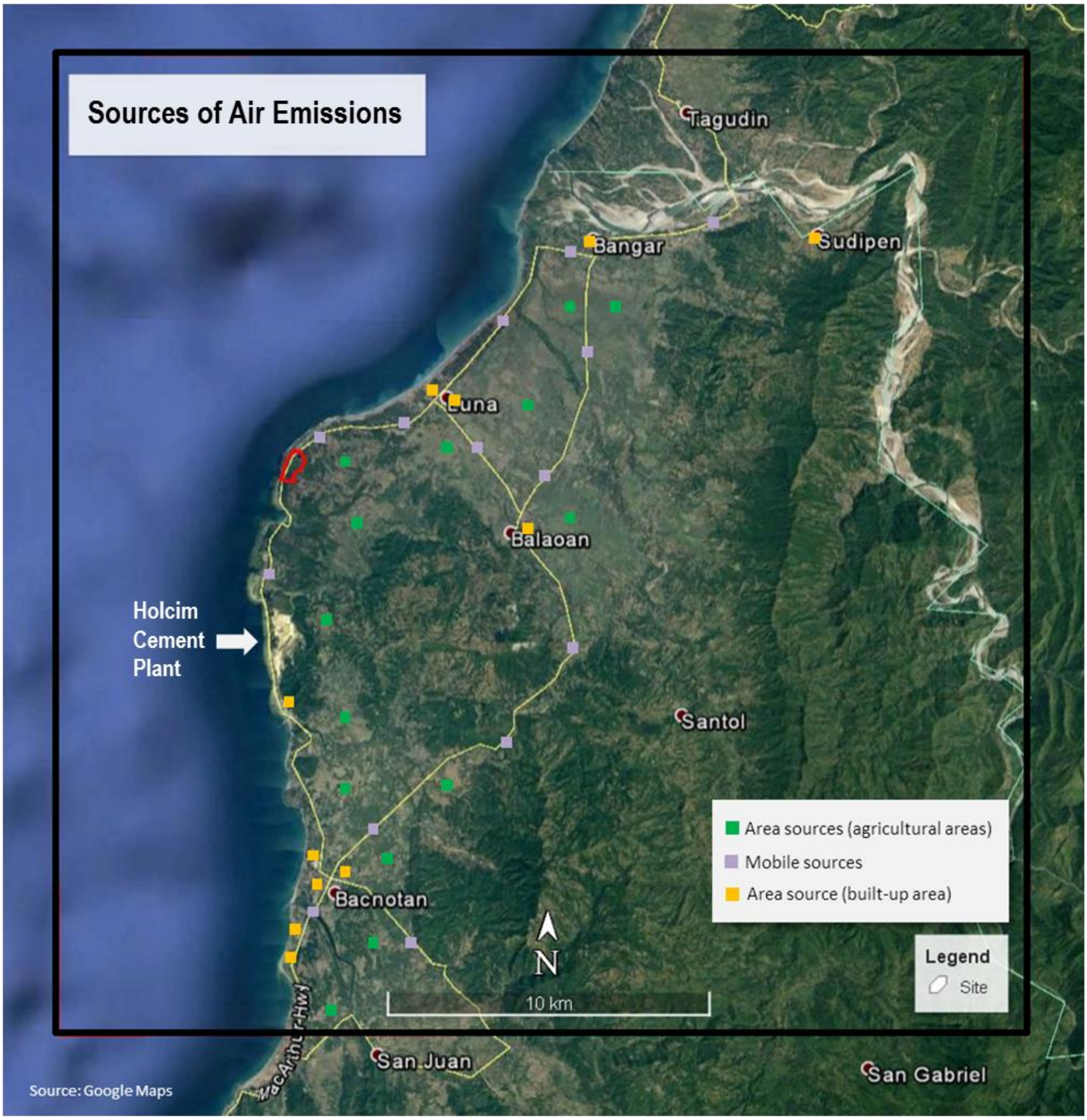


Figure EA-14. Air Emission Sources in the Model Domain	LEGEND: As above; and — Project Site	SCALE: As above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: Base map: Google Map Imagery Created by: Apercu Consultants_JACH (2017)	apercu

3.3.1.3 Modeling Results

The incremental impacts of stack emissions during operation were presented by showing statistical summaries of the predicted GLCs at the grid and discrete receptors during NORMAL and UPSET conditions. An index, i.e., ratio of predicted peak GLCs and the corresponding CAA standard and averaging time, was used to determine whether or not a GLC exceeded a certain limit value (*red fonts* in all tables).

The predicted GLCs were calculated using an AERMOD screening met data set. A screening met data set is used in the absence of on-site met data to uncover conservative GLCs for initially assessing incremental ambient air quality impacts from air pollution sources. Literature elsewhere indicated that predicted GLCs from Gaussian models using screening or onsite met data are likely overestimated by a factor of 2.5[2] or more than ten[3].

The spatial and temporal distributions of the calculated GLCs cannot be predicted using a screening met data set.

Since compliance to the CAA requires the determination of 98 percentile (98p) GLCs that can only be determined by using on-site met data, the exceedances presented only implies *apparent compliance* or *potential non-compliance* that has to be validated when the power plant is operational, by modeling using CEMS and on-site met data. In addition, the analysis of results focused on the one-hour GLCs because it is the only valid averaging time when using screening met data. The GLCs for other averaging times derived from multiplying factors in the EMB modeling guidelines were presented for comparison purposes and not to be construed as compliance. The predicted GLCs using a screening met data set are unlikely to be observed during actual operations when using actual on-site and CEMs data.

The modeling results included the long-term guideline values for relevant pollutants, e.g., SO2, TSP, PM10. However, model results only showed potential hotspots for the 24h SO2 and NO2 during normal conditions and 24h NO2 and TSP at upset conditions (**Table EA-22**).

Predicted Levels of Pollutants (Grid Receptors)

Gaseous Pollutants

Exceedances were predicted for the maximum 1h and 24h SO_2 and NO_2 GLCs during normal and upset conditions (orange cells in **Table EA-16**). The percentage occurrences of the exceedances however, were less than one percent of the total grid receptors (30,775 nodes) during normal conditions and less than seven percent of the total grid receptors during upset conditions. The locations of these exceedances are shown in **Figures EA-15 to EA-18** in the hotspots section. The simulation results showed that a more refined modeling is required using three-year on-site data and CEMS data[4] and that the pollutant of concern is NO_2.

The simulation showed that despite the exceedances, it is likely that the incremental impact of stack emissions will comply with the CAA standards during actual operations indicated by the 3rd quartile GLCs that were less than the CAA limits. Values less than the 1st or greater than 3rd quartiles are generally considered as outliers.

The UPSET scenario was included to demonstrate the impact of emissions should the SWFGD totally fail, i.e, SO_2 emissions are uncontrolled, a condition that is highly unlikely during actual operations.

[2] Stiggins, T.E., Parnell, C.B., Lacy, R.E., & Shaw, B.W. (2002)
[3] National Research Council of the National Academies (2003)
[4] EMB Air Dispersion Modeling Guidelines

Table EA-16
Predicted Gaseous Pollutant GLCs at the Grid Receptors during Operation

NORMAL CONDITIONS							
Pollutant	**SO_2, ug/ncm)**			**NO_2 (ug/ncm)**		**CO, mg/ncm**	
Averaging Time	**1h**	**24h**	**Annual**	**1h**	**24h**	**1h**	**8h**
Statistic							
Minimum	2.10	0.84	0.17	3.62	1.45	0.00384	0.00230
1st quartile	49.34	19.74	3.95	84.96	33.98	0.09034	0.05420
Median	66.08	26.43	5.29	113.79	45.52	0.12099	0.07259
3rd quartile	91.15	36.46	7.29	156.95	62.78	0.16689	0.10013
Maximum	462.49	185.00	37.00	796.35	318.54	0.84676	0.50806
CAA Standard	340	180	80	260	150	35	10
Index (Max GLC/CAA)	1.36	1.03	0.46	3.06	2.12	0.024	0.051
# of exceedance	13	1	0	292	118	0	0
% exceedance	0.043%	0.003%	0.000%	0.969%	0.392%	0.000%	0.000%
UPSET CONDITIONS							
Pollutant	**SO_2, ug/ncm)**			**NO_2 (ug/ncm)**		**CO, mg/ncm**	
Averaging Time	**1h**	**24h**	**Annual**	**1h**	**24h**	**1h**	**8h**
Statistic							
Minimum	0.00	0.00	0.00	0.00	0.00	0.003	0.002
1st quartile	46.94	18.78	3.76	120.53	48.21	0.103	0.062
Median	70.64	28.25	5.65	181.36	72.54	0.150	0.090
3rd quartile	78.86	31.54	6.31	202.47	80.99	0.166	0.100
Maximum	426.33	170.53	34.11	1094.59	437.83	0.896	0.538
CAA Standard	340	180	80	260	150	35	10
Index (Max GLC/CAA)	1.25	0.95	0.43	4.21	2.92	0.03	0.05
# of exceedance	7	0	0	2086	438	0	0
% exceedance	0.02%	0.00%	0.00%	6.78%	1.42%	0.00%	0.00%

Particulates

The predicted peak
-TSP and PM10 GLCs at all averaging times were less than the CAA standards at NORMAL conditions (**Table EA-17**).

Similar to the gaseous pollutants, the UPSET scenario was included to demonstrate the impact of emissions should the ESP totally fail, i.e, particulate emissions are uncontrolled. The results showed exceedances of the predicted peak GLCs at all averaging times with a high percentage occurrence for TSP (orange cells in **Table EA-17**).

Table EA-17
Predicted Particulate GLCs at the Grid Receptors during Operation

NORMAL CONDITIONS						
Pollutant	**TSP, ug/ncm)**			**PM10, ug/ncm)**		
Averaging Time	**1h**	**24h**	**Annual**	**1h**	**24h**	**Annual**
Statistic						
Minimum	0.02	0.01	0.0018	0.0026	0.0011	0.00021
1st quartile	22.21	8.89	1.78	0.06	0.02	0.00497
Median	29.95	11.98	2.40	0.08	0.03	0.00665
3rd quartile	41.21	16.48	3.30	0.11	0.05	0.00918
Maximum	99.88	39.95	7.99	0.58	0.23	0.04656
CAA Standard	300	230	90	200	150	60
Index (Max GLC/CAA)	0.33	0.17	0.09	0.003	0.002	0.001
# of exceedance	0	0	0	0	0	0
% exceedance	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
UPSET CONDITIONS						
Pollutant	**TSP, ug/ncm)**			**PM10, ug/ncm)**		
Averaging Time	**1h**	**24h**	**Annual**	**1h**	**24h**	**Annual**
Statistic						
Minimum	10.34	4.13	0.83	0.52	0.21	0.04
1st quartile	368.57	147.43	29.49	18.43	7.37	1.47
Median	534.33	213.73	42.75	26.72	10.69	2.14
3rd quartile	592.73	237.09	47.42	29.64	11.85	2.37
Maximum	3199.77	1279.91	255.98	159.99	64.00	12.80
CAA Standard	300	230	90	200	150	60
Index (Max GLC/CAA)	10.67	5.56	2.84	0.80	0.43	0.21
# of exceedance	24375	10584	414	0	0	0
% exceedance	80.88%	35.12%	1.37%	0.00%	0.00%	0.00%

Trace Metals (TM)

The predicted maximum TM GLCs were less than the CAA standards during normal and upset conditions (**Table EA-18**), with very low indices indicating likely compliance to the CAA limits.

Table EA-18
Predicted Trace Metal GLCs at the Grid Receptors during Operation

Operating Condition	Normal					Upset				
Pollutant	As	Cd	Cr	Pb	Hg	As	Cd	Cr	Pb	Hg
Averaging Time	30min	30min	1h	30min	1h	30min	30min	1h	30min	1h
Unit	mg/ncm	mg/ncm	ug/ncm	ug/ncm	ug/ncm	mg/ncm	mg/ncm	mg/ncm	ug/ncm	ug/ncm
Statistic										
Minimum	0	0	0	0	0	0	0	0.000024	0.000012	0
1st quartile	0	0	0.000012	0	0	0	0	0.000708	0.00036	0.000012
Median	0	0	0.000012	0.000012	0	0	0	0.001032	0.000516	0.000024
3rd quartile	0	0	0.000024	0.000012	0	0	0	0.00114	0.000576	0.000024
Maximum	0	0	0.000096	0.000048	0	0	0	0.006156	0.003096	0.00012
CAA Standard	0.02	0.01	ns	20	ns	0.02	0.01	ns	20	ns
Index (Max GLC/CAA)	0	0	-	0.000002	-	0	0	-	0.000155	-
# of exceedance	0	0	-	0	-	0	0	-	0	-
% exceedance	0	0	-	0	-	0	0	-	0	-

Predicted Level of Pollutants (Discrete Receptors)

Gaseous Pollutants

Except for a single instance of the 1h SO_2 (orange cell in **Table EA-19**), the predicted maximum GLCs across averaging times and conditions were less than the CAA standards.

Table EA-19
Predicted Gaseous Pollutant GLCs at the Discrete Receptors during Operation

Normal Conditions							
Pollutant	**SO_2, ug/ncm)**			**NO_2 (ug/ncm)**		**CO, mg/ncm**	
Averaging Time	**1h**	**24h**	**Annual**	**1h**	**24h**	**1h**	**8h**
Statistic							
Minimum	17.79	7.12	1.42	30.64	12.25	0.03	0.02
1st quartile	43.46	17.38	3.48	74.83	29.93	0.08	0.05
Median	55.30	22.12	4.42	95.22	38.09	0.10	0.06
3rd quartile	72.57	29.03	5.81	124.95	49.98	0.13	0.08
Maximum	348.75	139.50	27.90	600.49	240.20	0.64	0.38
CAA Standard	340	180	80	260	150	35	10
Index (Max GLC/CAA)	1.03	0.77	0.35	2.31	1.60	0.02	0.04
# of exceedance	1	0	0	16	10	0	0
% exceedance	0.27%	0.00%	0.00%	4.38%	2.74%	0.00%	0.00%
Upset Conditions							
Pollutant	**SO_2, ug/ncm)**			**NO_2 (ug/ncm)**		**CO, mg/ncm**	
Averaging Time	**1h**	**24h**	**Annual**	**1h**	**24h**	**1h**	**8h**
Statistic							
Minimum	19.51	7.80	1.56	50.09	20.04	0.04	0.02
1st quartile	53.64	21.46	4.29	137.73	55.09	0.11	0.07
Median	68.88	27.55	5.51	176.86	70.74	0.14	0.09
3rd quartile	89.08	35.63	7.13	228.72	91.49	0.19	0.11
Maximum	338.64	135.46	27.09	869.45	347.78	0.71	0.43
CAA Standard	340	180	80	260	150	35	10
Index (Max GLC/CAA)	0.996	0.75	0.34	3.34	2.32	0.02	0.04
# of exceedance	0	0	0	60	15	0	0
% exceedance	0.00%	0.00%	0.00%	16.44%	4.11%	0.00%	0.00%

Particulates

Except for the TSP during the upset scenario (orange cells in **Table EA-20**), maximum particulate GLCs at all averaging times and conditions were less than the CAA standards.

Table EA-20
Predicted Particulate GLCs at the Discrete Receptors during Operation

Normal Conditions						
Pollutant	**TSP, ug/ncm)**			**PM10, ug/ncm)**		
Averaging Time	**1h**	**24h**	**Annual**	**1h**	**24h**	**Annual**
Statistic						
Minimum	8.07	3.23	0.65	0.02	0.01	0.00
1st quartile	19.71	7.89	1.58	0.05	0.02	0.00
Median	25.09	10.03	2.01	0.07	0.03	0.01
3rd quartile	32.92	13.17	2.63	0.09	0.04	0.01
Maximum	158.21	63.28	12.66	0.44	0.18	0.04
CAA Standard	300	230	90	200	150	60
Index (Max GLC/CAA)	0.53	0.28	0.14	0.00	0.00	0.00
# of exceedance	0	0	0	0	0	0
% exceedance	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Upset Conditions						
Pollutant	**TSP, ug/ncm)**			**PM10, ug/ncm)**		
Averaging Time	**1h**	**24h**	**Annual**	**1h**	**24h**	**Annual**
Statistic						
Minimum	146.44	58.57	11.71	7.32	2.93	0.59
1st quartile	402.62	161.05	32.21	20.13	8.05	1.61
Median	517.00	206.80	41.36	25.85	10.34	2.07
3rd quartile	668.61	267.44	53.49	33.43	13.37	2.67
Maximum	2541.63	1016.65	203.33	127.08	50.83	10.17
CAA Standard	300	230	90	200	150	60
Index (Max GLC/CAA)	8.47	4.42	2.26	0.64	0.34	0.17
# of exceedance	358	125	15	0	0	0
% exceedance	98.08%	34.25%	4.11%	0.00%	0.00%	0.00%

Trace Metals

The predicted maximum trace metal GLCs at all discrete receptors were less than the CAA standards during both normal and upset conditions (**Table EA-21**) indicating likely compliance to the CAA limits during actual operations.

Location of Hotspots

Air pollution hotspots refer to areas within the model domain where GLCs exceeded the CAA standards ("*potential hotspots*") or where peak GLCs occurred ("areas of concern").

Areas of concern are locations within the domain where the predicted GLCs are greater than 50% of the standards and guideline value but no exceedance.

The simulations showed four potential hotspots and two areas of concern for the TSP and PM10 (yellow and orange cells in **Table EA-22**, respectively). The isopleths of the four potential hotspots are shown in **Figure EA-15** to **Figure EA-18**.

The predicted 24h NO_2 exceedances during the normal conditions were mostly located in high elevation terrain inside the domain found in the East-South sector of the project site with the nearest hotspot about seven kilometers southeast of the site (**Figure EA-15**).

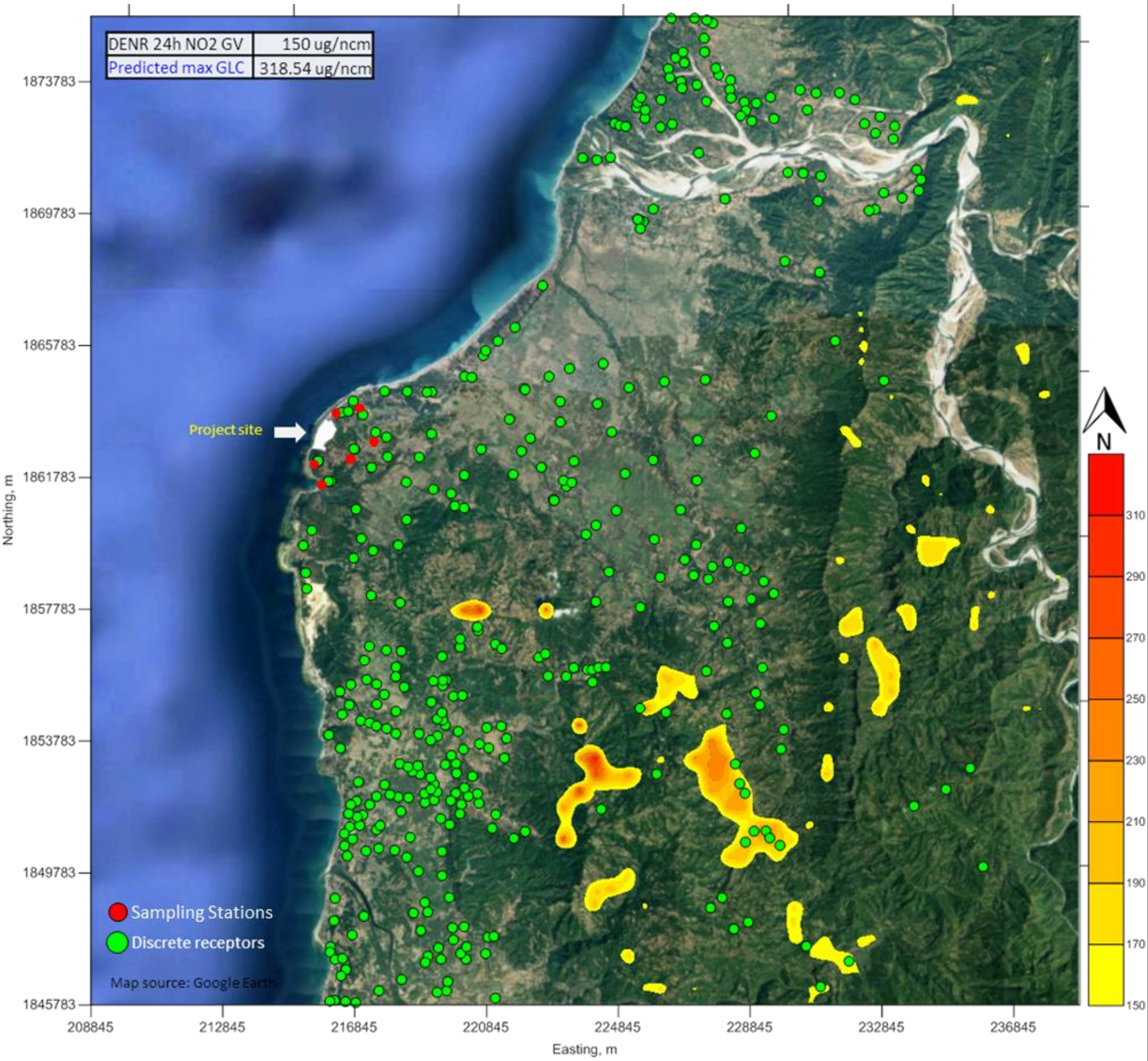


Figure EA-15. Isopleth of Predicted 24h NO_2 GLCs at Normal Conditions	LEGEND: As above	SCALE: As above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: Base map: Google Map Imagery Created by: Apercu Consultants_JACH (2017)	aperçu CONSULTANTS INC. PAGE 362

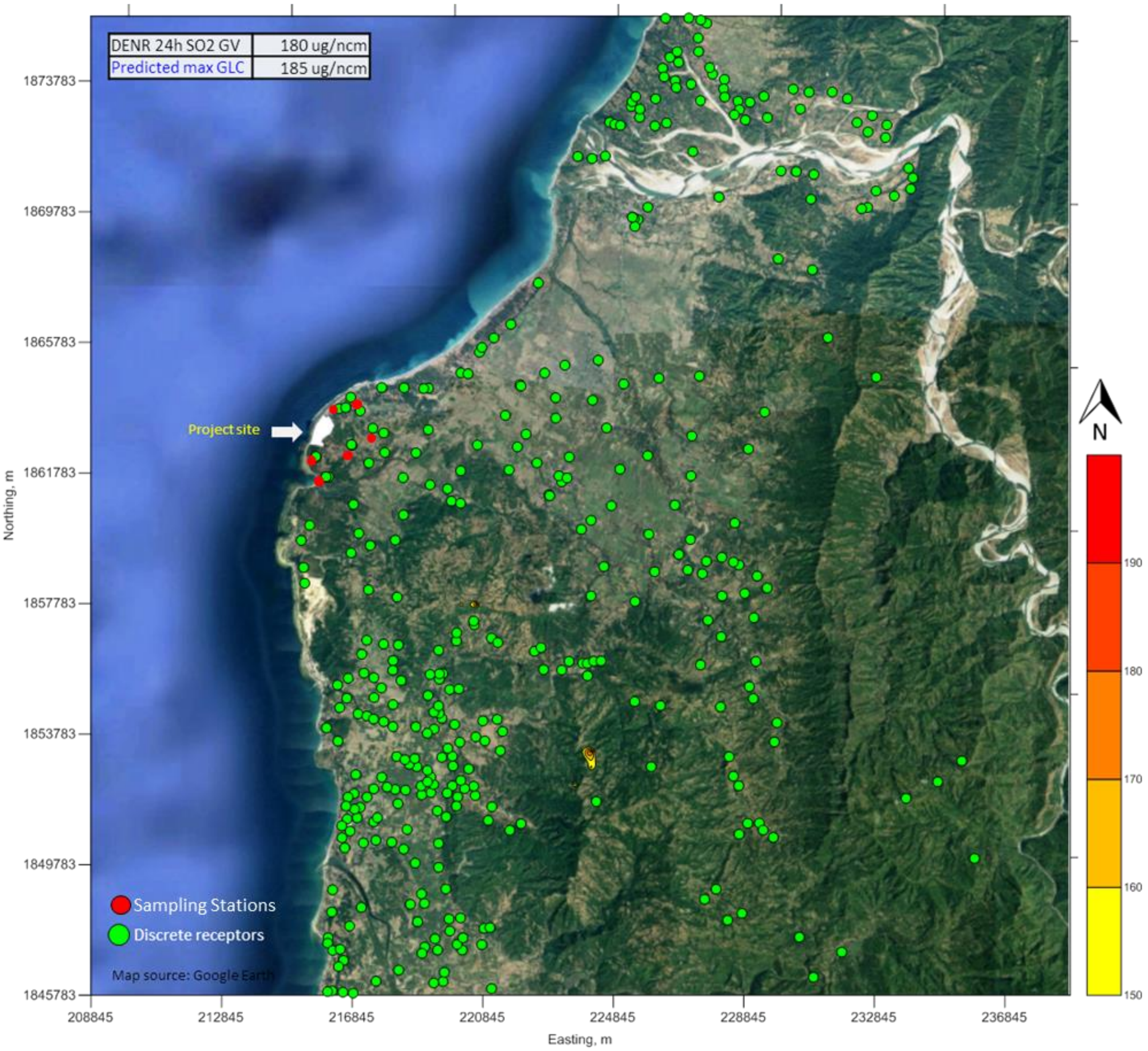


Figure EA-16. Isopleth of Predicted 24h SO_2 GLCs at Normal Condition	LEGEND: As above	SCALE: As above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: Base map: Google Map Imagery Created by: Apercu Consultants_JACH (2017)	PAGE 363

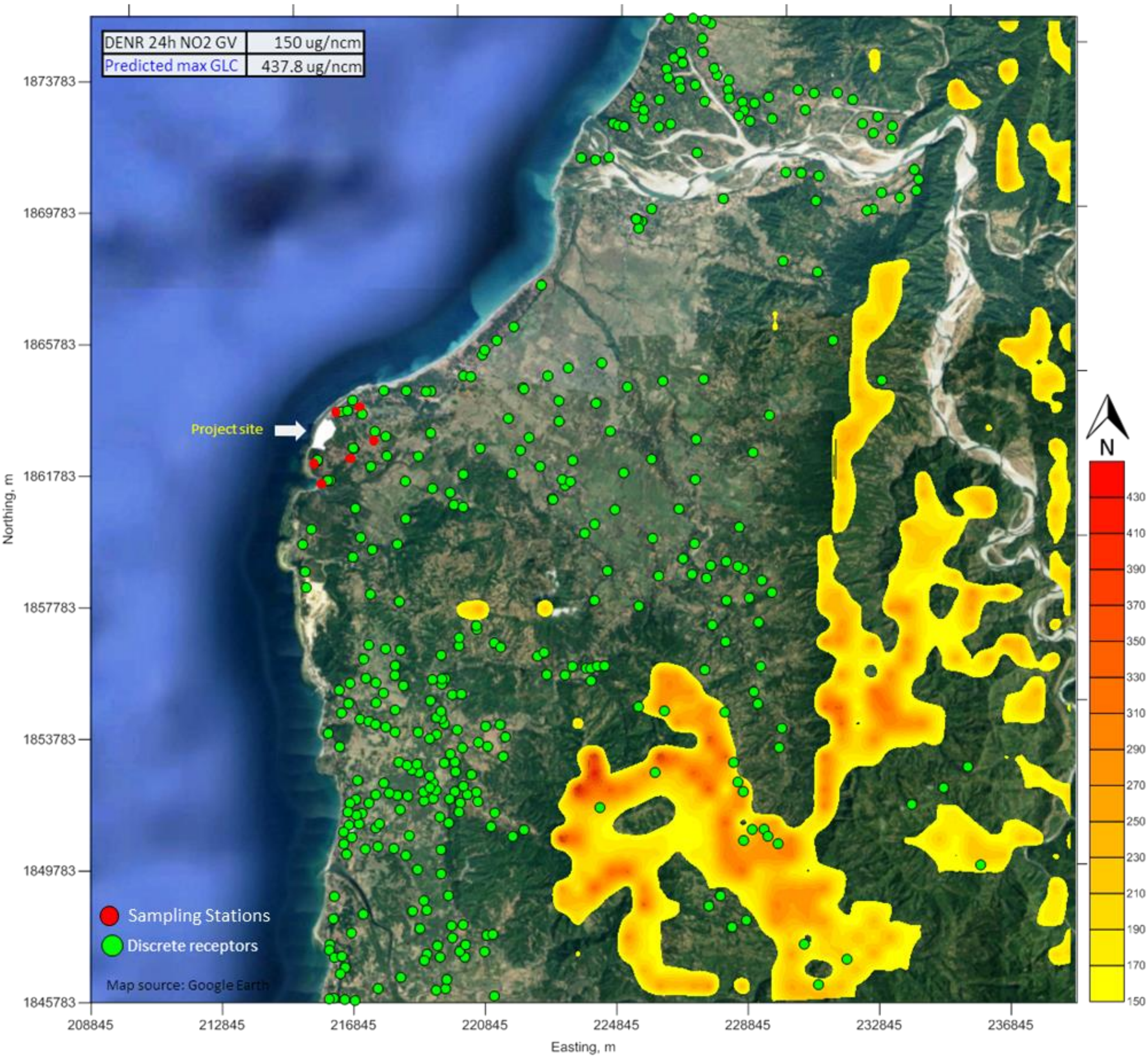


Figure EA-17. Isopleth of Predicted 24h NO_2 GLCs at Upset Conditions	LEGEND: As above	SCALE: As above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: Base map: Google Map Imagery Created by: Apercu Consultants_JACH (2017)	PAGE 364

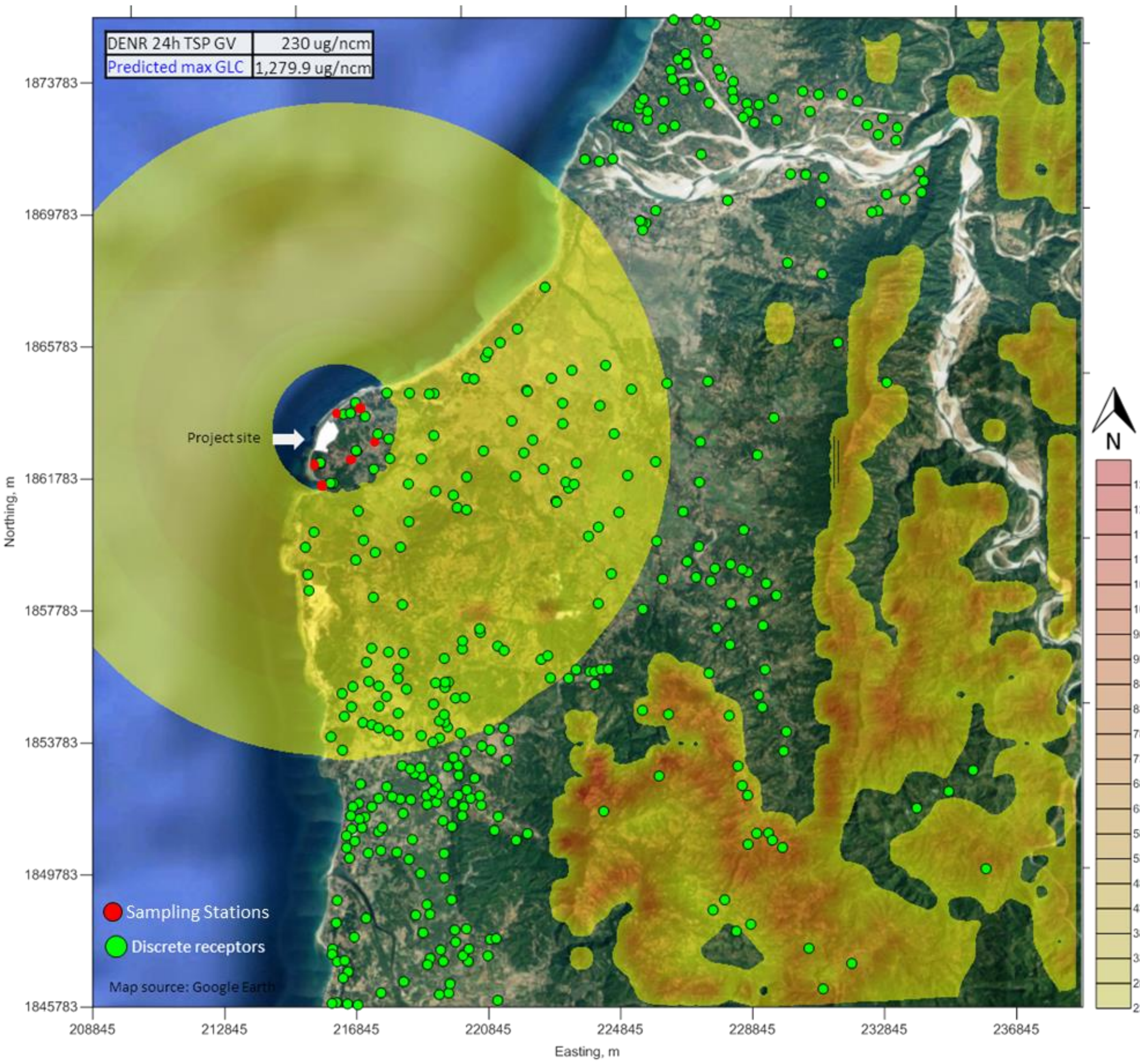


Figure EA-18. Isopleth of Predicted 24h TSP GLCs at Upset Conditions	LEGEND: As above	SCALE: As above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: Base map: Google Map Imagery Created by: Apercu Consultants_JACH (2017)	

Table EA-21
Predicted Trace Metal GLCs at the Discrete Receptors during Operation

Operating Condition	Normal					Upset				
Pollutant	**As**	**Cd**	**Cr**	**Pb**	**Hg**	**As**	**Cd**	**Cr**	**Pb**	**Hg**
Averaging Time	**30min**	**30min**	**1h**	**30min**	**1h**	**30min**	**30min**	**1h**	**30min**	**1h**
Unit	**mg/ncm**	**mg/ncm**	**ug/ncm**	**ug/ncm**	**ug/ncm**	**mg/ncm**	**mg/ncm**	**mg/ncm**	**ug/ncm**	**ug/ncm**
Statistic										
Minimum	0	0	0	0	0	0	0	0.000276	0.000144	0
1st quartile	0	0	0.000012	0	0	0	0	0.00078	0.000384	0.000012
Median	0	0	0.000012	0	0	0	0	0.000996	0.000504	0.000024
3rd quartile	0	0	0.000012	0.000012	0	0	0	0.001284	0.000648	0.000024
Maximum	0	0	0.000072	0.000036	0	0	0	0.004884	0.00246	0.000096
CAA Standard	0.02	0.01	ns	20	ns	0.02	0.01	ns	20	ns
Index (Max GLC/CAA)	0	0	-	1.8E-06	-	0	0	-	0.000123	-
# of exceedance	0	0	-	0	-	0	0	-	0	-
% exceedance	0	0	-	0	-	0	0	-	0	-

On the other hand, the predicted 24h SO_2 hotspot during normal conditions had a very small footprint about 13 km southeast of the site also in elevated terrain (**Figure EA-16**).

Table EA-22
Hotspot Matrix of Predicted GLCs

Type	Pollutant	Averaging time	NORMAL CONDITIONS			UPSET CONDITIONS		
			None	PH	AOC	None	PH	AOC
Criteria	SO_2	1hr		✓			✓	
		24hr		✓				✓
		Annual	✓			✓		
	NO_2	1hr		✓			✓	
		24hr		✓			✓	
	CO	1hr	✓			✓		
		8hr	✓			✓		
	TSP	1hr	✓					
		24hr	✓				✓	
		Annual	✓					
	PM10	1hr	✓					✓
		24hr	✓			✓		
		Annual	✓			✓		
Trace metal	As	30min	✓			✓		
	Cd	30min	✓			✓		
	Cr	1h	✓			✓		
	Pb	30min	✓			✓		
	Hg	1h	✓			✓		

Note: PH: Potential Hotspot; AOC: Areas of Concern

The project can cause an impact, particularly air pollution, to the site's ambient air quality. Sources of such impact during the construction phase include fugitive dust from site preparations to structure erections, and SO_2, NO_2, TSP, and PM10 emissions from heavy equipment and motor vehicles. During the operation phase, air pollution may come from stack emissions, standby generators and vehicle emissions, as well as carbon dioxide emissions. These impacts will be addressed by the proponent with proper design of the project and by installing pollution control devices. Dust suppression measures, replacement of vegetation, compacting of exposed soils, covering of trucks loaded with construction materials, and regular maintenance of equipment will be conducted by GLEDC. Before the operation of the plant commences, pollution control devices namely ESP, SWFGD, and NOx and CO reduction systems will be installed. A sustainable greening program will also be formulated and implemented by the proponent.

3.3.1.4 Uncertainties of Model Results and Recommendations

Lack of appropriate meteorological information is often the single most important limiting factor in the accuracy of the model. The EMB guidelines require at least three years of data with an hourly resolution at the site of interest (usually within a few hundred meters); however, one year of measurements can be allowed as long as it is justified. The minimum measurement requirements are wind speed and direction, surface temperatures (lower and upper), and net solar radiation. It is recommended that an on-site met station be installed to include net solar radiation and upper temperature measurements to validate the initial simulations done.

3.3.2 Summary of Potential Impacts and Mitigation Measures Related to Air Quality

Table EA-23 summarizes the potential impacts and proposed mitigation related to air quality.

Table EA - 23
Summary of Potential Impacts Related to Air Quality during Construction and Operation

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
I. Construction Phase			
Air pollution	Ambient air quality	Sources of air pollution during the construction phase include fugitive dust from site preparations to structure erections, and SO_2, NO_2, TSP, and PM10 emissions from heavy equipment and motor vehicles.	• Dust suppression measures, replacement of vegetation, compacting of exposed soils, covering of trucks loaded with construction materials, and regular maintenance of equipment will be conducted by GLEDC.
II. Operation Phase			
Air pollution	Ambient air quality	Air pollution may come from stack emissions, standby generators and vehicle emissions, as well as carbon dioxide emissions.	• These impacts will be addressed by the proponent with proper design of the project and by installing pollution control devices. • Before the operation of the plant commences, pollution control devices namely ESP, SWFGD, and NOx and CO reduction systems will be installed. A sustainable greening program will also be formulated and implemented by the proponent.
		The simulations at the worst-case, i.e., no attenuation, showed potential off-site noise impacts in the morning, daytime, evening, and nighttime).	• Sound levels generated by the equipment and ancillaries of the proposed power plant will be designed to comply with the Category A daytime, morning, evening, and nighttime DENR noise criteria at the property line. • Noise barriers can be constructed from earth, concrete, masonry, wood, metal, and other materials. • Regular maintenance of mufflers of standby generators and other pertinent equipment. • Provision of ear plugs to workers directly exposed to high noise equipment and areas at the plant. • Use of effective noise-attenuating materials for the plant's structure and walling. • Planting of the appropriate vegetation around the plant.

3.3.3 Mitigating Measures and Monitoring Plan

Air pollution control for the project can approached in three approaches:

1. Fuel quality control;
2. Boiler combustion optimization; and
3. End-of-pipe (flue-gas desulfurization, low-NOx burners).

The combination of these three approaches will ensure emissions will result to ambient air concentrations compliant with the CAA. In addition, it is prudent to conduct the following validation modeling at the following project stages: a) detailed engineering design using prognostic met data, and b) during operation using CEMS and on-site or prognostic met data.

Ambient air quality will be monitored quarterly during construction and operation phase. Stations shall be the same with the established sampling stations during EIA unless adjustments are deemed necessary. Parameters to be monitored include TSP, SO_2, NO_2, PM10, Pb, Cd, As, and Sb. A summary of the monitoring plan is provided in **Table EA-24**.

The installation of Continuous Ambient Air Monitoring System (CAMS) can be considered if required. The location of the continuous monitors should be determined by validation modeling previously mentioned since acquisition, operation, and maintenance of the CAMS require considerable costs.

Table EA-24
Monitoring Plan for Ambient Air Quality

Parameter	Sampling Station	Method	Frequency
Construction Phase			
TSP	Initially the same stations during the EIA	S) 24 hr High Volume- (A) Gravimetric USEPA 40 CFR, Part 50	Quarterly
SO_2		(S) 24-hr Gas Bubbler (A) Pararosaniline Method (West and Gaeke Method)	
NO_2		(S) 24-hr Gas Bubbler (A) Griess-Saltzman or Chemiluminescence Method	
Pb		(S) 24-hr High Volume (A) Atomic Absorption Spectrophotometry,USEPA 40 CFR, Part 50	
Cd		(S)Prescribed sampling method (A) AAS	
As		(S)Prescribed sampling method (A) AAS	
Sb		(S)Prescribed sampling method (A) AAS	
Operation Phase			
TSP, SO_2, NO_2	Stack	Installation of CEMS	Real time
PM10	Initially the same stations during the EIA	24-hr High Volume with 10 micron particle-size inlet (A) Gravimetric USEPA 40 CFR, Part 50	Quarterly
TSP		(S) 24 hr High Volume-	

Parameter	Sampling Station	Method	Frequency
		(A) Gravimetric USEPA 40 CFR, Part 50	
SO_2		(S) 24-hr Gas Bubbler (A) Pararosaniline Method (West and Gaeke Method)	
NO_2		(S) 24-hr Gas Bubbler (A) Griess-Saltzman or Chemiluminescence Method	
Pb		(S) 24-hr High Volume (A) Atomic Absorption Spectrophotometry,USEPA 40 CFR, Part 50, Appendix G	
Cd		(S)Prescribed sampling method (A) AAS	
As		(S)Prescribed sampling method (A) AAS	
Sb		(S)Prescribed sampling method (A) AAS	

Note: AAS – atomic absorption spectrophotometry; (S) method of sampling; (A) method of analysis

3.4 Noise

This section describes the existing sonic profile at the project site and determined the noise impacts during the construction phase by comparing the results of sound measurements and predicted sound levels with the Environmental Quality Standards for Noise in General Areas (**Table EA-25**) and noise criteria during construction (**Table EA-26**)[5].

Table EA-25
Environmental Quality Standards for Noise in General Area, dB(A)

Category	Daytime	Morning/Evening	Nighttime
AA	50	45	40
A	55	50	45
B	65	60	55
C	70	65	60
D	75	70	65

Note: Morning: 5am-9am; Daytime: 9am-6pm; Evening: 6pm-10pm; Nighttime 10pm-5am
Category description:
AA 100 m from schools, nurseries, hospitals, home of the aged
A residential area
B commercial area
C light industrial area
D heavy industrial area

[5] NPCC Memorandum Circular No. 002 issued May 12, 1980 (amending Section 78 of Presidential Decree 984)

Table EA-26
Maximum Noise Levels Allowed during Construction[6]

Class	Construction activities	Limit, dBA
1	Pile drivers (excluding manual type), riveting hammers or combination thereof. Does not include pile drivers used in combination with earth augers.	90
2	Rock drills, or similar equipment like jack hammers or pavement breakers	85
3	Air compressors (limited to compressors which use power other than electric motors with a rated output of 15kW or more). Air compressors power rock drills, jack hammers, and pavement breakers are excluded.	75
4	Batching plant operation (limited to those with mixer capacities of 200kg or more. Batching plants for mortar-making are excluded.	75

Note: No construction in Class AA, A, B areas (except during emergencies, calamities, disasters) from 7pm to 7am for Class 1&2 construction activities and from 9pm to 7am for Class 3&4 construction activities

3.4.1 Baseline Noise Condition

The general category at the sound monitoring stations was assumed residential due to the presence of households. A total of 1,728 sound readings were made at the six stations representing five-minute intervals for 24 hours.

The background sound levels (L_{90}) across stations ranged from 48 to a high of 59 decibels (red fonts in **Table EA-27**). This range represented sound levels from normal activities, i.e., activities done regularly at a relatively constant pace in the vicinities of the stations. Meanwhile, the intermittent sound levels (L_{10}) at the stations ranged from 52 to 74 dBA (green fonts in **Table EA-27**). The range represents short duration high sound levels from sources like passing motor vehicles. Comparing the Lmax values with the DENR environmental quality standards for noise in residential areas, results showed exceedances across timeframes and stations except at Station 5 during morning, daytime, and evening periods.

Table EA-27
Descriptors and Noise Impacts of Existing Sound Levels at the Sampling Sites

Station ID	Time Frame	Noise descriptor, dB(A)					DENR, dB(A)	Impact, dB(A)	
		Lmin	L_{90}	L_{50}	L_{10}	Lmax		Lmax	L90
Noise 1	Morning	58	59	61	64	73	50	-23	-9
	Daytime	49	57	58	63	68	55	-13	-2
	Evening	52	52	56	61	62	50	-12	-2
	Night time	45	59	61	63	68	45	-23	-14
Noise 2	Morning	52	54	59	64	72	50	-22	-4
	Daytime	56	57	62	68	78	55	-23	-2
	Evening	57	57	59	65	70	50	-20	-7
	Night time	57	58	67	69	73	45	-28	-13
Noise 3	Morning	57	58	62	66	74	60	-14	2
	Daytime	54	59	64	74	85	65	-20	6
	Evening	56	59	63	65	80	60	-20	1
	Night time	58	59	60	62	63	45	-18	-14
Noise 4	Morning	21	48	52	69	81	60	-21	12
	Daytime	52	54	58	70	87	65	-22	11
	Evening	48	52	56	69	72	60	-12	8
	Night time	48	48	49	54	70	45	-25	-3
Noise 5	Morning	49	49	51	53	58	60	2	11
	Daytime	47	48	50	53	60	65	5	17
	Evening	50	51	53	54	58	60	3	9
	Night time	50	50	51	52	53	45	-8	-5
Noise 6	Morning	46	57	61	64	68	60	-8	3
	Daytime	55	57	58	60	66	65	-1	8

[6] Measured at 30 meters

Station ID	Time Frame	Noise descriptor, dB(A)					DENR, dB(A)	Impact, dB(A)	
		Lmin	L_{90}	L_{50}	L_{10}	Lmax		Lmax	L90
	Evening	56	57	59	60	69	60	-9	3
	Night time	57	59	60	62	71	45	-26	-14

DENR – environmental quality standards for noise for Category A (residential)

Consolidating all the readings at the six stations by time frame showed that the morning, daytime, evening, and nighttime background sound levels (L90) ranged from 50 to 52 decibels (**Table EA-25**). The maximum sound levels exceeded the DENR environmental quality noise standards for residential areas during evening and nighttime periods (orange cells in (**Table EA-28**).

Table EA-28
Noise Descriptors Across Stations

Descriptor	Timeframe			
	Morning	Daytime	Evening	Night time
Lmin	21	47	48	45
L90	50	51	52	50
L50	59	59	59	59
L10	65	67	64	67
Lmax	81	87	80	73
DENR(a)	50	55	50	45
Impact	0	4	-2	-5

(a) DENR – environmental quality standards for noise for Category A (residential); Impact – difference between DENR and Lmax

The simulation showed that at the worst-case, i.e., no attenuation, the predicted maximum sound level was 81 dB(A), a value greater than the DENR limit for Classes 3 and 4 construction activities but less than Classes 1 and 2 (Figure EA-19). The exceedance however was predicted to occur within the site boundaries.

It should be emphasized that the model results were conservative, i.e., overestimates, because it was assumed that all construction equipment were operating simultaneously at a steady state at the boundary of the project. The assumption was made as worst-case scenario and because the actual type, usage factors, and location of construction equipment was unavailable. Noise levels during actual construction are likely to be lower than the modeled values.

During the operation phase, the simulations at the worst-case, i.e., no attenuation, showed potential off-site noise impacts in the morning, daytime, evening, and nighttime (Figure EA-20). The radii of the potential noise impacts are shown in Table EA-29.

Table EA-29
Approximate Distance of Predicted Noise Impacts during Operation Phase

Timeframe	Distance from the Site, m
Morning	1,148
Daytime	612
Evening	1,148
Nighttime	1,951

To avoid any potential exceedances from the noise limits set by DENR, mitigating measures will be considered and incorporated in the design of the project. An important option in construction noise control strategies is controlling sound at source by (a) muffler requirements, and (b) maintenance and operational requirements. Most construction noise originates from equipment powered by either gasoline or diesel engines where a large part of the noise emitted is from the intake and exhaust portions of the engine cycle. One remedy for minimizing engine noise is the use of adequate muffler systems. Reductions of 10 dBA or more can be achieved with optimal muffler systems (U.S.D.O.T). Muffler requirements can be easily integrated in contract specifications with enforcement simple and easily done. Mufflers are effective in reducing engine produced noise at a low cost to the user.

Poor maintenance of equipment may also cause very high noise levels. Faulty or damaged mufflers, loose engine parts, rattling screws, bolts, or metal plates all contribute to increasing the noise level of a machine as well as careless or improper handling and operation of equipment. Poor loading, unloading, excavation and hauling techniques are some examples of how lack of adequate guidance may lead to increased noise levels. Contract specifications can be written to require that all equipment be regularly inspected for deficiencies in the maintenance area. Likewise, specifications can require that equipment users be properly trained in the use of construction equipment.

Another effective approach in reducing noise impacts is using time and activity constraints. Construction activity noise is annoying and disruptive during leisure hours, during the hours of sleep, and any time where loud continuous noises affect certain special activities. During leisure hours and during periods of sleep, disturbance from equipment use can be kept to a minimum or totally avoided. Generally, this can be accomplished by requiring the contractors to perform such work during daylight hours when the majority of individuals who would ordinarily be affected by the noise are either not present or are engaged in less noise sensitive activities. Other measures are:

- Establishment of barriers and shielding stationary vibrating equipment to reduce noise impacts to workers and the community
- Scheduling “noisy” activities during daytime; and
- Provision of ear mufflers to workers directly exposed to vibrating and noisy equipment.

To control noise levels during the operation phase, sound levels generated by the equipment and ancillaries of the proposed power plant will be designed to comply with the Category A daytime, morning, evening, and nighttime DENR noise criteria at the property line.

Noise barriers can be constructed from earth, concrete, masonry, wood, metal, and other materials. To effectively reduce sound transmission through the barrier, the material chosen must be rigid and sufficiently dense (at least 20 kg/m^2). All noise barrier material types are equally effective, acoustically, if they have this density. For example, plant equipment can be installed with rubber footing to reduce vibration. Other possible sound attenuation measures include:

1) Regular maintenance of mufflers of standby generators and other pertinent equipment;
2) Provision of ear plugs to workers directly exposed to high noise equipment and areas at the plant;
3) Use of effective noise-attenuating materials for the plant’s structure and walling; and
4) Planting of the appropriate vegetation around the plant.

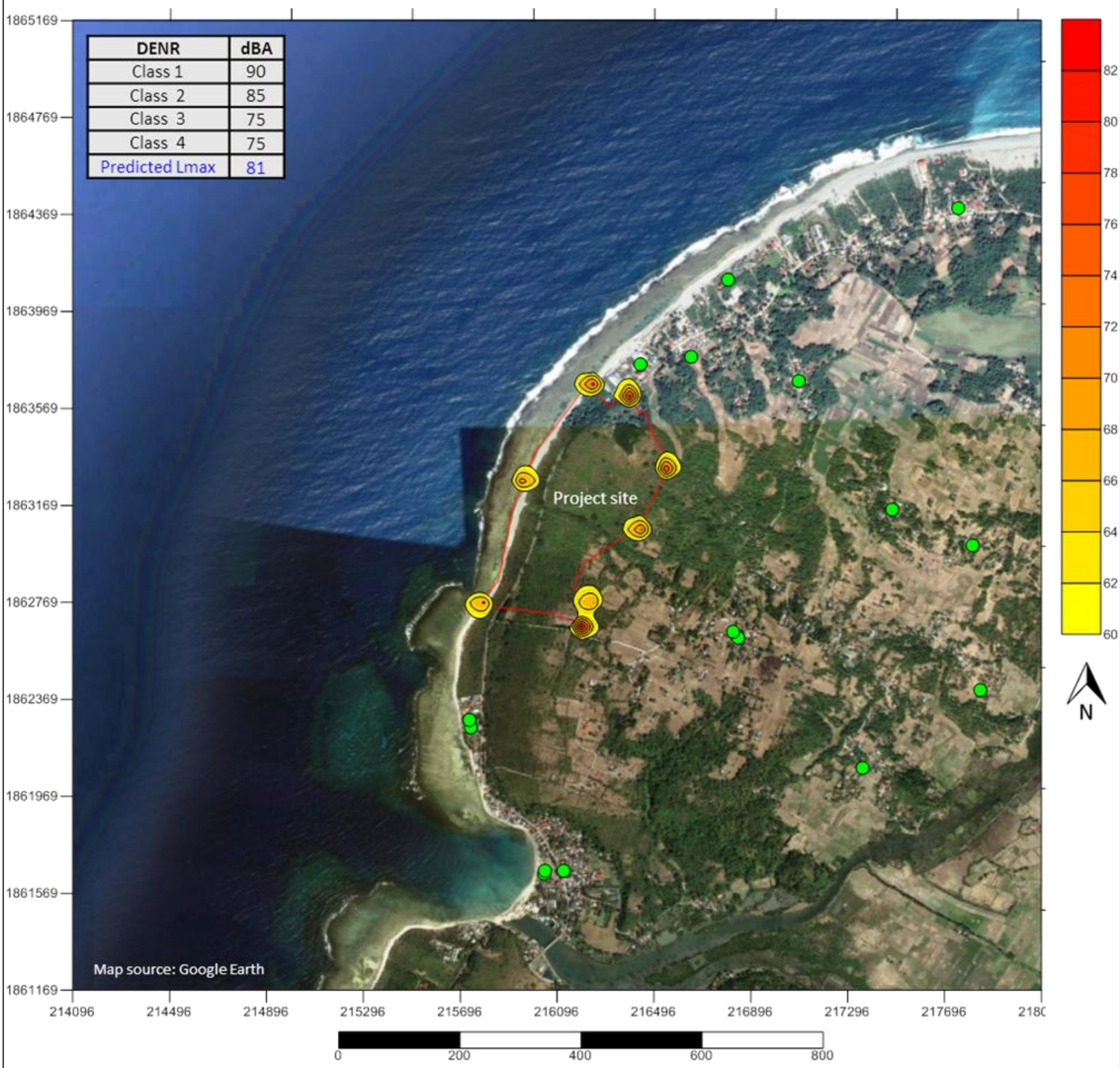
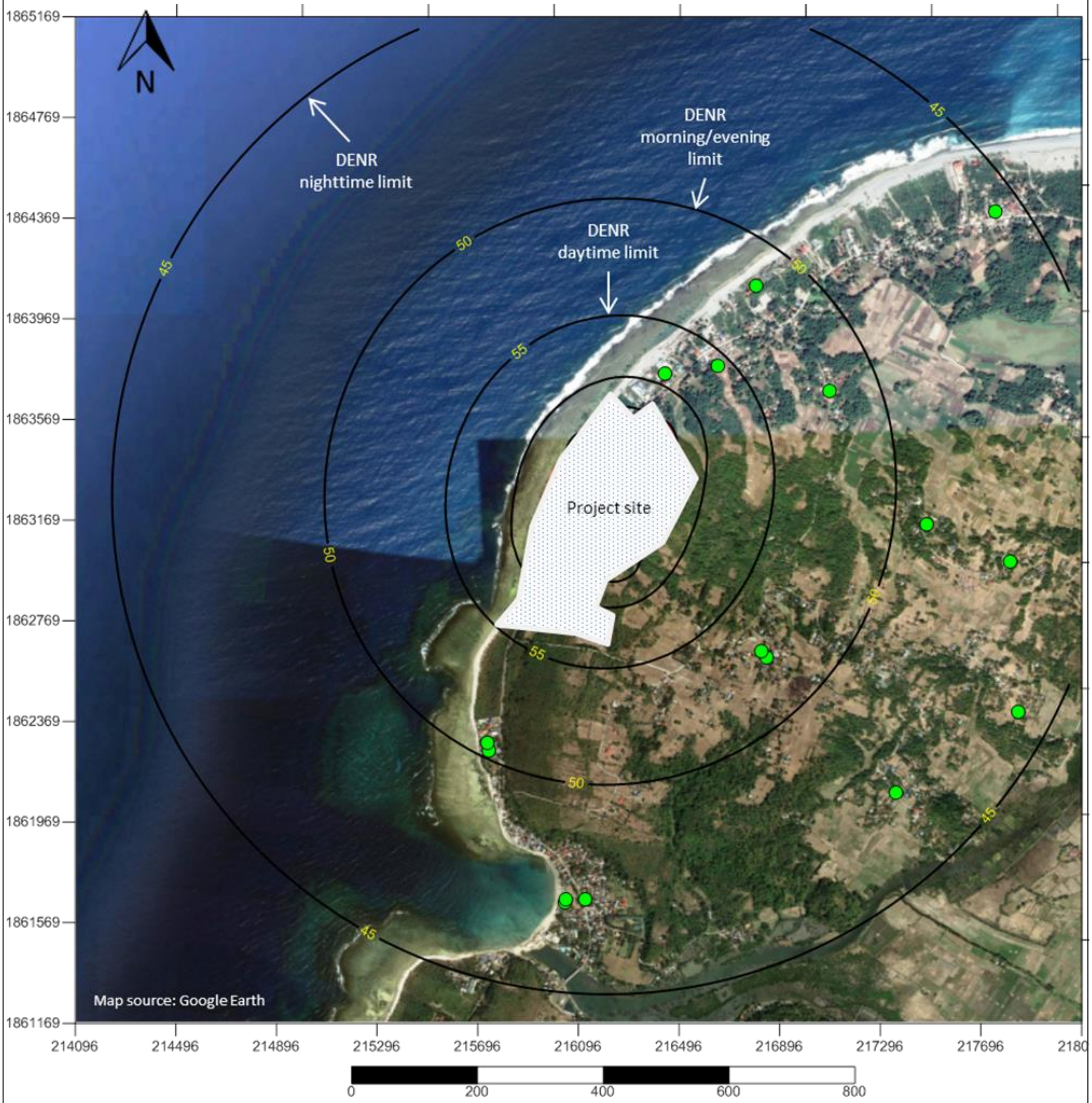


Figure EA-19. Isobels of Predicted Sound Levels During Construction Phase	LEGEND: As above	SCALE: As above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: Base map: Google Map Imagery Created by: Apercu Consultants_JACH (2017)	PAGE 374



Category	A (residential
Daytime	55
Morning	50
Evening	50
Nighttime	45
Predicted Lmax	89

Figure EA-20. Isobels of Predicted Sound Levels During Operation Phase

LEGEND: As above

SCALE: As above

ENVIRONMENTAL IMPACT STATEMENT
2x335MW COAL-FIRED POWER PLANT PROJECT

DATA INFORMATION/SOURCE:
Base map: Google Map Imagery
Created by: Apercu Consultants_JACH (2017)

3.4.2 Summary of Potential Impacts and Mitigation Measures Related to Noise

Table EA-30 summarizes the potential impacts and proposed mitigation related to noise.

Table EA-30
Summary of Potential Impacts Related to Noise during Construction and Operation

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
I. Construction Phase			
Noise	Maximum sound level	The simulation showed that at the worst-case, i.e., no attenuation, the predicted maximum sound level was 81 dB(A), a value greater than the DENR limit for Classes 3 and 4 construction activities but less than Classes 1 and 2 (Figure EA-19). The exceedance however was predicted to occur within the site boundaries. Noise levels during actual construction are likely to be lower than the modeled values.	• An important option in construction noise control strategies is controlling sound at source by muffler requirements, and maintenance and operational requirements. • Contract specifications can be written to require that all equipment be regularly inspected for deficiencies in the maintenance area. Likewise, specifications can require that equipment users be properly trained in the use of construction equipment. • Time and activity constraints requiring the contractors to perform such work during daylight hours. • Establishment of barriers and shielding stationary vibrating equipment to reduce noise impacts to workers and the community • Provision of ear mufflers to workers directly exposed to vibrating and noisy equipment.

3.4.3 Monitoring Plan for Noise

Sound level will be monitored during both construction and operation phase of the project. This will be done quarterly in the same stations during the EIA. A hand-held sound meter will be used to record 24-hour sound measurement.

4.0 People Module

4.1 Demographics

4.1.1 Methodology

Data presented in the following module include primary and secondary data gathered to determine baseline conditions of the host municipality. Primary data were obtained from the baseline and perception surveys of sample households from direct and indirect impact areas, and also from the comments of stakeholders during the information and education campaign activities. Secondary data were gathered from the Municipality of Luna's Planning and Development Office as well as from publications of the Philippine Statistics Office (PSA).

4.1.2 Municipal History

4.1.2.1 Etymology

The town of Luna was originally named "Namacpacan", an Ilocano word meaning "one who has given food." Travelers, especially from Vigan to Manila, used to stop and refresh at the place and as a gesture of hospitality, the residents would offer food and shelter. Perhaps, passing by the same route, travelers always go back to the 'namacpacan', eventually becoming a byword. By the course of history, however, "Namacpacan" was eventually changed to "Luna" in honor of the hero brothers, Antonio and Juan Luna.

4.1.2.2 Creation

Namacpacan was founded as a town and parish on November 25, 1690 with Darigayos being the original central settlement site. In 1741, the parish was eventually transferred from Darigayos to its current location in Victoria, perhaps to veer away from the "Ilocano-Spaniard uprising".

Namacpacan was one of the towns in the southern part of Ilocos Sur that were merged with some towns in the northern part of Pangasinan and the western part of Mountain Province that formed the Province of La Union in 1854. On October 18, 1906, by virtue of Philippine Commission Act No. 1543, the name "Namacpacan" was changed to "Luna" in honor of the Luna brothers – General Antonio and the painter, Juan – and in due respect to their mother, Dona Laureana Novicio Luna, a daughter of the town. Under the current government, Luna is one of the 20 municipalities of the Province of La Union.

4.1.3 Human Resources

4.1.3.1 Municipal Population Size, Growth, Distribution and Density

In 2010, official PSA data showed that Luna had a total population of 35,380, comprising 4.77 percent of the provincial population. It is the 11th municipality that has the highest population among the 20 municipalities of La Union. The municipality has an annual population growth rate of 0.96 percent, based on the geometric method for computing the growth rate covering the period 2000 to 2010. This is much lower than the provincial growth rate of 1.21 percent. It is projected that the municipal population will be 40,098 by 2023.

In terms of distribution, the population varies among the forty (40) barangays classified as either urban or rural. The four (4) barangays classified as urban by the PSA include Alcala, Magallanes, Salcedo, and Victoria. These barangays have an aggregate population of 5,116 or 14.46 percent of the municipal population. The urban barangays have a total population of 30,264 comprising about 86 percent of the municipal population. Of the 40 barangays, Magallanes, a coastal urban barangay situated on the southwestern part of the "poblacion", is the most populated with 1,934 residents while Mamay is the least populated with 357.

The construction of the power plant may increase the municipality's population since the project will attract in-migrants to work or stay in the Municipality of Luna, especially migrants who have work experience in other power plants. Possible in-migration patterns predicted as a result of the project are of two (2) types – short-term in-migrants that consist of workers who will be there only during the construction phase and; short-term migrants that could become attracted by developments in the area, thus becoming long-term migrants. Migrants that do not have skills but are willing to try to get a job would increase competition with local residents for job availability. On the other hand, migrants that do have skills, are productive and would be able to transfer their knowledge and skills to workers in Brgys. Nalvo Sur and Carisquis would be a welcome impact.

To control in-migration and its possible impacts, the proponent will assist and coordinate with the LGU in setting up a migration information center in barangay halls for easier migrant tracking. Job fairs will be conducted in designated areas with the help of barangay officials who can readily recognize the migrants. This will help address concerns on competition with migrants and ensure that legitimate residents are given priority during the hiring process.

Informal settlers, which may increase due to the availability of livelihood opportunities, may also be controlled through this tracking system especially if they have been staying for more than a month as visitors in their barangay.

Luna has a population density of 8.24 persons per hectare given a population of 35,380 (2010), and a land area of about 4,361 hectares. The municipal density is higher than the province's 5.61 persons per hectare. The population density of Barangays Magallanes, Alcala, Victoria and Salcedo – the barangays in the urban core -- is 17.28 persons per hectare (pph) while in the rural area, consisting of the rest of the barangays, the population density is 7.57 pph. **This indicates that the problems on congestion, scarcity of land, and overpopulation in the municipality are non-existent even with the fact that the population may increase once the project commences.**

4.1.3.2 Age Group, Marital Status, and Voting Population

<u>Age Group</u>

The age composition of the population is subdivided into three major broad groups namely: 0-14 years representing the young population; 15-64 years representing the productive/working age group and also representing potential labor force; and 65 years and older, the senior/older population.

As of 2010, Luna has 10,033 or 28.38 percent young population; 22,594 or 63.91 percent productive and 2,722 or 7.18 percent older population. The productive to dependent population (young and old) ratio is 2:1 which means that there are 2 productive persons for every dependent. **This means that there is a substantial workforce population that the project may tap into during the construction phase. However, the quality and type of the skills of this segment of population will need to be assessed.**

<u>Sex</u>

Of the 35,380 population of Luna, 17,602 or 49.79% are male while 17,747 or 50.20% are female. Evidently, the female population outnumbers the male population with a ratio of 101:100.

As to sex ratio by specific age, for the 0-14 age group, the ratio is 108:100 or 108 female per 100 male; for the 15 to 64 age group, the ratio is 100:104 or 100 females per 104 males; and for the 65 years and over, there are 100 females per 57 males or 100:57.

Hiring of qualified residents by the project, during both the construction and operation phases, will consider gender sensitivities.

Marital Status

Of the population aged 10 years old and over 11,698 or 40.61% are single; 12,618 or 43.80% are married; 1,876 or 6.51% are widowed and 345 or 1.19% are legally separated.

Voting Population

As of 2013, the Municipality of Luna had a voting population of 21,170, with Barangays Magallanes and Barrientos having the highest number of voters.

4.1.3.3 Vital Health Statistics

The Municipality's vital health statistics are presented below:

Table EP-1
Vital Health Statistics of Luna, La Union (2011-2015)

Vital Statistics	Year				
	2011	2012	2013	2014	2015
Livebirths	554	525	575	493	538
Deaths	224	219	175	190	185
Fetal Deaths	1	0	0	0	0
Maternal Deaths	0	1	3	0	1
Infant Deaths	0	3	0	0	2
Under 5 Deaths	1	0	4	1	0
Neonatal Death	0	0	0	0	1

Births

The total number of births recorded in the Municipality in 2011 was 554; 525 in 2012 and 575 in 2013.

A massive campaign on the Family Planning Program of the government and the assignment of health workers to remote barangays led to the gradual decrease of births per year, an indicator of the success of the Population and Family Planning program of the government.

Deaths

The recorded number of deaths in Luna in 2011 was 224. It decreased to 219 in 2012 and continually decreased to 175 in 2013. In 2014, it increased to 190 and decreased to 185 deaths in 2015.This indicates that a more than 15% decrease in death statistics is observed from year 2011 to 2015.

4.1.3.4 Culture and Lifestyle

Indigenous Groups

There are no indigenous groups present in the municipality or residing in the project area, thus, the project will have no effects on cultural change of indigenous people.

Lifestyle

In terms of lifestyle changes, during the construction phase, the barangay residents may have to increase the pace of their lifestyle to keep up with the increased demands of livelihood opportunities. However, an increased income during the plant operation may also effect a change in the lifestyle of the residents of the affected barangays. They may have additional disposable income for other non-basic

material goods. Industrialization in the municipality will also move the stakeholders to modernization. Concerns on abusive use of social media, increase in social crime, and existence of "night life" that may result from modernization were raised during the scoping activities. Furthermore, fisher folks who wish their children to follow their footsteps might find their children engaged in other jobs as the plant continues to operate. All identified potential impacts on the current lifestyle in the municipality can be regulated.The proponent will implement measures to enhance positive social impacts through the corporate social responsibility programs of the proponent. The proponent will also establish continued coordination with the LGU to regulate resources and opportunities.

4.1.3.5 Linguistic and Religious Affiliation

The Municipality's Comprehensive Land Use Plan (CLUP) states that there is diversity in the municipality in terms of language and faith. Generally, the people of Luna speak Iloco, the mother tongue, but there are also quite a number of people speaking other dialects such as Tagalog. In terms of religious affiliation, Luna is predominantly Roman Catholic composing 94.76 percent of the population followed by Evangelicals comprising 1.40 percent. A small percentage belong to other religious groups/ sects such as the Iglesia Ni Cristo, Crusaders, and Jesus is Lord, comprising about 3.8 percent of the population.

4.1.4 Physical and Cultural Resources

4.1.4.1 Tourist Spots

The Municipality of Luna is well known for their agricultural and livestock products such as rice, tobacco, vegetables, corn, peanuts, fish and poultry, which are supplied to other parts of the province and the region. Although their primary function is to supply agricultural products, Luna has developed as a tourist center for its historical, religious, natural sceneries, and man-made features. In the future roles cited in the Comprehensive Land Use Plan of Luna (2014-2023), the municipality assumes tourism to be their secondary role, agricultural products still being primary. A consolidated map showing the tourist spots within the municipality is presented in **Figure EP-1**, some of which are described in the succeeding section.

Historical Places

One of the well-known tourist spots in Luna is the Baluarte Watch Tower. The Baluarte was built during the Spanish era along the coast of Barangay Victoria. The structure was used by Guardia Civils as a watch tower and observation post for Japanese, Chinese, and Moro pirates who used to take advantage of the coastal towns and settlements of the Municipality.

Another historical landmark found in Luna is the United States Army Forces in the Philippines – Northern Luzon (USAFIP – NL) Military Shrine and Park, also known as Camp Spencer. The place served as headquarters for guerillas and soldiers who fought with American Forces against the Japanese. Today, the camp serves as a tourist spot where a memorial wall with the names of the 1,437 USAFIP-NL soldiers is inscribed. An annual Victory Day celebration of the Battle of Bessang Pass is also held at the camp every 14th day of June.

Religious Places

The Shrine of the Miraculous Image of Our Lady of Namacpacan is housed at the Saint Catherine of Alexandria Parish located in the urban core of Luna. The people of Luna believe that the image of the Blessed Virgin Mary that was brought to the province in 1871 was a *"lucky stroke of faith"*. The original destination of the image was Vigan, Ilocos Sur, where the Augustinian Priest who ordered the image attends. Brought by ship, the trip faced

Figure EP-1. Tourist Spots in the Municipality of Luna	LEGEND:	SCALE:	DATA INFORMATION/SOURCE:	PAGE 381
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	Project Site Historical Tourist Spots Religious Tourist Spots Natural Sceneries Man-made Tourist Spots	AS ABOVE	**Basemap:** GOOGLE EARTH IMAGERY **Created by:** APERCU CONSULTANTS_MMA (2017)	aperçu CONSULTANTS INC.

storms which forced the crew to stop at Darigayos (then Namacpacan). After the storm passed, the crew tried to sail to Ilocos Sur. However, each of their attempts was stopped by strong winds and uncooperative conditions to sail. After several unsuccessful efforts, the natives concluded that the Blessed Lady had chosen their town as sanctuary. "Namacpacan" being the name of the town at the time, the image was eventually recognized as Our Lady of Namacpacan.

Natural Sceneries

The Municipality is also known to tourists owing to its natural sceneries. One of these is the Ukkalong Waterfalls , found in the hilly forested area of Barangays Cabalitocan and Ayaoan. The stretch of the beach from Darigayos Cove to Rimos also attracts tourists. Darigayos Cove is visited for swimming and surfing purposes especially during the south swell from the months of May to September, where the characteristic of the surf is preferred by surfers of all levels. The beaches of Luna also serve as pebble picking areas where unique stones of different colors are found. These are hand-picked by the locals and serve as a means of livelihood.

Man-made Features

Man-made tourist destinations in Luna include the well-known Bahay na Bato, Namacpacan Museo, Old Ermita, Noble Tower, Pilgrim Inn, and a number of hotels and resorts around the municipality. These tourist attractions play a vital role in the development of the Municipality of Luna.

Among the tourist spots in the Municipality of Luna, six are situated within the impact barangays. Pebble Beach Resort and Morning Seven Resort and Hotel are the nearest tourist spots with a distance of 580m[1] north and 650m north respectively. Bahay na Bato is also at close proximity with a distance of 850m north. The three other tourist spots are Noble Tower (1.5km south), USAFIP-NL Military Shrine and Park (1.6km south), and Darigayos Cove (1.75km south). The rest of the identified tourist spots are outside the impact areas. The Baluarte Watch Tower is found 2.2km, Old Ermita at 4.5km, Namacpacan Museo and St. Catherine of Alexandria Parish at 4.9km, Rimos Beach at 6.9km all north of the project site, while the Ukkalong Waterfalls is found 4.5km south of the project site.

Although two tourist spots are found within the direct impact area, the project is not expected to negatively impact these resorts since construction activities will be confined within the project boundary. This also applies to the other tourist spots like Darigrayos Cove and Noble Tower, which offer surfing areas – these are outside the direct impact area. This means that the onshore structures that will be built for the project will not cause any obstruction to surfers nor will it cause impairment of visual aesthetics.

The construction of the power plant may actually have a positive impact on tourism development. Occupancy rate of the resorts are expected to increase with the increased demand for lodging during the construction phase.

The activities of the coal-fired power plant during the operation phase will not cause any additional impacts related to land use or tourist spots. In fact, the power plant itself may serve as a tourist spot in the future.

4.1.4.2 Mineral Resources

The municipality is blessed with non- metallic mineral in the form of red clay, which is used in making pots, bricks and other products. The mineral is found in eastern Barrientos in an area estimated to cover 30 hectares.

[1] Reference point for distance measurements of tourist spots is the center of the project site

Cobbles, pea size gravel, pebbles and sand also abound in the coastal barangays. These are gathered and sold to construction industries that serve not only the local demand but also the national demand where the project is expected to increase the local demad during the construction phase.

4.1.5 Infrastructure

4.1.5.1 Residential Setting

Majority of the built houses in the municipality are made of mixed materials like cement, wood and galvanized iron. Beautiful houses with modern architectural designs can be found along the major roads, but there are still some old residential structures that are remnants of the Spanish colonization.

Luna has one commercial low cost mass housing project, the BLISS project of the 70's built in Barangays Rimos 4 and Rimos 5. Some are already destroyed but some were also restored, repaired or developed by the residents. The project has been abandoned since the abolition of the Ministry of Human Settlements in early 1980's. The project can be revived but the area needs a seawall, earth filling prior to construction, and designs should use stilted or at least two storey-units.

In terms of resident resettlement, the project will not incur any displacement of settlers during construction and operation, nor will it cause force evacuation. This is because there are **no existing households, structures/improvements, and cultivated lands within the project site**. The proposed project site is a privately owned property that has been acquired by the project proponent and is covered by a transfer certificate of land title. **Therefore, issues in terms of conflicts in land ownership are not expected to arise. Apprehensions regarding right-of-way are also not likely to occur**.

The nearest residential structure to the project site is located 70m north of its boundary. **Figure EP-2** is a settlement map around the project area.

4.1.5.2 Irrigation and Other Agricultural Facilities

The major source of irrigation for the municipality is the Amburayan Dam. The National Irrigation Authority provides irrigation to about 1,180 hectares while 245 hectares is irrigated by the Communal Irrigation System. While there is a Communal Irrigation System, there is still a need for more irrigation facilities. Flow from local rivers like the Darigayos and Borobor rivers, as well as creeks and swamps in Darigayos, Mamay and Nalvo, do not provide sufficient water to irrigate crops. Farmers in the upland areas and the rainfed farms still depend on the unpredictable rainfall; and farmers still dig open wells and ditches on rice paddies to irrigate crops.

The municipal government annually allocates a budget to address these problems through the purchase of water pumps and hoses, the repair of the irrigation system, particularly the canal linings. Luna is a recipient of the 50-50 cost-sharing scheme on pumps and engine sets implemented by the Department of Agriculture.

The power plant will not draw excessive groundwater or tap the Darigayos River to supply its water needs. As such, the project will not compound these irrigation problems. On the contrary, the increased income of the municipality resulting from taxes paid by the project, once implemented, could be used to improve irrigation infrastructure in the municipality.

Figure EP-2. Settlement Map of the Project Vicinity	LEGEND:	SCALE: 1:8,000	DATA INFORMATION/SOURCE:	PAGE 384
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	Project Site National Road Settlements	0 250 500 Meters	Basemap: Google Earth Imagery Created by: Apercu Consultants, Inc._ALC_2017	aperçu CONSULTANTS INC.

4.1.5.3 Educational Facilities

The municipality, in coordination with the Department of Education, Division of La Union has adequate public and private schools for learners following the K-12 Curriculum.

Pre-schools

The Municipality of Luna has thirty-three (33) Day Care Centers for preschoolers, that is being managed by the municipal government through the Municipal Social Welfare Development Office.

Elementary Level

There are twenty (20) complete elementary schools in the municipality. Oaqui Elementary School and Luna Central School house the main offices of Luna District. These two schools often register the highest enrollment of Luna district.

Each of the indirect impact barangays have 1 elementary school. Among the two direct impact barangays, only Nalvo Sur has an elementary school.

Secondary Level

Luna has seven (7) secondary/high schools, namely: Luna National High School Central, LNHS Rimos Annex, LNHS Cantoria Annex, OANARI High School, Bungro Integrated High School, Luna National Vocational High School and Santa Catalina Academy.

Latest data gathered for School Year 2013-2014 show that there are 2, 590 public students enrolled in the municipality's secondary schools. The only private school in the municipality is the Santa Catalina Academy, which is a Diocesan School.

All of the secondary level schools in the municipality are located outside the impact barangays.

Tertiary Level, Post-Graduate and Vocational Schools

With the absence of Tertiary, Post-Graduate and Vocational Schools in the municipality, students avail of college or vocational education from universities, colleges and vocational schools in Balaoan, San Fernando City, and even as far as Baguio City and Metro Manila.

Non-Formal Education

The Municipal People's hall and the forty (40) Barangay Halls serve as Non-Formal Education Centers where non-formal education trainings, especially Livelihood Skills Training Programs, are provided to Out-of-School Youth, Sangguniang Kabataan Members, Women NGOs, Persons with Disabilities and Farmer Organizations.

Annual training programs are sponsored by the Local Government Unit through the Municipal Agriculture Office (MAO), the Public Employment & Service Office (PESO), and the Municipal Social Welfare & Development Office (MSWDO) in coordination with various government line agencies such as the Technical Education and Skills Development Authority (TESDA), Department of Trade & Industry (DTI), Department of Labor and Employment (DOLE), and the Department of Social Welfare & Development (DSWD) among others.

As part of the benefits, GLEDC intends to conduct skills training programs that will equip residents (e.g. welding) and qualify them for work during the construction phase.

4.1.5.4 Service-Oriented Facilities

Police Protection

The Philippine National Police has a Municipal Police Station with two jail cells located at the northern portion of the municipal hall in the poblacion. For CY 2014, Luna had a total strength of thirty two (32) personnel headed by a Chief of Police assisted by: one (l) Deputy Chief of Police; four (4) in the administrative section; two (2) in Operation Section; two (2) in PCR Section; seven (7) Investigators; seven (7) in Intelligence Section; six (6) in the Patrol and Beat Section; and one (1) Supply Officer serving the current municipal population of 36,769. Police personnel are assigned to a particular barangay for a more speedy dissemination and response to crime. Barangay Security Force (Tanod) members as well as the Barangay Peacekeeping Action Team (BPAT) are mobilized in every barangay to help ensure peace and order.

Fire Protection

The municipality does not have a fire truck or fire control facilities except for two staff who are detailed in the municipal building to monitor, receive, disseminate information and seek help from the neighboring municipal Fire Department when there is a fire.

The municipal government regularly conducts pre-disaster planning and security response trainings for rescue, evacuation and relief operations. These are done to increase the level of preparedness directed at preventing, preparing for, responding to, control of and recovering from disasters and other emergencies to ensure survival and minimize casualties. There are also flood control projects for the flood prone barangays. Increased taxes may enable the municipality to have their own fire trucks.

Utilities

In terms of electricity/ power, the service in Luna is being supplied by General Nacar Mariveles Power Plant with the transmission lines of the National Grid Corporation of the Philippines through the facilities of the La Union Electric Cooperative, Inc. (LUELCO). All the 40 barangays are provided with electricity, but some individual residences are yet to be serviced by LUEICO. Streetlights were installed in all barangays, as well as along the national highway of Luna-Balaoan road, and in parks and, in the plaza.

Communication services are available through telecommunication and telegraph communication. Telecommunication services (landlines), are provided by DOTC (Digitel) and PLDT for telephone and internet use, especially in the poblacion area. There are also cell sites like Smart, Globe and Suncellular installed in strategic spots in the municipality that provide connections for mobile telephone services, 3G Broadband, Mobile Data Connections, WI-FI Internet Connections, and telecommunication services in the rural areas. For telegraph communication, Luna has a post office found within the Municipal Hall.

For water services, Barangays Sucoc Norte, Sucoc Sur and some residents of Barrientos have a water system called the SALINTUBIG project. Other residents have jetmatic pumps and artesian wells for their water supply. The poblacion area has no municipal or community water system. Suppliers of commercial bottled mineral or distilled drinking water are also available in the municipality. Some purchase them from nearby municipalities.

With the implementation of the project, some residents fear the potential increase in competition for resources. An increase in economic activities may result to increased competition for community services such as police and fire protection, and medical services. Upon project abandonment, migrant workers may stay in the barangay and compete with the residents for basic services and natural resources in the area.

To mitigate these concerns, GLEDC will coordinate with the LGU and adhere to municipal policies regarding management of community resources and implementation of the updated CLUP of the

municipality. GLEDC will assist the LGU in the preparation of a Barangay Development Plan and Barangay Disaster Risk and Managament Plan for the affected barangays.

4.1.5.5 Waste Management

The municipality's dumpsite is in Barangay Sucoc Norte, which is outside the poblacion area. In this site, a community based composting facility for organic fertilizer production through Vermicomposting is installed. Luna has yet to have a sewage disposal facility.

GLEDC will implement a Solid Waste Management Plan within the vicinity of the plant. GLEDC will also comply with the Ecological Solid Waste Management Act of 2000 implemented by the LGU, such as solid waste diversion through re-use, recycle, and composting activities, and solid wastes segregation from point of waste source to "compostable", "non-recyclable", "recyclable", and "special wastes".

4.1.5.6 Sports and Recreation

The municipality gymnasium is the municipality's major sports and recreation facility. It is dedicated for indoor events such as sports fests, socio-cultural activities, seminars, and trainings. The gymnasium is large and can accommodate a big crowd. Outdoor court is also available for sports activities such as tennis, track and field, softball/base ball and even field presentations. Each barangay also has a basketball court, multi-purpose buildings and halls dedicated for various social events.

The project is not expected to negatively impact these facilities nor will it cause competition in these resources.

4.1.5.7 Cemetery/Memorial Parks

In general, the traditional practice of burying the dead is observed in the area. For this, three (3) major cemeteries are present within the following locations: Roman Catholic Cemetery operated and maintained by the Roman Catholic Church with an area of 19,323 square meters located at Brgy. Magallanes; the Municipal Cemetery with an area of 6, 560 square meters located west of the Roman Catholic Cemetery in the same barangay; and the Luna Memorial Park with an area of 330,000 square meters, also in the same barangay. Aside from these are the Municipal Cemeteries and the Holy Cross Cemetery located at Oaqui No. 4. All of these were established in conformity to existing guidelines and not susceptible to flooding.

There are no existing burial grounds within the project site.

4.1.5.8 Commercial Areas

Commercial areas are generally concentrated in the urban core near the municipal building and the Roman Catholic Church named St. Catherine of Alexandria Parish. Commercial establishments include the public market and major businesses such as drug stores, gasoline stations, grocery stores, funeral parlors, furniture shops, automotive repair shops, canteens and eateries, telephone stations, and dental and medical clinics. There are also two banks in the municipality namely Rural Bank of Luna and Rang-Ay Bank, both found in the Poblacion.

Luna's public market in Barangay Magallanes had minor repairs and food stalls were constructed, which when fully completed and operational, will boost trade and industry. Sectioning has already been implemented. Near the public market is the old municipal abattoir that has been recently converted and developed as the municipal food court.

Luna has an existing new municipal slaughterhouse located in Barangay Nagrebcan, along the Balaoan-Luna Road.

4.1.6 The Economic Structure

4.1.6.1 Revenue/Income Sources

Basically, Luna is an agricultural municipality although it has other potential revenue sources. Most residents generate income from farming but some derive their income from other economic activities, service-oriented businesses and other commercial activities. Others are salary-earning employees/workers, practicing professionals, overseas Filipino workers, and/or entrepreneurs.

Putting up of the power plant will result in an *economic multiplier effect,* which happens when a new demand is added into the circular flow of income. The construction of the power plant will have requirements that include, but are not limited to, food supplies, water supply, man power, accommodation, and other services. This in turn, will increase the income of stakeholders and the whole municipality.

The municipality generates revenues from internal sources such as real property taxes, business taxes, permit fees and other service charges and fees but depends much from its share from the national revenue.

The power plant will be an additional source of the municipality's revenue. GLEDC will promptly pay the taxes and other permits and licenses to the municipality, and will help the concerned LGUs to address their respective needs.

Luna is classified as a third class municipality in terms of income, earning average revenue of about 68 million pesos annually. It is the 6th highest earning municipality in the First District of La Union. Because of the projected increase in revenue/income sources, the municipality may become a first class municipality.

4.1.6.2 Average Family Income vs. Poverty Level

Luna has about 8,017 households or 23.59% of its total households living within the poverty threshold or those families earning a gross income of 8,609 pesos per month. Family earnings are basically spent on food, and basic needs like schooling, health and medical needs, clothing, transportation, communication, power, home development, recreation and entertainment. While most spend more than what they earn, others somehow manage to have savings.

Increase in household income is expected from the implementation of the project. The demands of the project will result to livelihood opportunities. People of Luna can generate income from selling food, water, providing man power, services, and accommodations to the workers of the plant.

4.1.6.3 Employment Rate

Among the five impact barangays, Brgy. Carisquis has the highest employment rate that is equal to 95.35%. The other three barangays follow with Brgy. Pila having 94.70% employment rate, Brgy. Nalvo Sur with 92.58%, and Brgy. Darigayos with 88.89%. Nalvo Norte, on the other hand, has the lowest employment rate at 79.33% (**Table EP-2**).

Table EP-2
Employment Status Distribution of the Residents of the Impact Barangays

Employment Status	Barangay				
	Carisquis	Darigayos	Nalvo Norte	Nalvo Sur	Pila
Employed	246	600	284	524	411
Unemployed	12	75	74	42	23
Total	**258**	**675**	**358**	**566**	**434**

Overall, the impact barangays have 90.13% employment rate.

4.1.6.4 Food Security

Despite being a main producer of agricultural products in the province, the municipality recognizes sustained food supply as one of its challenges and that there is a need to increase annual food production by 5%. The municipality aims to improve sufficiency/adequacy levels on meat and poultry, staple foods, fruits and vegetables, and fishery production.

4.1.7 Socio-economic Profile of the Direct Impact Barangays

Tables EP-3 and EP-4 summarize the socio-economic profile of the direct impact barangays
.

Table EP-3
Profile of the Barangays in the Direct Impact Area

Barangay	Number of Households	Land Area (hectares)	Population	Population density (Person/ha)	Male	Female	Number of Households that are Informal Settlers
Carisquis	365	133.24	544	4.08	150	394	2
Nalvo Sur	356	209.18	1723	8.23	866	857	4
Total							

Table EP-4
Basic Facilities in the Host Barangays

Barangay	Water Supply	Power Supply	Transportation Modes Possible (mobility/ connectivity)	Communication	Health Services and Facilities Available	Peace and Order/ Crime	Education Facilities	Recreational / Sports Facilities	Environmental Health and Sanitation Profile
Carisquis	NOT being served by a water station/company Deep well: 146 Open/dug well: 10	Electricity	Jeepney, tricycle	Personal cellphone, Cellular network/site	1 Barangay Health Center (BHC)	No reported crimes in the past 12 months	1 Day Care Center (DCC)	2 Basketball courts 2 Solar dryer	Dumping of waste, Burning
Nalvo Sur	NOT being served by a water station/company Deep well: 189 Other sources: 28	Electricity, kerosene	Jeepney, tricycle	Personal cellphone	1 Barangay Health Center (BHC)	No reported crimes in the past 12 months		3 Basketball courts 2 Solar dryer	Dumping of waste, Burning

4.2 Perception Assessment on the Project-Affected Families (PAFs)

4.2.1 Methodology

A survey was conducted on August 10, 11, 12, & 13 covering 306 households in the affected barangays – Carisquis, Darigayos, Nalvo Norte, Nalvo Sur, and Pila.

This survey was patterned after the recommended form of the Environment Management Bureau (EMB), which includes questions on Disaster Risk Reduction and Management (DRRM). Majority of the enumerators were barangay health workers who were experienced in conducting surveys for the Community Based Monitoring System (CBMS), the Census of Population and Housing by the National Statistics Office (NSO), and/or surveys for the *Pantawid Pamilyang Pilipino* Program (4Ps) by the Department of Social Welfare and Development (DSWD).

The perception survey has three (3) major components namely: (1) socio-economic profile, (2) experience with natural distasters and environmental changes and (3) project awareness and perception. The third component, project awareness and perception, is broken down into four parts, namely, (1) awareness of the proposed project, (2) perceptions about the project, (3) aspirations and (4) attitudes towards the project.

A sample questionnaire is provided as **Annex F.**

4.2.2 Socio-Economic Profile

4.2.2.1 Demography

The total number of household surveyed was 306, with an average household size of 4.8 and a family size of 1.32 (**Table EP-5**). Household size pertains to the number of members within a household while family size pertains to the number of families within a household.

The average household size of the province is 4.5 while that of the country is 4.4 persons (Philippine Statistics Authority, 2015). This indicates that the average household size in the barangay impact areas is slightly higher than the provincial and national average. Barangay Carisquis, in particular,has a higher household size than the other impact barangays.

Table EP-5
Demographic Profile of Household Respondents

Barangay	Average HH Size	Average Family Size	Total No. of Sample HH
Carisquis	5.26	1.15	34
Darigayos	4.45	1.35	71
Nalvo Norte	4.26	1.25	61
Nalvo Sur	4.46	1.34	74
Pila	4.84	1.36	66
General Average/ Total	**4.8**	**1.32**	**306**

Gender Ratio

Table EP-6 illustrates that 695 of the 1,403 household members are female while 708 are male. The civil status of the members indicates that 759 are single, 553 are married, 58 are widowers, 2 have a common law/live-in partner and 31 are separated.

Table EP-6
Gender and Civil Status Distribution of Household Members

Barangay	Population			Civil Status				
	Male	Female	Total	Single	Married	Widower	Common Law	Separated
Carisquis	91	88	179	109	63	5	0	2
Darigayos	166	150	316	176	122	11	0	7
Nalvo Norte	125	134	259	145	100	12	0	2
Nalvo Sur	170	160	330	157	149	15	0	9
Pila	156	163	319	172	119	15	2	11
Total	**708**	**695**	**1,403**	**759**	**553**	**58**	**2**	**31**
%	**50.46**	**49.54**	**100**	**54.10**	**39.42**	**4.13**	**0.14**	**2.21**

Age Distribution

The 0-10 age group comprise the highest of about 21% (302 of the total household members) while the 61 and above age group are the lowest with only 109 members or 7.77% (**Table EP-7**).

Table EP-7
Age Distribution of Household Members

Barangay	Age Group							
	0-10	11-20	21-30	31-40	41-50	51-60	61 and above	Total
Carisquis	49	22	27	26	16	23	16	**179**
Darigayos	62	58	71	43	34	34	14	**316**
Nalvo Norte	63	52	43	37	28	14	22	**259**
Nalvo Sur	63	50	56	54	52	28	27	**330**
Pila	65	69	41	41	51	22	30	**319**
Total	**302**	**251**	**238**	**201**	**181**	**121**	**109**	**1,403**
%	**21.53**	**17.89**	**16.96**	**14.33**	**12.90**	**8.62**	**7.77**	**100**

Education and Literacy Rate

Table EP-8 shows the highest educational attainment of household members in the five barangays. From the total of 1,403 surveyed household members, 295 are high school graduates, 158 are elementary graduates and at least 149 are college graduates. About 7.34% have no formal education.

Table EP-8
Highest Educational Attainment of Household Members

Barangay	Educational Attainment												
	No Formal Educ.	Day Care/ Prep	Elem Level	Elem Grad	HS Level	HS Grad	Tech Voc Level	Tech Voc Grad	College Level	College Grad And Higher	Post Grad With Units	Missing/ Not Indi-cated	Total
Carisquis	11	15	33	19	24	33	5	7	16	15	1	0	**179**
Darigayos	28	12	39	42	53	80	7	4	24	22	5	0	**316**
Nalvo Norte	22	6	59	25	35	62	6	2	13	27	3	2	**262**
Nalvo Sur	17	13	62	45	49	52	17	5	25	42	0	0	**327**
Pila	25	14	45	27	41	68	5	29	21	43	1	0	**319**
Total	**103**	**60**	**238**	**158**	**202**	**295**	**40**	**47**	**99**	**149**	**10**	**2**	**1,403**
%	**7.34**	**4.28**	**16.96**	**11.26**	**14.40**	**21.03**	**2.85**	**3.35**	**7.06**	**10.62**	**0.71**	**0.14**	**100**

Religious Affiliations

Table EP-9 shows that majority of the household respondents in the five impact barangays are Roman Catholic (92.16%) while the rest are Iglesia ni Cristo, Methodist, Muslim and of other denominations.

Table EP-9
Religious Affiliation of Household Respondents

Barangay	Roman Catholic	Iglesia Ni Cristo	Methodist	Islam	Others	Not Indicated	Total
Carisquis	25	1	0	0	4	4	34
Darigayos	67	0	0	0	4	0	71
Nalvo Norte	61	0	0	0	0	0	61
Nalvo Sur	66	0	1	0	2	5	74
Pila	63	0	0	1	1	1	66
Total	**282**	**1**	**1**	**1**	**11**	**10**	**306**
%	**92.16**	**0.33**	**0.33**	**0.33**	**3.59**	**3.27**	**100**

4.2.2.2 Income and Expenditures

The major source of income among households are farming (27%) and fishing (20%), while 32 households opted not to indicate their primary source of income (**Table EP-10**).

Table EP-10
Distribution of Respondents based on Primary Source of Income

Barangay	HH Primary Source									
	Animal Raising	Commerce/ Business	Cons-truc-tion	Factory Work	Farming	Fishing	Others	Services	Not Indicated	Total
Carisquis	2	0	0	0	13	2	13	1	3	34
Darigayos	0	3	12	2	4	35	5	10	0	71
Nalvo Norte	4	1	5	0	28	4	13	1	5	61
Nalvo Sur	8	3	4	0	20	16	8	8	7	74
Pila	5	1	6	1	17	4	14	5	13	66
Total	**19**	**8**	**27**	**3**	**82**	**61**	**53**	**25**	**28**	**306**
%	**6.21**	**2.61**	**8.82**	**0.98**	**26.80**	**19.93**	**17.32**	**8.17**	**9.15**	**100**

In terms of average monthly income, Barangay Pila has the highest income at Php 11,543.53 and Barangay Carisquis has the lowest income of Php 5,779.66 (**Table EP-11**). Overall, the average monthly income of the five barangays is Php 8,481.25. Sources for household income asked during the reference survey period are from farming and fishing activities, from households businesses and from salaries and/or wages of employed household members.

Table EP-11
Distribution of Respondents as to Income and Expenditures

Barangay	Average Monthly Income and Expenditure (Php)	
	Income	Expenditure
Carisquis	5,779.66	6,068.93
Darigayos	6,521.14	8,083.08
Nalvo Norte	7,836.81	6,376.85
Nalvo Sur	9,522.83	7,140.08
Pila	11,543.53	7,430.30
General	**8,481.25**	**7,146.49**

Barangay Darigayos has the highest average monthly expenditures of Php 8,083.08 and Barangay Carisquis has the lowest of 6,068.93. Overall, the average monthly expenditure of the five barangays is Php 7,146.49. Note that expenses being asked during the survey period only include expenses on food, utilities like electricity, water and communication, and school expenses like tuition fees and allowance. Most of the households spend most of their income on food.

Barangay Carisquis has the lowest average monthly income and expenditures.

4.2.2.3 House Characteristics

Table EP-12 above shows that 284 of the 306 households surveyed have single type of house, and 5 households have the duplex type.

Table EP-12
Distribution of Respondents as to Type of Dwelling

Barangay	Type of Dwelling Unit					
	Single	Duplex	Apartment	Two- Storey	Others	Total
Carisquis	34	0	0	0	0	34
Darigayos	66	3	0	0	2	71
Nalvo Norte	58	2	0	0	1	61
Nalvo Sur	69	1	0	1	3	74
Pila	57	1	0	2	6	66
Total	**284**	**7**	**0**	**3**	**12**	**306**
%	**92.81**	**2.29**	**0**	**0.98**	**3.92**	**100**

About 89.54% of the respondents use galvanized iron as materials for house roofs and the remaining use light materials such as cogon, nipa, pawid, anahaw and other materials (**Table EP-13**).

Table EP-13
Distribution of Respondents as to House Roofing Materials

Barangay	Description of Roof Materials			
	Galvanized Iron	Light Materials	Others	Total
Carisquis	34	0	0	34
Darigayos	60	11	0	71
Nalvo Norte	53	8	0	61
Nalvo Sur	65	6	3	74
Pila	62	1	3	66
Total	**274**	**26**	**6**	**306**
%	**89.54**	**8.50**	**1.96**	**100**

As to the materials used for house walls, 76.14% (233) are made of concrete and about 11.76% are of wood and the remaining 12.09% are made of other materials (**Table EP-14**).

Table EP-14
Distribution of Respondents as to the Wall Materials Used for their Houses

Barangay	Description of Wall Materials			
	Concrete	Wood	Others	Total
Carisquis	26	6	2	34
Darigayos	45	10	16	71
Nalvo Norte	48	10	3	61
Nalvo Sur	63	8	3	74
Pila	51	2	13	66
Total	**233**	**36**	**37**	**306**
%	**76.14**	**11.76**	**12.09**	**100**

About 192 dwelling units during the survey period needed minor repair and 59 need major repair (**Table EP-15**). Barangay Nalvo Sur recorded the highest number of dwelling units that are in need of major repair with 20 responses. Forty nine (49) out of the 306 respondents have houses that are recently built, within the past 2-3 years.

Table EP-15
Distribution of Respondents as to the Current Condition of their Dwelling Unit

Barangay	Current Dwelling Condition				
	Newly Built	Needs Major Repair	Needs Minor Repair	Not Indicated	Total
Carisquis	3	4	27	0	34
Darigayos	11	16	42	2	71
Nalvo Norte	8	9	44	0	61
Nalvo Sur	7	20	44	3	74
Pila	20	10	35	1	66
Total	**49**	**59**	**192**	**6**	**306**
%	**16.01**	**19.28**	**62.75**	**1.96**	**100**

On the residence ownership of the households surveyed, 210 of the 306 (69%) own both the house and lot, 39 own only the house but with permission from the owner on the use of lot. There are only 13 households that rent both the house and lot. Nineteen (19) households use the house and lot free of charge with permission from the owner (**Table EP-16**).

Table EP-16
Distribution of Respondents as to Ownership of their House and Lot

Barangay	Residence Ownership						
	Owns the House and Lot	Owns the House but Rents Lot	Owns House, Free Used of Lot with Permission from the Owner	Rents House and Lot	Free Used of House and Lot with Permission from the Owner	Not Indicated	Total
Carisquis	20	0	14	0	0	0	34
Darigayos	28	15	9	11	8	0	71
Nalvo Norte	49	7	2	2	1	0	61
Nalvo Sur	52	0	10	0	9	3	74
Pila	61	0	4	0	1	0	66
Total	**210**	**22**	**39**	**13**	**19**	**3**	**306**
%	**68.63**	**7.19**	**12.75**	**4.25**	**6.21**	**0.98**	**100**

4.2.2.4 Household Facilities

Two hundred twenty-two (222) households use firewood/charcoal as their main fuel for cooking while 78 households use Liquefied Petroleum Gas (LPG). Only 1 household uses an electric stove (**Table EP-17**).

Table EP-17
Distribution of Respondents as to the Fuel Used for Cooking

Barangay	Fuel Used for Cooking						
	Firewood/ Charcoal	LPG	Electric Stove	Kerosene	Others	Not Indicated	Total
Carisquis	31	3	0	0	0	0	34
Darigayos	43	27	0	1	0	0	71
Nalvo Norte	39	20	1	0	0	1	61
Nalvo Sur	57	15	0	1	0	1	74
Pila	52	13	0	0	1	0	66
Total	**222**	**78**	**1**	**2**	**1**	**2**	**306**
%	**72.55**	**25.49**	**0.33**	**0.65**	**0.33**	**0.65**	**100**

Electricity, with about 92.16% or 282 responses, is the major source of lightning for most of the households. Ten (10) households still use other lighting facilities like candles. Barangay Darigayos recorded the highest number of households that use other lighting facilities mainly kerosene lamps (**Table EP-18**).

Table EP-18
Distribution of Respondents as to the Lighting Facility Used

Barangay	Lighting Facility				
	Electricity	Candle	Others	Not Indicated	Total
Carisquis	31	2	0	1	34
Darigayos	63	3	2	0	71
Nalvo Norte	58	2	1	0	61
Nalvo Sur	66	2	1	5	74
Pila	64	1	0	1	66
Total	**282**	**10**	**4**	**7**	**306**
%	**92.16**	**3.27**	**1.31**	**2.29**	**100**

One hundred forty-two (142) of the 306 households surveyed get their water supply from deep wells, 110 households buy bottled water, and only 9 households are supplied by the community water system. The rest of the households use water from springs and other sources (**Table EP-19**).

Table EP-19
Distribution of Respondents as to their Source of Drinking Water

Barangay	Main Source of Water Supply						
	Community Water System	Deep Well	Spring Water	Bottled Water	Others	Not Indicated	Total
Carisquis	0	24	1	9	0	0	34
Darigayos	0	50	1	20	0	0	71
Nalvo Norte	0	26	10	22	3	0	61
Nalvo Sur	4	25	0	40	4	1	74
Pila	5	17	0	19	23	2	66
Total	**9**	**142**	**12**	**110**	**30**	**3**	**306**
%	**2.94**	**46.41**	**3.92**	**35.95**	**9.80**	**0.98**	**100**

Table EP-20 shows that 271 of the 306 households in the five barangays own water-sealed toilets while 23 households share the same facility with other households. Note that there is one household which does not have any toilet facility and is located in Barangay Pila.

Table EP-20
Distribution of Respondents with a Toilet Facility

Barangay	Toilet Facility							
	Water Sealed -Owned	Water Sealed-Shared	Open Pit	Closed Pit	No Toilet	Others	Not Indicated	Total
Carisquis	28	6	0	0	0	0	0	34
Darigayos	69	1	1	2	0	0	0	71
Nalvo Norte	54	6	0	1	0	0	0	61
Nalvo Sur	63	5	0	0	0	1	5	74
Pila	57	5	0	0	1	2	1	66
Total	**271**	**23**	**1**	**3**	**1**	**3**	**6**	**306**
%	**88.56**	**7.52**	**0.33**	**0.98**	**0.33**	**0.98**	**1.96**	**100**

4.2.2.5 Waste Management

The method of garbage disposal of the majority (239) of the households surveyed is through burning while 31 bury their wastes. Dumping of garbages is only observed from the residents of Barangay Pila (**Table EP-21**).

Table EP-21
Distribution of Respondents as to Methods of Garbage Disposal

Barangay	Method of Garbage Disposal					
	Garbage Collection	Burning	Burying	Throwing of Garbage in Rivers, Others	Not Indicated	Total
Carisquis	1	26	6	0	1	34
Darigayos	24	36	11	0	0	71
Nalvo Norte	0	59	2	0	0	61
Nalvo Sur	0	69	0	0	5	74
Pila	0	49	12	3	2	66
Total	**25**	**239**	**31**	**3**	**8**	**306**
%	**8.17**	**78.10**	**10.13**	**0.98**	**2.61**	**100**

4.2.2.6 Disaster Experiences

Disasters were classified into typhoons, floods, e.g. landslides or storm surges. Experience with typhoons comprise the biggest number with almost 95% of households. This was followed by floods.

Table EP-22
Distribution of Responses as to the Disaster that the Community Experienced*

Barangay	Disasters Experienced by HH				
	Typhoon	Flooding	Earthquake	Landslide	Storm Surge
Carisquis	34	0	0	0	0
Darigayos	69	50	4	0	1
Nalvo Norte	56	27	0	0	0
Nalvo Sur	66	22	0	0	0
Pila	65	12	1	0	0
Total	**290**	**111**	**5**	**0**	**1**
%	**94.77**	**36.27**	**1.63**	**0.00**	**0.33**

*Multiple responses

The magnitude of impact of the disasters to the respondents were described as either none, moderate, or severe. Majority of the respondents (67.97%) answered that these disasters contributed moderate effect, while 16.01% answered that the disasters had no effect at all. The remaining 9.15% of the respondents observed that these brought severe effect (**Table EP-23**).

Table EP-23
Distribution of Respondents as to their Perception on the Magnitude of Effect of the Disasters Experienced by the Community*

Barangay	Impact / Effect of Disasters to the Community		
	None	Moderate	Severe
Carisquis	3	25	4
Darigayos	3	66	2
Nalvo Norte	11	41	7
Nalvo Sur	20	35	7
Pila	12	41	8
Total	**49**	**208**	**28**
%	**16.01**	**67.97**	**9.15**

*Multiple responses

The proponent will coordinate with the LGU to develop and implement a Disater Risk Reduction and Management Program. A continuing IEC may be conducted as part of the program to address the perceived risks of natural disasters.

4.2.2.7 Environmental Changes Observed

Table EP-24 shows the environmental changes observed by the respondents in their community. Most of the respondents (68) have observed that occurrence of migration have been increasing over the past years. Increase in occurrence is also observed in fish/shellfish harvest with 52 responses. This activity, however, was also cited by 136 respondents to be decreasing in occurrence. Other environmental activities that have fewer occurrences compared to the past years include farm harvest (131 responses) and flooding in low land (120 responses).

In terms of effect on the surveyed households, 58 of the respondents said that decrease in farm harvest had the most effect on them, followed by flooding in low lands with 52 responses (**Table EP-25**). As a coastal community, 37 also state that decrease of harvest in fishing has affected their household and community.

4.2.3 Project Awareness and Perception

4.2.3.1 Awareness of the Project

Majority of the respondents (303) were aware of the proposed power plant project. Only a very small portion of the respondents, 1 in Brgy. Carisquis and 2 in Nalvo Sur, are not aware of the proposed project (**Table EP-26**).

Table EP-26
Distribution of Respondents as to their Awareness of the Project

Barangay	Awareness of the Proposed Project		
	Yes	No	Total
Carisquis	33	1	34
Darigayos	71	0	71
Nalvo Norte	61	0	61
Nalvo Sur	72	2	74
Pila	66	0	66
Total	**303**	**3**	**306**
%	**99.02**	**0.98**	**100**

4.2.3.2 Source of Project Information

Most of respondents (270) are warned or heard about the proposed facility from barangay and/or municipal officials (**Table EP-27**).

Table EP-27
Distribution of Respondents as to the Source of their Information about the Project*

Barangay	HH Source of Information about the Project							
	Radio	TV	Parish Priest	Family Member	Neighbor	Barangay/ Municipal Officials	Project Employees	Others
Carisquis	0	0	0	0	0	33	0	0
Darigayos	0	0	0	0	6	65	0	0
Nalvo Norte	0	0	0	16	16	44	0	1
Nalvo Sur	0	1	0	0	0	71	0	0
Pila	2	0	0	4	4	57	0	1
Total	**2**	**1**	**0**	**20**	**26**	**270**	**0**	**2**
%	**0.65**	**0.33**	**0.00**	**6.54**	**8.50**	**88.24**	**0.00**	**0.65**

*Multiple responses

Table EP-24
Distribution of Respondents as to their Perception on Environmental Changes and the Degree of Change

Barangay	Environmental Change																					
	Factories/ Power Plants / Industries		Fish/ Shellfish Harvest		Fishing Ground		Lands Converted into Subdivision		Farm Harvest		Flooding in Low Lands		Forest Cover		Population/ Migration		Water Pollution		Air/noise Pollution		Traffic Congestion	
	M*	L**	M*	L**	M*	L**	M*	L**	M*	L**	M*	L**	M*	L**	M*	L**	M*	L**	M*	L**	M*	Less
Carisquis	3	16	0	23	2	21	8	11	5	21	6	13	6	13	12	9	7	13	2	18	1	15
Darigayos	0	0	7	58	4	50	0	17	0	25	17	35	2	17	37	2	17	8	8	6	6	9
Nalvo Norte	4	6	8	30	5	7	3	6	6	32	4	33	2	5	7	4	4	7	5	8	3	8
Nalvo Sur	5	4	6	14	13	3	6	7	6	32	7	8	10	4	12	0	7	5	7	5	6	2
Pila	4	8	31	11	23	9	0	11	21	21	4	31	12	15	0	10	0	14	0	16	0	7
Total	**16**	**34**	**52**	**136**	**47**	**90**	**17**	**52**	**38**	**131**	**38**	**120**	**32**	**54**	**68**	**25**	**35**	**47**	**22**	**53**	**16**	**41**
%	**5.23**	**11.11**	**16.99**	**44.44**	**15.36**	**29.41**	**5.56**	**16.99**	**12.42**	**42.81**	**12.42**	**39.22**	**10.46**	**17.65**	**22.22**	**8.17**	**11.44**	**15.36**	**7.19**	**17.32**	**5.23**	**13.40**

*M – More
**L – Less

Table EP-25
Distribution of Respondents as to their Perception on which of the Environmental Changes had the Most Effect on their Household

Barangay	Environmental Change										
	Factories/ Power Plants / Industries	Fish/ Shellfish Harvest	Fishing Ground	Lands Converted into Subdivision	Farm Harvest	Flooding in Low Lands	Forest Cover	Population/ Migration	Water Pollution	Air/noise Pollution	Traffic Congestion
Carisquis	0	6	0	7	7	0	0	0	1	0	0
Darigayos	0	2	0	0	0	44	0	9	0	0	0
Nalvo Norte	2	9	0	0	23	6	0	0	1	2	1
Nalvo Sur	1	7	0	0	26	1	0	0	0	0	0
Pila	4	13	2	0	2	1	2	0	2	0	0
Total	**7**	**37**	**2**	**7**	**58**	**52**	**2**	**9**	**4**	**2**	**1**
%	**2.29**	**12.09**	**0.65**	**2.29**	**18.95**	**16.99**	**0.65**	**2.94**	**1.31**	**0.65**	**0.33**

4.2.3.3 Perceptions toward the Project

Positive Effects (multiple responses)

As to perceived positive impacts, 266 respondents believe that it will bring employment for some local residents and 122 respondents are optimistic that it can industrialize the community and 170 believe it can assist community projects or developments (**Table EP-28**). Also others (211) consider that it is an opportunity to augment revenue collection in the barangay. 24 respondents however perceive that no benefits can be derived from the proposed project.

Table EP-28
Distribution of Respondents as to their Perception about the Positive Effects/Impacts of the Project*

Barangay	Perceived Positive/Beneficial Effects/Impacts					
	None	Employment for some Local Residents	Industrialization of the Community	Revenue to the Barangay/ Municipality/ Province	Assisting Community Projects/ Development	Community Solidarity
Carisquis	3	29	20	19	22	13
Darigayos	0	63	29	67	35	21
Nalvo Norte	4	57	16	21	20	13
Nalvo Sur	12	57	19	45	50	21
Pila	5	60	38	59	43	34
Total	**24**	**266**	**122**	**211**	**170**	**102**
%	**7.84**	**86.93**	**39.87**	**68.95**	**55.56**	**33.33**

*Multiple responses

Negative Effects (multiple responses)

109 respondents are optimistic that the proposed project has no negative impacts or adverse effects to the community (**Table EP-29**). 92 and 80 respondents however answer air pollution and water pollution as a potential impact and another 93 respondents see health hazard as another potential effect.

Table EP-29
Distribution of Respondents as to their Perception about the Negative Effects/Impacts of the Project*

Barangay	Perceived Negative/Adverse Effects/Impacts									
	None	Decrease in Farm/ Tobacco Harvest	Flooding	Decrease in Ground water Resources	Health Hazard	Peace and Order Hazard	Water Pollution	Air Pollution	Noise Pollution	Traffic Congestion
Carisquis	2	13	3	9	17	9	15	19	7	2
Darigayos	19	21	35	25	28	14	28	30	17	6
Nalvo Norte	28	1	3	6	9	5	20	26	9	2
Nalvo Sur	20	8	1	4	29	15	12	6	3	1
Pila	40	4	1	1	10	3	5	11	1	0
Total	**109**	**47**	**43**	**45**	**93**	**46**	**80**	**92**	**37**	**11**
%	**35.62**	**15.36**	**14.05**	**14.71**	**30.39**	**15.03**	**26.14**	**30.07**	**12.09**	**3.59**

*Multiple responses

Over-all Effect

Overall, in the opinion of the 258 respondents, the proposed project will be able to help the community and local residents a lot (**Table EP-30**). The 34 respondents however are optimistic that it help the community although not much, 5 respondents perceive that it will not help the community at all. Only 2 respondents considered that the proposed project will be detrimental to the community.

Table EP-30
Distribution of Respondents as to their General Perception about the Project

Barangay	Opinion of the Proposed Project					
	Will Help the Community and Local Residents a Lot	Will be Able to Help but not Much	Will not Help the Community at All	Will be Detrimental to the Community	No Responses	Total
Carisquis	25	6	0	2	1	34
Darigayos	62	9	0	0	0	71
Nalvo Norte	58	3	0	0	0	61
Nalvo Sur	67	3	0	0	4	74
Pila	46	13	5	0	2	66
Total	**258**	**34**	**5**	**2**	**7**	**306**
%	**84.31**	**11.11**	**1.63**	**0.65**	**2.29**	**100**

4.2.3.4 Aspirations

Table EP-31 shows that 294 respondents, if given the chance, will take the opportunity or will allow household members to work for the project. This is because they believe that it can help augment their source of income. On the other hand, 6 respondents will not and other 6 respondents still are not sure whether to work or not.

Table EP-31
Distribution of Respondents as to their Aspiration in relation to the Project

Barangay	Aspiration, allow to work			
	Yes	No	Not Sure	Total
Carisquis	32	1	1	34
Darigayos	71	0	0	71
Nalvo Norte	59	0	2	61
Nalvo Sur	69	4	1	74
Pila	63	1	2	66
Total	**294**	**6**	**6**	**306**
%	**96.08**	**1.96**	**1.96**	**100**

4.2.3.5 Overall Attitude towards the Project

Table EP-32a shows that about 95.75 % (293) of the household respondents would approve the establishment of the project in their community. Only about 0.9% of the respondents will not approve of the project and about 3.27% are unsure whether to approve of it or not because they still have no knowledge or idea about the proposed power plant.

Table EP-32a
Distribution of Respondents as to their General Attitude towards the Project

Barangay	Will Approve of the Project			
	Yes	No	Not Sure	Total
Carisquis	29	0	5	34
Darigayos	71	0	0	71
Nalvo Norte	60	0	1	61
Nalvo Sur	68	2	4	74
Pila	65	1	0	66
Total	**293**	**3**	**10**	**306**
%	**95.44**	**0.98**	**3.26**	**99.67**

Only 3 respondents will approve of the project and 5 respondents still will not approve of it even upon abatement of perceived adverse effects. 5 respondents remain unsure (**Table EP-32b**).

Table EP-32b
Distribution of the 13 Respondents as to their Approval of the Project upon Abatement of Perceived Adverse Effect

Barangay	Yes	No	Not Sure	Total
Carisquis	1	3	1	5
Darigayos	0	0	0	0
Nalvo Norte	0	0	1	1
Nalvo Sur	2	1	3	6
Pila	0	1	0	1
Total	**3**	**5**	**5**	**13**
%	**0.98**	**1.63**	**1.63**	**4.25**

4.3 Information, Education and Communication (IEC) and Scoping Activities

4.3.1 Consultative Meetings/IEC/Focus Group Discussions (FGD)

IEC activities were done in June 2016 using a workshop style discussion where the details of the proposed project and the Environmental Impact Assessment (EIA) were discussed. Several sessions of IEC meetings with the stakeholders of the five impact areas were conducted to provide sufficient opportunity for the residents to participate in the information campaign. The Municipal Mayor, the Municipal Vice-Mayor and the members of the legislative council (*Sangguniang Bayan*), Barangay Chairs of Luna, and various sectoral groups participated in the IEC.

Focus Group Discussions (FGDs) were held right after each IEC session, where the project was presented and the EIA process was discussed with the sector groups.

Table EP-33 shows a summary of the stakeholders' concerns or perceived effects and their proposed solutions.

Table EP-33
Stakeholder's Concerns/Perceived Effects and their Proposed Solutions

Sector	Concerns/Perceived Negative Effects of the Proposed Project	Proposed Solution	Perceived Benefits/Positive Effect of the Proposed Project
Day 1: June 14, 2016			
Municipal officials, Department Heads and Association of Barangay Captains (ABC)	• Traffic • Possible abuse of political power • Health hazards • Influx of people/over population • Disturbance of peace and order; increase of social crimes • Decrease of fish harvest • Effects on the environment (pollution; trees will be cut)	• Additional Law enforcers; proper traffic management; regulation of issuance of franchise • Good governance • Establishment of health clinic with competent personnel • Provision of housing projects • Additional security forces; implementation of municipal ordinance on "curfew" • Close monitoring of the plant • Intensive IEC Follow DENR rules on tree cutting and replacement	• Employment; job opportunities • Influx of investors and tourists; business activities will flourish • Land and real properties will appreciate; increase of revenues • Development will accelerate • Students can avail themselves of scholarship assistance; literacy rate will improve; provision of scholarship programs • Livelihood projects and skills training • Lower electric bills/rates; solution to frequent brownout in the area • Upgrade of income classification
Religious Groups and Academe	• Effects on the environment (destruction of forest land in the proposed site; destruction of marine life; pollution; deforestation; acid rain; CO_2 emission; global warming; siltation; side effects of the project to underground water) • Disturbance to peace and order • Political conflicts • Health problems/hazards; • Influx of people with different culture • Hiring rivalry	• Reforestation after the construction of the project; maintain ecological balance; continuous tree planting project • Project proponent to use highly efficient equipment/gadgets • Close monitoring/supervision • Free health services; provision of hospital and clinic; • Promotion of culture adaptation; police visibility and intensify security • Fair recruitment process	• Increase of employment opportunities • Improvement of local economy; greater tax revenue • Educational opportunities (scholarship); subsidize electric power consumption of schools; assistance to school projects • Skills and development training • Construction of barangay roads
Day 2: June 15, 2016			
Barangay Carisquis (Youth, Senior Citizens, Women's Group, Men's Group, Barangay Officials)	• Effects on the environment (pollution to air, water; destruction of marine life/coral reef; destructive effect to water table/groundwater contamination; greenhouse effect; ocean	• Don't construct; Stop the project; NoToCoal (Youth Group) • Follow DENR standards • Need for more measure control	• Employment opportunities • Additional income source • Benefits for senior citizens • Educational assistance (scholarships)

Table EP-33 continued

Sector	Concerns/Perceived Negative Effects of the Proposed Project	Proposed Solution	Perceived Benefits/Positive Effect of the Proposed Project
	siltation) • Landslide and soil erosion • Oil and coal spill in the ocean; • Destruction of the ozone layer; radiation • Loss of tourism development; effect on beach resort • Loss of farm animals • Catastrophic burden • Unbalanced eco-system • Improper waste disposal • Health hazards (skin, respiratory & cardiovascular diseases); hazardous air pollutants (mercury, acid gases); • Short term benefits (25 years) vs lifetime effects • Traffic and noise pollution; effect to peace and order	• Need for intensive study • Provision of health center and personnel (doctor & nurses), and medicines	• Livelihood programs/ free training with allowance • Free hospitalization; health assistance • Additional power source; free electricity
Barangay Nalvo Sur (Women's Group, Men's Group, Barangay Officials)	• Pollution to air and water; • Loss of fish and shells; decrease of fish harvest; fishermen will be allowed to catch fish near the site • Health hazards; environmental health problems • Disturbance to peace and order • Assurance that every information and explanation about the proposed project are true and correct • Contamination of the sea; bad effects to marine life • Effects to ozone layer	• Anti-air pollution • Waste segregation; proper waste management; • Planting of trees • Maintain cleanliness • Provision of cooling system • Lakbay aral / Site visit to existing coal power plant • Use other sources like diesel power plant, solar energy, wind energy, etc	• More job/employment opportunities; establishments of small businesses like canteen • No power shortage • Improvement of farm to market roads; • More projects for the barangays • Increase of tax revenues • Increase of honorarium of barangay officials, bhw and tanod • Financial assistance to farmers and fishermen • Provision of livelihood programs, feeding programs, health assistance and educational assistance like scholarship

Table EP-33 continued

Sector	Concerns/Perceived Negative Effects of the Proposed Project	Proposed Solution	Perceived Benefits/Positive Effect of the Proposed Project
Day 3: June 16, 2016			
Barangays Pila, Darigayos and Nalvo Norte (Youth, Senior Citizens, Women's Group, Men's Group, Fisher folks, Barangay Officials)	• Over population; influx of people • Decrease of fishing grounds; destruction of marine life/resources; pollution to air and water; contamination of the sea water • Age limit when applying for job at the power plant • Political Conflict / Rivalry • Deforestation • Effects to peace and order • Health problems; effects to drinking / ground water • Effects of the radiation to the community • Effects to tourism development • Request to visit existing coal power plants since pictures are unreliable	• Provision of housing projects • Request for project proponent to help construct artificial craft for fisher folks. • Programs that will address concerns of senior citizens • Reforestation; provision of air/water filter • Medical assistance • Ensure no chemical leakage during construction and operation phase; Proper drainage for chemicals	• Free hospitalization and additional financial support to senior citizens • More establishments, more people meaning more benefits and more work • Scholarship programs to youth • Livelihood projects especially for women; trainings and seminars • More employment • No power shortage and free electricity • Provisions of health insurance and free medical check ups • Provision of support to farmers and fisher folks • Increased revenue for Brgys. Nalvo Sur and Carisquis • Improvement of the barangays; more access to projects

4.3.2 Public Scoping

The Public Scoping with Luna stakeholders, specifically the residents of the primary and secondary impact barangays, was conducted on July 13, 2016 at the Luna Sports Complex, Luna, La Union. Representatives of the Department of Environment and Natural Resources (DENR), the Provincial Government of La Union, and the Municipal Government of Luna were present. The Municipal Mayor, the Municipal Council, Municipal Department Heads, Barangay Officials, the media, several student representatives, and a few sectoral group representatives attended the Public Scoping activity.

The concerns raised and attendance sheets from the Public Scoping are provided as **Annex I.**

4.3.3 Local Benefits from the Project

Benefits from the project and effect on current livelihood are among the top concerns or comments raised during the scoping activities. With this, the Municipality of Luna should monitor the implementation of its recently updated Comprehensive Development and Land Use Plan (CLUP) to maximize the potential brought about by the establishment of a power plant in the municipality.

During the construction phase, construction activities will provide temporary employment to local residents. After plant construction, hired workers may find new job opportunities in the plant during operation phase, depending on the phase's skills demand, or use their experience to look for job opportunities outside the plant. Enterprising stakeholders will also have increased livelihood opportunities in terms of selling food and other daily needs to the construction workers and employees. During project operation, more jobs will be available and there will be an increase in livelihood opportunities for the residents who wish to sell food or provide lodging facilities to workers. Increased revenue is also projected for the LGUs concerned (Province of La Union, Municipality of Luna, and Brgys. Nalvo Sur and Carisquis). Community Development Projects would be funded from the mandated percentage of income that should be spent on community development.

To ensure that job opportunities are given to legitimate residents, the proponent will continually coordinate with the LGU. The plan of having a barangay job fair is a welcome idea so that the residents can readily recognize applicants coming from other areas. Job fairs also ensure the transparency of the hiring process. Skills training will be provided to the residents as a pro-active approach to help them gain employment opportunities.

A more active Barangay Development Council (BDC) will be developed to take part in continually enhancing these local benefits. The BDC will identify community projects that are responsive to the needs of the residents, and can be good candidates for GLEDC's Corporate Social Responsibility (CSR) projects. The proponent will assist the host LGU in implementing these projects through their CSR initiatives and through the increased revenue of the barangay.

Should the proponent decide to end plant operation, a community development planning will be conducted prior to the actual abandonment to assist and prepare residents whose source of income and livelihood is the power plant. A simple Community Development Plan is often used as basis for the Community Social Responsibility of the proponent. Upon project abandonment, local residents employed by the project would have benefited in terms of experience, additional skills, and knowledge.

4.3.4 Summary of Potential Impacts to People

Table EP-34 summarizes the potential impacts and proposed mitigation related to People.

Table EP-34
Summary of Potential Impacts to People during Construction and Operation

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
I. Construction Phase			
In-migration	Demographics	The construction of the power plant may increase the municipality's population since the project will attract in-migrants to work or stay in the Municipality of Luna, especially migrants who have work experience in other power plants. Possible in-migration patterns predicted as a result of the project are of two (2) types – short-term in-migrants that consist of workers who will be there only during the construction phase and; short-term migrants that could become attracted by developments in the area, thus becoming long-term migrants. Migrants that do not have skills but are willing to try to get a job would increase competition with local residents for job availability. On the other hand, migrants that do have skills, are productive and would be able to transfer their knowledge and skills to workers in Brgys. Nalvo Sur and Carisquis would be a welcome impact.	• The proponent will assist and coordinate with the LGU in setting up a migration information center in barangay halls for easier migrant tracking. Job fairs will be conducted in designated areas with the help of barangay officials who can readily recognize the migrants.
Physical and Economic Displacement during pre-construction and construction	Demographics	There are no indigenous groups present in the municipality or residing in the project area, thus, the project will have no effects on cultural change of indigenous people.	• No mitigation measures needed.
Increased LGU revenue and general economic development during pre-construction, construction and operation	Lifestyle	An increased income during the plant operation may effect a change in the lifestyle of the residents of the affected barangays. They may have additional disposable income for other non-basic material goods. Industrialization in the municipality will also move the stakeholders to modernization. Concerns that may result from modernization were raised during the scoping activities.	• The proponent will implement measures to enhance positive social impacts through the corporate social responsibility programs of the proponent. The proponent will also establish continued coordination with the LGU to regulate resources and opportunities.
Increased LGU revenue and general economic development during pre-construction, construction and operation	Revenue/Income Sources	Putting up of the power plant will result in an *economic multiplier effect,* which happens when a new demand is added into the circular flow of income. The construction of the power plant will have requirements that include, but are not limited to, food supplies, water supply, man power, accommodation, and other services. This in turn, will	• GLEDC will promptly pay the taxes and other permits and licenses to the municipality, and will help the concerned LGUs to address their respective needs.

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
		increase the income of stakeholders and the whole municipality.	
Impact on Common Property Resources during pre-construction and construction	Man-made features	Although two tourist spots are found within the direct impact area, the project is not expected to negatively impact these resorts since construction activities will be confined within the project boundary.	• No mitigation measures needed.
Physical and Economic Displacement during pre-construction and construction	Infrastructure	There are no existing households, structures/improvements, and cultivated lands within the project site. Issues in terms of conflicts in land ownership are not expected to arise. Apprehensions regarding right-of-way are also not likely to occur	• No mitigation measures needed.
II. Operations Phase			
Impact on Common Property Resources during operation	Man-made features	The activities of the coal-fired power plant during the operation phase will not cause any additional impacts related to land use or tourist spots.	• No mitigation measures needed.
Impact on Common Property Resources during operation	Irrigation	The power plant will not draw excessive groundwater or tap the Darigayos River to supply its water needs. As such, the project will not compound these irrigation problems.	• No mitigation measures needed.
Impact on Common Property Resources during operation	Utilities	With the implementation of the project, some residents fear the potential increase in competition for resources. An increase in economic activities may result to increased competition for community services such as police and fire protection, and medical services. Upon project abandonment, migrant workers may stay in the barangay and compete with the residents for basic services and natural resources in the area.	• GLEDC will coordinate with the LGU and adhere to municipal policies regarding management of community resources and implementation of the updated CLUP of the municipality. • GLEDC will assist the LGU in the preparation of a Barangay Development Plan and Barangay Disaster Risk and Managament Plan for the affected barangays.
Impact on Common Property Resources during operation	Waste Management	The municipality's dumpsite is in Barangay Sucoc Norte, which is outside the poblacion area. In this site, a community based composting facility for organic fertilizer production through Vermicomposting is installed. Luna has yet to have a sewage disposal facility.	• GLEDC will implement a Solid Waste Management Plan within the vicinity of the plant. GLEDC will also comply with the Ecological Solid Waste Management Act of 2000 implemented by the LGU.

4.4 Health Impact Study and Assessment

4.4.1 Methodology

4.4.1.1 Review of the Health System Capability of the Government

The first part of this study evaluates the health system capability of the government in the context of the establishment of a coal-fired power plant in Luna, La Union. The review consists of checking the national, provincial and municipal health care delivery system in place vis-à-vis the capacity to address any possible health impacts arising from the construction and operations of the power plant.

Since the municipal health care delivery capability needs to be understood in the context of its relation to national and provincial health networks, a general review of the national health system, now called the Duterte Health Agenda (2016), is presented. This is followed by a review of the provincial and local health care system in the impact area so that capacities and gaps can be identified and an evaluation made of the robustness of the system in addressing future needs of power plant health impacts.

4.4.1.2 Health Impact Assessment

The second part assesses the health impacts of the coal-fired power plant. A review of official records of the Department of Health, the Municipal Health Office of Luna, and the Municipal Operational Health Plan for Luna 2016 was conducted to obtain vital information on the health situation in the municipality as well as the five barangays affected by the project. A Focus Group Discussion with Key Health Personnel from all the five barangays as well as Key Informant Interviews with the Municipal Health Officer, Municipal Health Nurse, Municipal Dentist and officials from the Office of the Mayor were used in the investigation.

A Review of Literature was jointly made with health practitioners and occupational health specialists in U.P. Manila. For the identified concerns, mitigating actions were proposed. Various apprehensions and perceptions about the power plant were discussed with the Medical Team and the Project Engineer of the proponent. The probability of occurrence and the projected severity of impact were then weighed.

Potential risks identified from literature, focus group discussions and key informant interviews were reviewed. Mitigating measures were formulated and recommended based on these identified risks. Health impact analysis is presented using three tools:

a) Incidence Potential Rate
b) Health Consequence Rating
c) Health Risk Matrix

4.4.2 The National Health System

The Philippine Health System is designed such that it should be able to address the impacts of major industrial development projects, such as the proposed 2x335MW coal-fired power plant.

Lavado et al (2010) wrote "delivery of healthcare services in the Philippines is provided both by public and private providers. It is designed as a referral network, wherein Barangay Health Stations (BHS), manned by Barangay Health Workers (BHWs), serve as the base. They report to City Health Offices (CHOs) or Municipal/Rural Health Units (RHUs) usually located in a city or a town poblacion. CHOs/RHUs are usually staffed by a physician, nurses, a sanitary inspector, trained midwives, affiliated traditional birth attendants and BHWs. RHUs refer patients to primary hospitals, usually composed of 25 beds. Several RHUs can also be served by District Hospitals. Large provinces usually have secondary hospitals usually composed of provincial and city hospitals. Final referral hospitals are composed of medical centers, regional hospitals, and specialty care hospitals. With the devolution of health services in 1992, the referral network failed to work as envisioned."

The Philippine health care system has been undergoing changes. With health service delivery devolved to the Local Government Units (LGUs) in 1991, the fragmentation of health care delivery became an issue. National health budgets were designed for Department of Health (DOH) agenda and the support of DOH hospitals. With provincial and municipal level hospitals now funded by provincial and municipal budgets, health financial requirements became a burden to the local government units. Health human resource concerns worsened with problems of underemployment and skewed distribution favoring urban areas. Facilities were not upgraded since budgets for capital expenditures and operating expenses were low. This has resulted in gaps found not only in Luna but in many municipalities nationwide.

The present government has embarked on a Philippine Health Agenda, also called the Duterte Health Agenda to address these concerns. The Coal-Fired Power Plant under study is to be situated in a provincial site in Luna, La Union, and is therefore going to be located in an area affected by devolution and decentralization.

4.4.2.1 Goals and Values

In addressing the concerns of inadequate national health delivery, the government has announced its health care goals and values.

The health system aspired for has over-arching goals. These are the following:

1. Financial protection against high cost of health;
2. Better health outcomes with no disparity due to status; and
3. Responsiveness, Filipinos feel respected, valued and empowered in all their inter-actions with the health system.

In the delivery of health care nationwide, the Duterte Health Agenda is guided by these Value Statements:

1. Equity and inclusiveness in health care;
2. Transparency and accountability in health delivery and governance;
3. Efficiency in the use of resources; and
4. Provision of high quality resources.

4.4.2.2 Universal Health Care Agenda

For the past 30 years, the Philippine Health Care system has been built upon programs designed to deliver universal health care. These include:

(1) *Devolution and decentralization*; It was decided during the Cory Aquino administration that local government units would be more responsive in terms of the needs of the health constituency so the system of delivery was devolved. The Department of Health (DOH) is tasked with setting up the over-all health care delivery policy and program and has control over the regional level.

The local government unit, from the provincial to the barangay level, implements the programs and policies. In the case of Luna, the provincial government of La Union has a Provincial Health Officer who exercises governance over the provincial health system under the orders of the provincial governor. The Provincial Health Officer has management over the town health unit which is run by a Municipal Health Officer (MHO). The MHO is the local medical officer of the town and the town mayor exercises administrative and fiscal control over this officer. Municipal health officers derive their budgets and policy directives from the town mayor and the town council. There are barangay health units that derive marching orders from the MHO. Several barangays can cluster into an inter-local health zone with collaborative health management in these zones run by the MHO.

Several municipalities can collaborate and work through a wider District health zone, with a District Hospital under the direction of the Provincial Health Office. The next level is the provincial hospital where the district hospital will send cases beyond their capability. As previously mentioned, the actions of the devolved agencies from the provincial to the barangay are autonomous of direct DOH control.

The DOH has control only up to the regional hospitals. However, there are also retained DOH hospitals which have been returned by a local government unit to the DOH due to fiscal, budgetary and administrative concerns. For the province of La Union in general and the town of Luna in particular, the example for this case is the La Union Medical Center, which shall be discussed later because it is an example of best practices in governance as cited by the World Health Organization.

(2) *Use of Generic Drugs*; Generic alternatives to branded medicines are going to be the fundamental formulary medication nationwide. Procurement and distribution of medications will be restricted to generic drugs. Government policy will promote and enforce usage of generics. For Luna, an invigorated Generics Program will mean lower costs of medical care and a healthier population. A healthier population will be more productive, more fit to meet any health impact challenge and more able to address health concerns.

(3) *Local Health System Development*; Municipal and provincial health delivery systems shall be developed in terms of human health resource and facilities. The programs will be designed and monitored from DOH. Certain national programs like the TB Control Program shall be funded and rolled out from the national office, to be implemented at the local level by LGUs. The importance of this to the citizens of Luna is that the program to develop the local health system will translate to better facilities, better programs, more budget items and more manpower for the delivery of care to the area.

(4) *Fiscal Autonomy of Government Hospitals*; Hospitals will benefit from the advantages arising from the decentralization, which is the trend in the Asia-Pacific region. The La Union Medical Center is the best practice example of this thrust. As the hospitals earmarked for upgrade will comprise the referral hospital network for Luna, anticipated health impacts can be better serviced by the improved hospitals.

(5) *Philhealth Insurance;* Financial protection from a robust national health insurance system. Citizens will be covered for basic health services upon hospitalization. Philhealth was intended to be a single payor system, but there is still a significant out-of-pocket payment regime leading to impoverishment from catastrophic illnesses. For the citizens of Luna, an expanded Philhealth enrolment and a wider Philhealth program will mean financial health expenditure protection in any untoward health event.

(6) *Funding for Universal Health Care or UHC*; Universal Health Care is the goal of government Sin taxes since the United Nations Alma Ata Declaration and the establishment of Millenium Development Goals. Sin taxes of tobacco and sugared drinks, as well as PAGCOR gaming income and Philippine Charity Sweepstakes Office revenues will be tapped for this. For Luna, this will translate to more funding for health and more programs for delivery of health care to the anticipated affected areas.

(7) *Good Governance Programs*; Government will implement health care delivery under a regime of transparency and accountability. As mentioned previously, La Union is being described internationally as holding a best practice case in La Union Medical Center. Good governance programs will benefit the entire citizenry including those in Luna.

(8) *Milk Code that promotes "Unang Yakap" and Breastfeeding*. DOH will continue the mandatory breastfeeding initiative. For mothers in Luna, the budget for powdered milk purchases will be further liberated so that medical costs of other family medical concerns will be afforded.

4.4.2.3 "ACHIEVE" Agenda

The Duterte Health Agenda for the DOH and the Local Government Units (LGUs) is programmed to meet any adversity. Its working acronym is "ACHIEVE". According to DOH Secretary P. Ubial during the Health Summit of 2016 in SMX, Pasay City, this is broken down as follows (Personal communication, DOH, Secretary P. Ubial, 2016):

A: *Advance health promotion, primary care and quality*- setting up functional health networks, where 10 or more rural health units are clustered into a team under a District Hospital; providing health centers with more medicines and equipment; enforcing annual health visitations to poor families; This action agenda also includes the enforcement of rules and programs that limit exposure to risk factors. Such risk factor reduction measures will have an impact on the operations of the power plant, such that mitigating measures will be monitored and neglect thereof penalized. At the same time, DOH and the LGUs will be tasked to ensure the effective enforcement life-saving interventions. Other inputs will include quality control and surveillance bodies to be in place and for selected hospitals to be upgraded into "mega-hospitals".

C: *Cover all Filipinos against financial health risk*- in the event of a health impact, how will patients fund their treatment? Government is committed to mobilize funds for healthcare, to increase enrolment in Philhealth, ensure efficiency and to expand Philhealth benefits. There will be more programs to design added outpatient benefits, medicine support and blood availability.

H: *Harness the power of strategic Health Human Resource*- government is tasked to ensure increase health human resources in rural areas like Luna, with consequent increase in pay and training;

I: *Invest in eHealth and data for decision-making*- in the long run, for areas like Luna, this will mean more internet based medical records, processes and interventions, including Telemedicine or telehealth;

E: *Enforce standards, accountability and transparency*- part of the identified gaps in universal health care delivery is traceable to corruption and inefficiency. The Duterte Health Agenda seeks to enforce accountability and transparency so that outlying areas like Luna will not have the capital, manpower and operational deficiencies of the past;

V: *Value clients and patients*- thus Health Agenda will focus on the poorest 20 Million Filipinos, including segments of the health stakeholders in La Union. The DOH and the LGUs are tasked to improve delivery quality, efficiency and value for money by streamlining procedures, continuous monitoring processes and program evaluation;

E: *Elicit multi-sector support for health*- The Duterte Health Agenda will harness private sector support for the achievement of enhanced health delivery. There will be mandatory Health Impact Assessments for High-Risk, High Impact Projects. Identified specifically were mining, power generation and oil rigs. In this line, it will value corporate efforts in partnerships for building health communities.

4.4.3 Provincial Health System Capability

In a devolved health system like that of the Philippines, the provincial health system of La Union takes over-all governance over health promotion, protection, advocacy and enforcement in the province, including the health situation in the municipality of Luna, where the proposed power plant is to be situated.

The assessment of the study is that the La Union Health System is more than able to support any health impacts that may arise from the construction and operation of the power plant. The power plant site and the location of the affected barangays are within short referral travel time and distance to the nearby hospitals. The DOH regional headquarters and regional hospital, Ilocos Training and Regional Hospital,

is the reference hospital for the entire Ilocos Region, and it is situated in La Union. It is within 30-45 minutes travel time barring traffic. Any adverse event that needs further referral can be also handled by several referral health institutions in Baguio and in Manila. Manila is four hours away via TPLEX-SCTEX highway, and less than an hour away by plane from San Fernando City Airport. The profile of the La Union Health System is presented in Annex G.

As a testament to the robust hospital referral system in the Province of La Union, one of the referral hospitals for the Municipality of Luna, the La Union Medical Center, was cited as a best practice example of governance in the World Health Organization's Asia Pacific Observatory. According to the study of Astom (2004) La Union Medical Center (LUMC), a 100-bed hospital, is one of six hospitals that were turned over to the provincial government when health services were devolved in 1992. Prior to devolution, LUMC – originally called Doña Gregoria Memorial Hospital (DGMH) – served as the district hospital for 10 municipalities with a combined population of around 400,000 (Astom, 2012).

In a review of "Public Hospital Governance in the Philippines" by Picazo (n.d.) for the World Health Organization, it cites that "LUMC was given the prestigious Gawad Galing Pook Award for excellence in local governance in 2004, from among 189 entries nationwide. It is frequently cited as a model for Philippine hospital autonomization and corporatization. Among its key achievements have been the following: i) the total number of patient discharges per year has increased from an average of 8,056 in 1995–2001, prior to the autonomization, to 11,481 in 2002–2008 afterwards; ii) within the same period, charity inpatients declined from 84.7% of the total number discharged to 53.4% due to the enrolment of a significant number of households under the PhilHealth Sponsored Program whose premiums are subsidized by the Government; and iii) correspondingly, the proportion of PhilHealth inpatients increased from 10.2–38.8%, while private pay patients increased from 5.1–7.8%. Outpatient department patients increased from 23,856 in 2002 to 49,434 in 2008. In terms of financing, the hospital's PhilHealth collections increased several-fold from PHP 1.1 million in 2002 to PHP 19.1 million in 2008.

Moreover, total collections from all hospital services – inpatient as well as outpatient, pharmacy and diagnostic services – increased from PHP 11.1 million in 2002 to PHP 57.8 million in 2008. From the point of view of the hospital management, LUMC's conversion into an autonomous corporate entity has been helpful in obtaining greater management latitude through the exercise of hospital corporate powers; the acquisition of technical expertise in such areas as medical technology, organizational management and other scarce skills through hospital Board membership; entering into contracts and other legal transactions, especially with respect to the acquisition of medical equipment through PPP.

4.4.4 Luna Municipal Health Delivery Capability

The site of the power plant is not in an isolated geographical area. In fact, the Municipality of Luna is in the center of the main referral highway of the region. The power plant location is along the national highway, allowing fast and effective ambulance transport in case of emergencies, as well as efficient deployment of health manpower in case of health maintenance projects. There is also access to emergency evacuation and delivery by sea, since the site will have a jetty. The airport of the City of San Fernando is less than an hour away. This transportation network of land, sea and air accessibility will allow for easy access to health assistance and emergency medical teams in the event of an accident.

4.4.4.1 Municipal Health Facilities in Luna

The Municipal Health Officer, Dr. Primitivo Zambrano, reported on the facilities of the Municipal Health Center in a Key Informant Interview.

The municipality has a PhilHealth accredited health center located at the poblacion that provides general health care, birthing facilities, laboratory, and dental care facilities with resident doctors, nurses, midwives, other health personnel and ambulance drivers. It is open on weekdays from 8-5 but the personnel are always ready to render services on-call or even overtime. Emergency cases are readily acted upon with the application of first-aid remedies and then patients are eventually transported to a better facility in the city.

The Municipal Health Office maintains Barangay Health Stations (BHS) in each barangay. Midwives and barangay health workers man the health stations with at least one midwife assigned by the Municipality per barangay. There can be many volunteer barangay health workers. The health workers in Luna are given training courses in basic first aid, nutrition education and family planning education. The Municipal Health Nurse and the Municipal Health Officer visit the barangay health stations regularly, aside from manning the Municipal Health Clinic at the Poblacion.

The Municipal Health Unit delivers preventive and curative public health to the citizens in the catchment area. A referral system is designed such that patients from the barangay health stations are referred to the Municipal Health Office for illnesses that the midwives cannot handle. The Luna Municipal Health Office clinic is manned by Dr. Primitivo Zambrano and the Municipal Health Nurse Gloria Noveloza, Nurse II.

The municipal clinic also has a dental unit manned by a Public Health Dentist and a dental aide. It has a clinical laboratory where basic laboratory tests can be done, namely Complete Blood Count, Blood Typing, Urinalysis, Stool exam, Clinical Microscopy for parasites, Sputum examinations for TB, and Tests for Diabetes, Leprosy, Dengue, Pregnancy, Urinary protein for pre-eclampsia and Sexually Transmitted Disease tests. The Municipal Health Office clinic does not have ultrasound and x-ray machines, however. For these services, patients are referred to the District hospital in the adjacent town of Bacnotan, or to the Provincial Hospital. More advanced cases are referred to the DOH Regional Hospital in San Fernando. Referrals to private hospitals are also made, as listed in **Table EP-38**.

When asked about the capability of the Municipal Health Office in dealing with health concerns arising from the implementation of the power plant project, he described it as “adequate with room for improvement”. He said “there is on-going construction work being done to upgrade existing facilities in the Municipal Health Clinic in the Poblacion (or town center) and to build a new Lying-In Center and Infirmary. It will have several beds for overnight confinement for uncomplicated obstetric deliveries and for simple cases requiring observation and intravenous treatment, like mild diarrhea with moderate dehydration. This will help in addressing some of the future emergency care requirements. For the anticipated Coal Power Plant, we will need a complete Emergency Medical Team with the required Emergency Medical Equipment. We need to train both rural health workers and volunteer personnel for emergency care and accredit these for Philhealth. We have an existing disaster plan and a functional team for emergencies but the operation of a power plant will require an upgraded capability. ”

The MHO clinic is located in the center of the town or Poblacion. It is open 24 hours a day, 7 days a week. The MHO clinic has a dental office with sterilizing equipment, dental chair, and equipment and supplies for dental extraction and light cure procedures. The MHO clinic also has a TB control center with an isolation clinic. It has a TB microscopy unit with a medical technologist on duty and an adequate supply of TB medications. There is a basic laboratory for minor laboratory requirements like Complete Blood Count, Urinalysis, Fecalysis, Dengue Test Kits for NS1, Fasting Blood Sugar, HIV testing, pregnancy testing, VDRL test and simple other test strip based exams. Blood cultures and other advanced exams are then brought to the District Hospital or the Provincial Hospital. There are three ambulances with three drivers ready to convey any emergency – pulmonary or otherwise – to the higher-level facilities like the regional hospital. The MHO clinic does not have an X-ray or ultrasound machine to deal with pulmonary illnesses or fracture cases. It however has sufficient nebulization and emergency intravenous intervention capability for pulmonary cases, short of intubation and mechanical ventilator support. More complicated cases will be referred to the Referral Hospitals listed in **Table EP-38**.

4.4.4.2 Manpower Capability of the MHO in Luna

Table EP-35 presents the Health Manpower capability of the Municipal Health Office in Luna.

Table EP-35
Health Personnel of the Municipal Health Office, Luna, La Union

	Number of Staff in Municipal Health Office	Ratio of MHO Staff per Population	Ideal Ratio of MHO Staff per DOH Standards	Source
Doctors	1	1:35,000	1:20,000	MHO
Dentists	1 (shared with another town)	1:35,000	1:20,000	MHO
Nurses	1 Municipal Health Nurse and 1 Rural Health Nurse from DOH	1:20,000	1:20,000	MHO
Midwives	9, previously 10 but one just resigned	1:4,000	1:5,000	MHO
Barangay Health Workers (BHW)	340	1:2205	N/A, but assessed as adequate; BHW are principally volunteers	MHO
Barangay Nutrition Scholars	40	1 per barangay	1 per barangay	MHO
Sanitary Inspectors	2	N/A, but deemed sufficient	N/A	MHO
Dental Aide	1	1:35,000	1:20,0000	MHO
Medical Technologist	1, hired by DOH	N/A	N/A	MHO

N/A = not applicable
Source: Key Informant Interview with MHO, Luna, August 2, 2016

The assessment of the HIA study is that the Municipal Health Office has sufficient manpower resources to handle any anticipated health issues arising from the coal power plant.

4.4.4.3 Municipal Health Programs

The health programs being given priority by the Municipal Health Office of Luna, as evidenced by the Health Operational Plan 2016 is presented in **Table EP-36** below.

Table EP-36
Health Programs Prioritized by the Luna Municipal Health Office

I. Maternal, Neonatal and Child Health and Nutrition Services
IA. Maternal Health
1. Prenatal health care
2. Complete Child Birth Package
3. Complete Post-natal care Package for the Mother
4. Complete Post-natal care package for the baby
5. Family Planning Package
IB. **Child Care**
1. Out-patient Care, Age 1 month – 72 months
2. Expanded Program of Immunization
II. Prevention and Control of Infectious Diseases
1. TB Prevention and Control
2. Leprosy Program
3. Malaria Program
4. Dengue Prevention and Control Program
5. National Rabies Control Program
6. National AIDS/Sexually Transmitted Diseases Control Program
7. Control of Acute Respiratory Infection

Table EP-36 continued

III. Prevention and Control of Lifestyle Health Related Diseases
1. Cardiovascular Disease Prevention and Control Program
2. Cancer Control Program
IV. Integrated Helminth Control Program
V. Environmental Health Program
VI. Renal Disease Control Program
VII. Dental Health Program
VIII. Non-Program Diseases Prevention and Control

Source: Luna Municipal Health Office, Operational Health Plan, 2016

4.4.4.4 Capability of the Municipal Office

A separate key informant interview was conducted with the Municipal Mayor Victor Marvin U. Marron and the Executive Team of the Mayor's Office headed by the Executive Assistant Ricardo Manangan on September 29, 2016 via Skype Teleconference. A second series of interviews were conducted on August 2, 2016 and October 5, 2016.

From the KIIs, it was concluded that the Mayor's office and the Provincial Government are committed to ensuring that the safety of the power plant operations is uncompromised. The government will be active in the monitoring and policing of the construction and operations of the proposed plant. The Mayor is committed to preparing the Municipal Health Team in addressing the future needs of the community in the event that a power plant will be in operation. In particular, the Mayor will implement an upgrade of the Emergency Health Team capability of the MHO in Luna. Support for pulmonary and cardiovascular care, including advanced life support interventions prior to conduction to advanced medical facilities outside of Luna will be in play. The Mayor's Office is prepared to enact legislation that will create budgetary support for the above.

4.4.4.5 Availability of Referral Hospitals

In any municipality, the Municipal Health Units are not expected to be able to handle all disease cases. The existence of a working network of referral hospitals is a mark of a robust health system. In the event of accidents, disease outbreaks or major health patients with advanced requirements need to be referred to Level 2 and Level 3 hospitals. **Table EP-37** summarizes the classification of hospitals and health facilities according to DOH.

Table EP-37
2015 DOH Classification of General Hospitals

Functional Capacity Level	Staff Requirement	Facilities
1	PRC licensed medical, allied medical staff	Operating Room, Recovery Room, Delivery Room and Maternity facilities, Isolation facilities, Dental unit, Blood donation unit, Clinical Lab, Radiology, Pharmacy
2	All of Level 1 requirements plus Clinical Departments for OB, Pediatrics, Internal Medicine, Surgery	All of Level 1 requirements plus departmental facilities for OB, Pediatrics, Internal Medicine and Surgery, Intensive Care Unit (ICU), Neonatal ICU, Respiratory Therapy Service, Tertiary Laboratory Unit, Radiology Unit with portable x-ray and contrast x-ray capability
3	All of Level 2 requirements plus Teaching and Training for residents in specialty departments	All of Level 2 requirements plus Rehabilitation Therapy Unit, Ambulatory Surgery Clinic, Dialysis Facility, Blood Bank and Level 3 Imaging Facility with Interventional Radiology

[Reference: Administrative Order 2012-0012. Rules and Regulations Governing the New Classification of Hospitals and Other Health Facilities in the Facilities. Department of Health Philippines.]

The Municipal Health Office in Luna has access to capable referral hospitals. **Table EP-38** presents a list of referral hospitals used in conducting patients for any untoward event in Luna requiring Level 2 or Level 3 hospital facility care. This is a list of the hospitals used by the Municipal Health Office in Luna, La Union, as per information given by the Municipal Health Office. There are other private clinics and healthcare facilities in other towns and cities, 18 in San Fernando, La Union alone, that private individuals and companies can send patients to, but an analysis of all facilities is beyond the scope of the study.

Table EP-38
Referral Hospitals that Serve the Constituency of Luna, 2016

Name of Hospital	Service Delivery Category	Address	Contact Number	Number of Beds	Public or Private Ownership
Ilocos Training and Regional Hospital	Level 3, with advanced surgical and medical facilties, as well as residency training	San Fernando City La Union	072)8883671	200	DOH owned and operated
Bacnotan District Hospital	Level 2	Bacnotan, La Union	(072)7190059	25	DOH owned and operated
La Union Medical Center	Level 3	Nazareno, Agoo, La Union	(072)7100169	100	Renationalized, DOH controlled non-stock, non-profit Government Owned and Controlled Corporation (GOCC)
Northern La Union Maternity and Children's Hospital	Level 2	Balacan, La Union	0920-9509537	25	Private
Caba Medicare and Community Hospital	Level 1	Caba, La Union	(072)708029	15	Private
Naguilian District Hospital	Level 2	Natividad, Naguilian, La Union	(072)6091018	25	DOH owned and operated
Rosario District Hospital	Level 2	Concepcion, Rosario, La Union	(072)7121045	25	DOH owned and operated
Lorma Medical Center	Level 3, with over 100 specialists	Carlatan, San Fernando, La Union	(072) 888-2617	200	Private
Bethany Hospital	Level 3	San Fernando, La Union	(072)6078694	100	Private

For the purpose of assessing the health care delivery capability, the Luna Municipal Health Office is tasked to take a lead role in the delivery of health in the five barangays in the impact area under any contingency arising from the construction and operation of the power plant. An assessment of the impact population, the adequacy of human health resources, the health facilities and the health programs of the Municipal Health Office is presented in this section.

The population of the affected areas as served by the Health Delivery System of Luna is presented in **Table EP-39**.

Table EP-39
Population of Barangays Affected by the Coal Power Plant (2010)

Barangay	Directly Affected or Indirectly Affected	Population
Nalvo Sur	Directly Affected	1,721
Carisquis	Directly Affected	741
Pila	Indirectly Affected	1,373
Nalvo Norte	Indirectly Affected	1,462
Darigayos	Indirectly Affected	1,836
Total		**7,133**

Sources: Focus Group Discussion with Barangay Health Workers of Luna and Key Informant Interview with the Municipal Health Officer, Dr. Primitivo Zambrano,August 3, 2016 (Annex H)

4.4.5 Baseline Health Data for Top Mortality and Morbidity Cases in the Municipality of Luna, La Union

A review of the baseline health situation in Luna, La Union is presented to profile the current health situation in the area. In epidemiologic assessments, baseline mortality and morbidity information is important in noting the prevalent illnesses in a locality. After the operation of the power plant, incidence or new case data can be collected to see if there is a shift in disease patterns or if there is a rise in any particular illnesses.

Table EP-40 and **Table EP-41** show the top 10 Leading Causes of Morbidity and Mortality for the period 2011 to 2015.

In terms of health control outcomes, the disease prevalence and incidence data of Luna is at par with the health data in neighboring municipalities. The over-all health outcome performance of La Union is at par with the national data.

Based on the retrieved health records for the span of five years starting 2011, there were four (4) leading causes of morbidity observed every year namely: 1) hypertension, where a total of 2,032 cases recorded; 2) Allergic Dermatitis, where a total of 588 individuals were affected; and lastly 3) Pulmonary Tubercolosis, where 501 morbidity cases were recorded in total. On the other hand, the lead cause of mortality observed yearly for the same period of time are caner in all forms (115) and Pulmonary Tuberculosis (92).

Perceptions of the Municipal Health Team on Health Impacts in Luna after Coal-fired Power Plant Operations

The MHO believes that the main anticipated illness that will result from the power plant operations will be pulmonary cases such as Bronchial Asthma, secondary to noxious fumes and particulate pollution. He ranks this with a Probability of Occurrence of 3/5 and Severity of Impact of 3/5.

Dr. Zambrano and his team are also concerned about the possible accidents during the construction phase, which they rank with a Probability of 4/5 and a Severity Rating if it occurs of 4/5. The Municipal Health Nurse thinks the Probability of accidents during construction to be 1/5, and severity of 1/5. The Municipal Health Nurse bases the reason for her lower risk on seeing the coal power plant operations in Toledo, Cebu, during an exposure trip organized by the Mayor of Luna. This coal plant in Toledo, which received favorable assessment by the MHO Team, is operated by the Proponent.

Impacts from accidents during operation phase of the power plant were ranked by the MHO Team with a Probability of 3/5 and a Severity of 5/5.

The MHO sees ground water and sea pollution risk to have a Probability of 1-2/5 but the severity scale to be 0-1.

Table EP-40
Top 10 Leading Causes of Morbidity in a Span of Five Years

Year	Name of Disease	M	F	Total
2011	Upper Respiratory Tract Infection	776	759	1,535
	Hypertension	158	193	351
	Wound	155	77	232
	Acute Gastroenteritis	111	101	212
	Rhinitis	66	67	133
	Allergic Dermatitis	48	59	107
	Pharyngitis	42	60	102
	Gastritis	48	47	95
	Pulmonary Tuberculosis	60	30	90
	Vertigo	23	59	82
2012	ARI	913	969	1,882
	Hypertension	192	211	403
	Wound	146	80	226
	Acute Gastro Enteritis	105	97	202
	Allergic Dermatitis	34	65	99
	GUTI	32	65	97
	Pulmonary Tuberculosis	-	-	87
	Carbuncle	43	27	70
	Asthma	24	18	42
	Influenza	15	9	24
2013	ARI	897	934	1,831
	Hypertension	175	233	408
	Acute Gastroenteritis	129	119	248
	Rhinitis	97	99	196
	Wound	96	55	151
	Pharyngitis	47	62	109
	Pulmonary Tuberculosis	78	29	107
	Allergic Dermatitis	48	58	106
	Gastritis	32	57	89
	UTI	30	52	82
2014	ARI	770	814	1,584
	Hypertension	181	220	401
	Wound	130	50	180
	Allergic Dermatitis	63	90	153
	Rhinitis	62	60	122
	Pulmonary Tuberculosis	93	6	99
	UTI	30	56	86
	Dog bite	37	30	67
	Gastritis	23	40	63
	Carbuncle	27	25	52
2015	Acute Respiratory Infection	995	1,047	2,042
	Hypertension	166	303	469
	Acute Gastroenteritis	154	144	298
	Wound	99	81	180
	Rhinitis	57	79	136
	Allergic Dermatitis	47	76	123
	Pulmonary Tuberculosis	-	-	118
	Conjunctivitis	48	49	97
	Dog bite	39	45	84
	UTI	30	52	82

Table EP-41
Top 10 Leading Causes of Mortality in a Span of Five Years

Year	Name of Disease	M	F	Total
2011	Degenerative cardiac disease	31	57	88
	Cerebrovascular Accident/ Hypertension/ Myocardial Infarction	3	16	19
	Pulmonary Tuberculosis	22	5	27
	Cancer in all forms	9	10	19
	Congestive Heart Failure	4	3	7
	Bronchial Asthma	3	2	5
	Liver Cirrhosis	4	0	4
	Undetermined	3	1	4
	Gunshot Wound	3	1	4
	Chronic Renal Insufficiency	3	0	3
2012	Myocardial Degeneration	31	41	72
	Cancer in all forms	16	11	27
	Hypertension	9	12	21
	Pulmonary Tuberculosis	11	7	18
	Myocardial Infarction	7	7	14
	CVA	6	3	9
	DM	3	4	7
	Community Acquired Pneumonia	3	3	6
	Gunshot Wound	4	1	5
	Kidney Disease/Renal Failure	-	4	4
2013	Myocardial Degeneration	30	40	70
	Cerebrovascular Accident/ Hypertension/ Myocardial Infarction	22	4	26
	Cancer in all forms	10	9	19
	Pulmonary Tuberculosis	15	3	18
	Bronchial Asthma	2	3	5
	Community Acquired Pneumonia	2	3	5
	Liver Cirrhosis	4	0	4
	Asphyxia / Drowning	2	1	3
	Multi Organ Injury sec VA	3	0	3
	Renal Failure	3	0	3
2014	Myocardial Degeneration	27	35	62
	HPN/MI/CVA	19	17	36
	Cancer in all forms	18	8	26
	Pulmonary Tuberculosis	9	6	15
	Community Acquired Pneumonia	5	6	11
	VA, Gunshot	4	2	6
	Diabetes Mellitus	5	1	6
	Asphyxia/ Drowning	4	1	5
	CHF	4	0	4
	Bronchial Asthma	2	1	3
2015	Myocardial Degeneration	16	46	62
	Hypertension	10	15	25
	Cancer in all forms	13	11	24
	Pulmonary Tuberculosis	8	6	14
	Community Acquired Pneumonia	9	3	12
	Myocardial Infarction	7	5	12
	Renal Failure	2	3	5
	Vehicular Accident	5	0	5
	Asphyxia, Drowning and Hanging	4	0	4
	COPD and Asthma	4	2	6

Accidents due to toxic fumes were ranked at a Probability scale of 0/5 and a Severity scale of 0/5. However, accidents out of handling of coal were anticipated to be higher due to international reports of accidents in transportation and storage, especially during flooding from storm surges. The Probability of occurrence for these as rated by the MHO Team is 4-5/5, with a Severity scale of 1-2/5. The MHO team also was wary of ground water disturbance due to leaching and storm surge flooding causing contamination of water supply; the Probability of Occurrence is rated at 4/5 and severity at 5/5. These information are summarized in **Table EP-42**.

It is important to note that the MHO and his team were able to visit the coal power plant in Toledo, Cebu that is also operated by the same project proponent. Based on the exposure trip and the lectures delivered at that plant, they are confident that the project proponent will be able institute mitigating measures that will negate their fears of untoward events impacting on the citizenry in the affected barangays.

Table EP-42
Summary of the Probability and Severity Rating of Possible Impacts of the Proposed Project as Perceived by the Municipal Health Team

Anticipated Impact	Probability of Occurrence	Severity of Impact
Bronchial asthma	3	3
Accident during construction phase	4; 1	4; 1
Accident during operation phase	3	5
Toxic fumes-related activities	0	0
Handling of coal	4	1-2
Groundwater and sea pollution	1	0-1
Contamination of water supply	4	5

Note: Scale for the description of probability of occurrence and severity of impact ranged from 0-5, where 0 represents none occurrence and 5 represents the highest probability and severity of impact.

Project Assessment of the Municipal Health Team

The Municipal Health Officer and the MHO Team gave a positive assessment of the project and will support it in the public hearing. They also cite economic benefits of the plan, particularly its effect on the Internal Revenue Allotment for the Municipality of Luna, which will benefit the health sector, among others.

Subsequent discussions in this study will offer suggestions for setting up mitigating health measures for anticipated health impact concerns arising from the power plant project.

The assessment of the present Health Impact Assessment Study is that the Municipal Health Office possesses adequate capability in terms of personnel, equipment and programs, as well as access to referral care for this task.

4.4.6 EHIA Study Assessment of Health Capability

The assessment of the HIA study is that the human health resources, facilities, programs and referral network of the municipality are adequate to address the anticipated health risks. There is a need, however, to augment the capability of the Municipal Health Office vis-à-vis respiratory disease management. Coal health risks are primarily air borne pollution as noted in various studies. The #10 Top cause of Mortality in Luna is Chronic Obstructive Pulmonary Disease and Asthma Attack (Status Asthmaticus). While this is strongly related to the high prevalence of smoking in the municipality, and while asthma carries a genetic predisposition, a rise in air pollution will aggravate the situation. It is noted that there is an adequate referral network that can handle pulmonary diseases; hence this helps mitigate the situation. However, it is recommended that investment by the local government in respiratory therapy, as well as investments in radiology equipment be made. If the proponent can assist the municipality in establishing a pulmonary treatment unit, as a form of corporate social responsibility project, that can fast track the upgrade. As will be seen in the assessment to follow however, the HIA

study ranks coal air pollution impacts to be of relatively low probability given the advanced Supercritical Pulverized Coal (SPC) technology to be employed. At the same time, meetings with the Mayor of Luna and his executive team, including the MHO was very positive. The Mayor has broad-based support in the municipality and has the capability to harness human resources and political support for any program that will enhance health delivery. He expressed his commitment in assuring that the Municipality will actively participate in the monitoring team and will address any starting health concern with due haste. He is also committed to providing budgetary and manpower support to upgrading the facilities and human health resources required in addressing any health impact, particularly pulmonary impacts. This will start with immediate efforts to activate an advanced Emergency Health Team with an enhanced Disaster Risk and Emergency Medical Program.

4.4.7 Impact Assessment and Mitigation Measures for Health

GLEDC will comply to the regulating standards to protect health and environment. A review of the salient features of the power plant showed that GLEDC is committed to comply with relevant regulations per memo from GLEDC: "The Company is mandated to comply with RA 8749, RA 9275, RA 6969 and RA 9003. Environmental Impact Assessment will also be conducted to study the effect on people, land, air, water for proper mitigating measures inclusion to the ECC."

4.4.7.1 Chemical and Physical Hazards

Pollutants created during the various phases of the project may have adverse impacts on the health of workers and residents of nearby communities. This impact is discussed more extensively in other sections of this EIS, specifically in the land, water, and air modules.

Gas Emissions

In terms of gas emissions, international literature lists noxious fumes, particulate matter/dust and aerosolized chemicals from the operation of a coal-fired power plant. These would cause respiratory disease and poisoning if such chemicals were inhaled. The proponent will use Supercritical Pulverized Coal Technology which will emit less greenhouse gases and the risks that emissions pose will be negligible to minimal. Pollution control devices, specifically a desulphurization system and electrostatic precipitators, will be installed to meet emission limits set by the Philippine and World Bank Group. Evidence of health data gathered from a comparable power plant site in Cebu showed minimal health impacts in the existing plant from particulate pollutants.

Petroleum

A major risk in the construction phase is the spillage of petroleum that could find its way to the water sources. This has been documented in reports of projects of a similar nature. The Darigayos river is 2km away from the project site and is not likely to be affected. Still, the proponent will implement proper maintenance and cleaning of vehicles and heavy equipment to make sure that these are in a very good working condition and free of oil leaks. If machinery and vehicles have defects or problems, repairs will be done in a designated maintenance area that is cemented and provided with proper drainage and oil absorbing material. Oil-water separators, which will separate oil from water before it is released to the immediate environment, will also be provided.

Cement Particles and Solid Wastes

Water quality change and contamination can be due to pollutants like cement particles and solid waste (from construction camps during the construction phase) causing water borne diseases. Workers and contractors will be oriented to environmental awareness to effectively implement proper solid waste management and good housekeeping practices within the construction sites. Temporary sanitary facilities will be provided and ponds to remove sediments prior to releasing into the immediate environment.

Noise Pollution

Construction noise would be a disturbance in the few households living near the construction site. Trucks and equipment used can also create noise for the area, causing disturbance in communities that the trucks and equipment use for transit. Mitigating measures include preventing the blowing of horns at night and regulation in the time allowed for trucks to pass populated areas. The proponent will limit construction activities at night to prevent noise disturbances and sound attenuation measures will be implemented. Hearing protective gear will also be provided for the construction workers.

Water Quality Degradation

Water quality change and contamination from leeching are possible impacts if coal storage areas are affected by flooding. Although the area is at low risk for flooding (as reported by the Office of the Mayor), apprehensions on this risk were expressed in Focus Group Discussions and Key Informant Interviews about flooding seen in storm surges. Water quality change will be detrimental to community health. People in far flung areas use river water for cooking and for drinking. Contaminated water may also cause fish kills and contaminate fish food resources, according to respondents in the Focus Group Discussion.

Proper engineering practices, such as installation of special lining material and appropriate elevation design, will be implemented to ensure that seepage of chemicals into underground water table is prevented. The Proponet will ensure that the coal yard will not be flooded. Most importantly, water discharges will comply with the DENR Standards for effluent.

Water Temperature Rise from Cooling of the Plant using Sea Water

Seawater will be used to cool down the plant during operations. Citing reports from the related literature, respondents in the Focus Group Discussions and Key Informant Interviews expressed some apprehension that the cooling system of the plant will cause a rise in temperature in the sea around the plant. This will primarily affect fish in the area and subsequently affect the livelihood of fisher folk. This in turn will translate to low income and increased indirect health impacts.

An aeration basin will be incorporated in the design of the plant where seawater used in the condenser will be treated before releasing it back to the sea. Aeration basin will help lower the temperature so that seawater that will be discharged will not exceed the maximum 3°C temperature rise limit prescribed the Clean Water Act.

Air Pollution

Rapporteurs also cited air pollution from coal-fired power plants which includes sulfur dioxide, nitrogen oxides, particulate matter (PM-10), and heavy metals, leading to smog, acid rain, toxins in the environment, and numerous respiratory, cardiovascular, and cerebrovascular effects.

The project proponents will institute measures to mitigate this concern, including: (1) desulphurization system to meet SO_2 limit of 200mg/Nm^3; (2) Electrostatic precipitator (ESP) and gas heater (GGH) to meet PM limit of 50mg/Nm^3; and (3) Low NOx burner to meet GLEDC's specified NOx emission limit of 450mg/Nm^3 that is lower than both IFC's NOx emission limit of 510mg/Nm^3 and the Philippine regulatory limit of 1000mg/Nm^3.

Coal Fires

Coal fires can occur in coal waste piles as mentioned by Key Informant Interview respondents citing Wikipedia. According to respondents, internationally, underground coal fires are observed and global coal fire emissions cause tons of mercury going into the atmosphere annually, and cause 3% of the world's annual carbon dioxide emissions.

The coal yard of the power plant will be covered with roofing so that the coal is not exposed to sunlight, rain and other possible contributing factors that may lead to fire. Proper coal handling will be employed such as regular inspection for spontaneous combustion. Coal yard will also be provided with fire-fighting equipment. Section 4 of the Environmental Risk Assessment provides specific measures that GLEDC will implement to prevent spontaneous combustion of coal fills.

Radiation

Another concerns raised during the EIA study scoping is the fear of radiation among the stakeholders. In a 1978 paper for *Science*, J.P. McBride at Oak Ridge National Laboratory (ORNL) and his co-authors estimated that individuals living near coal-fired installations are exposed to a maximum of 1.9 millirems of fly ash radiation yearly. To put these numbers in perspective, the average person encounters 360 millirems of annual "background radiation" from natural and man-made sources, including substances in Earth's crust, cosmic rays, residue from nuclear tests and smoke detectors. According to Dana Christensen, Associate Laboratory Director for Energy and Engineering at the ORNL, health risks in coal by-products are low. "Other risks like being hit by lightning," he adds, "are three or four times greater than radiation-induced health effects from coal plants."

In the United States, the U.S. Geological Survey (USGS) maintains an online database of fly ash-based uranium content for sites across the country. In most areas, the ash contains less uranium than some common rocks. In Tennessee's Chattanooga shale, for example, there is more uranium in phosphate rock.

Robert Finkelman, a former USGS coordinator of coal quality who oversaw research on uranium in fly ash in the 1990s, says that for the average person the by-product accounts for a miniscule amount of background radiation, probably less than 0.1% of total background radiation exposure. According to USGS calculations, buying a house in a stack shadow—in this case within 1km of a coal plant—increases the annual amount of radiation you're exposed to by a maximum of 5%. But that's still less than the radiation encountered in normal yearly exposure to X-rays.

Radiation from uranium and other elements in coal might only form a genuine health risk to miners, Finkelman explains. "It's more of an occupational hazard than a general environmental hazard," he says. "The miners are surrounded by rocks and sloshing through ground water that is exuding radon." (Hvistendal, M., Scientific American, "Coal Ash is More Radioactive Than Nuclear Waste", December 13, 2007.

The U.S. Environmental Protection Agency (EPA) in its website https://www3.epa.gov/radtown/coal-fired-power-plants.html states that the disposal of coal residuals is strictly regulated so that the risk of radiation will be insignificant. **As long as the Proponent will comply with industry standards, the risk of radiation exposure from a modern coal power plant is insignificant.**

The EPA writes: "Fly ash, bottom ash and boiler slag from coal-fired power plants contain small amounts of naturally occuring radioactive material.

Naturally radioactive materials that were in coal before processing mostly end up in fly ash, bottom ash and boiler slag.

About 80 to 90 percent of fly ash, bottom ash and boiler slag is non-radioactive minerals, typically silicon, aluminum, iron and calcium.

When coal burns, most of the radioactive material does not burn and ends up in three types of wastes:

- **Fly ash** is carried by hot gases and trapped by stack filters. It is the largest of the coal combustion wastes (about half) by weight.
- **Bottom ash** is too large or heavy to be carried by gases and settles to the bottom of the boiler. Just over ten percent of coal combustion waste is bottom ash.
- **Boiler slag** is formed when ash melts under the intense heat of combustion and collects at the bottom of the boiler and in exhaust stack filters. It makes up about two percent of coal combustion waste.

Generally, these wastes are only slightly more radioactive than the average soil in the U.S.

While 99% of fly ash is captured by filters, small amounts can escape into the air. Government regulations require power plants to limit the amount of fly ash that escapes into the environment and to dispose of collected ash properly."

Stack filtration devices, such as electrostatic precipitators, bag houses and scrubbers are routinely used to reduce the emission of fly ash. They are about 99% effective. Only about one percent is released into the air (EPA, n.d., "Radiation Protection" Retrieved from https://www.epa.gov/radiation/tenorm-coal-combustion-residuals, Accessed on May 23, 2017).

The amount of natural radiation in wastes from coal-fired power plants is so small that no precautions need to be taken for the health of the affected population.

4.4.7.2 Health Risks to Construction Workers and of In-Migration near Construction Areas

One major concern of respondents is the safety of their town mates who will become employed during the construction phase, during which time there will be job opportunities for residents. There were many cases of construction workers being injured in major construction projects before (like in the construction of dams and hydroelectric power plants). Workers and contractors will be trained and oriented and Personal Protective Equipment (PPE) will be provided to ensure their safety. Other safety protocols will be strictly implemented and safety signages will be installed around the plant.

Employment of local residents will increase especially during the construction and operation. With this, the employees may be exposed to ergonometric stress and they may be exposed to high level of noise, dust and heat. They may also be exposed to occupational hazards associated with heavy lifting, moving heavy equipment and the like. Thus, occupational safety must be considered. The proponent, GLEDC, shall provide a safe working environment for workers. There shall be (1) a provision of safety and environmental awareness trainings for workers, which includes an orientation on occupational health and safety, (2) limited construction especially at night time to reduce ambient sound, (3) a provision of Personal Protective Equipment (PPE) for workers, and (4) a strict implementation of safety protocols. Furthermore, during construction phase, ample potable water will be provided in the plant site. First aid facilities will be placed at the community center/hall and a safety officer shall be designated to monitor safe working conditions.

There are positive and negative aspects to this. Wherever there are jobs, people will migrate to those areas. They sometimes bring their families along. Informal settlers beside construction site will have solid waste and safe water issues. This will result in problems related to crowding and the importation of disease causing germs. There will be major concerns with health and sanitation issues like toilet lack or safe water lack in the congested areas with informal settlers. More people will get sick and they will become a burden to the limited resources of the local health system. **To mitigate this impact, the proponent will participate in programs that will be implemented by the LGU to track migrants and control the increase in their number. An example of this is the conduct of job fairs in a designated area where barangay officials can attend and watch for migrants.**

4.4.8 Health Impact Analysis

Health impact analysis is presented using three tools, namely, an Incidence Potential Rate, a Health Consequence Rating and a Health Risk Matrix. The paper presents a summary of these findings in a Health Impact Assessment Summary at the end.

Environmental and Health Incidence Assessment will be presented as:

A. Incidence Potential Rating
B. Health Consequence Rating
C. Health Risk Matrix

Health Impact Assessment Summary is later presented to give an overall picture of risk agents, health implication, probability, severity, mitigating action, and persons/organizations responsible.

4.4.8.1 Incidence Potential Rating

Incidence is defined as the number of new cases from a defined cause within a specified period in a defined location. The Incidence Potential Rating reflects the potential or estimated probability of an event or untoward condition happening. This allows planners and monitoring teams to rank by priority the mitigating measures to be implemented. It also helps the health team to identify and rank possible health issues and remedies.

A rating of the probability of occurrence of chemical, physical, vehicular and biological events is presented based on responses to the Focus Group Discussion, interviews and surveys done.

The incidence potential of adverse events was evaluated by the Health Impact Assessment Study and is tabulated in **Table EP-43**.

Table EP-43
Incidence Potential Rating

Impact	Barangay Affected					
	Carisquis	Nalvo Sur	Darigayos	Nalvo Norte	Pila	Other Barangays Beyond the Impact Zone
Diseases from Water quality change or pollution	A	A	A	A	A	A
Diseases from Air quality change due to construction work and coal plant operations	D	D	D	D	D	A
Diseases from Noise pollution	C	C	C	C	C	A
Worker's health issues from risks in plant site work	D	D	D	D	D	D
Diseases arising from influx of migrants	D	D	D	D	D	D
Diseases arising from coal spillage or chemical pollution during handling or storage, including storm surge flooding	A	A	A	A	A	A
Diseases from radiation associated with coal	A	A	A	A	A	A

Legend: (A) Unlikely to happen; (B) Theoretically possible to happen but no report of the occurrence is available locally and abroad; (C) Has happened once in the Philippines or abroad in an industry or development quite similar to the project being proposed; (D) Has happened more than once in the Philippines or abroad in an industry or development quite similar to the project being proposed; (E) Has happened during the operation of similar development owned and operated by the project proponent in other parts of the Philippines and abroad.

4.4.8.2 Health Consequence Rating

A rating of the severity of the presence or impacts of chemical hazards, physical hazards, biological hazards and vehicular events is tabulated. This intends to provide a picture of anticipated urgency and priority of interventions needed in the implementation of the project. **Table EP-44** presents the health consequence rating of agents anticipated in the operation of a coal power plant.

Table EP-44
Health Consequence Rating

Impact/Agent	Locality Directly Affected Barangays [Carisquis, Nalvo Sur]	Locality Indirectly Affected Barangays [Darigayos, Nalvo Norte, Pila]
Coal-related Water quality change	2	2
Coal particulate matter and noxious agents causing Air quality	3	2
Noise pollution	2	2
Thermal pollution of sea water due to pumping of water for cooling of plant	1	1
Biological agents like Sexually transmitted microorganisms and other infectious agents from migrant workers and ambulant vendors HIV	2 [4-5 rating if for HIV]	2 [4-5 rating if for HIV]
Fuel and chemical spillage in construction work	2	2

Legend: (1) Impacts/Agents not hazardous to health; (2) Impacts/Agents have limited health effects that are reversible; (3) Impacts/Agents are capable of causing irreversible damage without serious disability; (4) Impacts/Agents are causes of Permanent total disability or fatality (small exposed population); (5) Impacts/Agents with potential to cause multiple fatalities (large exposed population)

4.4.8.3 Health Risk Matrix

Table EP-45 shows the consequence rating of agents and the severity of their impact. The research was undertaken with the use of FGDs, interviews and surveys.

Table EP-45
Environmental Health Risk Assessment - Surrounding Residents

Consequence Rating	Incidence Potential Rating				
	Very Low (A)	Low (B)	Medium (C)	High (D)	Very High (E)
(1) Slight injury/ illness	Odor, Noise Heat, Thermal water impacts, Vibration and Ergonomic stress during construction work				
(2) Minor injury/ illness	Fuel spillage during construction work	Biological threats; illness brought in by migrant workers	Particulate matter and other air pollutants during construct-ion phase		
(3) Major injury/ illness	Coal spillage during transport by sea and by land trucking	Oil and coal waste spillage in water sources; Vehicular accidents; Contaminated water supply	Particulate matter and noxious chemical air pollution if not mitigated		

Table EP-45 continued

Consequence Rating	Incidence Potential Rating				
	Very Low (A)	Low (B)	Medium (C)	High (D)	Very High (E)
(4) Permanent total disability or fatality		Severe vehicular and construction accidents			
(5) Multiple fatalities		Severe vehicular and construction accidents			

4.4.9 Health Impact Summary

There are numerous environmental impacts of a coal-fired power plant. Any health impact assessment will have to address the effects identified in literature and in discussions with Key Informants and Focus Groups.

Table EP-46 below gives a summary of the disruptions from the construction and operations phases of the proposed project. The assessment used a review of literature on other projects of a comparable nature, Key Informant Interviews and Focus Group Discussions and Interviews with the technical team of the proponent.

This final summary reflects the professional opinion of the Health Impact Investigator after weighing various sources.

Table EP-46
Health Impact Assessment Summary for Luna Coal-Fired Power Project
Possible Sources of Impact, Probability, Severity, Possible Mitigating
Approaches and Agents Responsible [Rating Scale: Weakest =1; Strongest = 5]

Disruption	Potential Impact	Probability of Occurrence	Severity Impact	Possible Mitigating Action	Person or Group Responsible
CONSTRUCTION PHASE					
Health impact due to soil erosion and soil disturbance and soil disturbance during construction phase	Rise in dust related air pollution and pollution related illness like nasal allergies, bronchial asthma and skin diseases	1	1	▪ Confine soil disturbance and/ or vegetation clearing to predefined and planned areas ▪ Minimize sedimentation through coffer dams and perimeter controls ▪ Revegetate as soon as possible ▪ Protect vulnerable spaces with any one or combination of bonded fiber matrices, erosion control blankets, silt fence, fiber rolls, and keeping storm water off the slopes through diversion channels and/or berms	Project Contractor and Project Monitoring Team
Health impact due to water	Rise in water borne diseases	1	3	▪ Implement solid waste and hazardous materials	Project Contractor and Project

Table EP-46 continued

Disruption	Potential Impact	Probability of Occurrence	Severity Impact	Possible Mitigating Action	Person or Group Responsible
contamination and water quality change due to siltation, chemical pollutants and human solid waste	like gastro-enteritis	1	3	management systems; construction water treatment ▪ Provide propoer sanitation and sewage at work sites; enforce sanitation discipline among workers	Monitoring Team
Air quality change due to dust and gas emissions due to construction activities	Rise in pulmonary diseases among citizens in the area or among workers	1	1	▪ Maintain air quality within national air quality standards like the WHO Air Quality Guidelines ▪ Ensure dust coverage on trucks and construction machinery ▪ Limit engine idling ▪ Prevent waste and vegetation burning ▪ Limit the speed of vehicles in construction site	Project Contractor and Monitoring Team
Impact of noise pollution	Rise in hearing disorders and disruption of sleep cycle among workers and residents near construction areas	1	1	▪ Limit engine noise through use of machinery and vehicles with better technology; use of well maintained machinery; limit engine idling time ▪ Limit use of noisy equipment to 8am - 5pm, or whatever working time is agreed upon with the community affected ▪ Enforce rules on no blowing of horns and playing of loud music in project sites; ▪ To protect worker health, enforce use of ear mufflers and sound pollution control systems	Project Contractor and Monitoring Team
Health Impact on citizens of Luna who are hired to become workers of the project	Accidents and diseases caused by poor training and lack of protective gear during construction	1	2	▪ Maintain safe worker housing; ▪ Enforce safety and health policies like the use of protective gear; set up emergency response systems; ▪ Ensure a system of spoil/garbage disposal and implementation of eco-friendly spoil and sewage management	Project Contractor and Monitoring Team

Table EP-46 continued

Disruption	Potential Impact	Probability of Occurrence	Severity Impact	Possible Mitigating Action	Person or Group Responsible
Impact of migration into areas with construction activity	Influx of potential STD carriers and other infectious diseases; waste disposal or health and sanitation issues	2	2	More aggressive public health monitoring, treatment and contact tracing (for STDs if detected)	PHO and MHO
Impact of exposure chemicals during the construction period (like petroleum spillage)	Skin, gastro-intestinal and respiratory illnesses from spillage of chemicals during the construction phase)	1	2	Control measures to prevent accidental spillage of chemicals like fuel	Project Contractor
OPERATION PHASE					
Transportation of Coal via trucks and barges from cargo ships, which release air pollution such as soot	Air pollution and soot leading to respiratory illness or environmental disasters like the Shen Neng 1 collission, Australia	1	1	Adequate safety measures strictly enforced; Accident prevention prioritized; Covering and sealing of transport containers; safety measures in marina for barge docking safety	Government Project Proponent
Air pollution from coal-fired power plants	Sulfur dioxide, nitrogen oxide, particulate matter leading to smog, acid rain, toxins in the environment, and numerous respiratory, cardiovascular, and cerebrovascular effects.	3	1-2	▪ Desulphurization system to meet SO_2 limit of 200mg/Nm^3; ▪ Electrostatic precipitator (ESP) and gas heater (GGH) to meet PM limit of 50mg/Nm^3; and ▪ Low NOx burner to meet GLEDC's specified NOx emission limit of 450 mg/Nm^3 that is lower than both IFC's NOx emission limit of 510mg/Nm^3 and the Philippine regulatory limit of 1000mg/Nm^3. ▪ Monitoring of air quality	Project Proponent Government
Coal fires in coal waste piles	Carbon dioxide and mercury air pollution causing respiratory illness and/or mercury poisoning	1	2	▪ Protect with either explosion venting and/or explosion suppression systems; ▪ Use of appropriate isolation system to prevent flame propagation to other equipment; ▪ Equip with appropriate fire detector, control and fire suppression systems; ▪ Ground dust collector bags or use	Proponent

Table EP-46 continued

Disruption	Potential Impact	Probability of Occurrence	Severity Impact	Possible Mitigating Action	Person or Group Responsible
				semiconductor bags to prevent static electricity discharge; ▪ Equipment design should be compliant with local and international fire/explosion standards and codes.	
Leeching due to rain flooding coal combustion waste	Contamination of rivers, underground water or seashore	1	1	▪ Implement proper engineering practices, such as installation of special lining material and appropriate elevation design to ensure that the coal yard will not be flooded. ▪ Most importantly, water discharges will comply with the DENR Standards for effluent.	Proponent
Heavy metal from Coal	Lead, mercury, tin, nickel, cadmium, antimony, arsenic and radio isotopes of thorium and strontium pollution of the air	2	3-4	See measures above for air pollution control	Proponent Government
Thermal pollution	degradation of water quality when water used as a coolant is returned to the natural environment at a higher temperature decreasing oxygen supply, and affecting ecosystem composition	1	1	Incorporate an aeration basin in the design of the plant where seawater used in the condenser will be treated before releasing it back to the sea.	Proponent Government

4.4.10 Overall Analysis

The final health impact assessment for the 2x335 MW Coal-Fired Power Plant Project is **positive**.

The national, provincial and municipal health care capability to deliver medical care and emergency intervention in the *unlikely* event of a health outbreak or major health incident is high. La Union has one of the best provincial health governance systems in the country and has been described as a best practice example by the World Health Organization. The network of referral systems servicing the area of Luna is very robust. Mobility, availability of telecommunications and transportation facilities is positive. The baseline health data from the municipal community and the barangays identified as directly and indirectly affected are indicative of a relatively healthy population, although the prevalence of smoking is high. The health system in Luna will be upgraded as per commitment of the Mayor even before the project is begun in order to upgrade emergency health team capability and medical response to pulmonary and cardiovascular disease incidence rise.

The identified health risks associated with the plant were weighed as to impact probability and severity. Consultations with the proponent revealed that the new technology to be put in place will allow for mitigating factors to address anticipated risks. Government intervention, monitoring and technical support will also contribute to the prevention and mitigation of untoward health impacts.

In order to ensure public safety during the plant operation project, an Information-Education-Communication (IEC) plan shall be formulated and implemented. The objective of the IEC is to inform the local communities of the operation projects, its activities, the duration, the person / company responsible for the operation and the management of the project. It shall also contain information on safety aspects like portions of operation areas and equipment that should be avoided. Priority should be given to schools in Brgys. Nalvo Sur and Carisquis since children are more vulnerable to safety hazards.

4.5 Traffic Study

A traffic study was conducted in the vicinity of the proposed project site to determine the current transportation and traffic situation in the area.

4.5.1 Methodology

Two traffic survey stations were established, each having four different routes. For Station 1, routes included are (1) Luna to Bacnotan, (2) Bacnotan to Luna, (3) going to Brgy. Carisquis, (4) and going out of Brgy. Carisquis. Station 2 routes included are (1) from Balaoan to Luna, (2) Bangar to Luna, (3) Public Market to Highway, and (4) the route from Luna going to Bangar/Balaoan. There were two sampling dates purposely scheduled on a weekend (August 19, 2016) and a weekday (August 20, 2016), both covering a 12-hour period of observation from 6:00 am to 6:00 pm. The vicinity of the project site as well as the two sampling stations are shown in **Figure EP-3** below.

The volume of vehicles passing the above mentioned routes were recorded using data sheets and hand-held counters. Vehicles observed are categorized to two main modes of transportation – private and public. Listed under private mode of transportation are car/jeep, van/truck, big truck, motorcycle, bicycle, pedicab, and others which may include *kuliglig*. Public vehicles include public utility jeepneys or PUJ, bus, minibus, tricycle, and others. The volume of vehicles was also assessed on an hourly basis.

4.5.2 Roads and Transportation System

4.5.2.1 Road Network

Luna has a total road network of 220.36 kilometers, with the following classifications: 0.85% secondary national, 9.89%provincial, 7.40% municipal, and 81.85 % barangay.

In general, Luna's road network is very satisfactory. The major roads of the municipality namely, Major Marcos Highway that extends from Darigayos to Rimos No. 5 and the Luna-Balaoan Road, and the Barrientos to Ayaoan Road are concrete roads that are passable all year round. Only a small kilometrage of the municipal and barangay roads need to be cemented.

Interconnecting with the major road network of the municipality are farm to market roads that provide accessibility and make it easy for farmers to transport their produce.

Figure EP-3. Traffic Study Sampling Stations	LEGEND: Project Site; Barangay Boundaries; Sampling Stations	SCALE: As above	DATA INFORMATION/SOURCE: Basemap: Google Earth Imagery Created by: Apercu Consultants, Inc. (2017)	PAGE 432
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT				

The proposed coastal road construction and rehabilitation/development of the abandoned railroad that extends from Cabalitocan to Rimos into a diversion road could further enhance social and economic development of the municipality and could address flooding problems in existing provincial, municipal and barangay roads.

4.5.2.2 Transportation

The project site covers both sides of the Major Marcos Highway running along Barangays Nalvo Sur and Carisquis between KO295 and KO300, thus having direct access to the highway. The Marcos highway has two lanes each catering to the northbound and southbound directions. It has an asphalt road surface and has a good condition as per the road data of DPWH (2015). On the southern boundary of the project site is a road going east which serves as an access road to Barangay Carisquis. It is also where the first sampling station is located. The barangay road has a single lane thus accommodating unidirectional traffic at a time.

About 4 kilometers northeast of the project site is the cross road connecting Luna to Balaoan, Bangar, and the road to the public market. These roads are made of concrete and are in fair to good condition (DPWH Road Data 2015). All these roads have two lanes catering to bi-directional traffic.

Tricycle is the major mode of transportation within the municipality. The painted blue units provide transportation only within the municipality, while those with blue and pink are for passengers going to Balaoan. Special trips however may be arranged with any tricycle owner or driver for a higher fare.

A total of seven hundred forty seven (747) tricycles with duly approved franchises operate in the municipality, most of which provide transport services within the Poblacion area during daytime; while some others chartered for trips to distant rural areas and other adjacent places such as Balaoan, Bangar, Bacnotan, especially during nighttime.

Next to tricycles are public utility jeepneys. Trips to San Fernando, La Union that are scheduled every 20 minutes to an hour are available with loading in the plaza, beside the public gymnasium. Luna via Bacnotan also has a terminal located in Darigayos dispatched every 10 minutes.

The municipality has also a total of 60 public utility jeepneys and 4,422 privately owned-cars.

Buses bound for Baguio City, Cubao, Pasay, Quezon City, Pangasinan, Nueva Viscaya, isabela and other northern Luzon provinces can be availed of in nearby Balaoan municipality which is traversed by the Manila North Road.

At times, during traffic and impassability of some bridges along the national road, detour is made via the Major Marcos Highway in Luna exiting through Bacnotan or through Balaoan-Luna Road.

4.5.3 Weekend Traffic Volume

For the duration of the weekend sampling, a total of 13,334 vehicles were recorded to use the routes of the two stations. A higher percentage was observed with private vehicles comprising 56% of the total count while the public transportation only amounted to 44%.

The first station is located southwest of the project site encompassing the Bacnotan – Luna road, and the entry and exit point of Brgy. Carisquis. For the first route observed (Luna to Bacnotan), the number of vehicles totaled to 1,072 units with 30% public vehicles and 70% private. The assessment of volume of vehicles per vehicle type showed that on a weekend the route is mostly used by motorcycles comprising 41% of the route's total, followed by tricycle at 27% (**Figure EP-4a**). Among the listed vehicle types, pedicabs, buses, and minibuses were not at all observed. The volume of vehicles was also assessed in an hourly basis from 6:00 am to 6:00 pm (**Figure EP-4b**). The highest volume tallied was during the 12:01 pm to 1:00 pm and 5:01 pm to 6:00 pm period both having the counts of 130 vehicles (12%). The lowest volume of vehicles on the other hand was observed during the 6:00 am to 7:00 am time period with only 48 vehicles recorded (4%).

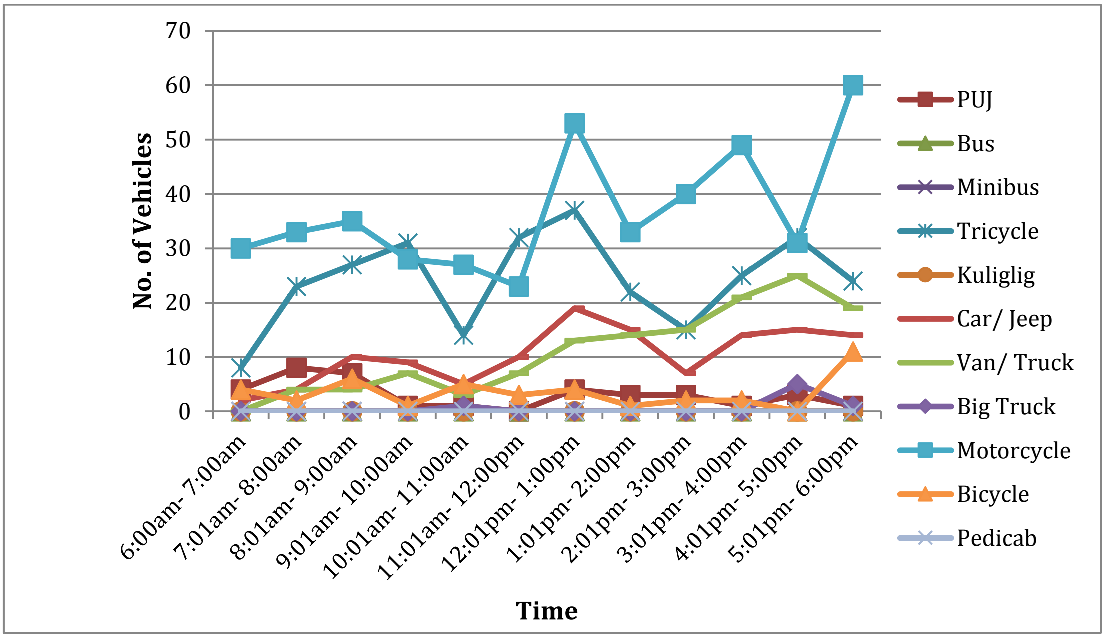


Figure EP-4a. Weekend Traffic Volume per Vehicle Type (Station 1 – Luna to Bacnotan)

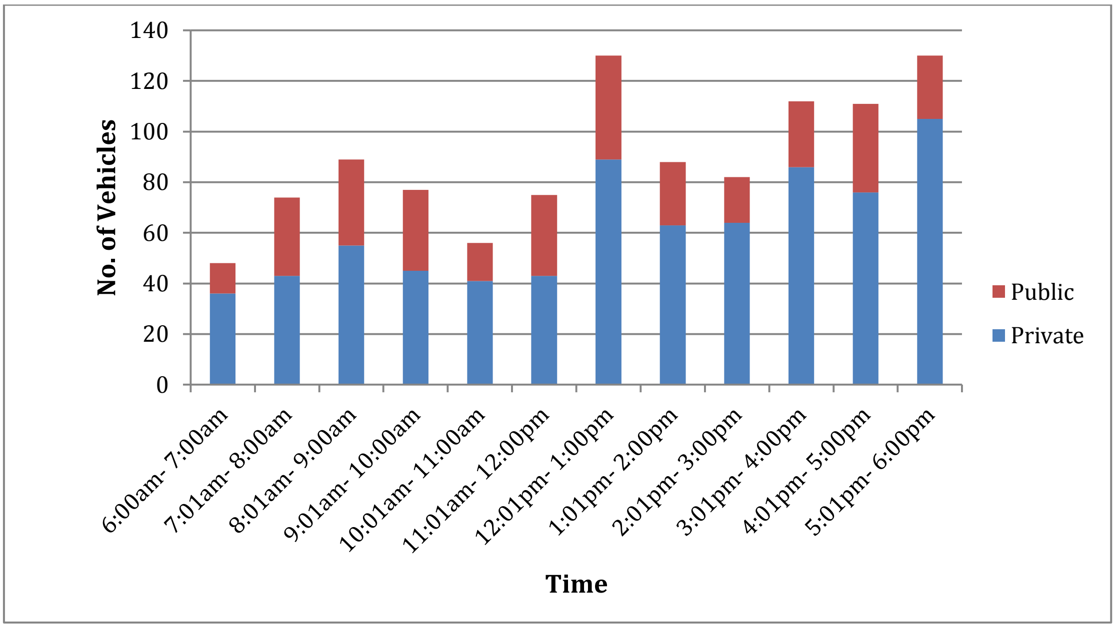


Figure EP-4b. Weekend Traffic Volume per Time Period (Station 1 – Luna to Bacnotan)

The second route is from Bacnotan to Luna with a total of 1,001 vehicles tallied, 30% public and 70% private vehicles. The most observed vehicle, according to **Figure EP-5a** is also motorcycle (40%) followed by tricycle (27%). In the observation per each time period, the volume of vehicles was at its peak at 3:01 pm to 4:00 pm (12%) and at the lowest at 10:01 am to 11:00 am period (7%). The trend can be seen in **Figure EP-5b**.

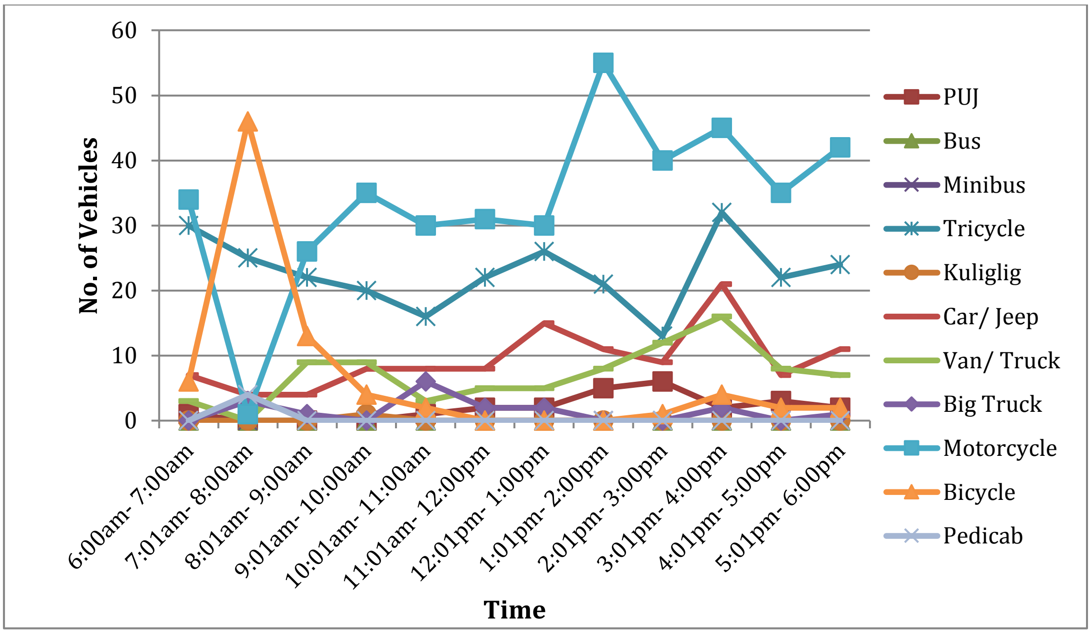


Figure EP-5a. Weekend Traffic Volume per Vehicle Type (Station 1 – Bacnotan to Luna)

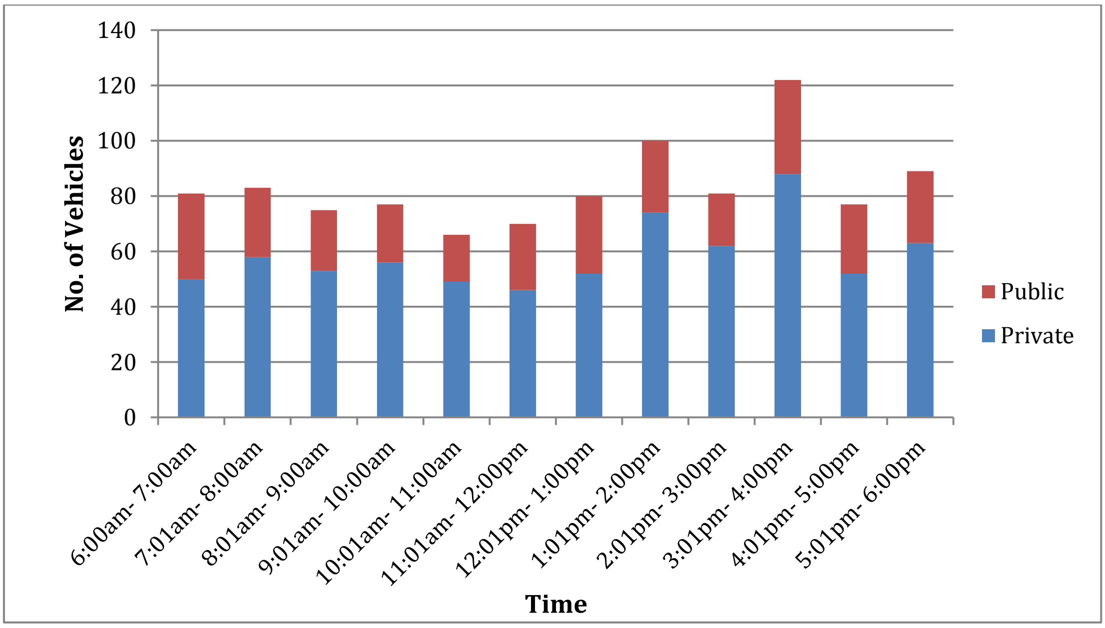


Figure EP-5b. Weekend Traffic Volume per Time Period (Station 1 – Bacnotan to Luna)

The third route for the first station is the road going to Brgy. Carisquis. All vehicles headed towards Brgy. Carisquis totaled to 131 with 43% public transportations and 57% privately owned cars. Among these vehicles, motorcycle was tallied with most number (41%) followed by tricycle (34%). In this route, no buses, minibuses, big trucks, nor pedicabs were seen during the 12-hour period (**Figure EP-6a**). In the observation of volume of vehicles per time period, the highest number was recorded at 1:01 pm to 2:00 pm (11%) and the lowest at 12:01nn to 1:00 pm (5%) (**Figure EP-6b**).

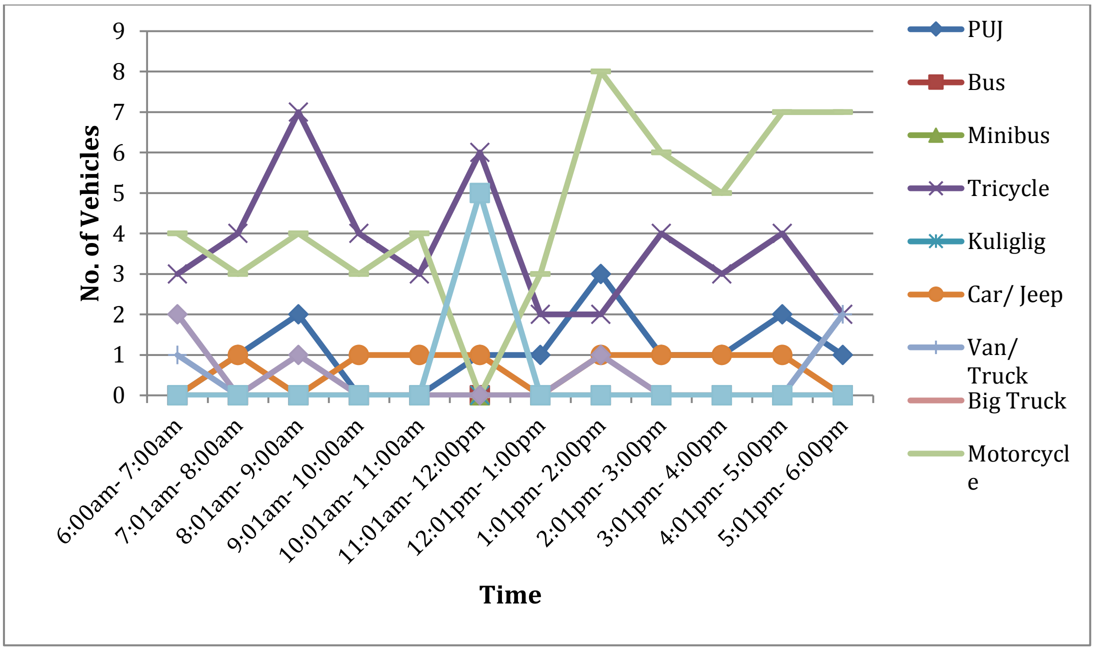


Figure EP-6a. Weekend Traffic Volume per Vehicle Type (Station 1 – Going to Brgy. Carisquis)

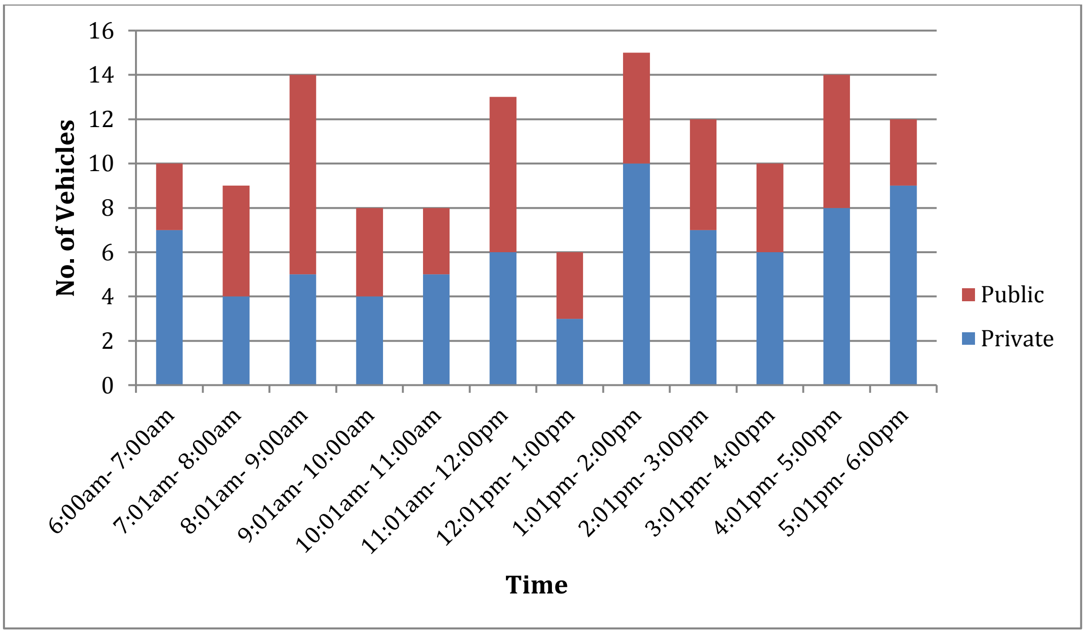


Figure EP-6b. Weekend Traffic Volume per Time Period (Station 1 – Going to Brgy. Carisquis)

For the last route under the first station, private and public vehicles going out of Brgy. Carisquis were tallied. The total of which is 92 vehicles with 39% public modes of transportation and 61% privately owned vehicles.

Considering the data in **Figure EP-7a**, it can be seen that among the vehicle types listed, motorcycles have the highest number with 51% followed by the tricycles with 37%.

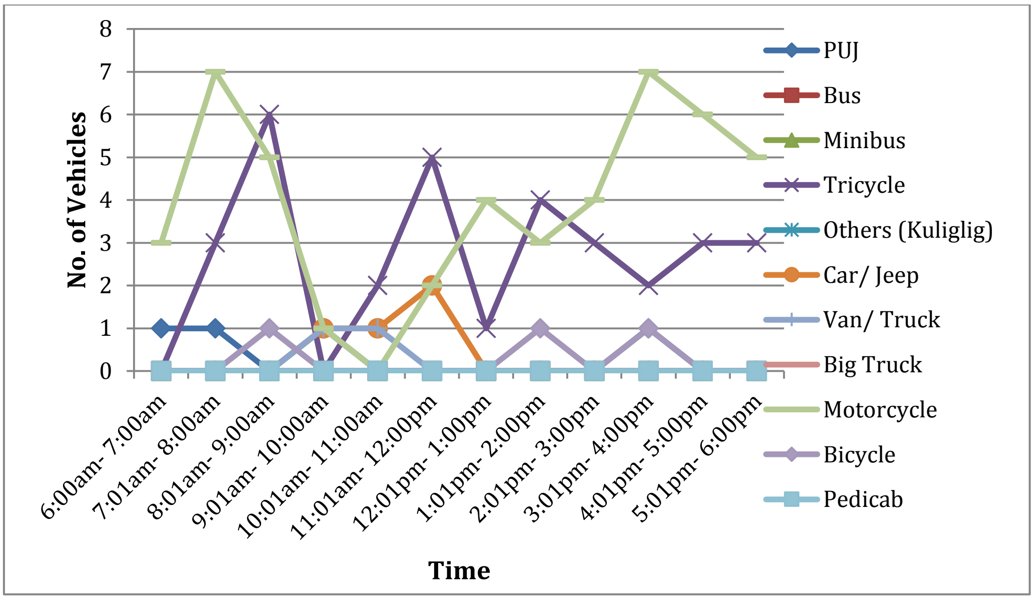


Figure EP-7a. Weekend Traffic Volume per Vehicle Type (Station 1 – Going out of Brgy. Carisquis)

For the volume of vehicles per time period on the other hand, **Figure EP-8b** shows that the number of vehicles passing by was at its peak during 8:01 am to 9:00 am period. Three time periods showed the lowest volume reaching only 4% of the routes total. These are (1) 6:00 am to 7:00 am, (2) 9:01 am to 10:00 am, and (3) 10:01 am to 11:00 am.

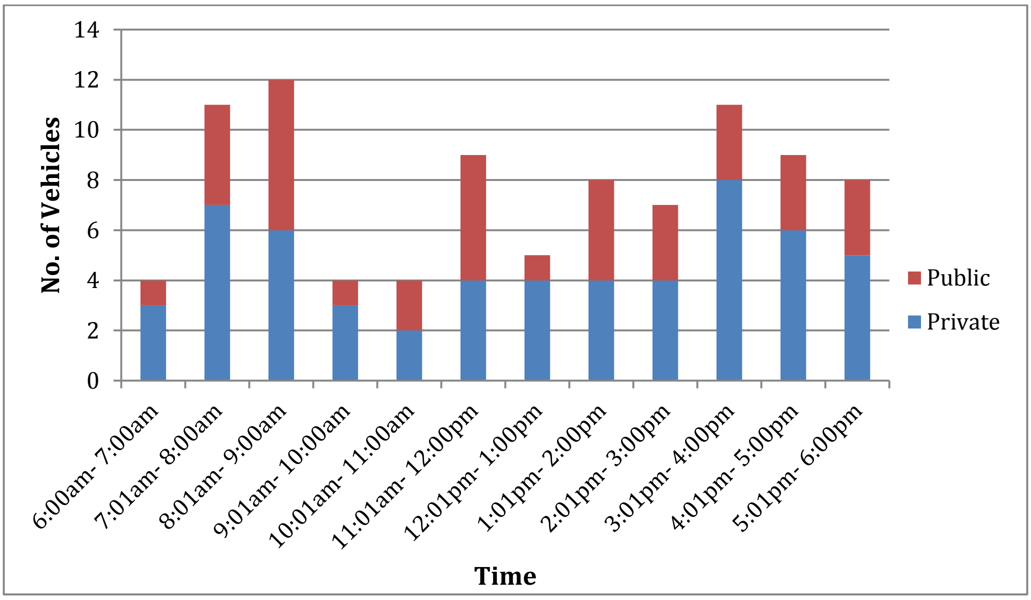


Figure EP-7b. Weekend Traffic Volume per Time Period (Station 1 – Going out of Brgy. Carisquis)

Four routes were included for the **second station** of the traffic study. Two of which are routes going to Luna, one from Balaoan, and the other from Bangar, while the other two routes were from Luna to Bangar/Balaoan and from Public Market to Highway. The weekend sampling conducted on August 20, 2016 recorded a total of 10,544 vehicles passing through station two which is composed of 5,516 (52%) privately owned cars and 5,028 (48%) public vehicles. This showed that a higher percentage of the vehicles passing through station two are privately owned.

In the first route, from Balaoan headed to Luna, a total of 2,914 vehicles were observed to pass by. In terms of volume per vehicle type passing through the first route, tricycle showed the highest number with a total of 1,233 (42%) out of the 2,914 vehicles observed in this route, followed by motorcycle with a total count of 1,023 (35%). On the other hand, neither buses nor minibuses were observed in the station. This data is shown in **Figure EP-9a.**

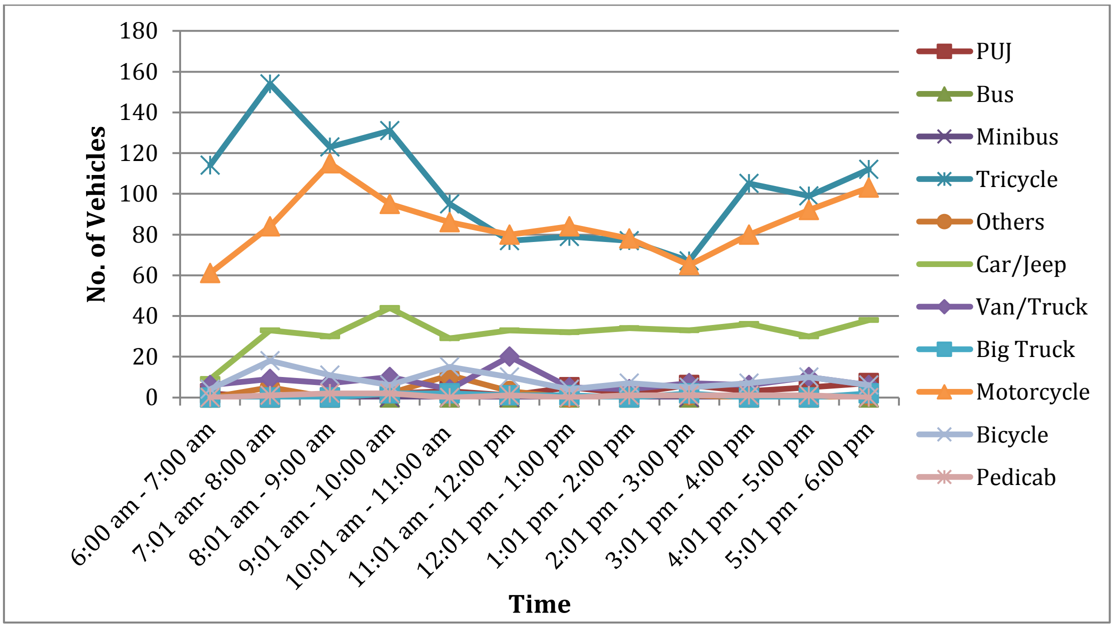


Figure EP-8a. Weekend Traffic Volume per Vehicle Type (Stataion 2 – Balaoan to Luna)

Figure EP-9b shows the volume of vehicles for the same route on an hourly basis. From the total of 2,914 vehicles observed, the highest number was recorded from 7:01 am – 8:00 am (304 vehicles or 10%) and the lowest number observed from 2:01 pm to 3:00 pm (187 vehicles or 6%).

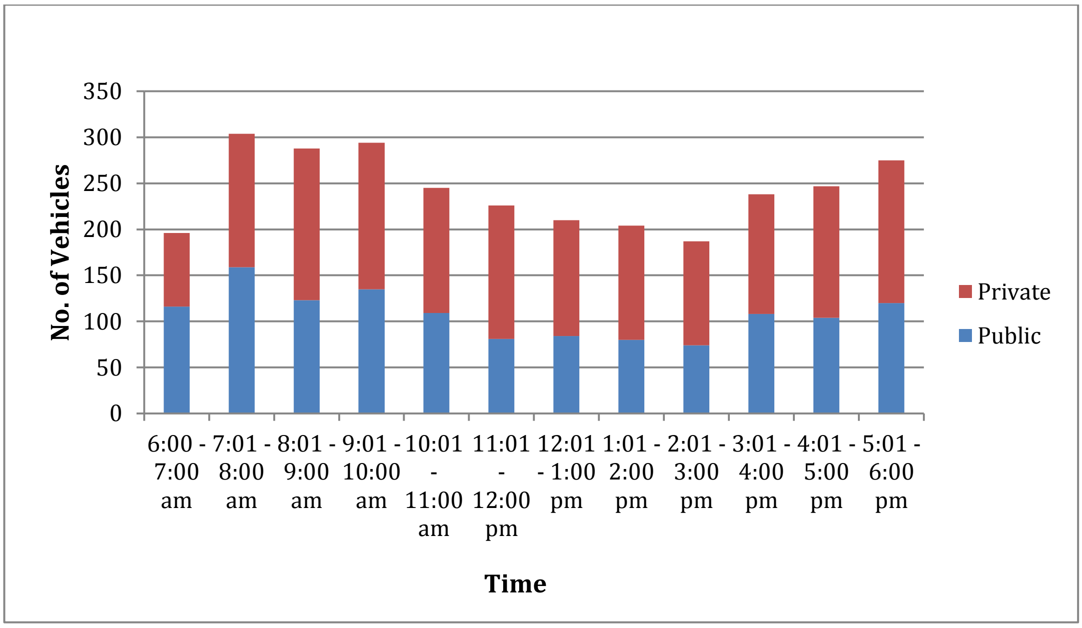


Figure EP-8b. Weekend Traffic Volume per Time period (Station 2 – Balaoan to Luna)

The second route observed is from Bangar to Luna. A total of 2,091 vehicles were observed to pass by the route. Of the total, 979 (47%) were public transportation while 1,112 (53%) were privately owned. **Figure EP-10a** shows the volume per vehicle type where the highest number was observed for tricycle (952 units or 46%) followed by motorcycle (673 units or 32%). Same with the first route, neither buses nor minibuses were observed in this route.

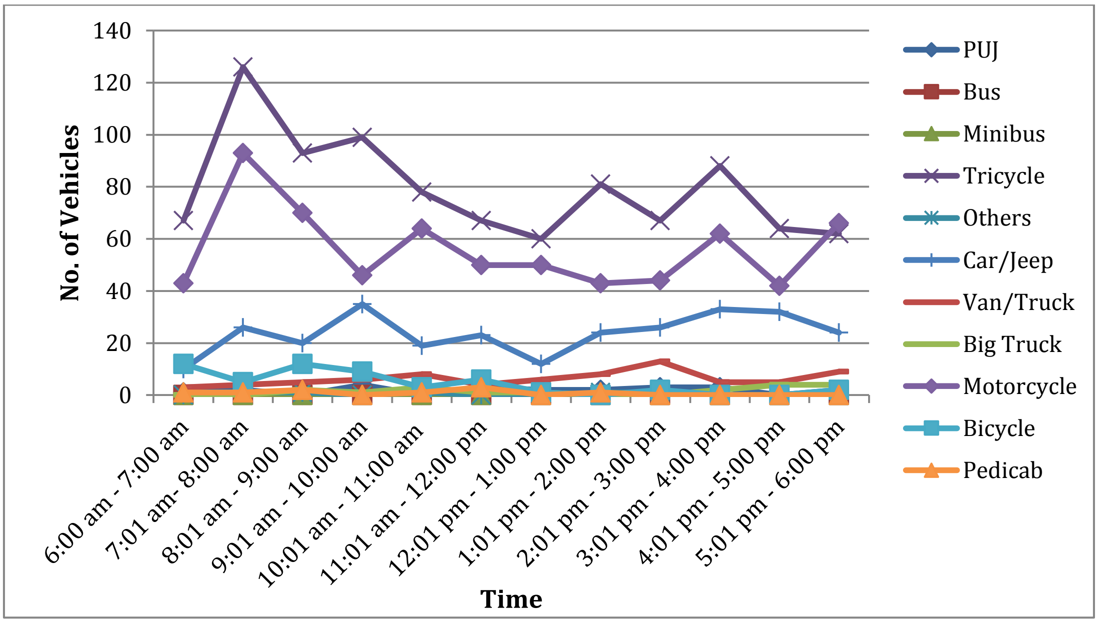


Figure EP-9a. Weekend Traffic Volume per Vehicle Type (Station 2 – Bangar to Luna)

Figure EP-10b shows the volume of vehicles on an hourly basis for the second route. The highest number of vehicles was observed from 7:01 am – 8:00 am (258 vehicles or 12%) and the lowest number from 12:01 pm – 1:00 pm (132 vehicles or 6%).

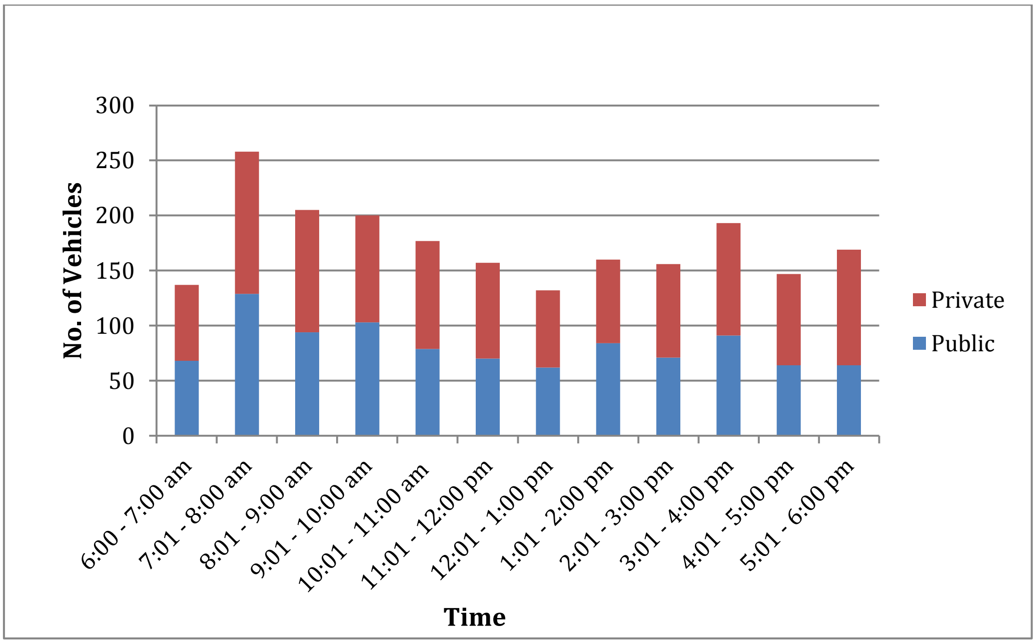


Figure EP-9b. Weekend Traffic Volume per Time Period (Station 2 – Bangar to Luna)

The third route is from Public Market to Highway with a total number of 1,904 vehicles observed, composed of both public transportation vehicles and privately owned. The most observed vehicle in this route is tricycle (1,006 units) followed by motorcycle (560 units). On this route too, neither buses nor minibuses were observed. This can be seen in **Figure EP-11a**. On **Figure EP-11b** is the trend on the vehicle volume per hour where most vehicles were observed from 9:01 am to 10:00 am, 247 vehicles or 13% of the route's total, and the least number of vehicles were observed from 6:00 am to 7:00 am and 2:01 pm to 3:00 pm, both having a count of 90 vehicles or 5% of the route's total.

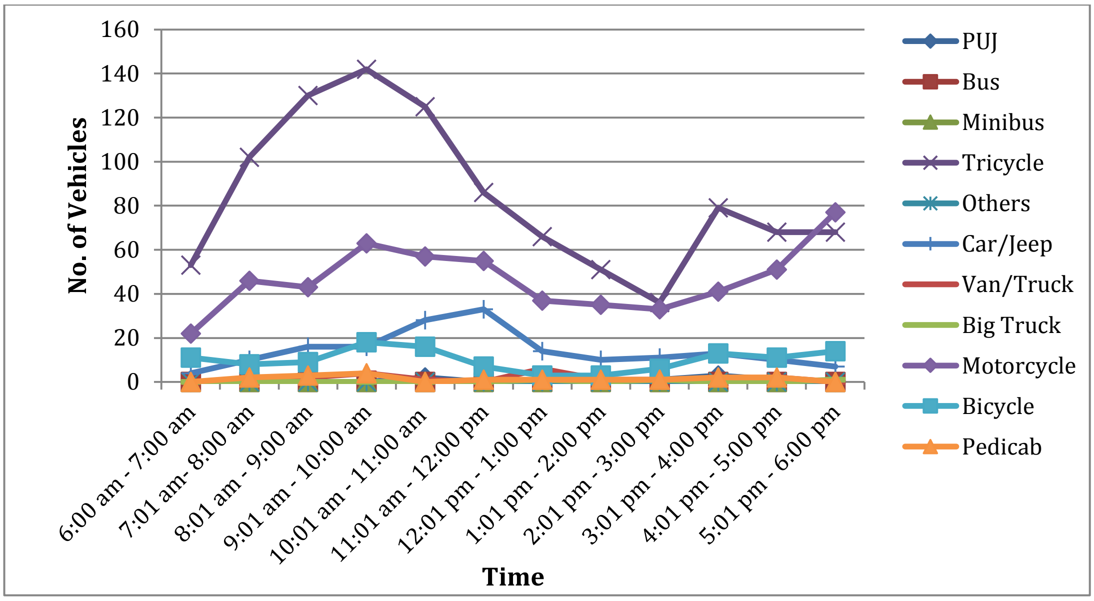


Figure EP-10a. Weekend Traffic Volume per Vehicle Type (Station 2 – Public Market to Highway)

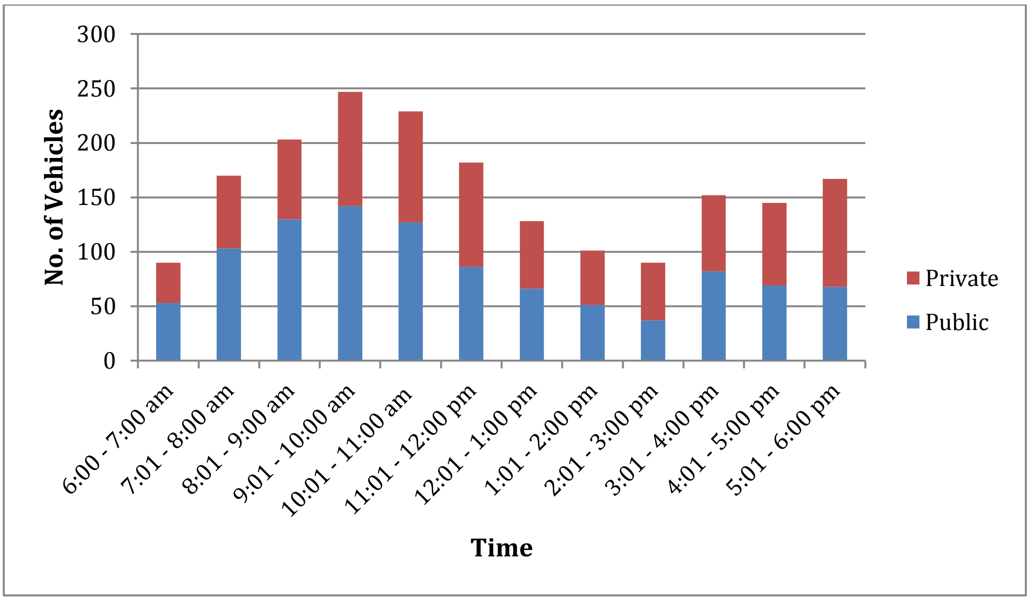


Figure EP-10b. Weekend Traffic Volume per Time Period (Station 2 – Public Market to Highway)

The fourth route which is from Luna to Bangar/Balaoan has the most number of vehicles observed for the second station which totals to 3,635 vehicles or 34% of the total, both private and public vehicles. The type of vehicle that has the highest number recorded was tricycle, same as the first three routes, totaling to 1,658 units or 46% of the route's total, followed by motorcycle with a total count of 1,228 units or 34% of the route's total. Buses and minibuses were also not observed in this route (**Figure EP-11a**).

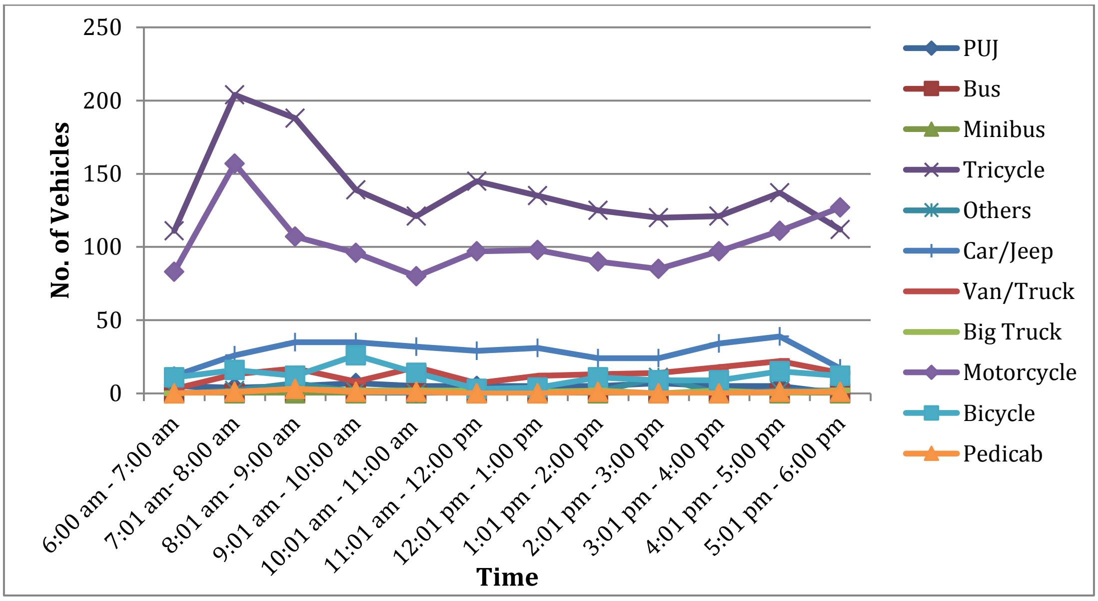


Figure EP-11a. Weekend Traffic Volume per Vehicle Type (Station 2 – Luna to Bangar/Balaoan)

In **Figure EP-11b** is the volume of vehicles per hour for the fourth route. Highest number was observed from 7:01 am to 8:00 am with 424 vehicles or 12% of the route's total while lowest number of vehicles was observed from 6:00 am to 7:00 am with 225 vehicles or 6%.

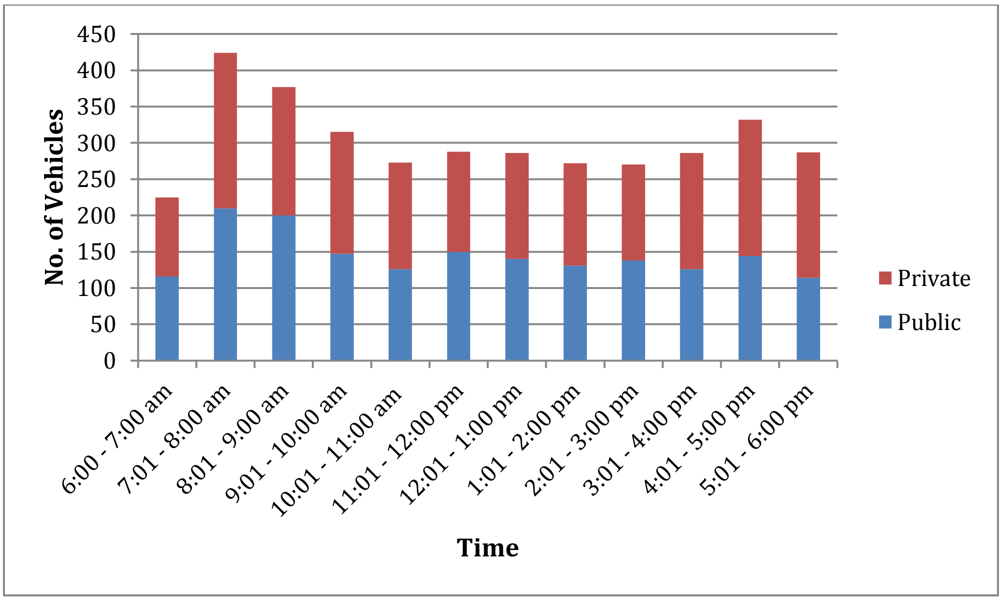


Figure EP-12b. Weekend Traffic Volume per Time Period (Station 2 – Luna to Bangar/Balaoan)

4.5.4 Weekday Traffic Volume

The second sampling date for the traffic study was conducted on August 20, 2016 which falls on a weekday. The length of period of observation is the same as that of the weekend running from 6:00 in the morning to 6:00 in the evening. Same stations and routes were observed which in total tallied 13,304 vehicles with 50% private owned cars and the other 50% being public modes of transportation.

For the first route of Station 1, which is from Luna to Bacnotan, **Figure EP-12a** shows that motorcycle at 37% had the highest volume in terms of vehicle type followed by tricycles at 23%. In this route, only minibus and a locally known vehicle called *kuliglig* was not observed. Bus and pedicabs were tallied with the lowest volume among those observed sitting at only 0.1%. **Figure EP-12b** shows that the peak period is at 5:01 pm to 6:00 pm and lowest at 1:01 pm to 2:00 pm, majority of which are private vehicles at 69% for the peak period.

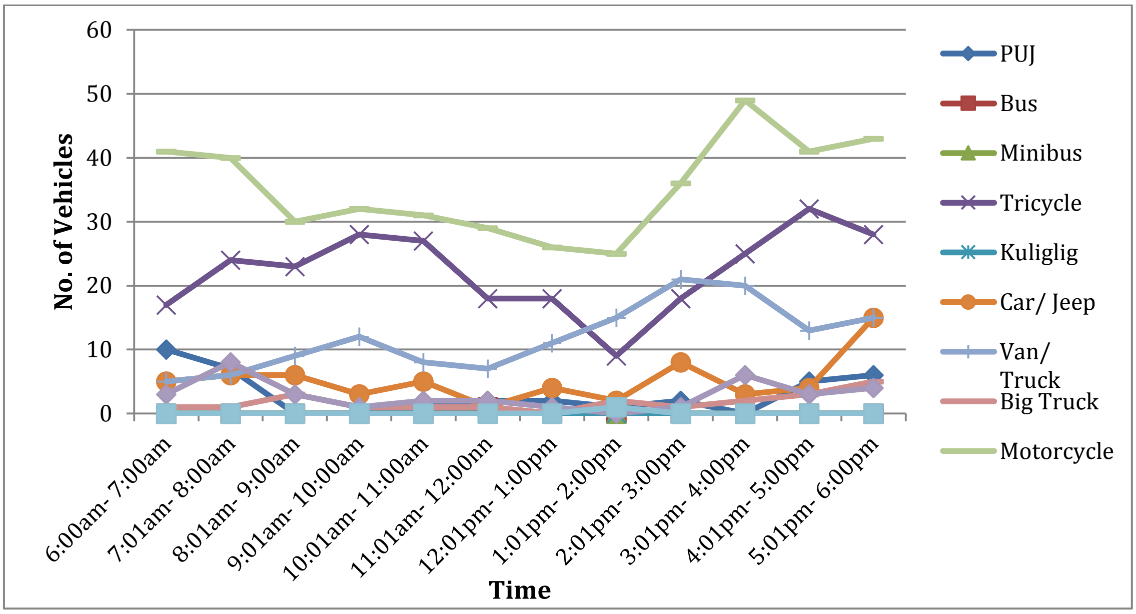


Figure EP-12a. Weekday Traffic Volume per Vehicle Type (Station 1 – Luna to Bacnotan)

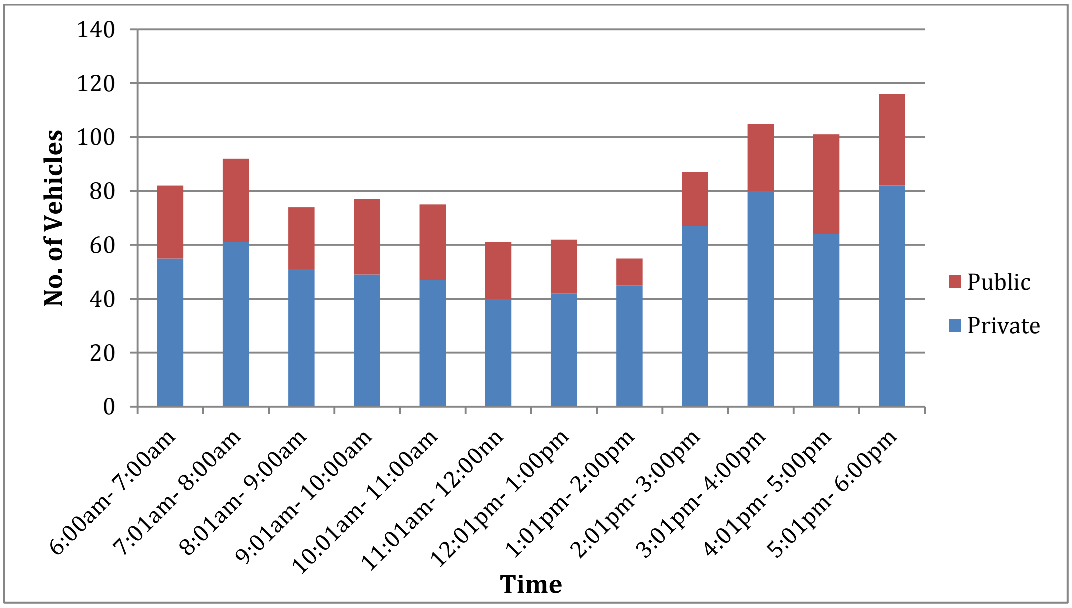


Figure EP-12b. Weekday Traffic Volume per Time Period (Station 1 – Luna to Bacnotan)

In the second route, Bacnotan to Luna, where a total of 956 vehicles were observed, motorcycles numbered highest in volume at 44%, again followed by tricycles at 28% (**Figure EP-13a**). In the assessment per time period, the highest volume of vehicles was recorded from 9:01 am to 10:00 am and lowest at 11:01 am to 12:00 pm (**Figure EP-13b**).

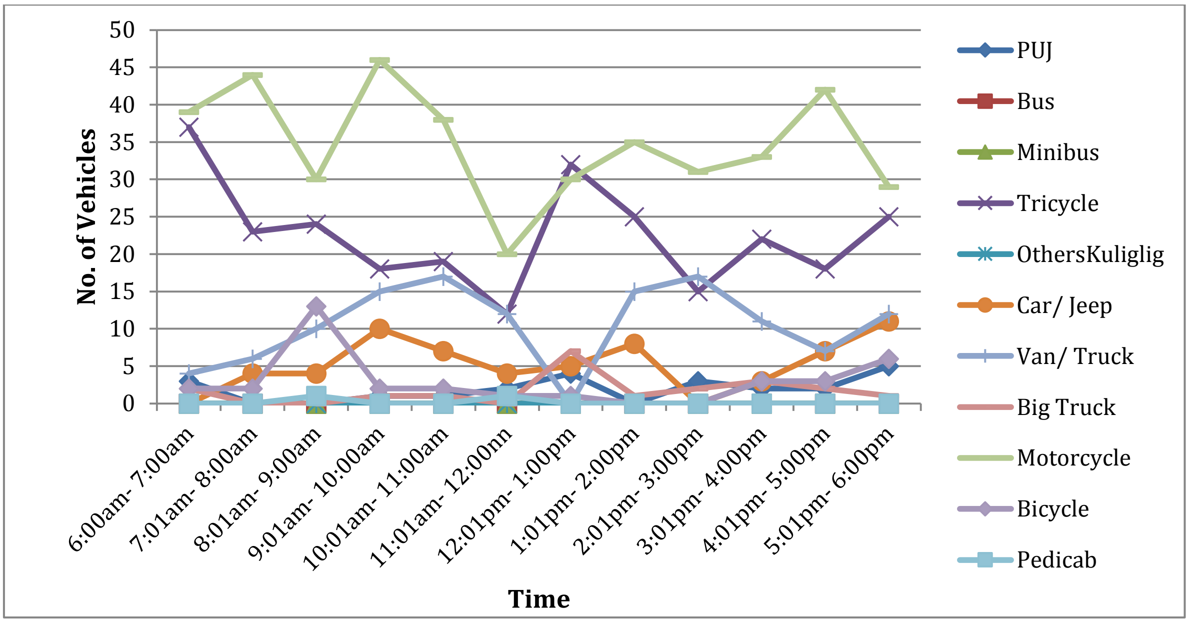


Figure EP-13a. Weekday Traffic Volume per Vehicle Type (Station 1 – Bacnotan to Luna)

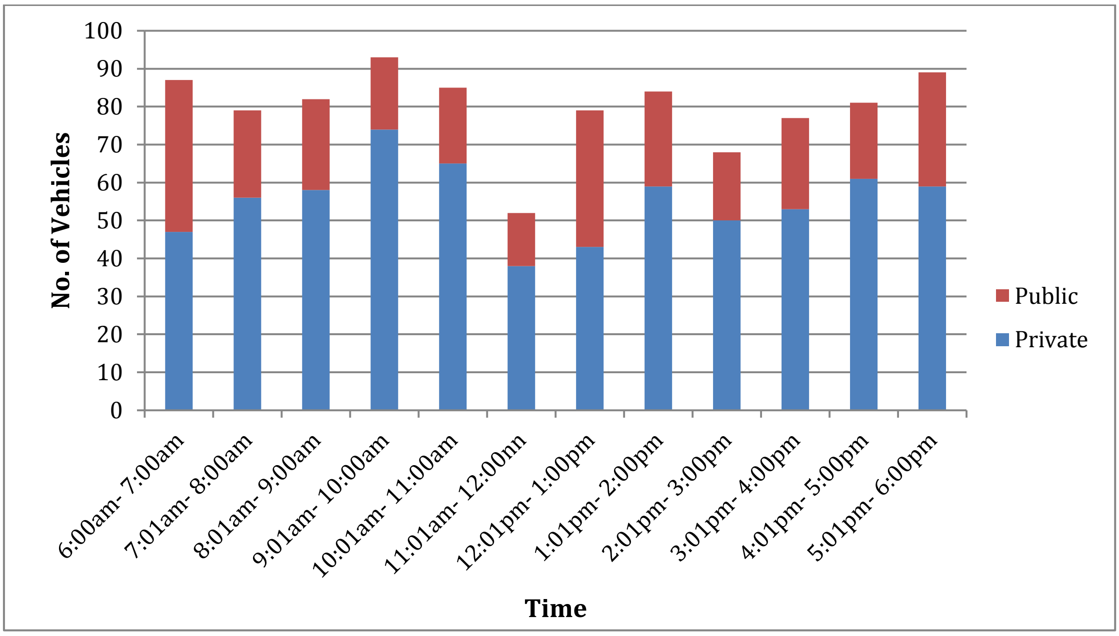


Figure EP-13b. Weekday Traffic Volume per Time Period (Station 1 – Bacnotan to Luna)

The third route, which involves vehicles going to Brgy. Carisquis, amounted to 175 vehicles composed of 57% private cars and 43% public. The most frequent vehicle types during the 12 hours period were motorcycles at 43% and followed by tricycles at 31%. Buses, minibuses, *kuliglig*, big trucks, and pedicabs were not observed in this route (**Figure EP-14a**).

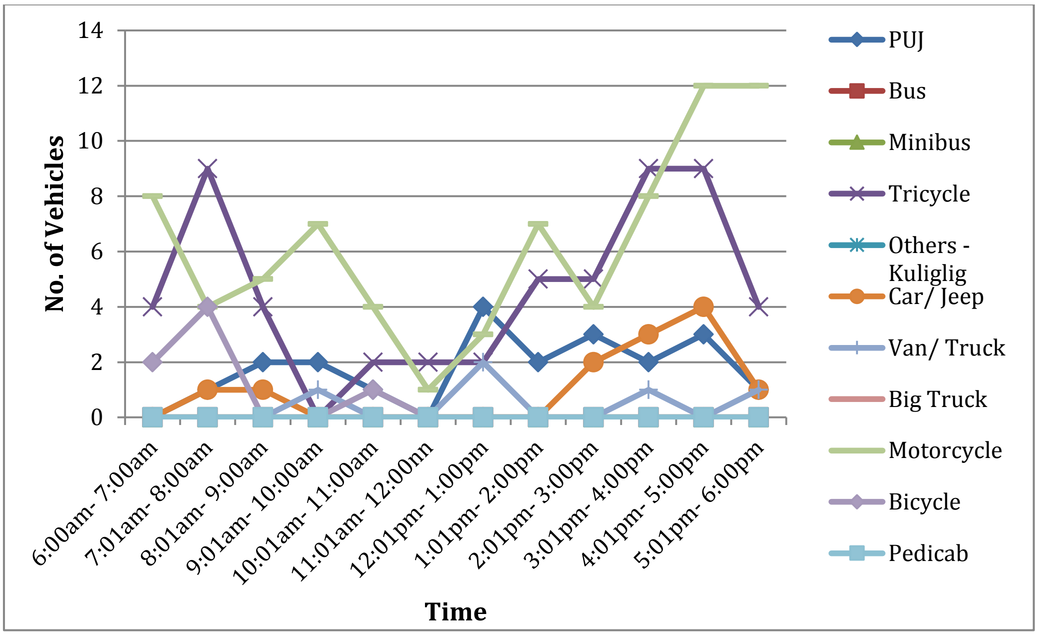


Figure EP-14a. Weekday Traffic Volume per Vehicle Type (Station 1 – Going to Brgy. Carisquis)

For the volume of vehicles per hour, as shown in **Figure EP-14b**, the period 4:01 pm to 5:00 pm had the highest volume (16%) while 11:01 am to 12:00 noon had the lowest volume at 2%.

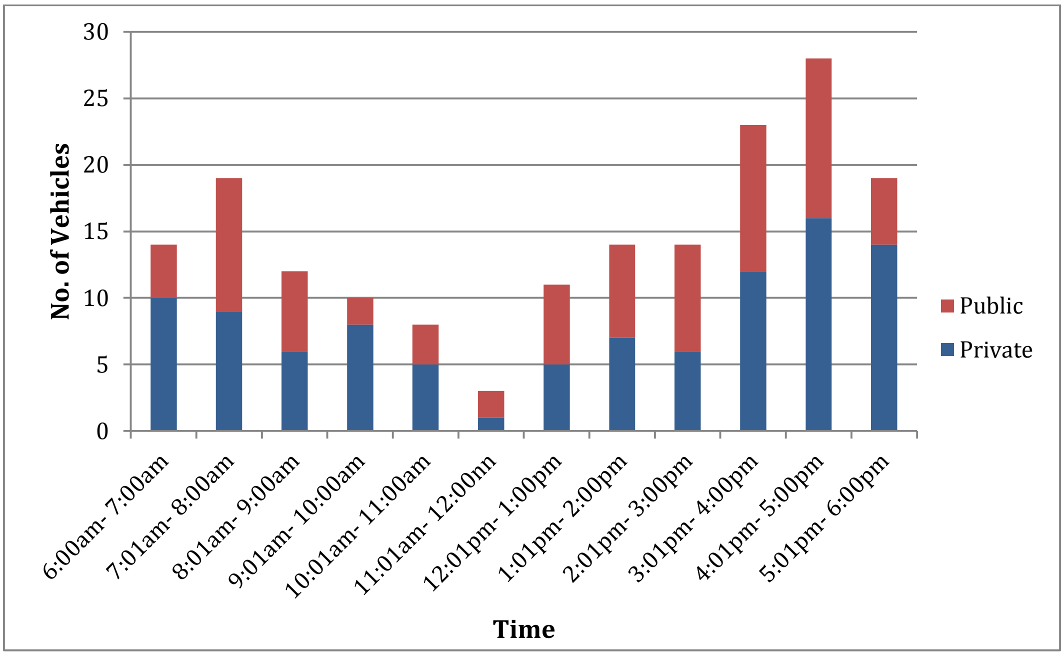


Figure EP-14b. Weekday Traffic Volume per Time Period (Station 1 – Going to Brgy. Carisquis)

The last route tallied vehicles going out of Brgy. Carisquis. There were a total of 148 vehicles with private vehicles tallied a higher percentage at 57%. The most observed vehicle type was again the motorcycle (45%), the same as the first three routes. It is also followed by tricycle with only 3% difference (42%). For those observed, car/jeep got the lowest percentage at 0.7% while bus, minibus, *kuliglig*, big truck, and pedicabs were not at all observed on this route (**Figure EP-15a**).

Tallying the vehicle volume on an hourly basis, **Figure EP-15b** shows that the volume of vehicles was at its peak from 5:01 pm to 6:00 pm (14%) and lowest during four time period which are (1) 11:01 am to 12:00 noon, (2) 12:01 pm to 1:00 pm, (3) 2:01 pm to 3:00 pm, and (4) 3:01 pm to 4:00 pm – all recording only 6% of the route's total volume.

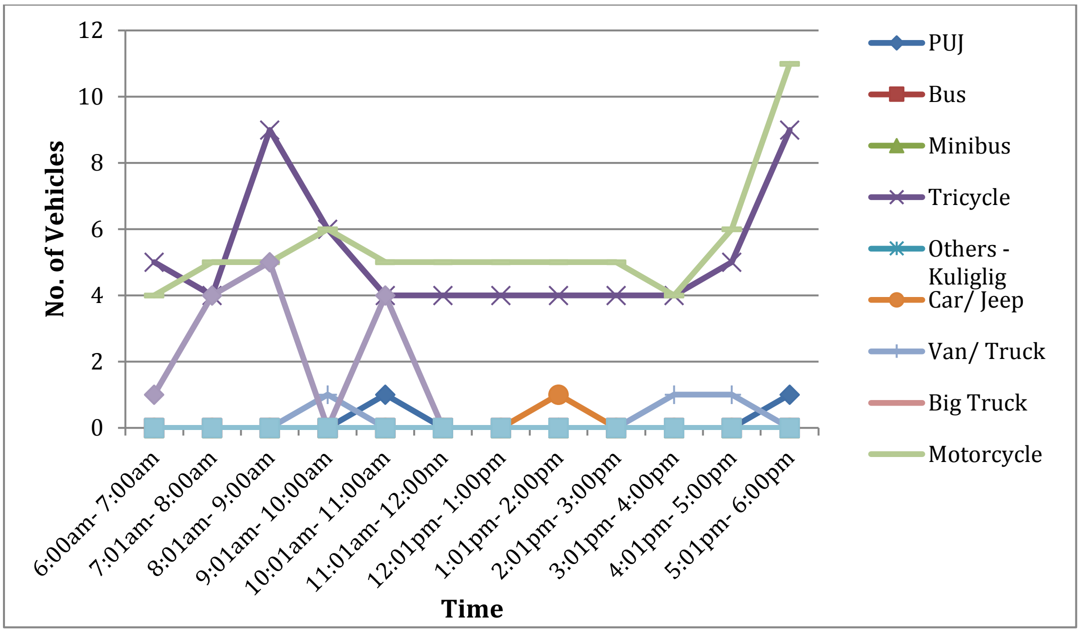


Figure EP-15a. Weekday Traffic Volume per Vehicle Type (Station 1 – Going out of Brgy. Carisquis)

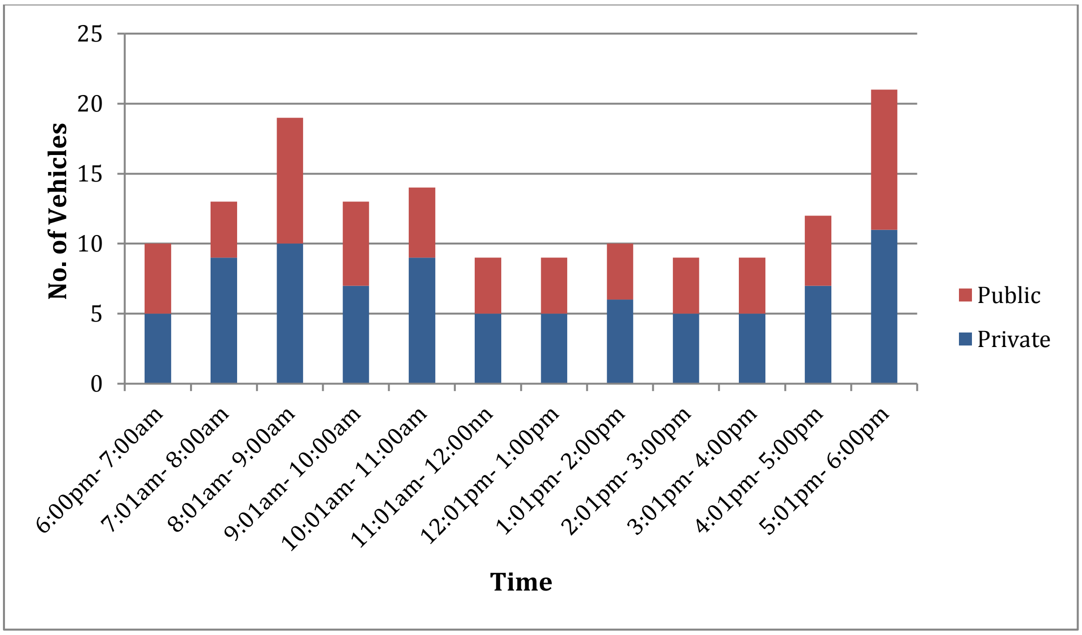


Figure EP-15b. Weekday Traffic Volume per Time Period (Station 1 – Going out of Brgy. Carisquis)

During the 12-hour period, a total of 11,308 vehicles were recorded at the second station which comprises 85% of the total vehicles observed that day. Among these are 5,858 private cars (53%) and 5,180 public cars (47%). Four routes are included in this station - (1) Balaoan to Luna, (2) Bangar to Luna, (3) Public Market to Highway, and (4) Luna to Bangar/Balaoan.

The first route, from Balaoan to Luna, recorded a total of 3,056 vehicles where in the most frequent vehicle type was tricycle with a total count of 1,310 (43%) followed by motorcycle at 1,139 vehicles (37%). Big trucks had the least volume among those observed counting only 7 (0.2%). The bus and minibus were not observed at all. The data is represented in **Figure EP-16a**.

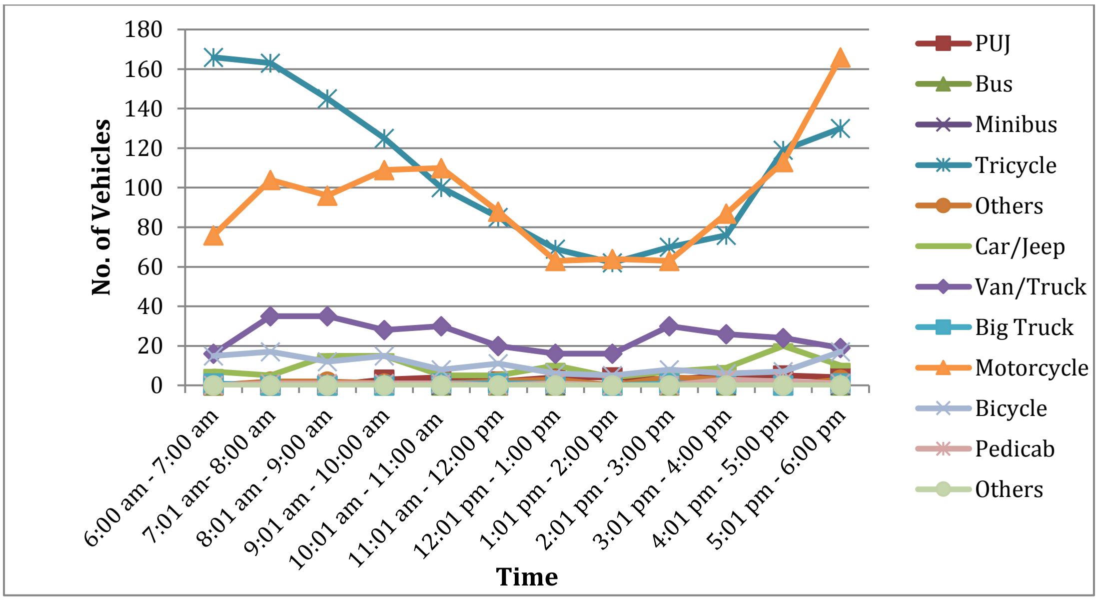


Figure EP-16a. Weekday Traffic Volume per Vehicle Type (Station 2 – Balaoan to Luna)

In **Figure EP-16b** is the data on the volume of vehicles per time period where in the peak of vehicles was tallied from 5:01 pm to 6:00 pm with 351 cars (11%), both private and public, and lowest at 1:01 – 2:00 pm with only 155 vehicles counted (5%).

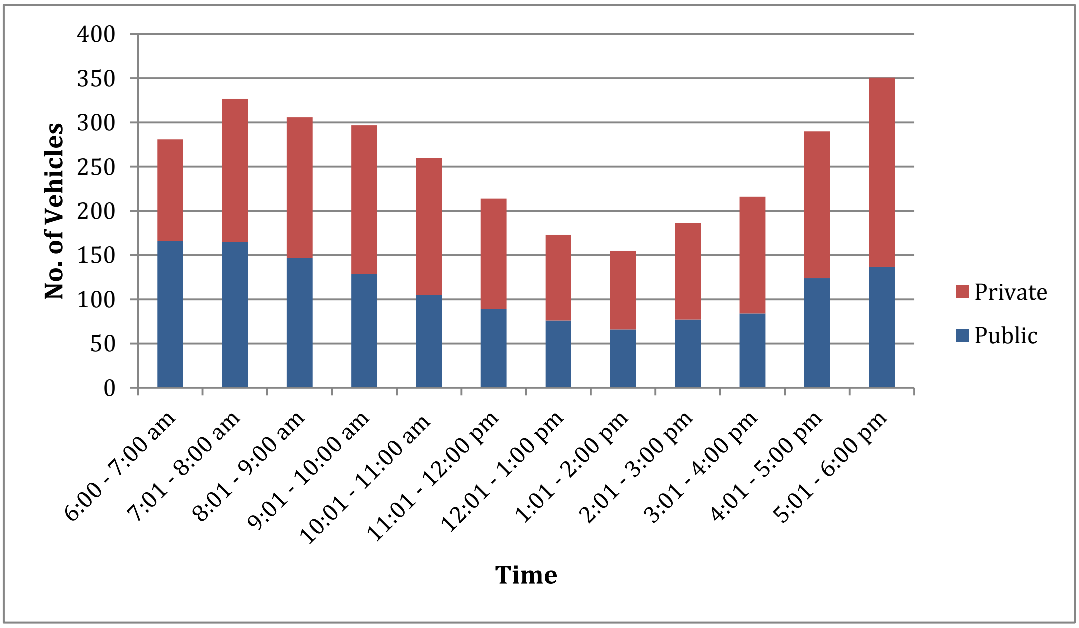


Figure EP-16b. Weekday Traffic Volume per Time Period (Station 2 – Balaoan to Luna)

In the route from Bangar to Luna, a total of 2,521 vehicles were seen – 1,365 are private cars (54%) and 1,156 are public transport (46%). The most numerous type of vehicle was the tricycle totaling to 1,130 (45%) followed by motorcycles at 798 (32%). The Bus was the only vehicle type that was not seen in this route (**Figure EP-17a**). The volume of vehicles was observed to be highest during the 4:01 pm to 5:00 pm period (12%) and lowest during the 2:01 pm – 3:00 pm period (6%) (**Figure EP-17b**).

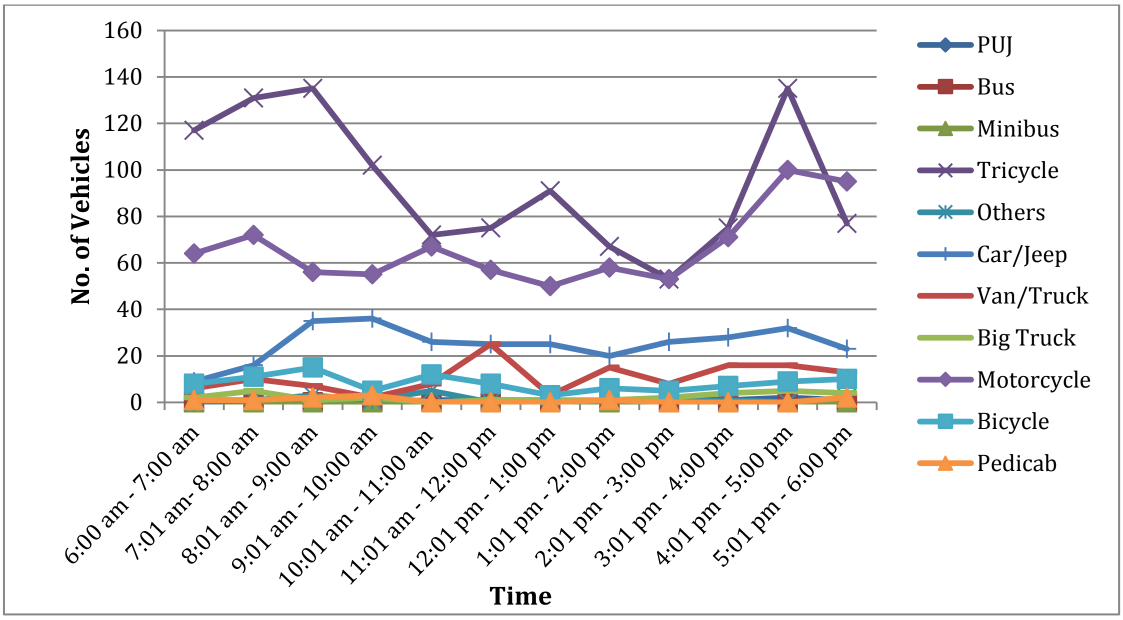


Figure EP-17a. Weekday Traffic Volume per Vehicle Type (Station 2 – Bangar to Luna)

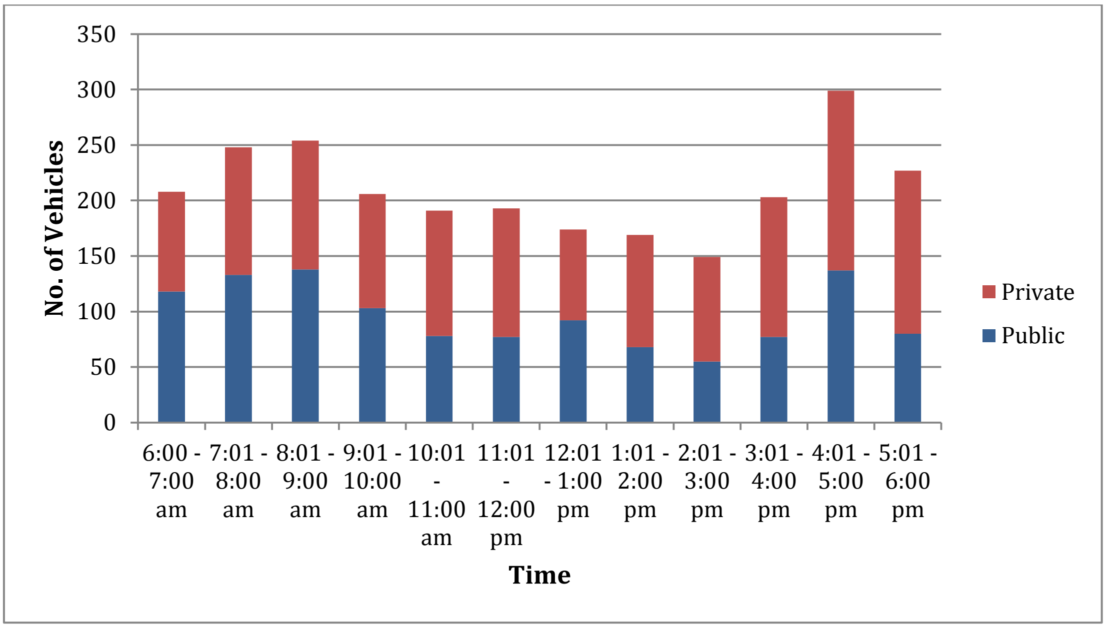


Figure EP-17b. Weekday Traffic Volume per Time Period (Station 2 – Bangar to Luna)

The third route is from Public Market to Highway where 1,783 vehicles were observed. 50% are public utility vehicles means of transportation and 50% are privately owned. In **Figure EP-18a** is the volume for each vehicle type, where tricycles was most observed (50%) followed by motorcycles (33%). Again, neither busses nor minibuses were observed on this route. For the volume of vehicles for each time period of observation, highest volume was recorded from 10:01 am to 11:00 am with a total of 235 vehicles (13%) and lowest from 2:01 pm to 3:00 pm with only 73 vehicles (4%). This data can be seen in **Figure EP-18b**.

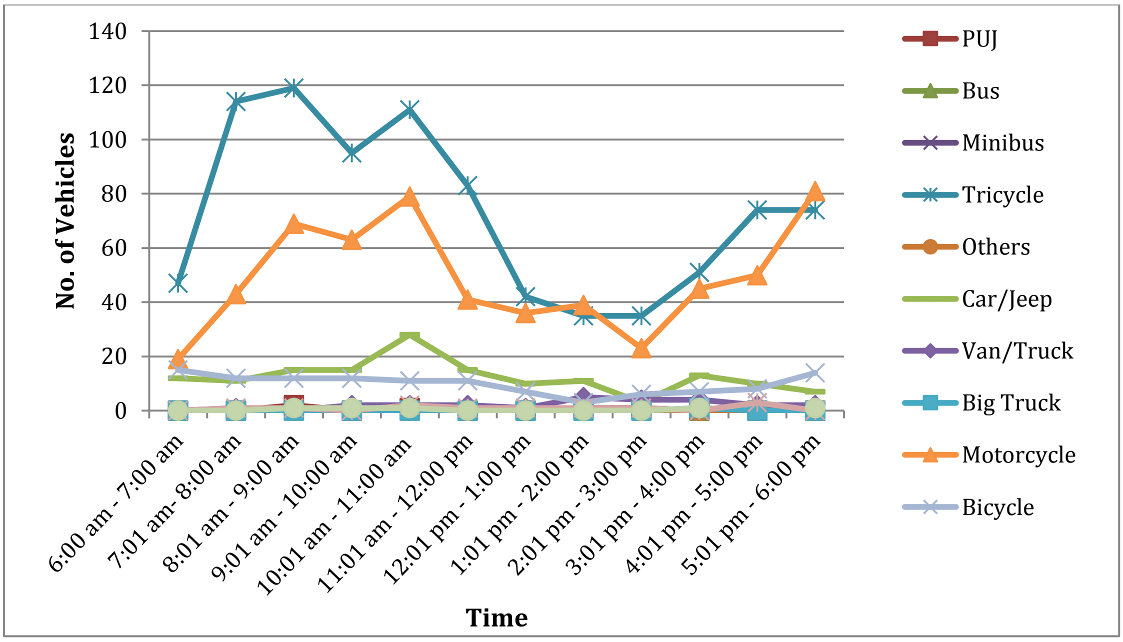


Figure 18a. Weekday Traffic Volume per Vehicle Type (Station - Public Market to Highway)

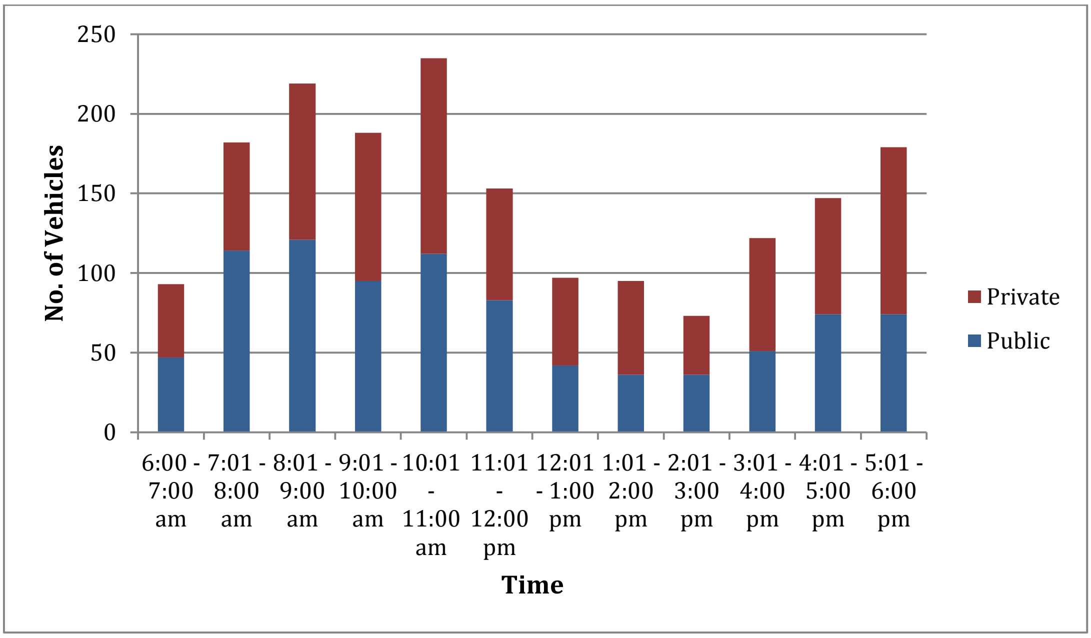


Figure 18b. Weekday Traffic Volume per Time Period (Station 2 – Public Market to Highway)

The last route observed was Luna going to Bangar/Balaoan where a total of 3,678 vehicles was recorded, 48% of which are public vehicles and 52% are private vehicles. **Figure EP-19a** shows the volume of each vehicle type seen passing by the route. Of these vehicles, tricycles showed the most number comprising 47% of the route's total and was followed by motorcycles, which comprised 34% of vehicles observed. Like the three other routes observed on the same day, neither buses nor minibuses were observed to use this route.

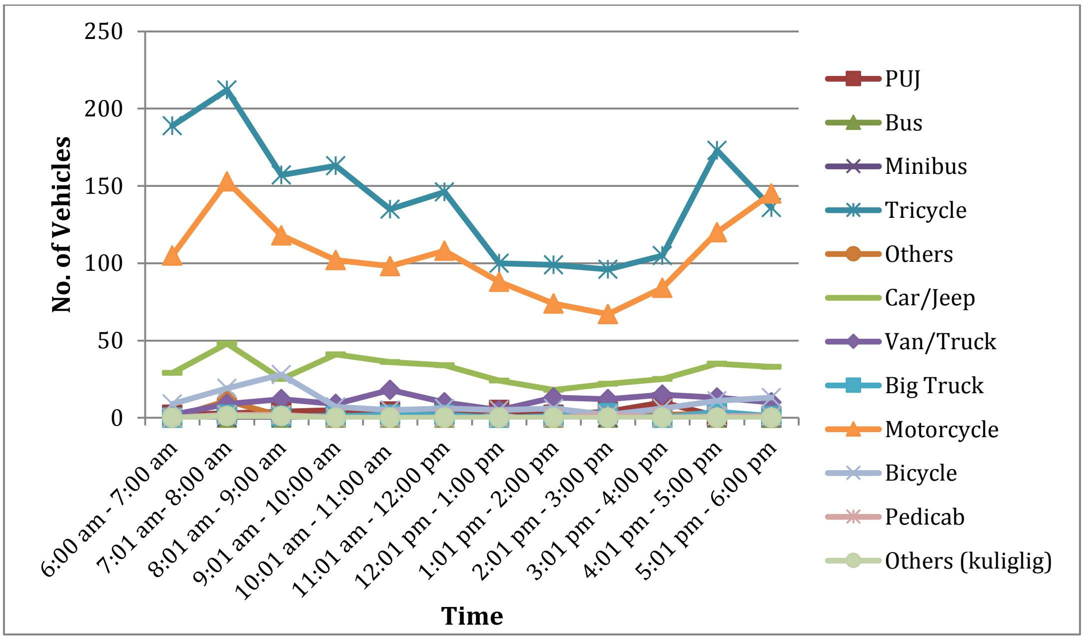


Figure EP-19a. Weekday Traffic Volume per Vehicle type (Station 2 – Luna to Bangar/Balaoan)

In **Figure EP-19b** is the volume of vehicles for each time period where the peak was observed at 7:01 am to 8:00 am. 460 vehicles were observed during this hour (13%). The lowest volume of vehicles on the other hand, was during the 2:01 pm to 3:00 pm period with only 209 vehicles observed (6%).

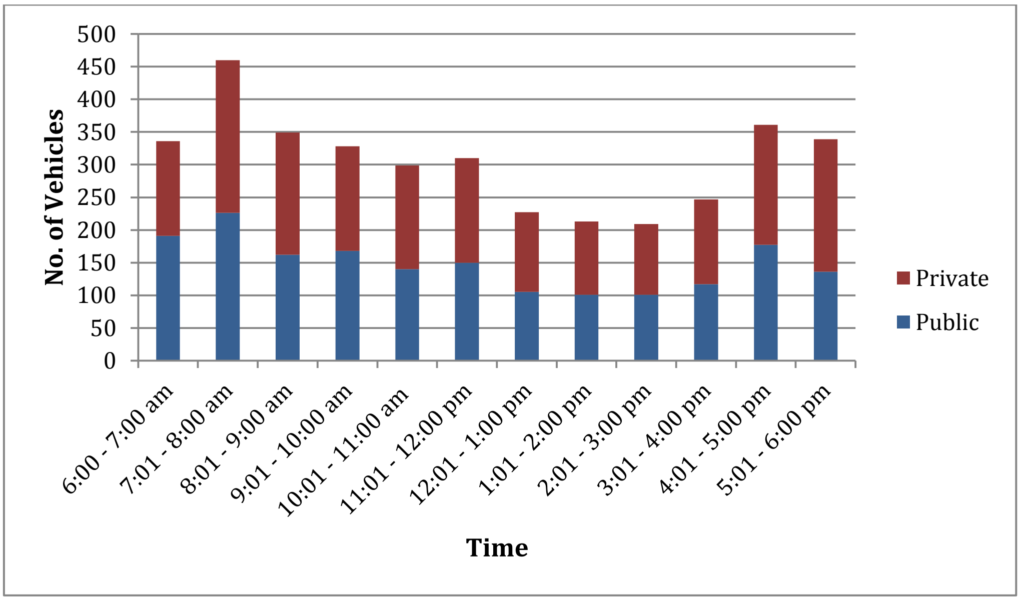


Figure EP-19b. Weekday Traffic Volume per Time Period (Station 2 – Luna to Bangar/Balaoan)

4.5.5 Comparison of Weekend and Weekday Traffic Volume

For the first station composed of four routes along Bacnotan – Luna road as well as Brgy. Darigayos road, vehicles observed both weekend and weekday totaled to 4,562 vehicles. Comparing the two sampling dates, data showed that the weekend sampling tallied only a little higher volume at 50.3% compared to that of the weekday at 49.7%. The trend is represented in **Figure EP-20**.

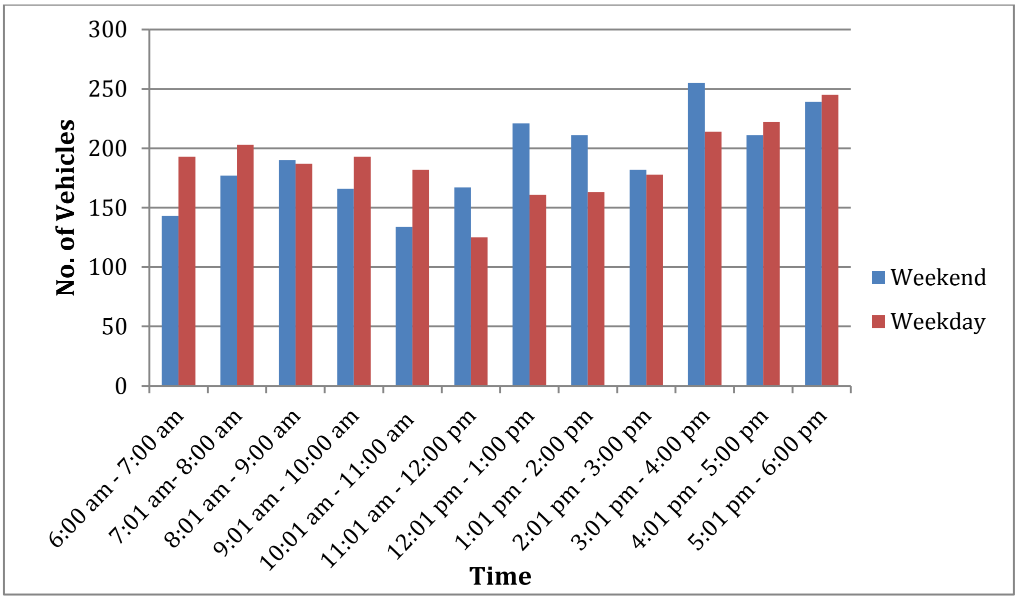


Figure EP-20. Comparison of Weekend and Weekday Traffic Volume for Station 1

On the contrary, opposite trend was recorded for Station 2 (**Figure EP-21**). Of the total 21,582 vehicles observed for the station from 6:00 am to 6:00 pm, 11,038 were tallied on the weekday sampling (51%) while only 10,544 were seen during the weekend. Though opposite trend is observed, the difference is also relatively small.

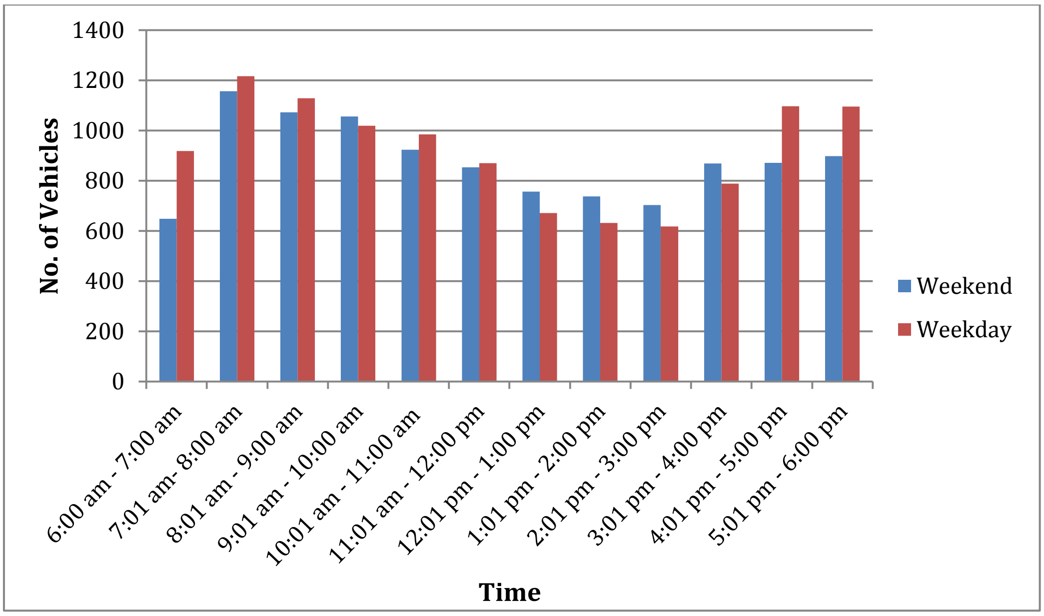


Figure EP-21. Comparison of Weekend and Weekday Traffic Volume for Station 2

4.5.6 Analysis and Summary of Findings

Tables EP-46 shows a summary of the findings of weekend and weekday traffic, respectively. Based on the findings, majority of the vehicles observed on both weekend and weekday were private transportation. The top recorded vehicle types are motorcycles which are frequent in Station 1 and which are frequent in Station 2. Big trucks, buses, minibuses, pedicabs and kuligligs are not observed to be using the route going to and from Brgy. Carisquis. There were generally little to none occurrence of buses and minibuses traveling in both stations.

Implementation of the project may alter the traffic situation in the project site and vicinity. During construction, equipment and materials will be delivered to the site. Hence, trucks and big vehicles will transport to and fro the site. Presence of big vehicles carrying construction materials as well as operating vehicles may also pose a threat to public safety, especially in areas near the project site.

Station 1, which is nearest to the project site and most likely be used by vehicles transporting materials from Manila, have higher volume of passing vehicles during the weekend and are mostly motorcycles. Traffic congestion is only expected during construction and is manageable by proper coordination with the LGU in implementing a traffic management plan. Schedule of construction activities and delivery of materials will also be developed. Traffic signs will be posted, both for prevention of traffic congestion as well as public safety.

Traffic congestion is not expected during the operation phase.

4.5.7 Summary of Potential Impacts to Traffic and Mitigation Measures

Table EP-47 summarizes the potential impacts and proposed mitigation related to traffic.

Table EP-47
Summary of Potential Impacts to Traffic during Construction and Operation

Project Phase and Potential Impact	Environmental Component Likely to be Affected	Description	Mitigation or Enhancement Measures
I. Construction Phase			
Increase in traffic	Traffic	Implementation of the project may alter the traffic situation in the project site and vicinity. During construction, equipment and materials will be delivered to the site. Hence, trucks and big vehicles will transport to and fro the site. Presence of big vehicles carrying construction materials as well as operating vehicles may also pose a threat to public safety, especially in areas near the project site.	• Traffic congestion is only expected during construction and is manageable by proper coordination with the LGU in implementing a traffic management plan. • Schedule of construction activities and delivery of materials will also be developed. • Traffic signs will be posted, both for prevention of traffic congestion as well as public safety.
II. Operations Phase			
Increase in traffic	Traffic	Traffic congestion is not expected during the operation phase.	• No mitigation measures needed.

Table EP-48
Summary of Weekend and Weekday Traffic Volume

Weekend	S1, R1	S1, R2	S1, R3	S1, R4	S2, R1	S2, R2	S2, R3	S2, R4
# Vehicles	1072	1001	131	92	2914	2091	1904	3635
% Public	30%	30%	43%	39%	44%	47%	53%	48%
% Private	70%	70%	57%	51%	56%	53%	47%	52%
Highest vol. of vehicles (Timeslot)	12:01 – 1:00 pm and 5:01 – 6:00 pm	3:01 – 4:00 pm	1:01 – 2:00 pm	8:01 – 9:00 am	7:01 – 8:00 am	7:01 – 8:00 am	9:01 – 10:00 am	7:01 – 8:00 am
Lowest vol. of vehicles (Timeslot)	6:00 – 7:00 am	10:01 to 11:00 am	12:01 – 1:00 pm	6:00 – 7:00 am	2:01 – 3:00 pm	12:01 – 1:00 pm	6:00 – 7:00 am and 2:01 – 3:00 pm	6:00 – 7:00 am
Highest vol. of vehicles (Vehicle type)	Motorcycle (41%), Tricycle (35%)	Motorcycle (40%), Tricycle (30%)	Motorcycle (54%), Tricycle (34%)	Motorcycle (51%), Tricycle (35%)	Tricycle (42%), Motorcycle (35%)	Tricylce (46%), Motorcycle (32%)	Tricycle (53%), Motorcycle (29%)	Tricycle (46%), Motorcycle (34%)
Other remarks	No Pedicabs, buses, minibuses, kuligligs	No Pedicabs, buses, minibuses, kuligligs	No Pedicabs, buses, minibuses, kuligligs, big trucks	No Pedicabs, buses, minibuses, kuligligs , big trucks	No Buses, minibuses	No Buses, minibuses	No Buses, minibuses	No Buses, minibuses
Weekday	**S1, R1**	**S1, R2**	**S1, R3**	**S1, R4**	**S2, R1**	**S2, R2**	**S2, R3**	**S2, R4**
# Vehicles	987	956	175	148	3056	2521	1783	3678
% Public	31%	39%	43%	43%	45%	46%	50%	48%
% Private	69%	61%	57%	57%	55%	54%	50%	52%
Highest vol. of vehicles (Timeslot)	5:01 – 6:00 pm	9:01-10:00 am	4:01 – 5:00 pm	5:01-6:00 pm	5:01 – 6:00 pm	4:01 – 5:00 pm	10:01 – 11:00 am	7:01 - 8:00 am
Lowest vol. of vehicles (Timeslot)	11:01 am – 12:00 pm	11:01-12:00 pm	11:01- 12:00 pm	11:01 am – 12:00 nn, 12:01 – 1:00 pm and 3:01 – 4:00 pm	1:01 – 2:00 pm	2:01 – 3:00 pm	2:01 – 3:00 pm	2:01 – 3:00 pm
Highest vol. of vehicles (Vehicle type)	Motorcycle (37%), Tricycle (23%)	Motorcycle (44%), Tricycle (28%)	Motorcycle (45%), Tricycle (41%)	Motorcycle (31%), Tricycle (29%)	Tricycle (43%), Motorcycle (37%)	Tricycle (45%), Motorcycle (32%)	Tricycle (50%), Motorcycle (33%)	Tricycle (47%), Motorcycle (34%)
Other remarks	No minibus and kuligligs	No buses, minibuses and kuligligs	No pedicabs, big trucks, buses, minibuses and kuligligs	No pedicabs, big trucks, buses, minibuses and kuligligs	No buses and minibuses	No buses	No buses, minibuses	No buses, minibuses

Legend:
S1 = Station 1 S1 R1 = Luna to Bacnotan S1 R2 = Bacnotan to Luna S1 R3 = Going to Brgy. Carisquis S1 R4 = Going out of Brgy. Carisquis
S2 = Station 2 S2 R1 = Balaoan to Luna S2 R2 = Bangar to Luna S2 R3 = Public Market to highway S2 R4 = Luna to Bangar/Balaoan

III. Environmental Risk Assessment

1.0 Rationale/Background

The Environmental Risk Assessment aims to identify the hazards and to qualitatively and quantitatively characterize the associated risks. Risk quantification focused on estimation of accident consequences (in terms of loss of human lives or injuries), on estimation of accident frequencies, and on determination of risk incidences, particularly the Location-specific Individual Fatality Risk (LSIFR) and of Societal Risk.

1.1 Scope

The various physical and chemical environmental hazards associated with the project were analyzed. This ERA focused on safety risks, which are characterized by low probability, high consequence, accidental nature and acute effects" in compliance with the *Procedural Guidelines for Scoping of Environmental Risk Assessment, Annex 2-7e of the Revised Procedural Manual of DAO 03-30* (EMB-EIAMD, 2007). It took into consideration the PAGASA-predicted climate changes, as expected by the years 2020 and 2050. It undertook the simulation of several accident scenarios for fire/explosion involving coal and other flammables, as well as hazards associated with release of toxic chemicals. Analyzed environmental hazards were fire/explosion arising from the storage and use of coal and light fuel oil (LFO) and acute toxicological hazards from substances that will be stored and used in the plant.

The scope of this ERA included the following aspects:

1. Hazard Identification;
2. Risk screening activity that included all substances projected to be used, handled, or stored at the Plant site;
3. Consequence analysis based on projected plant conditions, chemico-physical properties of hazardous substances, and meteorological data;
4. Use of accident scenarios and valid hazard endpoints in modeling postulated accident consequences;
5. Application of appropriate modeling tools in consequence analysis; and
6. Generation of consequence hazard footprints or maps

2.0 ERA Conceptual Framework

2.1 The Environmental Risk Assessment Process

Environmental risk assessment (ERA), as defined in the *Procedural Manual for DAO 2003-30*, is "the use of universally accepted and scientific methods to assess the risks associated with a project. It focuses on determining the probability of occurrence of accidents and their magnitude (e.g., failure of containment or exposure to hazardous materials or situations.)". Risk is defined as a measure of potential human injury/ death, economic loss, or environmental damage in terms of the probability and magnitude if these incidents occur. Risk involves two measurable parameters: consequence and probability. Risk refers to qualitative or quantitative measure of hazards associated with the proposed 2 X 300-MW net capacity coal-fired power plant project. It is the integrated result of the calculated consequence of a postulated accident scenario and the calculated probability or frequency of occurrence of postulated events.

2.2 General Risk Assessment Process

The general framework of this ERA is illustrated in **Figure RS-1.**

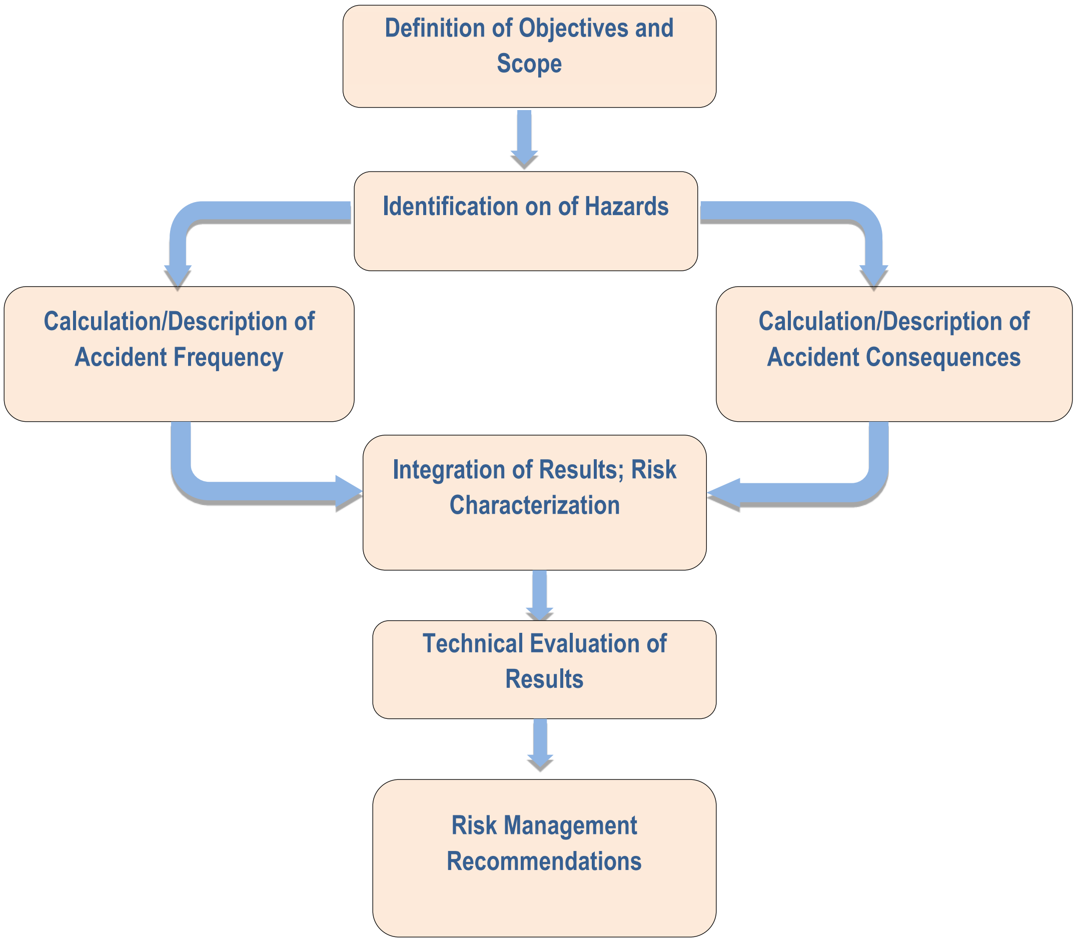


Figure RS-1. Flow diagram of the risk assessment process

2.3 Methodology

2.3.1 Hazard Identification

This stage involves the identification of various hazardous processes, activities and substances that could lead to disastrous or fatal incidents. The focus is on the substances' flammability and explosive and toxicity potential. All substances to be used, handled and stored at the project site were included in the risk screening. The potential of each substance to pose hazards to the environment, public, and the facility was analyzed based on a thorough review of its intrinsic physical, chemical and hazard characteristics. Risk screening was done according to the process and criteria described in the *Revised Procedural Manual of DAO 2003-30: Guidelines for the Conduct of Environmental Risk Assessment*, particularly *Annex 2-7e*. The risk screening procedure enabled the identification of substances that have to be included in the quantitative aspect of the risk assessment.

2.3.2 Consequence Analysis

Consequence analysis involves quantitative calculation or estimation of unwanted consequences, effects, impacts or outcomes of potential major hazard incidents in the facility based on a postulated accident scenario. Major hazard incidents include hazardous activities or substances that have impacts in terms of death, injury, evacuation of people, damage to property or lasting harm to the environment. It focuses on accident scenarios that involve the release of flammable, explosive and/or toxic substances.

Calculation of accident consequences was done in two steps. First, distances to specified endpoints or levels of concern of accident impacts were calculated. Secondly, the number of potential fatalities and injured people from the accident were estimated. Earlier derived calculations were used to generate footprints of the fatality or injury zones on the map of the project site, utilizing Google map and the software, MARPLOT®. Then the numbers of potentially affected population were estimated based on the number of counted houses/infrastructures that fall within the fatality zone.

2.3.2.1 Accident Scenarios

Accident scenario analysis was done to estimate the consequences of accidents or events in terms of number of potential fatalities and or injured. The postulated worst-case incidents did not take into account the effects of mitigation measures. The endpoints of concern are the acute effects in terms of fatality and injuries to people.

2.3.2.2 Calculation of Maximum Distances to Specified Levels of Concern (LOC)

For explosion accidents, distances to at least four levels of concern (LOC) of blast overpressures were measured. The overpressure LOC is a threshold level of pressure above which certain hazards may result. The blast overpressure endpoints and their relevance are summarized in **Table RS-1**.

Table RS-1
Levels of Concern for Blast Overpressure

Explosion Overpressure (psi)	Expected Damage/Relevance[1]
1.0	Possible serious injury due to flying glass and missiles; Probability of injury is 10%; Fatality not expected; Partial demolition of houses; Usually used as the threshold overpressure value for regulatory purposes by USEPA; Used to delineate the maximum Injury Zone.
3.0	20% chance of fatality to a person in a building. Used to Delineate the maximum Fatality Zone.
5.0	Nearly complete destruction of houses; Threshold of eardrum damage; 50% chance of fatality for a person in a building and 15% chance of fatality for a person in the open.
10.0	Threshold of lung damage; 100% chance of fatality for a person in a building or in the open; Complete demolition of houses

Sources: Taylor, 1994; USEPA, et al., 1990.

For fires, maximum downwind distances to specified thermal radiation levels of concern were calculated. The thermal radiation LOC is a threshold level of thermal radiation, the level above which a hazard may occur. Three thermal radiation endpoints were used in the consequence analysis for fire hazards. These endpoints are described in **Table RS-2.**

Table RS-2
Levels of Concern for Thermal Radiation Effects of Fires

Thermal Radiation Dose (kW/m^2)	Expected Damage/Relevance
5	People will feel pain after 13 seconds and receive second-degree burns after 40 seconds. Used to define the injury zone.
12.5	Used to define the 7% fatality zone after 20 seconds of exposure for persons not protected by clothing or shelter
35	Used to define the 100% fatality zone after 20 seconds of exposure for persons regardless of protection of clothing or shelter; This thermal radiation dose could burn clothing and houses

[1] "Guidelines for Hazard Analysis." Advisory Paper No. 6, Department of Planning. Sydney, Australia.

2.3.3 Frequency Analysis

Frequency analysis was undertaken using a historical data approach. Generic data of frequency of equipment failure and probability of events were based on peer reviewed data from the databases in the "TNO Red Book" of VROM of the Netherlands (*Methods for Determining and Processing Probabilities, 2005*) and/or from the UK HSE's *Failure Rate and Event Data for Use within Risk Assessments* (2012).

2.3.4 Risk Characterization

Risk characterization involves the integration of the results of the consequence analysis and frequency analysis. Associated risks were characterized and prioritized through the use of the two criteria prescribed by DENR, namely: (1) Location-specific Individual Fatality Risk (LSIFR), and the (2) Societal Risk FN-Curve. The Location Specific Individual Fatality Risks (LSIFR) were calculated and compared with the criteria set by DENR. The Societal Risk FN-Curves were also plotted to analyze the significance of the derived risk values vis-à-vis DENR's criteria.

2.3.4.1 Location-specific Individual Fatality Risk (LSIFR)

The ERA Guidelines in the Revised DAO 2003-30 has set 10^{-6} fatalities per year as the maximum acceptable individual risk criterion, subject to "supplemental guidelines that may be issued by the DENR Secretary". LSIFR is defined by DAO-2003-30 as "the risk of death to an individual person, if present 24 hours per day (in the open) at a particular location for a whole year". Its value can be interpreted as the probability for an individual to die in a year.

2.3.4.2 Societal Risk

DAO 2003-30 has set the acceptable societal risk criterion as an "FN curve with slope = -1 and with intercept at N = 1 of 10^{-3}, subject to supplemental guidelines that may be issued by the DENR Secretary. "F" is defined as the frequency of N or more fatalities per year. As such, it is the product of frequency of accidents (f, events/year) and the average number of fatalities per event (N).

2.3.5 Risk Management

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.

3.0 Risk Screening Results

3.1 Hazard Identification

In the context of this ERA, environmental hazards associated with the proposed project are fire/explosion accidents due to coal dust, fuel oil, and lube oil; toxic vapor cloud dispersion from catastrophic releases of toxic process/maintenance chemicals; potential to release very hot steam; inherent presence of high voltage electricity; and occupational hazards (exposure to toxic chemicals, electricity, extreme temperatures, high voltage electricity, etc.). Factors that may contribute to coal dust fire/explosion are shown in **Table RS-3**.

Diesel oil fire accidents may occur at the diesel oil storage tank or piping system. Turbines and transformers are susceptible to oil fires since these are insulated with lube oil. Fire accidents may happen in turbines and transformers due to ignition of pressurized oil releases (mostly due to malfunctioning bearings); ignition of accumulated oil pool from unpressurized oil leaks; and ignition of flowing oil (Moran, 2012).

The expected impact of PAGASA's predictions on climate change was also integrated in the risk analysis. Based on data provided by the project proponent, the following substances will be stored and used at the project site: coal, light fuel oil (diesel), sodium hydroxide (40%), hydrochloric acid (31%), and ammonium hydroxide.

The acute hazards associated with the various processes, substances and climate factors in the facility are shown in the hazard analysis matrix below **(Table RS-3)**.

Table RS-3
Hazard Analysis Matrix

Unit Operation/ Activity	Major Hazards	Initiating/ Contributing Factors
A. Coal Storage/Handling/Utilization and Energy Generation		
1. Coal Stockyards	• Coal fire/explosion	• Extremely high ambient temperatures; • Spontaneous combustion; • Presence of ignition sources in the vicinity or within the stockpiles; • Activities that create friction in the stockpiles; • Confining conditions; • Too high volatile contents of the coal; • Too high coal fines content; and • Sabotage
2. Coal Crusher/ pulverizer	• Coal dust fire/explosion	• Frictional sparks created by presence of foreign materials, such as tramp metals and spikes in the coal feed to the pulverizer; • Failure of inert gas source, introducing air into the pulverizer, subsequently igniting collected pyrites below the pulverizing bed; • Failure to follow inerting procedures; • Failure to follow proper isolation, clearing, start up or shutdown procedures; • Backing up of hot furnace gases into the pulverizer system; • Failure of explosion suppression and/or chemical isolation systems; • Substandard equipment; • Failure of or inadequate delagration detection and control systems for the equipment
3. Coal Dust Collectors (Bag Houses)	• Coal dust fire/explosion	• Ignition created by uncontrolled high static electricity due to typically high temperatures and coal dust suspension; • Entry of sparks, flames or smoldering embers from dust production areas; • Failure of explosion venting and/or explosion suppression; • Failure of or inadequate deflagration detection and control systems for the equipment
4. Pulverized Coal silos	• Coal dust fire/Explosion	• Entry of sparks, flames or smoldering embers from dust production areas from adjoining processes; • High static electricity; • Failure of or inadequate explosion suppression system; • Failure of or inadequate chemical isolation system; • Failure of or inadequate delagration detection and control systems for the equipment
5. Electrostatic Precipitators	• Fire/Explosion	• Continuous spark generation and mechanical rapping serve as inherent sources of ignition; • Failure of explosion venting system and/or chemical isolation systems; • Failure of or inadequate deflagration detection and control systems for the equipment
6. Steam Pipes and Boiler; Boiler House	• Release of extremely hot steam;	• Failure of equipment and pipes; • Failure of pressure detection and control systems;

Table RS-3 continued

Unit Operation/ Activity	Major Hazards	Initiating/ Contributing Factors
	• Fire/ explosion	• Uncontrolled pressure elevation due to obstruction and other factors; • Inadequate maintenance and housekeeping; • Earthquakes; • Extreme weather conditions (eg. very strong typhoons, tsunami, etc.)
7. Steam Turbines	• Fire/explosion	• Leaks in the lubrication or control oil system
8. Cable Channels, Room and Galleries	• Fire/explosion	• Overheating due to excess load resulting to short circuits
9. Other Factors	• Fire/explosion	• Frictional sparks from broken fans, ducting system, etc.; • Defective electrical equipment; • Accumulation of coal dusts in bends in ducting and dead areas; • Unplanned shutdown of the coal firing system; • Failure of component parts, lack of maintenance; • Inadequate housekeeping measures, allowing coal dusts to accumulate in various areas of the facility.
B. Liquid Fuel Storage (Diesel)	• Fire/ explosion following major releases/ spills	• Presence of ignition sources in the vicinity of storage tanks; • Hit by lightning;; • Breach of containment; • Mechanical impacts; • Exposure to fires and high heat of storage tanks; • Corrosion of tanks and accessories; • Defective or substandard materials; pipeline and/or pump failure • Vandalism
C. Storage of Hydrochloric Acid (32%)	• Toxic vapor cloud dispersion following major accidental release; • Corrosive ; • Causes severe skin and eye burns; mist or vapor • Extremely irritating to eyes and respiratory tract	• Spills/leaks from storage tanks; • Lack of or inadequate bunding system; • Earthquakes; • Severe weather conditions (very strong typhoons, etc.) • Damage to storage tanks, piping or accessories.
D. Storage of Sodium Hydroxide (50%)	• Contact with and inhalation of substance following accidental release; • Corrosive to body tissues and metallic materials; • Causes severe skin burns and eye damage	
E. Storage of Ammonium Hydroxide (23%)	• Toxic vapor cloud dispersion following accidental major release; • Extremely corrosive to skin, tissues and metals; • Toxic when inhaled; • Flammable/explosive vapors (may be released at 40.8^{o}C and above)	• Spills/leaks from storage carboys; • Inadequate ventilation and confined spaces in storage area; • Inadequate bunding system; • Elevated temperature in storage area • Physical damage to containers; • Impact to containers; • Failure to properly close containers; • As in "E. Storagfe of Ammonium Hhdroxide" above; • Fire in the vicinity
F. Electrical Hazards (mostly occupational)	• Electrical burns from flash arcs and direct contact with electricity • Electrical shocks from	• Inherent presence of electrical safety hazards inside the Plant; • Failure of electrical equipment and accessories; • Human error (non-compliance with operation protocols, etc.;); • Loitering in off limits areas of

Table RS-3 continued

Unit Operation/ Activity	Major Hazards	Initiating/ Contributing Factors
	direct contact with electricity	• Lack of/inadequate PPEs; • Poor or inadequate housekeeping; • Inadequate safety trainings and drills
G Climate Changes and Extremes (as predicted by PAGASA)	• Intensification of many aspects of risks	• Greater frequency of temperature extremes (≥ 35^{o}C)
1. Increased frequency and intensity of tropical cyclones	• Increased risks from fire/ explosions due to equipment/facility damages (eg. toppling of storage tanks; electrical posts, etc.) • Increased risks from direct contact with electricity	• Poor engineering design and zoning; • Poor maintenance of structures; • Defective warning systems; • Inadequate program/plan on Emergency Prevention and Response; • Failure to adequately integrate Disaster Risk Management considerations in the Plant's design and safety mgt plan; • Inadequate trainings and drills on emergency recognition, prevention and control.
2. Increased intensity and frequency of rains during rainy season	• Increased risks from fires due to more frequent shut downs and restarts; lightning hits; • Increased risks from contact with high voltage electricity due to flash floodsand wet conditions	
3. Drier dry seasons; increased ambient temperatures; greater frequency of extreme temperatures	• Increased risks from fire/explosions incidents; • Increased toxic risks from chemicals; • Increased risks from spontaneous combustion of coal	• Presence of ignition sources, especially near storage of fuel and chemicals; indiscriminate disposal of live cigarette butts; • Increased vapor pressures of stored fuel and chemicals contributing to greater volatilization of hazardous components; • Decreased water supply for fire suppression and control.

3.1.1 Risk Screening of Hazardous Substances at the Facility

According to *Annex 2-7e of the RPM of DAO 2003-30* conduct of an ERA is required if a proposed project will use, handle, transport, or store substances that are explosive, flammable, oxidizing, or toxic. The project would require an ERA as it involves the use of toxic, flammable and oxidizing substances. These hazardous substances are the following: coal, diesel, hydrochloric acid (31%), ammonium hydroxide (23% and sodium hydroxide (50%).

The level of ERA coverage is defined by the type of hazardous substance and the expected maximum inventory of this substance to be stored or handled at the project site at any one time. The levels of ERA coverage are as follows (*Annex 2-7e of the RPM of DAO 2003-30*):

- 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;
- 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 an Emergency/Contingency Plan based on the worst case scenario. The Plan shall be based on a Hazard Analysis study; and
- Risk screening level – specific facilities or the use of certain processes shall require the conduct of a risk screening study even if the projected or estimated inventory does not reach the threshold levels.

Potentially toxic substances were screened and classified according to level of toxicity based on procedure prescribed in the RPM of DAO 2003-30. Results of the screening and classification are shown in **Table RS-4**.

Table RS-5 shows the maximum amount of the identified hazardous substances that may be stored at the project site at any one time, their hazard classification, the corresponding DENR Threshold Inventory Levels (Level 1 and Level 2) for each of the substance, and the value of "q_n/Q_n".

As there is more than one hazardous substance involved, the risk screening procedure made use of the *Total Indicative Sum* (TIS) equation in deciding whether an ERA was to be undertaken. Based on the RPM of DAO 2003-30, the computation of the TIS should be based on the following equation:

$$\mathbf{TIS} = \frac{\mathbf{q1}}{\mathbf{Q1}} + \frac{\mathbf{q2}}{\mathbf{Q2}} + \frac{\mathbf{q3}}{\mathbf{Q3}} \ldots + \mathbf{qn/Qn}$$

Where: q = the quantity of hazardous substance
Q_x = the indicative threshold level of the dangerous substance

TIS computation yielded a TIS value 0.2386 for Threshold Inventory Level 1 screening (refer to Table RS-6). "q/Q" value for coal cannot be computed as there is no defined Threshold Inventory Level for combustible substances. Coal is classified as a combustible substance since its flash point is greater than 55°C. *Annex 2-7e of the RPM of DAO 2003-30* defines flammable substances as "substances and preparations having a flash point equal to or greater than 21°C and less than or equal to 55°C, capable of supporting combustion". Coal has a much higher flash point at above 127°C (Sprague, 2013). A layer of dust has ignition temperature of 170°C to 180°C while coal dust in a dust cloud has minimum ignition temperature of 440°C (Snell, 2013). The "q/Q" value of sodium hydroxide (50%) cannot be computed likewise as its category is below the "Low Toxicity" level, which has no defined value under the DENR's threshold Inventory Levels.

Table RS-5 shows the hazard description/ratings of each substance, the hazard category used in screening, the maximum possible inventory of the hazardous component, the DENR threshold inventory levels, and the value of "q/Q" and TIS.

Though coal cannot be considered as a flammable substance based on the technical definition of the term as described in Annex 2-7e of the RPM of DAO 2003-30, it was nevertheless included in the worst-case scenario analysis of the environmental risk assessment because of its combustibility, the potential for explosion of coal dusts, and the large amount of material involved.

Results of the risk screening procedure indicated that the level of ERA required was a Hazard Study coupled with recommendations on an Emergency Response Plan. Worst-case accident scenario (WCAS) modeling were done on substances deemed to generate relatively significant adverse impacts in terms of fire/explosion and/or toxic vapor cloud dispersion especially in cases of catastrophic loss of containment. WCAS modeling were conducted for the following substances: coal, diesel, ammonium hydroxide (23%) and hydrochloric acid (31%). Consequence (WCAS) modeling was not done on sodium hydroxide (50%) as this substance possess very low level of toxicity and its vapor pressure is so low or insignificant to generate enough toxic vapor clouds under normal circumstances of spillage.

Table RS-4
Screening and Classification of Substances for Toxicity Classification

Substance	Max. Inventory of Substance (tons)	Maximum Inventory of Hazardous Component (tons)	LC50 per 4-H, inhalation (rats)[2]	Vapor Pressure (bar) [3]	"a" value[4]	"b" value[5]	"a + b" value[6]	Toxicity Class
1. Hydrochloric acid solution (31%)	6.6	2.05 (as HCl)	2095 ppm	0.084	3	2	5	Low toxicity substance
2. Ammonium hydroxide solution (assumed at 23%)	1.12	0.26 (as NH_3)	2000 ppm	0.62	3	3	6	Low toxicity substance
3. Sodium hydroxide solution (50%)	11.4	5.7 (as NaOH)	1463 ppm	0.008 at 40°C	3	1	4	Below low toxicity substance

[2] Lethal Concentration 50 for rats for 4-hours of continuous exposure to the substance through the inhalation route.
[3] Vapor pressure at 30°C, unless specified.
[4] The "a" value refers to the calculation number that is based on LC50 (Table 2, Annex 2-7e, Revised Procedural Manual for DAO 2003-30).
[5] The "b" value refers to the calculation number that is based on the physical properties of the substance (Table b, Annex 2-7e, Revised Procedural Manual for DAO 2003-30).
[6]The "a+b" values range from 6 to 10, with "6" representing low toxicity substances and "10" representing the extremely toxic substances (Table 1, Annex 2-7e, Revised Procedural Manual for DAO 2003-30).

Table RS-5
Screening of Hazardous Substances to be Stored/Used at the Project Site

Substance	Hazard Ratings/ Description	Hazard Classification (as screened)[7]	Maximum Inventory of the Substance (tons)	DENR Level 1 Threshold Inventory[8] (tons)	DENR Level 2 Threshold Inventory[9] (tons)	q_n/Q_n value for Level 1
1. Coal	NFPA Hazard Rating: Fire – Slightly Flammable (1); Health – slight (1)	Combustible substance	117,000	None defined	None defined	Not applicable
2. Diesel	NFPA Hazard Rating: Fire -Moderately flammable (2); Health – slight (1)	Flammable substance	420.5	5,000	50,000	0.0842
3. Hydrochloric acid (31%)	SAF-T-DATA Rating: Health hazard - severe (3); Contact – 4 (extremely corrosive); Fire – 0 (not flammable); not explosive	Low toxicity substance	6.6 (as HCl 31% solution)	50 50	200 200	0.132
4. Ammonium hydroxide (23%)	NFPA Hazard Rating: Health –3 (high), Fire – 1 (slight), reactivity – 0 (normally stable); Corrosive	Oxidizing Substance Low Toxicity Substance	1.12 (as NH_4OH 23% solution)	50 50	200 200	0.0224
6. Sodium hydroxide (50%)	NFPA Hazard Ratings: Health – 3 (high), Fire – 0 (insignificant), Reactivity – 1 (slight); Corrosive	Below Low Toxicity substance	11.4 (as NaOH 50% solution)	None defined	None defined	Not applicable
TIS						**0.2386**

[7] For toxicity hazard category, refer to **Table RS-4**
[8] At this level or greater, preparation of emergency/contingency plan is required.
[9] At this level or greater, preparation of QRA is required.

3.1.2 Characteristics of Identified Hazardous Substances

Coal and liquid fuel (diesel) are the primary substances identified to have potential for fire and/or explosion hazards. Hydrochloric acid, ammonium hydroxide and sodium hydroxide are all corrosive substances that pose hazard if contacted with the skin and body tissues or if vapors are inhaled. These substances also exhibit below low toxicity to low toxicity characteristics.

3.1.2.1 Coal

Coal is a solid fossil fuel that originated from the remains of plants in swampy ecosystems. Water and mud saved the plant remains from oxidation and biodegradation. A readily combustible black or brownish-black rock, coal is primarily composed of carbon along with assorted other elements, including sulfur. Coals are usually classified by rank, according to the degree of metamorphism.

Coal dust explosion and fire are among the major hazards in coal-fired power plants. Though readily combustible, coal is not classified as highly flammable material. It is a complex mixture containing variable amounts of volatile combustible matter, the components of coal (except for moisture) which are released or volatilized at high temperature in the absence of air. The presence of coal dust and the co-presence of methane, a flammable gas, influence the potential of coal for flammability. In coal utilization, it is the process, rather than the coal itself, that may present fire and explosion hazards. Further, the flammability of coal could vary with its origin (geological characteristics), the percentage of volatile matter and the calorific value, factors that influence the ease of combustion (Bingham et al., 2001).[10] Although it has been demonstrated that methane and other short-chained hydrocarbons (ethane, ethylene, propane, propylene and butane) may be present in coal with no apparent methane emission, the amount of these residual gases is very minimal. Based on the study by Kim and Douglas (1973), the amount of residual gases in coal merely ranges from 0.0007 to 0.524 ft^3/ton of coal.[11]

An analysis of the coal (to be imported from Indonesia) to be used in the project, is shown in **Table RS-7.**

Table RS-7
Coal Analysis for High Gross Calorific Value Specification

Parameters	Minimum	Guaranteed	Rejection	Unit
Quality Parameters				
Gross calorific value (ARB)	6,100	6,200	<6,100	kcal/kg
Total moisture (ARB)	-	8	>13	%
Total sulfur (ADB)	-	0.6	>1	%
Proximate Analysis (ADB)				
Ash	-	8	>13	%
Volatile matter	-	34-40	-	%
Fixed carbon	-	34-40	-	%
Inherent moisture	6	-	-	%
Hard grove grindability index	40	-	>50	
Nominal size, 0-50mm	-	90	-	%
Rejection >100mm	-	-	-	
Fines <2mm	-	-	>20	

[10] Patty's Toxicology, Fifth Edition, Volume 1, Edited by Eula Bingham, Barbara Cohrssen, and Charles H. Powell, Jonh Wiley & Sons 2001 (cited in http://www.hc-sc.gc.ca/ewh-semt/pubs/occup-travail/whmis-simdut/compli-conform/index_e.html).
[11] A.G. Kim and L.J. Douglas. *Gases Desorbed from Five Coals of Low Gas Content*. Bureau of Mines Report of Investigations/ 1973**.** U.S. Department of the Interior. (From www.cdc.gov/niosh/mining/pubs/pubreference/ri7768.htm).

Explosion/Fire Hazards of Coal

Coal dust explosion requires the following five necessary elements, referred to as the explosion pentagon, to occur concurrently: fuel, heat, oxygen, suspension, and confinement. It should be noted that the first three elements (fuel, heat and oxygen) compose the so-called fire triangle. Removing any one of the five elements would prevent an explosion from propagating. For the fuel element, there are three prerequisites for coal dust to be explosive: (1) a volatile ratio exceeding 0.12, (2) particle size of 841 microns (0.841 mm) or less, and (3) the quantity of coal dust available at least meet the minimum explosive concentration (MEC), the quantity of dust in suspension that will propagate a coal dust explosion and generate sufficient pressure to cause damage. MEC for bituminous coal is approximately 100 grams per cubic meter. A person cannot breathe in an atmosphere containing dust at MEC. A layer of coal dust on the floor with potential to be at MEC if suspended is around 0.00127-mm thick, enough for footprints to be visible. Also, if coal dust is visible on the walls of a plant, it is considered to be enough to propagate an explosion (Stephan). The Indonesian coal has volatile ratio of 0.40 and size of coal dust particles could be 0.841 mm or less. As such, dust from this coal can explosive, if present in sufficient quantity and there are elements of confinement, oxygen, heat and suspension.

For the heat element, the ignition temperature of a coal dust cloud decreases as the volatile content increases. The ignition temperature of a coal dust cloud with high volatile content approaches a limiting temperature as low as 440°C. The ignition temperature of coal dust layer with high volatile content approaches a limiting temperature as low as 160°C (Stephan, n.d).

Confinement is a necessary element to complete the explosion pentagon. It keeps the fine coal particles in close proximity after being suspended. This proximity enables heat transfer to occur fast enough to allow continued propagation. If an explosion is vented to the atmosphere outside the plant, confinement is removed and only part of the coal forced out of the vent will be burned. The rest of the unburned coal dust will fall to the ground (Stephan, n.d).

The coal dust explosion hazard increases with decreasing coal particle sizes. Coal dust explosion hazard can exist in coal processing/utilization plants, such as in the proposed coal-fired power plant project. Particle sizes of coal that can propagate a dust explosion may occur within cyclone dust collectors, coal mills, dust collectors/bag houses, and coal feed bunkers (Alameddin and Luzik, 1987). Coal dust explosion may be triggered by spontaneous coal dust combustion or by ignition sources such as sparks. In coal feed bunkers fires may be triggered by unplanned shutdowns and power interruptions. During such events, coal in the bunker may undergo spontaneous combustion because of prolonged residence time. Exothermic reaction is accelerated in the confined space of the bunker, which could lead to uncontrolled heating and eventually to spontaneous combustion (General Electric, 2013).

Electrical or frictional sparks can also provide the heat source to initiate a fire or explosion, even in the absence of methane. Dust clouds of sub-bituminous coals can ignite with as little as 30 millijoules of energy. All coal dusts are predisposed to ignition when exposed to the frictional sparks of badly maintained machinery or in the presence of contaminating tramp metal (Stephan, n.d.).

Vulnerable Equipment and Processes to Coal Dust Explosion

The areas/equipment most susceptible to coal dust fire/explosion accidents are the coal silos/bunkers, coal conveyor belts, crusher building and coal pulverizers. Due to their propensity to accumulate coal dusts, at high risk to coal dust explosion are coal silos, bunkers and dust collectors (F.E. Moran Special Hazard Systems, 2012).

Studies on the causes of coal dust explosion accidents on coal-fired power plants show that coal-fired power plant equipment with the highest coal dust explosion potential are the following: coal pulverizer, dust collector, cyclone, electrostatic precipitator, coal storage bins and silos, and transport pipes and ducts connecting the vulnerable equipment. Of these equipment, the dust collectors (bag houses) had the highest frequency of explosion accidents. Causes of and predisposing factors to explosion include the following (Fike Corporation, 2001; FM Global Property, Jan. 2000; General Electric, 2013):

- Unplanned shutdowns and power interruptions leading to prolonged coal residence time in feed bunkers, which could lead to spontaneous combustion, fire and/or explosion;
- Failure of inert gas source in coal pulverizer, introducing air and subsequently igniting collected pyrites below the pulverizing bed;
- Failure to follow inerting procedures;
- Sparks created by foreign objects (eg. tramp metals and spikes) in the coal feed;
- Ignition created by uncontrolled high static electricity in the dust collector due to typically high temperatures and coal dust suspension;
- Entry of sparks, flames or smoldering embers from dust production areas into vulnerable equipment, particularly dust collectors, cyclones or electrostatic precipitators;
- Continuous spark generation and mechanical rapping in electrostatic precipitators serve as inherent sources of ignition;
- Poor equipment maintenance (eg. broken fans can generate frictional sparks); and
- Poor housekeeping can lead to build up of coal dusts in bunkers, crusher house, hidden crevices and others, predisposing to coal fire and explosion.

Explosion/Fire Hazards in Coal Stockyards

Coal dust explosion in open areas where coal is massively stored or handled, as in the stockyard, is highly unlikely due to the absence of the confinement element of the explosion pentagon. The coal stockyard is simply a roofed but open area that is well ventilated and far from combustible structures and populated areas. The worst-case accident scenario that could occur is a flaming fire resulting from uncontrolled/unchecked smoldering of coal. Uncontrolled smoldering/combustion of coal dust below the surface can volatilize flammable gases from the volatile combustible matter of coal to generate flames that may spread rapidly on the surface. The component of coal that will take part in the combustion process will be limited to the volatile combustible matter. Volatile matters in coal are the components of coal, except for moisture, which are liberated at high temperature (900-950^{o}C) in the absence of air. An index of gaseous fuels present in coal, volatile matter includes methane, hydrocarbons, hydrogen and carbon monoxide, and incombustible gases like carbon dioxide and nitrogen that are found in coal. Indonesia coal has approximately 42% volatile matter.

Severe fires are unlikely in coal stockyards if the area is installed with adequate and proper fire detection and control systems. In fact, of the 26 fire and explosion accidents investigated by MSHA from 10 June 1977 to 4 February 1985 in coal-fired cement plants throughout the United states, none occurred at the coal stock yard.

3.1.2.2 Light Fuel Oil (Diesel)

Fire Hazards of Diesel

Diesel is a moderately flammable liquid fuel. The National Fire Protection Agency (NFPA) of the U.S.A. assigns to diesel a Flammability Rating 2 (ignites when moderately heated). Distillation temperature of diesel at 90% point is between 282-338^{o}C. Its minimum flash point temperature is 52^{o}C. Its other physic-chemical and toxicological properties are listed in **Table RS-8**.

Table RS-8
Physico-chemical and Toxicological Properties of Diesel

Property	Value/ Description
CAS RN No(s).	68334-30-5; 68476-30-2; 68476-31-3
UN Number	1993
Maximum Inventory at the Site	500 m^3
Flammability Designation/Code	Moderately Flammable
Flash Point, °C	52
Lower flammability limits in air (%)	1.3
Upper flammability limits in Air (%)	6
Autoignition Temperature, °C	254-285
Boiling/Condensation point (°C) at 1 atm	282-338
Specific gravity (liquid)	0.841 at 16°C
Vapor pressure	0.0028 bar at 21°C

Health Hazards of Diesel

Diesel is assigned an NFPA Health Hazard Rating of 1, meaning that it is slightly hazardous to health. The slight health hazard associated to the substance is mainly due to its volatile organic compound components (VOCs), which is approximately 1.5% of its total weight. VOCs from diesel may include benzene, toluene, ethylbenzene, xylene and other alkylbenzenes. High level exposure to these substances usually results to disorientation, euphoria, giddiness and confusion, progressing to unconsciousness, paralysis, convulsion, and death from respiratory or cardiovascular arrest. Chronic exposure to levels above the threshold level values may result to specific organ toxicity.

Table RS-9 provides the short-term exposure limits (STEL) and threshold level values in time weighted average (TLV-TWA) of the various VOC components of diesel. STEL is the maximum concentration of a substance to which workers can be continuously exposed for 15 minutes without suffering adverse health effects. The TLV-TWA is defined by the American Conference of Governmental Hygienists (ACGIH) as the average airborne concentration of a substance at which nearly all workers may be exposed for an 8-hour working day during a 40-hour week without suffering adverse health effects. It should be noted that these exposure limits are applied in a 40-hour working situation where subjects are mostly adults and not to household situations where children or the ill and elderly are included and are exposed for more than 8-hours per day (Hume and Ho, 1994).

Table RS-9
Threshold Limits of Air Concentration of Hazardous VOCs

Substance	STEL (ppm)	TLV-TWA (ppm)
1. Benzene	5	1
2. Toluene	200	300 (C)[12]
3. Ethylbenzene	125	100
4. Xylene	150	100

3.1.2.3 Hydrochloric Acid (HCl) 31% Solution

Hydrochloric acid is an aqueous solution of hydrogen chloride, an acidic gas. It is a colorless, watery liquid with a sharp, irritating odor. The solution produces toxic and irritating vapors when heated. Inhalation of fumes results in coughing and choking sensation, and irritation of nose and lungs. Contact with the liquid causes burns (USCG, 1999). Its hazard description and physico-chemical properties are in **Table RS-10**. Hydrochloric acid is not considered a fire hazard. It however reacts with metal or heat to release the flammable hydrogen gas.

[12] C = ceiling concentration.

The toxicity of hydrochloric acid is exerted through its corrosive effects. Inhalation of vapors can produce coughing, choking, and inflammation of the nose, throat, and upper respiratory tract. In severe cases, it causes pulmonary edema, circulatory failure and death. When contacted with skin, it can cause redness, pain and severe burns. Deep ulcers and skin discoloration may result from contact with concentrated solutions. Erosion of teeth may result from exposure to concentrated vapors. People with pre-existing skin disorders may be more susceptible to the effects of this substance.

Table RS-10
Physico-chemical and Hazardous Properties of
Hydrochloric Acid (31%), Ammonium Hydroxide (23%), and Sodium Hydroxide (40%)

Properties	HCl (31%)	NH_4OH (23%)	NaOH (40%)
CAS Number	7647-01-1	1336-21-6	1310-73-2
Physical form	Liquid	Liquid	Liquid
Flammability	Not flammable	Slightly flammable; may liberate flammable and explosive vapors	Not flammable
Vapor Pressure (bar)	0.084 at 30°C	0.62 at 30°C	0.008 at 40°C
Boiling Point °C at 1atm	50.6	40.8	145
Molecular Weight	36.46 as HCl	35.05 as NH_4OH	34.01as NaOH
% Volatile by volume	100% at 21°C	100% at 100°C	Not applicable
Density at 15°C	1.05 g/mL	0.768 g/mL	1.53 g/mL at 15.5°C
Exposure Limits/ Guidelines			
STEL in air	5 ppm (ACGIH TLV ceiling)	35 ppm (as NH_3 vapor)	2 mg/m^3 (ACGIH)
TLV-TWA in air	2 ppm (ACGIH)	25 ppm (as NH_3 vapor)	2 mg/m^3 (OSHA)
IDLH[13] in air	50 ppm (CAMEO)	300 ppm (NIOSH)	
AEGL-1	1.8 ppm	30 ppm	Not listed
AEGL-2	22 ppm	160 ppm	Not listed
AEGL-3	100 ppm	1100 ppm	Not listed
Hazard Ratings	SAF-T-DATA Rating System	NFPA Rating System	NFPA Hazard Rating System
Health Hazard	3 – severe poison	3 – highly toxic	3 – high
Flammability Hazard	0 – non-flammable	1 - slight	0 – insignificant
Contact Hazard	4 – extremely corrosive	4 – extremely corrosive (SAF-T-DATA)	Corrosive (no rating provided)
Reactivity Hazard	2 – moderately reactive	0 – not reactive	1 - slight
LC50 (inhalation, rats)	3124 ppm (1- hr)	2000 ppm (4 hrs)	1463 ppm (4 hrs)

Brief Explanation of Some Toxicological Terms

Acute Exposure Guideline Levels (AEGLs) are toxic levels of concern (LOCs) that can be used to predict the area where a toxic gas concentration might be high enough to harm people, including sensitive individuals. The National Research Council's National Advisory Committee on AEGL's of the USA is responsible for its development. AEGL's are threshold limit values that are meant to protect nearly all people, including sensitive individuals. AEGL-1 is the level at which notable discomfort, irritation, or certain asymptomatic nonsensory effects are felt. The effects however are transient and reversible upon cessation of exposure. AEGL-2 is the level at which people "experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape". At AEGL-3 people begin to manifest life-threatening health effects or death (ALOHA 5.4.7 ® Help).

[13] IDLH – Immediately Dangerous to Life and Health

3.1.2.4 Ammonium Hydroxide (assumed as 23% solution)

Also known as aqua ammonia, ammonium hydroxide solution ($NH_4OH + H_2O$) is a colorless liquid with a pungent odor. The concentrated solution to be kept at the plant is assumed to be in the form of 23% ammonia (23% anhydrous ammonia, 77% water). **Table RS-9** shows the general physico-chemical and toxicological properties of ammonium hydroxide solution. Ammonia (NH_3) is the hazardous component of ammonium hydroxide. Ammonia vapor is released when ammonium hydroxide solution is heated to its boiling point (at 1 atm, 40.8°C for 23% solution, 31°C for 26.5%-27.5% solution, and 29˚C for 29.0%-29.9% solution). The vapor is lighter than air at 0.596 density (air = 1). Ammonium hydroxide is 100% soluble in water.

Fire and Explosion Hazards

With flammability rating of 1 (NFPA), the substance is considered as slightly flammable. The flammability limit of ammonia in air is 16% to 25% (listed as 15% to 28% by NIOSH). If uncatalyzed, its auto-ignition temperature is 651°C. Generally, ammonia is not a fire hazard outdoors. Indoors or in confined areas, however, ammonia may be a fire hazard, especially in the presence of oil and other combustible materials. Heat exposed storage containers may become explosion hazards if relief valves are defective. Nitrogen oxides can form as combustion product of ammonia. At temperatures above 450°C, ammonium hydroxide decomposes to hydrogen and nitrogen gases. Hydrogen gas is highly flammable and explosive.

Health Hazards

Irritant and corrosive to the skin, eyes, respiratory tract and mucous membranes, ammonia may cause severe chemical burns to the eyes, lungs and skin. Exposure to this substance may also aggravate existing skin and respiratory diseases. The substance is not recognized or listed as a carcinogen. Routes of exposure to ammonia vapors are through eye and skin contact and inhalation. For the ammonium hydroxide solution, routes of exposure include contacts with eyes and skin and ingestion. Effects of overexposure to ammonia vapor or ammonia solution include the following symptoms: eyes – tearing, edema or blindness; skin – irritation, corrosive burns and blisters; inhalation – severe irritation of the respiratory tract, bronchospasm, edema and respiratory arrest; ingestion – caustic burns to throat and gastrointestinal tract. Death from spasm, inflammation or edema may result from extreme exposure to the substance.

Chemical Reactivity

Ammonium hydroxide is generally stable at room temperature. In contact with acids, exothermic reaction results, ammonia vapors are released when enough heat is produced. Contact of the substance with chemicals such as mercury, chlorine, iodine, bromine, silver oxide or hypochlorites should be prevented as explosive compounds may result. Contact of the substance with chlorine may result to generation of chloramine gas, a primary skin irritant and sensitizer. The substance has a corrosive reaction with copper, brass, bronze, aluminum alloys, mercury, galvanized surfaces, gold and silver (Tanner Industries, Inc., May 2001).

3.1.2.5 Sodium Hydroxide (40%)

Also known as caustic soda solution, lye solution, sodium hydrate solution, and white caustic solution, sodium hydroxide (NaOH) 40% solution is a water white liquid with no appreciable odor. The substance is generally corrosive to body tissues and metallic materials. At this 40% concentration, the substance is severely irritating to the eyes and skin. When contacted with the skin, it can cause major burns. Sodium hydroxide can aggravate skin and lung disorders. Being a strong base, it may react violently with acids. When spilled or disposed into water bodies or soil, it can greatly upset the pH condition of the environment and make it more basic.

Sodium hydroxide solution is not flammable or explosive. It is not expected to form any hazardous combustion products. Its impact on people is mainly through direct contact. As such, unless the substance flows out of the Plant perimeters through waterways, through overflows or through flooding events, its impact are expected to remain localized within the Plant premises. **Table RS-9** describes the pertinent physical, chemical and toxicological properties of sodium hydroxide. It is not classified or suspected as carcinogenic to animals or humans.

3.2 Consequence Analysis

3.2.1 Accident Scenario

The consequences of significant hazards in the facility were calculated using earlier identified methodologies. The consequences of the worst-case accident scenarios involving the said hazardous materials and/or activities were analyzed. The consequence analysis focused on significant hazards involving fire/explosion and/or toxicological hazards from coal dusts, liquid fuel (diesel) in storage, hydrochloric acid and ammonium hydroxide.
The accident scenarios were selected/ formulated based on the principle that such will give the highest accident consequences. As such, the highest possible amount of the substance of consideration was employed. For coal dust, the highest volume of pulverized coal is found in the pulverized coal feed silos (PC silos). As such the worst case analysis for coal dust explosion was assumed to take place in the silo. Coal density was assumed at 561 kg/m^3. The largest inventory of liquid fuel is found in the liquid fuel storage farm. These various accident scenarios are described in **Table RS-11.**

Table RS-11
Various Accident Scenarios Included in the Worst-Case Accident Scenario Analysis

Description of Accident Scenario	Scenario Designa-tion	Substance Involved	Equipment Description/ Location	Released Amount of Substance
1. Coal dust explosion in 1 coal silo (500 m^3 volume)	Coal Dust Explosion	Pulverized Coal	Pulverized coal silo	196.4 tons (silo is 70% full)
2. Diked area fire following catastrophic release of 1 diesel storage tank of diesel	Diesel Pool fire	Diesel	Diesel storage tank in tank farm	420.5 tons
3. Toxic vapor cloud dispersion following catastrophic release of HCl acid from storage tank	HCl-ToxVC	HCl	HCl storage tank	6.6 tons of solution
4. Toxic vapor cloud dispersion following catastrophic release of NH_4OH from 1 carboy.	NH_4OH-ToxVC	NH_4OH	1 carboy (60-L) of NH4OH at storage area	53.7 kg of solution

3.2.2 Consequence Estimation for Coal Dust Explosion in Pulverized Coal Silo

This scenario was chosen as the worst-case scenario for coal dust explosion at the coal-fired power plant, since the silo contains the biggest quantity of pulverized coal at this facility. The quantity of pulverized coal that would be involved in the explosion in the silo was assumed to be the maximum amount of pulverized coal contained in a silo (about 196.35 tons or 70% of the total mass contained in the 500-m^3 silo). Coal dust explosion was modeled as Unconfined Vapor Cloud Explosion that occurred secondary to a primary explosion that occurred inside the silo, which subsequently damaged it, releasing the entire contents of pulverized coal. The released contents subsequently ignited and exploded. Consequence calculation was done by first computing for the TNT equivalent mass of the coal dust involved. Then, distances for potential overpressure impacts were computed using the base equation used in the ARCHIE model for Unconfined Vapor Cloud Explosion. The equation used to compute for the TNT equivalent mass is described in the *Handbook of Chemical Hazard Analysis Procedures* (FEMA, et al, 1989, p. B-44) and is designated as Equation No. B.55.The equation is as follows:

$$\mathbf{M_{TNT} = M_{cloud} * (H_c/1155) * Y_f}$$

where: M_{TNT} = TNT equivalent mass, lbs
M_{cloud} = Mass of coal dust in cloud, lbs
H_c = Lower heat of Combustion of coal, kcal/kg
Y_f = Yield factor (assumed as 0.03)

The bases for the computation of the TNT equivalent mass (M_{TNT}) are shown in **Table RS-12.**

Table RS-12
Bases for the Computation of the TNT Equivalent Mass
for Postulated Coal Dust Explosion at Pulverized Coal Silo

Parameters	Value	References/ Comments
Mass of pulverized coal in a silo (Assumed at 70% full; 500 m^3 capacity silo)	196,350 kg (432,878 lbs)	Max capacity (280,500 kg) * 70%
Mass in cloud (M_{cloud}) (assumed 100%)	196,350 kg (432,878 lbs)	
Heat of combustion (H_c)	4,565kcal/kg	
Yield factor (Y_f)	0.03	FEMA, et al., 1989.; EC, 2015
Heat of TNT detonation (H_{TNT})	1155 kcal/kg	FEMA, et al., 1989
TNT Equivalent mass (M_{TNT})	29,939 kg (51,326 lbs)	Computed

Results of the calculations for the various distances to specified overpressure impacts and their relevance are in **Table RS-13.** The said distances are expectedly overestimated since the impediments posed by the walls of the silo and other structures are not taken into account in modeling.

Table RS-13
Computed Distances to the Various Overpressure Endpoints
for the Postulated Coal Dust Explosion at the Pulverized Coal Silo

Explosion Overpressure (psi)	Expected Damage/Relevance[14]	Max. Distance to Endpoint (m)	Number Potentially Injured Persons (External)
1.0	Possible serious injury due to flying glass and missiles; Probability of injury is 10%; Fatality not expected.; Partial demolition of houses; Usually used as the threshold overpressure value for regulatory purposes by USEPA; Used to delineate the maximum **Injury Zone.**	299	0
3.0	20% chance of fatality to a person in a building.Used to Delineate the maximum **20%Fatality Zone.**	141	0
05.0	Nearly complete destruction of houses; Threshold of eardrum damage; 50% chance of fatality for a person in a building and 15% chance of fatality for a person in the open. This delineates the **50% Fatality Zone**.	103	0
10.0	Threshold of lung damage; 100% chance of fatality for a person in a building or in the open; Complete demolition of houses. This delineates the **100% Fatality Zone**.	70	0

Summary of Consequences

The maximum distance to the threshold overpressure for possible serious injuries (1.0 psi)[15] is 299 meters, corresponding to a hazard zone that is mostly confined within the perimeters of the project site. Map overlay analysis, using MARPLOT® software, shows that there are no existing houses in the affected area. The 1 psi explosion overpressure zone however, traverses the existing Bacnotan-Luna-Balaloan Road, which traverses the

[14]"Guidelines for Hazard Analysis."Advisory Paper No. 6, Department of Planning. Sydney, Australia.
[15] USEPA uses 1.0 psi as the threshold limit for possible serious injuries in risk assessment modeling and for regulatory purposes.

proposed project site. The rest of the overpressure levels of concern lie well within the confines of the proposed project site.

The overpressure that may possibly result to 20% chance of fatality of persons within a building (3.0 psi) covers a radius of 141 m from the center of explosion. For purposes of this assessment, this radius will be regarded as the ***20%fatality radius*** for persons within buildings. The hazard radius for threshold lung damage and 100% fatality to persons within a building or in the open is 70 meters. The 20% fatality zone (radius of 141 m) will definitely not result to any external fatality. It may, however, put at risk personnel and workers staying within that zone at the time of the postulated coal dust explosion. So are the higher levels of concern. **Figure RS-2** shows the hazard footprints for the postulated coal dust explosion at the silo, respectively.

3.2.3 Consequence Estimation for Diesel Fire

The hazards associated with the storage and use of diesel at the power plant was evaluated. Vapor cloud explosions and vapor cloud fires are not significant hazards to this particular substance because of the low vapor pressure of the liquid (0.042 psia at 21°C). The assessment and calculations therefore focused on the fuel's potential to cause pool fires within bunded premises. It was assumed that the fire will be confined within the bunded area surrounding the fuel tank.

The derivation of downwind distances to specific thermal radiation levels were conducted using the pool fire equations (D-22 and D-23) described in USEPA-CEPPO's (1999) "*Risk Management Program Guidance for Offsite Consequence Analysis (RMPGOCA)*". The *Pool Fire Equations* are as follows:

$$q = \frac{f * m * Hc * \tau a}{4 * \pi * X\hat{}2} \qquad \textbf{(D-22)}$$

where:
- q = Radiation per unit area received by the receptor (Watts per square meter)
- m = Rate of combustion (kilograms per second)
- τ_a = Atmospheric transmissivity
- H_c = Heat of combustion (Joules per kilogram)
- f = Fraction of heat of combustion radiated
- x = Distance from point source to receptor (meters)

$$m = \frac{0.0010 * Hc * A}{Hv + Cp * (Tb - Ta)} \qquad \textbf{(D-23)}$$

where:
- m = Rate of combustion (kilograms per second)
- H_c = Heat of combustion (Joules per kilogram)
- H_v = Heat of vaporization (Joules per kilogram)
- C_p = Liquid heat capacity (Joules per kilogram-degree K)
- A = Pool area (square meters)
- T_b = Boiling temperature (K))
- T_a = Ambient temperature (K)
- 0.0010 = Constant

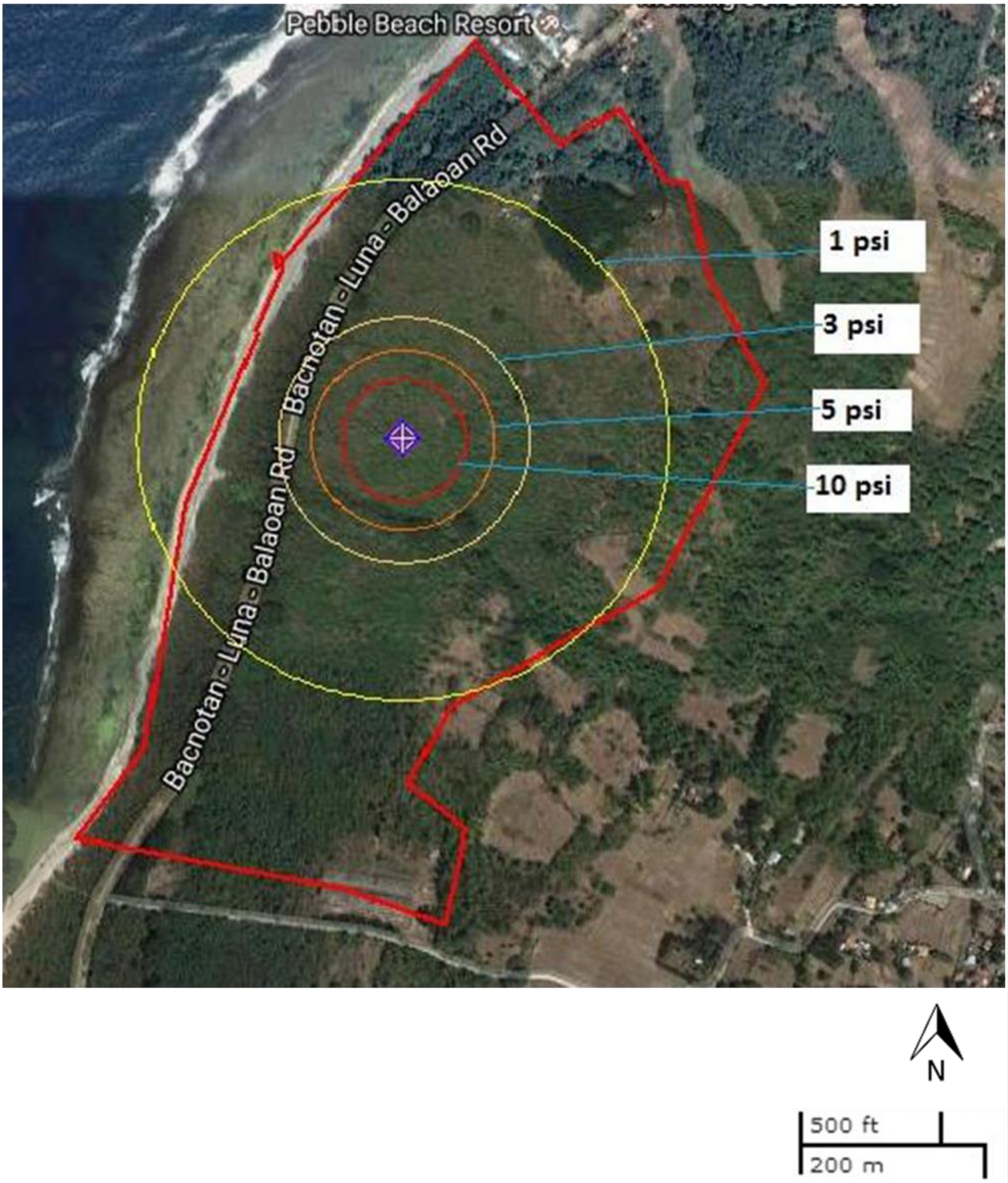


Figure RS-2. Hazard Footprints for the Postulated Coal Dust Explosion from the Pulverized Coal Silo	LEGEND: As above; and Project Site	SCALE: As above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: Base map: Google Earth Imagery Created by: Apercu Consultants_TDC (2017)	

Accident Scenario and Assumptions

Catastrophic failure of the storage tank was assumed, instantaneously spilling the entire contents of the 500 m^3-capacity (420.5 metric tons) diesel storage tank into bunded premises. Subsequent ignition was assumed to take place resulting to a bunded area fire. Ambient temperature was assumed at 30°C; the receiving ground surface is assumed to be concrete and relatively flat; the spilt liquid fuel spreads fully before igniting. External fatalities and injuries to persons were used as endpoint consequences of the Worst Case Accident Scenario (WCAS). Thermal radiation endpoints used were 5.0 kW/m^2, 12.5 kW/m^2, and 35 kW/m^2, the significance of which are shown in **Table RS-15**.

Table RS-14 shows the properties of diesel fuel and other variables that were used in computing for the distances to specific thermal radiation endpoints (injury radius, fatality radius, etc.) using Equations D-22 and D-23. The Microsoft program EXCEL® was used for the computations.

Table RS-14
Variables Used in the Calculation of Distances to the Various Thermal Radiation Endpoints

Variable	Value
Heat of Combustion (H_c)	45,000,000 J/kg
Fraction of Hc radiated (f)	0.1
Heat of Vaporization (H_v)	176,000 J/kg
Liquid Heat Capacity (C_p)	1,951.5 J/kg-K
Ambient Temperature (T_a)	303 K
Boiling Temperature (T_b)	583 K
Atmospheric transmissivity (t_a)	1
Constant	0.0010

Table RS-15 shows the results of the calculations of the distances to specific thermal endpoints or hazard radii. The "injury radius" (5 kW/m^2 thermal radiation dose) was estimated at about 47 meters from the burning pool of diesel. The fatality radius, on the other hand is about 26.3 meters from the burning pool. At a distance of about 23.6 meters from the fire, vegetation may burn and plastic materials can melt. At a distance of about 13.6 meters, persons exposed for 1 minute to the fire can quickly die; and process equipment, steel structures and steel pipes maybe damaged. Various hazard footprints were drawn on a map based on the calculated hazard radii. Then potential number of external fatalities and injured were estimated (refer to **Figure RS-3**). Based on the drawn hazard map, it is obvious that the hazard zones are confined to the vicinity of the fuel storage tanks and will not cause any external fatality or injury.

Figure RS-3. Hazard Zones Resulting from Bunded Diesel Fire Consequent to Catastrophic Failure of Diesel Storage Tank	LEGEND: As above; and Project Site	SCALE: As above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: Base map: Google Earth Imagery Created by: Apercu Consultants_TDC (2017)	PAGE 474

Table RS-15
Downwind Distance to Thermal Radiation Endpoints
and Number of Potential External Fatalities for Diesel Pool Fires

Thermal Radiation Endpoint (kW/m^2)	Endpoint Description	Hazard Radius (m)	Potential External Fatalities (persons)
5.0	People will feel pain after 13 seconds and receive second-degree burns after 40 seconds. Used to define the injury zone.	47	0
12.5	Used to define the 7% fatality zone after 20 seconds of exposure for persons not protected by clothing or shelter.	30	0
35	Used to define the 100% fatality zone after 20 seconds of exposure for persons regardless of protection of clothing or shelter; This thermal radiation dose could burn clothing and houses.	18	0

3.2.4 Consequence Estimation for HCl Toxic Cloud Dispersion

Catastrophic failure of a storage tank filled to capacity (6.29 m^3) with hydrogen chloride solution (32%) was assumed. The liquid was assumed to spill into a concrete bunded area of 6.5 m^2. Atmospheric stability condition was assumed to be neutral (Class D, wind speed = 6mps). Vapor release duration was assumed as 1 hour; ambient temperature = 30^{o}C.The toxic vapor endpoints made use of the Acute Exposure Guideline Levels (AEGLs) for HCl, which are as follows: AEGL-2 = 18 ppm, AEGL-2 = 22 ppm (injury radius), and AEGL-3 = 100 ppm (fatality radius). The worst case scenario analysis considered the impacts of toxic vapor cloud dispersion from the spilled hydrochloric acid (HCl) solution using the software, ALOHA® 5.4.7, a computer modeling tool used to calculate the downwind distances to toxic vapor endpoints and to map the hazard footprints. MARPLOT® was coupled with ALOHA® in mapping the hazard footprints on the project site.

Modeling Results

The maximum downwind distances to the specified toxic vapor endpoints AEGL-1 (discomfort zone), AEGL-2 (injury zone) and AEGL-3 (possible fatality zone) are shown in **Table RS-16**. **Figure RS-4** show the hazard footprints due to toxic vapor cloud dispersion subsequent to catastrophic HCl spill into bunded area. Note that the toxic vapor cloud hazard footprint is elliptical in shape and only occupies a small portion of the hazard (injury or fatality) zone. The location of the ellipse depends on wind direction. For the depicted HCl injury footprint, wind direction is southwesterly.

Figure RS-4. Hazard Footprints of the 31% HCl Solution Worst Case Scenario Event	LEGEND: As above; and Project Site	SCALE: As above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: Base map: Google Earth Imagery Created by: Apercu Consultants_TDC (2017)	aperçu PAGE 476

Table RS-16
Downwind Distances to Toxic Vapor Endpoints and Number of Potentially Injured following Catastrophic Release of 31% Hydrochloric Acid Solution

Toxic Vapor Endpoint (ppm)	Endpoint Description	Hazard Radius (m)	Potential External Fatalities (persons)
AEGL[16]-1 (18 ppm)	The airborne above which the general population could experience notable discomfot, irritation, or certain asymptomatic nonsensory effects	159	0
AEGL-2 (22 ppm)	The airborne concentration above which the general population could experience irreversible or other serious, long-lasting adverse health effects	43	0
AEGL-3 (100 ppm)	The airborne concentration above which the general population could experience life threatening health effects or death	18	0

3.2.5 Consequence Estimation for 23% NH_4OH Solution Toxic Cloud Dispersion

Assigned a health rating of 3 (highly toxic) by NFPA, ammonium hydroxide when heated to its boiling point can release ammonia (NH_3) vapors, a substance that is irritant and corrosive to the skin, eyes, respiratory tract and the mucous membrane. It was therefore assessed for the acute toxic effects of its vapor cloud. ALOHA® 5.4.7 was used to calculate the downwind distances to toxic vapor endpoints. MARPLOT® was used to map the hazard footprint on the proposed project site.

Accident Scenario and Assumptions

One full carboy (60-L capacity) of 23% ammonium hydroxide was assumed to catastrophically spill into bunded premises measuring 0.25 m^2. It took one hour before clean-up was accomplished, such that the ammonia (NH_3) gas evaporated from the spilled pool of NH_4OH solution for one hour. Ambient temperature was assumed to be 30^oC and atmospheric stability was neutral (Class D), wind speed was 6 mps. The Acute Exposure Guideline Levels (AEGLs) for NH_4OH were used to define the injury and fatality radii. The injury radius corresponds to the AEGL-2 with NH_3 vapor concentration of 160 ppm while the fatality radius corresponds to AEGL-3 with NH_3 vapor concentration of 1100 ppm. AEGL-1 (discomfort zone) was likewise mapped.

Modeling Results

Table RS-17 shows the maximum injury radius and fatality radius for NH_3 vapor cloud dispersion as computed using ALOHA® 5.4.1. The injury and fatality zones falls within 23 meters and less than 10 m, respectively, from the edge of the bund walls surrounding the spilled NH_4OH carboy. The hazard zones are well within the Plant perimeters and are not expected to affect any communities outside of the Plant. It may, however, affect workers and personnel who happen to be within the said zones at the time of the accident. **Figure RS-5** shows the toxic vapor cloud hazard footprints of the catastrophic release of 1 carboy of 23% NH_4OH solution.

[16] AEGL = Acute exposure guideline levels

Figure RS-5. Hazard Footprints of the Catastrophic Release of a Carboy of 23% NH4OH Solution	LEGEND: As above; and Project Site	SCALE: As above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: Base map: Google Earth Imagery Created by: Apercu Consultants_TDC (2017)	PAGE 478

Table RS-17
Downwind Distances to Toxic Vapor Endpoints and Number of Potentially Injured Persons Following Catastrophic NH_4OH Release

Toxic Vapor Endpoint (ppm)	Endpoint Description	Hazard Radius (m)	Potential External Fatalities (persons)
AEGL-1 (30 ppm)	The airborne above which the general population could experience notable discomfot, irritation, or certain asymptomatic nonsensory effects	56	0
AEGL-2 (160 ppm)	The airborne concentration above which the general population could experience irreversible or other serious, long-lasting adverse health effects	23	0
AEGL-3 (1100 ppm)	The airborne concentration above which the general population could experience life threatening health effects or death	10	0

3.2.6 Summary of Results and Consequence Analysis

Table RS-18 below presents a summary of the results of the consequence analysis. No potential external fatality is expected from any of the postulated worst-case accident scenarios. None of the postulated accident scenarios, except the pulverized coal explosion accident, had hazard zones that went beyond the Plant perimeters. The pulverized coal dust explosion scenario produced an injury hazard zone that went a little beyond the Plant's perimeters towards the unpopulated beach area. All potential fatality zones however were confined within the Plant's perimeters.

Table RS-18
Hazard Radii and External Consequences of the Various Worst-Case Accident Scenarios

Substance	Accident Scenario and Designation	Level of Concern and Description	Potential Fatality Radius (m)	Potential External Fatalities (persons)
Pulverized Coal	Coal dust explosion involving 1 pulverized coal silo (Coal Dust Explosion)	3 psi (20% fatality for persons within a bldg.)	141	0
		5 psi (50% fatality for persons within a bldg.)	103	0
		10 psi (100% fatality)	70	0
Diesel	Diked area fire following catastrophic release of 1 storage tank of diesel into bunded premises (Diesel Pool Fire)	12.5 kW/m^2 (7% fatality zone for persons exposed in the open)	30	0
		35 kW/m2 (100% fatality zone)	18	0
HCl, 32%	Toxic vapour cloud dispersion following catastrophic release of 1 storage tank of HCl into bunded premises (HCl-ToxVC)	AEGL-3 (100 ppm, possible fatalities)	18	0
NH_4OH, 23%	Toxic vapour cloud dispersion following catastrophic release of 1 carboy (60 L) of hydrazine into bunded premises (NH_4OH-ToxVC)	AEGL-3 (1100 ppm; possible fatalities)	10	0

3.3 Frequency Analysis

3.3.1 Coal Dust Explosion

The bases and results of frequency estimation for coal dust explosion, which used the generic historical database approach, are presented in **Table RS-19.** The estimated frequency of occurrence of the postulated accident scenario for coal dust explosion involving one pulverized coal feed silo was **3.25 x 10^{-7}** event per year.

Table RS-19
Frequency of Accident Occurrence for the Coal Dust Explosion Accident Scenario in a Pulverized Coal Silo

Parameters	Value	Description	Reference
Basic Frequency of failure (BF_f) (per year)	5 x 10^{-6}	Catastrophic failure of large (>450 m^3) atmospheric, fixed position, single-walled vessel	(VROM, 2005) TNO Purple Book, p. 46; (HSE, 2012)
Probability of Ignition (P_{ig})	0.065	For heavy industry	(VROM, 2005) "TNO Purple Book"
Computed Frequency of Event (CF_e), per year	**3.25 x 10^{-7}**	BF_f x P_{ig}	(VROM, 2005) "TNO Purple Book"

3.3.2 Other Events

Table RS-20
Frequency of Failure (Ff) for the Containers of the Various Hazardous Substances

Substance and Type of Release	Container Volume (m^3)	Failure Rate/Unit	Unit	No. of Units	F_f (yr^{-1})	References for Failure rate
1. Diesel –catastrophic	500	5.00E-06	per tank/year	1	5.0E-06	(HSE, 2012), p.8
2. HCl – catastrophic	6.5	8.00E-06	per tank/year	1	8.0E-06	(HSE, 2012), p.10
3. NH_4OH – catastrophic	60 L	1.50E-06	per carboy/year	21	3.6E-05	(HSE, 2012), p.75

The frequency of event occurrence (F_e) for the various postulated event scenarios were estimated based on the computed frequency of failure per year (F_f) of the tanks or containers in combination with other factors, such as the probability of ignition for flammable substances. **Table RS-21** below shows the results of the computations for the F_e.

Table RS-21
Frequency of Occurrence (Fe) for the Various Event Scenarios

Event Designation	F_f (yr^{-1})	Prob. of Ignition (P_{ig})	F_e (events/yr)
1. Coal Dust Explosion	5.0E-06	0.065	3.250E-07
2. Diesel Pool Fire	5.0E-06	0.065	3.250E-07
3. HCl-ToxVC	8.0E-06	Not applicable	8.0E-06
4. NH_4OH-ToxVC	3.6E-05	Not applicable	3.6E-05

3.4 Risk Calculation and Characterization

Environmental risks from the postulated worst-case accident scenario were calculated and characterized from the results of the consequence and frequency analyses. Associated risks were calculated and described in terms of the two criteria prescribed by DENR, namely: (1) Location-specific Individual Fatality Risk (LSIFR), and (2) Societal Risk FN Curve.

3.4.1 Location-specific Individual Fatality Risk (LSIFR)

The Location Specific Individual Fatality Risk (LSIFR) for each event scenario at a particular location was calculated using the Equation for LSIFR as provided in the VROM's *Purple Book* (2005), which is as follows:

$$LSIFR = F_f * P_{ig} * P_m * P_\phi * P_d$$

Where: F_f : Frequency of failure of equipment (yr^{-1})
P_{ig} : Probability of ignition
P_m : Probability of weather stability-wind speed condition
P_ϕ : Probability of wind direction
P_d : Probability of death

3.4.1.1 Frequency of Failure of Equipment (Ff)

The F_f of the various storage containers for the various hazardous substances studied were earlier discussed in **Section 3.3.2** of this document.

3.4.1.2 Meteorological Probabilities (Pm, P_ϕ)

Meteorological probabilities for weather stability-wind condition and wind direction were not factored in the analysis due to paucity of data for the site. As such, the values of P_m and P_ϕ were simply assumed to be "1" in the computations.

3.4.1.3 Probability of Death

Exposure to Thermal Radiation from Pool Fires

The probabilities of death due to exposure to thermal radiation from pool fires were computed based on the Probit Equation as described in the TNO's "Purple Book" (VROM, 2005). The probabilities of death, for specific thermal radiation doses were computed and are shown in **Table RS-22** below.

Table RS-22
Probabilities of Death for the Various Thermal Radiation Doses

Radiation Dose, Q (KW/m^2)	Time (s)	Computed Probit Value, Pr	Pd
5	20	0.36	0
10	20	2.73	0.02
12.5	20	3.49	0.07

Exposure to Toxic Vapor Clouds (TVC)

The probability of death (Pd) due to exposure to a toxic cloud was calculated using a probit equation as described in TNO's "Purple Book" (VROM, 2005, p.5.3). The probit function for death due to toxic exposure is expressed in the following equation (VROM, 2005):

$$\mathbf{Pr} = \boldsymbol{a} + \boldsymbol{b} * \ln(\boldsymbol{C}^{\wedge}\boldsymbol{n} * \boldsymbol{t})$$

Where:

Pr : probit corresponding to the probability of death (-)
a, b, n : constants describing the toxicity of a substance (-)
C : Airborne concentration (mg/m^3)
T : exposure time (minutes, limited to maximum of 30 minutes)

Results of the computations for P_d due to exposure to AEGL-3 levels of toxic vapor clouds of NH_3 (liberated from NH_4OH) and HCl vapors were both below 1%. For purposes of LSIFR computations, the P_d values for both substances were assumed to be 1% probability of death.

3.4.1.4 Results of LSIFR Calculations

Results of the calculations and the bases of calculation of the Location Specific Individual Fatality Risk (LSIFR) for each event scenario are shown in **Table RS-23**. Also shown in the Table are the corresponding hazard radii for each LSIFR. **Figure RS-6** shows the LSIFR isopleths for the Pulverized Coal Explosion scenario.

Table RS-23
Bases of Calculations and Corresponding Hazard Distances for the Project

Scenario Designation	Hazard dose	F_f (yr-1)	P_{ig}	P_m	P_ψ	P_d	LSIFR	Hazard Radius (m)
1. Coal Dust Explosion	3 psi	5.00E-06	0.065	1	1	0.2	6.50E-08	141
	5 psi	5.00E-06	0.065	1	1	0.5	1.63E-07	103
	10 psi	5.00E-06	0.065	1	1	1	3.25E-07	70
2. Diesel Pool Fire	12.5 kW/m^2	5.00E-06	0.065	1	1	0.07	2.28E-08	30
	35 kW/m^2	5.00E-06	0.065	1	1	1	3.25E-07	18
3. HCl-ToxVC	100 ppm	8.00E-06	NA	1	1	0.01	8.00E-08	18
4. NH4OH-ToxVC	1100 ppm	3.60E-05	NA	1	1	0.01	3.60E-07	10

Summary: The computed LSIFR for each event scenario ranged from 6.50E-08 3.6E-07 chances of death per year, values which are all below the DENR's standard LSIFR value of 10^{-6} chances of death per year. The isopleths or hazard contours for all of the said LSIFR fall well within the perimeters of the Plant. As such, it could be concluded that environmental risks are within acceptable limits as far as the LSIFR criteria is concerned.

3.4.2 Societal Risk

Societal Risk was calculated by combining the results of the consequence analysis, in terms of number of fatalities, with the event frequency (F_e). The potential number of fatalities was earlier calculated in **Section 3.2.6** (**Table RS-18**). Event frequencies were earlier calculated in **Section 3.3.2, Table 5.3** of this document. Meteorological probabilities were not factored in the computations. **Table RS-24** shows the matrix of event consequences (in terms of fatalities to persons) and frequencies of events (F_e).

All significant hazard distances were confined within the limits of the project site's boundaries. As such, it can be expected that all potential fatalities resulting from the postulated accident scenarios are internal to the project or are project workers. There are no expected fatalities from the surrounding communities.

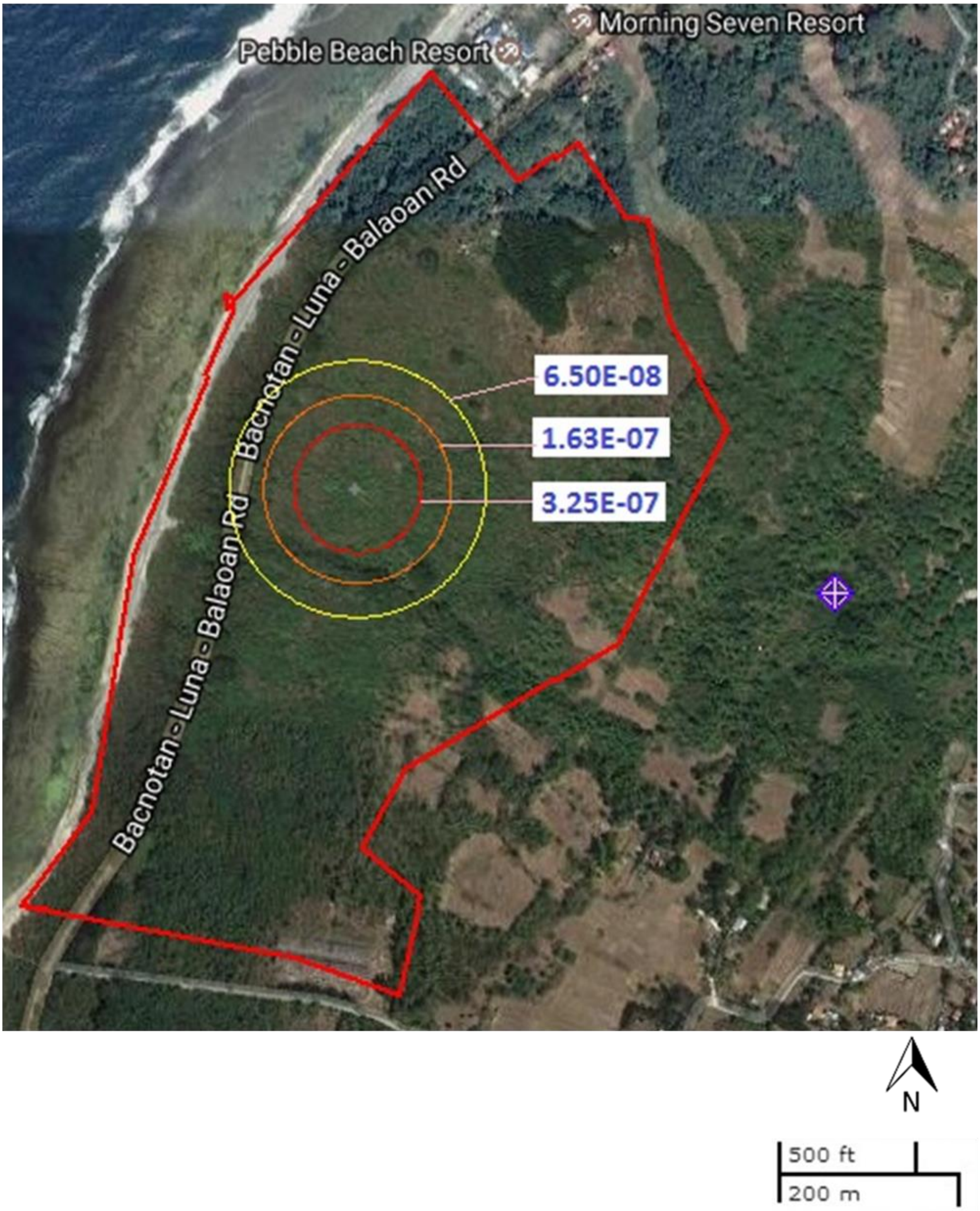


Figure RS-6. LSIFR Hazard Contours for the Pulverized Coal Explosion Scenario	LEGEND: As above; and Project Site	SCALE: As above
ENVIRONMENTAL IMPACT STATEMENT 2x335MW COAL-FIRED POWER PLANT PROJECT	DATA INFORMATION/SOURCE: Base map: Google Earth Imagery Created by: Apercu Consultants_TDC (2017)	PAGE 483

Table RS-24
Matrix of Potential External Fatalities and Event Frequencies of the Various Accident Scenarios

Accident Scenario and Designation	Level of Concern	Potential Fatality Radius (m)	Potential External Fatalities (persons)	Event Frequency (events/year)
Coal dust explosion involving 1 pulverized coal silo (**Coal Dust Explosion**)	3 psi	141	0	3.250E-07
	5 psi	103	0	3.250E-07
	10 psi	70	0	3.250E-07
Diked area fire following catastrophic release of 1 storage tank of diesel into bunded premises (**Diesel Pool Fire**)	12.5 kW/m^2	30	0	3.250E-07
	35 kW/m2	18	0	3.250E-07
Toxic vapour cloud dispersion following catastrophic release of 1 storage tank of HCl into bunded premises (**HCl-ToxVC**)	AEGL-3	18	0	8.0E-06
Toxic vapour cloud dispersion following catastrophic release of 1 carboy (60 L) of hydrazine into bunded premises (**NH_4OH-ToxVC**)	AEGL-3	10	0	3.6E-05

Since the study showed that no external fatalities were expected from the Project, based on the postulated worst-case accident scenarios, the societal Risk FN Curve was no longer constructed. It can be expected that societal risks arising from the Project are within acceptable limits.

Summary

Environmental societal risks associated with the storage and utilization of coal, diesel, HCl solution and NH_4OH solution are all within acceptable limits based on the Societal Risk Criteria set by DENR. The consequence analyses showed that neither external fatalities nor injuries are expected from even the most severe postulated accident scenario investigated.

4.0 Environmental Risk Management Program

The timely anticipation, recognition, elimination, reduction and control of hazards associated with the Project is paramount in the management of environmental risks. The appropriate management of environmental risks is beneficial not only to the public and the workers but more importantly to the economic well-being of the proposed coal-fired power plant project. Major considerations in risk reduction are appropriate plant design; compliance with standards in the design, construction and maintenance of the pulverized coal-fired power plant, equipment and facilities; well-maintained safety systems; well-trained and motivated workforce; and the establishment of an appropriate emergency response and contingency systems. **Table RS-25** below lists the recommended risk management measures for particular identified hazards.

Table RS-25
Recommended Risk Management Measures for Particular Hazards

Unit Operation	Hazards	Preventive and Control Measures
A. Coal Storage/Handling/Utilization and Energy Generation		
1. Coal Stockyards	• Coal fire/explosion	• Observe proper stockpiling procedures to avoid creation of frictional sparks; • Ensure that no ignition sources are in the vicinity of the stockpiles;

Unit Operation	Hazards	Preventive and Control Measures
		• Avoid confining conditions in the stockpiles; • Ensure that delivered coals are compliant with set specifications, especially on % volatile contents and % coal fines; • Ensure the security of the stockpiles from trespassers; • Ensure timely maintenance of conveyor system and other equipment in the stockyard; • Equip stockyards with fire detection and control systems (eg. automatic water spray system, CO and smoke detectors) • Good housekeeping to avoid accumulation of coal dusts, especially in confined places.
2. Coal Crusher/ pulverizer	• Coal dust fire/explosion	• Ensure that no foreign objects are introduced into the equipment to avoid frictional sparks (use of metal detectors and magnets to remove tramp iron); • Proper inerting of the system (use of O_2 deficient air under normal operating conditions); • Equip with temperature sensor and fire detection and control systems; • Contain the system or equip with an explosion suppression system; • Use of chemical isolation on the inlet and outlet of pulverizer to prevent flame propagation to other equipment
3. Coal Dust Collectors, Pulverized coal silos/bins, Electrostatic Precipitators	• Coal dust fire/explosion	• Protect with either explosion venting and/or explosion suppression systems; • Use of appropriate isolation system to prevent flame propagation to other equipment; • Equip with appropriate fire detector, control and fire suppression systems; • Ground dust collector bags or use semiconductor bags to prevent static electricity discharge; • Equipment design should be compliant with local and international fire/explosion standards and codes.
4. Steam Pipes, Boiler, and Boiler House	• Release of extremely hot steam; • Fire/ explosion	• Equip with pressure detection, fire detection and control systems; • Equip boiler house with adequate fire extinguishers and hydrant systems; • Regular and timely maintenance; • Good housekeeping
5. Steam Turbines	• Fire/explosion	• Equip with smoke, flame and/or heat detectors and control systems; fire extinguishing system (eg. automatic or semi-automatic water mist system, etc.);
6. Cable Channels, Room and Galleries	• Fire/explosion	• Equip with appropriate fire detection and control systems; • Equip with automatic water mist system
7. General Considerations	• Fire/explosion	• Install lighting arrestors in strategic areas; • Make available auxiliary power systems to operate key equipments in the event of power failure; • Eliminate/ control all ignition sources; • Welding and cutting operations should only be done with proper authority and in accordance with safety codes and guidelines; • Education and training on fire/explosion safety, prevention and control and on safety SOPs; • Safety procedures should be written; specific, readily accessible to all operating personnel; contain necessary information for system checkout,

Unit Operation	Hazards	Preventive and Control Measures

		warm up,shut down and emergency conditions; and regularly reviewed;
		• Regular conduct of fire fighting and response drills;
		• Develop and implement a preventive maintenance program that include routine maintenance for equipment that are sensitive to breakdowns; and periodic inspections to ensure that equipments are in good operating conditions;
		• Implement good housekeeping practices:
		  ○ Ensure that there are no coal dust build up in all areas, especially in confined areas, duct bends and in dead areas Implement regular and timely maintenance of all equipments;
		  ○ Prevent dust accumulation by control of spillage, leakage and degradation of coals to fines;
		  ○ Clean and remove unnecessary combustible materials in the workplace.

B. Liquid Fuel Storage (Diesel)	• Fire/ explosion following major releases/ spills	1. Provide each tank with concrete bund containment equivalent to at least 110% of maximum inventory; 2. Install lightning arrestors in strategic areas to prevent lightning strikes; 3. Equip storage tanks with appropriate lever sensors to prevent overfilling that could lead to spills; 4. Design, construction and materials of storage tank are compliant with industry standards; 5. Install fire detection devices and fire control systems (eg. CO_2 deluge system, foam deluge system, cooling water spray, etc.) in the area; 6. Install sump pumps, spill drainage and treatment system; 7. Remove/reduce ignition sources in the area; 8. Ensure regular inspection and maintenance of tanks, pipings, valves, gauges and other accessories; 9. Maintain a safety radius or buffer zone around the faclity. 10. Set up and implement an effective spills and fire prevention and control program; 11. Ensure that chemical tank/container labels are readable and in standard format; 12. Good housekeeping practices 13. Implement necessary security measures to prevent any unauthorized persons from loitering in storage areas
C. Storage of Hydrochloric Acid (32%)	• Toxic vapor cloud dispersion following major accidental release; • Corrosive; • Extremely irritating to eyes and respiratory tract	• Also implement Recommendation Numbers 1, 2, 3 ,5, 7, 8, 9, 10, 11, 12, 13 of "B. Liquid Fuel"; • Other Recommendations: 1. Familiarize all staff and workers with the particular hazards of each chemical and the appropriate procedures to follow in case of accidental release; contact, inhalation and toxicity arising from the chemical; 2. Post the MSDS of each chemical in conspicuous and appropraite areas (eg. storage rooms, laboratories, etc.); 3. Ensure installation of hazard signages and labels describing the adverse effects of hazardous chemicals; 4. Ensure that appropriate PPEs are worn in the laboratory. 5. Separate from incompatibles (eg. water, metals and bases for HCl; water, metals and acids for NaOH)
D. Storage of Sodium Hydroxide (50%)	• Contact with and inhalation of substance following accidental release; • Corrosive to body tissues and metallic materials; • Causes severe skin burns and eye damage	

Table RS-25 continued

Unit Operation	Hazards	Preventive and Control Measures
E. Storage of Ammonium Hydroxide (23%) (stored in carboys)	• Toxic vapor cloud dispersion following accidental major release; • Extremely corrosive to skin, tissues and metals; • Toxic when inhaled; Flammable/explosive vapors (may be released at 40.8°C and above)	• Also Implement Recommendations Numbers 2, 5, 7, 9, 11, 12, 13 in "B. Liquid Fuel"; Recommendation Numbers 1, 2, 3, 4, 5 in "C. &D." above; 1. Store in cool, dry and well-ventilated area (temperature should not exceed 25°C for NH_4OH and 38°C for hydrazine); 2. Keep in a tightly closed container; 3. Separate from incompatibilities (eg. acids, water, metals, etc.for NH_4OH); 4. Protect from direct sunlight (for NH_4OH)
F. Electrical Hazards (mostly occupational)	• Electrical burns from flash arcs and direct contact with electricity • Electrical shocks from direct contact with electricity	• Ensure provision and wearing of appropriate PPEs by personnel and workers (eg. fire retardant clothing, gloves, safety shoes, etc.); • Put up signages to indicate electrical hazard areas; • Limit access to identified electrical hazard areas to authorized persons only
G. Climate Change (as predicted by PAGASA)	• Intensification of many aspects of environmental risks	• Integrate the factor of climate change in the design,. operational plans, safety program, and Emergency Prevention and Response Program (EPRP) of the power plant; • Orient, educate and train all personnel and workers on EPRP of the Plant, and SOPs in case of emergency.
1. Increased frequency and intensity of tropical cyclones; 2. Increased intensity and frequency of rains during rainy season	• Increased risks from fire/ explosions due to equipment/facility damages; more frequent shut downs and start ups; greater probability of lightning strikes • Increased risks from direct contact with electricity due to flash floods and wet conditions.	
3. Drier dry seasons; increased ambient temperatures; greater frequency of extreme temperatures	• Increased risks from fire/explosions incidents; • Increased toxic risks from chemicals; • Increased risks from spontaneous combustion of coal	

5.0 Emergency Preparedness and Response Plan (EPRP)

The project proponent is currently in the process of preparing an Emergency Preparedness and Response Plan. This plan will address particular hazards and risks associated with the Coal-Fired Power Plant Project such as the following:

- Fire and Coal Dust Explosion
- Steam Leaks/Steam Pipe Explosions
- Electrical Hazards
- Release of hazardous Toxic Chemicals (HCl, NH_4OH, NaOH, others)
- Extreme Natural Events (storm surge, tsunami, flooding, earthquakes, others)

The EPRP will likewise incorporate the following components:

- Objectives
- EPRP Organization
- Actions in Case of an Emergency
- Evacuation Procedures and Plan

Towards meeting any contingency, the Coal-Fired Power Plant should be well-equipped with fire detection, prevention and control equipment and facilities. Fire/explosion vulnerable equipment should be equipped with appropriate fire/explosion detectors, prevention, suppression and/or pressure venting systems. Storage tanks and containers for flammable liquids and chemicals should be provided with secondary containment systems, and fire prevention and control equipment/facilities (e.g. fire/smoke detectors, fire hydrants, fire suppressants, temperature-controlled storage rooms, etc.). A well-laid out evacuation plan should also be located in conspicuous places and should be well understood by all personnel and workers. Safety devices and early warning systems should be installed.

The entire workforce should be properly oriented on safety and emergency procedures and measures. Towards this, it should be ensured that trainings and drills on these matters be adequately planned and implemented. They should likewise be provided with appropriate personnel protection equipment (PPEs) such as safety shoes, fire retardant clothing, masks, ear mufflers, gloves, hard hats, etc. Workers and personnel should likewise be provided with adequate health monitoring and intervention especially on ailments and diseases related to their occupation. Of particular concern are occupation-related diseases and safety issues such as electrical shock and burns, fall from heights, pneumoconiosis and other respiratory diseases, and hearing loss.

6.0 Summary and Recommendations

Hazards associated with the Project are fire/explosion from storage and utilization of coal, liquid fuel and ammonium hydroxide; toxic and corrosive hazards from process and maintenance chemicals (HCl, NH_4OH, NaOH); electrical hazards; natural hazards; noise; air pollution; water pollution; and occupational hazards. The risk assessment focused only on fire/explosion hazards, toxic and corrosive hazards, and on electrical hazards as the other hazards are covered in other EIA components. The intensification of hazards by predicted climate changes were taken into consideration. Fire/explosions hazards and acute toxic hazards from chemicals were assessed both qualitatively and quantitatively.

The risk assessment covered both qualitative and quantitative aspects, though only substances and processes identified to exert significant impacts were included in the quantitative analysis. Risk screening was undertaken to prioritize the covered hazards to be included in the worst-case scenario analysis. The magnitude of consequences from postulated accident scenarios were quantified in two steps: (1) derivation of hazard distances using several modeling tools and equations (eg. ALOHA ver. 5.4.7, TNT equivalence, pool fire equation); and (2) mapping of hazard footprints using the MARPLOT® software. Frequency analyses were done using generic failure rates data from peer reviewed literatures (historical method). Based on the results of the consequence and frequency analyses, corresponding individual and societal risks were computed and compared with DENR standards for LSIFR and societal risk criteria.

Based on the consequence analysis conducted, no external fatality (fatality involving persons outside the facility) is expected from any of the worst-case accident scenarios postulated. Only the injury zone resulting from coal dust explosion originating from the pulverized coal silo reached some areas outside the perimeters of the Plant. The fatality zone from this accident scenario was confined within the Plant. The postulated accident scenarios from all other substances were all confined within the plant with minimal hazard footprints. The most severe worst-case accident scenario was due to the postulated coal dust explosion from the pulverized coal silo. It produced the longest potential fatality radius (141 m).

The highest accident frequency (3.6E-05 accidents per year) was due to the postulated release of NH_4OH solution from a carboy, subsequently liberating the toxic NH_3 gas. Potential fatality radius from the release, however, is limited to a 10-meter radius. All other accident scenario has approximate frequency value of 3.250E-07 to 8.0E-06 events per year. Analysis of the Location-Specific Individual Fatality Risks (LSFIR) and Societal Risks showed that risks associated with the various postulated worst-case accident scenarios are all within the "Acceptability" standards set by DENR. As such, it could be said that risks due to explosion/fire hazards and chemical toxicity hazards are within acceptable limits.

Table RS-26 below summarizes the results of the environmental risk assessment conducted. It shows the hazardous chemicals that were analyzed, the accident scenarios, the fatality radii, and the number of potential fatalities (external to the Plant), the event frequency, and the estimated LSIFR.

Table RS-26
Summary of the Results of the ERA Study

Accident Scenario and Designation	Level of Concern Zone/ Significance	Potential Fatality Radius (m)	Potential External Fatalities (persons)	Event Frequency (events/year)	LSIFR (chances of death/yr)
Coal dust explosion involving 1 pulverized coal silo (**Coal Dust Explosion**)	3 psi (20% fatality inside bldgs.)	141	0	3.250E-07	6.50E-08
	5 psi (50% fatality inside bldgs.)	103	0	3.250E-07	1.63E-07
	10 psi (100% fatality)	70	0	3.250E-07	3.25E-07
Diked area fire following catastrophic release of 1 storage tank of diesel into bunded premises (**Diesel Pool Fire**)	12.5 kW/m^2 (7% fatality for persons unprotected by clothing or shelter)	30	0	3.250E-07	2.28E-08
	35 kW/m^2 (100% fatality)	18	0	3.250E-07	3.25E-07
Toxic vapor cloud dispersion following catastrophic release of 1 storage tank of HCl into bunded premises (**HCl-ToxVC**)	AEGL-3 = 100 ppm (life threatening health effects)	18	0	8.0E-06	8.00E-08
Toxic vapor cloud dispersion following catastrophic release of 1 carboy (60 L) of hydrazine into bunded premises (**NH_4OH-ToxVC**)	AEGL-3 = 1100 ppm (life threatening health effects)	10	0	3.6E-05	3.60E-07

Major considerations in risk reduction are appropriate plant design; compliance with standards in the design, construction and maintenance of the pulverized coal-fired power plant, equipment and facilities; well-maintained safety systems; well-trained and motivated workforce; and the establishment of an appropriate emergency response and contingency systems.

Particular recommendations to mitigate and manage identified hazards are listed in **Table RS-25** in **Section 4.0** of this document**.** The proposed project should be appropriately designed, constructed and maintained. The design, construction materials, construction, equipment and maintenance procedures should conform to internationally recognized standards and to local laws. The infrastructures should be designed to withstand adverse natural calamities, especially in the face of climate change predictions. The personnel and workers should be adequately equipped with knowledge and skills in coping with various emergency procedures and in the prevention of such emergencies.

IV. ENVIRONMENTAL MANAGEMENT PLAN

GLEDC identified appropriate mitigation management measures for each of the identified potential impacts. Each environmental component which is likely to be affected, namely land, air, water, and people was addressed per project phase. GLEDC assumes responsibility for these mitigation management measures, while most costs are included in the project development cost. Financial arrangements are included in the MOA with the contractors. Table EMP-1 summarizes the management plan.

Table EMP-1
Environmental Management Plan for the 2x335MW Coal-Fired Power Plant Project

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
I. PRE-CONSTRUCTION PHASE						
II. CONSTRUCTION PHASE						
	A. The Land	Change/Inconsistency in Land Use	▪ Project site is compatible with the existing comprehensive land use and zoning plan of Luna – **the area is categorized as a special industrial zone.** ▪ A vegetated area will be created around the proposed coal fired power plant to separate the neighboring residential and tourism establishments.	GLEDC and contractors	Included in Project Development cost	Include in the MOA with contractors
		Project is in an area which constitutes the habitat of endangered or threatened species	▪ Secure a tree cutting permit ▪ Collect seedling of indigenous species and establish a nursery with these ▪ Establish a vegetated area using these indigenous species	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors
		Project site is an area frequently visited or had-hit by natural calamities – prone to storm surges and tsunamis	▪ Build the plant at an elevation at least equal to elevation of the national road	GLEDC	N/A	N/A
		Devaluation of land value as a result of improper solid waste management and other related impacts	▪ Comply with the Ecological Solid Waste Management Act of 2000 implemented by the LGU, such as: ○ Solid wastes diversion through re-use, recycle, and composting activities; ○ Solid wastes segregation from point of	GLEDC	N/A	N/A

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			waste source to "compostable", "non-recyclable", "recyclable"< "special wastes"			
		Change in surface landform/topography/terrain/slope	▪ Install appropriate slope protection. ▪ Remove loose rocks to prevent occurrence of rock fall ▪ Provide appropriate drainage design for roads that will be constructed to avoid road failure ▪ Provide appropriate drainage in the area of intermittent creek	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors
		Inducement of subsidence or collapse	▪ Conduct further geotechnical studies prior to construction to determine presence or absence of solution cavities and use the results as inputs to the detailed engineering designs to minimize the threat of subsidence ▪ Comply with the recommended foundation design based on the result of the detailed geotechnical studies	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors
		Soil erosion/loss of topsoil/ overburden and bank stability	▪ Limit excavation and land clearing to what is required for project construction. ▪ Stabilize stockpiles and provide enclosures for excavated soils to minimize occurrence of erosion and minimize sediment transport particularly during the rainy season. ▪ Prioritize major earthworks during the dry season ▪ Provide siltation ponds or silt traps around work areas ▪ Re-vegetate exposed areas	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors
		Change in soil quality/fertility	▪ Designate an equipment and vehicle maintenance area that is cemented and provided with proper drainage channels ▪ Inspect vehicles and machinery regularly. ▪ Use oil sumps in engine rooms and vehicle equipment maintenance areas. ▪ Collect and store oil sludge in oil sludge tanks	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			that are lined with impermeable materials. ▪ Dispose hazardous wastes through a DENR accredited hazardous waste transporter and treater ▪ Establish an ash pond that is lined with clay and HDPE			
		Vegetation removal and loss of habitat	▪ Establish a vegetated area around the project site. ▪ Collect seeds and wildlings of indigenous species such as narra, mahogany, bani, bolong eta, danglin, isis, and molave, prior to construction and use these to establish a nursery ▪ Limit vegetation clearing and movement of workers only to designated work areas	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors
		Threat to existence and/or loss of important local species	▪ Limit development activities within the proposed project area ▪ Delineate areas to be cleared to avoid unnecessary clearing ▪ Establish a nursery using important local species	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors
		Threat to abundance, frequency and distribution of important species	▪ Limit vegetation clearing only to designated work areas ▪ Establish a nursery using important local species on the buffer zone and identified tree-planting sites	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors
		Disturbance or loss of species due to habitat loss	▪ Limit vegetation clearing and movement of workers only to designated work areas ▪ Ensure compliance with all regulations relevant to minimizing noise generated from construction of the power plant	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors
	B. The Water	Change in drainage morphology/inducement of flooding/reduction in stream volumetric flow	▪ Design an efficient drainage system with silt traps and with a storm water outfall that discharges to the sea ▪ Re-align and/or reroute any affected portion of the intermittent creek or replace the natural	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			drainage system by providing a system of open canals to ensure that rainwater flow to the main storm water outflow will not be impeded ▪ Provide channel ditches and/or pipe drains to carry the generated flows, around work areas, to the main storm water outfall, especially before backfilling the existing drainage and depression in the project area			
		Change in stream, lake water depth	▪ The project is not expected to cause a change in stream depth. The intermittent creek within the project site will be re-aligned prior to construction of plant facilities.	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors
		Depletion of water resources/ competition in water use	▪ Freshwater demands of the power plant during both construction and operation phases will be supplied by a water service provider ▪ There are no NWRB water grantees within the project boundary. All water grantees are located upstream of the project site. ▪ If groundwater will be tapped, conduct groundwater study and apply for necessary NWRB permit prior to use of groundwater	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors
		Occurrence or aggravation of flooding in nearby areas	▪ Re-align and/or improve the channel of the creek draining the project site	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors
		Change/disruption in water circulation pattern, littoral current, coastal erosion and deposition	▪ Design the jetty, the intake and outfall pipes to minimize disruption of circulation patterns ▪ Ensure that construction activities will be confined only within necessary areas ▪ Establish levees and wave deflectors on the shore during the construction of the coastal structures	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors
		Change in water circulation pattern	▪ Design the jetty, the intake and outfall pipes to minimize disruption of circulation patterns	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
		Change in bathymetry	▪ Design and orient the jetty, and the intake and outfall pipes to minimize disruption of circulation patterns and prevent sediment build-up in the jetty area	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors
		Degradation of groundwater quality	▪ Schedule the construction activities during the dry season (as much as possible) ▪ Maintain construction equipment, machinery and trucks in good condition (e.g. free of oil leaks) ▪ Repair impaired machinery and vehicles in a designated and cemented maintenance area with equipped with proper drainage and oil absorbing materials ▪ Orient and train workers and contractors to effectively implement safe environmental management practices within the construction sites ▪ Provide on-site toilets and facilities at work areas ▪ Establish and implement ecological solid waste management plans	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors
		Degradation of surface water quality	▪ Create and implement a sedimentation and erosion control plan. Set up devices to retain sediments and materials and prevent these from being carried away by run-off ▪ Provide on-site toilets and facilities at work areas ▪ Establish and implement ecological solid waste management plans ▪ Re-vegetate construction sites to prevent erosion.	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors
		Degradation of coastal/marine water quality	▪ Create and implement a sedimentation and erosion control plan. Set up devices to retain sediments and materials that may find its way to the sea ▪ Dispose excess soil in order to prevent storm water from carrying the particles into the coastal	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			waters ▪ Orient and train workers and contractors to effectively implement safe environmental management practices within the construction sites ▪ Provide on-site toilets and facilities at work areas			
		Threat to existence, abundance, distribution and/or loss of important local species and habitat	▪ Use the EIA coral map to identify pathways of least disturbance to benthic life form communities in determining the most suitable location for the coastal structures ▪ Install silt curtains and adopt entrapment mechanisms to prevent sediments and silt from blanketing coral reef areas ▪ Protect and induce expansion of seagrass colonies ▪ Implement mangrove reforestation, where feasible ▪ Adopt engineering designs that will ensure that pipe lying will have the least disturbance to coral colonies ▪ Conduct coral transplantation, where feasible ▪ Avoid building of permanent structures in sensitive areas where bivalves are assessed to reproduce	GLEDC and contractors	Included in construction cost	MOA with EPC Contractor Include in MMT manual of operations
	C. The Air	Change in local micro-climate	▪ Establish a greening program in cooperation with PENRO	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors
		Contribution in terms of greenhouse gas emissions *Applicable only for projects with significant GHG emissions	▪ Regular maintenance of heavy equipment and motor vehicles to avoid amplified greenhouse gas emissions ▪ Install pollution control devices	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors
		Degradation of air quality	▪ Implement dust suppression measures such as water application and speed restrictions (15-20 kph), in active construction areas	GLEDC and contractors	Included in construction cost	MOA with EPC Contractor Include in MMT

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			▪ Vegetate non-structure areas to minimize wind erosion of topsoil ▪ Compact exposed soil surfaces ▪ Provide tarpaulin cover on trucks loaded with construction materials ▪ Haul spoils/excavated earth materials immediately after excavation ▪ Regular maintenance of heavy equipment and motor vehicles ▪ Install pollution control devices ▪ Construct stack with appropriate height to ensure effective emission dispersion			manual of operations
		Increase in ambient noise level	▪ Regular maintenance of mufflers of standby generators and other noise generating equipment ▪ Provision of ear plugs to workers directly exposed to high noise equipment ▪ Use of effective noise-attenuating materials for the plant's structure and walling ▪ Planting of the appropriate vegetation around the plant	GLEDC and contractors	Included in construction cost	MOA with EPC Contractor Include in MMT manual of operations
	D. The People	Displacement/ disturbance of properties	▪ There are no residents within the project site that will be displaced	GLEDC	N/A	N/A
		Change/conflict in landownership	▪ The proposed site is private property that has been acquired by the project proponent. The property is covered by a transfer certificate of title.	GLEDC	N/A	N/A
		Change/conflict in Right of Way	▪ The proposed project site has already been acquired by the proponent and is covered by a transfer certificate of land title. No conflict in right-of-way is expected.	GLEDC	N/A	N/A
		In-migration	▪ Provide the barangay with a complete list of the project's workers, contractors and employees.	GLEDC, LGU, Barangay Council	P10,000 as initial fund	Initial Fund – GLEDC; Succeeding Funds to come from Migrants'

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
						Registration Fees
		Proliferation of Informal Settlers	▪ Assist and coordinate with the LGU to set-up a migration information center in barangay halls for easier migrant tracking ▪ Report visitors staying in the area for more than a month	GLEDC, LGU, Barangay Council	No additional cost	N/A
		Threat to delivery of basic services/resource competition	▪ Assist the LGU in the proper planning of community resources ▪ Assist the LGU in the proper implementation of the CLUP ▪ Assist the LGU in the preparation of Barangay Development Plans and Barangay Disaster Risk Reduction Management Plan for barangays Carisquis and Nalvo Sur	GLEDC CRO and LGU	Part of CRO fund	GLEDC in coordination with LGU
		Threat to public health and safety	For power plant employees: ○ Provide safety and environmental awareness trainings for workers ○ Orient and train workers on occupational health and safety ○ Provide Personal Protective Equipment (PPE) ○ Implement safety protocols ○ Provide ample potable water within the construction site ○ Provide first aid facilities at the community centers/halls and designate a safety officer to monitor safe working conditions For threats to public health due to pollutants: ○ Install pollution control devices to meet emission limits ○ Undertake excessively noisy activities during the day ○ Provide proper sanitation and sewage at work sites; enforce sanitation discipline among workers	GLEDC and LGU	Php 100,000	Corporate funds, ER 1-94, Sec 89 of LGC

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			○ Re-vegetate disturbed soil as soon as possible Implement solid waste and hazardous materials management systems			
		Generation of local benefits from the project	▪ Payment of taxes and fees on time ▪ Assist LGU in tapping revenues generated under ER 1-94 (e.g. assist in the preparation of required documents, assist in liaising with DOE) ▪ Assist in the development of a more active Barangay Development Council (BDC) to coordinate and enhance local benefits	GLEDC and LGU	Part of CRO fund	GLEDC in coordination with LGU
		Enhancement of employment and livelihood opportunities	▪ Provide skills training to residents of the community prior to the hiring process to increase the likelihood of barangay residents being hired ▪ Assist LGU in identifying and planning development projects ▪ Implement CSR projects in coordination with the LGU	GLEDC and LGU	Php 700,000	Corporate funds, ER 1-94, Sec 89 of LGC
		Increased business opportunities and associated economic activities	▪ Assist LGU in identifying and planning development projects ▪ Implement CSR projects in coordination with the LGU	GLEDC and LGU	Part of livelihood program	Corporate funds, ER 1-94, Sec 89 of LGC
		Increased revenue of LGUs		GLEDC and LGU	Php 100,000	Corporate funds, ER 1-94, Sec 89 of LGC
		Traffic Congestion	▪ Install appropriate traffic and safety signs, especially on the national highway segment encompassed by the project	GLEDC	N/A	N/A
III. OPERATION PHASE						
	A. Land	Inducement of subsidence or collapse	▪ Subsidence, caused by excessive groundwater withdrawal, is not expected from the project	GLEDC and contractors	N/A	N/A
		Change in soil quality/fertility	▪ Establish a designated and cemented area for equipment and vehicle parking and maintenance ▪ Establish a cemented fuel storage area ▪ Inspect and maintain equipment and machinery to avoid oil spills and leaks ▪ Use oil sumps in engine rooms and vehicle	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			equipment maintenance areas ▪ Collect and store oil sludge in oil sludge tanks ▪ Dispose hazardous waste through a DENR accredited hazardous waste transporter and treater			
	B. Water	Degradation of groundwater quality	▪ Provide cemented areas and proper drainage channels for rainwater runoff for ○ Vehicle repair and maintenance area ○ Fuel oil storage area ○ Coal storage area	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors
		Degradation of coastal/marine water quality	▪ Use discharge pipe design that promotes rapid and efficient mixing ▪ Use wastewater treatment plant to ensure water quality of any effluents will not exceed DENR effluent standards	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors
		Threat to existence and/or loss of important local species and habitat	▪ Keep alterations in the land-sea interface to a minimum ▪ Ensure that construction activities will be confined only within necessary areas ▪ Avoid building permanent structures and remove temporary structures immediately in sensitive areas where bivalves are assessed to reproduce	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors
		Threat to abundance, frequency, and distribution of species	▪ Continuously support strategies to improve fish production and recruitment such as campaign against use of fine mesh nets and other destructive fishing methods; provide alternative livelihood programs ▪ Establish a Coastal Resource Management Program focusing on the immediate coastal vicinity of the project site, in coordination with the LGU and relevant government agencies	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors
	C. Air	Change in local microclimate	▪ Establish and implement a greening program in cooperation with PENRO	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
		Air pollution from stack emissions	▪ Ensure operation and maintenance of PC boilers are according to specifications; ▪ Ensure proper operation and maintenance of ESP, SWFGD, and NOx and CO reduction systems	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors
		Air pollution from standby generators and vehicle emissions	▪ Ensure proper operation and maintenance of generator set engines ▪ Formulate and implement a motor vehicle maintenance program, including emissions testing	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors
		Carbon dioxide emissions	▪ Establish and implement a greening program in cooperation with PENRO	GLEDC and contractors	Included in construction cost	Include in the MOA with contractors
	D. People	Threat to public health and safety	For power plant employees: ○ Provide safety and environmental awareness trainings for workers ○ Orient workers on occupational health and safety ○ Provide Personal Protective Equipment (PPE) ○ Implement safety protocols ○ Provide first aid facilities at the community centers/halls and designate a Safety Officer to monitor safe working conditions ○ Put up appropriate safety signages around the plant For threats to public health due to pollutants: ○ Ensure proper operation and maintenance of pollution control devices and water treatment facilities to meet emission and effluent limits, respectively ○ Promote proper sanitation and sewage storage at work sites; enforce sanitation discipline among workers	GLEDC and LGU	Php 100,000	Corporate funds, ER 1-94, Sec 89 of LGC

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
		Threat to delivery of basic services/resource competition	▪ Assist in the Implementation of the updated Comprehensive Land Use Plan of the Municipality of Luna ▪ Assist LGU in the preparation of Barangay Development Plans and Barangay Disaster Risk Reduction and Management Plans for Brgys Nalvo Sur and Carisquis	GLEDC CRO LGU DA DTI TESDA	Part of CRO fund	GLEDC in coordination with all agencies involved
		Lifestyle change	▪ Conduct continuous IECs to include talks on lifestyle changes as a result of increased income	GLEDC and LGU	Part of CRO fund	Agreement with the Municipality of Luna
		Generation of local benefits from the project	▪ Provide employment opportunities for local residents ▪ Pay taxes to concerned LGUs on time ▪ Assist LGU in identifying and planning development projects ▪ Implement CSR projects in coordination with the LGU	GLEDC, LGU, Barangay Development Council	Part of CRO fund	GLEDC in coordination with LGU
IV. ABANDONMENT PHASE						
	A. Land	Displacement of habitat for flora and fauna	▪ Perform Assisted Natural Regeneration (ANR) using threatened species identified during the EIA right after dismantling all the structures	GLEDC and contractors	Included in the abandonment cost	Included in ECC conditions
	B. Water	Disposal of wastes and abandoned structures	▪ Supervise proper waste disposal and implement proper solid waste management ▪ Ensure appropriateness of the selected land fill site for wastes, including ash ▪ Re-vegetate the project site	GLEDC and contractors	Included in the abandonment cost	Included in ECC conditions
		Abandonment of jetty and other offshore structures	▪ Remove structures and monitor recovery of the coastline from any previous accretion and/or scouring	GLEDC and contractors	Included in the abandonment cost	Included in ECC conditions
	D. People	Impact on employment and livelihood	▪ Conduct community development planning prior to abandonment so that residents, whose source of income and livelihood is the power plant, will be prepared for the eventual abandonment/decommissioning of the project	GLEDC and LGU	Included in the abandonment cost	MOA with contractors and cooperative agreement with the concerned LGUs

V. SOCIAL DEVELOPMENT PLAN / FRAMEWORK

1.0 Social Development Plan

1.1 SDP Framework

This Social Development Plan/Framework is based on the results of the discussions with various stakeholders during the IEC, the Public Scoping, and the Focus Group Discussions (FGDs) conducted in the direct impact Barangays of Nalvo Sur and Carisquis, as well as the indirect impact Barangays of Nalvo Norte, Darigayos and Pila.

Livelihood and community development programs/activities were also based on the baseline/perception survey that identifies the skills and educational attainments of the residents of the affected communities. It also aims to address the social impacts identified.

Table SDP-1
Social Development Plan/Framework

Plans/Programs based on Applicable Various EIA Concerns	Responsible Community Member/ Beneficiary	Government Agency/ Non-government Agency and Services	Proponent	Indicative Timeline	Source of Fund
***In-Migration*[1]**					
Setting up of the Barangay Migration Information Center to register new and temporary residents (to possibly provide assistance to them and to determine how the residents and migrants could work together and lessen possible competition for scarce resources and job opportunities)	Barangay Chair Barangay Secretary Barangay Treasurer	• Municipal Planning and Development Office (MPDO) • Population Management Center	Barangay Council	Six (6) months	Initial Fund – GLEDC; Succeeding Funds to come from Migrants' Registration Fees
Threat to Public Health					
Continuing IEC activities regarding real and perceived threats to public health	GLEDC Community Relations Officer, Barangay Kagawad, Committee Chairperson in-charge of Health	• Barangay • Municipal Health Office (MHO)	GLEDC	Continuing	GLEDC

[1] Migration, as defined by the Philippine Statistics Authority (http://nap.psa.gov.ph/glossary/terms/indicatorDetails.asp?strIndi=67), is the movement of people across a specific boundary for the purpose of establishing a new or semi permanent residence. This section in the SDP refers to internal migration (migration within the Philippines)

Table SDP-1 continued

Plans/Programs based on Applicable Various EIA Concerns	Responsible Community Member/ Beneficiary	Government Agency/ Non-government Agency and Services	Proponent	Indicative Timeline	Source of Fund
Access to Health Care Facilities especially for Children, Women, Youth, and Senior Citizens in Barangays Nalvo Sur and Carisquis	Barangay Kagawad, Committee Chairperson in-charge of Health and Barangay Health Workers (BHWs)	• Municipal Health Office (MHO)	Municipal Health Office	Continuing	GLEDC MHO Philippine Charity Sweepstakes Office (PCSO)
Establishment of additional health clinics with competent personnel	Municipal Health Officer (MHO) Barangay Kagawad, Committee Chairperson in-charge of Health	• Municipal Health Office (MHO)	Municipal Health Office	Preparatory works: six (6) months • Feasibility Study preparation • Application with DOH • Fund sourcing	GLEDC DOH
Provision of Seminars on the prevention of cardiac and other lifestyle diseases to address the leading causes of mortality and morbidity	Barangay Chair Barangay Kagawad in charge of Health	• Municipal Government of Luna, specifically the Municipal Health Office (MHO) • Department of Health (DOH)	Barangay Council	Ongoing	GLEDC LGU/MHO DOH
Seminars / Orientation / IEC on: ▪ Safety and environmental awareness Provision of Personal Protective Equipment (PPE) for workers Strict implementation of safety protocols Close/Strict monitoring of the plant	Barangay Kagawad, Committee Chairperson in-charge of Health and other Barangay Health Workers (BHWs)	• Municipal Health Office (MHO) • GLEDC and its contractors	Municipal Health Office GLEDC, CRO and EHS Youth group	Continuing	MHO GLEDC & its contractors
Threat to Delivery of Basic Services / Resource Competition					
Support to the **Local Government's Development Plan** • Provide advisory support to LGUs in the mainstreaming of Disaster Risk Reduction and Management as well as Climate Change Adaptation (DRR-CCA) measures in the LGUs' updated comprehensive development plan • Provide advisory support to LGUs in the	• Barangay Chairperson or Identified Key Leader/s • Direct and indirectly affected persons / communities	• Barangay Officials • LGUs • MPDO • MDRRMO	LGUs Office of Civil Defense GLEDC	Prior to and during construction, and operation	Proponent LGUs

Plans/Programs based on Applicable Various EIA Concerns	Responsible Community Member/ Beneficiary	Government Agency/ Non-government Agency and Services	Proponent	Indicative Timeline	Source of Fund
promotion of local culture					
Preparation of a Traffic Management and Public Safety Plan • To include projects that would address public safety and security	Mayor's Office; Municipal Planning and Development Office (MPDO); Municipal Engineering Office (MEO); Philippine National Police (PNP)	Mayor's Office; Municipal Planning and Development Office (MPDO); Municipal Engineering Office (MEO)	Municipal Planning and Development Office (MPDO); Philippine National Police (PNP)	Six (6) months • Plan Preparation Continuing • IEC and plan implementation	GLEDC LGU
Review/Inventory of Vehicles granted franchises; Regulation of issuance of franchises	Municipal Permits and Licenses Office				
Provision of Housing Projects	Mayor's Office; Municipal Planning and Development Office (MPDO); Municipal Engineering Office (MEO)	Mayor's Office; Municipal Planning and Development Office (MPDO); Municipal Engineering Office (MEO)	Municipal Planning and Development Office (MPDO)	Preparatory works: six (6) months • Feasibility Study preparation • Application with NHA • Fund sourcing	GLEDC LGU Individual household beneficiaries (for their counterpart)
Preparation of a Solid Waste Management Plan	Municipal Environment and Natural Resources Office (MENRO)	Mayor's Office; Municipal Planning and Development Office (MPDO); Municipal Environment and Natural Resources Office (MENRO)	Municipal Environment and Natural Resources Office (MENRO)	Six (6) months • Plan Preparation Continuing IEC and plan implementation	GLEDC DENR
Reforestation activities	Municipal Environment and Natural Resources Office (MENRO)	Mayor's Office; Municipal Planning and Development Office (MPDO); Municipal Environment and Natural Resources Office (MENRO)	Municipal Environment and Natural Resources Office (MENRO)	Continuing	GLEDC DENR
Local Benefits from the Project					
Provision of Employment Opportunities / and Training Programs for local community	Barangay Kagawad, Committee Chairperson in-	• LGU (Public Employment Service Office)	PESO GLEDC	Three (3) months – Barangay Council to	GLEDC *Policy for employment on

Plans/Programs based on Applicable Various EIA Concerns	Responsible Community Member/ Beneficiary	Government Agency/ Non-government Agency and Services	Proponent	Indicative Timeline	Source of Fund
	charge of Employment and Livelihood *GLEDC community relation officer to ensure that the Equal Opportunity Principle is followed	• Civic Groups • Technical Education and Skills Development Authority (TESDA) to provide skills training to qualify barangay residents for the quality of work required by GLEDC • DTI • DA	Barangay Council	pass an Ordinance Skills-Training -- continuing	project related activities – priority should be residents of Barangays Nalvo Sur and Carisquis *Ensure fair recruitment processes Civic Groups Technical Education and Skills Development Authority (TESDA)
Seminars / Orientation / IEC on Coal-Fired Power Plants Lakbay Aral to an existing coal-fired power plant	Barangay Chair	• Mayor's Office; Municipal Planning and Development Office (MPDO); Municipal Environment and Natural Resources Office (MENRO)	Barangay Council; Municipal Environment and Natural Resources Office (MENRO)	Continuing	GLEDC

1.2 Activities Undertaken

The Social Development Plan (SDP) seeks to address the issues and concerns identified during the public scoping meeting, the various public participation activities (i.e. FGD and KII) and those impacts identified during the assessment process. The SDP will be formulated through a participatory workshop that will be conducted specifically to draft this plan. Among the participants will be representatives of project proponent, municipal and barangay officials, and stakeholders.

1.3 Proposed Indicative SDP

The specific sectoral projects and programs of the indicative SDP are aligned with the programs presented in the Comprehensive Land Use Plan of Luna, La Union (2014-2023). These projects and programs have been identified, discussed and prioritized from the barangays to the municipal levels in cooperation with the different national line agencies. Given that there is a long list of projects and programs, GLEDC will coordinate with the LGU officials and reprioritize all the identified projects and programs into a single list, germane to the proposed power plant.

1.3.1 Community Relations Office

A community relations officer (CRO) will be established to undertake on its own or in coordination with other corporate units the implementation of the social development plan (SDP). It will be headed by a community relations officer and ably supported by necessary staff. It may hire the necessary specialists and experts on short duration to implement the development programs of the project.

The CRO shall be the front liner of the company in its interaction with the host community and local government officials. The CRO shall be responsible in prioritizing the needs of the community and shall approve and/or endorse such needs to the proper corporate authorities. CRO shall also spearhead the development assistance with the affected communities.

The following paragraphs discuss the different programs proposed under the SDP. There are instances wherein the funds will be tapped outside of the corporate funds. In these instances, the CRO will be the lead internal unit of the proponent who will coordinate with other units to ensure that sufficient funds will be available to fund these programs.

1.3.2 Employment Assistance Program

The residents and barangay officials are expecting that a portion of the manpower requirements in the construction and operation phases will be given to qualified residents of the affected barangays. This was confirmed in the results of the perception survey where employment was perceived as the primary positive impact of the project.

CRO shall be responsible for ensuring that priority in employment will be given to the residents of the affected barangay. Pre-selected qualified applicants shall undergo the usual pre-employment procedures.

1.3.3 Educational Assistance Program

The municipality has adequate learning facilities, private and public, for students under the K-12 curriculum. However, tertiary, post-graduate, and vocational schools are lacking in the municipality. Students need to go to nearby municipalities or even as far as Baguio City or Metro Manila to avail higher education. Financial assistance will greatly help deserving students to attain higher education and pursue careers that will contribute to the development of their community.

The proponents through its corporate funds shall set aside Php500,000 a year to finance elementary, high school, and college scholarships for deserving students residing within the adopted barangays commencing from the first year of plant operation. In addition, the plant shall coordinate and explore possibilities with DepEd on how to improve the educational system in the barangay.

1.3.4 Local Government Assistance Program

The proponent shall promptly pay the taxes and other permits and licenses to the municipality to ensure adequate and timely financial resources for the concerned LGUs to address their financial obligations as well as the delivery of basic services. The CRO shall coordinate with the concerned corporate units who are responsible for the payment of these taxes and licenses.

The proponent shall assist the municipality and concerned barangays in tapping the funds provided by Section 289 of the Local Government Code and ER 1-94 of the Department of Energy. Under ER 1-94, the proponent shall set aside P0.01/kWh of generated electricity sales as financial benefit to host communities. Generation facility located in non-highly urbanized city shall apply the following allocation scheme: Electrification Fund (EF) at 50% of one centavo per kWh (P0.005/kWh) electricity sales, Development and Livelihood Fund (DLF) at 25% of one centavo per kWh (P0.0025/kWh) electricity sales, and Reforestation, Watershed Management, Health and/or Environment Enhancement Fund (RWMHEEF) at 25% of one centavo per kWh (P0.0025/kWh) electricity sales. The CRO in coordination with the LGU officials shall identify these projects, assist in the ER 1-94 availment process and other and possible sources of funds.

The proponent, through the CRO, shall assist the barangay in identifying and reporting the arrival of informal dwellers in the barangay. Under the Urban Development and Housing Act (UDHA), local officials are mandated to prevent the construction of any kind of illegal dwelling units of structures within their respective localities. These reports will assist local officials to comply with their legal responsibilities under the said law.

1.3.5 Health Assistance Program

The proponent shall assist in monitoring the health conditions of the nearby local communities in coordination with the existing rural health units and barangay health workers, and contribute to the improvement of health services and facilities. Health program shall be funded by the corporate funds of the proponent amounting to at least Php300,000 per year and/or under the ER 1-94 of one-fourth centavo per kilowatt-hour (Reforestation, Watershed Management, Health and/or Environmental Enhancement Fund).

1.3.6 Livelihood Program

Fisher sector – as part of the proponent’s corporate social responsibility to protect, conserve, and enhance natural fishing grounds, assistance should be provided for the local fishermen in its effort to develop and improve the existing fishing activities in the locality. Alternative livelihood programs may be undertaken to provide livelihood opportunities to fisher folks. Budget will come from the corporate funds and/or the Development and Livelihood Fund under ER 1-94 and under Section 289 of the Local Government Code.

Women sector – skills training and orientation for women shall be implemented for them to be more equipped and qualified in facing development and engaging in productive economic activities. Possible trainings are in the field of duck raising, goat raising, and quail egg production. The particular skill training and start-up of a livelihood project will depend on the demand of a particular product.

An annual fund of Php300,000 shall be allocated for the livelihood training projects, which will come from the corporate funds and/or the Development and Livelihood fund under ER 1-94 and/or under Section 289 of the Local Government Code.

1.3.7 Electrification Program

Being a producer of electric power, the proponent adopts the electrification program to energize far-flung barangays and establish missionary power lines in coordination with the local electricity distribution utility. It may also engage in power saving and IEC activities that will lower the cost of the electricity to assist the communities. This program adopts the radiating order of benefits enunciated under ER 1-94. Funds will come from allocations under Section 289 of Local Government Code and/or the Electrification fund under ER 1-94.

1.3.8 Reforestation Program

The proponent shall establish a reforestation program in coordination with the pertinent government agencies. This will address the expected emissions from the project even if it is expected to be within the DENR standards. It is also recommended that indigenous fruit tree species be considered in reforestation. Program funds will come from the Development and Livelihood fund under ER 1-94. The Reforestation program includes the conduct of regular tree-planting activities to be organized by GLEDC.

GLEDC will arrange consultation meetings with the barangay and municipal officials of the project's impact areas to determine the appropriate sites to conduct tree-planting activities. However, the tree-planting activities will not be limited on the impact areas only. GLEDC will coordinate with other agencies such as the provincial government, the DENR and other organizations that can help identify tree-planting sites or area. Accordingly, the officials of the impact areas shall be notified and consulted for tree-planting activities to be conducted outside their areas.

1.3.9 Establishment of a Multipartite Monitoring Team

The proponent shall establish a Multipartite Monitoring Team (MMT) to be represented by relevant stakeholder groups. This team will be responsible for the monitoring the environmental impacts of the project. It should be noted that the establishment of a MMT in majority of cases is a condition prescribed in the environmental compliance certificate.

Table SDP-2
Matrix of Social Development Plan

Program	Budget (Php)	Timeline
A. Corporate Funds		
1. Educational Assistance Program	500,000	Plant operations
2. Health Assistance Program	300,000	Plant operations
3. Livelihood Program	300,000	Plant operations
4. Reforestation Program	100,000	Plant operations
B. ER 1-94 funded programs GLEDC shall set aside P0.01/kWh of generated electricity sales as financial benefit to host communities. Generation facility located in non-highly urbanized city shall apply the following allocation scheme:		
1. Electrification Programs	Electrification Fund (EF) at 50% of one centavo per kWh (P0.005/kWh) electricity sales	Plant operations
2. Development and Livelihood Programs	Development and Livelihood Fund (DLF) at 25% of one centavo per kWh (P0.0025/kWh) electricity sales	Plant operations
3. Reforestation, Watershed Management, Health and/or Environment Enhancement Programs	Reforestation, Watershed Management, Health and/or Environment Enhancement Fund (RWMHEEF) at 25% of one centavo per kWh (P0.0025/kWh) electricity sales	Plant operations

2.0 Information, Education and Communication (IEC)

2.1 IEC Framework

The Information, Education and Communication (IEC) framework aims to provide sufficient information using appropriate media and materials. The IEC provides project information to the stakeholders and also gathers their feedback about the status of the project, including their understanding, different issues, and concerns.

Stakeholders in the local community, especially in the host barangays Nalvo Sur and Carisquis, will be the target sectors in the IEC campaign. Brief and precise discussion of the project information will be formulated and will also include the studies conducted and proposed development in local communities. The proposed IEC activities include IEC on Disaster Risk Reduction and Climate Change Adaptation (DRR-CCA) to ensure that the DRR-CCA measures are integrated in the local plans.

2.2 IEC Activities Undertaken

IEC activities were already conducted in June 2016. Stakeholders and concerned sectors from the host municipality were covered by the IEC activities undertaken. The proponent presented the project information and project plant process using vidoes and power point presentations. Flyers were also distributed containing project information, which may be reviewed by the stakeholders from time to time.

Based on the result of the IEC activities in the host municipality, the stakeholders have several perceived benefits and possible effects that they can get from the project. Concerns on possible negative effects, however, were also raised by the stakeholders together with their proposed solution.

2.3 Proposed IEC Activities

The IEC framework below was based on the initial IEC activities conducted, as well as on the continuing activities of the Community Relations Officer (CRO) of GLEDC.

Table SDP-3
General IEC Plan

Target Sector Identified as Needing Project IEC	Major Topics of Concern in Relation to the Project	IEC Scheme / Strategy /Methods	Information Media	Indicative Timeline and Frequency	Indicative Cost
1. LGU • Provincial Government of La Union • The Congressional Representatives' Office	Project Description Benefits due to the Province (share from the taxes to be derived from the Project) Updates on the Project	Letter and Project Description Seminar/Orientation Handouts or Powerpoint Presentation of Project Description Lakbay Aral	Multi-media (print, face-to-face meeting, powerpoint presentation)	Project Description and Benefits – prior to Project Start Updates – at the start of every major phase in the project	Transport costs Printing of IEC Materials
2. LGU • Municipal Government of Luna	Project Description Benefits due to the Municipality (share from the taxes to be derived from the Project) Updates on the Project	Letter and Project Description Seminar/Orientation Handouts or Powerpoint Presentation of Project Description Lakbay Aral	Multi-media (print, face-to-face meeting, powerpoint presentation)	Project Description and Benefits – prior to Project Start Updates – at the start of every major phase in the project	Transport costs Printing of IEC Materials
3. LGU • Barangays Nalvo Sur and Carisquis • Secondary Impact Barangays Darigayos, Pila and Nalvo Norte	Project Description; Benefits due to the Barangay (share from the taxes to be derived from the Project) Updates on the Project	Letter and Project Description Seminar/Orientation Handouts or Powerpoint	Multi-media (print, face-to-face meeting, powerpoint presentation)	Project Description and Benefits – prior to Project Start; Updates – at the start of every major phase in the project	Transport costs Printing of IEC Materials

Target Sector Identified as Needing Project IEC	Major Topics of Concern in Relation to the Project	IEC Scheme / Strategy /Methods	Information Media	Indicative Timeline and Frequency	Indicative Cost
		Presentation of Project Description *(translated in the dialect)* Lakbay Aral			
4. LGU • Barangays Nalvo Sur and Carisquis	Employment opportunities and qualifications for hiring	Information Sheet on Project Manpower Requirement *(translated in the dialect)*	Print	As necessary	Transport costs Printing of IEC Materials
5. Residents of Barangays Nalvo Sur and Carisquis, as well as those from secondary impact barangays	Detailed phases of power plant operation; information on safety aspects like portions of operation areas and equipment that should be avoided	Information Sheet on Safety Measures to be followed by residents *(translated in the dialect)*	Print	As necessary	Transport costs Printing of IEC Materials

VI. ENVIRONMENTAL COMPLIANCE MONITORING

The Environmental Compliance Monitoring (ECM) system was written in accordance to EMB's Memorandum Circular No. 2010-14. As specified, the ECM shall contain the following sections:

- Self-Monitoring Plan
- Multi-sectoral Monitoring Framework; and the
- Environmental Guarantee and Monitoring Fund Commitment

1.0 Self-Monitoring Plan

The proposed Self-Monitoring Plan for the 2x335MW Coal-Fired Power Plant Project is presented in **Table ECM-1.** It is composed of the key environmental components – land, water, air, and people – categorized per project phase, together with the identified potential impacts to which DENR Rules and Regulations may apply. The SMP aims to ensure that all emissions and effluents from the proposed project will comply with the DENR Rules and Regulations such as the Clean Air and Water Act, Pollution Control Law, and Hazardous Waste Management, among others. The SMP provides early warning information of adverse environmental conditions, which is further specified in the Environmental Quality Performance Levels (EQPL).

The EQPLs specified in **Table ECM-1** are assigned the following values:

- **Alert (warning): 70% of the limit**
- **Action: 80% of the limit**
- **Limit: 90% of the limit**

GLEDC will be stringent in monitoring that the listed parameters will not reach the "limit" and ensure that all effluents and emissions will be maintained within the DENR standard value. GLEDC will also make sure that any early signs of exceedance will be addressed immediately in the most appropriate manner.

Table ECM-1
Self-Monitoring Plan for the 2x335MW Coal-Fired Power Plant Project

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			MGT MEASURE		
			Method	Frequency	Location			ALERT	ACTION	LIMIT	ALERT	ACTION	LIMIT
PRE-CONSTRUCTION PHASE													
The pre-construction phase covers activities like planning, feasibility study, ocular surveys, and permit procurement. Earth moving activities, delivery of materials and similar activities are included in the Construction Phase.													
CONSTRUCTION PHASE – LAND COMPONENT													
Land Component (Soil Quality)	Soil Erosion	Extent of the soil erosion, size of the exposed soil surface	Ocular inspection	Twice a month	Entire construction site	GLEDC Environmental Officer/ Pollution Control Officer	Part of construction cost	Detection of noticeable soil erosion in active construction sites	Increased occurrence of soil erosion in active construction sites	Excessive occurrence of soil erosion in active construction sites and immediate vicinity	Investigate and report the areas with occurrence of soil erosion	Investigate and report the areas with increased occurrence of soil erosion. Identify the cause of soil erosion and improve control measures	Investigate and report the areas with excessive soil erosion. Identify the cause of soil erosion and fortify control measures and barriers
	Soil Contamination	As Hg Cr^{+6} Cd Pb	Collection of soil samples from surface and at 0.5m to 1m depth Analysis of soil samples by an accredited DENR laboratory	Annually	Soil monitoring stations (Figure ECM1)	GLEDC Environmental Officer/ Pollution Control Officer	*Part of construction cost	As = 20.3 Hg = 2.1 Cr+6= 70 Cd = 0.56 Pb = 59.5 (all in mg/kg) (Represent 70% of Dutch TV values)	As = 23.2 Hg = 2.4 Cr+6 = 80 Cd = 0.64 Pb = 68 (all in mg/kg; Represent 80% of Dutch TV values)	As = 26.1 Hg = 2.7 Cr+6 = 90 Cd = 0.72 Pb = 76.5 (All in mg/kg; represent 90% of Dutch TV values)	Conduct inspection and testing at the sampling stations	• If the source is from the site, inform GLEDC mgm to improve mitigating measures • If the source is not from the site, inform MMT regarding possible source of contamination for the groups' investigation and coordination with the LGU • Conduct re-testing from a DENR accredited 3rd Party laboratory to confirm test results	• Coordinate with the GLEDC operations/ Utilities, Engineering/ Environmental Officer • Conduct joint investigation with LGU and MMT • Fortify the mitigating measures and replace defective control equipment/ material. Emergency response measures must be employed to reduce pollutants.
Land Component (Terrestrial Flora)	Loss of important species (mahogany, narra, is-is, etc.	Counts of transplanted/ saved seedlings Mortality/ survival rates	Counts	Monthly	Nursery and reforestation site if established during the constructio	GLEDC Environmental Officer/ Pollution Control Officer	*Part of construction cost	15% reduction in the abundance and diversity index based on baseline data	20% reduction in the abundance and diversity index based on baseline data	30% reduction in the abundance and diversity index based on baseline data	Assess nursery and or reforestation conditions and causes of mortality	Provide inputs to improve growth (fertilizer, weeding, water. Collect more seedlings from the site and add	Enhance nursery with seedlings sourced from outside the plant site of from other nurseries and commercial gardens

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			MGT MEASURE		
			Method	Frequency	Location			ALERT	ACTION	LIMIT	ALERT	ACTION	LIMIT
					n phase							seedlings to the nursery	
CONSTRUCTION PHASE – AIR COMPONENT													
Air component (Ambient air quality)	Ambient air pollution receptor areas	TSP	(S) 24 hr High Volume- (A) Gravimetric USEPA 40 CFR, Part 50, Appendix B	Quarterly	Initially the same stations during the EIA	• GLEDC EO Consultant	To be determined	155	186	207 ug/ncm	• Check weather condition during the sampling if location is downwind of the construction site • Conduct monitoring • ID pollutant source (construction activity, facility, or equipment)	• Conduct visit at the smapling stations and conduct retesting using 3rd party DENR accredited sampling firm to confirm • If the source is from the site, inform area and implement appropriate corrective action at identified pollution source • Implement dust suppression measures	• If the source is from the site: • Immediately stop all works involving excavation and movement • Increase the contractor's de-dustmechanism • Conduct re-testing from a DENR accredited 3rt party laboratory to verify test results • Coordinate with the operations/utilities, engineering/ environmental officer regarding the matter • Upon visual clearing of the site, resume work
Air component (Ambient air quality)	Ambient air pollution receptor areas	SO_2	(S) 24-hr Gas Bubbler (A) Pararosaniline Method (West and Gaeke Method	Quarterly	Initially the same stations during the EIA	• GLEDC EO Consultant	To be determined	122	146	162 ug/ncm			
Air component (Ambient air quality)	Ambient air pollution receptor areas	NO_2	(S) 24-hr Gas Bubbler (A) Griess-Saltzman or Chemiluminescence Method	Quarterly	Initially the same stations during the EIA	• GLEDC EO Consultant	To be determined	101	122	135 ug/ncm			
Air component (Ambient air quality)	Ambient air pollution receptor areas	Pb	(S) 24-hr High Volume (A) Atomic Absorption Spectrophotometry,USEPA 40 CFR, Part 50, Appendix G	Quarterly	Initially the same stations during the EIA	• GLEDC EO Consultant	To be determined	No values assigned. These parameters form part of the baseline prior to operation of the power plant			n/a	n/a	n/a
Air component (Ambient air	Ambient air pollution receptor areas	Cd	(S)Prescribed sampling method	Quarterly	Initially the same stations	• GLEDC EO Consultant	To be determined				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			MGT MEASURE		
			Method	Frequency	Location			ALERT	ACTION	LIMIT	ALERT	ACTION	LIMIT
quality)			(A) AAS		during the EIA								
Air component (Ambient air quality)	Ambient air pollution receptor areas	As	(S)Prescribed sampling method (A) AAS	Quarterly	Initially the same stations during the EIA	• GLEDC EO Consultant	To be determined				n/a	n/a	n/a
Air component (Ambient air quality)	Ambient air pollution receptor areas	Sb	(S)Prescribed sampling method (A) AAS	Quarterly	Initially the same stations during the EIA	• GLEDC EO • Consultant	To be determined				n/a	n/a	n/a
Air component (Ambient sound levels)	Noise impacts in receptor areas	Sound levels	24 hr sound measurements using hand-held sound meter	Quarterly	Initially the same stations during the EIA	• GLEDC EO Consultant	To be determined	3 dB less than limit	2 dB less than limit	1 dB less than limit	• Identification of possible source of noise • Issuance of ear plugs	• Corrective action on noise equipment source • Re-scheduling of "noisy activities"	Avoid use of noisy equipment
CONSTRUCTION PHASE – WATER COMPONENT													
Water Component (Coastal Water)	Impacts on marine quality in West Philippine Sea	pH	In situ using pH meter/ Glass electrode	Quarterly	Same as sampling stations in baseline study	GLEDC Environmental Officer/ Consultant	Included in annual in-house monitoring budget	5.8 and 8.7	5.6 and 8.9	5.4 and 9.0	• Identify pollutant source • Conduct re-testing to verify parameters are within allowable limit • Monitor the conduct of temperature measurements	• Implement appropriate corrective action on the identified pollution source • Conduct re-testing to verify parameters are within allowable limit • Monitor the conduct of temperature measurements	• Temporary stoppage of activity • Conduct re-testing to verify parameters are within allowable limit • Monitor the conduct of temperature measurements
		Temperature	In situ using temperature/ DO meter					Not more than 2°C rise from ambient for thermal discharges	Not more than 2.5°C rise from ambient for thermal discharges	Not more than 2.7°C rise from ambient for thermal discharges			
		Oil and grease	(S) Grab samples, glass bottle washed with solvent, acidification with nitric acid to pH 2, preserved at 4°C (A) Petroleum Ether Extraction					1.89mg/L	2.16mg/L	2.7mg/L			
		Dissolved	In situ					4.5mg/L	4.0 mg/L	3.5 mg/L			

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			MGT MEASURE		
			Method	Frequency	Location			ALERT	ACTION	LIMIT	ALERT	ACTION	LIMIT
		oxygen	measurements using DO meter/ Iodometric								• Identify pollutant source • Conduct re-testing to verify parameters are within allowable limit	• Implement appropriate corrective action on the identified pollution source • Conduct re-testing to verify parameters are within allowable limit	• Temporary stoppage of activity • Conduct re-testing to verify parameters are within allowable limit
		TSS	(S) Grab samples, preserved at 4°C (A) Gravimetric method (dried at 103-105°C)					50.4 mg/L	57.6 mg/L	72 mg/L			
		Heavy metals (Hg, Cd, As, Cr, and Pb)	Approved methods of analysis in DAO 90-35					Not more than: Cr+6: 0.0315 Pb: 0.0315 Cd: 0.00315 Hg: 0.00126 As:0.0126	Not more than: Cr+6: 0.036 Pb: 0.036 Cd: 0.0036 Hg: 0.00144 As: 0.0144	Not more than: Cr+6: 0.045 Pb: 0.045 Cd: 0.0045 Hg: 0.0018 As: 0.018			
		Total coliform	(S) Grab samples, washed and disinfected glass bottle, preserved at 4°C					3500 MPN	4000MPN	5000 MPN			
		Sulfate	Turbidimetric method					1,514mg/L	1,730mg/L	1,947mg/L			
		Ammonia	Phenate method					0.35mg/L	0.40mg/L	0.45mg/L			
		Phosphate	Stannous Chloride Method					0.70mg/L	0.80mg/L	0.90mg/L			
		Nitrate	Colorimetry - Brucine					14mg/L	16mg/L	18mg/L	• Identify pollutant source • Conduct re-testing to verify parameters are within allowable limit	• Implement appropriate corrective action on the identified pollution source • Conduct re-testing to verify parameters are within allowable	• Temporary stoppage of activity • Conduct re-testing to verify parameters are within allowable limit
		Chloride	Argentometric Method					-	-	-			
		Boron	Turbidimetric Method					14mg/L	16mg/L	18mg/L			
		Copper	Flame AAS - MBK Extraction					0.028mg/L	0.032mg/L	0.036mg/L			
		Zinc						1.05mg/L	1.20mg/L	1.35mg/L			
		Nickel						0.21mg/L	0.24mg/L	0.27mg/L			

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			MGT MEASURE		
			Method	Frequency	Location			ALERT	ACTION	LIMIT	ALERT	ACTION	LIMIT
												limit	
Water Component (Ground Water)	Impacts on ground water quality/ potability	pH	In situ using pH meter/ Glass electrode	Quarterly	Same as sampling stations in baseline study	GLEDC Environmental Officer/ Consultant	Included in annual in-house monitoring budget	5.8 and 8.7	5.6 and 8.9	5.4 and 9.0	• Identify pollutant source • Conduct testing of water quality to verify parameters are within allowable limit • Monitor the conduct of sampling	• Implement appropriate corrective action on the identified pollution source • Improve mitigating measures/ equipment • Conduct re-testing to verify parameters are within allowable limit • Monitor the conduct of sampling • Inform MMT/LGUs	• Repair/ replace control equipment/ materials • Conduct re-testing to verify parameters are within allowable limit • Monitor the conduct of sampling • Inform MMT/LGUs
		Heavy metals (Hg, Cd, As, Cr, and Pb)						Not more than: Cr+6: 0.0504 Pb: 0.0063 Cd: 0.00189 Hg: 0.00063 As: 0.0315	Not more than: Cr+6: 0.0576 Pb: 0.0072 Cd: 0.00216 Hg: 0.00072 As:0.036	Not more than: Cr+6: 0.072 Pb: 0.009 Cd: 0.0027 Hg: 0.0009 As:0.045			
		Total coliform						Any detection		0 MPN			
		TDS						400 mg/L	450 mg/L	500 mg/L			
Water Component (Marine Ecology)	Impacts on marine ecology in coastal areas fronting the project site	Percent cover of corals and Seagrass	Manta Tow Line Intercept Transect (LIT) Method Plankton sampling	Semi-annual	Same as sampling stations in baseline studies that have been converted to permanent monitoring stations (for LIT stations)	GLEDC Environmental Officer/ Consultant	To be determined	Average 10 % decrease in coral cover from baseline findings of all manta tow and LIT stations 10%decrease in seagrass cover from baseline conditions	Average 20% decrease coral cover from baseline findings in all manta tow and LIT 20% decrease in seagrass cover from baseline conditions	Average 30% decrease in coral cover at all manta tow and LIT stations from baseline findings 30% decrease in seagrass cover from baseline conditions	Conduct marine biota monitoring; GLEDC to check if effluent released complies with DAO 2016-08 Check temperature of thermal discharge	Increase frequency of conduct of marine biota monitoring to semi-annual; GLEDC to check if effluent released complies with DAO 2016-08 Increase monitoring frequency of thermal discharge temperature	Increase the frequency of conduct of marine biota monitoring to Quarterly; GLEDC to check if effluent released complies with DAO 2016-08 Increase monitoring frequency of thermal discharge temperature

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			MGT MEASURE		
			Method	Frequency	Location			ALERT	ACTION	LIMIT	ALERT	ACTION	LIMIT
								5%Increase in number HABs present In phytoplankton analysis	10% increase in number of HABs present in phytoplankton analysis	15% increase in number of HABs present in phytoplankton analysis	Check temperature of thermal discharge	Increase monitoring frequency of thermal discharge temperature	Increase monitoring frequency further of thermal discharge temperature
CONSTRUCTION PHASE – PEOPLE COMPONENT													
People Component (Health and Safety; Peace and Order)	Potential property damage, fire, accidents, injury and loss of life	Number of crimes (index) Number of complaints and accidents	Survey, incident reporting, documentation	Monthly	Project site/ all construction work areas	GLEDC PCO & Safety Officer	Part of construction cost	Negative reports from employees and communities	Increase in crime incidence Increase in number of complaints and accidents recorded involving project personnel, contractors and subcontractors	Multiple complaints filed by the community and employees due to increase in crime and accidents involving project personnel, contractors and subcontractors	GLEDC to investigate the cause of negative reports.	GLEDC to investigate the cause of negative reports. Reinforce the implementation of the Health and Safety guidelines lead by Health and Safety Officers/Team	Fortify the implementation of the OSH standards. GLEDC to investigate the cause of negative reports.
	Health and safety risks from construction activities	Health Statistics, number of patient consultations, type of disease, and number/type of accidents	Medical and dental examinations, surveys, and documentation	Quarterly	Site clinic/all construction work areas	GLEDC Medical Personnel & Municipal Health Office	Part of construction budget	Negative reports from employees and community	Increase in number of patients, incidences of diseases and accidents	Multiple complaints filed by the community and employees due to increase in number of patients, diseases and accidents	GLEDC to investigate the cause of negative reports.	GLEDC to investigate the cause of negative reports. Reinforce the implementation of the Health and Safety guidelines lead by Health and Safety Officers/Team.	Fortify the implementation of the OSH standards. GLEDC to investigate the cause of negative reports.

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			MGT MEASURE		
			Method	Frequency	Location			ALERT	ACTION	LIMIT	ALERT	ACTION	LIMIT
People Component (Physico-social)	Perception of water and air pollution Perception of non-compliance to environmental laws	Number of IECs conducted	Documentation and reporting	Quarterly	Brgys. Nalvo Sur and Carisquis	GLEDC in coordination with Luna and Brgys. Nalvo Sur and Carisquis LGUs	Part of construction budget	Negative feedback from community	Increase in complaints of community	Multiple complaints filed by the community	GLEDC to investigate the cause of negative reports. Conduct IEC activities.	GLEDC to investigate the cause of negative reports. Conduct IEC activities and consultation with community.	GLEDC to investigate the cause of negative reports. Conduct IEC activities and consultation with community.
People Component (Economic)	Employment and business opportunities	• Number of IECs conducted on available jobs • Number of workers hired from Brgys. Nalvo Sur and Carisquis • Number of skills training • Taxes remitted	Document and reporting Tax receipts	Quarterly (all) & Annual (taxes)	Project site and Brgys. Nalvo Sur and Carisquis	GLEDC in coordination with Luna and Brgys. Nalvo Sur and Carisquis LGUs	Part of construction budget	Negative reports from employees and community	Increase in complaints of community	Multiple complaints filed by the community	GLEDC to investigate the cause of negative reports. Conduct IEC activities.	GLEDC to investigate the cause of negative reports. Conduct IEC activities and consultation with community.	GLEDC to investigate the cause of negative reports. Conduct IEC activities and consultation with community.
OPERATION PHASE – LAND COMPONENT													
Land Component (Soil Quality)	Soil contamination	As		Annually	Soil monitoring stations	GLEDC Environmental Officer/	*Part of construction cost	As = 20.3 Hg = 2.1 Cr+6= 70	As = 23.2 Hg = 2.4 Cr+6 = 80	As = 26.1 Hg = 2.7	Conduct inspection and testing at the sampling stations	• If the source is from the site, inform GLEDC mgm to	• Coordinate with the GLEDC operations/ Utilities, Engineering/

Key Environmental Aspects per Project Phase	Potential Impacts per Envt'l Sector	Parameter to be Monitored	Sampling & Measurement Plan: Method	Sampling & Measurement Plan: Frequency	Sampling & Measurement Plan: Location	Lead Person	Annual Estimated Cost	EQPL MANAGEMENT SCHEME – EQPL RANGE: ALERT	EQPL RANGE: ACTION	EQPL RANGE: LIMIT	MGT MEASURE: ALERT	MGT MEASURE: ACTION	MGT MEASURE: LIMIT
		Hg Cr^{+6} Cd Pb	Collection of soil samples from surface and at 0.5m to 1m depth Analysis of soil samples by an accredited DENR laboratory		(Figure ECM1)	Pollution Control Officer		Cd = 0.56 Pb = 59.5 (all in mg/kg) (Represent 70% of Dutch TV values)	Cd = 0.64 Pb = 68 (all in mg/kg; Represent 80% of Dutch TV values)	Cr+6 = 90 Cd = 0.72 Pb = 76.5 (All in mg/kg; represent 90% of Dutch TV values)		improve mitigating measures • If the source is not from the site, inform MMT regarding possible source of contamination for the groups' investigation and coordination with the LGU • Conduct re-testing from a DENR accredited 3rd Party laboratory to confirm test results	Environmental Officer • Conduct joint investigation with LGU and MMT • Fortify the mitigating measures and replace defective control equipment/ material. Emergency response measures must be employed to reduce pollutants.
Land Component (Terrestrial Flora)	Loss of important local species	Biodiversity indices (Abundance, frequency, and diversity indices)	Interviews, transect walks, mist netting, setting of traps, ocular for birds and other wildlife	Every two years	To be determined	GLEDC Environmental Officer	Included in operation budget	10% reduction in the abundance and diversity index based on baseline data of the vegetated buffer zone and reforestation area	20% reduction in the abundance and diversity index baseline data	30% reduction in the abundance and diversity index baseline data	Conduct an investigation and identify possible source. If GLEDC is not the source, inform MMT. If GLEDC is the source, inform the management to improve mitigating measures.	Determine possible source and conduct ocular inspection at the sampling stations and inform MMT. Coordinate with LGUs/MMT. Conduct enrichment planting/ ANR. Provide artificial nesting areas for avifaunal species and monitor Quarterly. Conduct IEC activities on significance of biodiversity to stakeholders.	Determine possible source and conduct ocular inspection at the sampling stations and inform MMT. Intensify mitigating measures. Monitor avifaunal species monthly. Conduct IEC activities on significance of biodiversity to stakeholders.
Land Component (Terrestrial Fauna)	Loss of species	Species richness, abundance, percent cover, species	Quadrat sampling, ocular survey, and interviews	Annually	Vegetated buffer zone area	GLEDC Environmental Officer	Part of construction cost	10% reduction in the abundance and diversity index of avifauna based on	20% reduction in the abundance and diversity index of avifauna from	30% reduction in the abundance and diversity index of avifauna from baseline	Conduct an investigation and identify possible source. If GLEDC is not the source, inform MMT.	Determine possible source and conduct ocular inspection at the sampling stations and inform MMT. Coordinate with	Determine possible source and conduct ocular inspection at the sampling stations and inform MMT. Intensify mitigating measures.

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			MGT MEASURE		
			Method	Frequency	Location			ALERT	ACTION	LIMIT	ALERT	ACTION	LIMIT
		indices						baseline data for vegetated buffer zone	baseline data for the vegetated buffer zone	data of the vegetated buffer zone	If GLEDC is the source, inform the management to improve mitigating measures.	LGUs/MMT. Conduct enrichment planting/ ANR. Provide artificial nesting areas for avifaunal species and monitor Quarterly. Conduct IEC activities on significance of biodiversity to stakeholders.	Monitor avifaunal species monthly. Conduct IEC activities on significance of biodiversity to stakeholders.
OPERATION PHASE – AIR COMPONENT													
Air component (Stack emissions)	Ambient air pollution receptor areas	TSP, SO_2, NO_2	Installation of CEMS[1]	Real time	Stack	GLEDC EO and Consultant	To be determined	TSP: 101 SO2: 472 NO2: 675	TSP: 122 SO2: 567 NO2: 810	TSP: 135[2] SO2: 630 NO2: 900	Check CEMS operations	Implement appropriate corrective action at the CEMS	Temporary stoppage of PC boiler
Air component (Ambient air quality)		PM10	24-hr High Volume with 10 micron particle-size inlet (A) Gravimetric USEPA 40 CFR, Part 50, Appendix J	Quarterly	To be determined based on validated the model		To be determined	101	122	135 ug/ncm	• ID source of pollutant • Evaluate plant process that emits the pollutant	• Corrective action on plant process that emits the pollutant. • Conduct monitoring after corrective action	Temporary stoppage of polluting source
		TSP	(S) 24 hr High Volume- (A) Gravimetric USEPA 40 CFR, Part 50, Appendix B				To be determined	155	186	207 ug/ncm			
		SO_2	(S) 24-hr Gas Bubbler (A)				To be determined	122	146	162 ug/ncm	• ID source of	• Corrective action on	

[1] Continuous Emission Monitoring System
[2] All units are in mg/ncm

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			MGT MEASURE		
			Method	Frequency	Location			ALERT	ACTION	LIMIT	ALERT	ACTION	LIMIT
			Pararosaniline Method (West and Gaeke Method								pollutant • Evaluate plant process that emits the pollutant • Monitor ambient levels at stations • Conduct air dispersion modeling	plant process that emits the pollutant. Conduct monitoring after corrective	Temporary stoppage of polluting source
		NO_2	(S) 24-hr Gas Bubbler (A) Griess-Saltzman or Chemiluminescence Method				To be determined	101	122	135 ug/ncm			
		Pb	(S) 24-hr High Volume (A) Atomic Absorption Spectrophotometry,USEPA 40 CFR, Part 50, Appendix G				To be determined	1.01	1.21	1.35 ug/ncm (c)			
		Cd	(S)Prescribed sampling method (A) AAS				To be determined	0.007	0.008	0.009 mg/ncm (d)			
		As	(S)Prescribed sampling method (A) AAS				To be determined	0.014	0.016	0.018 mg/ncm (d)			
		Sb	(S)Prescribed sampling method (A) AAS				To be determined	0.014	0.016	0.018 mg/ncm (d)			
Air component (Ambient sound levels)	Noise impacts in receptor areas	Sound levels	24 hr sound measurements using hand-held sound meter	Quarterly	Initially the same stations during the EIA	• GLEDC EO Consultant	To be determined	(a)	(b)	Will depend on the category of the receptor (AA, A, B, C,D)	• Identification of possible source of noise • Check buffer zones and noise attenuation measures • Conduct noise modeling	• Corrective action on noise equipment source • Conduct monitoring after corrective action	Temporary stoppage of noise source
OPERATION PHASE – WATER COMPONENT													

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			MGT MEASURE		
			Method	Frequency	Location			ALERT	ACTION	LIMIT	ALERT	ACTION	LIMIT
Water Component (Coastal Water – Water Quality and Effluent Monitoring)	Impacts on Marine Water Quality in West Philippine Sea	pH	In situ using ph meter/ Glass electrode	Quarterly	Same sampling stations used in the baseline study and waste water treatment plant effluent	GLEDC PCO & Consultant	Included in the annual in-house monitoring budget	5.8 and 8.7	5.6 and 8.9	5.4 and 9.0	• Identify pollutant source • Conduct testing of water quality to verify parameters are within allowable limit • Monitor the conduct of sampling	• Implement appropriate corrective action on the identified pollution source • Improve mitigating measures/ equipment • Conduct re-testing to verify parameters are within allowable limit • Monitor the conduct of sampling	• Temporary stoppage of activity • Repair/ replace control equipment/ materials • Conduct re-testing to verify parameters are within allowable limit • Monitor the conduct of sampling
		BODs	(S) Grab samples, preserved at 4°C (A) Azide Modification dilution technique					4.9 mg/L	5.6 mg/L	6.3 mg/L			
		Temperature	In situ using DO/ temperature meter					Not more than 2oC rise from ambient for thermal discharge	Not more than 2.5oC rise from ambient for thermal discharge	Not more than 3oC rise from ambient for thermal discharges			
		Oil and grease	(S) Grab samples, glass bottle washed with solvent, acidification with nitric acid to pH 2, preserved at 4°C (A) Petroleum Ether Extraction					1.89mg/L	2.16mg/L	2.7mg/L			
		Dissolved oxygen	In situ measurements using DO meter/ Iodometric					4.5 mg/L	4.0 mg/L	3.5 mg/L			
		TSS	(S) Grab samples, preserved at 4°C					50.4 mg/L	57.6 mg/L	72 mg/L			

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			MGT MEASURE		
			Method	Frequency	Location			ALERT	ACTION	LIMIT	ALERT	ACTION	LIMIT
			(A) Gravimetric method (dried at 103-105oC)										
		Heavy metals (Hg, Cd, As, Cr, Pb)	Approved methods of analysis in DAO 2016-08 (Class SC)					Not more than: Cr+6: 0.0315 Pb: 0.0315 Cd: 0.00315 Hg: 0.00126 As:0.0126	Not more than: Cr+6: 0.036 Pb: 0.036 Cd: 0.0036 Hg: 0.00144 As: 0.0144	Not more than: Cr+6: 0.045 Pb: 0.045 Cd: 0.0045 Hg: 0.0018 As: 0.018			
		Total coliform	Multiple Tube Fermentation					3500 MPN	4000MPN	5000 MPN			
		Sulfate	Turbidimetric method					1,514mg/L	1,730mg/L	1,947mg/L			
		Ammonia	Phenate method					0.35mg/L	0.40mg/L	0.45mg/L			
		Phosphate	Stannous Chloride Method					0.70mg/L	0.80mg/L	0.90mg/L			
		Nitrate	Colorimetry - Brucine					14mg/L	16mg/L	18mg/L			
		Chloride	Argentometric Method					-	-	-			
		Boron	Turbidimetric Method					14mg/L	16mg/L	18mg/L			
		Copper	Flame AAS - MBK Extraction					0.028mg/L	0.032mg/L	0.036mg/L			
		Zinc						1.05mg/L	1.20mg/L	1.35mg/L			
		Nickel						0.21mg/L	0.24mg/L	0.27mg/L			
Water Component (Groundwater)	Impacts on ground water quality/ potability	pH	In situ using ph meter/ Glass electrode	Quarterly	Same sampling stations used in the baseline study	GLEDC PCO & Consultant	Included in the annual in-house monitoring budget	5.8 and 8.7	5.6 and 8.9	5.4 and 9.0	• Identify • pollutant source • Conduct testing of water quality to verify parameters are within allowable limit • Monitor the conduct of sampling	• Implement • appropriate corrective action on the identified pollution source • Improve mitigating measures/ equipment • Conduct re-testing to verify parameters are	• Repair/ replace • control equipment/ materials • Conduct re-testing to verify parameters are within allowable limit • Monitor the conduct of sampling • Inform MMT/LGUs
		Heavy metals (Hg, Cd, As, Cr, Pb)	Grab sampling and analysis by a DENR accredited laboratory					Not more than: Cr+6: 0.0504 Pb: 0.0063 Cd: 0.00189 Hg: 0.00063 As: 0.0315	Not more than: Cr+6: 0.0576 Pb: 0.0072 Cd: 0.00216 Hg: 0.00072 As:0.036	Not more than: Cr+6: 0.072 Pb: 0.009 Cd: 0.0027 Hg: 0.0009 As:0.045			
		TDS						400 mg/L	450 mg/L	500 mg/L			
		Total						Any detection		0 MPN			

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			MGT MEASURE		
			Method	Frequency	Location			ALERT	ACTION	LIMIT	ALERT	ACTION	LIMIT
		coliform										within allowable limit • Monitor the conduct of sampling • Inform MMT/LGUs	
Water Component (Marine Ecology)	Impacts on marine ecology in coastal areas fronting the project site	Coral cover and seagrass cover Phytoplankton Fish abundance	Manta Tow Line Transect Method (Photo-transect) Fish Visual Census plankton sampling	Annual	Same stations during baseline study LIT stations to be established permanent monitoring stations	GLEDC EO/ Consultant	To be determined	Average 10 % decrease in coral cover from baseline findings of all manta tow and LIT stations 10%decrease in seagrass cover from baseline conditions 5% Increase in number HABs present In phytoplankton analysis	Average 20% decrease coral cover from baseline findings in all manta tow and LIT 20% decrease in seagrass cover from baseline conditions 10% increase in number of HABs present in phytoplankton analysis	Average 30% decrease in coral cover at all manta tow and LIT stations from baseline findings 30% decrease in seagrass cover from baseline conditions 15% increase in number of HABs present in phytoplankton analysis	Conduct marine biota monitoring; GLEDC to check if effluent released complies with DAO 2016-08	Increase the frequency of conduct of marine biota monitoring to semi-annual; GLEDC to check if effluent released complies with DAO 2016-08	Increase the frequency of conduct of marine biota monitoring to Quarterly; GLEDC to check if effluent released complies with DAO 2016-08
OPERATION PHASE – PEOPLE COMPONENT													
People Component (Health and Safety; Peace and Order)	Potential property damage, fire, accidents, injury and loss of life	Number of crimes (index) and incidence of complaints	Survey, incident reporting, documentation	Monthly	Project site	GLEDC PCO & Safety Officer	Included as part of operations budget	Negative reports from employees and community	Increase in crime incidence Increase in number of complaints and accidents recorded involving project personnel and	Multiple complaints filed by the community and employees due to increase in crime and accidents involving project personnel and	GLEDC to investigate the cause of negative reports.	GLEDC to investigate the cause of negative reports. Reinforce the implementation of the Health and Safety guidelines lead by Health and Safety Officers/Team	Fortify the implementation of the OSH standards. GLEDC to investigate the cause of negative reports.

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			MGT MEASURE		
			Method	Frequency	Location			ALERT	ACTION	LIMIT	ALERT	ACTION	LIMIT
									support staff	support staff			
	Health and safety risks from operation activities	Health Statistics, number of patient consultations, type of disease, and number/type of accidents	Medical and dental examinations, surveys, and documentation	Quarterly	Site clinic Brgys. Nalvo Sur and Carisquis	GLEDC Medical Personnel & Municipal Health Office	Included as part of operations budget	Negative reports from employees and community	Increase in number of patients, incidences of diseases and accidents	Multiple complaints filed by the community and employees due to increase in number of patients, diseases and accidents	GLEDC to investigate the cause of negative reports.	GLEDC to investigate the cause of negative reports. Reinforce the implementation of the Health and Safety guidelines lead by Health and Safety Officers/Team.	Fortify the implementation of the OSH standards. GLEDC to investigate the cause of negative reports.
People Component (Psycho-social)	Perception of water and air pollution; Perception of Non-compliance to pollution standards	Number of IECs conducted	Documentation and reporting	Quarterly	Brgys. Nalvo Sur and Carisquis	GLEDC in coordination with Luna and Brgys. Nalvo Sur and Carisquis LGUs	Included as part of operations budget	Negative feedback from community	Increase in complaints of community	Multiple complaints filed by the community	GLEDC to investigate the cause of negative reports. Conduct IEC activities.	GLEDC to investigate the cause of negative reports. Conduct IEC activities and consultation with community.	GLEDC to investigate the cause of negative reports. Conduct IEC activities and consultation with community.
People Component (Demographic and Livelihood)	Displacement of fishermen from traditional fishing grounds	Recorded and complaints from fishermen	Ocular inspection, surveys, dialogues and conflict resolution methods	Quarterly; after complaints received	Project site and vicinity	GLEDC in coordination Brgys. Nalvo Sur and Carisquis LGU	Included as part of operations budget	Negative feedback from community	Increase in number of complaints from fishermen	Multiple complaints filed by the community and complaints from fishermen	GLEDC to investigate the cause of negative reports.	GLEDC to investigate the cause of negative reports. Corrective actions to be determined with coordination with LGUs of Brgys. Nalvo Sur and Carisquis and the municipality of Luna	GLEDC to investigate the cause of negative reports. Corrective actions to be determined with coordination with LGUs of Brgys. Nalvo Sur and Carisquis and the municipality of Luna
People Component (Economic)	Employment and business opportunities	• Number of IECs conducted on available jobs • Number of workers hired from Brgys. Nalvo Sur and	• Document and reporting • Tax receipts	Quarterly (all) & Annual (taxes)	Project site and Brgys. Nalvo Sur and Carisquis	GLEDC in coordination with Luna and Brgys. Nalvo Sur and Carisquis LGUs	Included as part of operations budget	Negative reports from employees and community	Increase in complaints of community	Multiple complaints filed by the community	GLEDC to investigate the cause of negative reports. Conduct IEC activities.	GLEDC to investigate the cause of negative reports. Conduct IEC activities and consultation with community.	GLEDC to investigate the cause of negative reports. Conduct IEC activities and consultation with community.

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			MGT MEASURE		
			Method	Frequency	Location			ALERT	ACTION	LIMIT	ALERT	ACTION	LIMIT
		Carisquis • Number of skills training • Taxes remitted											
ABANDONMENT PHASE													
(to be formulated 2 years before decommissioning)													

2.0 Multi-sectoral Monitoring Framework

A Multi-partite Monitoring Team (MMT) will be created to ensure compliance of the proponent with various monitoring activities in the project area. The following shall be represented in the MMT:

- LGU representatives (Brgys. Nalvo Sur and Carisquis, and Municipality of Luna)
- Locally accredited NGOs/POs (i.e. Carisquis Farmer's Association, TODA)
- Community

Its chief responsibility is to validate the environmental performance, with the following specific functions:

i) Validate project compliance with the conditions stipulated in the ECC and the EMP;
ii) Validate proponent's conduct of self-monitoring;
iii) Receive complaints, gather pertinent information to facilitate determination of validity of complaints or concerns about the project and timely transmit to the Proponent and EMB recommended measures to address the complaint;
iv) Prepare, integrate and disseminate simplified validation reports to community stakeholders;
v) Make regular and timely submission of MMT Reports based on the EMB-prescribed format.

3.0 Environmental Guarantee and Monitoring Fund Commitment

3.1 Environmental Guarantee Fund (EGF)

The Environmental Guarantee Fund (EGF) will be established for the rehabilitation, compensation, clean-up activities, and damage prevention programs in the probable adverse environmental effects of the project operation. The determination of the amount to be set up for RGF will take into consideration the value of EIA committed projects, the degree of environmental risk involved, value of resources that will be most likely affected and the proponent's financial capability.

The specific amount will be agreed upon by the proponent and the DENR in consultation with the LGU of Luna, La Union. For this project, the indicative amounts for the Trust Fund and Cash Fund that comprise the EGF are **Php 1,000,000.00** and **Php 2, 000, 000.00,** respectively. These are to be finalized at a later date. A Memorandum of Agreement will be prepared by the proponent as soon as the specific amount is determined.

3.2 Environmental Monitoring Fund (EMF)

The Environmental Monitoring Fund (EMF) is a fund that GLEDC shall commit to establish in support to the activities of the MMT for the compliance monitoring. The EMF budget will be incorporated in the proposed MOA for the MMT. Indicative budget for the EMF will be approximately **Php1, 000,000.00**, also to be finalized at a later date. The actual amount will be agreed upon when the MMT is formed.

The EMF shall be incorporated in the proposed MOA for the MMT, as provided in **Annex L.**

VII. DECOMMISSIONING/ ABANDONMENT/REHABILITATION POLICY

A detailed abandonment plan shall be developed prior to the closure of the facility and within the timeframe that will be specified in the ECC. The plan shall include rehabilitation measures/clean-up, remediation of areas affected by the project and proposed alternative projects at the site.

The abandonment plan will address the following:

- Proposed abandonment/decommissioning measures for the power plant and all appurtenant facilities constructed as part of the project.
- Site restoration, if removal of all equipment and structures is needed.
- Cost associated with the proposed abandonment / decommissioning activities and the source of funds for the implementation of the activities.
- Compliance with the environmental standards and other applicable regulations and standards, as well as conformance with the local/regional plans.

The plan will be submitted to DENR for review and approval prior to the implementation of the abandonment /decommissioning activities.

VIII. INSTITUTIONAL PLAN FOR EMP IMPLEMENTATION

The institutional plan provides the roles and responsibilities of different institutions such as the proponent, contractors, LGUs and the MMT that will form the Environmental Unit (EU). **Table IP-1** presents the institutional plan for EMP implementation.

Table IP-1
Institutional Plan for EMP Implementation

Institutions	Responsibilities
Proponent (and appointed consultants)	• Monitor compliance to EMP by contractors • Coordinate and participate in monitoring compliance
Contractors	• Implement the mitigation measures stated in the EMP
LGU	• Issue necessary permits and clearances • Guarantee that the proponent complies with the local ordinances and regulations • Provide and send representatives to the MMT • Ensure coordination and participation with the proponent (vice versa) regarding socio economic concerns
MMT	• Conduct compliance monitoring

The Environmental Unit to be headed by an Environmental Manager (EM) will be responsible for implementing the EMP. The Environmental Manager will regularly coordinate with the members of the EU to ensure the project's compliance to the DENR rules and regulations. The EM will work with the Community Relations Officer (CRO) to facilitate communication and coordination with the members of the MMT and the host community, as shown in **Figure IP-1.**

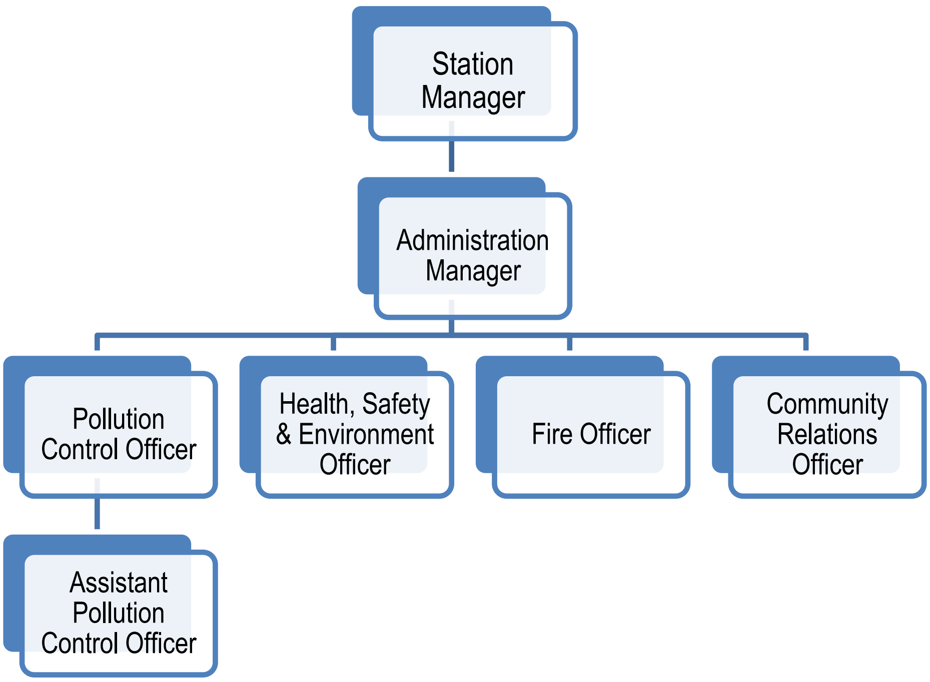


Figure IP-1. Preliminary Organizational Chart of GLEDC Environmental Unit

REFERENCES

Acebes JM, Aca EQ (Assessors) (2012) Megaptera novaenglidae. Pp. 36 – 39. In Alava MNR, MLL Dolar, ER Sabater, MTR Aquino, MD Santos (eds). Red list status of marine mammals in the Philippines. Bureau of Fisheries and Aquatic Resources – National Fisheries Research and Development Institute. 194 p.

Alameddin, A.N. and Luzik, S.J., 1987. "Coal Dust Explosions in the Cement Industry", Industrial Dust Explosions, ASTM STP 958, Kenneth L. Cashollar and Martin Hertzberg, Eds., American Society for Testing and Materials, Philadelphia. pp. 217-233

Alava MNR, Cantos JAR (2004) Marine protected species in the Philippines. Pp 109 – 117. In DA-BFAR (Department of Agriculture-Bureau of Fisheries and Aquatic Resources). In Turbulent Seas: The status of Philippine marine fisheries. Coastal Resources Management Project of the Department of Environment and Natural Resources. Cebu City, Philippines.

Alava MNR, MLL Dolar, ER Sabater, MTR Aquino, MD Santos (eds). (2012) Red list status of marine mammals in the Philippines. Bureau of Fisheries and Aquatic Resources – National Fisheries Research and Development Institute. 194 p.

Alava MNR, Yaptinchay AASP (1997) Marine mammals. Pp 169 – 246. In Wildlife Conservation Society of the Philippines. Philippine Red Data Book. Bookmark, Inc and Wildlife Conservation Society of the Philippines, Inc. Makati, Philippines. 262 p.

Alcala AC (1986) Amphibians and reptiles. Volume X.: Guide to Philippine Flora and Fauna. Natural Resources Management Center, Ministry of Natural Resources and University of the Philippines. Quezon City, Philippines. 195 p.

Alcala, A.C. 1986. Guide to Philippine Flora and Fauna (Vol X): Amphibians and Reptiles. Manila, Philippines: Natural Resources Management Center, Ministry of Natural Resources and University of the Philippines. 195 pp.

Alcala, A.C. and Brown, W.C. 1998. Philippine Amphibians: an illustrated field guide. Makati City: Bookmark, Inc. 116 pp.

Allen, G, R. Stene, P. Humann, and N. deLoach, 2003. Reef Fish Identification - Tropical Pacific. New World Publications.

Aquino MRT, MNR Alava, GM Cadigal, ED Solis, R Lucero, BS Albalasin, M Santos, TU Bagarinao, JPA Gaudiano (Assessors) (2012) Globicephala macrorhynchus. Pp. 46 – 51. In Alava MNR, MLL Dolar, ER Sabater, MTR Aquino, MD Santos (eds). Red list status of marine mammals in the Philippines. Bureau of Fisheries and Aquatic Resources – National Fisheries Research and Development Institute. 194 p.

Aquino MTR, BS Albasin, MNR Alava, AASP Yaptinchay, MIG Cadigal, ED Solis, R Lucero, A Salting, R Cruz (Assessors) (2012) Dugong dugon. Pp 144 – 152. In Alava MNR, MLL Dolar, ER Sabater, MTR Aquino, MD Santos (eds). (2012) Red list status of marine mammals in the Philippines. Bureau of Fisheries and Aquatic Resources – National Fisheries Research and Development Institute. 194 p.

Aquino MTR, MNR Alava, GIM Cadigal, ED Solis, R Lucero, BS Albalasin, MD Santos, TU Bagarinao, JPA Gaudiano, JMO Daclan, AP Tagarino, R Cruz, A Salting, AASP Yaptinchay (Assessors) (2012) Grampus griseus. Pp. 52 – 57. In Alava MNR, MLL Dolar, ER Sabater, MTR Aquino, MD Santos (eds). Red list status of marine mammals in the Philippines. Bureau of Fisheries and Aquatic Resources – National Fisheries Research and Development Institute. 194 p.

Arvin Diesmos, Angel Alcala, Rafe Brown, Leticia Afuang, Genevieve Gee, Katie Hampson, Mae Leonida Diesmos, Aldrin Mallari, Perry Ong, Marisol Pedregosa, Dondi Ubaldo, Baldwin Gutierrez 2004. Limnonectes macrocephalus. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on 27 August 2014.

Association of Structural Engineers of the Philippines. "National Structural Code of the Philippines, 6th edition." 2010. https://www.scribd.com/doc/146198521/NSCP-2010-6th-Edition (accessed July 29, 2016).

Asian Development Bank, Environmental Risk Assessment; Operational Summary, ADB Environment Paper No. 7, 1991.

Au, W. W. L., Popper, A.N., and Fay, R.R. 2000. Hearing bywhales and dolphins. Springer Handbook of Auditory Research. Springer-Verlag, New York.

Aurelio, M., Galapon, J., Hizon, V. and Sadsad, D.. "Stress behaviour from fault data sets within a transdtensional zone, South Central Cordillera, Luzon, Philippines:Implications for mineral occurrences." Island Arc, 2009: 144-154.

Aurelio and Peña, 2004. Geology and Mineral Resources of the Philippines, Volume I: Geology. Mines and Geosciences Bureau, DENR.

Avantor. Material Safety Data Sheet: Hydrochloric Acid. MSDS ID: H3880 Version #: 11 Revision date: 01-17-2012. Accessed from http://www.avantormaterials.com/documents/msds/usa/english/H3880_msds_us_cov_Default.pdf on Oct. 28, 2014.

Babcock & Wilcox Power Generation Group, Inc. 2011. Coal Fire Detection Systems. Ohio. Accessed from www.babcock.com/library/Documents/ps-447.pdf on Oct. 28, 2014.

Bacatio, C.D., L.R. Retamar, L.F. Costelo, N.A. Cruceno, T.V. Retamar, and S. Fabula, 2010. Major Lowland Rice/Corn Soils of the Philippines and their Characteristics. Soilscape (BSWM Publication), Vol. 1, No. 2, pp. 8-11. https://www.google.com.ph/webhp?sourceid=chrome-instant&ion=1&espv=2&ie=UTF-8#

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling.1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002.U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Bellinger, E.G. and D.C. Sigee. 2010. Freshwater Algae: Identification and Use as Bioindicators. John Wiley and Sons Ltd., 271 pp.

Benson SR, PH Dutton, C Hitipeuw, B Samber, J Bakarbessy, D Parker (2007) Post-nesting migrations of leatherback turtles (Dermochelys coriacea) from Jamursba-Medi, Bird's Head Peninsula, Indonesia. Chelonian Conservation and Biology 6(1): 150 – 154.

Benson SR, T Eguchi, DG Foley, KA Forney, H Bailey, C Hitipeuw, BP Samber, RF Tapilatu, V Rei, P Ramohia, J Pita and PH Dutton (2011) Large-scale movements and high-use areas of western Pacific leatherback turtles, Dermochelys coriacea. Ecosphere 2(70): art84.doi.10.1890/ES11-00053.1.

Berkman Systems, Inc. 2012. Environmental Impact Statement for the Proposed 1,750 MW LNG-Fired Combined Cycle Power Plant Project in Brgy Villa Ibaba, Atimonan, Quezon. Report prepared for MERALCO Powergen Corporation

besprenRAM (2006) Atimonan: butanding1 https://www.youtube.com/watch?v=Asx8zf1V2d8 You Tube (Uploaded on Nov 19, 2006). Accessed 22 August 2014.

besprenRAM (2006) Atimonan: butanding2 https://www.youtube.com/watch?v=jFvHHY0PIIA You Tube (Uploaded on Nov 19, 2006). Accessed 22 August 2014.

BFAR – Data Base of Registration System

Bingham, E. Cohrssen, B. and Powell, C.H. and Powell, C.H. (2001). Patty's Toxicology. 5th Ed.n, Vol.1. Jonh Wiley & Sons. (cited in http://www.hc-sc.gc.ca/ewh-semt/pubs/occup-travail/whmis-simdut/compli-conform/index_e.html).

BirdLife International 2012. Gallicolumba luzonica. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on 21 September 2014.

Bjorndal KA (1997) Chapter 8: Foraging ecology and nutrition of sea turtles. Pp 199 – 231. In PL Lutz and JA Musick (editors) The biology of sea turtles. CRC Press LLC. Florida, USA. 432 p.

BM Alliance Coal Operations Pty Ltd., 2001. Coal Stockpile and Reject Dump Safety Management.

Bouchard, S.S. and Bjorndal, K.A. 2000. Sea turtles as biological transporters of nutrients and energy from marine to terrestrial ecosystems. Ecology 81: 2305-2313.

Brown, Gordon L. Human Health Risk Assessment Process for Coal-Fired Power Plants in Alberta.

Canadian Council of Ministers of the Environment, 1997. Recommended Canadian Soil Quality Guidelines. Retrieved from: http://www.ccme.ca/files/Resources/supporting_scientific_documents/pn_1268_e.pdf

Carmichael, W.W., 1992. A Status Report on Planktonic Cyanobacteria (Blue-Green Algae) and Their Toxins, EPA/600/R-92/079, Environmental Systems Laboratory, ORD, USEPA, Cincinnati, OH 45268, June, 1992, 141 pp.

Carpenter, K and V. Niem, eds (1998). FAO Species Identification Guide, Vol. 1: Seaweeds, corals, bivalves and gastropods.

Cerexagri, Inc. (2004, Oct.). MSDS-Agchlor 310 (Sodium hypochlorite 12.5%). Retrieved from http://www.cheminternational.ca/technicaldocuments/Industrial%20Bleach.pdf

CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) (2014) Appendices I, II and III: valid from 24 June 2014

Clark, C.W., Ellison,W. T., Southall, B. L., Hatch, L., Van Parijs, S. M., Frankel, A., and Ponirakis,D. 2009. Acoustic masking in marine ecosystems: intuitions, analysis, and implication. Marine Ecology Progress Series, 395: 201–222.

CLUP (2014). Comprehensive Land Use Plan of the Municipality of Luna, La Union

Compagno LJV, Last PR, Stevens JD, Alava MNR (2005) Checklist of Philippine chondrichthyes. CSIRO Marine Laboratories Report 243

Croll,D. A., Clark, C.W., Calambokidis, J., Ellison,W. T., and Tershy, B. R. 2001. Effect of anthropogenic low-frequency noise on the foraging ecology of Balaenoptera whales. Animal Conservation, 4: 13–27.

Cruz RD (2002) Marine turtle distribution and mortality in the Philippines. In I Kinan (ed) Proceedings of the Western Pacific Sea Turtle Cooperative Research and Management Workshop. February 5-8, 2002. Honolulu, Hawaii, USA. Honolulu, HI: Western Pacific Regional Fishery Management Council. Pp 146 – 152.

Cruz RD (2006) Status of the leatherback in the Philippines. Pp 108 – 111. In Indian Ocean – South-East Asian Leatherback Turtle Assessment. IOSEA Marine Turtle MoU – 2006

Culik BM (compiler) (2004) Review of small cetaceans: Distribution, behaviour, migration and threats. Marine Mammal Action Plan/Regional Seas Reports and Studies No. 177. United Nations Environment Programme (UNEP) and the Secretariat of the Convention on the Conservation of Migratory Species (CMS). Bonn, Germany. 343 pages.

De Veyra RR (1997) Marine turtles. pp 52-71. In Wildlife Conservation Society of the Philippines. Philippine Red Data Book. Bookmark, Inc and Wildlife Conservation Society of the Philippines, Inc. Makati, Philippines. 262 p.

DENR Administrative Order 2007-01: Establishing the National List of Threatened Philippine Plants and their Categories, and the List of Other Wildlife Species. DENR.

DENR (Department of Environment and Natural Resources) (2004) DENR Administrative Order No. 2004-15: Establishing the list of threatened species and their categories, and the list of other wildlife species pursuant to Republic Act No. 9147, otherwise known as the Wildlife Resources Conservation and Protection Act of 2001. May 22, 2004.

Department of Environment & Natural Resources, Revised Procedural Manual of DAO 2003-30, Quezon City 2007.

Department of Environment and Natural Resources (DENR), 2015. Integrated Coast Management Plan 2015-2020. 1-55 pp.

Dermawan A (2004) Indonesia. Pp 53 – 60. In Talib Z, A Ali, KKK Yaacob and M Isa (editors) Conservation and enhancement of sea turtles in the Southeast Asian Region. Marine fishery Resources Development and Management Department, Southeast Asian Fisheries Development Center.

Diez CE, Ottenwalder, JA (1999) Habitat surveys. Pp 41– 44. In KL Eckert, KA Bjorndal, FA Abreu-Grobois, M Donnelly (eds) Research and Management Techniques for the Conservation of Sea Turtles. IUCN/SSC Marine Turtle Specialist Group Publication No. 4. 235 pp.

Dolar MLL (1994) Incidental takes of small cetaceans in fisheries in Palawan, Central Visayas and northern Mindanao in the Philippines. In WF Perrin, GP Donovan and J Barlow (editors) Gillnets and cetaceans: Incorporating the Proceedings of the Symposium and Workshop on the Mortality of Cetaceans in Passive Fishing Nets and Traps. Report of the International Whaling Commission Special Issue 15.

Dolar MLL and Sabater ER (Assessors) (2012) Balaenoptera musculus. Pp 25 – 30. In Alava MNR, MLL Dolar, ER Sabater, MTR Aquino, MD Santos (eds). Red list status of marine mammals in the Philippines. Bureau of Fisheries and Aquatic Resources – National Fisheries Research and Development Institute. 194 p.

Dolar MLL, ER Sabater, JPA Gaudiano, TU Bagarinao, PME Sorongon, ALB Barcelona, AP Tagarino, JMO Daclan (Assessors) (2012a) Balaenoptera edeni. Pp. 20 – 30. In Alava MNR, MLL Dolar, ER Sabater, MTR Aquino, MD Santos (eds). Red list status of marine mammals in the Philippines. Bureau of Fisheries and Aquatic Resources – National Fisheries Research and Development Institute. 194 p.

Dolar MLL, ER Sabater, JPA Gaudiano, TU Bagarinao, PME Sorongon, ALB Barcelona, AP Tagarino, JMO Daclan, MD Santos (Assessors) (2012b) Stenella attenuata. Pp. 85 – 88. In Alava MNR, MLL Dolar, ER Sabater, MTR Aquino, MD Santos (eds). Red list status of marine mammals in the Philippines. Bureau of Fisheries and Aquatic Resources – National Fisheries Research and Development Institute. 194 p.

Dolar MLL, ER Sabater, JPA Gaudiano, TU Bagarinao, PME Sorongon, ALB Barcelona, AP Tagarino, JMO Daclan, MD Santos (Assessors) (2012c) Stenella longirostris longirostris. In Alava MNR, MLL Dolar, ER Sabater, MTR Aquino, MD Santos (eds). Red list status of marine mammals in the Philippines. Bureau of Fisheries and Aquatic Resources – National Fisheries Research and Development Institute. 194 p.

Dolar MLL, ER Sabater, JPA Gaudiano, TU Bagarinao, PME Sorongon, ALB Barcelona, AP Tagarino, JMO Daclan, MD Santos (Assessors) (2012d) Tursiops aduncus. In Alava MNR, MLL Dolar, ER Sabater, MTR Aquino, MD Santos (eds). Red list status of marine mammals in the Philippines. Bureau of Fisheries and Aquatic Resources – National Fisheries Research and Development Institute. 194 p.

Dolar MLL, ER Sabater, JPA Gaudiano, TU Bagarinao, PME Sorongon, ALB Barcelona, AP Tagarino, JMO Daclan, MD Santos (Assessors) (2012e) Tursiops truncatus. In Alava MNR, MLL Dolar, ER Sabater, MTR Aquino, MD Santos (eds). Red list status of marine mammals in the Philippines. Bureau of Fisheries and Aquatic Resources – National Fisheries Research and Development Institute. 194 p.

Dolar MLL, ER Sabater, JPA Gaudiano, TU Bagarinao, PME Sorongon, ALB Barcelona, AP Tagarino, JMO Daclan, MD Santos (Assessors) (2012f) Physeter macrocephalus. In Alava MNR, MLL Dolar, ER Sabater, MTR Aquino, MD Santos (eds). Red list status of marine mammals in the Philippines. Bureau of Fisheries and Aquatic Resources – National Fisheries Research and Development Institute. 194 p.

Dolar MLL, JPA Gaudiano, ER Sabater, TU Bagarinao, PME Sorongon, ALB Barcelona, AP Tagarino, JMO Daclan and MD Santos (Assessors) (2012) Lagenodelphis hosei. Pp. 58 – 61. In Alava MNR, MLL Dolar, ER Sabater, MTR Aquino, MD Santos (eds). Red list status of marine mammals in the Philippines. Bureau of Fisheries and Aquatic Resources – National Fisheries Research and Development Institute. 194 p.

DolarMLL, WF.Perrin, AASP Yaptinchay, SARHJ Jaaman, MD Santos, MN Alava and MSB Suliansa (1997) Preliminary investigation of marine mammal distribution, abundance and interactions with humans in the southern Sulu Sea. Asian Marine Biology 14 (1997): 61 – 91.

Dutch Target and Intervention Values (February 2000) :Retrieved from: http://www.esdat.net/Environmental%20Standards/Dutch/annexS_I2000Dutch%20Environmental%20Standards.pdf

Ecological Impacts of Culverts. Retrieved from: https://www.shef.ac.uk/doncatchment/work/projects/culverts

Eckert SA, MLL Dolar, GL Kooyman, WF Perrin and RA Rahman (2002) Movements of whale sharks (Rhincodon typus) in South-east Asian waters as determined by satellite telemetry. J. Zool. Lond (2002) 257: 111 – 116.

English, S., C. Wilkinson and V. Baker, Editors (1997). Survey manual for tropical marine resources. 2nd ed. Australian Institute of Marine Sciences, Queensland, 390 p.

F.E. Moran Special Hazard Systems. (2012, May 21). Coal Fired Power Plants: Additional Hazards Require Additional Solutions. Retrieved March 21, 2015, from http://www.femoranshs.com/site/files/978/106677/389493/623385/QSR-72-201_PRB_article_-Final.pdf

FEMA, USDOT, and USEPA, 1989. Handbook of Chemical Hazard Analysis Procedures. Federal Emergency Management Agency (FEMA), U.S. Dept. of Transportation (USDOT) and U.S. Environmental Protection Agency (USEPA).

Fernando, E.S., B.Y. Sun, M.H. Suh, H.Y. Kong, and K.S. Koh (2004). Flowering Plants and Ferns of Mt. Makiling. ASEAN-Korea Environmental Cooperation Unit.

Fernando, E.S., J. B. Balatibat, J. R. Peras, and R.J. J. Jumawid (1998). Resource Inventory and Assessment of Biodiversity in the Subic Bay Metropolitan Authority (SBMA). PCARRD-DOST.

Fike. Oct, 2001. Pulverized Coal in Power Plants. Form No. EAP 1010. Fike Corporation . Accessed from http://www.fire-protection.com.au/CMSTemplates/files/fireprotection.com.au/4c/4c5d7de0-cb09-4163-9896-7a40383659c5.pdf on Oct. 28, 2014.

FMC Wyoming Corporation. May 13, 2009. Material Safety Data Sheet: Sodium Hydroxide 50% Solution. MSDS Ref. No.: 1310-73-2-3. Philadelphia.

Fox, J., and Moyer M. 1973. Some effects of a power plant on marine microbiota. Chesapeake Science 14: 1-10.

Fukushima, Y. and Tanaka, T.. "A New Attenuation Relation for Peak Horizontal Acceleration of Strong Earthquake Ground Motion in Japan." Bulletin of the Seismological Society of America, 1990: 757-778.

Froese, R. and D. Pauly. Editors. 2011. FishBase. World Wide Web electronic publication. www.fishbase.org, version (06/2011).

Gapud, V.P. and L.C. Raros. 1986. Guide to Philippine Flora and Fauna vol. VIII: Water Bugs and Mites.NRMC NMC and UP, JMC Press Inc., Quezon City, Phils. 204 pp.

General Electric. (2013, June). Power stations retard coal oxidation in feed bunkers by capping with DusTreat* C9136. Retrieved from GE Power & Water: Water & Process Technologies: www.gewater.com

Gill FB (1990) Ornithology. W.H. Freeman and Company. USA. 660 p.

Halliburton. June 22, 2007 Rev. Material Data Sheet: Hydrochloric Acid. Halliburton Australia Pty. Ltd.

Harrison P (1983) Seabirds: An identification guide. Houghton Mifflin Company, Boston Massachusetts USA. pp 448.

Haynes, A. 2001.Freshwater snails of the tropical Pacific Islands. Oceania Printers, Suva: Fiji. 112pp.

Heaney LR, MLL Dolar, DS Balete, JA Esselstyn, EA Rickart and JL Sedlock (2010a) Synopsis of Philippine mammals: Globicephala macrorhynchus: www.fmnh.org/Philippine_Mammals/species/SP_99.asp. Accessed on 19 August 2014.

Heaney LR, MLL Dolar, DS Balete, JA Esselstyn, EA Rickart and JL Sedlock (2010b) Synopsis of Philippinemammals: Grampus griseus: www.fmnh.org/philippine_mammals/species/SP_100.asp Accessed on 19 August 2014.

Heaney LR, MLL Dolar, DS Balete, JA Esselstyn, EA Rickart and JL Sedlock (2010c) Synopsis of Philippine mammals: Lagenodelphis hosei: www.fmnh.org/Philippine_Mammals/species/SP_125.asp Accessed on 19 August 2014.

Heaney LR, MLL Dolar, DS Balete, JA Esselstyn, EA Rickart and JL Sedlock (2010d) Synopsis of Philippine mammals: Orcinus orca: www.fmnh.org/philippine_mammals/species/SP_155.asp Accessed on 19 August 2014.

Heaney LR, MLL Dolar, DS Balete, JA Esselstyn, EA Rickart and JL Sedlock (2010e) Synopsis of Philippine mammals: Stenella attenuata: www.fmnh.org/philippine_mammals/species/SP_214.asp Accessed on 19 August 2014.

Heaney LR, MLL Dolar, DS Balete, JA Esselstyn, EA Rickart and JL Sedlock (2010f) Synopsis of Philippine mammals: Stenella longirostris longirostris: www.fmnh.org/philippine_mammals/species/SP_217.asp Accessed on 19 August 2014.

Heaney LR, MLL Dolar, DS Balete, JA Esselstyn, EA Rickart and JL Sedlock (2010g) Synopsis of Philippine mammals: Tursiops aduncus. www.fmnh.org/philippine_mammals/species/SP_241.asp. Accessed on 19 August 2014.

Heaney LR, MLL Dolar, DS Balete, JA Esselstyn, EA Rickart and JL Sedlock (2010h) Synopsis of Philippine mammals: Kogia breviceps: www.fmnh.org/philippine_mammals/species/SP_124.asp Accessed on 19 August 2014.

Heaney LR, MLL Dolar, DS Balete, JA Esselstyn, EA Rickart and JL Sedlock (2010i) Synopsis of Philippine mammals: Kogia sima: www.fmnh.org/philippine_mammals/species/SP_123.asp Accessed on 19 August 2014.

Heaney LR, MLL Dolar, DS Balete, JA Esselstyn, EA Rickart and JL Sedlock (2010j) Synopsis of Philippine mammals: Physeter macrocephalus: www.fmnh.org/Philippine_Mammals/species/SP_166.asp Accessed on 19 August 2014.

Heaney LR, MLL Dolar, DS Balete, JA Esselstyn, EA Rickart and JL Sedlock (2010k) Synopsis of Philippine mammals: Indopacetus pacificus: www.fmnh.org/Philippine_Mammals/species/SP_117.asp. Accessed on 19 August 2014.

Heaney, L., Balete, D., Rosell-Ambal, G., Tabaranza, B., Ong, P., Ruedas, L., Gonzales, J.C. & Oliver, W. 2008. Phloeomys cumingi. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on 21 September 2014.

Heaney, L.R., D.S. Balete, M.L. Dolar, A.C. Alcala, A.T.L. Dans, P.C. Gonzales, N.R. Ingle, M.V. Lepiten, W.L.R. Oliver, P.S. Ong. E.A. Rickart, B. R. Tabaranza and R.C.B. Utzurumm. 1998. A synopsis of the mammalian fauna of the Philippine Islands. Fieldiana: 1483.

Heaney, L.R., Dolar M.L., Balete D.S., Esselstyn J.A., Rickart E.A. and J.L. Sedlock. 2010. Synopsis of Philippine Mammals. The Field Museum of Natural History.

Hickman P (2006) Birds of prey rescue: Changing the future for endangered wildlife. Pamela Hickman. Fireflybooks Ltd. New York, USA. 64 p.

Hilsenhoff, W.L. (1987). An improved biotic index of organic stream pollution. Great Lakes Entomol. 20:31-39.

Hitchcock,D. R., and Bell, S. 2004. Physical impacts of marine aggregate dredging on seabed resources in coastal deposits. Journal of Coastal Research, 20: 101–114.

HSE. (2012). Failure Rate and Event Data for Use Within Risk Assessments. The United Kingdom: Health and Safety Executives (HSE).

Ingle, N. and L. Heaney. (1992). A key to the bats of the Philippine Islands. Fieldiana: 44 pp

IUCN Red List of Threatened Species (2016) retrieved from "http://www.iucnredlist.org/search"

Jarre-Teichmann A and D Pauly (1993) Seasonal changes in the Peruvian upwelling ecosystem. Pp 307 – 314. In V Christensen and D Pauly (eds.) Trophic models of aquatic ecosystems. ICLARM Conf. Proc. 26, 390 p.

Jefferson TA, Leatherwood X, Weber MA (1993) FAO Species identification guide: Marine Mammals of the World. UNEP/FAO, Rome. 320 p.

Kaymakc E., V. Didari, (2000) Relations between Coal Properties and Spontaneous Combustion Parameters, Department of Mining Engineering, Zonguldak Karaelmas University, Zonguldak, Turkey.

Kennedy RS, PC Gonzales, EC Dickinson, HC Miranda Jr, TH Fisher (2001) A Guide to the birds of the Philippines. 369 p.

Kennedy, R.S., Gonzales, P.C., Dickinson, E.C., Miranda Jr., H.C. and T.H. Fisher. A Guide to the Birds of the Philippines. 2000. New York City: Oxford University Press Inc. 369 pp

Moran, F.E. May 21, 2012. Special Hazard Systems. Coal-Fired Power Plants. Accessed from http://www.femoranshs.com/site/files/978/106677/389493/623385/QSR-72-201_PRB_article_-Final.pdf on Oct. 30, 2014.

Laist,D.W., Knowlton, A. R.,Mead, J. G., Collet, A. S., and Podesta, M. 2001. Collisions between ships and whales. Marine Mammal Science, 17: 35–75.

Lucke, K., Siebert, U., Lepper, P. A., and Blanchet, M. A. 2009. Temporary shift in masked hearing thresholds in a harbor porpoise (Phocoena phocoena) after exposure to seismic airgun stimuli. Journal of the Acoustical Society of America, 125: 4060–4070.

Mooney, T. A., Nachtigall, P. E., Breese, M., Vlachos, S., and Au,W.W. 2009. Predicting temporary threshold shifts in a bottlenose dolphin (Tursiops truncatus): the effects of noise level and duration. Journal of Acoustical Society of America, 125: 1816–1826.

Martinez-Arroyo, A., S. Abundes, E. Gonzales, and I. Rosas. 1999. On the influence of hot water discharges on phytoplankton communities from a coastal zone of the Gulf of Mexico. Water, Air and Soil Pollution 119: 209-230.

Municipal Fisheries Profile of Luna, La Union. January – April 2016.

Mines and Geosciences Bureau. Geology and Mineral Resources of the Philippines, Volume 1: Geology. Quezon City, 2010.

Mines and Geosciences Bureau. Geologic Map of the Philippines, Volume 1: Geology. Quezon City, 2010.

Lampert, W. and U. Sommer. 2007. Limnoecology 2nd ed. : The Ecology of Lakes and Streams. Oxford University Press Inc.: New York. 323pp.

Lapidez, J.P., J. Tablazon, L. Dasallas, L.A. Gonzalo, K.M. Cabacaba, M.M.A. Ramos, et al. 2015. Identification of storm surge vulnerable areas in the Philippines through simulation of Typhoon Haiyan-induced storm surge levels over historical storm tracks. Natural Hazards and Earth System Sciences, 12, 1473-1481. Retrieved from http://www.nat-hazards-earth-syst-sci.net/15/1473/2015/nhess-15-1473-2015.pdf

Lawler I, H Marsh, B McDonald and T Stokes (2002) Dugongs in the Great Barrier Reef: Current state of Knowledge. CRC Reef Research Center. Brochure. 6 p.

Ledesma, M., Brown, R., Sy, E. & Rico, E.L. 2009. Hydrosaurus pustulatus. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on 21 September 2014.

LGU of Luna, La Union. Contingency Plan (Hazard Mapping) for 2015-2020.

Mamaril, A. Sr., Rosell, N.C., Cariaso B.J. and R.G. Garcia. 1986. Guide to Philippine Flora and Fauna vol. VII: Zooplankton, Barnacles, and Swimming Crabs.NRMC NMC and UP, JMC Press Inc., Quezon City, Phils. 268 pp.

Mandaville, S.M., 2002. Benthic Macroinvertebrates in Freshwaters-Taxa Tolerance Values, Metrics, and Protocols

Marsh H, H Penrose, C Eros and J Hugues (Compilers) (2002) Dugong: Status report and action plans for countries and territories. Early Warning Assessment Report Series. UNEP.

Marsh H, O'Shea TJ and Reynolds JE III (2011) Conservation Biology 18: Ecology and conservation of the Sirenia Dugongs and manatees. Cambridge University Press. 512 p.

Massachussets Stream Crossings Handbook www.streamcontinuity.org/pdf_files/ecological_considerations_streams_crossings_pdf

Mateo and Siringan, 2007. Tectonic Control of High Frequency Holocene Delta Switching and Fluvial Migration in Lingayen Gulf Bayhead, Northwestern Philippines. Journal of Coastal Research: 23:1:182-194. Retrieved from http://scinet.dost.gov.ph/union/Downloads/ACD%20Siringan2_5084.pdf

Mattison C (1986) Snakes of the world. Cassell (Octopus Publishing Group Ltd.), UK. 190 p.

Musick JA and CJ Limpus (1997) Habitat utilization and migration in juvenile sea turtles. Pp 137 – 164. In PL Lutz and JA Musick (editors) The biology of sea turtles. CRC Press LLC. Florida, USA. 432 p.

National Oceanic and Atmospheric Administration, ND. NOAA Ocean Acidification Program. Retrieved: September 25, 2014 from (http://oceanacidification.noaa.gov/AreasofFocus/OceanAcidificationMonitoring.aspx)

National Oceanic and Atmospheric Administration, ND. NOAA Acidification Program Monitoring Approach

National Water Resources Council, 1983. Framework Plan for the Quezon Province Basins. PHI/77/SO3 –United Nations Development Program Assistance to the National Water Resources Council.

Nichols S., Coysh J., Sloane P., Williams C. and Norris R. 2000 Australian Capital Territory (ACT) AUSRIVAS Sampling and Processing Manual. (http://ausrivas.canberra.edu.au/man/ACT/)

Nillos PA, NE Palomar, DS Torres and JD Matillano (2005) Sightings of cetaceans (whales and dolphins) of the western and southern coasts of Palawan. In A.C. Alcala and M.C.G. Rañola (eds) Occasional papers of the Silliman University-Angelo King Center for Research and Environmental Management (SUAKCREM) Exercise Luzon Sea Phase I (Palawan Expedition) January 2005 1(1): 74 – 81.

NRC. 2005. Marine Mammal Populations and Ocean Noise— Determining When Noise Causes Biologically Significant Effects. The National Academics Press,Washington, DC.

Oliver, W. & Heaney, L. 2008. Sus philippensis. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on 29 August 2014.

Oliver, W., MacKinnon, J., Ong, P. & Gonzales, J.C. 2008. Rusa marianna. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on 21 September 2014.

Olivieri RA, A Cohen and FP Chavez (1993) An ecosystem model of Monterey Bay, California. Pp 315 – 322.In V Christensen and D Pauly (eds.) Trophic models of aquatic ecosystems. ICLARM Conf. Proc. 26, pp 390.

Ong PS, LE Afuang and RG Rosell-Ambal (eds.) (2002) Philippine biodiversity conservation priorities: A second iteration of the national biodiversity strategy and action plan. Department of Environment and Natural Resources – Protected Areas and Wildlife Bureau, Conservation International Philippines, Biodiversity Conservation Program – University of the Philippines Center for Integrative and Development Studies, and Foundation for the Philippine Environment. Quezon City, Philippines.

Ong, P., Rosell-Ambal, G., Tabaranza, B., Walston, J., Balete, D., Alcala, E., et al. 2008. Eonycteris robusta. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on 21 September 2014.

Opitz S (1993) A quantitative model of the trophic interactions in a Caribbean coral reef ecosystem, p. 259 – 267. In V Christensen and D Pauly (eds.) Trophic models of aquatic ecosystems. ICLARM Conf. Proc. 26, pp 390.

Palma JAM (1993) Marine turtle conservation in the Philippines. Pp 113-128. In AF Nacu, RB Trono, JAM Palma, DS Torres and FG Agas, Jr (eds) Proceedings of the First ASEAN Symposium-Workshop on marine turtle conservation. Manila, Philippines.

Patrick Colin and C. Arneson, 1995. Tropical Pacific Invertebrates. Coral Reef Press.

Perrin WF, RR Reeves, MLL Dolar, TA Jefferson, H Marsh JY Wang and J Estacion (1996) Report of the second workshop on the biology and conservation of small cetaceans and dugongs in South-east Asia. United Nations Environment Programme (UNEP) and the Secretariat of the Convention on the Conservation of Migratory Species (CMS). Bonn, Germany. 343 p.

Perrin,W. F.,Wursig, B., and Thewissen, J. G. M. 2009. Encyclopedia of Marine Mammals. Academic Press, San Diego, CA, USA.

Philippine Institute of Volcanology and Seismology. "Active Faults and Trenches." 2000. http://www.phivolcs.dost.gov.ph/index.php?option=com_content&view=article&id=78&Itemid=500024 (accessed July 29, 2016).

Philippine Institute of Volcanology and Seismology. "Earthquake Records 1907 to 2015." Quezon City, 2016.

Pilcher NJ and Kwan D (2012) Dugong questionnaire survey project manual. CMS-UNEP Abu Dhabi Office. United Arab Emirates. September 2012. 44 p.

Plafkin, J.L. M.T. Barbour, K.D. Porter, S.K. Gross, R.M. Hughes. 1989. Rapid Assessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish. EPA: Washington, D.C. Rosenberg, D.M., V. H. Resh (eds). 1993. Freshwater Biomonitoring and Benthic Macroinvertebrates. Chapman & Hall:New York, NY.

Pritchard PCH, Mortimer JA. (1999) Taxonomy, external morphology and species identification. Pp 21-38. In KL Eckert, KA Bjorndal, FA Abreu-Grobois, M Donnelly (eds) Research and Management Techniques for the Conservation of Sea Turtles. IUCN/SSC Marine Turtle Specialist Group Publication No. 4. 235 pp.

Quimio, J.M. (1996). Grassland Vegetation in Western Leyte, Philippines. Schriftenreihe des Institutes fuer Landespflege der Universitaet Freiburg 22: 1- 195.

Reichart HA (1993) Synopsis of biological data on the olive ridley sea turtle Lepidochelys olivacea (Eschscholtz, 1829) in the western Atlantic. NOAA Technical Memorandum NMFS-SEFSC-336, 78 p.

Reilly, S.B., Bannister, J.L., Best, P.B., Brown, M., Brownell Jr., R.L., Butterworth, D.S., Clapham, P.J., Cooke, J., Donovan, G.P., Urbán, J. & Zerbini, A.N. (2008a) Balaenoptera musculus. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on 23 August 2014.

Reilly, S.B., Bannister, J.L., Best, P.B., Brown, M., Brownell Jr., R.L., Butterworth, D.S., Clapham, P.J., Cooke, J., Donovan, G.P., Urbán, J. & Zerbini, A.N. (2008b) Megaptera novaeangliae. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on 23 August 2014.

Reyes, T.D. Jr. (2006). Plant-Environment Relations in the Philippine Tarsier Habitats and Territories. Unpublished MS Thesis. Wageningen University and Research Centre. The Netherlands.

Reynolds, J. E., Perrin,W. F., Reeves, R. R., Montgomery, S., and Ragen, T. 2005. Marine Mammal Research—Conservation Beyond Crisis. John Hopkins University Press, Baltimore, MD.

Rimando, R. and Kneupfer, P.. "Neotectonics of the Marikina Valley Fault System (MVFS) and tectonic framework of structures in northern and central Luzon, Philippines." Tectonophysics, 2006: 17-38.

Robinson, S. P., Theobald, P.D., Hayman, G.,Wang, L. S., Lepper, P. A., Humphrey, V., and Mumford, S. 2011. Measurement of underwater noise arising from marine aggregate dredging operations. Marine Aggregate Levy Sustainability Fund MEPF report 09/P108

Rolland, R. M., Parks, S. E., Hunt, K. E., Castellote, M., Corkeron, P. J., Nowacek, D. P., Wasser, S. K., et al. 2012. Evidence that ship noise increases stress in right whales. Proceedings of the Royal Society B: Biological Sciences, 279: 2363–2368.

Schroeder B, Murphy S (1999) Population surveys (ground and aerial) on nesting beaches. Pp 45 – 55. In KL Eckert, KA Bjorndal, FA Abreu-Grobois, M Donnelly (eds) Research and Management Techniques for the Conservation of Sea Turtles. IUCN/SSC Marine Turtle Specialist Group Publication No. 4. 235 pp.

Scottish Environment Protection Agency, SEPA Position Statement to Support the Implementation of the Water Environment: Regulations 2005: Culverting of Watercourses, www.sepa.org.uk/wfd/guidance/engineering

Segers, H. 2004. Rotifera: Monogononta. In: Yule, C.M. & H.S. Yong (Eds). Freshwater Invertebrates of the Malaysian Region. Academy of Sciences of Malaysia, Kuala Lumpur. 106-120

Segers, H. 2007. Annotated checklist of the rotifers (Phylum Rotifera), with notes on nomenclature, taxonomy and distribution, Zootaxa1564: 104 pp.

Servais, P., and Billen G. 1989. Impact of a nuclear power plant on primary production and bacterial activity in the River Meuse and Tihange (Belgium). Arch. Hydrobiol. 114: 415-429.

South East Asia Association of Seismology and Earthquake Engineering. "Catalogue of the Philippine Earthquakes." 1985.

Southall, B. L., Bowles, A. E., Ellison,W. T., Finneran, J. J., Gentry, R. L., Greene, C. R., Kastak,D., et al. 2007. Marinemammalnoise exposure criteria, initial scientific recommendations. Aquatic Mammals, pp. 411–414.

Stephan, Clete,. Coal Dust Explosion Hazards, Mine Safety and Health Administration, Pittsburgh, Pennsylvania.

Stewart I and Falconer IR (2008) "Cyanobacteria and cyanobacterial toxins" Pages 271–296 in Oceans and human health: risks and remedies from the seas, Eds: Walsh PJ, Smith SL and Fleming LE. Academic Press, ISBN 0-12-372584-4.

Suthers, I.M. and D. Rissik. 2009. Plankton: A Guide to Their Ecology and Monitoring for Water Quality. Collingwood VIC CSIRO Publishing, Australia. 273 pp.

Tambiah C (1999) Interviews and market surveys. Pp 156 – 161. In KL Eckert, KA Bjorndal, FA Abreu-Grobois, M Donnelly (eds) Research and Management Techniques for the Conservation of Sea Turtles. IUCN/SSC Marine Turtle Specialist Group Publication No. 4. 235 pp.

Tham Ah Kow, T Chang Man, Gan Mee Yin, Tan Chiow Sang, Foo Ho Tar and Gan Jer Lay. 1970. The Distribution of Plankton in Singapore Straits for the Period from April 1968 to March 1969. In Proc. of the 2nd CSK Symposium, Tokyo, Japan, pp. 309-324.

The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on 21 September 2014.

Thenhaus, P. C., Hanson, S.L, Algermissen, S. T., Bautista, B.C., Bautista, MLP, Punongbayan, BJT., Rasdas A.R., Nillos, T.E., and Punongbayan, R.S.("Estimates of the Regional Ground-Motion Hazard in the (Phi)." National Conferene on Natural Disaster Mitigation. Manila, 1993. pp 45-69.

tksouthernluzon (2008) Butanding (whaleshark) in Brgy. Caridad Ilaya Aug 18, 2008 https://www.youtube.com/watch?v=v4Zq3CxKnK8 You Tube (Uploaded on Aug 21, 2008). Accessed 22 August 2014.

Tomas, C. R. 1997. Identifying marine phytoplankton. Academic Press, California. Valiela,I 1984.Marine Ecological Process. Springer-Verlag, New York, pp546.

Torres DS (2011) Seabirds (Genera: Sterna, Fregata) occurring with whalesharks (Rhincodon typus) and associated fishes in Honda Bay, Palawan: Vulnerabilities to climate change effects." Presented at the 11th

National Symposium in Marine Science held by the Philippine Association of Marine Science on 20 to 22 October 2011 at the Development Academy of the Philippines, Tagaytay City, Cavite.

Torres DS, IA Lim, CT Reyes and E Narida (2000) Notes on the characteristics of whale sharks (Rhincodon typus) in Honda Bay (Palawan, Philippines). Papers in the American Elasmobranch Society (AES) Symposium on Natural History during the 16th Annual Meeting of the AES, University Autonoma de Baja California Sur, La Paz, B.C.S., Mexico. June 14 – 20, 2000. Program Book and Abstracts

Torres DS, Palomar NE, Nillos PA, Zakaraiah ZM. (2005) Preliminary assessment of sea turtle habitats in Southern Palawan, Philippines. Exercise Luzon Sea Phase I (Palawan Expedition): Report on the Status of the Marine Environment and the Marine Resources of Southern Palawan, Philippines. Occasional papers of Silliman University-Angelo King Center for Research and Environmental Management (SUACKREM). Vol. 1 No. 1. January 2005.

Torres DS, Santa Cruz ES, Manzanero LIO, Santa Cruz GS (2004) Conservation of a remnant hawksbill (Eretmochelys imbricata) population nesting in Punta Dumalag, Barangay Matina Aplaya, Davao City, Philippines. Agham Mindanaw 2004. Vol 2. pp 35-39. Ateneo de Davao University.

Torres, DS (2004) Tagging of marine turtles in the Philippines. Country Report presented during the ASEAN-SEAFDEC Regional Technical Consultation on the Management and Conservation of Sea Turtles is Southeast Asia. Shah Jalan, Malaysia.

Umali AF (1950) Guide to the classification of fishing gear in the Philippines. Research Report 17. Fish andWildlife Service, United States Department of the Interior.

UP Planning and Development Research Foundation, Inc. (UP PLANADES) 2001. Situational Analysis for the Comprehensive Land Use Plan for Atimonan, Quezon.

US-EPA, 1994. The Water Quality Standards Handbook: Second Edition. https://www.epa.gov/wqs-tech/water-quality-standards-handbook

U.S. Department Of Health And Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Toxicological Profile For Fuel Oils, Georgia, June 1995.

U.S. Department of Transportation (DOT), The 2012 Emergency Response Guidebook (ERG2012), 2012.

Viloria AT and Yaptinchay AASP (2011) Philippine country report on the status of dugongs. Paper presented in the Conference of the Memorandum of Understanding for the Conservation and Management of Dugongs and their Habitats throughout their Range held at Sarawak, Malaysia on 26 – 29 July 2011.

Viloria, AT. (2009) Marine turtle nesting beaches of the Philippines. Sylvatrop

VROM. (2005). Guidelines for Quantitative Risk Assessment: Publication Series on Dangerous Substances (PGS3, "TNO Purple Book"). The Netherlands: Ministry of Housing, Spatial Planning and the Environment (VROM).

Wells, D. and Coppersmith, K.. "New Empirical Relationship among Magnitude, Rupture Length, rupture Width, Rupture Area, and Surfce Displacement ." Bulletin of the Seismological Society of America, 1994: 974 - 1002.

Wilhm, J.L. 1975. Biological indicators of pollution. In Aquatic Ecology, ed. B.A. Whitton, pp. 375-402. Univ. of California Press, Berkeley, CA.

Witzell WN (1983) Synopsis of biological data of the hawksbill turtle Eretmochelys imbricata (Linnaeus, 1766). Food and Agriculture Organization of the United Nations. Rome. 78 p.

Wright, A., Soto, N., Baldwin, A., Bateson, M., Beale, C. M., Clark, C., Deak, T., et al. 2007. Do marine mammals experience stress related to anthropogenic noise? International Journal of Comparative Psychology, 20: 274–316.

Yano K, A Ali, AC Gambang, IA Hamid, SA Razak and A Zainal (2005) Sharks and rays of Malaysia and Brunei Darussalam. SEAFDEC-MFRDMD/SP/12. Kuala Terengganu. 557 pp