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Name of the Project	Wawa Bulk Water Supply Project – Upper Wawa Dam Component	
Project Location	Rizal Province	
Project Area	City of Antipolo and Municipalities of San Mateo and Rodriguez	
Nature Type of Project	Infrastructure: Dam	
Proposed Installed Capacity	518 MLD	
Summary of Major Components	**Major Components**	**Brief Description**
	Upper Wawa Dam, Spillway and Reservoir	**Type**: Earth Core Rockfill Dam (ECRD) or Roller Compacted Concrete (RCC) **Spillway type:** Gated Ogee weir with open air chute channel **Energy Dissipation**: Ski jump with Deflector with an Excavated plunge pool **Crest Level:** EL 140.0 m ASL **Full Supply Level (FSL):** EL 135.0 m ASL **Minimum Operating Level (MOL):** EL 87.0 m ASL **Maximum Water Level:** EL 135.0 m ASL **Spillway Design flood**: PMF (7,300 m³/s) **Inundated Area at FSL:** 414.28ha **Inundated Area at MOL:** 74.33ha **Dam Height (above riverbed):** 84 m **Dam Crest Length:** 425 m **Drainage Area**: 258 km² **Number of Bays:** 4 **Ogee level**: 121.70 m **Gate Type**: Radial gates with flap gates **Number of gates:** 4 **Spillway Check Flood:** Probable Maximum Period **Spillway Design Flood:** 10,000 years Return Period
	Pumping Station	Type: Wet Pit, circular shape, 3 pits Pump Type: Vertical Turbine Type Number of Pumps: 6 (4 100% operating, 2 stand-by) Pump Capacity: 1.5m³/s each, net head ≥100 m
	Conveyance Pipe	From: Pump Station To: Calawis WTP (to be developed by MWC) Approximate Length: 3,480m Diameter: 1800mm Type: Buried Steel Pipe
Project Cost	PhP 14 billion	
Construction Period	2020 - 2025	
Commercial Operation Date	December 31, 2025	
Proponent Name	WawaJVCO, Inc.	
Proponent Authorized Representative	Mr. Melvin John M. Tan Authorized Representative	
Proponent Address and Contact Details	16th F, Three E-Com Center Mall of Asia Complex, Pasay City Telephone No.: (02) 396 5320 E-mail Address.: mjtan@primemetroinfra.com	
EIA Preparer	Aperçu Consultants, Inc.	
Preparer Contact Person	Lilli Beth S. Yazon Managing Director	
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Project Description Summary

This Environmental Impact Statement (EIS) is prepared for the application of an Environmental Compliance Certificate (ECC) for an earth core rockfill dam with a water storage capacity of 120.1MCM that produces at least 518 MLD. The proposed project will be known as the Wawa Bulk Water Supply Project – Upper Wawa Dam Component (Upper Wawa Dam Project or Project) owned by WawaJVCo, Inc. (WawaJVCo), a joint venture between Prime Metroline Infrastructure Holdings Corporation and San Lorenzo Ruiz Builders (SLRB).

The Upper Wawa Dam Component has an estimated catchment of 242km^2. It will involve the construction of a 84-meter high dam with a storage capacity of 120.1MCM for water supply. It also has a proposed flood control component that can hold 43.7MCM of flood water. Raw water from the dam will be pumped to the Calawis Water Treatment Plant which will be developed by Manila Water. The project aims to address the increasing water demand and flood concerns in Metro Manila. It will be located within the within the Wawa River Basin, which is part of the Upper Marikina River Basin Protected Landscape (UMRBPL).

The proposed project is in the Province of Rizal, specifically in Barangay Calawis in Antipolo City, Barangay Pintong Bukawe in San Mateo, and Barangay San Rafael in Rodriguez. The Dumagats hold a Certificate of Ancestral Domain Title (CADT) in Rodriguez, Rizal and a Certificate of Ancestral Domain Claim (CADC) application in Antipolo City. WawaJVCo is currently in the advance stages of the Free, Prior and Informed Consent (FPIC) process with NCIP for the project's first component. The proponent already signed a Memorandum of Agreement (MOA) for the Antipolo Ancestral Domain and is already scheduled to conduct the MOA Negotiation for the Montalban AD.

EIA Process Documentation

EIA Team

The environmental impact assessment was conducted by a team of specialist and consultants who have expertise in their respective fields. **Table ES-1** lists the members of the team.

Table ES-1
List of EIA Team Composition

Module/Component	Team Member	Registration No.
Project Management	Lilli Beth S. Yazon	IPCO-094
Project Coordinator	Kiara Aline B. Gawaran	IPCO-508
Project Co-Coordinator	Joshua Punongbayan	-
Land Use and Pedology Geology and Geomorphology	Armie Jean H. Perez	IPCO-071
Terrestrial Ecology – Flora	Tomas Reyes, Ph. D	IPCO-386
Terrestrial Ecology – Fauna	Diane Shiela C. Castillo	IPCO-295
Hydrology and Hydrogeology	Dolores Cleofas, Ph.D	IPCO-293
Freshwater Ecology	Vivian Camacho, Ph. D	IPCO-213
Water Quality	Joshua Punongbayan	-
Traffic Study	Kiara Aline B. Gawaran	IPCO-508
Ambient Air Quality and Noise; Environmental Risk Assessment	Jethro Alden C. Hipe	IPCO-005
Socio-economics and Cultural Heritage	Ma. Theresa Agravante	IPCO-151

The WawaJVCo, Inc. Team that worked closely with the EIA Team included:

Mr. Melvin John Tan
Mr. Karl Zapanta
Mr. Jeff Go

The DENR Review Committee for this project is composed of the following members:

Engr. Elsie Cezar	Air & Water Quality
Dr. Teresita Perez	Freshwater & Terrestrial Ecology
Dr. Soledad Natalia Dalisay	Social Impact Assessment
Dr. Ramon Quebral	Geotechnical Engineering/ ERA
Mr. Oskar Cruz	Geology/PAGASA
Mr. Daniel Garino – BMB	Resource Person, BMB
Engr. Carlo Vic. Arida	EMB Case Handler
Engr. Lene E. Ramboyong	EMB Co-Case Handler

EIA Study Schedule

The duration of the environmental impact assessment was from June 2019 to October 2020. **Table ES-2** shows the list of activities conducted.

Table ES-2
EIA Study Schedule

Activity	Date	Place/Module
IEC Activities/FGDs	September 17, 2020	Barangay Calawis
	September 16, 2020	Barangay Pintong Bukawe
	September 23, 2020	Barangay San Rafael
	July 22, 2020	Municipality of Rodriguez via video conference
	September 29, 2020	Municipality of San Mateo via video conference
	October 08, 2020	Antipolo City via video conference
Technical Scoping	June 29, 2020	Video Conference via Microsoft Teams
Data Gathering	November 14 and 19, 2019 September 10 and 12, 2020	Land Use and Pedology
	November 14 and 19, 2019	Geology
	November 17-21, 2019	Terrestrial Flora
	November 23-27, 2019 August 9-14, 2019	Terrestrial Fauna
	August 3-6, 2019 November 15-16, 2019	Hydrology
	June 11-13, 2019 July 5-6, 2019 August 6-7, 13, 2019 November 30 to December 2, 2019 July 22-24, 2020 September 10-11, 2020	Water Quality
	August 4 to 6, 2019 November 30 to December 2, 2019	Freshwater Ecology
	January 10-11, 2020 February 2-3, 2020 January 11-12, 2020 February 1-2, 2020 August 7-8, 2020 August 8-9, 2020	Ambient Air and Noise
	August 14-15, 2020	Traffic

EIA Study Area

The proposed project is within the Upper Marikina River Basin Protected Landscape (UMRBPL), which covers one (1) city: Antipolo and two (2) municipalities: Rodriguez and San Mateo. The project reservoir will cover six (6) river systems: Wawa River, Montalban River, Boso-Boso River, Payagwan River, Tayabasan River, and Sapa Bute-Bute River. The project impact areas, including the inundated areas and areas for temporary facilities are shown in **Table ES-3.**

Table ES-3
Location of Project Facilities

Location	Infrastructure
Barangay San Rafael, Rodriguez	Dam Area, Spillway, Pumping Stations, Water Conveyance Pipeline and Road, Tunnel, Access Road, Quarries 1 & 2, Disposal Areas, Deposit of Dangerous Elements, Powder Magazine, Store and Associated Open Storage Areas, Generators, Fuel Tanks, Mechanical Workshops, Truck and Equipment Washing Area, Site Office, Batching Plants, Parking Area, Store, Crushing and Screening Plant, Camp and Offices, Wastewater Treatment Plant, Electrical Transmission Line
Barangay Calawis, Antipolo City	Portion of Transmission / Water Conveyance Pipeline and Road
Barangay Pintong Bukawe, San Mateo	Portion of Access Road

EIA Methodology

The environmental impact assessment was conducted based on the guidelines provided under the Revised Procedural Manual for DAO 2003-30 issued on August 2007 and the Revised Guidelines for Coverage Screening and Standardized Requirements (EMB MC 2014-05). The scope of and methods of assessment was agreed upon by the Review Committee during the Technical Scoping meeting held on June 29, 2020. **Table ES-4** shows the methods used in the study.

Table ES-4
EIA Methodology

Module/Section	Baseline Sampling Methodology	Stations and/or Parameter or Indices
LAND MODULE		
Land Use Classification	Review of CLUPs Review of satellite imagery Walk through surveys/Ground truthing and mapping	Land Use Mapping of watersheds using satellite imagery and NAMRA maps
Geology and Geomorphology	Review of geological reports and hazard maps Walk through surveys Geotechnical drilling	Reginal Tectonic Setting Regional Stratigraphy Geomorphology, Topography, Slope Site Geology Geomorphology Hazard Identification (seismic hazards, mass movements, flooding, volcanic hazards) Seismicity Climate Change
Pedology	Review of soil map Walk through surveys Geotechnical drilling Soil augering Physico-chemical analysis of soil samples	Wet Season: Nine (9) soil sampling stations Dry Season: Five (5) soil sampling stations Soil Type and Quality Parameters: pH, total organic matter, nitrogen, phosphorus, potassium, copper, iron, manganese, zinc, arsenic, cadmium, lead, molybdenum, mercury, hexavalent chromium, boron and chloride

		Soil erosion susceptibility
Terrestrial Flora	Quadrant sampling Transect surveys Wet season: Purposive Quadrat Sampling • 10m x 10m plots • 2m x 2m plots Dry season: (SMEC, 2019) Stratified Random Sampling • 40m x 40m for trees • 4m x 4m for regenerants	Wet season: established 304 plots consisting of 138 10m x 10m plots and 166 2m x 2m for the wet season Dry season: established 178 plots with a dimension of 40m x 40m for trees and 4m x 4m for regenerants (SMEC, 2019) Density and Relative Density Dominance and Relative Dominance Occurrence Frequency and Relative Frequency Importance Value Diversity Index Evenness Index Endemicity Conservation Status
Terrestrial Fauna	Transect surveys for herpetofauna Transect surveys and mist-netting for birds Mist netting for volant mammals Cage trapping for nonvolant mammals Conduct of informal interviews	Wet and dry season: Five (5) transect stations for birds and herpetofauna Five (5) mist-netting stations for birds and volant mammals Five (5) cage trapping stations for nonvolant mammals Relative Abundance Species Richness Diversity Index Dominance Index Evenness Index Endemicity Conservation Status Sources of Environmental Degradation
WATER MODULE		
Hydrology and Hydrogeology	Review of topographic maps from NAMRIA and SRTM-DEM data Review of the General Geology and Mineral Resources of the Philippines from MGB Review of rainfall and climatologic data of relevant synoptic/rainfall stations from PAGASA and EFCOS Review of stream flow data of relevant gauging stations from NWRB and DPWH-BRS Spring and well inventory Groundwater inventory (spring and wells) Surface water inventory Stream flow measurements Spring flow measurements Conduct of informal interviews	Wet season: three (3) spring, two (2) deep well, and six (6) surface water stations Dry season: three (3) spring, two (2) deep well, and seven (7) surface water stations Hydrological setting and Drainage system identification Watershed delineation and characterization Hydrogeological setting Historical rainfall and streamflow records Spring and well inventory Current water user study Water availability and dependability analysis Water balance study Flood frequency analysis and Probable maximum flood Review of PAGASA 2020 & 2050 climate change projections Groundwater vulnerability
Water Quality	Surface water and groundwater sampling Surface water sampling at three (3) depths Physico-chemical analysis of water samples	Wet season: 18 surface water and four (4) groundwater sampling stations Dry season: 11 surface water and four (4) groundwater sampling stations

	In-situ measurements of selected parameters	Parameters for surface water: pH, Temperature, DO, Turbidity, Conductivity, BOD_5, TDS, TSS, Oil and Grease, Fluoride, Fecal Coliform, Iron, Phosphate, and Nitrate Parameters for groundwater: pH, Temperature, DO, Turbidity, Conductivity, BOD_5, TDS, TSS, Oil and Grease, Fluoride, Fecal Coliform, Iron, Phosphate, and Nitrate
Freshwater Ecology	Plankton sampling through a plankton net Sediment sampling and rock inspection for macroinvertebrates Conduct of informal interviews for fish and river use In-situ measurements to obtain basic limnological variables Flowrate measurements using float method	Wet season: eight (8) sampling stations Dry season: ten (10) sampling stations Density and Relative Density River Use Biota species: plankton, macroinvertebrates, fish Water quality parameters: DO, temperature, TDS, and pH Physical characterization: land use; bank conditions; stream origin and type; riparian vegetation features; sediment type; and instream width, depth, and flow
AMBIENT AIR AND NOISE MODULE		
Climate and Meteorology	Review of meteorological data from relevant PAGASA stations	Regional meteorology and local meteorology PAGASA climate projections
Ambient Air Quality	24-hour baseline sampling of ambient air using Staplex high volume sampler AERMOD Modeling Review of PAGASA 2020 & 2050 Projections on Climate Change	six (6) sampling locations Parameter: TSP, PM10, SO2 & NO2
Ambient Noise	24-hour baseline sampling of ambient noise Noise sampling for daytime, nighttime, and morning/evening periods using noise meter	six (6) sampling locations
PEOPLE MODULE		
Socio-economics	IECs Sessions and meetings with city/municipal and barangay officials, sectoral and community leaders and residents, and representatives of project affected households Key Informant Interviews Health profile assessment Review of profile of the host province, municipalities, and barangays Review of Land Use Plans Review of Forest Land Use Plans Review of Ecological Review of Socio-Economic Profiles, Situational Analysis Reports, Department Reports and Lists Review of Comprehensive Upper Marikina River Basin Protected Landscape Management Plan and internet-based materials	LGU, women, youth, elder, tribal leaders, NGO, NCIP Physical and Demographic Characteristics, Proximity of Barangay Location to Basic Services and Service Institutions, Peace and Order Situation, and Barangay Programs and Services Three (3) direct impact barangays: San Rafael, Pintong Bukawe, Calawis Three (3) indirect impact barangays: Pintong Bukawe, San Jose, San Juan Health profile: Health statistics (mortality and morbidity), health programs and facilities,

	Review of CLUPs Review of municipal health data Review of Resettlement Action Plan	
Traffic	Vehicle counts from 6am to 6pm (weekday and weekend day)	Six (6) traffic routes
Environmental Risk Assessment (ERA)	Literature review regarding controlled blasting, explosive and fuel storage, and amounts	Hazard identification Consequence analysis Frequency analysis Risk assessment Risk management

Public Participation Activities

Table ES-5 provides the public participation activities conducted in the EIA study.

Table ES-5
List of Public Participation

Date of IEC Sessions/Community Consultations	Venue	Activity
September 17, 2020	Barangay Calawis, Antipolo City	IEC zSessions/ FGDs
September 16, 2020	Baranagay Pintong Bukawe, San Mateo	
September 23, 2020	Barangay San Rafael, Rodriguez	
July 22, 2020	Municipality of Rodriguez	
September 29, 2020	Municipality of San Mateo	
October 08, 2020	Antipolo City	

The concerns raised during the consultations revolved around these topics:

Environmental Concerns:

- Will the proponent secure permit for the protected area? What measures are in place to ensure that protected area is not affected by the project?
- What about permit for the ancestral domains?
- Will this project generate electricity? Or just water supply? This may cause water supply problems during the dry season.

Social Concerns:

- Project will affect three barangays. Will relocation site accommodate all affected stakeholders from three barangays?
- Will there be employment in host barangays?
- Will barangay residents be able to access the dam so the barangay can develop tourism programs once the project is operational? What is allowed perimeter from project structures?
- Are the affected families located inside the project site? How about those located in low lying areas (downstream of the dam), will these communities not be affected by the project?
- What if accidents and emergencies occur (i.e., flooding)?
- How will the affected families be affected by the project? Are they affected by construction or inundation?
- Will the project include incentives for host LGUs, for example free water supply for LGUs?

Summary of Free, Prior, and Informed Consent (FPIC)

The proponent has made representations to the NCIP regarding this. The latter informed the proponent that the CP /FPIC application has to be deferred until the completion of the on-going CP/FPIC process for the Tayabasan Multi-Basin System Project also under Wawa JVCo. INC. There is a ruling under IPRA that a company can apply for only one CP/FPIC application per project at a time.

Summary of Baseline Characterization, key Environmental Impacts and Management & Monitoring Plan, and EMF & EGF Commitments

Summary of Baseline Characterization

The existing environment of the project site from the baseline surveys conducted is shown in **Table E6-6**.

Table ES-6
Baseline Characterization Summary

Module	Baseline Characteristics
LAND MODULE	
Land Use	The proposed Wawa Bulk Water Supply Project (Upper Wawa Dam (EWD) Component) is located within Antipolo City and the municipalities of San Mateo and Rodriguez in Rizal Province. Rizal is generally an agricultural province with more than 51% of its total land area classified as forestland and the rest as alienable and disposable land. There are four protected areas in the province, with the proposed project site located within the Upper Marikina River Basin Protected Landscape (UMRBPL). Land uses in the host city and municipalities are briefly discussed below: • Antipolo City with a total land area of 38,504.44 hectares has the second largest land area in Rizal Province. It consists of 16 barangays, the largest of which are San Jose, Calawis and San Juan. Land uses in Antipolo City consist of forests (26,679.88 hectares or 69.29%), built up areas (8,597.38 hectares or 22.33%), agricultural land (2,006.72 hectares or 5.21%) and miscellaneous land uses (1,220.46 hectares or 3.17%). A large portion of the UMRBPL is located within Antipolo City. • The Municipality of Rodriguez is the largest municipality in Rizal Province with a total land area of 33,564.81 hectares. It consists of 11 barangays, eight of which are urban while three are rural. A total of 81.17% of the municipal land area is occupied by forests, 5.54% by built up areas, 10.21% by agricultural areas and 3.08% by miscellaneous land uses. • The Municipality of San Mateo has a total land area of 4,825.10 hectares and is subdivided into 15 barangays. Land uses in the municipality consist of agricultural, built up, protected open spaces, and miscellaneous land uses. Commercial zones are located along major roads while industrial areas are located on the western side of the municipality. The major land uses in the vicinity of the proposed project site include wooded grassland, shrubland and grassland. Minimal land use changes were observed in the project site from the 2015 EIA for the Wawa Dam Project until November 2019 during the fieldwork for the present study. The project site and vicinity overlap with the following protected areas and tenurial instruments issued by the Philippine Government: • The entire project site is within the UMRBPL, a protected area that was included as a component in the Expanded National Integrated Protected Areas System (NIPAS) Act of 2018. It encompasses a total area of 26,125.64 hectares. The Upper Marikina River drains Antipolo City and the municipalities of Baras, Rodriguez, San Mateo and Tanay. The UMRBPL is surrounded by other reservations and protected areas, except at the south where it is bound by alienable and disposable lands.

<table>
<tr><th>Module</th><th>Baseline Characteristics</th></tr>
<tr><td></td><td>

The project site is located south of the Montalban CADT, an ancestral domain covering an estimated area of 19,000 hectares and belonging to the Remontado Dumagats. Another CADC application in Antipolo City covering 9,347 hectares is located south of the Montalban CADT. The inundation area of the upper dam covers <1% of the Antipolo CADC.
The possibility of overlap with National Greening Program sites of DENR will be investigated prior to commencement of any project activity, as several NGP projects are located in Barangay Puray (Rodriguez) and in several barangays of Antipolo City.

<u>Land uses and land cover in the areas where the major facilities are located are</u>:
Dam, spillway = Built up, agriculture, brush and shrubland
Diversion tunnel, reservoir = Built up, agriculture, brush and shrubland
Reservoir = Built up, agriculture, grassland, brush and shrubland
Diversion tunnel, reservoir = Built up, agriculture, brush and shrubland
Reservoir, transmission pipeline, pumping stations, water treatment plant (not part of the project) = Built up, agriculture, grassland, brush and shrubland, production forest
</td></tr>
<tr><td>Geology and Geomorphology</td><td>
The project site, located on the southern part of the Sierra Madre Mountains, has generally rugged topography set over the elevated terrain known as the Antipolo Plateau. The project will be located along Upper Wawa River, a tributary of the Marikina River System. The drainage systems generally flow westward and merge with other rivers as they discharge towards Manila Bay.
The proposed Upper Wawa Dam is underlain by clastic rocks belonging to the Madlum Formation. Sandstone, siltstone/shale, and conglomerates were observed in the proposed site Along Wawa River. Thickly bedded to massive conglomerates and sandstone-siltstone alternations also belonging to the Madlum Formation were found along Boso-Boso River (southeast of the dam site); while rocks belonging to Kinabuan Formation and Angat Formation were seen in Tayabasan River (northeast of the dam site). The proposed dam structure will be set across a relatively narrow gorge of Wawa River.
Based on its soil conditions, the project site is perceived to experience very strong to violent ground shaking with moderate to heavy damage during strong earthquakes.
No threat from ground rupture is expected considering that there are no active faults in the vicinity of the project site vicinity.
Threat from liquefaction and differential settlement is low since the project site is underlain by a relatively competent bedrock.
Due to the hilly terrain and thick soil layer of the project site, it has moderate to high susceptibility to landslide hazards. Landslides are mostly caused by heavy rains, but it can also be can be brought upon by earthquake or the construction and agricultural activities on the hillsides.
Flooding normally occurs in Wawa and Marikina rivers through flashfloods, riverine floods, and standing floods. However due to its high elevation, the project site is not susceptible to flooding.
Since the project site is located far from active volcanoes, there is no direct threat from volcanic activities. However, tephra or ashfall may reach the project site during large volcanic eruptions.
</td></tr>
<tr><td>Pedology</td><td>
Four (4) soil types occur in the general area of the project site: Dystropept-Tropudalf-Tropudult Association, Pinugay Clay, Dystropept-Troporthent Association and Lumbangan Clay.
Soils obtained for analysis were slightly acidic (pH 5.3 to 5.9) to normal (pH 6-8). Phosphorus values, which should not be detectable, ranged from 270 mg/kg to 1,180 mg/kg. It is assumed that the phosphorus in the soil comes from the decomposition of organic material and can be correlated to soil pH since stations with acidic soils have high phosphorus content. Although there are still no standards for total organic matter and nitrogen content, the soil was found to contain 0.33% to 5.22% and 143
</td></tr>
</table>

Module	Baseline Characteristics
	mg/kg to 469 mg/kg for these parameters, respectively. Meanwhile, potassium values ranged from 397 mg/kg to 2,520 mg/kg. The sources of potassium in soil are minerals such as feldspars and micas which release the element as the minerals are weathered. Copper values range from 17 mg/kg to 64 mg/kg and is within the Canadian Soil Quality Guidelines value of 91 mg/kg. Iron values range from 9,620 mg/kg to 68,200 mg/kg. Manganese values range from 657 mg/kg to 2,590 mg/kg. Zinc values range from 38 mg/kg to 120 mg/kg and are well within the Canadian Soil Quality Guideline value of 360 mg/kg. Arsenic, cadmium, lead and boron values are low and within the Canadian Soil Quality Guideline values while molybdenum, mercury and hexavalent chromium were mostly not detected in the soil samples. Some steeply sloping areas observed near Montalban River are cultivated for annual crops, which makes the slopes highly susceptible to erosion. Natural erosion rates are also aggravated by the uncontrolled and unsustainable farming practices in upland area as well as cutting of trees for charcoal making.
Terrestrial Flora	Three (3) ecosystem types were observed in the project site: natural bamboo stands and karst vegetation, banana farms, and other agricultural farms. Bamboo stands and karst vegetation covers more than 50% of the whole area, which is abundantly dominated by several species of bamboo. Banana is the most commonly cultivated agri-commodity in the area, and banana farms are seen in all stations. The annual and perennial farms, also known as other agricultural farms, are in distinct patches of vegetation in the watershed. These include upland rice, vegetables and occasionally corn, while perennial crops are comprised of coconut, nangka, caimito, citrus, kape, cacao and other edible fruits, other than banana. A total of 315 species of plants belonging to 239 genera and 83 families were recorded in the study area during wet season, while a total of 107 species of regenerants and 89 mature tree species were recorded during dry season. Trees dominate in terms of the number of species, followed by herbs and shrubs, among all other plant types. The establishment of banana farms, harvesting of pole-sized trees for charcoal production, and kaingin are still rampant which has totally changed the original vegetation and species composition in the area. About 1,120 hectares within the watershed was identified as planting sites under the National Greening Program (NGP) of DENR in 2012, where the program aims to plant 600,000 seedlings. The NGP also employed the residents involved in charcoal making and kaingin farming to establish and maintain nurseries, plant trees, maintain bench terraces, and establish fire lines. Vegetation species of concern under the IUCN listing include: 4 tree species that are Endangered (Kamagong, Narra, Ebony, and Philippine teak) 15 tree species that are Vulnerable (Tindalo, Molave, Anubing, Aplas, Balete, Big-leaf mahogany, Is-is, Kamansi, Katmon, Nangka, Niog-niogan, Pakiling, Malakape, Betis, and Tanglin) Vegetation of concern under the DAO 2007-01 listing: 1 tree species that is Critically Endangered (Kamagong) 4 tree species that are Endangered (Tindalo, Molave, Philippine teak, and Betis) 7 tree species that is Vulnerable (Narra, Ebony, Katmon, Bagawak morado, Bolong eta, Pahutan, and Anang) 6 tree species that are Other Threatened Species (Anislag, Kalomata, Lanutan, Malasaging, Piling liitan, and Tanglin) Among these threatened species, Narra (*Pterocarpus indicus*), Molave (*Vitex parviflora*), Mahogany (*Swietenia macrophylla*), Nangka (*Artocarpus heterophyllus*), Is-is (*Ficus ulmifolia*), Niog-niogan (*Ficus pseudopalma*), and Pakiling (*Ficus odoratissimus*) were seen in most stations. About 24 endemic plant species were observed during wet season while 95 species during dry season.

Module	Baseline Characteristics
Terrestrial Fauna	A total of 33 species of terrestrial fauna from 30 families during wet season and a total of 42 species from 31 families during dry season were recorded at the project site vicinity. Thirteen (13) species were determined as endemics in both seasons. Five (5) amphibian and nine (9) reptile species during wet season while two (2) amphibian and five (5) reptile species during dry season were recorded which include toads, frogs, skinks, lizards, snakes, and turtles. A total of 22 and 30 bird species were recorded during wet season and dry season, respectively, dominated by Luzon bleeding-heart (*Gallicolumba luzonica*), Yellow vented bulbul (*Pycnonotus goiavier*), Philippine Bulbul (*Hypsipetes philippinus*), and Common kingfisher (*Alcedo atthis*), which were observed in all stations. Two (2) ground mammals during wet season while five (5) during dry season were observed. Five (5) volant species were observed during wet season while none during wet season. During wet season, species under IUCN Red List include the Philippine cobra and Luzon bleeding heart as near threatened, and the Philippine sailfin lizard, Malaysian pond turtle, Chinese softshell turtle, Common kingfisher, and Chinese egret as vulnerable. Chinese softshell turtle and Common kingfisher were the only species under IUCN Red List observed during dry season. There was no culturally significant fauna identified in the project site.
WATER MODULE	
Hydrology	The Upper Wawa Dam will be located along Wawa River which is composed of 280 km^2 of drainage area and a dendritic river system with around 45km of main river that stretches from the peak of Mt. Palagyo to the confluence located in Balite, Rodriguez, Rizal. The drainage of the Upper Wawa Dam covers the watershed of six (6) rivers namely namely Boso Boso River, Montalban River, Payagwan River, Sapa Bute Bute River, Tayabasan River, and Wawa River. It is approximately 242km^2 and composed of 28 sub-basins. During wet season, most of the groundwater sources within the basin are free flowing springs from the fractured rocks in the mountains that eventually discharges into the river. This indicates a major aquifer manifestation in the area. Significant reductions in flow were observed during the dry season. There are 25 NWRB water permits issued within close proximity to the study area. Six (6) grantees draw water from surface sources, eight (8) from deep well sources, and 11 from springs, of which one (1) surface source, seven (7) deep wells, and one (1) spring are within the catchment of the Upper Wawa Dam. Water is sourced for used for domestic, irrigation, commercial, municipal, and livestock purposes. The generated flow duration curve for the entire year shows that the 80% dependable flow of Wawa River is estimated at 7.00 m^3/s, varying from 13.33 m^3/s for the wet season to 4.72 m^3/s for the dry season. The minimum environmental flow (10% of the dependable flow) is 0.70 m^3/s, that is 1.33 m^3/s for the wet season and 0.47 m^3/s for the dry season. The annual groundwater recharge of Upper Wawa river basin is 24% of its mean annual rainfall, which is equivalent to an average daily volume of approximately 14.4 x $10^7 m^3$. Approximately 40% of the total rainfall becomes surface runoff, while 36% is lost as actual evapotranspiration.
Freshwater Ecology	All sampling stations surveyed had riparian vegetation with generally clear to opaque waters. Majority of the stations have no periphyton and aquatic macrophytes. Secondary forest and agricultural/ agroforest were seen in some areas. Activities observed in the vicinity of some stations include piggery farm, pasture areas, recreational areas, residential areas, and boat terminal. A total of 25 phytoplankton taxa representing three (3) algal phyla (Bacillariophyta, Chlorophyta, and Cyanophyta) were observed, with Bacillariophyta consistently dominating during dry season (71%) and wet season (63.5%) of the phytoplankton. Mean densities ranged from low to high. Overall,

Module	Baseline Characteristics
	Merismopedia (13.9%) has the highest relative density, followed by Fragilaria (10.6%) and Synedra (10.4%). The presence at moderate densities of Melosira, Fragilaria, and Oscillatoria at majority (about 80%) of the surveyed stations suggests eutrophic conditions brought by domestic activities. Only five (5) zooplankton taxa representing three (3) animal phyla (Arthropoda, Nematoda, and Protozoans) were recorded, with Protozoans dominating during the wet season (51.4% of the total count) while Arthropods during dry season (100% of the total count). Zooplankton mean density was low (1 to 5 individulas/liter), which is typical in flowing waters. About 25 macroinvertebrates taxa representing three (3) phyla (Annelida, Arthropoda, and Mollusca) were recorded, with Annelida (45%) and Arthropoda (41%) co-dominating during dry season while Mollusca (71.5%) dominating during wet season. The consistent dominance of Diptera and Oligochaeta in five (5) stations indicates eutrophic water condition. However, dominance of Ephemeroptera in three (3) stations shows good water quality. Macroinvertebrates mean density ranged from 16 to 160 animals/m^2. Six introduced freshwater fish species with least concern status were reported during the wet season: *Clarias batarchus*, *Gambusia affinis*, one species of Family Gobiidae, *Oreochromis mossambicus*, *Oreochromis aureus*, and *Poecilia reticulata*. Interviews with locals show the presence of *Oroechromis niloticus* (Nile tilapia), *Glossogobius* sp. (gobies or biya) and *Hypostomus plecostomus* (janitor fish) in the freshwater bodies. Levels of four water quality parameters measured at all stations fall within the normal/ usual range of values for freshwater bodies, suggesting that the overall water quality conditions are suitable for survival of aquatic organisms. Air quality results showed low to undetectable concentrations of NO2, SO2 and particulate matter (PM10) and Total Suspended Particulates (TSP) in all stations, suspended particulates in air can be carried over long distances by wind and may settle in river water systems Air quality results showed low to undetectable concentrations of NO_2, SO_2 and particulate matter (PM_{10}) and Total Suspended Particulates (TSP) in all stations. Data suggests that overall air quality conditions at the surveyed stations in one seasons will not affect the survival of aquatic organisms found in the Project site.
Water Quality	A total of eighteen (18) sampling stations were selected and sampled during wet season and eleven (11) stations during dry season at the proposed project site. Location of eighteen (18) sampling stations during wet season - three (3) stations along Boso Boso River, six (6) stations along Montalban River, one (1) station along Payagwan River, two (2) stations along Sapa Bute Bute River, three (3) stations along Tayabasan River and three (3) stations along Wawa River. Location of eleven (11) sampling stations during dry season - two (2) stations along Boso Boso River, two (2) stations along Montalban River, one (1) station along Payagwan River, two (1) stations along Sapa Bute Bute River, two (2) stations along Tayabasan River and three (3) stations along Wawa River.. Eleven (11) stations were only covered during dry season because the accessibility of the stations that were not covered was determined to be risky during the sampling period in wet season, which was conducted beforehand. To ensure the raw water that will be produced by the UWD Project, the Manila Water is in-charge of water treatment before distributing to its consumers. Samples analyzed were pH, Temperature, DO, Turbidity, Conductivity, BOD_5, TDS, TSS, Oil and Grease, Fluoride, Fecal Coliform, Iron, Phosphate, and Nitrate for surface water and groundwater Results for surface water were compared with the DENR Administrative Order No. 2016-08 (DAO 2016-08) Clean Water Act standard for Class C waters while 2007 Philippine National Standards for

Module	Baseline Characteristics
	Drinking Water (PNSDW) Guidelines for Drinking Water for groundwater. Majority of the parameters were within the Class C Standards across all stations except for exceedances at the following points: **Surface water:** ▪ **Temperature**: 4 out 11 stations during the dry season (23.6°C to 24.9°C) and 8 out of 18 stations during the wet season (23.9°C to 24.77°C) were below the minimum temperature standard of 25°C - 31°C. ▪ **BOD**: 2 out of 11 stations during dry season (11mg/L and 9mg/L) and 1 out of 18 stations during wet season (13mg/L) exceeded the maximum standard of BOD at 7.0mg/L. ▪ **TSS**: 2 out of 18 stations during wet season had a TSS level of 110.0mg/L and 367mg/L which exceeded the maximum standard of 80.0mg/L. ▪ **Oil & Grease**: Station SW2 (Boso Boso River) during dry season had an Oil and Grease levels of 3.10mg/L which exceeded the maximum standard of 2.0mg/L. ▪ **Fecal coliform**: 7 out of 11 stations during dry season (240 MPN/100mL to 2,400 MPN/100mL) and 16 out of 18 stations during wet season (920 MPN/100mL to 54,000,000 MPN/100mL) exceeded the Fecal Coliform standard of 200MPN/100mL. ▪ **Phosphate**: 3 out of 18 stations during wet season with phosphate levels of 6.2, 2.5, and, 2.6 mg/L exceeded the maximum standard of 0.5mg/L. **Groundwater:** ▪ **pH**: GW1 and GW with pH at 6.2 and 6.1, respectively, during dry season were below the PNSDW standard of 6.5-8.5. ▪ **TDS**: GW4 with TDS at 848mg/L during dry season exceeded the PNSDW maximum standard of 500mg/L. ▪ **Iron**: GW1 with iron at 12mg/L during wet season exceeded the PNSDW Standard of 1.0mg/L.
AMBIENT AIR AND NOISE MODULE	
Ambient Air	There are very few sources of air residuals at the project area due to its remote location. The dominant air pollution sources are gaseous pollutants (SO2, NO2, CO) and fugitive particulate (TSP, PM10) emitted from motor vehicles travelling the main road to the site and domestic activities like household cooking, backyard waste burning, and occasional burning of agricultural wastes. The 24h sampling confirmed the absence of significant source of emissions at the project area (concentrations less than the CAA GV). For example, concentrations of NO2 and SO2 were very low with two SO2 results below the method detection level. The particulate detections (TSP and PM10) were likely due to fugitive dust from exposed soil surfaces and roads in the vicinity of the stations.
Noise	Major sound sources in the project area were motorcycles with loud mufflers and workers fixing Manila Water pipelines near Stations AQ5 and AQ6. The lowest and peak sound levels ranged from 46 to 59 decibels and 56 to 90 decibels respectively with a 24h average range of 49 to 77 decibels.
Meteorology	• The project area falls under a Type III climate characterized by no very pronounced maximum rainy period and a dry season lasting only for one to three months (December to February or March to May). • The project area may experience a monthly rainfall range of 14.6 (February) to 504.2 mm (August) with an annual average of 2574.4 mm. • The highest mean temperature at the Project area may reach 29.7◦C in May with a low of 25.7 ◦C in January resulting to a normal seasonal difference is about four degrees and an annual mean of 27.7◦C. • The project area may experience a relative humidity range of 67 to 84% with an annual average relative humidity of 78%. • The monthly cloud cover at the project area may range from four to seven okta resulting to generally cloudy conditions from June in October. • The potential prevailing wind speed at the project area may range at 1.2 to 1.7 meters per second (average of 1.4) in the North direction prevailing all year round. • The project is located in an area with high typhoon risk and may be visited by two cyclones every year.

Module	Baseline Characteristics
PEOPLE MODULE	
Socio-economics	The project will be hosted by three (3) barangays in the Province of Rizal including Barangay Calawis in the City of Antipolo, Barangay Pintong Bukawe in the Municipality of San Mateo, and Barangay San Rafael in the Municipality of Rodriguez. Located east of Metro Manila, Rizal can be reached from Manila via Ortigas Avenue, and from Quezon City via Marcos Highway and Sumulong Highway. Antipolo City is Rizal's major economic, financial and service center. It is a first-class component city which has recently become the provincial capital. It is also categorized as a sub-regional center of Region 4A Rodriguez, formerly called Montalban, is a first-class municipality of Rizal, located in northernmost town in the province. Measuring 36,307.31 hectares, Rodriguez is the largest municipality of Rizal Province in land size. It should be noted however that almost 3/4 or 72.97% is forestland. Agricultural land is 8.6% and built-up area is 6.4%. Agro-industrial land comprises 0.13%; mining and quarrying (0.84%) and tourism (1.67%). San Mateo is a first-class municipality of Rizal and is also part of the Metro Luzon Urban Beltway. Its total land area as of the 1976 cadastral survey is approximately 4,825.10 hectares divided into 15 barangays. All three (3) barangays are upland zones with Barangay Calawis and Barangay Pintong Bukawe being mountainous and urban, whereas Barangay San Rafael is on a plain, rural, and the most populated. The health facility available within the three (3) barangays is a Barangay Health Center. Only Barangay Calawis and Barangay San Rafael have a maternity and child clinic. Education facilities in all three (3) barangays include day care centers, pre-school, elementary, and secondary schools with no vocational schools or colleges. Barangay San Rafael and Barangay Calawis has a written DRR plan, equipment, evacuation center and emergency response team while Barangay Pintong Bukawe has no written DRR pla but has an evacuation center Barangay San Rafael have water supply systems served by MWSS while Barangay Calawis have water supply served by water cooperatives, PATUBIG and MAKINAFAI. Only Barangay Pintong Bukawe have water sources mainly on wells and springs, and water delivery trucks. All three (3) barangays are serviced by MERALCO. All three (3) barangays have a Materials Recovery Facility but no open dump site, landfill or compost pits.
Traffic	The weekday sampling recorded 16,674 vehicles, which was 19% lower than the weekend sampling of 20,570 vehicles. Majority of the vehicles observed during the period were private units. The vehicle type with highest overall volume throughout the duration of the survey was motorcycle, followed car/jeep. In volume per vehicle by route, motorcycles were still the most frequently observed in all routes, followed by car/jeep in some routes. Bicycles, minibuses, buses, and PUJs were also observed but in small number. Because of the pandemic and its guidelines, private vehicles are the most observed type of vehicle in the area rather than public vehicles.
Environmental Risk Assessment (ERA)	The hazardous materials present during the project implementation are ammonium nitrate-fuel oil (ANFO), emulsion explosives, and industrial diesel. The ANFO and emulsion explosives will be used for drilling and controlled blasting of rocks during the construction of the tunnels. All explosives will be stored in the storage magazine, while the industrial diesel will also have s separate storage area. The consequence analysis showed that the potential exclusion zone from the storage magazine is at least 360 meters, which can be done by either relocating the magazine or the Temporary Construction Facilities and Camp & Office. At the worst-case, that is all stored ANFO are detonated (yield=1), light injuries (1 psi) and a 100% fatality rate (20 psi) were predicted to occur at radii of 361 and 67 meters from the storage magazine. The lowest explosion yield (10%) that results to light injuries (1 psi) and a 100% fatality rate (20 psi) were predicted to occur at radii of 167 and 31 meters from the storage

Module	Baseline Characteristics
	magazine. In addition, hazard zones will reach the Temporary Construction Facilities if 20%, 40%, and 80% of the stored ANFO are detonated

There were no alternatives considered for the site location as well as the technology choice for the project, considering the viability and potential of Wawa River as a water supply source, the ideality of the location from the offtake delivery point, and the desired capacity and O&M costs. **Table ES-7** shows the summary of alternatives considered for the Project.

Table ES-7
Summary of Alternatives

Project Alternatives	Major Criteria	Description
Site Location	Wawa River in Rizal Province	▪ Proponent has existing water permit in the area/ river. ▪ No other site alternatives can yield the 518MLD capacity requirement in the Offtake agreement ▪ Location of the water treatment plant to be developed by MWC is already fixed and is the agreed delivery offtake point of the UWD Project.
Design	Capacity Dam Type Spillway	▪ The water storage will have a capacity of 120.1MCM that produces at least 518 MLD. ▪ An Earth Core Rockfill Dam (ECRD) structure or a Roller Compacted Concrete (RCC) dam structure will be built to maintain its stability. ▪ The spillway will allow the discharge of PMF flood with a discharge of 7,300m³/s.
Technology/ Operation Processes	Chosen type of technology: Dam	Dam is more reliable because of the following: ▪ Produces and stores high amount of water per day that can sustain water supply demands ▪ Dam accommodate stronger cyclic loading of bigger intensities and is less demanding in terms of foundation quality. ▪ Capable of providing processed clean water to urban and rural areas. ▪ Provides flood control benefits Dam has greater advantage because: ▪ Best technology option to sustain the demand of water supply in the Philippines. ▪ Capable of providing water supply services that can support irrigation systems. ▪ Reliable and efficient functioning of water supply.
Environmental Conditions		▪ Moderate impact from earthquake induced landslide considering the terrain and slope of the project area. ▪ No active faults in the project area, and therefore no threat from fault ruptures ▪ Low liquefaction potential since project area is underlain by competent bedrock ▪ No ground rupture expected ▪ Since the location of the project site is located far away from a volcano (Mt. Taal) and coastal area, low level of threat was considered from volcanic hazard and tsunami.

Table ES-8 summarizes the hazards associated with the project based on the findings during the assessment and the proposed mitigating measures to address them.

Table ES-8
Summary of Identified Hazards

Hazards	Rating	Implications	Mitigations	
			Structural Measure	Non-Structural Measures
Earthquake induced landslides and mass movement	Moderate to high susceptibility to landslides	▪ Moderate level of threat from earthquake induced landslide due to the terrain and slope in the project site and vicinity. ▪ Landslides may damage gates, spillway, retaining walls and other surface equipment.	▪ Use the appropriate seismic design of the proposed structures that should consider the maximum credible earthquake that can affect the project site and vicinity.	▪ Conduct a geotechnical studies and detailed slope stability assessment to provide slope support/protection measures.
Liquefaction/ Differential settlement	Low probability of occurrence	▪ Low level of threat in liquefaction potential since project area is underlain by competent bedrock	▪ Place excavated materials in spoils area.	▪ Establish provision of enclosures for stockpiles of sand and gravel to minimize transport of sediments during heavy rains.
Ground shaking	Moderate to heavy damage during strong earthquakes Very strong to severe shaking	▪ Moderate to high level threat from ground shaking that causes vibrations and structural distortions in dams and, appurtenant structures. ▪ Rock falls and landslides that may cause damage to gates, spillway, retaining walls and other surface equipment.	▪ Consider the most appropriate dam and component design by considering determined peak ground acceleration from the seismicity study.	▪ Conduct preliminary dam stability analysis. ▪ Conduct a geotechnical studies and detailed slope stability assessment to provide slope support/protection measures.
Ground rupture	No active fault identified in the vicinity of the project	▪ No threat from fault rupture is expected on the project site.	N/A	N/A
Flooding	Flooding normally occurs in Wawa and Marikina Rivers. Upstream section of Wawa River is not susceptible to flooding.	▪ Threats of flashfloods, riverine floods, and standing floods in the downstream of Wawa River. ▪ Low level of threat from flooding in the project site.	N/A	▪ Conduct a geotechnical studies and detailed slope stability assessment to provide slope support/protection measures.
Tsunami	The site is located inland	▪ Low level of threat from tsunami.	N/A	N/A
Volcanic Hazards	No active volcanoes in the project site	▪ Low level of threat but ashfall may reach the project site during large volcanic eruptions	N/A	N/A

Social Development Plan/Framework

The Social Development Plan (SDP) provides plans and programs for the identified issues and concerns raised during the Public Consultation Activities. The IPDP will be made for this Project after the completion of the ongoing CP/FPIC process of the project's first component, the Tayabasan Multi-Basin System Project. Since the Tayabasan Project is also under WawaJVCo. Inc., it can only initiate the FPIC process for the Wawa Bulk Water Supply Project after the FPIC process for the Tayabasan Multi-Basin System Project is completed. This is in compliance with the NCIP ruling under IPRA that a company can apply for only one CP/FPIC application per project at a time.

Information, Education, and Communication Framework

WawaJVCo will establish IEC programs to properly disseminate information about the different activities of the project in order to effectively communicate with the stakeholders on the status of the project as well as the management of environmental impacts.

Multi-Partite Monitoring Team

In accordance with the DAO 2003-27, a Multi-partite Monitoring Team (MMT) who will be responsible for the implementation and supervision of the conduct of monitoring activities of the project will be created. A Memorandum of Agreement will be prepared showing the composition and respective responsibilities of the MMT. The MMT will be composed of representative from different stakeholders, including the LGU, NGOs/Pos, IP community, EMB RO, PAMB, DOE, and the proponent.

Environmental Guarantee and Monitoring Fund Commitment

WawaJVCo will setup the environmental guarantee and monitoring funds in accordance with DAO 2003-30 (RPM Annex 3-6).

The indicative amounts for the Trust Fund and Cash Fund that comprise the Environmental Guarantee Fund (EGF) are PhP 1,000,000 and PhP 500,000 respectively, to be finalized a later date. A Memorandum of Agreement will be prepared by the proponent as soon as the specific amount is determined. The specific amount will be agreed upon by the proponent and the DENR in consultation with the LGU of Antipolo City, Municipalities of Rodriguez and San Mateo, and NGO/PO representatives.

The Environmental Monitoring Fund (EMF), which is a fund that the proponent shall commit to establish in support of the activities of the MMT, will also be incorporated in the proposed MOA or the MMT. Indicative budget for EMF will be approximately PhP 250,000 also to be finalized at a later date. The final amount will be agreed upon when the MMT is formed.

I. PROJECT DESCRIPTION

1.0 Project Overview

WawaJVCo INC. (WawaJVCo), a joint venture between Prime Metroline Infrastructure Holdings Corporation and San Lorenzo Ruiz Builders (SLRB), intends to develop the **Wawa Bulk Water Supply Project – Upper Wawa Dam Component** (Upper Wawa Dam Project or Project) in the Province of Rizal.

The entire Wawa Bulk Water Supply Project (including the Upper Wawa Dam component) is one of the Flagship Infrastructure Projects by the national government and approved by the National Economic and Development Authority (NEDA)[1].

Annex A-1 presents the MWSS Resolution (Resolution No. 2019-074-CO) endorsing Wawa JVCo as the lead developer for the Wawa Bulk Water Supply Project including the Upper Wawa Dam while **Annex A-2** is the Raw Water Supply and Offtake Agreement between Wawa JVCo, MWC and MWSS that was signed on 06 August 2019. As part of the Offtake Agreement, the intention of the project was to successfully convey water from the reservoirs through the pumping stations and conveyance pipeline up to Calawis Water Treatment Plant (CWTP) with an amount of 518 MLD.

2.0 Project Location and Area

The proposed Project site is in the Province of Rizal in Luzon in the Philippines. It is located approximately 25km northeast of Metro Manila and spans one (1) city: Antipolo and two (2) municipalities: Municipality of Rodriguez and Municipality of San Mateo. **Figure PD-1** shows the regional location, the city/ municipal area and barangays covered by the proposed Project.

The Project (middle of the dam), will be located within geographic coordinates 14°42'4.11"N north latitude and 121°12'5.20"E, east longitude as shown on the NAMRIA topographic map (**Figure PD-2**). The Municipality of Rodriguez does not appear to be straddled by the Project on this map, but is nonetheless included, in view of the ongoing boundary disagreements with the Municipality of San Mateo. The barangays to be straddled by the project include Barangay Calawis in Antipolo City, Barangay Pintong Bukawe in San Mateo and Barangay San Rafael in Rodriguez.

The general location of the Upper Wawa Dam Project is within the Wawa River Basin (**Figure PD-3**), which is part of the Upper Marikina River Basin Protected Landscape (UMRBPL). The UMRBPL, previously known as the Marikina Watershed Reservation, was declared as a protected area under the category of protected landscape by Presidential Proclamation No. 296, dated 24 November 2011. It covers five (5) city/ municipalities of Rizal Province, namely Rodriguez, Antipolo City, Baras, San Mateo and Tanay.

The Wawa River basin has a drainage area of about 281 km^2. Wawa River and its tributaries serve as the headwaters of the Marikina River. The Project reservoir will cover six (6) river systems: Wawa River, Montalban River, Boso-Boso River, Payagwan River, Tayabasan River and Sapa Bute-Bute River (**Figure PD-3**).

The Indigenous Peoples (IPs) that inhabit the Project are the Dumagat/Remontados. The IPs on the side of Rodriguez Municipality have been granted a Certificate of Ancestral Domain Title (CADT), while those in Barangay Calawis, Antipolo City are recognized by the NCIP as covered by the Antipolo City Ancestral Domain. WawaJVCo is currently in the advance stages of the Free, Prior and Informed Consent (FPIC) process with NCIP for the project's first component. The proponent already signed a Memorandum of Agreement (MOA) for the Antipolo Ancestral Domain and is already scheduled to conduct the MOA Negotiation for the Montalban AD.

[1] Source: http://www.neda.gov.ph/infrastructure-flagship-projects/ No. 99 in the list (Accessed on 06 June 2020).

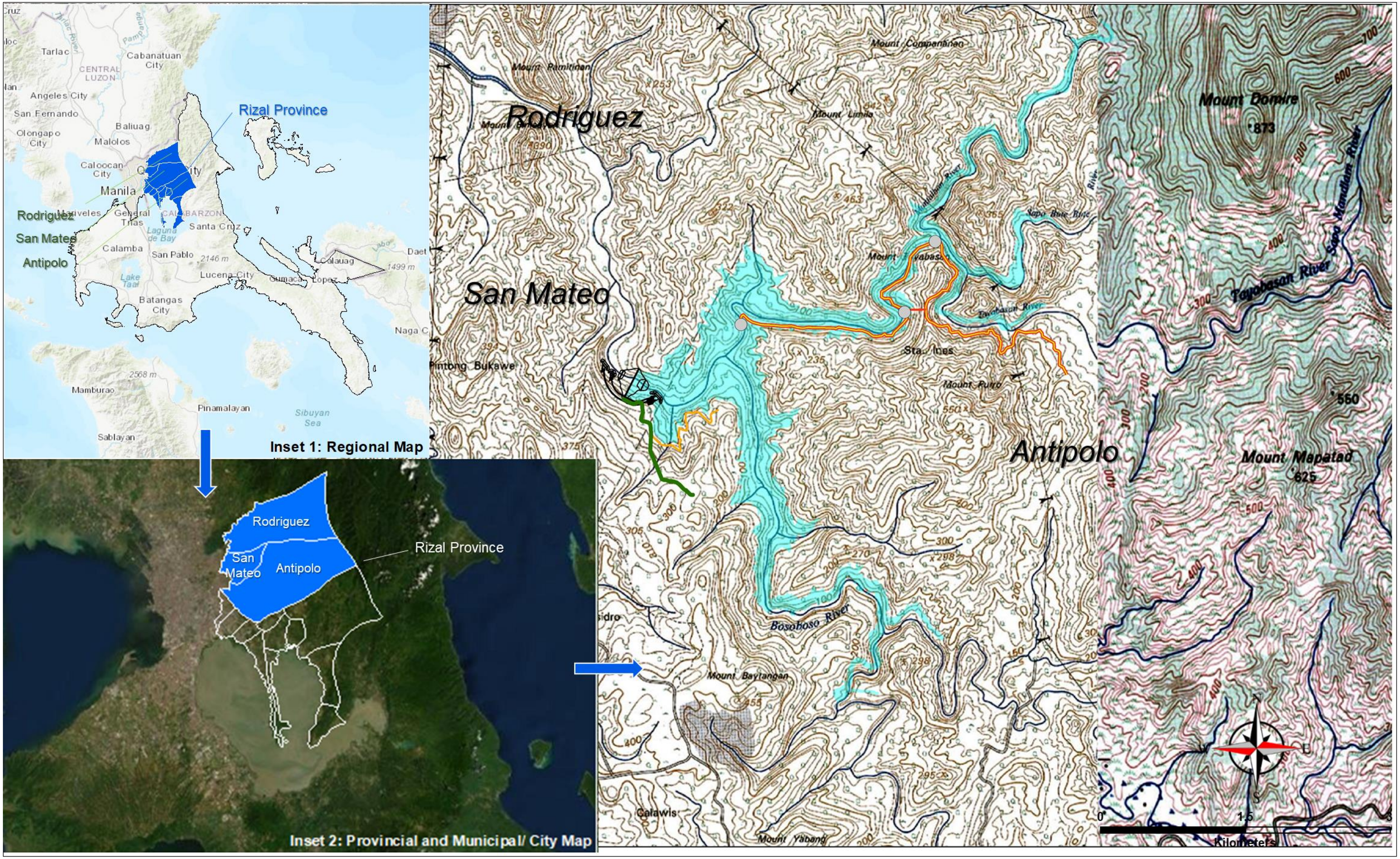

Figure PD-1. Location of the Project

ENVIRONMENTAL IMPACT STATEMENT
PROJECT DESCRIPTION
Wawa Bulk Water Supply Project – Upper Wawa Dam

Legend

- Pump Station
- Transmission Pipeline via Tunnel Optional
- UWD Optional Access Road (New)
- UWD Access Road (Original)
- Access Road to WTP / Transmission Pipe
- UWD Dam and Diversion Tunnel
- Transmission / Water Conveyance Pipeline
- UWD Reservoir

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCO, Inc. (2020)
Basemap: NAMRIA Topographic Map: Sheet 3230-III Quezon City and Sheet 7272-II Baras
Created by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.

apercu CONSULTANTS INC.

SCALE: 1: 30,000

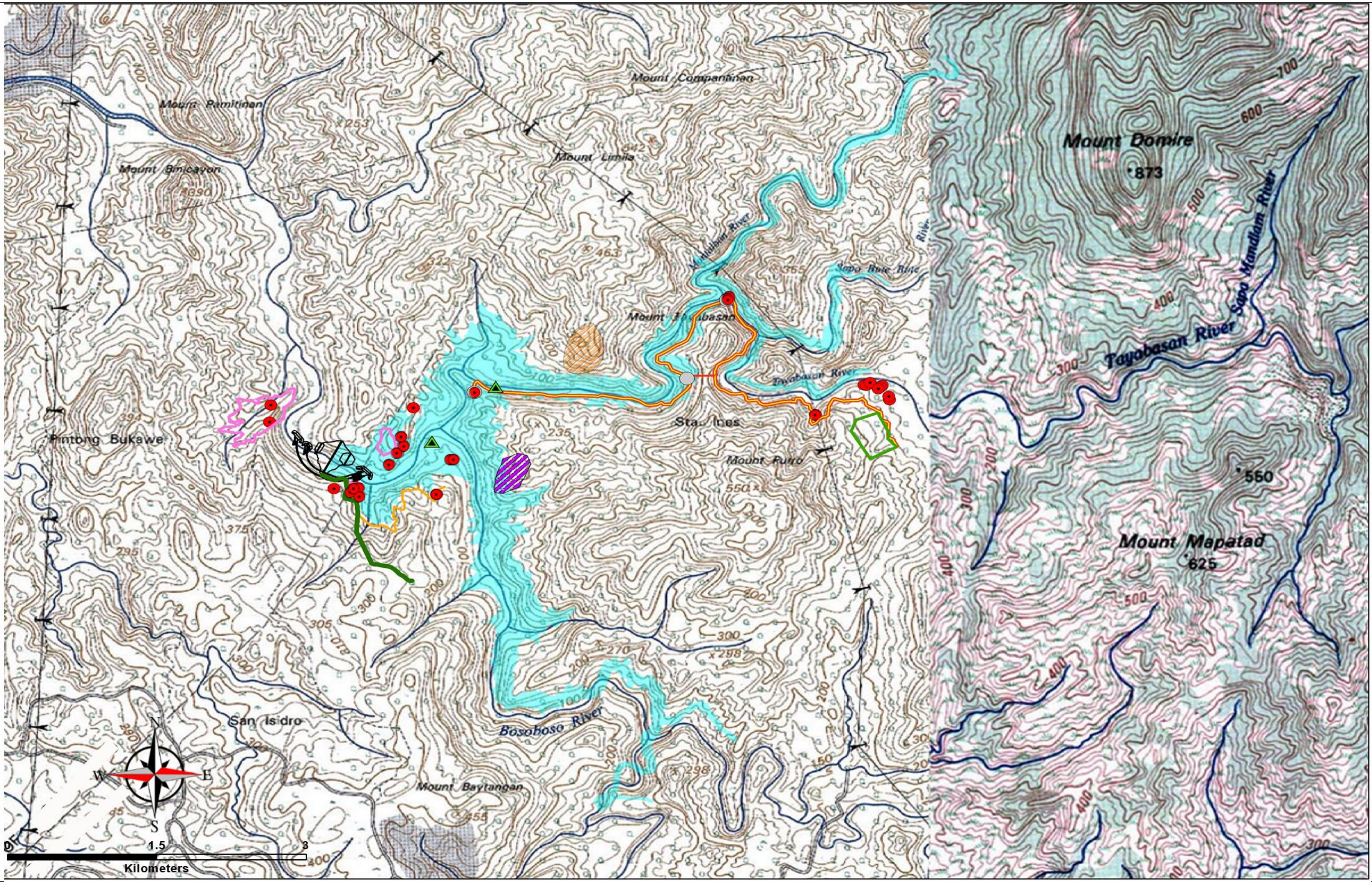

Figure PD-2. NAMRIA Topographic Map of the Project Site

ENVIRONMENTAL IMPACT STATEMENT
PROJECT DESCRIPTION
Wawa Bulk Water Supply Project – Upper Wawa Dam

Legend

- Pump Station
- Critical Areas
- Transmission Pipeline via Tunnel Optional
- UWD Optional Access Road (New)
- UWD Access Road (Original)
- Temporary Facility
- Access Road to WTP / Transmission Pipe
- UWD Dam and Diversion Tunnel
- Transmission / Water Conveyance Pipeline
- Quarry Option 1
- Quarry Option 2
- UWD Reservoir
- Temporary Facilities
- Calawis Water Treatment Plant or CWTP (not part of the Project)

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCo, INC. (2020)
Basemap: NAMRIA Topographic Map: Sheet 3230-III Quezon City and Sheet 7272-II Baras
Created by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.

apercu CONSULTANTS INC.

SCALE: 1: 30,000

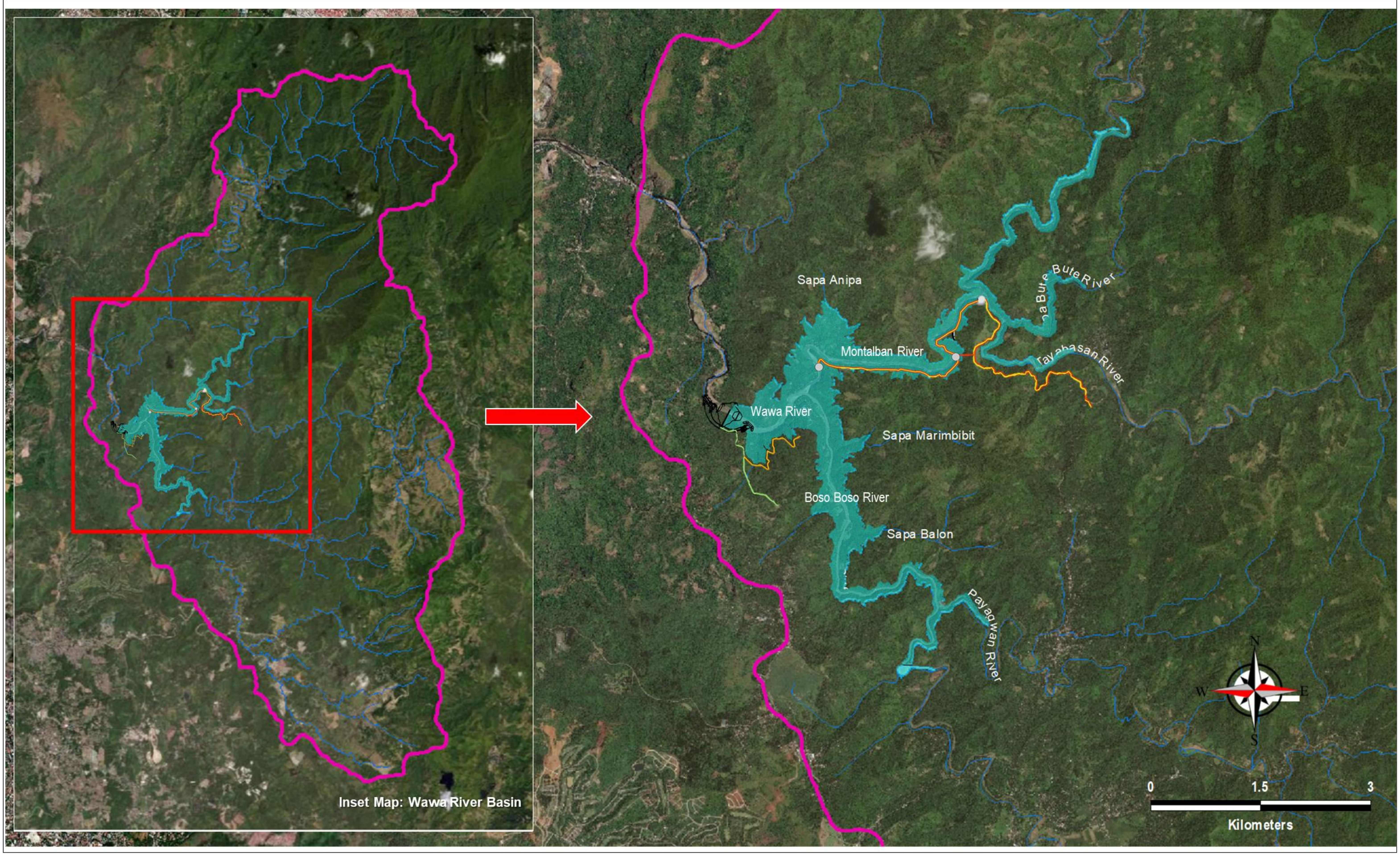

Figure PD-3. Wawa River Basin in Relation to the Project

ENVIRONMENTAL IMPACT STATEMENT
PROJECT DESCRIPTION
Wawa Bulk Water Supply Project – Upper Wawa Dam

Legend
- Pump Station
- Transmission Pipeline via Tunnel Optional
- UWD Optional Access Road (New)
- UWD Access Road (Original)
- Access Road to WTP / Transmission Pipe
- UWD Dam and Diversion Tunnel
- Transmission / Water Conveyance Pipeline
- Wawa River Basin
- River System
- UWD Reservoir

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCO, Inc. (2020)
Basemap: ArcGIS Imagery, 2020
Created by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.
apercu CONSULTANTS INC.

SCALE: 1: 50,000

Thereafter, they will also apply for a Certificate of Precondition (CP) and undergo another FPIC Process for the Upper Wawa Dam component.

Annex B provides the Project site maps and aerial photos.

2.1 Project Impact Area

Following the Philippine Environmental Impact Statement (EIS) System IRR or DAO 2003-30, the Project-affected areas are defined as follows:

- Primary Impact Area/Zone, also referred to as he Direct Impact Area (DIA); and,
- Secondary Impact Area/Zone, also referred to as the Indirect Impact Area (IIA).

According to DAO 2003-30 guidelines, the DIA generally refers to areas where the project facilities or infrastructures are proposed to be constructed/located or traversed such as buildings or structures, irrigation, drainage and other utility areas, quarry sites, access roads and other areas and facilities to be set up during the construction and operation phases.[2]

The Project's identified primary impact areas will be those areas where the infrastructure components will be sited, including surface areas to be inundated as a result of building a dam along the Wawa River (**Table PD-1)**. These also include areas that will be used to set up temporary facilities (e.g. office, workers' camp, motor pool area, staging areas) and stockpile spoil materials.

Table PD-1
Location of Primary Impact Areas

Infrastructure	Barangay	Municipality
Dam	San Rafael	Rodriguez
Spillway	San Rafael	Rodriguez
Pumping Stations	San Rafael	Rodriguez
Transmission / Conveyance Pipeline	San Rafael to Calawis	Rodriguez to Antipolo
Diversion Tunnels	San Rafael	Rodriguez
Access roads	Pintong Bukawe and San Rafael	San Mateo and Rodriguez
Temporary Facilities		
• Quarry 1	San Rafael	Rodriguez
• Quarry 2	San Rafael	Rodriguez
• Disposal Areas	San Rafael and Calawis	Rodriguez and Antipolo
• Deposit of Hazardous Materials	San Rafael	Rodriguez
• Powder Magazine	San Rafael	Rodriguez
• Store and Associated Open Storage Areas	San Rafael and Calawis	Rodriguez and Antipolo
• Generators	San Rafael and Calawis	Rodriguez and Antipolo
• Fuel Tanks	San Rafael and Calawis	Rodriguez and Antipolo
• Mechanical Workshops	San Rafael and Calawis	Rodriguez and Antipolo
• Truck and Equipment Washing Area	San Rafael	Rodriguez
• Site Office	San Rafael	Rodriguez
• Batching Plants	San Rafael and Calawis	Rodriguez and Antipolo
• Parking Area	San Rafael	Rodriguez
• Store	San Rafael and Calawis	Rodriguez and Antipolo
• Crushing and Screening Plant	San Rafael	Rodriguez
• Camp and Offices	San Rafael and Calawis	Rodriguez and Antipolo
• Wastewater Treatment Plant	San Rafael and Calawis	Rodriguez and Antipolo

[2] EMB Website: http://www.emb.gov.ph/portal/Portals/8/Documents/Planning%20files/DAO%2096-37%20chapter%201-3.pdf (Accessed on: November 2019).

The IIA generally refers to the influence area of the project that could be indirectly affected by the proposed development. This could include areas in the vicinity of the DIA. Examples of these may include communities or settlements outside of the DIA which can also be benefited by the employment opportunities created by the project; and/ or sub-tributaries of the river system which can be indirectly affected by the Project.

The secondary impact areas includes the downstream stretch of the dam, barangays (**Table PD-2**), located along the access roads leading to the proposed dam and reservoir and the communities of the three (3) host city/ municipalities (Antipolo City, Municipality of San Mateo and Municipality of Rodriguez) that are located outside the designated primary impact areas. **Figure PD-4** delineates the potential impact areas on a map.

Table PD-2
Indirect Impact Areas

Barangay	Municipality
San Juan	Antipolo
San Jose	Antipolo
Pintong Bukawe	San Mateo

2.2 Shapefile Configuration

Geographic coordinates of the Project Area and critical structures (i.e. Relic stones, bridges) within the Project Area are presented in **Annex C** and **Figure PD-5**.

2.3 Project Site Accessibility

To access the Project site, vehicles coming from Aurora Boulevard corner Katipunan Avenue, Quezon City take Marcos Highway for about 20km. There are two existing roads from Marcos Highway that are about 3km apart: the Calawis Road (eastern route) and the Pintong Bukawe Road (western route). Both roads are about 6m wide; a combination of mud trails and paved concrete, with limited shoulders or curve widenings, suffer from vehicular and pedestrian congestion due to encroachment of dwellings close to the road, lack street parking, and lack pedestrian facilities.

The Pintong Bukawe Road is the current access to the Upper Wawa Dam and ends at Sitio Casili. One has to cross the river by foot during the dry season or via bamboo boat during the wet season, to access the dam area.

The Calawis Road is the access to the tail-end of the reservoir along the Tayabasan and Sapa Bute Bute River, all of which are located in Barangay Calawis. **Figure PD-6** is a vicinity map of the Project site.

3.0 Project Rationale

3.1 Water Supply and Demand

During the early 1900s, Wawa Dam was constructed to serve as the main source of water for the then residents of Metro Manila. When Angat Dam was built in the 1960s across Angat River, Wawa Dam was abandoned and is now used as a recreational area. Up until now, Angat Dam is the major source of water for Metro Manila, with more than 90% of required water taken from it. Angat Dam lies on the Marikina West Valley Fault (MWVF). With the looming threat of the "Big One" earthquake[3], which can severely damage Angat Dam and the growing water demand of Metro Manila, the Philippine Government is looking for alternatives to supplement the water supply from Angat Dam.

[3] A potential disastrous earthquake that can be caused by the Marikina West Valley Fault which is already ripe for movement, according to the Philippine Institute of Volcanology and Seismology (PHIVOLCS).

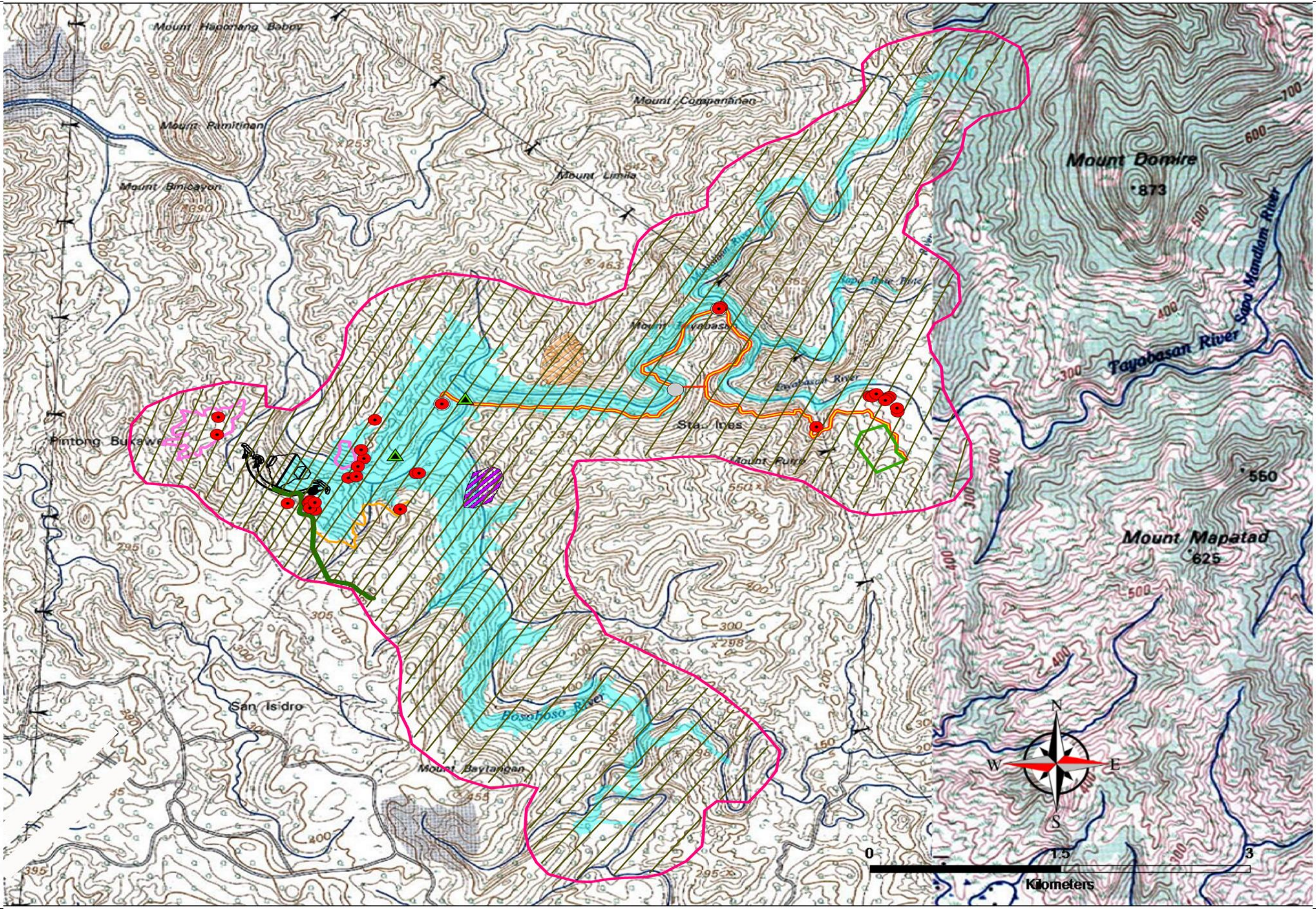

Figure PD-4. Impact Area Map of the Project Site
ENVIRONMENTAL IMPACT STATEMENT **PROJECT DESCRIPTION** **Wawa Bulk Water Supply Project – Upper Wawa Dam**

Legend
- Pump Station
- Critical Areas
- Transmission Pipeline via Tunnel Optional
- UWD Optional Access Road (New)
- UWD Access Road (Original)
- Temporary Facility
- Access Road to WTP / Transmission Pipe
- UWD Dam and Diversion Tunnel
- Transmission / Water Conveyance Pipeline
- Quarry Option 1
- Quarry Option 2
- UWD Reservoir
- Temporary Facilities
- Direct Impact Area
- Calawis Water Treatment Plant or CWTP (not part of the Project)

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCO, Inc. (2020)
Basemap: NAMRIA Topographic Map: Sheet 3230-III Quezon City and Sheet 7272-II Baras
Created by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.
aperçu CONSULTANTS INC.

SCALE: 1: 30,000

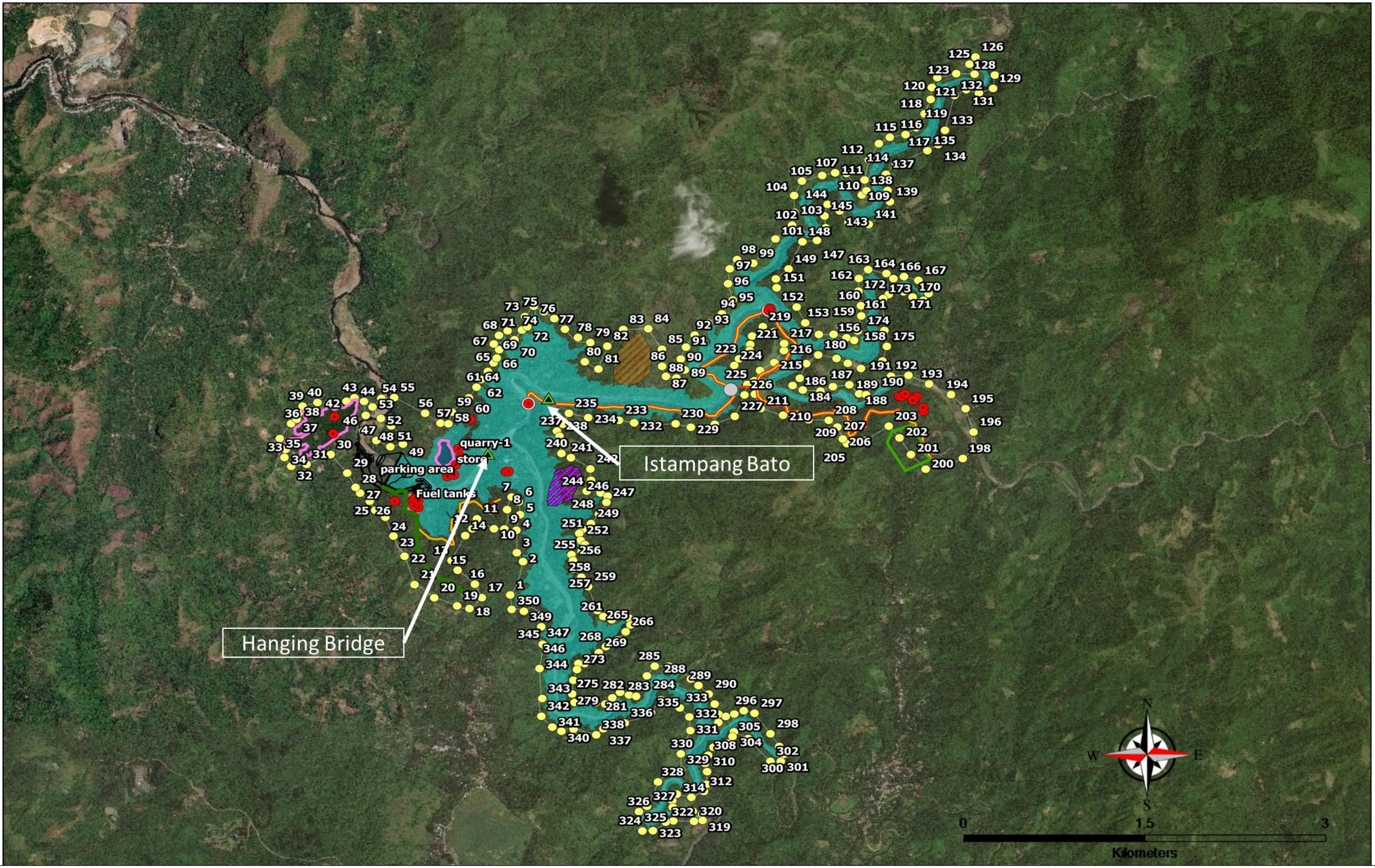

Figure PD-5. Shapefile Configuration Map

ENVIRONMENTAL IMPACT STATEMENT
PROJECT DESCRIPTION
Wawa Bulk Water Supply Project – Upper Wawa Dam

Legend
- Pump Station
- Critical Areas
- Transmission Pipeline via Tunnel Optional
- UWD Optional Access Road (New)
- UWD Access Road (Original)
- Temporary Facility
- Access Road to WTP / Transmission Pipe
- UWD Dam and Diversion Tunnel
- Transmission / Water Conveyance Pipeline
- Quarry Option 1
- Quarry Option 2
- UWD Reservoir
- Temporary Facilities
- Project Footprints points
- Calawis Water Treatment Plant or CWTP (not part of the Project)

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCo, INC. (2020)
Basemap: ArcGIS Imagery, 2020
Created by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.
apercu CONSULTANTS INC.

SCALE: 1: 30,000

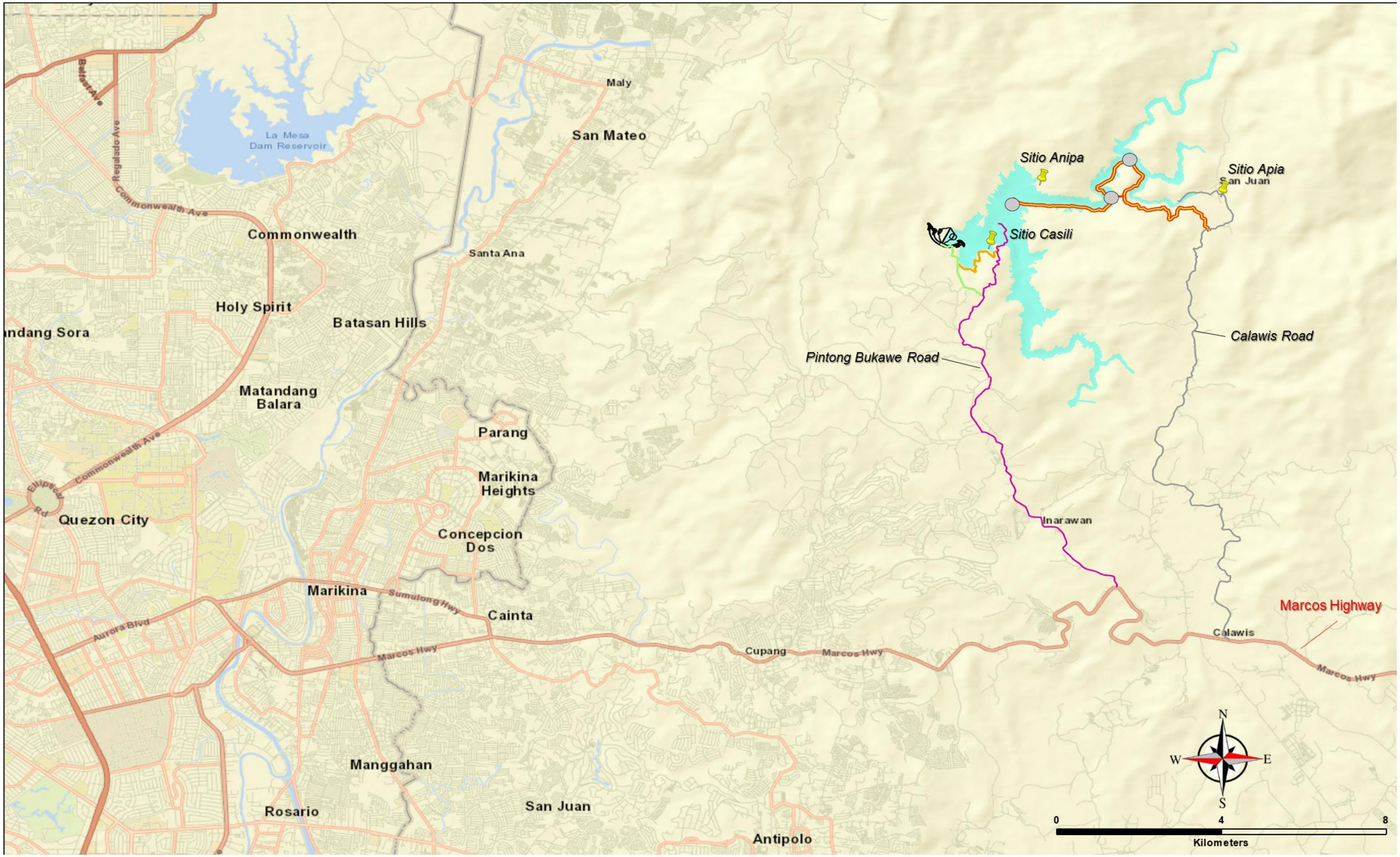

Figure PD-6. Vicinity Map of the Project Site

ENVIRONMENTAL IMPACT STATEMENT
PROJECT DESCRIPTION
Wawa Bulk Water Supply Project – Upper Wawa Dam

Legend
- Pump Station
- UWD Dam and Diversion Tunnel
- Transmission / Water Conveyance Pipeline
- UWD Reservoir
- Sitios
- Pintong Bukawe Road
- Calawis Road
- Transmission Pipeline via Tunnel Optional
- UWD Optional Access Road (New)
- UWD Access Road (Original)
- Access Road to WTP / Transmission Pipe

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCo, INC. (2020)
Basemap: ArcGIS Street Map, 2020
Created by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.
apercu CONSULTANTS INC.

SCALE: 1: 62,500

The MWSS had several prospective large water source projects in its pipeline but decades have passed, and Metro Manila is still dependent largely on Angat Dam. The improvement in the non-revenue water (NRW) levels of MWSS's two concessionaires (Maynilad and Manila Water), which is a limited water source, has functioned as a medium-term measure to ensure that water reaches the growing customer base. Manila Water Company (MWC) attained and even exceeded world class levels in NRW, however, it will no longer be economically viable to further "extract new water" from the NRW. Also, since MWC has consistently attained NRW of around 12% for several years, and coupled with anticipated climate change impacts, there will be years when the water sources will be affected by severe droughts. Hence, it becomes imperative that new water sources, either large or small, be developed and made operational.

The increasing demand and expanding service sections of MWC's concession area, the East Zone of Metro Manila, is creating a deficiency of available water supply in the concession area. To date, 40% of Angat Dam's allocation (about 1,600MLD) is provided to MWC to supply its service area. This is the same allocation from MWSS at the start of the concession in 1997. If not for the aggressive reduction of NRW, MWC would not have been able to provide 24/7 water availability due to the absence of a new water source.
Current demand outlook shows shortage of water supply now and into the future in the East Zone. MWC's customers are already feeling this across the whole concession. Presently, MWC is burdened with a supply deficit of around 150MLD that is why it has to make operational adjustments that includes water supply rationing/water supply cut-offs in order to refill its reservoirs to normal levels. This continues to be a challenge given the increasing demand from its customers.

Figure PD-7 shows the graph of the East Zone demand projection against the existing water supply.

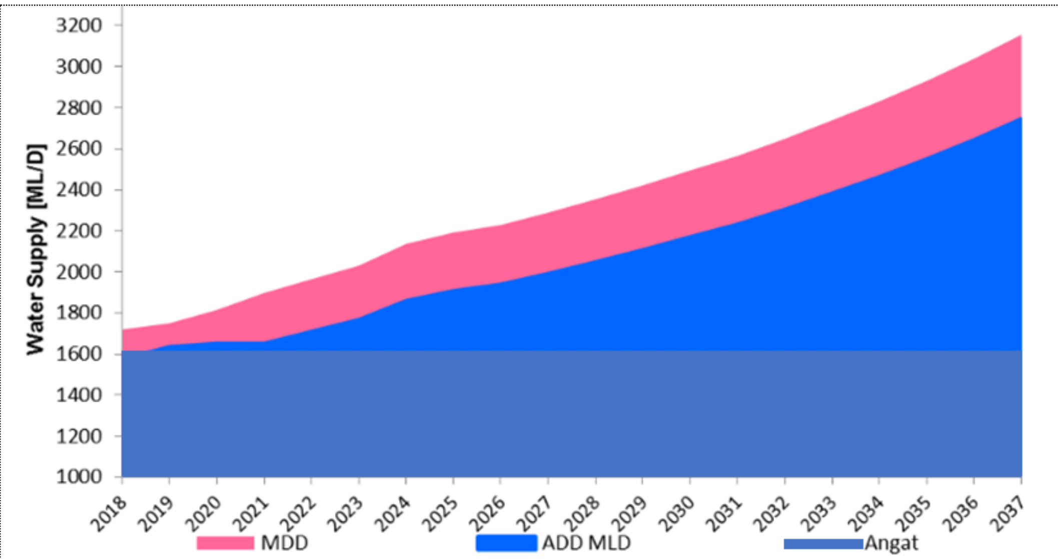

Figure PD-7 – Water Demand in the East Zone of Metro Manila.
Source: Wawa Bulk Water Supply Project Feasibility Study, 2019.

Based on the above chart showing the supply and demand needs of MWC, it is evident that MWC already has a supply deficit starting even before 2018 with regards to the Maximum Daily Demand (MDD). It means that MWC is not hitting its service obligation of providing 24/7 water supply for some of its customers. The current raw water allocation from Angat Dam is 1,600MLD while the water supply requirement at MDD is at 1,750MLD, corresponding to a 150MLD deficit.

The required ecological flow by NWRB is the historical minimum flow as provided in the NWRB Resolution in 1979 or the 10% of the 80% of the flow duration curve as provided in Resolution in 2001 whichever has not or minimal impact in the bypassed reach of the river. Discussion on the environmental flow of the Upper Wawa Dam Project is further discussed in **Section 2.1.3.7 of Water Module Report**.

Currently, customers of the East Zone experience water supply rationing due to a supply deficit of approximately 150MLD of treated water. MWC is already using its reserve, the La Mesa Dam, for its customers' use. However, this dam is now below critical level. Combined treated water supply with the raw water coming from Angat Dam is at 1,496MLD while the augmentation from different sources like Cardona Treatment Plant, deep wells, and cross-border flows from Maynilad contributes 88MLD. These productions combined is still short by 166MLD if the required flows during peak demand of 1,750MLD is taken into account. Considering the next few years prior to the commissioning of the Kaliwa Dam Project in 2023, MWC will need a medium-term source that will carry it through up to the availability of the long-term east source in 2028.

For the year 2021, MWC's demand in the East Zone is projected to be 1,898MLD and this will go up to 2,192MLD by 2025. Such a scenario necessitates immediate activation of a Medium-Term Source, this includes the additional capacity that will be brought by the Wawa Bulk Water Supply Project.

As shown in **Figure PD-8**, water supply at Upper Wawa Dam area is more than 518MLD required for the project, with an average water supply availability of 1,074MLD (**Table PD-3**). With this, Wawa JVCo can extend its water supply level for an additional 774MLD, enough to further support and sustain the increasing demand in Metro Manila. Considering the existing 300 MLD water permit of the WawaJVCo, the NWRB has approved the request of WawaJVCo to increase their water permit to 1,074 MLD on June 18, 2020. With this resolution, the project can support the increasing water demand in Metro Manila East Zone.

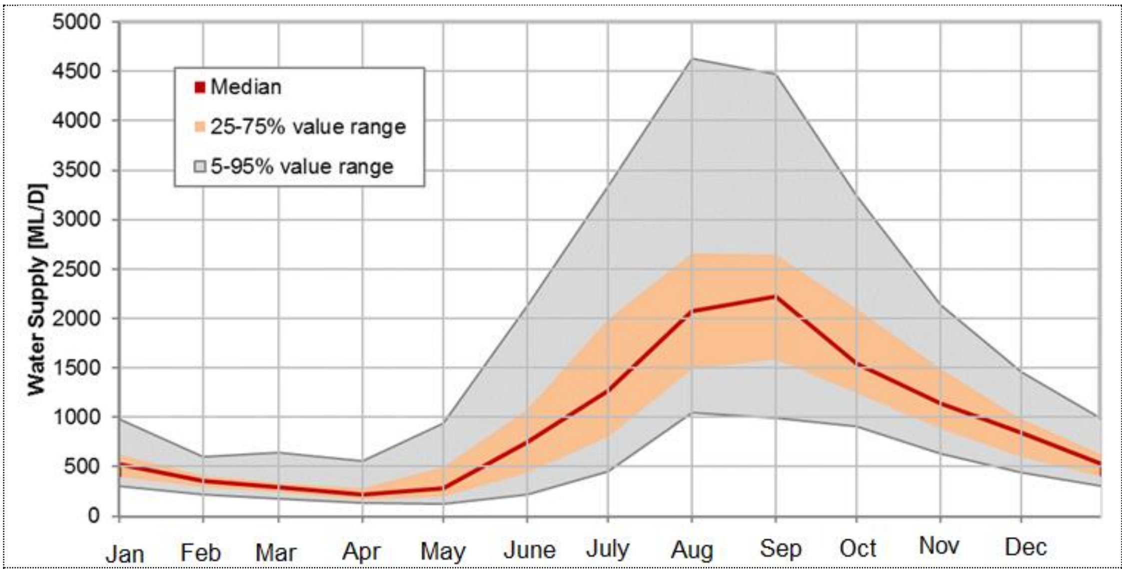

Figure PD- 8 – Monthly discharge variation at Upper Wawa Dam for the period from 1962 to 2018.
Source: Updated Technical Note on the Feasibility Study Report, 2020.

Table PD-3
Water Supply Availability at the Upper Wawa Dam (MLD)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Total Available water supply	542.5	369.5	304.6	257.6	401.0	854.6	1573.4	2340.4	2336.5	1793.6	1243.0	875.1	1074.3
Existing water permit	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0
Permissible (Available) Water Supply	242.5	69.5	4.6	-	101.0	554.6	1273.4	2040.4	2036.5	1493.6	943.0	575.1	774.3

In addition, the MWC's Calawis Treatment Plant (MWC's CTP) was located near the location of the Project and is the offtake delivery point of the Project.

3.2 Flood Mitigation

Wawa River, one of the main tributaries to Marikina River and eventually to Pasig River, is one of the contributors of heavy flooding in Metro Manila, especially during heavy rainfall events. With around 280km^2 of catchment area (calculated from the existing Wawa Dam), a significant volume of stormwater runoff drains to Marikina River and Pasig River and eventually to Manila Bay and Laguna Lake. With the poor drainage conditions and floodplain characteristics of Metro Manila, it is difficult to route such magnitude of stormwater runoff to the receiving bodies of water (Manila Bay and Laguna Lake) especially during high intensity rains, resulting to floods in parts of Metro Manila.

The Project is expected to provide inherent flood mitigation benefits to help alleviate future flood problems in Metro Manila as the Project will act as a flood mitigation structure that will hold stormwater from Wawa River and release it in a regulated manner so as not to cause severe flooding downstream.

According on the hydrological study made and considering the geological conditions of the area, a dam with a height of about 80m is needed, not only to meet the water supply allocation, but also to mitigate flood and surcharge surplus for a 100-year probable maximum flood and sediment load.

3.3 Local Socio-Economic Benefits of the Project

At the local level, the proposed project will provide the following social and economic benefits to the barangays, municipalities and the province.

- **Compensation and continuing development assistance** will be given to the identified directly affected households and peoples (both IPs and non-IPs);
- **Targeted development projects** for IP groups within the host municipalities, as contained in the Memorandum of Agreement (MOA) to be generated from the FPIC process;
- **Increased employment opportunities**, with priority employment and training programs for constituents of host communities during the construction phase and long-term employment to qualified residents with dam operation experience during the operation of the project;
- **Construction of access roads** and possible development and improvement of existing roads; and,
- **Development assistance** consistent with local development plans and priorities offered by the project as part of its corporate social responsibility efforts to enhance the quality of life of host communities.

4.0 Project Alternatives

4.1 Site Selection

The Project has chosen the Wawa Basin, specifically the Wawa River, because of its viability and potential as a water supply source. The Upper Wawa Dam in the Wawa Basin will be a good source of water for the increasing demand of water supply in Manila.

Additionally, the location of the MWC's Calawis Treatment Plant (MWC's CTP), which is the offtake delivery point of the Project, is already fixed and no alternative locations can yield the 518MLD required by the MWSS and MWC under the Offtake Agreement, therefore no other sites were thoroughly studied as an alternative location for the Project.

4.2 Source Alternatives

Similar to **Section 3.1**, no other water sources alternatives were thoroughly studied to be developed as those alternative sources will either not yield the required 518MLD requirement and supply raw water to the offtake delivery point (MWC's CTP) or will be able to provide the 518MLD requirement but will require higher O&M costs. Alternative water sources are briefly discussed and assessed below to provide as reference.

In the report titled "Metro Manila Water Security Study" released by the World Bank and MWSS in July 2012, alternative water sources (aside from fresh surface water) and non-dam alternatives were considered. These include marine/coastal (thru desalination) and rainwater (rainwater harvesting). Additionally, groundwater source was also assessed. **Table PD-4** below summarizes the advantages and/or setbacks that may facilitate or deter these solutions from being realistically achieved for the needed 518MLD supply of the Project.

Table PD-4
Comparison of Water Sources and Non-Dam Alternative Sources

Source	Advantage	Disadvantage	Conclusion
Marine water (Desalination)	• Plentiful and sustainable resources; • Could supply huge demand; • Technically reliable; • Independent of climate.	• Utilizes an Industrial process; • High construction cost; • Substantial coastal land take; • High energy and O&M costs; • Marine environment damaged by brine	Highly feasible, but very expensive. Not considered.
Groundwater	• Most of the water from the groundwater sources can be supplied • Suitable for conjunctive-use; • Better quality than surface water; • Diverse source locations; • Modest carbon footprint.	• Limited future use due to overexploitation • Resources currently ill-defined; • Probably insufficient to supply huge demand • Recharge climate-dependent; • Substantial energy costs.	Location of Resources will need to be quantified
Rainwater Harvesting	• Basic technology; • Local sources; • Low carbon footprint	• Ill-suited to high-rise urban areas; • Climate dependent; therefore, cannot be used as baseload water supply.	At best, it will contribute to household supply or compound non potable water use

4.3 Technology Selection

Dam was chosen as the best technology option for this project as it can produce and store large amount of water that can sustain to increasing demand of water supply in Philippines. Developing a dam in areas that has a deficiency water supply, would significantly improve the amount of water that can be sourced. Dam also serve as a barrier that will reduce the impact of upcoming calamities such as floods around the area where it was developed.

Another technology was studied for this project, rainfall harvesting. This type of technology collects water from rain that can be stored into water tanks. However, this technology is climate dependent which can only store water during rainy season and has a limited capacity. Also, this type of technology only fits in household as a supply of water and this technology can't supply large amount of water in many areas at one time.

The succeeding sections, however, discuss the project alternatives that is considered for the structures and components.

4.3.1 Dam Type

Based on the Tender Design Report of Tractebel (June 2020), the previous feasibility study from SMEC for Wawa JVCo has proposed a Roller Compacted Concrete (RCC) gravity dam with an effective height of 90m above riverbed level and one diversion tunnel of 13m diameter. The study also proposed a spillway type that has an uncontrolled ogee designed for a peak flow of 4.174 m3/s. The Peak Ground Accelerations were estimated based on a simplistic approach to values of 0.2g - 0.3g.

After receiving and reviewing the results of the seismicity study, it was foreseen that the proposed Peak Ground Acceleration was higher (PGA=1.06g, 10 000 years Return Period). Therefore, the most favorable dam type was revised in the light of this seismic loading for the reliability of the project.

Based on the consultant extensive experience of high dam design under seismic loading, it is needed to add arching effect to the gravity RCC dam to be able to withstand safely and economically such a seismic loading. The available partial geotechnical investigation at the time of this dam type assessment presents that it was not possible to confirm the feasibility of such dam type.

After careful evaluation of all the available parameters and considering the seismic hazard class of the dam site, the use of an Earth Core Rockfill Dam (ECRD) or Roller Compacted Concrete (RCC) was identified as alternative dam type suitable for the project, as this type of dam can accommodate stronger cyclic loading of bigger intensities and is less demanding in terms of foundation quality.

A preliminary stability analysis done for the ECRD or RCC showed acceptable behavior in the Safety Evaluation Earthquake loading of 1.06g. The decision of the type of dam influences significantly the total project setup, especially considering that a gravity dam can be overtopped in flooding events, but an embankment dam cannot. The final choice of the type of dam will be determined later to account for a stress test on the project schedule and the required delivery of water to Manila Water.

4.3.2 Dam Capacity

During the Full Supply Level (FSL), the reservoir of the project will have a surface area of approximately 414.28 hectares extending 8.2km upstream that can store for about 120.1MCM of water. On Minimum Operating Level (MinOL), the dam reservoir has an about 87masl, at which level the reservoir will have a surface area of 74.33ha. and a total storage volume of 7.2MCM.

4.4 Environmental Conditions

The project location was evaluated for its susceptibility/vulnerability to the various hazards and the resulting assessments are tabulated below (**Table PD-5**).

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

Hazard	Assessment
Earthquake induced landslides and mass movement	Moderate level of threat from earthquake induced landslide due to the terrain and slope in the project site and vicinity (**Section 1.2.5.1. of Land Use Report**). If a landslides occur, it may still damage the gates, spillway, retaining walls and other surface equipment.
Liquefaction	Low level of threat in liquefaction potential since project area is underlain by competent bedrock
Ground Shaking	Moderate to high level threat from ground shaking that causes vibrations and structural distortions in dams and, appurtenant structures.

Hazard	Assessment
	Rock falls and landslides that may cause damage to gates, spillway, retaining walls and other surface equipment.
Ground Rupture	No threat from fault rupture is expected on the project site
Flooding	High level of threat from flooding. Flashfloods normally occur in Wawa and Marikina rivers that result from the rapid accumulation of runoff during heavy rains.
Tsunami	Low level of threat since the project site is located inland, far from the coast.
Differential settlement	Low level of threat in differential settlement since the settlement can only occur if sediments undergo expansion, contraction or movement. Changes in soil condition may result from drought, flooding, earthquake or vibration
Volcanic Hazards	Low level of threat since the project site is located far from active volcanoes such as Taal and Pinatubo to be directly affected by volcanic activities. Tephra or ashfall may still reach the project site during large volcanic eruptions (**Section 1.2.5.1. of Land Use Report).**

4.5 Summary of Project Alternatives

Table PD-6 shows the summary of project alternatives considered for the Upper Wawa Dam Project.

Table PD-6
Summary of Project Alternatives Considered

Environmental Aspects	Major Criteria	Description
Site Location	Wawa River in Rizal Province	▪ Proponent has existing water permit in the area/ river. ▪ No alternative location was considered since the project area specifically the Wawa River is a great source of water. ▪ Location of the water treatment plant to be developed by MWC is already fixed and is the agreed delivery offtake point of the UWD Project.
Design	Capacity Dam Type Spillway	▪ The water storage will have a capacity of 120.1MCM that produces at least 518 MLD. ▪ An Earth Core Rockfill Dam (ECRD) structure or a Roller Compacted Concrete (RCC) dam structure will be built to maintain its stability. ▪ The spillway will allow the discharge of PMF flood with a discharge of 7,300m³/s.
Source Alternatives		▪ No other alternatives sources of water can yield the 518MLD capacity requirement in the Offtake agreement.
Technology/ Operation Processes	Chosen type of technology: Dam	Dam is more reliable because of the following: ▪ Produces and stores high amount of water per day that can sustain water supply demands ▪ Dam accommodate stronger cyclic loading of bigger intensities and is less demanding in terms of foundation quality. ▪ Capable of providing processed clean water to urban and rural areas. ▪ Provides flood control benefits Dam has greater advantage because: ▪ Best technology option to sustain the demand of water supply in the Philippines. ▪ Capable of providing water supply services that can support irrigation systems. ▪ Reliable and efficient functioning of water supply.
Environmental Conditions		▪ Moderate impact from earthquake induced landslide considering the terrain and slope of the project area. ▪ No active faults in the project area, and therefore no threat from fault ruptures ▪ Low liquefaction potential since project area is underlain by competent bedrock ▪ No ground rupture expected ▪ Since the location of the project site is located far away from a volcano (Mt. Taal) and coastal area, low level of threat was considered from volcanic hazard and tsunami.

4.6 No Project Option

Dam as a source of water is important to an economy as it can support the increasing demand for water. Without this project, the water supply in Metro Manila will be limited or in a worst-case scenario, no potable water will be rationed to the consumers which could lead to health problems due to sanitation problems resulting from the lack of water.

According to World Health Organization (WHO)[4], the supply of clean water in the Metro Manila and in other parts of the Philippines is very limited. Scarcity of water can trigger serious health consequences to people who are forced to rely on water that is not safe for consumption. With this project, shortages in water will be reduced and potable water will be distributed around the Metro Manila. Also, it is important to note that this project will serve as barrier when constructed that will prevent floods around Metro Manila, reducing the risk of the upcoming calamities.

5.0 Project Components

5.1 Dam and Spillway

Figure PD-9 shows the general arrangement of the Upper Wawa Dam and Spillway**.** Details for the dam and spillway of UWD Project are presented in the following sections:

5.1.1 Dam

The Project's general site was projected to be located in a high seismic zone based on a geological study. Data from geological study shows that the project area is within 10km-radius of two major and minor active faults.The major faults are the Marikina Valley Fault System (MVFS) and the Philippine Fault Zone (i.e. PFZ: Infanta Segment), to the west and further east respectively, whilst the minor ones are still unnamed by PHIVOLCS. Due to the geological location of the dam, Wawa JVCo is currently implementing a full seismic hazard assessment and is considering the Earth Core Rockfill Dam (ECRD) or the Roller Compacted Concrete (RCC) gravity dam as the most reasonable alternative. **Figure PD-10** provides an artist's rendition of the dam.

5.1.1.1 Dam Characteristics

For the zoning of the dam, it will include a central clay core with a watertight material. The upstream and downstream of the clay core is a fine filter (2A zone) followed by a coarse filter/drain (2B zone) which are designed to accommodate the drain of the water towards the downstream and prevent transfer of material through the dam and possible washout and piping mechanisms development that could lead to dam breach. The width of each of these zones is 4m. The main part of the embankment is constructed by selected and processed rockfill material. Rip rap is used at the upstream and downstream faces for slope protection. The core must be compacted having optimum moisture (±3%) with a padfoot roller to a compaction up to 98% of standard maximum dry density. The general description of the zones is presented in **Table PD-7** below.

Table PD-7
Dam Zones Description

Zone	Component	Description
Zone 1	Core Design	Impervious earth fill – selected lateritic soil
Zone 2A	Filter Design	Filter zone to prevent the migration of materials between different zones, such as core and shell
Zone 2B	Drainage Design	Transition/drainage zone. Selected rockfill from quarry
Zone 3	Shell Design	Best quality higher strength rock, compacted to provide section stability

[4] Source: https://www.who.int/philippines/news/feature-stories/detail/water-shortage-in-the-philippines-threatens-sustainable-development-and-health, last accessed: July 31, 2020

Zone	Component	Description
Zone 4	Riprap	Rock blocks from quarry, to act as erosion protection on the upstream and downstream face of the dam. For durability reasons the rock type will be based on ongoing geotechnical investigations

For the stability of the dam, the concept Earth Core Rockfill Dam (ECRD) or Roller Compacted Concrete (RCC) structure was chosen for this project. The dam can provide a watertight structure to retain the water from reservoir. It will have an upstream face of 2.5H/1V and downstream slope of 2.5H/1V while the crest of the dam is 10m wide. These measurements guarantee the reliability and steadiness of the dam under all scenarios studied (**Figure PD-11**).

5.1.1.2 Safety and Stability Features

To guarantee the effectiveness and reliability of the dam, a 2D Finite element model was developed to analyze stability and the overall seismic behavior of the Upper Wawa Dam in normal and extreme loading conditions. The dam is modeled with three main materials, namely the foundation, the shell, and the core materials (**Table PD-8**). As mentioned in above section, the upstream and downstream slope are both designed as 2.5H:1V. Staged construction was applied for the dam to represent an accurate stress state of the material after construction.

Table PD-8
Strength and Physical Properties of the dam

Materials	Unit Weight (kN/m3)	Shear Strength Envelope	C (kPa)	Phi (°)	A	B	Permeability (m/s)
Foundation	22.0	Mohr-Coulomb	20	41	-	-	1.0E-06
Shell	22.4	Curved	-	-	1.6	0.9	4.0E-04
Core	22.0	Mohr-Coulomb	40	28	-	-	6.0E-08

The PGA values obtained from the Seismicity study and defined for the 145 Operating Base Earthquake (OBE), 10.000 Safety Evaluation Earthquake (SEE) return periods, are used in the stability analysis and are shown in (**Table PD-9**).

Table PD-9
Input of PGA of the Upper Wawa Dam Site

Earthquake	PGA Horizontal (g)	PGA Vertical (g)
OBE	0.220	0.147
SEE	1.06	0.707

The factor of safety (FoS) of potential sliding planes is assessed for various load cases. The load cases are categorized into USUAL, UNUSUAL and EXTREME according to their probability of occurrence and duration. For each loading condition, the critical safety factor found shall be equal or higher than the minimum safety factor allowed (**Table PD-10**).

Table PD-10
Safety Criteria for Static Conditions

Load Case	Condition	Minimum FoS	Factor of Safety
Usual	Operational Condition at FSL	1.5	1.64
Unusual	End of construction	1.3	2.53
Unusual	Earthquake (OBE=0.22g)	1.3	1.7
Extreme	Earthquake (SEE=1.06g)	1.0	<1.0

For Extreme earthquake conditions, the pseudo static analysis is too conservative. Therefore, a complete dynamic (time-history) analysis has been performed to assess the behavior of the dam under earthquake conditions. This analysis includes the linear equivalent approach including the non-linear variation of key parameters as dynamic modulus and material damping. The time-history calculations are followed by a Newmark analysis to assess

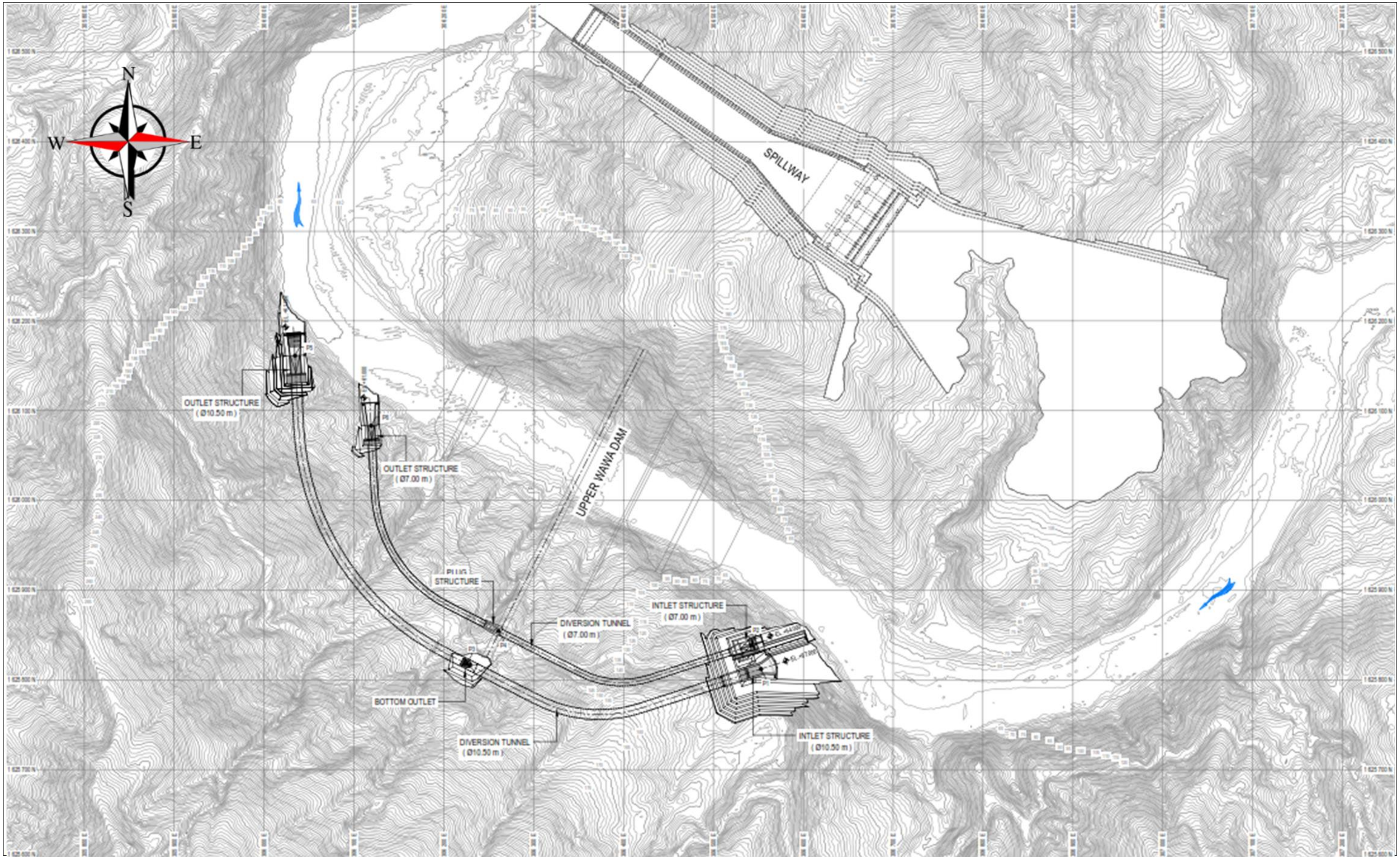

Figure PD-9. Overview of the Upper Wawa Dam and Spillway

ENVIRONMENTAL IMPACT STATEMENT
PROJECT DESCRIPTION
Wawa Bulk Water Supply Project – Upper Wawa Dam

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCo, INC. (2020)
Source Map: Tractebel (2020)
Modified by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.

aperçu CONSULTANTS INC.

SCALE: Not to Scale

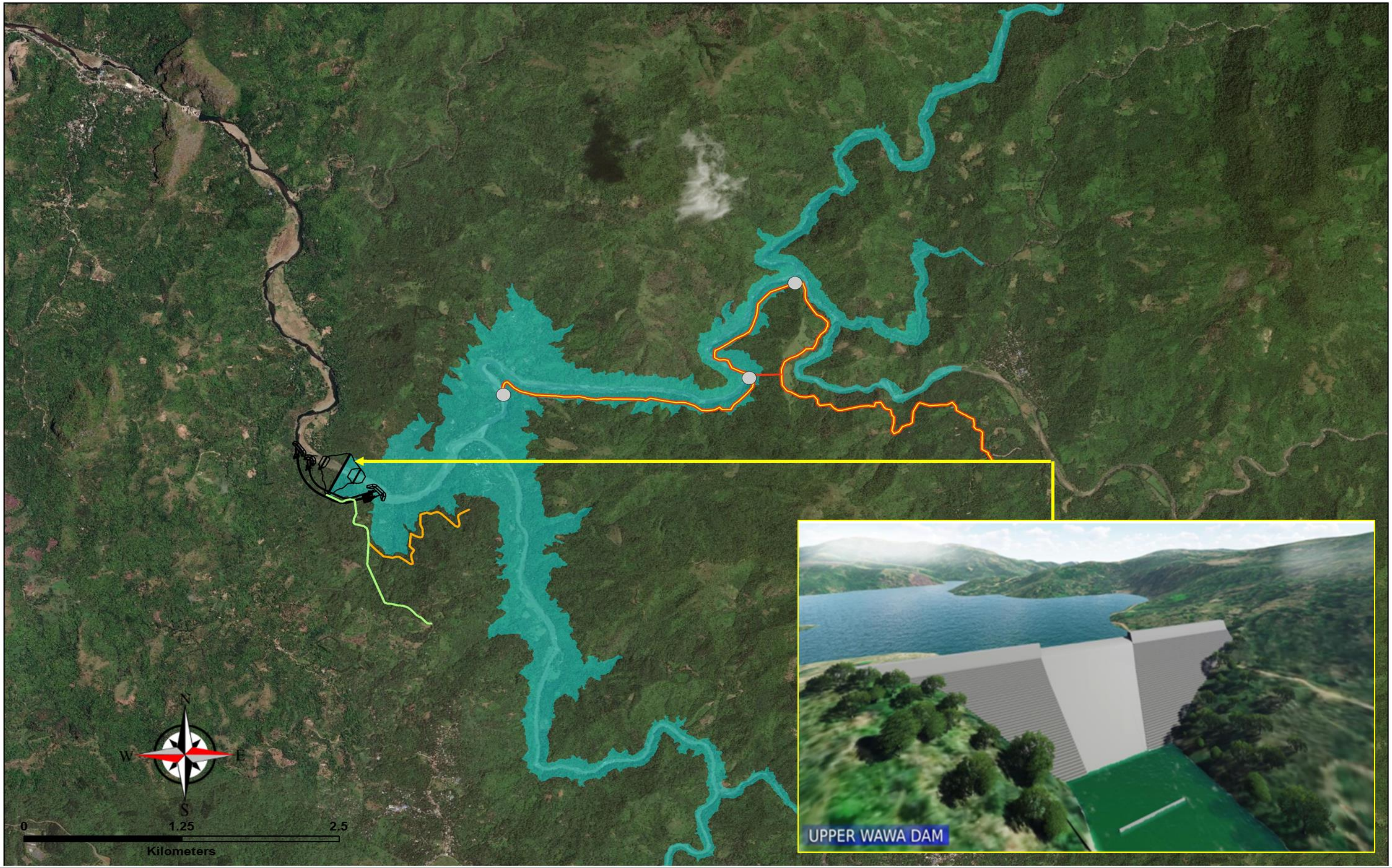

Figure PD-10. Artist's Rendition of the Dam	Legend	**DATA INFORMATION/SOURCE:**	**WawaJVCo INC.** apercu CONSULTANTS INC.
ENVIRONMENTAL IMPACT STATEMENT PROJECT DESCRIPTION Wawa Bulk Water Supply Project – Upper Wawa Dam	Pump Station; UWD Dam and Diversion Tunnel; Transmission / Water Conveyance Pipeline; UWD Reservoir; Transmission Pipeline via Tunnel Optional; UWD Optional Access Road (New); UWD Access Road (Original); Access Road to WTP / Transmission Pipe	**Project Components:** Wawa JVCo, INC. (2020) **Basemap:** ArcGIS Imagery, 2020 **Created by:** APERCU CONSULTANTS, INC (2020)	**SCALE: 1:25,000** **PAGE 36**

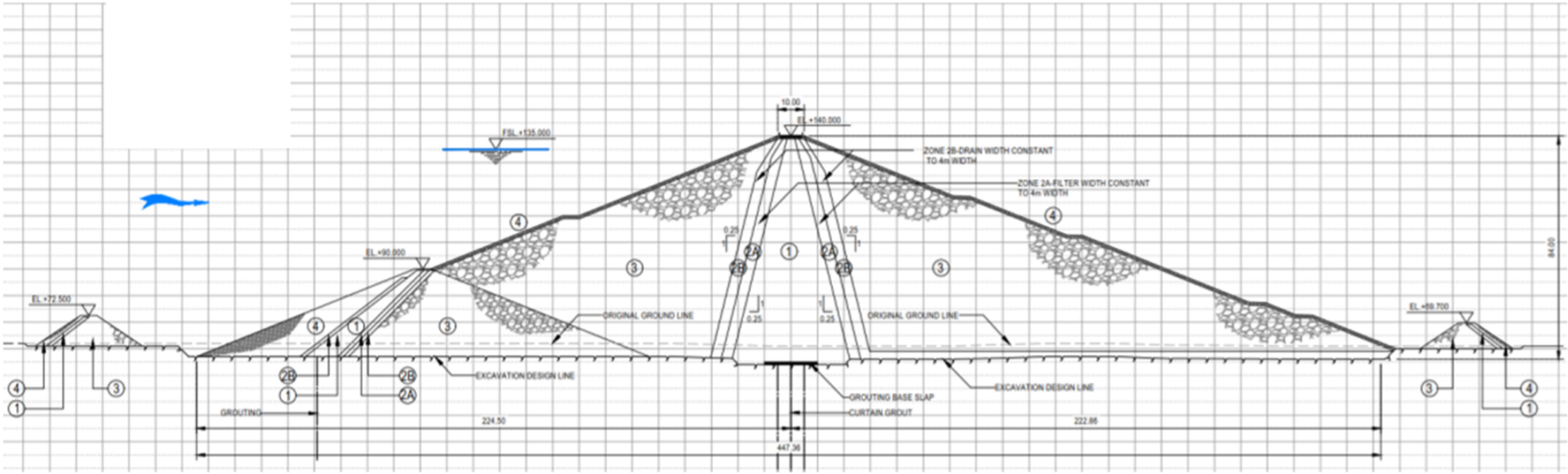

Figure PD-11. Typical Section of the UWD Earth Core Rockfill Dam or Roller Compacted Concrete

ENVIRONMENTAL IMPACT STATEMENT
PROJECT DESCRIPTION
Wawa Bulk Water Supply Project – Upper Wawa Dam

LEGEND

- 1 Impervious Core
- 2B Fine Transition
- 2A Course Transition
- 3 Rockfill
- 4 Riprap

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCo, INC. (2020)
Source Map: Tractebel (2020)
Modified by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.
aperçu CONSULTANTS INC.

SCALE: Not to Scale

potential sliding distance along different sliding surfaces. Results point out that sliding displacement for the most critical earthquake (SEE) reaches 0.42m, which can be handled by the dispositions provided in the filters. For OBE, no displacement is calculated showing the good performance of the dam.

5.1.1.3 Instrumentation

The dam will be equipped with instrumentation to monitor the dam the behavior, performance, and safety of the dam during construction and operation phases. The purpose of the instrumentation is to monitor and measure the following:

- Settlement within the dam;
- Surface displacement;
- Earth pressures in the dam;
- Pore water pressure instruments;
- Internal settlements and deformations;
- Accelerations at different levels of the dam,
- Seepage and Water levels;
- Ground water levels;
- Flow releases; and,
- Earthquake motion.

For the Upper Wawa Dam, it was decided that three cross sections, one at the maximum height of the dam and one each on the left and right abutments, be instrumented fully to monitor internal behavior of the embankment.

5.1.2 Spillway

To ensure the safety and reliability of entire Upper Wawa Project, the spillway structure design considered the economic aspects, construction costs and maintenance to be as low as practicable without jeopardizing Project safety nor performances.

The location of the right abutment was chosen as the most convenient from morphology point of view. Given the topographical conditions at site, and the Full Supply Level, the excavation volumes are significant. Therefore, spillway's axis location is chosen carefully to ensure a safe and reliable release of flows downstream, and to avoid excessive excavations. No suitable locations within left bank of the valley are found.

Considering the requirements for safety, control over floods, the significant flood levels at site, and the economic constraints, the most suitable solution for the Spillway is a gated control spillway, a free surface conveyance structure and a dissipation structure.

During the operation phase of the Upper Wawa Dam Project, it will be in a constant reservoir level of 135masl. The spillway will be able to operate, fully or partially, after an earthquake event up to 10.000 years return period. The gated spillway is designed to safely pass up to the Design Flood corresponding to the 10 000-years return period, the Full Supply Level (135 masl), considering one inoperative gate (N-1). This spillway allows the discharge of PMF flood with a discharge of 7,300m^3/s (**Figure PD-9)**.

The works comprising the Spillway Structure are divided in five (5) parts (**Figure PD-12**):

- The approach channel;
- The control structure;
- The transition chute,
- The steep chute; and,
- The energy dissipation structure.

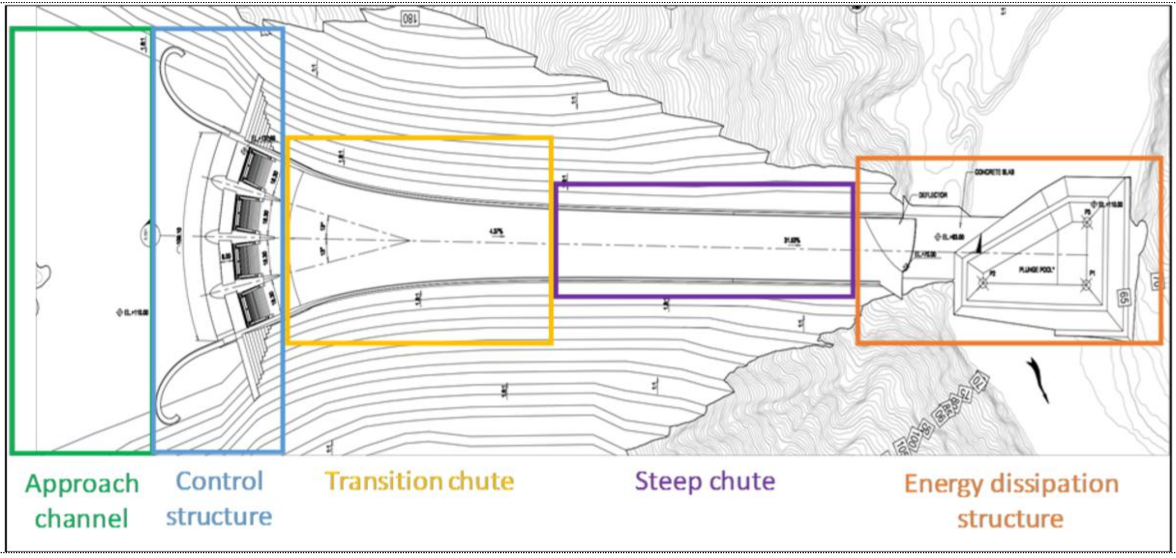

Figure PD-12 – Main parts of the Spillway structure
Source: Tender Design Report by Tractebel, June 2020.

5.1.2.1 Approach Channel

The purpose of the approach channel is to create the proper inlet conditions which are required to guide the flow towards the weir (control structure), avoiding flow detachments, which would lead to flow contraction and reduction of the discharge capacity of the structure. Moreover, it could generate cavitation or vibrations affecting the civil structures and hydromechanical equipment.

The upstream platform draws a gradual transition to the spillway section, with a horizontal rock platform excavated at 110 elevation. The excavation slopes of this transition with around 120m long are foreseen according to the rock characteristics.

5.1.2.2 Weir Gates

There are two (2) parameters evaluated in the weir gates design for the spillway of the Project; the maximum water level and the evacuated discharge. The main geometric characteristics of the overflow weir are presented below:

- Creager weir crest shape,
- The total length of the overflow weir is 73.2 m (four gated spans of 18.30 m),
- Three elliptical shape piers among the 4 spillway spans
- Crest elevation at el. 121.70,
- The design hydraulic head of the spillway is 12 m (free flow),
- Weir height of 11.70 m above the horizontal approach channel,
- Four (4) tainter gates of 13.30 m high over the overflow crest.

The longitudinal profile of the chute channel aims at conveying flow to a supercritical flow, avoiding at the same time the issues related to cavitation, and stationary waves (**Figure PD-13**). The longitudinal gradient was projected to minimize the excavation quantities, while ensuring a minimum Froude number of 2 all along the structure.

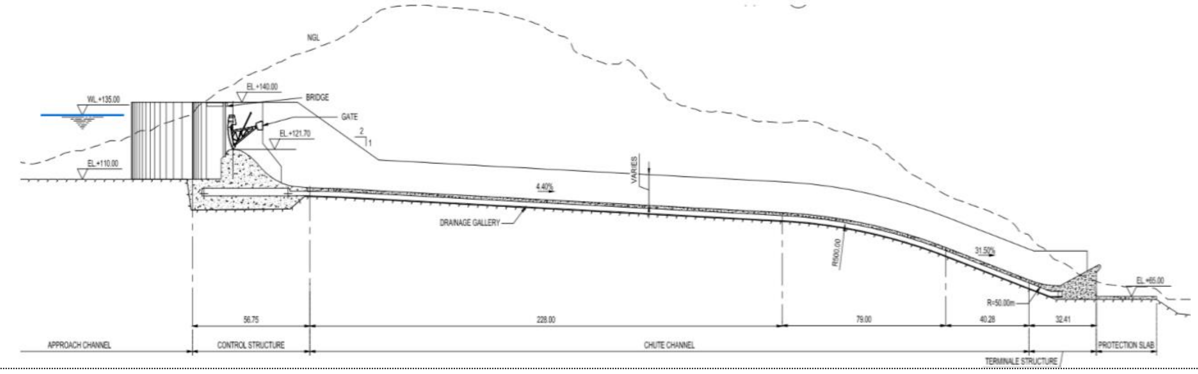

Figure PD-13 – Landscape view of Spillway Chute
Source: Tender Design Report by Tractebel, June 2020.

Each span of the overflow weir control structure is then equipped with an 18.3 x 13.3 m radial gates, with a top 2.70 m crest flap gate allowing to clean and minor discharges up to 2 years return period flood, with an approximate peak discharge of about 540 m3/s, at Full Supply Level at 135.00 masl. In **Figure PD-14**, the Upper Wawa Spillway and the gates are presented in a 3D layout.

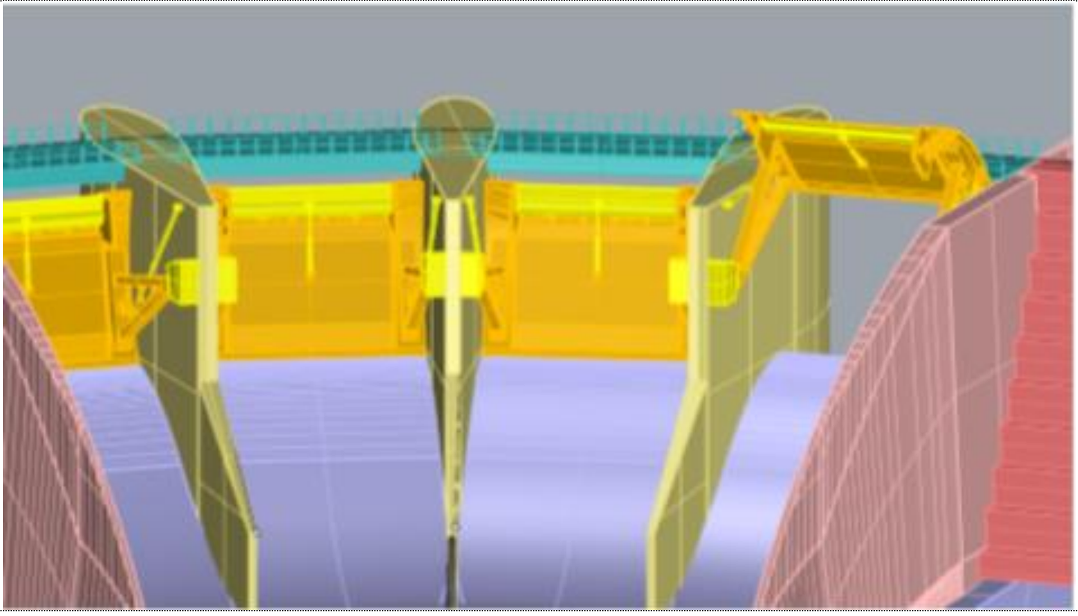

Figure PD-14 – Spillway crest view equipped with four radial gates.
Source: Tender Design Report by Tractebel, June 2020.

5.1.2.3 Energy Dissipation Structure

The flow energy is dissipated by mean of a deflector bucket, which allows for a maximum flow dispersion within air, and therefore achieving energy dissipation; while redirecting the flow towards the river natural alignment, which allows to avoid excessive recirculating flows towards upstream.
Jet impact is set within a pre-excavated plunge pool, which allows to avoid excessive scouring downstream from the dam and provides a water volume for extra energy dissipation at the water impact.

5.1.2.4 Grout Curtain and Drainage System

The entire spillway structure is drained through a dedicated system of galleries and gutters. Four (4) main galleries are foreseen:

- An upstream transversal gallery implemented within the control structure. It allows for drainage and grouting curtains works and collect drainage flows.
- A downstream transversal gallery, implemented within the control structure; It allows for drainage curtain works, and collect drainage flows.
- A longitudinal gallery, connected to the control structure galleries, develops along the chute central axis, releasing drainage flow through the downstream transversal gallery. A fishbone arrangement of gutters ensures the drainage of all parts and is connected to the central longitudinal gallery.
- A downstream transversal gallery, located within the deflector bucket structure, allows for structure inspection, and collects all drainage flows, while allowing for control over release conditions.

5.2 Reservoir Characteristics

The basis for the reservoir volume and area calculation are LiDAR data and 1m contour lines derived from the LiDAR point measurements (**Figure PD-15**). The dam will impound a reservoir that will have a Full Supply Level of 135masl. At the FSL, the reservoir will have a surface area of approximately 414.28 hectares extending 8.2km upstream and will store 120.1MCM of water. The reservoir will cover six (6) river systems: Wawa River, Montalban River, Boso-Boso River, Payagwan River, Tayabasan River and Sapa Bute-Bute River.

The Minimum Operating Level (MinOL) of the reservoir will be about 87masl, at which level the reservoir will have a surface area of 74.33ha. and a total storage volume of 7.2MCM. The reservoir and dams have been designed such that the water level in the reservoir remains more than 5m below the dam crest during flood events.

5.3 Pumping Station and Transmission / Water Conveyance Pipeline

Characteristics for the pumping station and conveyance pipeline are shown below:

Table PD-11
Characteristics of Pumping Station and Transmission Pipeline

Pumping Station	
Type	Wet Pit, circular shape, 3 pits
Pump Type	Vertical Turbine Type
Number of Pumps	6 (4 100% operating, 2 stand-by)
Pump Capacity	1.5m^3/s each, net head ≥100 m
Operating Levels	
Maximum operating level	135 masl
Mean operating level	120 masl
Minimum operating level	87 masl
Calawis water level in flocculation tank	164.5 masl
Conveyance Pipeline	
From	Pump Station
To	Calawis WTP (to be developed by MWC)
Approximate Length	3.474 km
Type and size of Transmission Pipe	Buried Steel Pipe, Dia. 1800mm

5.3.1 Pumping Station

Considering the elevations and associated gross heads of Calawis Treatment Plant and Pumping Station, a gravity conveyance is not considered in this Project because the water level at starting point of water conveyance is lower than the water level at the flocculation tank. Therefore, a pumping station is required to deliver the water from the reservoir through conveyance pipeline up to interface point at CWTP. A pumping station will be developed for this project that will have a capacity of 777 MLD (518 MLD for normal service capacity and 259 MLD for standby/backup capacity) to cope up with water supply generation. Generally, the project will only develop one (1) pumping station.

Aside from the proposed location of the Pumping Station, two (2) alternative location was considered shown in **Figure PD-16**.

The pump will have a characteristics of total dynamic head (TDH) of the networks, i.e. which include:

- The geometrical height;
- Friction losses in the rising main pipes.

The access road from Calawis treatment plant to the pumping station is of similar properties, except that it incorporates the installation of the conveyance pipeline (**Figure PD-16**).

5.3.2 Transmission / Water Conveyance Pipeline

The transmission or conveyance pipeline will be buried in trench pipeline, with a portion of it may be tunneled, DN1800 of approximately 3.500m and accessories. The pipeline follows a route from the pumping station to Calawis treatment plant at the edge of the canyon. This route is above the elevation of the reservoir to provide access to the pumping station for operation and maintenance reasons all over the year. The pipeline will have a 3.474 km long road and will be placed under the access road from pumping station to Calawis WTP.

On the other hand, an alternative route for the transmission or conveyance pipeline via tunnel was considered in the Project connecting to the alternative location of the Pumping Station (**Figure PD-16 and 17**). It suggests a shortcut of conveyance pipe through a 180m long tunnel to convey water from the alternative Pumping Station and serve as an access road at the same time. However, the alternative was evaluated in technical and economic aspects and was found more expensive and technically more difficult considering the need of a tunnel excavation. For this reason, the transmission / water conveyance pipeline from the proposed pumping station up to the Calawis Water Treatment Plant was proposed and followed. Overview of the access road with the transmission / water conveyance pipeline are shown in **Figure PD-16**.

5.4 Access Roads

The access road for the Upper Wawa Dam will be using the existing barangay roads of Sitio Casili. The existing barangay road from Sitio Casili to the Upper Wawa Dam cannot be used as a permanent access road because will be inundated after the impounding of the reservoir. A new access road will be constructed in elevations above the river full supply level that will connect to dam and dam to spillway (**Figure PD-18)**. The old access road was decided to be refurbished slightly, to accommodate the early access to upper Wawa Inlet and Outlet areas and allow for the start of the diversion scheme construction works. The Upper Wawa Dam will have two optional locations of access road (original and new) that branches from the existing road upstream of the Upper Wawa Dam. Both of the optional access road (original and new) is planned on the left bank at elevation 140masl. Total length of the proposed original access road is 1.4 km while the proposed new access road is 1.6km.

The access roads analytically are:

- Access road from the existing road reaching the location of the future Calawis Water Treatment Plant, at the location of the interface point to the pumping station.
- Access road from the existing refurbished barangay road leading to Sitio Casili, to Upper Wawa dam crest and along downstream slope down to the bottom outlet structure,
- Access road from the Upper Wawa Dam crest to the gated spillway,
- Access road from the existing road to the operator camps
- Access road from the dam crest road to the Bottom outlet shaft
- Access road from pumping station to Calawis Water Treatment Plant.

An access road will also be constructed following the route of the Transmission / Water conveyance Pipeline (**Figure PD-16 and 17**).

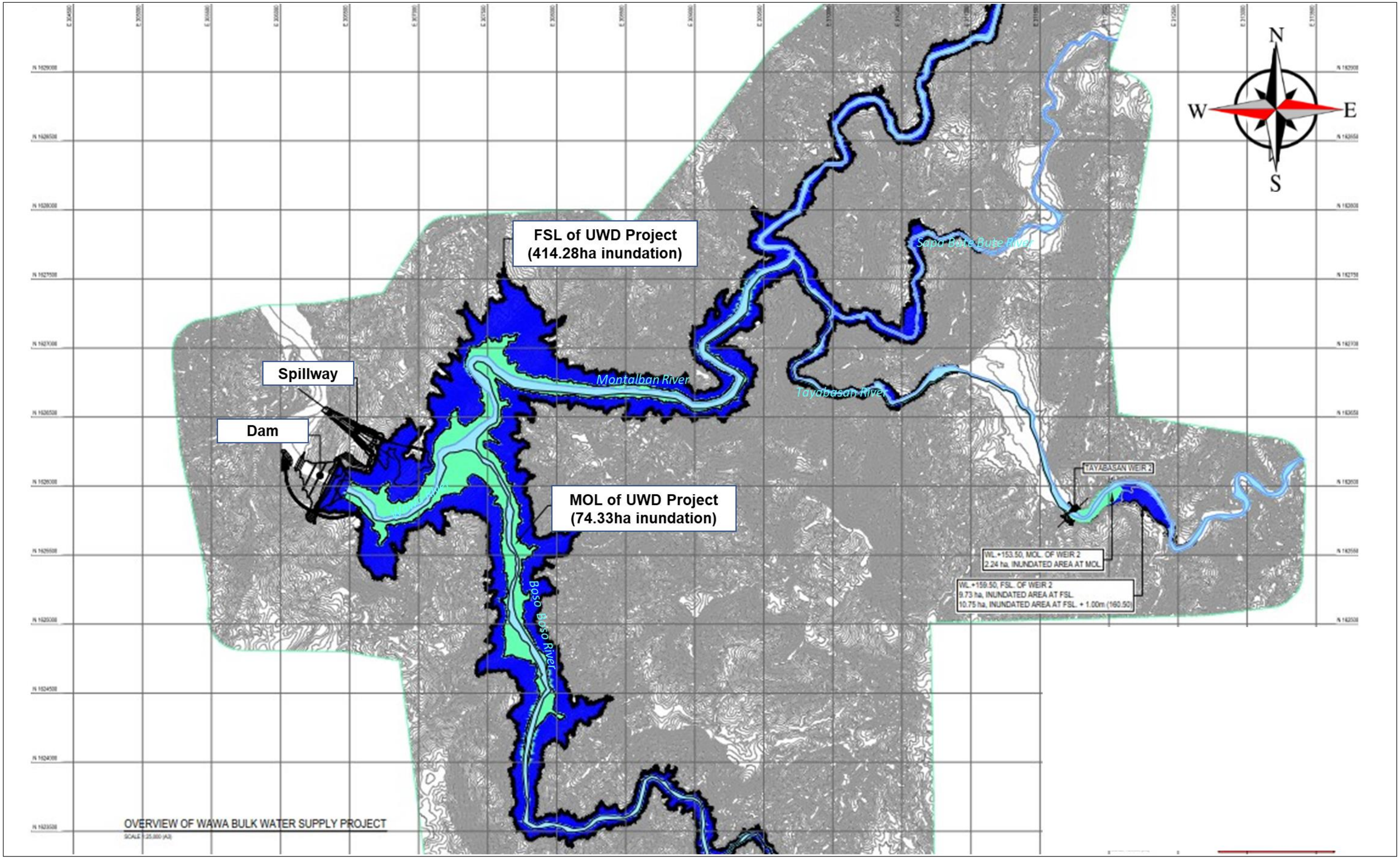

Figure PD-15. Upper Wawa Dam Reservoir	**LEGEND (as above)**	**DATA INFORMATION/SOURCE:**	**WawaJVCo INC.** aperçu CONSULTANTS INC.
ENVIRONMENTAL IMPACT STATEMENT **PROJECT DESCRIPTION** **Wawa Bulk Water Supply Project – Upper Wawa Dam**	Top view of average water level in natural condition Top view of inundated area at MOL Top view of inundated area at FSL	**Project Components:** Wawa JVCo, INC. (2020) **Source Map:** Tractebel (2020) **Modified by:** APERCU CONSULTANTS, INC (2020)	**SCALE:** Not to Scale

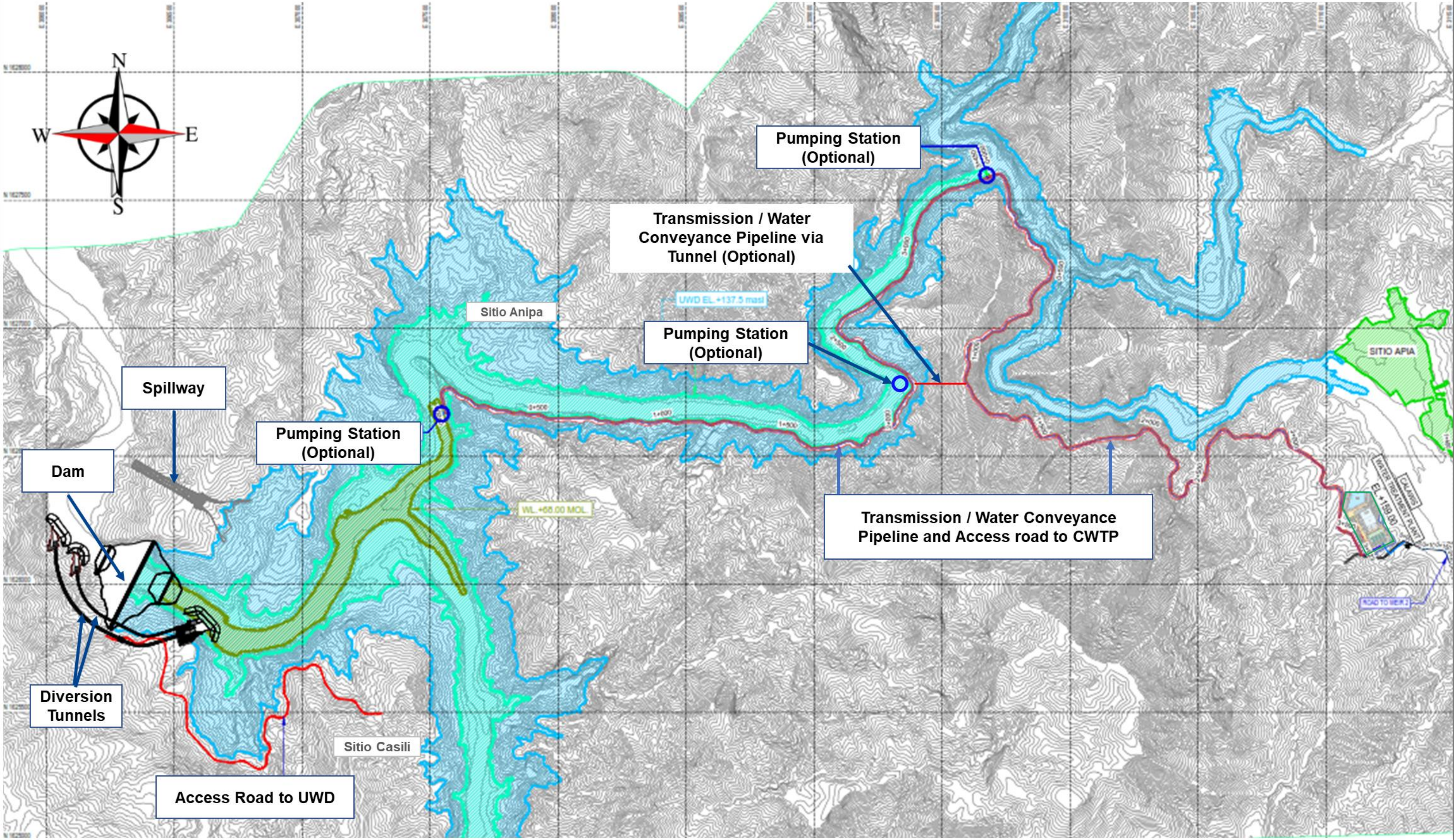

Figure PD-16. Overview of Pumping Stations, Transmission / Water Conveyance Pipeline and their alternatives and Access Road to CWTP **ENVIRONMENTAL IMPACT STATEMENT** **PROJECT DESCRIPTION** **Wawa Bulk Water Supply Project – Upper Wawa Dam**	**LEGEND (as above)** Top view of inundated area at MOL Top view of inundated area at FSL Dam and Diversion Tunnels Spillway Proposed Access Roads	**DATA INFORMATION/SOURCE:** **Project Components**: Wawa JVCo, INC. (2020) **Source Map**: Tractebel (2020) **Modified by:** APERCU CONSULTANTS, INC (2020)	**WawaJVCo INC.** aperçu CONSULTANTS INC. **SCALE: Not to Scale**

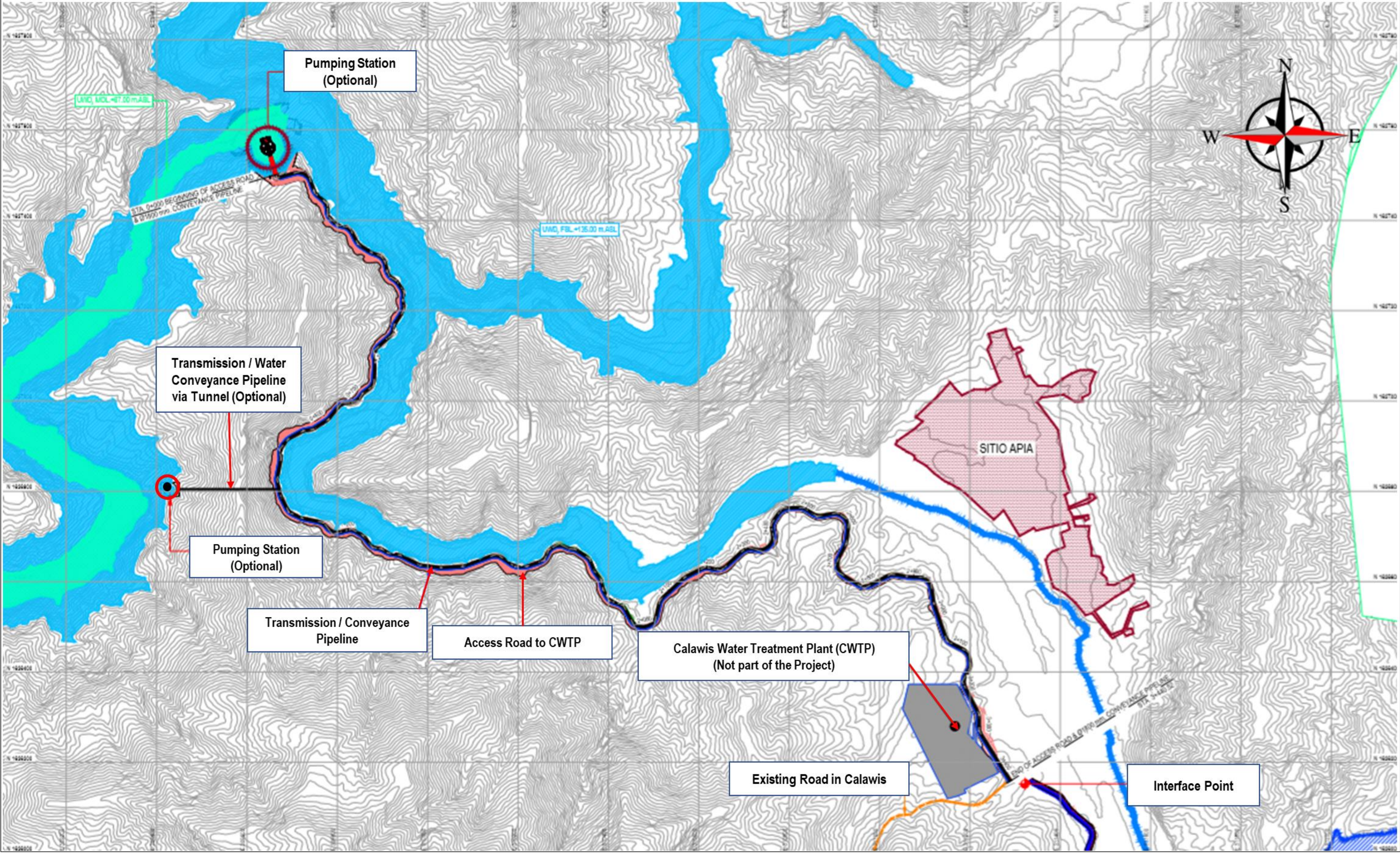

Figure PD-17. Overview of Transmission / Conveyance Pipeline and Access Road from CWTP to Pumping Station

ENVIRONMENTAL IMPACT STATEMENT
PROJECT DESCRIPTION
Wawa Bulk Water Supply Project – Upper Wawa Dam

LEGEND (as above)

- Top view of inundated area at MOL
- Top view of inundated area at FSL
- Transmission / Conveyance Pipeline
- Transmission / Conveyance Pipeline via Tunnel (Optional)
- Proposed Access Road

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCo, INC. (2020)
Source Map: Tractebel (2020)
Modified by: APERCU CONSULTANTS, INC (2020)

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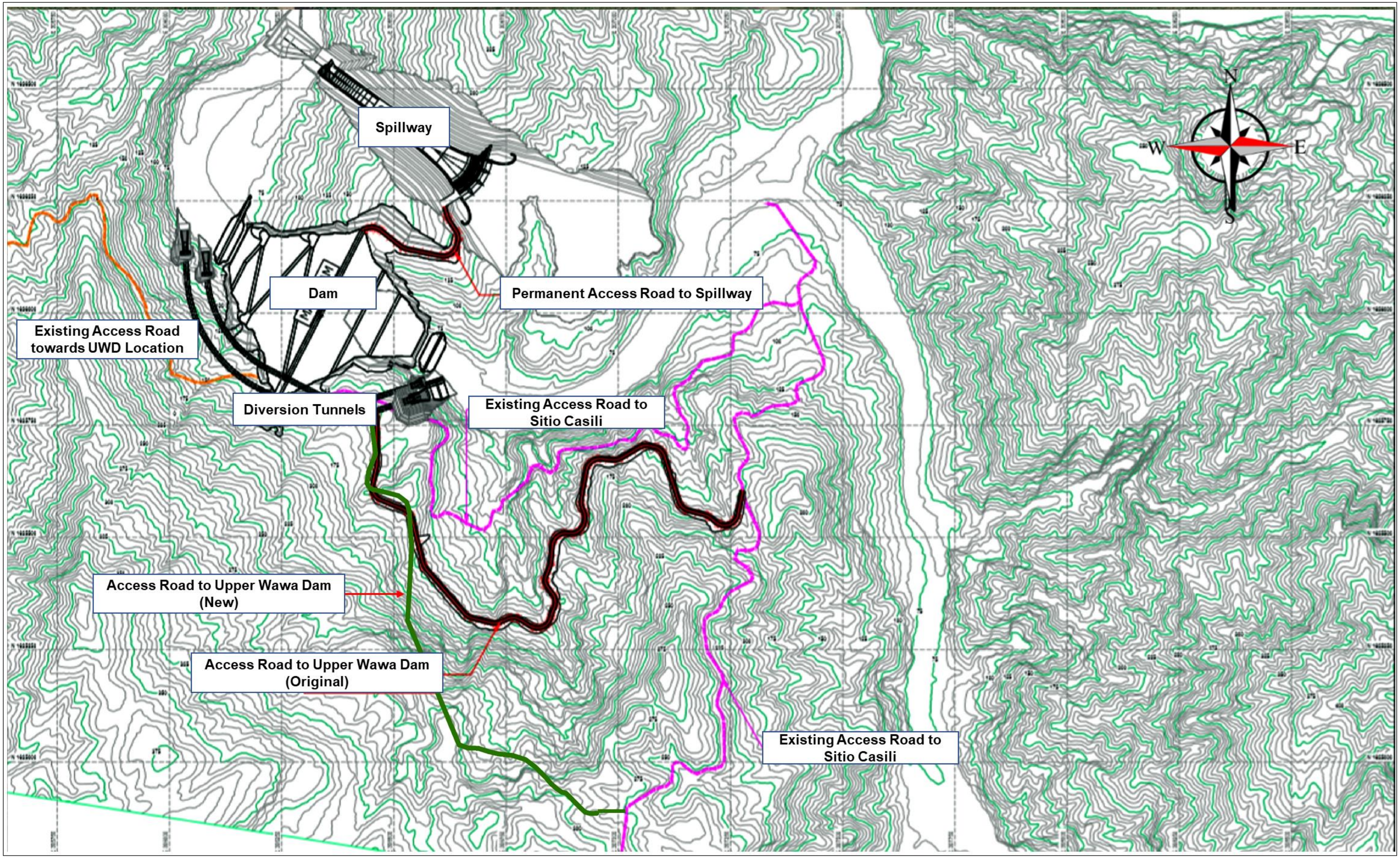

Figure PD-18. Overview of the Upper Wawa Dam, Spillway and Access roads

ENVIRONMENTAL IMPACT STATEMENT
PROJECT DESCRIPTION
Wawa Bulk Water Supply Project – Upper Wawa Dam

LEGEND (as above)
- Dam and Diversion
- Spillway
- Proposed Access Road to Upper Wawa Dam (New)
- Proposed Access Road to Upper Wawa Dam (Original)
- Existing Access Road to Sitio Casili
- Existing Access Road towards UWD Location

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCo, INC. (2020)
Source Map: Tractebel (2020)
Modified by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.
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5.5 Explosive Magazine/Storage

There will be controlled blasting activities to be conducted in the construction area specifically;

- for the surface excavation in the areas of the tunnel portal,
- for tunnel excavation,
- for the dam and pumping station area excavation,
- for the route of transmission pipeline; and
- for quarrying of aggregate rocks for construction materials.

Safety precautions will be implemented before commencing any controlled blasting activities in the project site. A magazine area will be established for controlled blasting materials and will be located away from the work and camp areas. Discussion for the components and controlled blasting activities is seen in **Section 2.0 of the ERA Report**.

5.6 Support Facilities

5.6.1 Temporary Construction - Related Project Components

5.6.1.1 Diversion Tunnel and Cofferdam

To isolate the dam during construction, the river will be guided into two (2) diversion tunnels (8.75m diameter tunnel buried each) by an upstream cofferdam. A downstream cofferdam will also be constructed to protect the dam construction area from back water discharge from the two (2) tunnels.

Cofferdams are temporary concrete or rockfill structures that are used to divert and dry out the river channel and allow construction of the permanent project facilities. The project will require six (6) cofferdams: two (2) main cofferdam in upstream and downstream of the main dam, two (2) cofferdam in upstream and downstream of the main cofferdams (before construction), and two (2) cofferdam for the diversion tunnel.

Overview for the proposed diversion tunnels and cofferdams for the Project is shown in **Figures PD-19** and **PD-20.**

5.6.1.2 Concrete Batching Plants and Crushers

Batching plants supported by crushers will be set up to meet cement requirements during construction. These will all be equipped with suitable dust suppression measures.

The Project will operate the batching plants and crushers for internal consumption only. Quarrying permits will be acquired after the ECC has been granted. Optional locations of the proposed quarries are presented in **Figure PD-21**

5.6.1.3 Worker's Camps and Camp Offices

Work camps/offices will be developed during construction. All workers who are based in the construction site will be accommodated by the construction camps.

The construction of work camps, offices and construction sites will be equipped with adequate temporary sanitary facilities/toilets to avoid potential discharge both of gray and black wastewaters to ground or nearby surface watercourses.

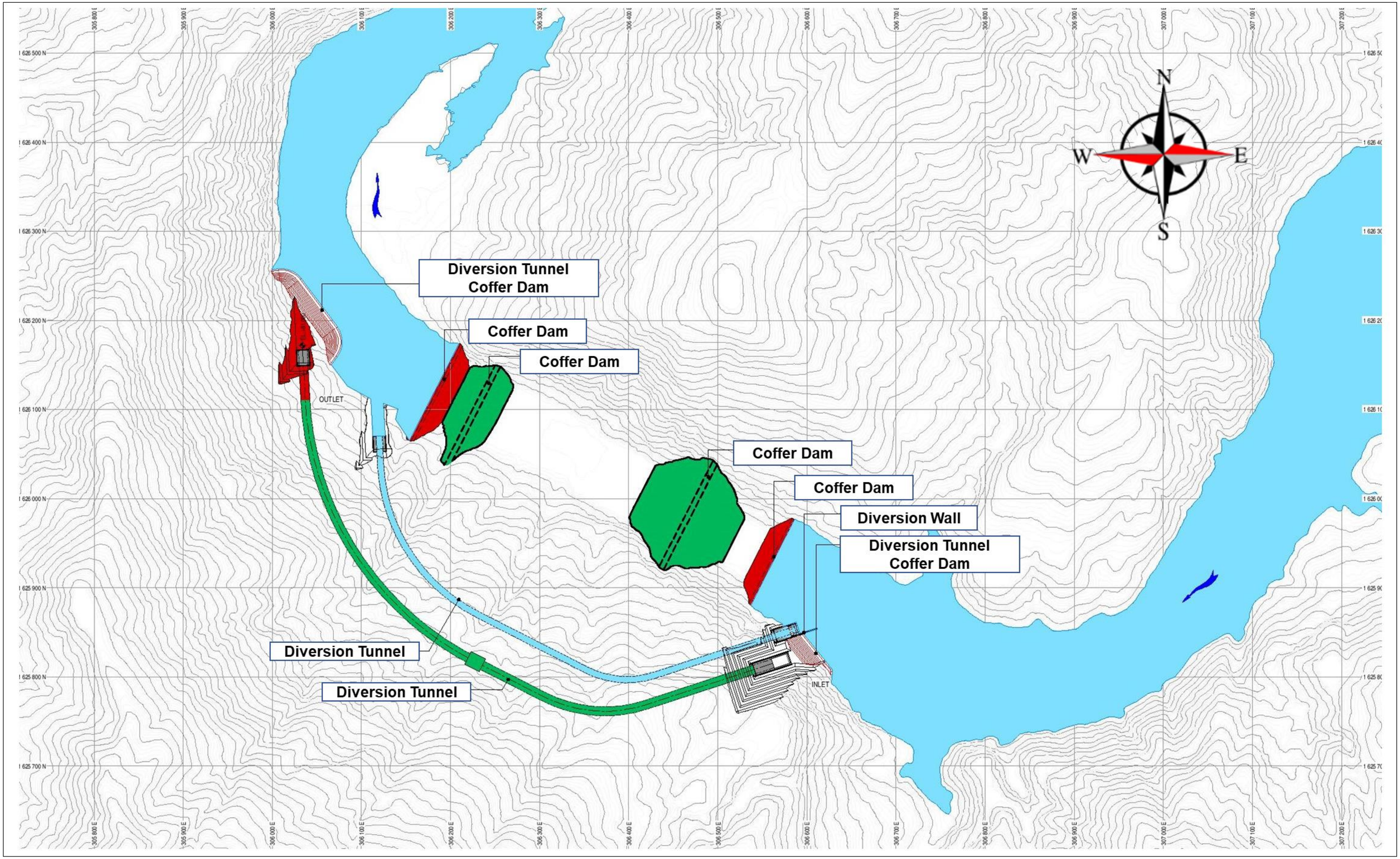

Figure PD-19. Overview of the Diversion Tunnels and Coffer Dams

ENVIRONMENTAL IMPACT STATEMENT
PROJECT DESCRIPTION
Wawa Bulk Water Supply Project – Upper Wawa Dam

Legend:

- UWD Reservoir
- Diversion Tunnel
- Diversion Tunnel
- Coffer Dams
- Coffer Dams

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCo, INC. (2020)
Source Map: Tractebel (2020)
Modified by: APERCU CONSULTANTS, INC (2020)

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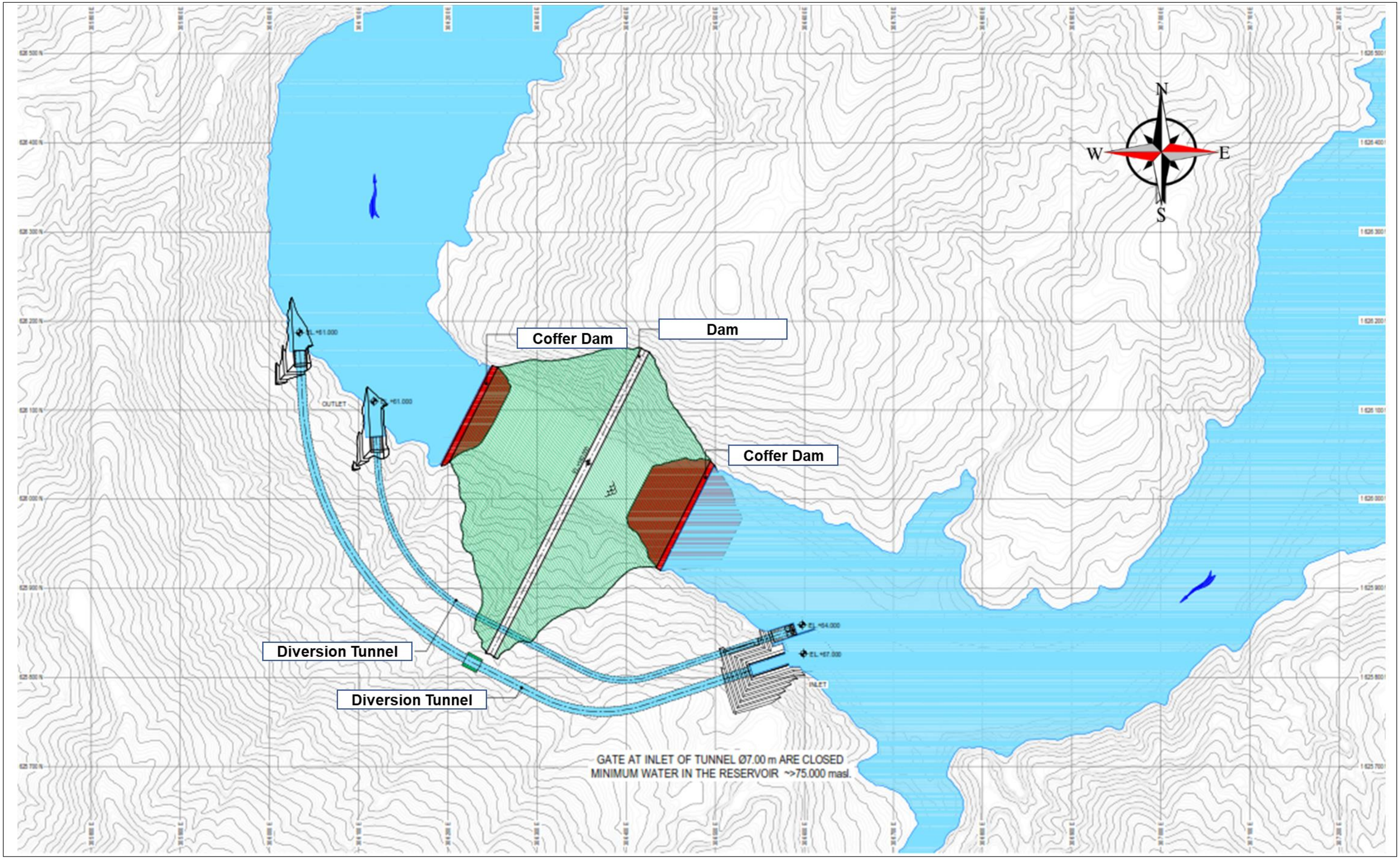

Figure PD-20. Overview of the Diversion Tunnels, Coffer Dams and Main Dam

ENVIRONMENTAL IMPACT STATEMENT
PROJECT DESCRIPTION
Wawa Bulk Water Supply Project – Upper Wawa Dam

Legend:
- Dam
- UWD Reservoir
- Diversion Tunnel
- Diversion Tunnel
- Coffer Dams

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCo, INC. (2020)
Source Map: Tractebel (2020)
Modified by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.
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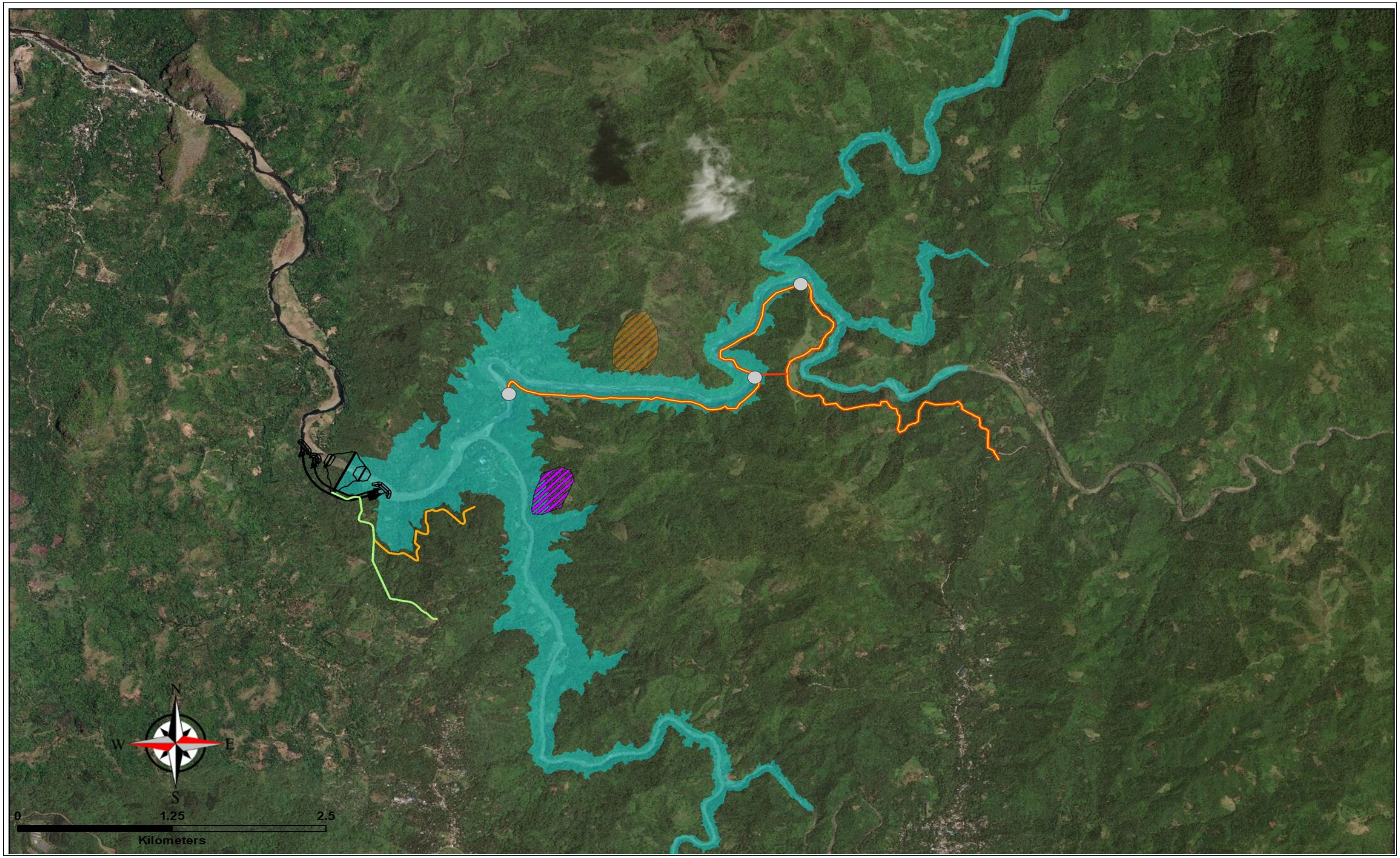

Figure PD-21. Quarry Locations (Optional)

ENVIRONMENTAL IMPACT STATEMENT
PROJECT DESCRIPTION
Wawa Bulk Water Supply Project – Upper Wawa Dam

Legend
- Pump Station
- Transmission Pipeline via Tunnel Optional
- UWD Optional Access Road (New)
- UWD Access Road (Original)
- Access Road to WTP / Transmission Pipe
- UWD Dam and Diversion Tunnel
- Transmission / Water Conveyance Pipeline
- Quarry Option 1
- Quarry Option 2
- UWD Reservoir

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCO, Inc. (2020)
Basemap: Google Earth Pro, 2020
Created by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.

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5.7 Pollution Control Devices

5.7.1 Storm Water Drainage

To prevent the potential release of sediments during construction phase, the proponent will establish suitable construction practices, appropriate drainage and will ensure sufficient staff training, and monitoring of the site and environmental receptors. The proponent will install drainage and mitigation measurements appropriate for the area being worked.

5.7.2 Solid Waste Management Systems

Before the commencement of the construction activities, waste management areas shall be surveyed and inspected by the contractor or its nominated sub-contractor to ensure the quality of the area wherein management of solid waste will be conducted. Employees and transporters working with any of the subject will receive appropriate training prior to actual waste, material handling, processing and stockpiling.

To properly manage the waste materials, waste containers will be installed in project area and will have a signage of "Hazardous Waste" and for "Non-Hazardous Waste" for separation and sorting of waste. Collected waste will be stored in appropriate facilities (e.g. bins, stockpiles, secure compounds), with hazardous waste stored away from streams and rivers in secure areas.

A nominated Contractor Environment Officer will inspect each waste storage facilities and disposal site established in the project site. A Notice to Proceed will be issued to the project if the site or facility is in accordance with the Waste Management Plan and any variations required by the Wawa JVCO manager.

Wawa JVCO will undertake regular collection and disposal of wastes (by contractor or authorized third party) to sites approved by local authorities. Hazardous waste will be disposed of according to appropriate best practices.

Waste segregation will occur at source to the maximum extent possible, separating reusable/recyclable material from non-hazardous waste (packing timber, steel, wire, cables, aluminum, bricks, plaster, roofing material, glass, clay/ sand/ gravel, concrete, insulation material, tiles, fiberglass, cured asphalt, paper, cardboard, plastic, food waste) and hazardous waste (waste oils, oil filters, oily rags, used absorbent, old chemical/paint/fuel/oil drums, batteries, acids, alkalis, welding rods, sewerage sludge, and used tires).

Recycling facilities will be established that will collect all recyclable waste generated by the project (including batteries, tires, glass, paper, scrap metal, aluminum cans and timber) to properly manage the waste materials. Secure lids will be fitted to bins that store food waste to prevent scavenging by birds and animals.

5.7.3 Vehicle and Machinery Area

During the course of construction period, several equipment, machinery and trucks will be operated in the construction site. If the machinery and vehicles have defects or problems, it will require repair in a designated maintenance area that is cemented and equipped with proper drainage and oil absorbing materials. The proponent will establish a cemented area for vehicles and machinery repairs and maintenance activities.

5.7.4 Spoils Disposal Area

A spoils disposal area will be established during the construction phase of project to properly manage the spoils from the excavation activities. Spoils will be re-used by the proponent for the construction of road and for foundation preparation. Surplus soils will be disposed properly to avoid erosion and destabilization of the spoil disposal area, which could lead to sedimentation of water courses and release of chemicals in runoff. Gabions will be installed in the spoil disposal area to prevent erosion.

5.8 General Layout of Facilities

A general layout of the facilities is presented as **Figure PD-17 and Figure PD-22**

6.0 Process / Technology

The Upper Wawa Dam is a water bulk supply project that was designed to convey water from the reservoirs through the pumping stations and conveyance pipeline with a designated delivery point called "Interface Point" near the Calawis Water treatment plant The flow to be conveyed to the Calawis Water Treatment Plant (CWTP) based on the demands is 518 MLD. The pumping stations will have a guaranteed flow capacity of 518 MLD in normal capacity and 259 MLD for additional back-up/standby. Using a vertical turbine, the pump station can deliver the raw water from the reservoir up to the interface point at CWTP through conveyance pipeline. By pumping water from the reservoir, the project will supply raw water on CWTP that will be managed by Manila Water Company located in Barangay Calawis in Antipolo, Rizal for treatment that will be supplied to consumers during periods of peak consumption. The overall process of the Project is shown in (**Figure PD-23**). Maintenance activities at predetermined time intervals will be in place to ensure quality and reliable operation of the equipment in the service environment through planned, periodic inspection and checking of components and systems.

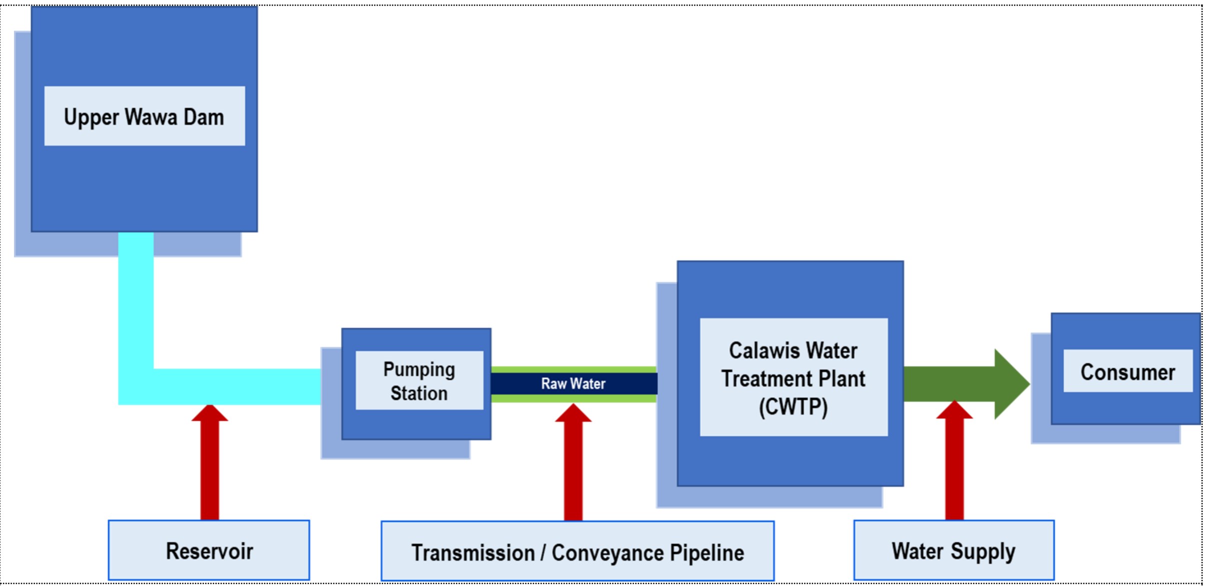
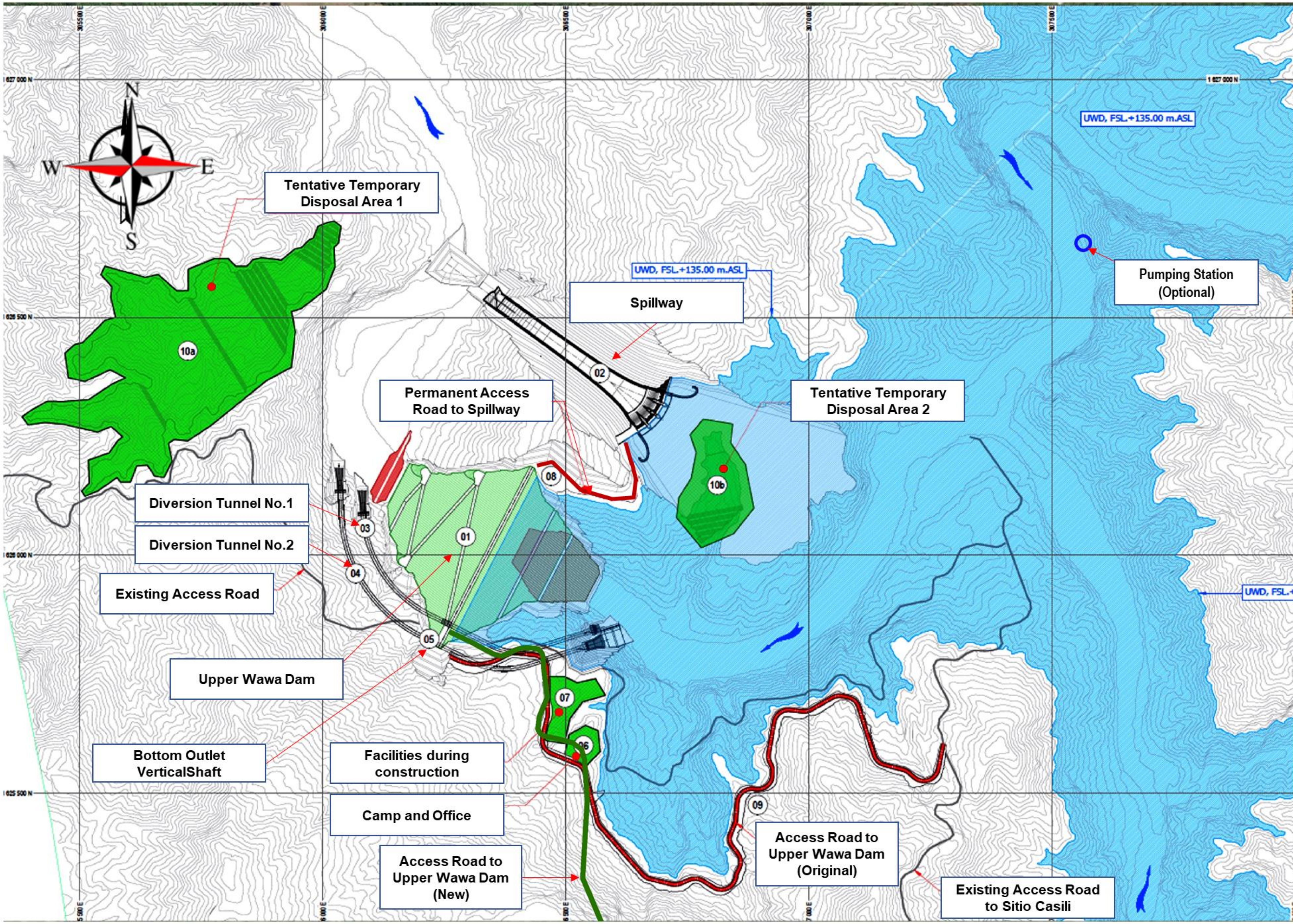


Figure PD-23 – Schematic Diagram of the Upper Wawa Dam Project

The source of electricity for the pumping stations will be supplied by power tapping from grid through a 34kV overhead line. The project will install an overhead line along the road to support the tapping of electricity. A 12 MVA outdoor MV/LV transformer will be installed close to the Pump station to supply power to the pumps and associated equipment. The overhead line will be able to transport the 12 MVA serviced to the pump station, the control building and around area.

For the power consumption of the Project, the electrical power requirements for the Upper Wawa Dam includes but are not limited to the below permanent structures:

- the spillway with four gates equipped with flap gates and one electrical gantry crane,
- the bottom outlet equipped with one service gate and one guard gate
- the complete pumping station with a capacity of 518 MLD from normal operation and an additional backup/standby capacity of 259MLD, with all the required fitting and equipment.
- the permanent facilities, including operator camps needed for the operation and maintenance for each structure of the Project.



ID	ITEM
01	UPPER WAWA MAIN DAM
02	SPILLWAY
03	DIVERSION TUNNEL No. 1
04	DIVERSION TUNNEL No. 2
05	BOTTOM OUTLET VERTICAL SHAFT
06	CAMP AND OFFICE (AREA ~ 4,400 m^2)
07	FACILITIES DURING CONSTRUCTION (AREA ~ 8,800 m^2)
08	PERMANENT ACCESS ROAD TO SPILLWAY
09	PERMANENT ACCESS ROAD TO UPPER WAWA DAM (PROVIDED BY OTHER)
10a	TENTATIVE TEMPORARY DISPOSAL AREA 1 (AREA ~ 158,800 m^2)
10b	TENTATIVE TEMPORARY DISPOSAL AREA 2 (AREA ~ 27,700 m^2)

Figure PD-22. General Layout of Facilities for the UWD Project

Legend:
- Dam
- UWD Reservoir
- Spillway
- Temporary Facilities
- Diversion Tunnels
- Access Road (Original)
- Access Road (New)
- Existing Access Road

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCo, INC. (2020)
Source Map: Tractebel (2020)
Modified by: APERCU CONSULTANTS, INC (2020)

ENVIRONMENTAL IMPACT STATEMENT
PROJECT DESCRIPTION
Wawa Bulk Water Supply Project – Upper Wawa Dam

WawaJVCo INC.
aperçu CONSULTANTS INC.

SCALE: Not to Scale

Table PD-12 presents the preliminary maximum load estimation is for the Project.

Table PD-12
Preliminary Maximum Load Estimation for the Upper Wawa Dam Project

Description	Power P.U. [kW]	Qty /demand factor	Total Power [kW]
UWD Pumping Station			
Main Pumps including VSD losses	1712	4	6849
Valve actuators	4	4	16
Surge vessel compressors	40	1	40
Ancillary equipment at Pumping Station			
SCADA, instrumentation	30	1	30
Overhead Traveling Crane	20	2	40
VAC system	200	1	200
Lift elevator	25	1	25
Lighting system	100	1	100
Socket outlets	100	1	100
UWD Spillway			
3.1 Gates HPU and Control	15	1	15
3.2 Overhead Traveling Crane	25	0.25	6
3.3 Lighting system	20	1	20
3.4 Socket outlets	10	1	10
UWD Bottom Outlet			
Gates HPU and Control	15	1	15
Overhead Traveling Crane	25	0.25	6
Lighting system	10	1	10
Socket outlets	10	1	10
Miscellaneous			
Owner Camp and admin buildings	100	1	100
Miscellaneous Electrical losses			
Transmission line losses	76	1	76
Step down transformers losses	152	1	152
Total (kW)			**7,820**
Total (kVA) at pf 0.9			**8,689**

* Pump power consumption at the pumping station will vary based on the reservoir water level. Above estimation is based on the maximum power consumption at minimum water level in the reservoir

7.0 Project Size[5]

Table PD-13 summarizes the capacities, volumes and dimensions of the major components of the Wawa Bulk Water Supply Project – Upper Wawa Dam or UWD.

Table PD-13
Main Project Components of the Upper Wawa Dam

Component	Description
Dam	• The dam will be built on Earth Core Rockfill Dam (ECRD) or Roller Rockfill Concrete (RCC) structure with FSL at 135.0m ASL • An upstream and downstream cofferdam will be constructed • Two diversion tunnels and associated cofferdams will be built • A permanent access road from the existing Casili Road to the dam crest
Spillway	• A concrete gated spillway and control house will be established in the Project site

[5] All the data presented are provisional and might be updated in the later stages of study and design. The data presented are based on the latest preliminary design and engineering study results for the Project.

Component	Description
	• An access road from dam crest connected to spillway will be constructed
Pumping Station	• A Pumping station with a capacity of 518 MLD with be established with all the required fitting and equipment and needed power supply.
Conveyance Pipeline	• The conveyance pipeline will have an approximate length of 3.474 km and an access road of roughly 3.5 km from the Pumping station to the Calawis Treatment Plant.
Access roads	• Optional location of the access roads is planned on the left bank at elevation 140masl • The total length of access road is approx.1.4km that branches from the existing road upstream of the Upper Wawa dam

The broad salient features of the Project are shown in **Table PD-14.**

Table PD-14
Salient Features for Upper Wawa Dam

1	**Location**	
	River	Wawa
	Dam Axis	121°12'5.20" E, 14°42'4.11" N
2	**DAM**	
	Dam type	Earth Core Rockfill Dam (ECRD) or Roller Rockfill Concrete (RCC) structure
	Spillway type	Gated Ogee weir with open air chute channel
	Energy Dissipation	Ski jump with Deflector with an excavated plunge pool
	Crest Level	EL 140.0 m ASL
	FSL	EL 135.0 m ASL
	MOL	EL 87.0 m ASL
	Maximum water level	EL 135.0 m ASL
	Spillway Design flood	PMF (7,300 m^3/s)
	Inundated Area at Full Supply Level	414.28 Ha
	Inundated Area at Minimum Operating Level	74.33 Ha
	Dam Height (above riverbed)	84 m
	Dam Crest Length	425 m
	Drainage Area	258 km^2
	Number of Bays	4
	Ogee level	121.70 m
	Gate Type	Radial gates with flap gates
	Number of gates	4
	Spillway Check Flood	Probable Maximum Period
	Spillway Design Flood	10,000 years Return Period
3	**Pumping Station**	
	Type	Wet Pit, circular shape, 3 pits
	Pump Type	Vertical Turbine
	Number of Pumps	6 (4 100% operating, 2 stand-by)
	Pump Capacity	1.5m^3/s each, net head ≥100 m
	Operating Levels	
	Maximum operating level	135 masl
	Mean operating level	120 masl
	Minimum operating level	87 masl
	Calawis water level in flocculation tank	164.5 masl
4	**Conveyance Pipeline**	
	From	Pump Station
	To	Calawis WTP (to be developed by MWC)
	Approximate Length	3.474 km
	Type and size of Transmission Pipe	Buried Steel Pipe, Dia. 1800mm

8.0 Development Plan, Description of Project Phases and Corresponding Timeframes

Figure PD-24 shows the development schedule of the Upper Wawa Dam Project.

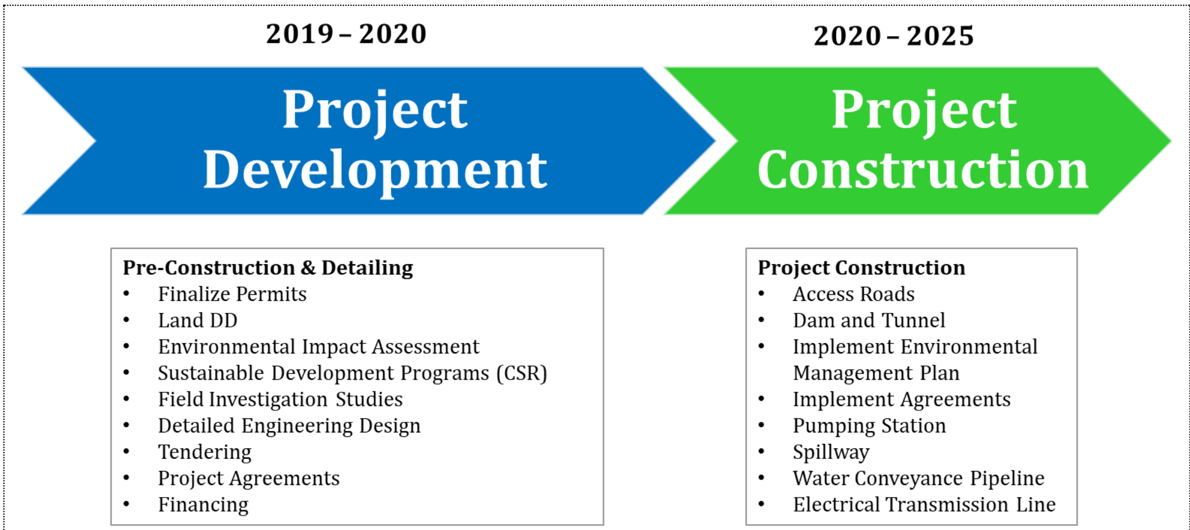


Figure PD-24 – Upper Wawa Dam Development Schedule.

The detailed schedule of project implementation for the construction of the Project is shown in **Table PD-15 and Figure PD-25.** The water delivery of 518MLD is expected on December 31, 2025 with the final construction of UWD Project expected to be completed by December 15, 2025.

Table PD-15
Project Schedule for Upper Wawa Dam

Activities	Schedule
Upper Wawa Dam (UWD)	66 months
Tender	5.5 months
Solicitation / Prequalification	0 month
ER and Tender Documents	0 month
ITB Issuance	0 month
Bid Clarification / Preparation	3.5 months
Bid Submission	0 month
Bid Review / Evaluation / Award	1.5 months
Permanent Access Road to UWD	23 months
Tender	5.5 months
Solicitation / Prequalification	0 month
Engineering Design (PBMD)	3 months
Preliminary Designs	1 month
Final Designs	2 months
ITB Issuance	0 month
Bid Clarification / Preparation	3.5 months
Bid Submission	0 month
Bid Review / Evaluation / Award	1.5 months
Construction Period	67.5 months
Diversion System	23 months
Pre-Construction Stage	6.5 months
Cofferdams	7 months
Construction of Main Dam	56.5 months
Construction of Spillway	55.5 months

CODE	TASK DESCRIPTION	START	FINISH
	PACKAGE B: UPPER WAWA DAM (UWD)	**1-Jan-20**	**30-Jun-25**
2	**Upper Wawa Dam (UWD)**	1-Jan-20	30-Jun-25
2.1	Tender	23-Jan-20	30-Jun-20
2.1.1	Solicitation / Prequalification	23-Jan-20	31-Jan-20
2.1.2	ER and Tenders Documents	29-Feb-20	29-Feb-20
2.1.3	ITB issuance	3-Feb-20	3-Feb-20
2.1.4	Bid Clarification / Preparation	4-Feb-20	18-May-20
2.1.5	Bid Submission	19-May-20	19-May-20
2.1.6	Bid Review / Evaluation / Award	20-May-20	30-Jun-20
3	**Permanent Access Road to UWD**	1-Jan-20	30-Nov-21
3.1	Tender	23-Jan-20	30-Jun-20
3.1.1	Solicitation / Prequalification	23-Jan-20	31-Jan-20
3.1.2	Engineering Design (PBMD)	5-Dec-19	2-Apr-20
	Preliminary Design	19-Dec-19	31-Jan-20
	Final Design	3-Feb-20	2-Apr-20
3.1.3	ITB issuance	3-Feb-20	3-Feb-20
3.1.4	Bid Clarification / Preparation	4-Feb-20	18-May-20
3.1.5	Bid Submission	19-May-20	19-May-20
3.1.6	Bid Review / Evaluation / Award	20-May-20	30-Jun-20
4	**Construction Period**	1-Jun-20	15-Dec-25
4.1	Diversion System	1-Feb-20	31-Dec-21
4.2	Pre-Construction Stage	19-Sep-20	31-Mar-21
4.3	Cofferdams	8-Nov-20	15-May-21
4.4	Construction of Main Dam	1-May-21	15-Dec-25
4.5	Construction of Spillway	1-Nov-20	31-May-25

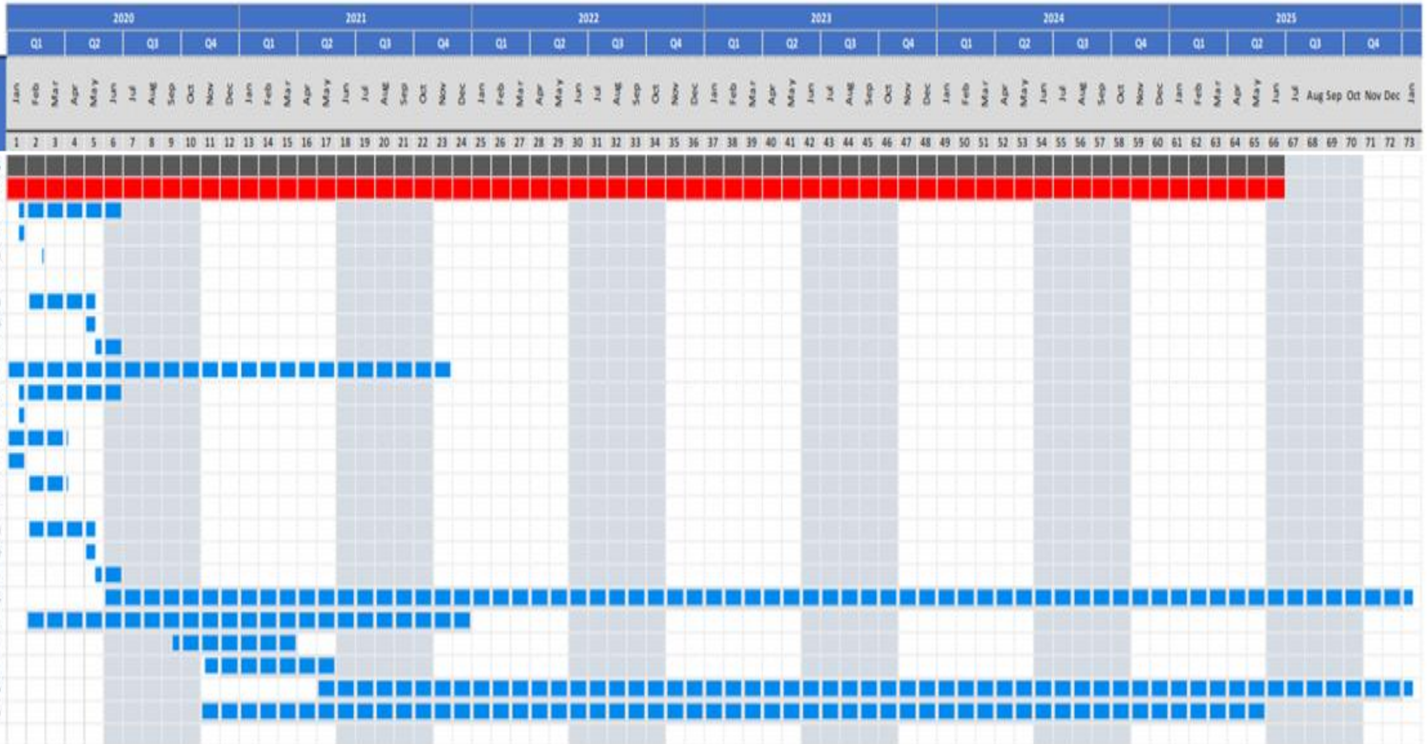


Figure PD-25 – Project Implementation Schedule for Upper Wawa Dam.

8.1 Pre-Construction

For the pre-construction of the project, activities to be conducted on this phase are estimated to take approximately one year. During this time, preparatory activities for the construction phase will be included.

1. Land Acquisition – The proponent will acquire the land wherein the following project components will be established: Dam and Spillway Area, Pumping Station Area, Route of Transmission Pipeline, Diversion Tunnels (2 units) Area, Access Roads, Quarry Areas 1 and 2, Contractors and Engineers' Office, Batching Plant Area, Crush and Screening Plant Area, Powder. Magazine Area, Mechanical Workshop Areas, Disposal Area, Wastewater Treatment Plant Areas, Store and Associated Storage Areas, Parking Area, Truck, Equipment Washing Area and Electrical Transmission Line.
2. Preliminary Engineering Studies – Below items are the preliminary engineering studies being undertaken by the proponent for the project:
   - Geological Mapping
   - Topographic Surveys
   - Site Geotechnical Drilling
   - Ground Penetration Radar (GPR) Surveys
   - Cadastral Surveys
   - Resistivity Profiles
   - Seismic Surveys

The site geotechnical clearing activities in the locations of the proposed dam locations dam, spillway, tunnel, quarry and pumping station sites is completed on June 2020. **Figure PD-26** presents the locations of the boreholes within the project site.

3. Other activities such as obtaining the following permits and documents (but not limited to):
   - Water Permit – On December 5, 2019, the proponent was granted water rights for the Wawa River System by the NWRB, under the PD 424 and 1067 (**Annex A-3)**. The permit was previously owned by the San Lorenzo Ruiz Builders (SLRB) under the Application No. 18964 and was for 300MLD (**Annex A-4)** and this was increased to over 1,000 MLD by NWRB last June 18, 2020 (**Annex A-5**). An offtake agreement was established between the proponent and the SLRB prior to the transfer of water rights (**Annex A-1**).
   - FPIC Clearance – The proponent will secure the Free Prior Informed Consent from NCIP.
   - Tree Cutting Permit – The proponent will secure the tree cutting permits for the construction of project components (i.e. Dam, spillway, access road, etc.). The Tree Cutting Permit Area is shown in **Annex M**.
   - LGU endorsement and other local permits for the Upper Wawa Dam Project.

8.2 Construction Phase

The construction phase of the dam will take approximately 5 years.

8.2.1 Mobilization of construction equipment and materials

This part of construction phase will involve mobilization of construction equipment and materials, such as cement, fuel, construction materials, construction waste, equipment and machinery materials along the roads to the dam site and within construction area. Setting up of camp sites and temporary facilities, laydown area, disposal area and batching plant will be established for the use of construction.

8.2.2 Diversion of Water around Cofferdams

Before the construction of main project components, construction of diversion tunnels will be constructed to divert the water from the river. Cofferdams will also be constructed to prevent water discharges in the dam construction area. This scheme is planned to be developed during the dry season to let the maximum dry season flood to pass through it. During this activities, temporary fluctuations in the flow regime of the river are expected, as well release of sediments from the construction of the cofferdams.

8.2.3 Excavation and Earth Moving Activities

Excess materials during the construction of the project are expected to generate from the excavation that will require disposal. This cut materials will come from the excavation of the roads and platforms, the excavations in the dam and spillway area and the tunneling works. The major contributors of spoil will be:

- Removal of unsuitable foundation material at excavations (i.e. dams and platform).
- The requirement for roads to be mainly constructed in cut due to the steepness of the site terrain, which otherwise would result in impractically long fill batters.

8.2.4 Quarrying

The project intends to open quarry areas as source of aggregate rocks for concrete for the construction of the project components and road surface materials. Quarrying activities such as removing overburden, including topsoil that will be stocked pile for later use, controlled blasting, rock crushing and sorting will be conducted. Potential impacts on people and wildlife arise from noise and vibration from hammers, controlled blasting and dust. There is also a risk of release of sediment and chemicals into warehouse from washing activities.

8.2.5 Construction of Main Structures

The construction of the following main structures will take place during this phase. Descriptions of the structures are further discussed in **Section 5.0 of the report**.

Dam – Construction of the Earth Core Rockfill Dam (ECRD) or Roller Compacted Concrete (RCC) structure will involve excavation of rocks, filling, drilling and controlled blasting, hauling, disposal, form works, rebar works, concreting, electrical activities.

Spillway – Construction of the spillway will involve excavation of rocks, filling, drilling and controlled blasting, hauling, disposal, form works, rebar works, concreting, electrical activities.

Pumping Station - – Construction of the pumping station will involve excavation, filling, drilling and controlled blasting, disposal, form works, rebar works, concreting, pump installation, electrical activities.

Transmission / Conveyance Pipeline - Construction of the Transmission / Conveyance Pipeline will involve excavation, filling, drilling and controlled blasting, hauling, disposal, concreting, bituminous surfacing.

Diversion Tunnels – Construction of diversion tunnels will involve drilling, controlled blasting, hauling and disposal.

Access Roads – Construction of access roads to dam and spillway will involve drilling, hauling and disposal.

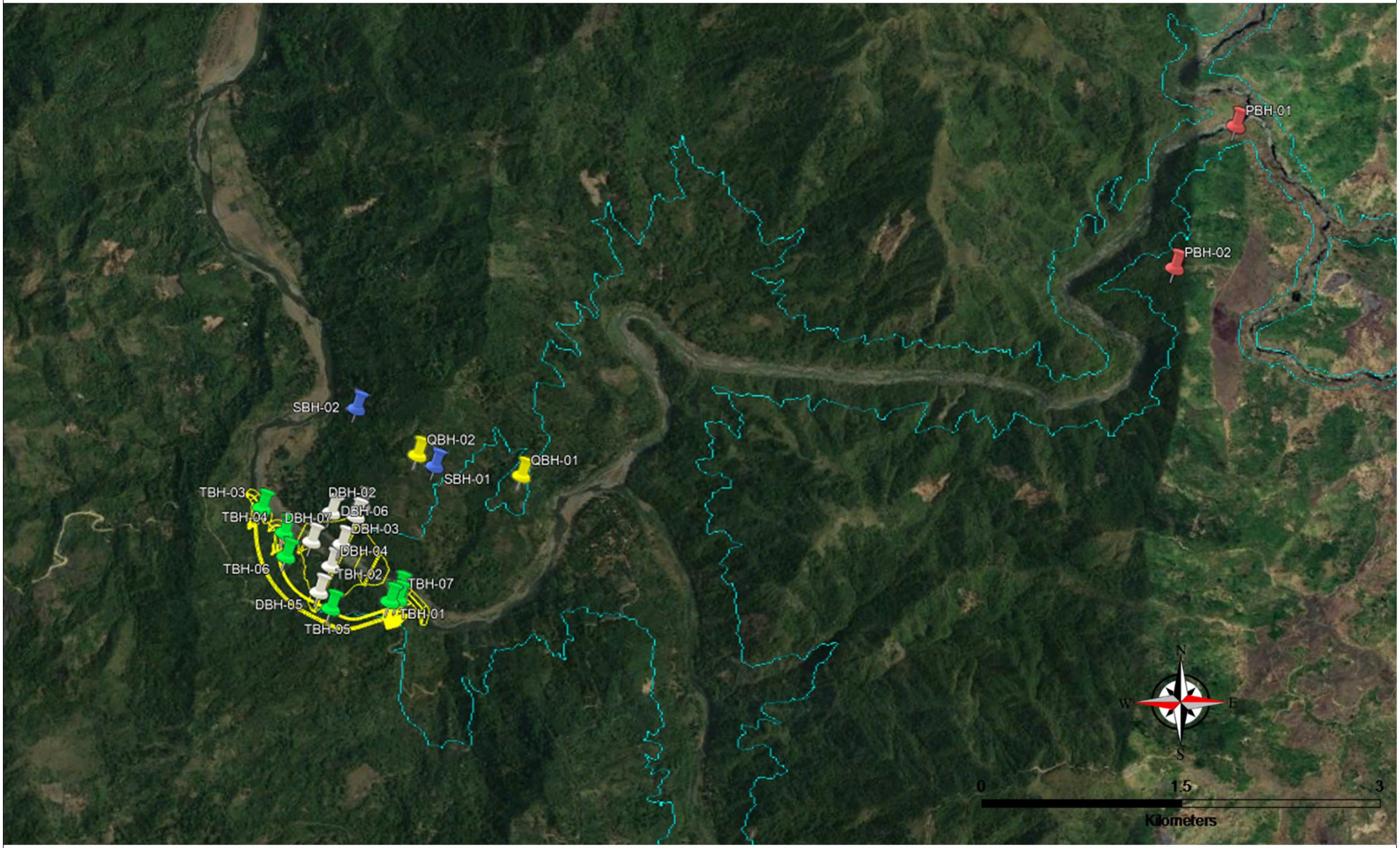


Figure PD-26. Borehole Locations

ENVIRONMENTAL IMPACT STATEMENT
PROJECT DESCRIPTION
Wawa Bulk Water Supply Project – Upper Wawa Dam

Legend:
- Dam Boreholes
- Spillway Boreholes
- Tunnel Boreholes
- Pump Station Boreholes
- Quarry Area Boreholes

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCO, Inc. (2020)
Basemap: Google Earth Pro (2020)
Created by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.

aperçu CONSULTANTS INC.

SCALE: 10,000

8.2.6 Decommissioning of Construction Facilities

After the construction of the project, the construction facilities, quarries, stores, equipment and machinery, and worker camps used on the construction will be safely removed and the waste and chemicals produced will be disposed properly. All disturbed area will be rehabilitated and re-vegetate to maintain the environmental aspects of the area.

8.3 Operation Phase

During the operation, the dam will impound a reservoir that will have a Full Supply Level of 135masl with minimum operating level of 87masl. At Full Supply Level, the reservoir will have a surface area of approximately 414.28 hectares extending 8.2km upstream capable of storing 120.1MCM of water. At minimum operating level, the reservoir will have a surface area of 74.33 hectares with as total storage volume of 7.2MCM. The required environmental flow will be release downstream of the dam during regular operation to ensure the ecological sustainability downstream of the Upper Wawa Dam.

In case of emergency scenarios such as flooding, the dam will be needing to release water downstream. The spillways gates will be operated during flooding in accordance with the operational rules, to minimize the impacts. Before operating the spillway gates, the people/residents living on the downstream area will be informed on the expected water level increase in accordance with the spillway gates operation rules and emergency action plan.

On maintenance of main project components such as dam, spillway, pumping station, transmission pipeline and other facilities and structures, regular inspection will be held to ensure the quality of operation and reliability of each equipment. Checking-up of the equipment will be held daily, weekly, monthly and quarterly as per the maintenance schedules.

8.3.1 Upper Wawa Dam Land Use Plans

During the operation phase of the project, land uses in the area is expected to change from a terrestrial ecosystem into an aquatic ecosystem. From here, WawaJVCo will develop and implement a land use and watershed management plan to mitigate the impacts on land such as loss of grassland and shrubland that can lead to erosion and sediment buildup at the base of the reservoir. This plan will be part of the Catchment Area Treatment Plan (CAT) that will be implemented by proponent.

WawaJVCo will be developing a Comprehensive Development and Management Plan (CDMP) in coordination with the DENR to apply for the Integrated Forest Management Agreement (IFMA) that will give rights to develop, manage, protect and utilize a specified area of forestland and forest resource in the project area. A Special Use Agreement within Protected Areas (SAPA) and a PAMB Clearance will also be applied by WawaJVCo to Protected Area and Management Bureau (PAMB) after the ECC issuance since the location of project facilities are located with the protected area. Application of the Project proponent is shown in **Annex A-6**.

In the **Section 1.1.3.2 of Land Module Report,** the map of the land uses in the watershed of Upper Marikina River Basin or Upper Marikina River Watershed around the vicinity of the project site was presented.

8.3.2 Emergency Action Plan

The Emergency Action Plan (EAP) and its process for the Upper Wawa Dam Project in case of emergency scenarios are presented in the **Section 2.0 of VII. Emergency Response Guidelines Report**. This plan identifies who is to be notified of a dam safety incident, by whom, and in what order. The flowchart is required to have a valid information for the timely notification of those responsible for taking emergency actions.

8.4 Decommissioning/Abandonment/Rehabilitation Phase

The project will not have a decommissioning/abandonment/rehabilitation phase. After the concession period of the project, the facilities of the project will be in possession of the government to maintain the supply in water to its consumers.

9.0 Manpower

WawaJVCo will prioritize qualified residents from Barangay Calawis, Barangay San Rafael, Barangay Pintong Bukawe, Antipolo City, Municipality of Rodriguez and Municipality of San Mateo. The anticipated manpower requirement for the project will be as follows.

Table PD-16
Manpower Requirements

Development Phases	Manpower Requirement	Details
Pre-construction	100	The UWD Project will hire at least fifty percent (50%) of the unskilled and thirty percent (30%) of the skilled labor requirements from the residents in the province, city and municipality
Construction	1000	
Operation	40	Lumped with Maintenance team
Maintenance	40	Lumped with Operations team

The estimated manpower requirements during the construction phase will be approximately 1,000 personnel, while about 40 personnel will be required during the operation phase. These are provisional estimates of the manpower requirements for the Project that include Wawa JVCo personnel as well as engineering supervision and contractor management staff. Worker numbers do not include security personnel, administration and ancillary staff. Staff numbers are expected to reach a peak in the middle of the construction schedule when all work fronts will be in peak production.

10.0 Project Cost

The estimated total capital cost of the project is 14 billion PHP.

II. BASELINE KEY ENVIRONMENTAL IMPACTS

1.0 Land

This section covers the description of the existing environment, assessment of potential impacts and proposed mitigation measures for the following land-related environmental aspects:

- Land Use (**Section 1.1**);
- Geology (**Section 1.2**);
- Pedology/Soils (**Section 1.3**); and
- Terrestrial Ecology (**Section 1.4**)

1.1 Land Use

The proposed Wawa Bulk Water Supply Project (Upper Wawa Dam (UWD) Component) is located in Antipolo City and the municipalities of San Mateo and Rodriguez in Rizal Province. Rizal is a first-class province and is one of five provinces comprising Region IV-A or the CALABARZON Region. The province has a total land area of 130,892 hectares or 1,308.92km^2, comprising about 8% of the total land area of the region. It is bounded by the province of Bulacan on the north, Quezon Province on the east, Laguna Province on the southeast, Laguna de Bay on the south and Metro Manila on the west. Rizal province is characterized by a combination of valleys and mountains with flat low-lying areas on the western portion and rugged ridges and rolling hills on the east forming part of the Sierra Madre Mountain Range. It is politically subdivided into 13 municipalities, one city, four congressional districts (two for the province and two for Antipolo City) and a total of 188 barangays. Of the total land area of Rizal, 63,889 hectares (48.81%) are classified as alienable and disposable land while the remaining 67,003 hectares (51.19%) are classified as forestland. The land area and land classification in Rizal Province is presented in **Table EL-1**.

Table EL-1
Land area and classification in Rizal Province

Land Classification	Land Area (hectares)	Percent (%)
Certified A and D	63,889	48.81
Total Forestland	67,003	51.19
Classified Forestland	67,003	51.19
Established Forest Reserves	22,582	17.25
Established Timberland	43,857	33.51
Military and Naval Reservations	564	0.43
Total Land Area	**130,892**	**100.00**

Rizal is generally an agricultural province with its agricultural potential largely untapped and large land areas still undeveloped for agricultural use. Fishing is one of the major economic activities in the province with the Laguna de Bay as the primary source of freshwater fish species. Mining of non-metallic minerals is also practiced, specifically for guano, rock aggregates, sand and gravel, limestone, clay and other construction materials. Protected areas in Rizal Province are listed in **Table EL-2** while the land use map of Rizal Province is shown in **Figure EL-1**. It may be gleaned from the map that a large portion of the provincial land area is occupied by forestland (protected area) on the east. Agricultural and built up areas occupy the low-lying areas on the western side. **Figure EL-7** shows the location of protected and watershed areas in Region IV-A.

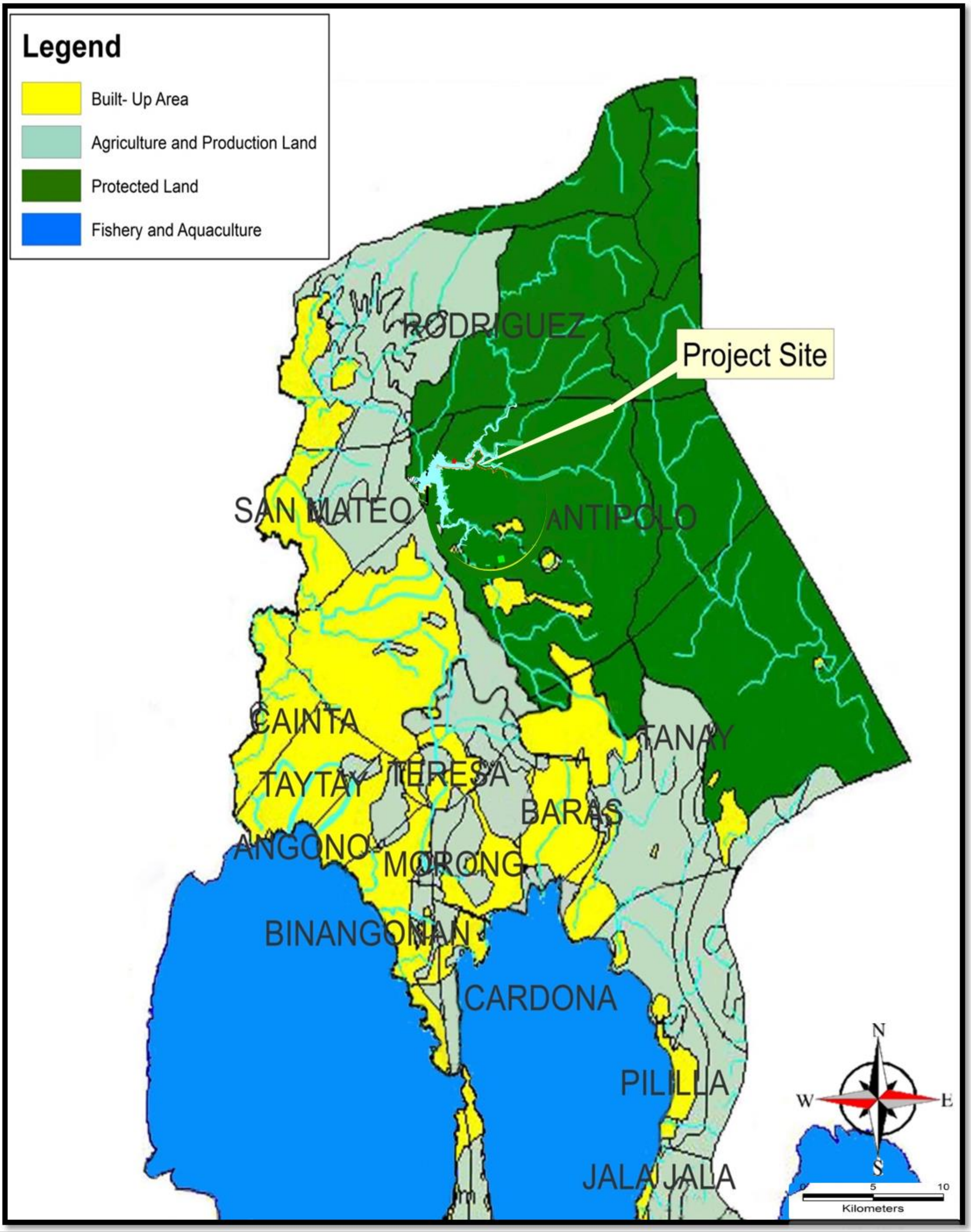


Figure EL-1. Existing land use map of Rizal Province	Legend Pump Station Transmission Pipeline via Tunnel Optional UWD Optional Access Road (New) UWD Access Road (Original) Access Road to WTP / Transmission Pipe UWD Dam and Diversion Tunnel Transmission / Water Conveyance Pipeline UWD Reservoir	DATA INFORMATION/SOURCE: Source Map: Rizal LGU, 2015 Modified by: Apercu Consultants Inc.	WawaJVCo INC. apercu CONSULTANTS INC.	
ENVIRONMENTAL IMPACT STATEMENT LAND MODULE Wawa Bulk Water Supply Project – Upper Wawa Dam			SCALE: As above	PAGE 64

Table EL-2
List of protected areas in Rizal Province

Protected Area	Location	Land Area (hectares)
Hinulugang Taktak Protected Landscape	Antipolo City	3.20
Pamitinan Protected Landscape	Rodriguez	608.00
Kaliwa Watershed	Tanay, Rizal General Nakar, Quezon	27,608.00
Upper Marikina River Basin Protected Landscape	Rizal Province (Antipolo, Baras, Rodriguez, San Mateo and Tanay)	26,125.00

1.1.1 Existing Land Use Classification

The proposed project is located in Antipolo City and the municipalities of San Mateo and Rodriguez. Land uses in these local government units (LGUs) are classified into built up, agricultural, forest, and miscellaneous land uses. Forested areas include protection and production forests, integrated social forestry areas and wooded grassland. Built up areas include those occupied by residential, commercial, institutional and industrial land uses as well as planned unit developments (PUD). Agricultural areas include land planted to various agricultural products (rice, corn, fruits, vegetables, root crops, etc.), agricultural areas and Strategic Agriculture and Fisheries Development Zones (SAFDZ). Miscellaneous land uses include mining and quarry areas, parks and recreational areas, tourism areas, cemeteries, and sanitary landfill.

Table EL-3 presents a tabulation of the land uses within the three host LGUs. The largest built up area is located in Antipolo City while the largest forestland and agricultural areas are located in Rodriguez. Descriptions of land uses in the host city/municipalities are presented in succeeding sections.

Table EL-3
Land Uses in the Host Municipalities/Cities

Land Use Category	Antipolo		Rodriguez		San Mateo	
Source of data	CLUP 2010-2020		CLUP 2012-2022		CLUP 2010-2020	
Land Uses	**Land Area (has)**	**Percent**	**Land Area (has)**	**Percent**	**Land Area (has)**	**Percent**
Built-up areas	*8,597.38**	*22.33*	*1,862. 76**	*5.54*	*3,201**	*60.49*
Residential	7,467.55		1,696.07		1,705	
Socialized housing	381.00		NDP		NDP	
Commercial	298.16		66.59		38	
Institutional	129.81		36.97		7	
Industrial	242.86		38.04		1,451	
PUD	78.00		NDP		NDP	
Major roads	NDP		22.40		NDP	
Agricultural	*2,006.72**	*5.21*	*3,381.34**	*9.31*	*525*	*9.92*
Agro-industrial	172.14		45.81		NDP	
Agricultural	926.58		399.02		NDP	
Agricultural- CARP	908.00		1,432.37		NDP	
SAFDZ	NDP		1,549.96		NDP	
Forest Areas	*26,679.88**	*69.29*	*27,243.87**	*75.04*	*1,456*	*27.51*
Protection forest	18,408.05		NDP		NDP	
Production forest	2,289.46		NDP		NDP	
ISF	5,982.37		NDP		NDP	
Wooded grassland	NDP		NDP		NDP	
Miscellaneous land uses	*1,220.46**	*3.17*	*1,033.71**	*3.08*	*110**	*2.08*
Mining/Quarry	652.17		304.13		30	
Parks and recreation	114.97		n/a		13	
Tourism	16.31		606.49		26	
Cemetery	28.01		17.95		15	

Land Use Category	Antipolo		Rodriguez		San Mateo	
Sanitary landfill	10.00		33.02		NDP	
Water Zone	399.00		72.12		NDP	
Special Use	NDP		NDP		2	
Buffer	NDP		NDP		24	
Total	**38,504.44**	**100.00**	**36,307.31**	**100.00**	**5,292**	**100.00**

1.1.1.1 Antipolo City

Antipolo City has a total land area of 38,504.44 hectares and has the second largest land area in Rizal next to the municipality of Rodriguez. Its land area is almost 30% of the provincial land area. Antipolo consists of 16 barangays. The largest barangays in terms of land area are San Jose, Calawis and San Juan. The land area distribution by barangay is presented in **Table EL-4**.

As shown on **Table EL-3**, a total of 69.29% (26,679.88 hectares) of the city's land area is occupied by forests while built up areas occupy 22.33% (8,597.38) of the city's land area. Agricultural land makes up 5.21% (2,006.72 hectares) while miscellaneous land uses make up 3.17% (1,220.46 hectares) of the city's land area.

Table EL-4
Land Area Distribution per Barangay of Antipolo City, Rizal

Barangay	Land Area (hectares)	Percent (%)
1. San Jose	13,778.77	35.78
2. Calawis	5,581.12	14.49
3. San Juan	3,326.69	8.64
4. Cupang	568.23	1.48
5. Inarawan	959.90	2.49
6. Sta. Cruz	725.52	1.88
7. San Roque	723.25	1.88
8. De la Paz	597.99	1.55
9. Mayamot	540.74	1.40
10. San Luis	502.99	1.31
11. San Isidro	479.70	1.25
12. Muntindilaw	473.11	1.23
13. Dalig	406.48	1.06
14. Mambugan	368.21	0.96
15. Bagong Nayon	301.34	0.78
16. Beverly Hills	28.76	0.07
17. San Jose (Baras side)	4,387.48	11.39
18. San Jose (San Mateo side)	1,481.66	3.85
19. Calawis	2,935.34	7.62
20. De La Paz	196.54	0.51
21. Mambugan	70.34	0.18
22. Cupang	70.28	0.18
Total	**38,504.44**	**100.00**

Note: Nos. 17-22 are currently outside the political jurisdiction of Antipolo but historically belonged to the city (CPDO).

A large portion of the Upper Marikina River Protected Landscape is located within Antipolo City. Of the total forested area in Antipolo, 47.81% or 18,408.05 hectares are protection forests while 8.58% (2,289.46 hectares) are production forests. Integrated Social Forestry (ISF) areas occupy 22.42% of the total forested areas of Antipolo. Being a highly built up area, agricultural areas occupy a small portion of the city's land area. Most of the former agricultural areas in Antipolo have been converted to other uses such as residential and commercial. Mining activities are limited to 652.17 hectares although data from the Mines and Geosciences Bureau indicates that 1,484.52 hectares have been awarded to 14 different contractors for commercial extraction of rock aggregates and other raw materials for construction in various parts of the city.

The existing land use map of Antipolo is shown on **Figure EL-2**.

1.1.1.2 Municipality of Rodriguez

Rodriguez is formerly known as Montalban and is the largest municipality in terms of land area in the Province of Rizal. Rodriguez is a first-class municipality that is located on the slopes of the Sierra Madre Mountain Range. The Montalban Gorge is located in Rodriguez and is widely known as the location of the Legend of Bernardo Carpio. The gorge forms part of the Pamitinan Protected Landscape.

Rodriguez has a total land area of 36,307.31 hectares or 363.07 km^2 (Rodriguez CLUP, 2012-2022). The municipality is politically subdivided into 11 barangays, eight of which are urban while three are rural. A total of 81.17% of the municipal land area is occupied by forests while built up areas, agricultural areas and miscellaneous land uses occupy 5.54%, 10.21% and 3.08% of the municipal land area, respectively.

The land use map of Rodriguez is shown on **Figure EL-3** while the urban land use distribution per barangay is presented in **Table EL-5**.

Table EL-5
Urban land use distribution per barangay of Rodriguez, Rizal

Barangay	Commercial	Industrial	Institutional	Major Roads	Residential	Total
Balite	3.560	-	3.461	0.839	14.568	22.43
Burgos	8.844	1.606	6.484	1.327	185.715	203.96
Geronimo	1.023	-	1.236	0.361	25.651	28.27
MAcabud	-	-	-	0.651	113.727	114.36
Manggahan	9.769	2.618	1.922	1.840	68.708	84.86
Mascap	-	-	-	-	48.583	48.58
Rosario	2.831	-	-	-	19.033	21.86
Puray	-	-	-	-	26.295	26.30
San Isidro	8.570	6.749	2.393	1.604	661.798	681.11
San Jose	23.516	24.711	22.412	11.135	377.582	459.36
San Rafael	8.476	2.359	1.758	4.639	154.411	171.64
Total	**66.600**	**38.040**	**39.670**	**22.400**	**1,696.07**	**1,862.76**

1.1.1.3 Municipality of San Mateo

San Mateo occupies a total land area of 4,825.10 hectares according to the 1976 cadastral map (CLUP 2010-2020) while the municipal website states that the municipality has a total land area of 7,556.47 hectares. For purposes of this characterization, the municipal land area given in the CLUP will be used. However, the breakdown of existing land uses in the municipality brings the total land area to 5,292 hectares (**Table EL-6**). San Mateo is subdivided into 15 barangays. Land area distribution per barangay is shown below. The land use map of San Mateo is shown in **Figure EL-4**.

Land uses in the municipality are classified into agricultural, commercial, industrial, residential, utilities zone, protected open spaces and institutional. Agricultural areas in San Mateo are located in Barangay Dulong Bayan where farming and animal raising are done. Commercial zones are located along major roads and found in Barangays Sta. Ana, Ampid I and II, Banaba, Gulod Malaya, Sto. Niño, Guitnang Bayan and portions of Dulong Bayan and Guinayang. Industrial areas are located on the western part of the municipality particularly in the upper portion of Barangay Guinayang and in small areas of Barangays Sta. Ana, Dulong Bayan and Malanday. Residential areas are located in the barangay centers mostly located on the western side of the municipality. Expansion of residential and commercial areas is expected to have occurred given the natural increase in population in the municipality.

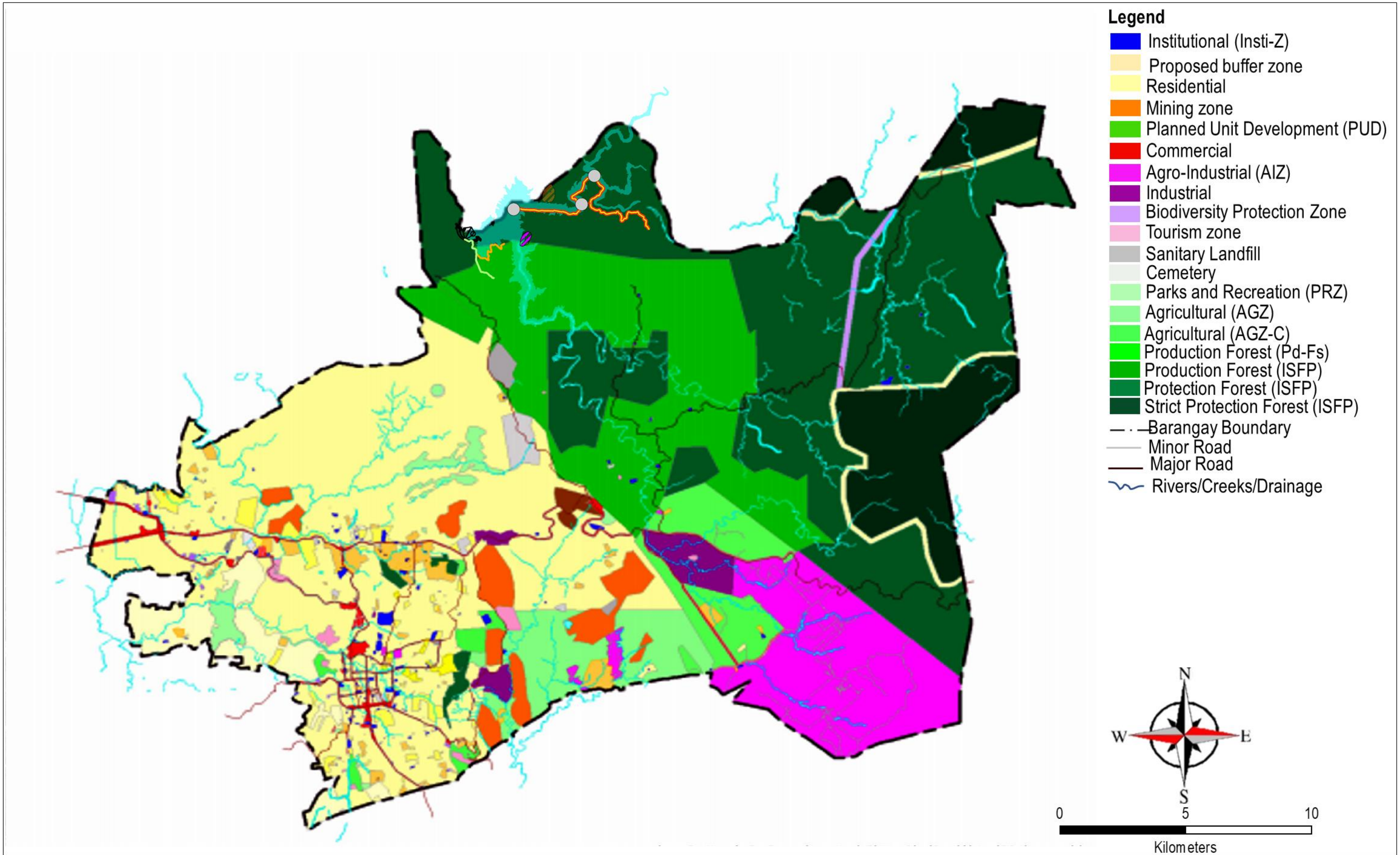


Figure EL-2. Existing land use map of Antipolo City, Rizal

Legend
- Pump Station
- Transmission Pipeline via Tunnel Optional
- UWD Optional Access Road (New)
- UWD Access Road (Original)
- Access Road to WTP / Transmission Pipe
- UWD Dam and Diversion Tunnel
- Transmission / Water Conveyance Pipeline
- UWD Reservoir
- Quarry Option 1
- Quarry Option 2

ENVIRONMENTAL IMPACT STATEMENT
LAND MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

DATA INFORMATION/SOURCE:

Source Map: Antipolo City, Rizal; CLUP (2010-2020)
Modified by: APERCU CONSULTANTS, INC (2020

WawaJVCo INC.

aperçu CONSULTANTS INC.

SCALE: 1:125,000

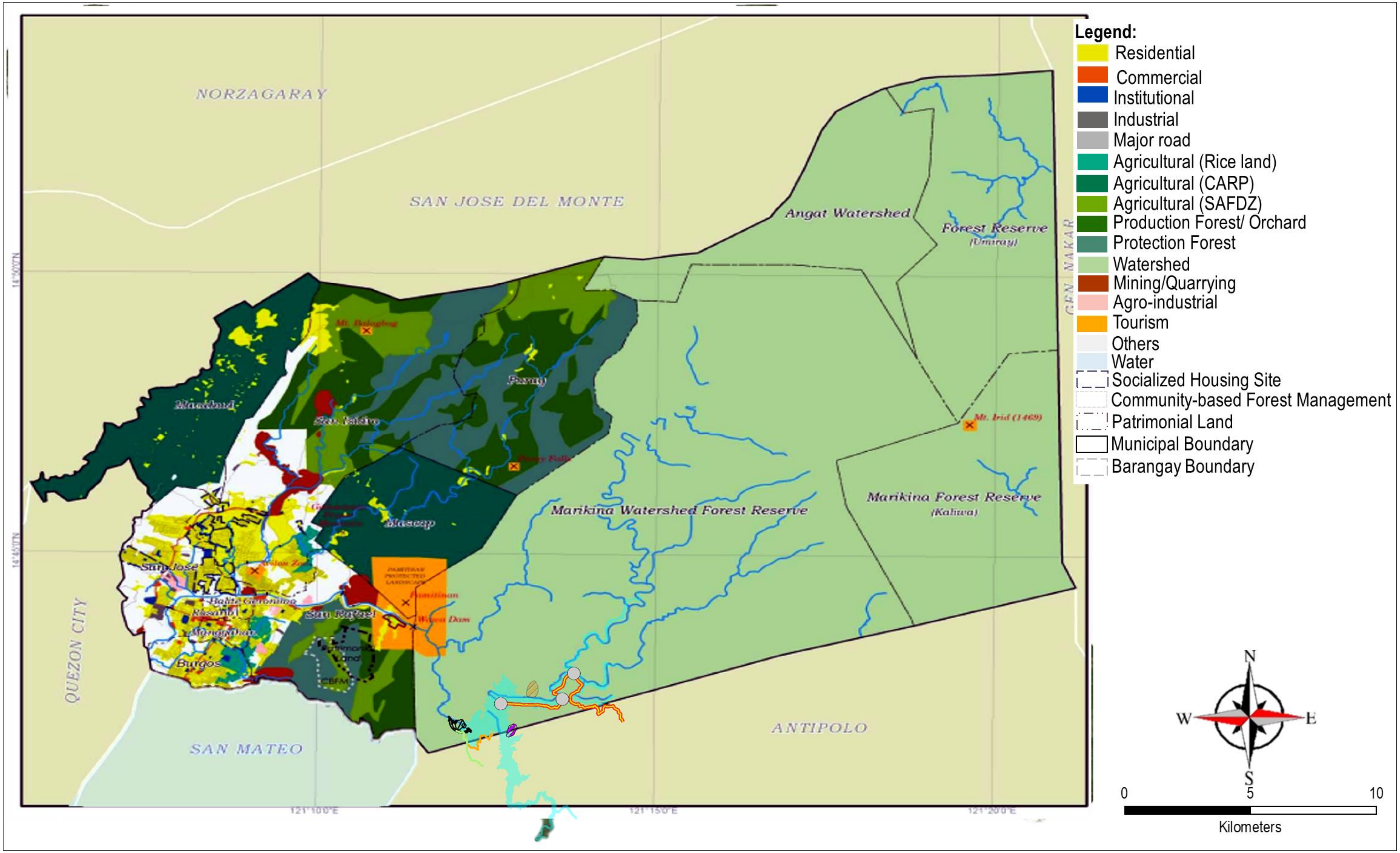


Figure EL-3. Existing land use map of Rodriguez, Rizal

ENVIRONMENTAL IMPACT STATEMENT
LAND MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

Legend	
Pump Station	UWD Dam and Diversion Tunnel
Transmission Pipeline via Tunnel Optional	Transmission / Water Conveyance Pipeline
UWD Optional Access Road (New)	Quarry Option 1
UWD Access Road (Original)	Quarry Option 2
Access Road to WTP / Transmission Pipe	UWD Reservoir

DATA INFORMATION/SOURCE:

Source Map: Rodriguez, Rizal CLUP (2012-2022)
Modified by: APERCU CONSULTANTS, INC (2020

WawaJVCo INC.

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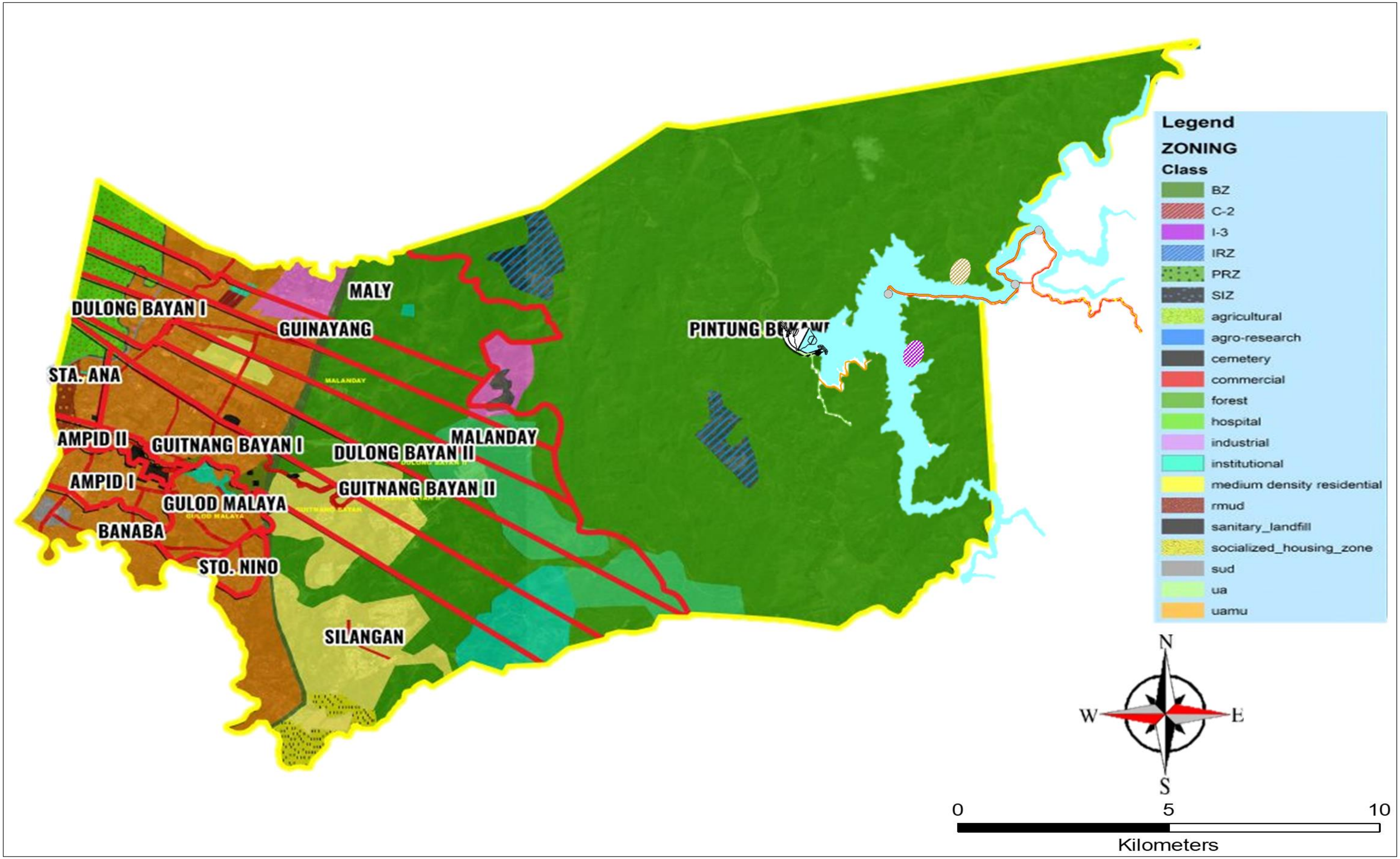

Figure EL-4. Existing land use map of San Mateo, Rizal	Legend	DATA INFORMATION/SOURCE:	WawaJVCo INC.
ENVIRONMENTAL IMPACT STATEMENT LAND MODULE Wawa Bulk Water Supply Project – Upper Wawa Dam	Pump Station Transmission Pipeline via Tunnel Optional UWD Optional Access Road (New) UWD Access Road (Original) Access Road to WTP / Transmission Pipe UWD Dam and Diversion Tunnel Transmission / Water Conveyance Pipeline UWD Reservoir Quarry Option 1 Quarry Option 2	**Source Map**: San Mateo, Rizal CLUP (2012-2022) **Modified by:** APERCU CONSULTANTS, INC (2020	aperçu CONSULTANTS INC. SCALE: 1:120,000

Table EL-6
Land area distribution per barangay of San Mateo, Rizal

Barangay	Land Area (hectares)	Percent (%)
Ampid I	131.60	2.73
Ampid II	24.50	0.51
Banaba	138.20	2.86
Dulongbayan I	58.79	1.22
Dulongbayan II	430.00	8.91
Guinayang	273.00	5.66
Guitnangbayan I	412.00	8.54
Guitnangbayan II	614.00	12.72
Gulod Malaya	139.40	2.89
Malanday	353.00	7.32
Maly	565.00	11.71
Pintong Bukawe	753.00	15.61
Sta. Ana	80.00	1.66
Sto. Nino	87.11	1.80
Silangan	765.50	15.86
Total	**4,825.10**	**100.00**

Protected open spaces include special reserved zones, parks and recreational zones and forest areas. These are mostly found on the eastern side of the municipality, large portions of which are located in Barangays Pintong Bukawe and Dulong Bayan II. Institutional land uses include schools, government offices, hospitals, and churches. These are located within the built-up areas of the urban and rural barangays.

1.1.2 Land Use and Classification in the Project Site and Vicinity

More than 90% o the total land area of the Upper Marikina River Basin is declared as a river basin reservation, with the alienable and disposable land accounting for only 2.5% (746.5 has) of the total land area while the rest (3.6% or 1,061.2 has) is classified as forest reserve (Aecom, 2012). Most of the alienable and disposable lands, forest reserve and unclassified public forest are located in the Wawa River Subriver Basin (SRB) (see **Table EL-7** and **Figure EL-5**). The rest of the A&D land is located in the Boso-Boso SRB while the rest of the forest reserves are located in the Boso-Boso and Montalban SRBs. Land area in the Upper Marikina River Basin is distributed as follows: Boso-Boso SRB (9,951.8 has), Montalban SRB (7,160.4 has), Tayabasan SRB (7,361.7 has), Wawa SRB (2,886.9 has).

Table EL-7
Land Classification in the Upper Marikina River Basin

Land Classification	Area (hectares)				Total (has)	%
	Boso-Boso	Montalban	Tayabasan	Wawa		
Alienable/Disposable	124.1			622.3	746.5	2.5
Forest Reserve	2.9	377.5		680.8	1,061.2	3.6
Unclassified Public Forest				714.8	714.8	2.4
River Basin Reservation	9.951.8	6,782.9	7,361.7	2,886.9	26,983.3	91.5
Total	**10,078.8**	**7,160.4**	**7,361.7**	**4,904.9**	**29,505.8**	
%	34.2	24.3	24.9	16.6		100.0

Source: AECOM, 2012

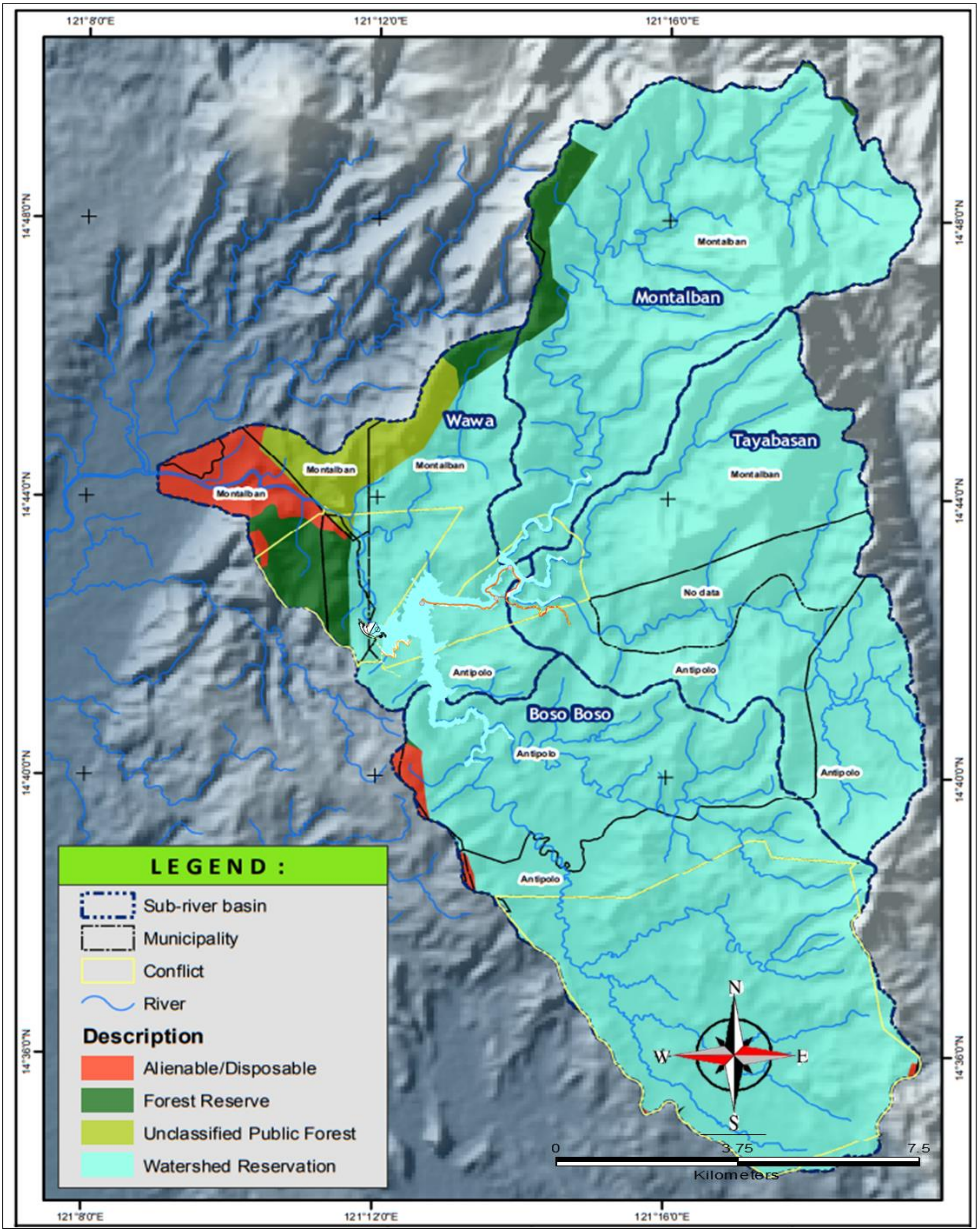

Figure EL-5. Land Classification of the Upper Marikina River Basin	Legend Pump Station UWD Reservoir Transmission Pipeline via Tunnel Optional UWD Optional Access Road (New) UWD Access Road (Original) Access Road to WTP / Transmission Pipe UWD Dam and Diversion Tunnel Transmission / Water Conveyance Pipeline	**DATA INFORMATION/SOURCE:** Source Map: **AECOM (2012)** Modified by: **Apercu Consultants Inc. (2020)**	**WawaJVCo INC.** apercu CONSULTANTS INC.	
ENVIRONMENTAL IMPACT STATEMENT LAND MODULE Wawa Bulk Water Supply Project – Upper Wawa Dam			**SCALE:** As above	**PAGE** 72

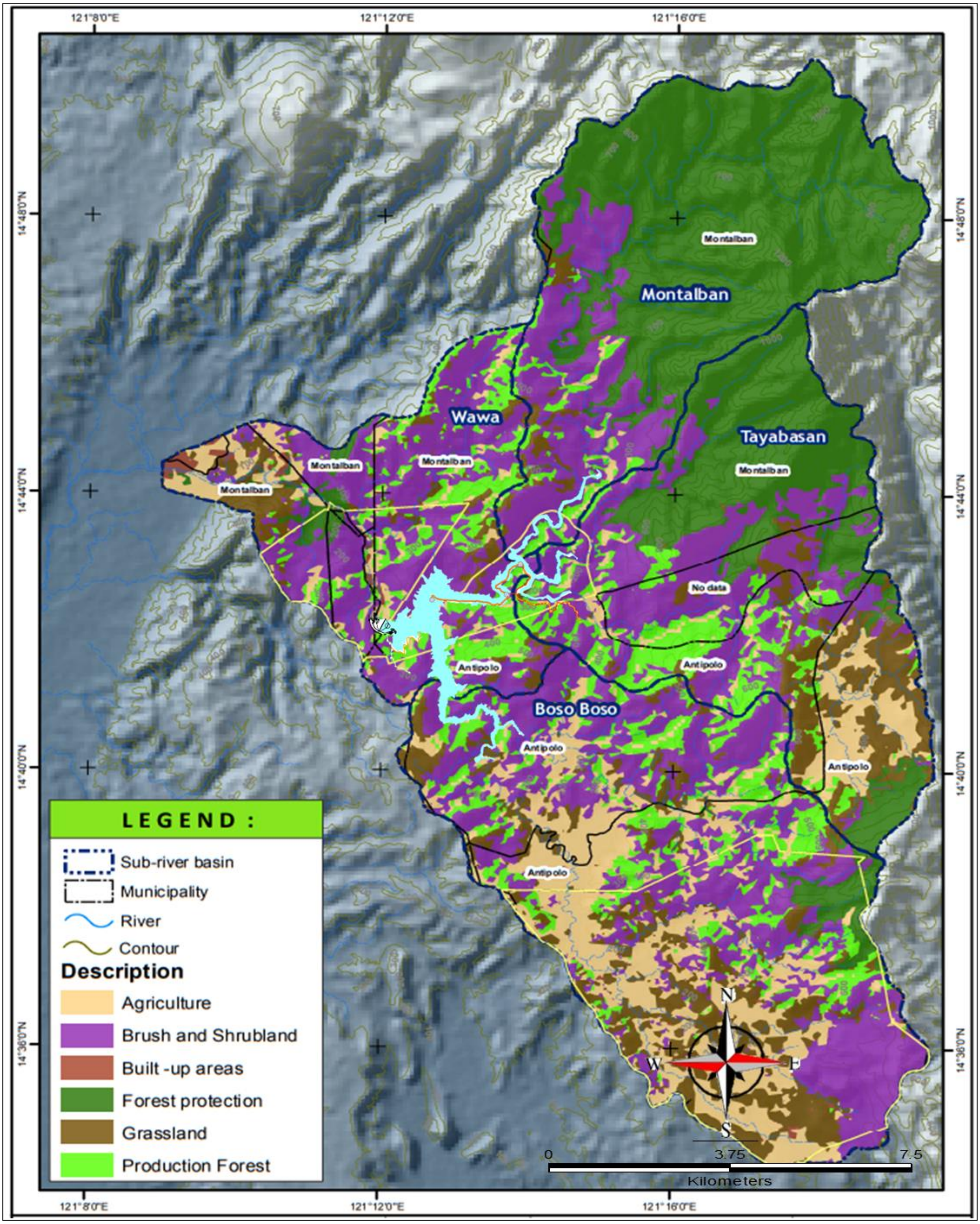

Figure EL-6. Land use map of the Upper Marikina River Basin

ENVIRONMENTAL IMPACT STATEMENT
LAND MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

Legend
- Pump Station
- UWD Reservoir
- Transmission Pipeline via Tunnel Optional
- UWD Optional Access Road (New)
- UWD Access Road (Original)
- Access Road to WTP / Transmission Pipe
- UWD Dam and Diversion Tunnel
- Transmission / Water Conveyance Pipeline

DATA INFORMATION/SOURCE:

Source Map: **AECOM (2012)**
Modified by: **Apercu Consultants Inc. (2020)**

WawaJVCo INC.

aperçu CONSULTANTS INC.

SCALE: As above

The land use distribution in the Upper Marikina River Basin is presented in **Table EL-8** and shown on **Figure EL-6. Table EL-8** shows that almost 34% (9,965.5 hectares) of the land area in the river basin is occupied by brush and shrubland while almost 28% (8,222.5 has) is occupied by protection forest. The remaining land uses in the river basin include agriculture (4,216.7 has or 14.3%), production forest (3,521.2 has or 11.9%), grassland (3,458.6 hectares or 11.7%) and built up areas (121.4 hectares or 0.4%). Most of the protection forest is located in Montalban and Tayabasan SRBs while most of the brush and shrubland are located in the Boso-Boso and Wawa SRBs. A large part of the built-up areas are located in the Wawa SRB while agricultural areas are mostly located in the Boso-Boso SRB.

Table EL-8
Land Uses in the Upper Marikina River Basin

Land Use	Sub-river Basin Area (has)				Total	Percentage
	Boso-Boso	Montalban	Tayabasan	Wawa		
Agriculture	2,813.6	75.0	707.7	621.2	4,216.7	14.3
Brush and shrubland	3,798.4	1,542.5	2,080.4	2,544.2	9,965.5	33.8
Built-up areas	30.6		0.4	90.3	121.3	0.4
Forest protection	299.9	5,126.8	2,604.0	191.8	8,222.5	27.9
Grassland	1,737.4	169.7	1,036.6	514.9	3,458.6	11.7
Production forest	1,399.0	246.3	933.2	942.7	3,521.2	11.9
Total	**10,078.8**	**7,160.4**	**7,361.7**	**4,904.9**	**29,505.8**	
%	34.2	24.3	24.9	16.6		100.0

Source: AECOM (2012)

The entire project site is located within the Upper Marikina River Basin Protected Landscape. This protected area will be discussed further in succeeding sections. Among the three impact barangays (**Table EL-9**), only Barangay Calawis is entirely located within the protected area.

The major project facilities (dam, spillway, diversion tunnel) will be located within Sitio Inigan of Rodriguez and Sitio Casili, shared by the municipalities of San Mateo and Rodriguez. The inundation/reservoir area will be located within Sitio Casili and Sitio Apia of Barangay San Rafael (Rodriguez) and portions of Sitio Apia of Barangay Calawis (Antipolo), specifically banks and hillsides bounding Boso-Boso, Montalban, and Tayabasan Rivers as well as Sapa Bute-Bute. Land uses in these areas include settlements, agricultural areas on riverbanks and hillsides, and brushland/shrubland (see **Table EL-9**).

Table EL-9
Land Uses in the Project Site and Vicinity

Sitio	Barangay	City / Municipality	Project Facility	Sub-river Basin Location	Existing Land Uses
Inigan	San Rafael	Rodriguez	Dam, spillway	Wawa	Built up, agriculture, brush and shrubland
Casili	San Rafael	Rodriguez	Diversion tunnel, reservoir	Wawa	Built up, agriculture, brush and shrubland
Anipa	San Rafael	Rodriguez	Reservoir	Montalban	Built up, agriculture, grassland, brush and shrubland
Casili	Pintong Bukawe	San Mateo	Diversion tunnel, reservoir	Wawa	Built up, agriculture, brush and shrubland
Apia	Calawis	Antipolo	Reservoir, transmission pipeline, pumping stations, water treatment plant (not part of the project)	Montalban, Tayabasan, Boso-Boso	Built up, agriculture, grassland, brush and shrubland, production forest

Plate EL-1 and **Plate EL-2** show some of the representative land uses in the general vicinity of the Project site.

Plate EL- 1. Shrubland and grassland areas observed in the vicinity of the proposed UWD site.

Plate EL-2. Grasses and shrubs are the dominant land cover at the downstream section of the proposed UWD site. Adjacent hillsides are cultivated with annual crops and covered with trees and shrubs.

1.1.3 Impact Assessment and Mitigation Plan for Land Use

1.1.3.1 Impact in Terms of Compatibility with Existing Land Use

Land use change is expected in areas where major project facilities will be constructed. The biggest land use change will be the conversion from a terrestrial environment into an aquatic environment. This will affect grasslands/ shrubland and wooded grassland areas.

Loss of land cover due to clearing of vegetation in preparation for construction of project facilities will lead to erosion and sediment build up at the base of the river and could increase the probability of flooding upstream.

In preparation for construction, access roads will be constructed to the site. This will improve the road access in the project site. Improvement of the road will benefit the residents of nearby sitios.

Land use change will also occur in quarries, borrow pits and spoils stockpile areas. This effect is usually localized and can be mitigated by choosing the least environmentally and socially damaging areas.

The proposed project will be inconsistent with the current land use classification of the project site which is forest/open area. The proponent will have to secure a Special Use Agreement in Protected Areas (SAPA) since the proposed bulk water supply project will be located within the protected area (**Annex D)**.

Land use change from a terrestrial ecosystem into an aquatic ecosystem is a residual project impact. This will lead to loss of grassland and shrubland that can lead to erosion and sediment buildup at the base of the reservoir. To mitigate this impact, a land use and watershed management plan will be implemented. This will be part of the Catchment Area Treatment (CAT) that the project proponent is expected to implement.

The proponent will coordinate with the DENR and PAMB to develop a portion of the protected area. Coordination with these agencies will also ensure the effective implementation of the watershed management plan for the Wawa River/Upper Marikina River Watershed.

Land use change in areas where the major facilities will be constructed are also unavoidable impacts of the project. The proponent will apply for a SAPA which shall include a Comprehensive Development Management Plan and a PAMB Clearance after ECC issuance since project facilities will be located within the protected area.

1.1.3.2 Impact on Compatibility with Classification as an Environmentally Critical Area (ECA)

The location of the proposed Wawa Bulk Water Supply Project is within the Upper Marikina River Basin Protected Landscape (UMRBPL), a component of the National Integrated Protected Areas System (NIPAS) under Republic Act 11038 or the Expanded NIPAS Act of 2018. The protected area covers a total land area of 26,125.64 hectares. The Upper Marikina River drains Antipolo City and the municipalities of Baras, Rodriguez, San Mateo and Tanay in the Province of Rizal. The UMRBPL is surrounded by other reservations and protected areas, except on the south, which is bounded by alienable and disposable lands. Lungsod Silangan Townsite Reservation and Pamitinan Watershed form the western boundary of UMRBPL, Kaliwa Watershed Forest Reserve forms the eastern boundary while the Angat Watershed Reservation forms the northern boundary. An Integrated Social Forestry Program forms the southwest boundary of the UMRBPL. The location of protected areas and watersheds in the CALABARZON region is shown on **Figure EL-7**.

A comprehensive management plan for the UMRBPL was prepared as a planning document and roadmap that identifies the roles of stakeholders and tasks that need to be undertaken to protect, conserve, rehabilitate and sustainably manage the protected area. About 1,120 hectares within the watershed was identified as planting sites under the National Greening Program of DENR in 2012. The program employed the residents previously involved in charcoal making and kaingin farming to establish and maintain nurseries, plant trees, maintain bench terraces, and establish fire lines. The program aims to plant 600,000 seedlings within the 1,200-hectare NGP-identified planting sites.

The Upper Marikina River Basin Protected Landscape is delineated by the watershed boundary in the land use map on **Figure EL-8**. As stated in Section 18 of the Implementing Rules and Regulations of the NIPAS Act (RA 7586), construction and operation of waterworks and other public utilities in the protected area will need to get approval from the Protected Area Management Board (PAMB).

Table EL-10 presents the assessment of the project site against the ECA categories presented in DENR Administrative Order No. 2003-30. As gleaned from the table, the project site falls within eight of the 12 ECA categories namely:

1) Areas declared by law as protected area;
2) Areas set aside as potential tourist spot;
3) Areas constituting habitat of endangered or threatened species;
4) Areas of unique cultural interest;
5) Areas traditionally occupied by cultural communities or tribes;
6) Areas with critical slope;
7) Recharge areas of aquifers; and
8) Water bodies tapped for domestic purposes.

Projects within ECAs are required to prepare an Environmental Impact Statement (EIS) for the purpose of securing an Environmental Compliance Certificate (ECC) from DENR-EMB. For this project, the application is to be filed at the DENR-EMB Central Office. The project proponent will also have to coordinate with the Protected Area Management Board and comply with the Protected Area Management Plan of the Upper Marikina River Basin Protected Landscape.

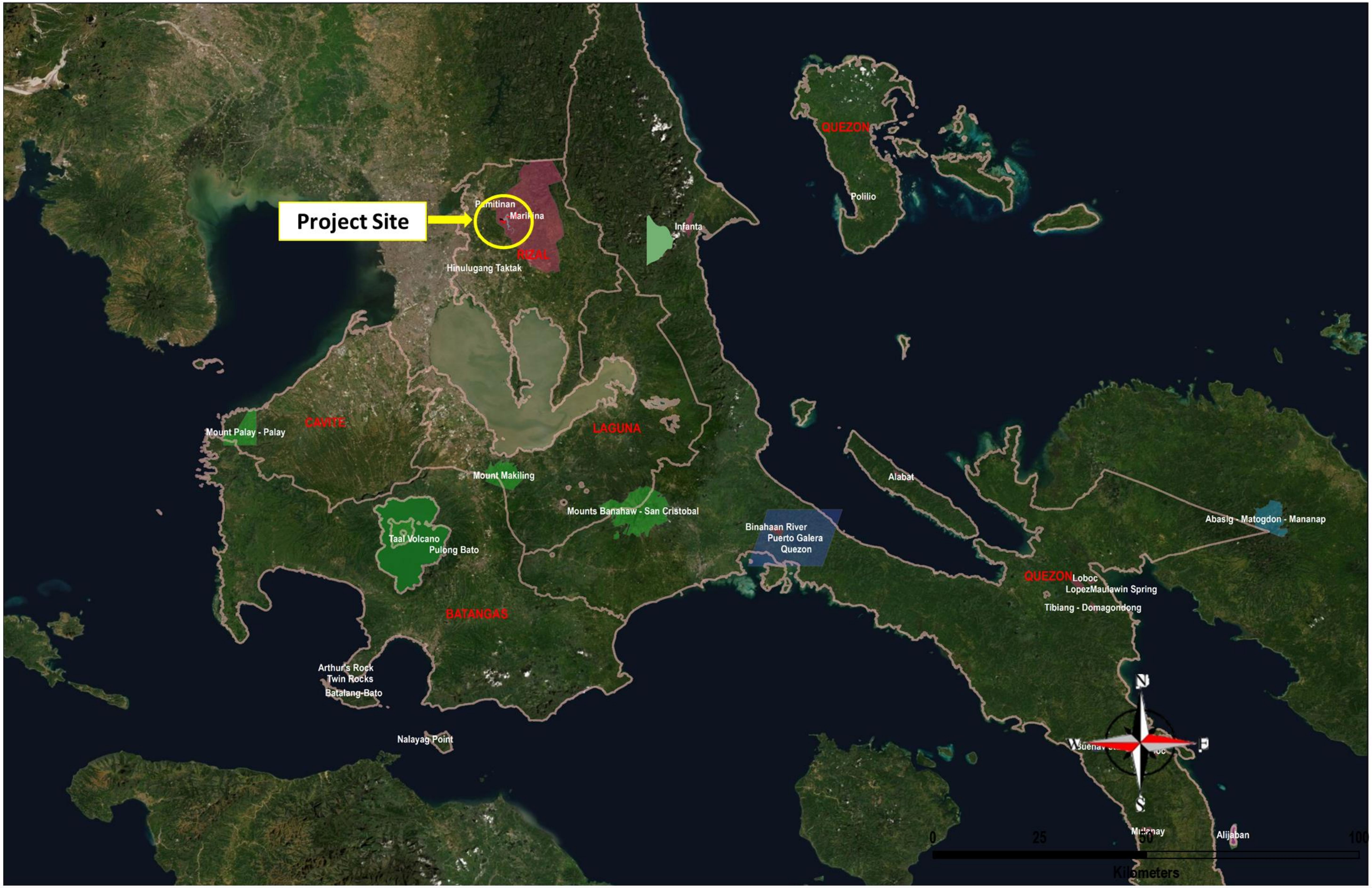

Figure EL-7. Location of Protected and Watershed Areas in Region IV-A

ENVIRONMENTAL IMPACT STATEMENT
LAND MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

Legend:

- Provincial Boundary
- Fish Sanctuary
- Fishery Refuge and Sanctuary
- National Park
- Natural Biotic Area
- Protected Landscape
- Protected Landscape/Seascape
- UNESCO-MAB Biosphere Reserve
- Watershed Forest Reserve
- Wilderness Area
- Kaliwa_Watershed

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCO, Inc. (2020)
Base Map: Google Earth Imagery (2020)
Shapefile: PhilGIS
Created by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.

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SCALE: 1:750,000

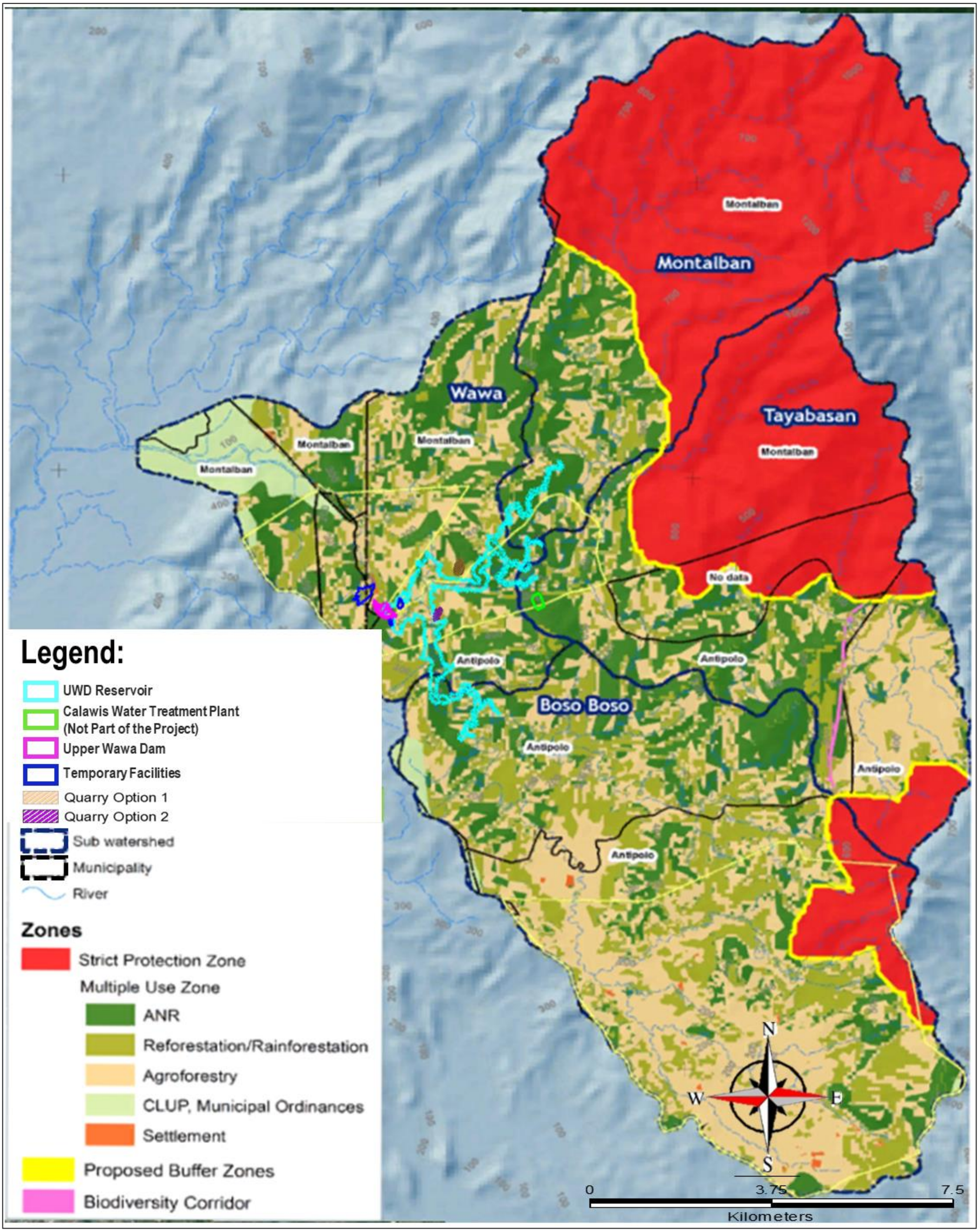

Figure EL-8. Buffer Zone and Biodiversity Corridor for Upper Marikina River Basin	DATA INFORMATION/SOURCE: Source Map: **AECOM (2012)** Modified by: **Apercu Consultants Inc. (2020)**	WawaJVCo INC. apercu CONSULTANTS INC.
ENVIRONMENTAL IMPACT STATEMENT LAND MODULE Wawa Bulk Water Supply Project – Upper Wawa Dam		SCALE: As above / PAGE 78

Table EL-10
Assessment of the Project Site Against ECA Categories of DENR

12 ECA Categories	Project Falls within ECA Description		Remarks	Reference
	Yes	No		
A. All areas declared by law as national parks, watershed reserves, wildlife preserves, and sanctuaries	✓		Map of City of Antipolo and the Municipalities of Rizal, Rodriguez, San Mateo	Proclamation No. 296, R.A No. 7586 RA No. 11038
B. Areas set aside as aesthetic potential tourist spots	✓		Project site is a potential zone for tourism	Key informant interviews
C. Areas which constitute the habitat of any endangered or threatened species of indigenous Philippine wildlife (flora and fauna)	✓		EIS report states that 3 wildlife species are near threatened. For flora, 2 species are endangered.	EIS report
D. Areas of unique historic, archaeological, geological or scientific interests	✓		The project site has a unique historical "sacred stone"	EIS report
E. Areas which are traditionally occupied by cultural communities or tribes	✓		There are indigenous peoples in the project site (Dumagat tribe)	CLUP
F. Areas frequently visited and/or hard-hit by natural calamities (geologic hazards, floods, typhoons, volcanic activity, etc.)		✓	Low to moderate susceptibility to flooding and landslide	Quezon city landslide and flood susceptibility map Site Surveys – EIS report
G. Areas with critical slope	✓		Very steep slopes border the river channels in some areas. Steep slopes are also found in Mt. Purro	Slope Map
H. Areas classified as prime agricultural lands		✓	The site is not considered as prime agricultural land	Existing and proposed land use maps of Antipolo, Rizal
I. Recharge areas of aquifers	✓		The project site is within the recharge area of the city and municipality	Antipolo and Rodriguez CLUPs
J. 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.	✓		Project area is tapped for domestic purposes and within the UMRBPL	Key informant interviews; Proclamation No. 296 and Proc. No. 412
K. Mangrove areas characterized by one or any combination of the following conditions: 1. with primary and pristine and dense young growth 2. adjoining mouth or major river system 3. near or adjacent to traditional productive fry or fishing grounds 4. which acts as natural buffers against shore erosion, strong winds and storm floods 5. on which people are dependent for their livelihood, pursuant to and taking into consideration RA No. 7161 which prohibits the cutting of mangrove species		✓	There are no mangrove areas in the project site	Ocular visit
L. Coral reefs characterized by one or any combination of the following conditions: 1. with 50% and above live coralline cover 2. spawning and nursery grounds for fish 3. which act as a natural breakwater of coastlines		✓	Area is mountainous rather than coastal and therefore there are no coral reefs in the area	Ocular visit

1.1.3.3 Impact on Existing Land Tenure Issues

Land tenure issues discussed in this section include ancestral domains and social forestry projects including Integrated Forestry Management Agreement (IFMA) and Community-Based Forestry Management Agreement (CBFMA). Except for these two land tenures, there are no other land tenures reported in the sitios where the proposed project facilities are located.

The mining tenements map of Rizal Province (**Figure EL-9**) show that there are no mining tenements in the boundary between the municipalities of San Mateo and Rodriguez and Antipolo City where the proposed bulk water supply project is located. Although there are reported quarries in Barangay San Rafael (Rodriguez), the quarry material is basalt which is not found within the project site.

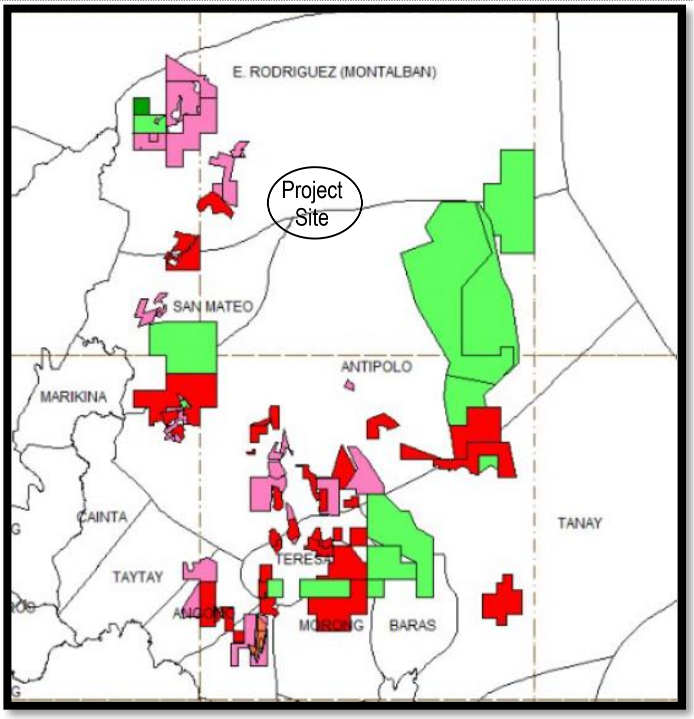

Figure EL-9. Mining tenement map of Rizal Province
Source: MGB Region IV-A, 2020

Ancestral Domain

As defined in Republic Act 8371 or the Indigenous Peoples Rights Act of 1997, ancestral domains refer to all areas belonging to Indigenous Cultural Communities/Indigenous Peoples (ICCs/IPs) and include lands, inland waters, coastal waters and natural resources held therein under the claim of ownership, occupied or possessed by ICCs/IPs communally or individually since time immemorial. Ancestral domains include ancestral lands, forests, pasture, residential, agricultural, and other lands individually owned whether alienable, disposable or otherwise, hunting grounds, burial grounds, worship areas, bodies of water, mineral lands or other natural resources.

Ancestral domain titles include the following:

- Certificate of Ancestral Domain Title (CADT), which formally recognizes the rights of possession and ownership of ICCs/IPs over their ancestral domain identified and delineated in accordance with RA 8371;
- Certificate of Ancestral Domain Claim (CADC), which certifies the ICC's/IP's claims over the ancestral domain;

- Certificate of Ancestral Lands Title (CALT), which formally recognizes the rights of ICCs/IPs over their ancestral lands;
- Certificate of Ancestral Land Claim (CALC), which certifies the ICC's/IP's claim over the ancestral land; and
- Sustainable Traditional Resource Rights, which refers to the rights of ICCs/IPs to sustainably use, manage, protect and conserve a) land, air, water and minerals; b) plants, animals and other organisms; c) collecting, fishing and hunting grounds; d) sacred sites; and e) other areas of economic, ceremonial and aesthetic value in accordance with indigenous knowledge, beliefs, systems and practices.

The indigenous peoples residing on the mountains of Rizal Province belong to the Remontado Agta or the Remontado Dumagat. These IPs are traditionally found on the Sierra Madre Mountain Range in Rizal and Quezon Provinces. They have an estimated population of around 2,500. The Remontados are believed to be descendants of lowlanders who have opted to live in the mountains to avoid subjugation by the Spaniards. They subsequently intermarried with the Negritos. The Remontados are semi-nomadic but they roam within a specific geographic range that is considered as their home base. The Dumagats hold a CADT covering an estimated area of 19,000 hectares located in Rodriguez, Rizal while a CADC application in Antipolo City covers 9,347 hectares. The inundation area of the upper dam, which is the water source of the bulk water supply project, covers <1% of the land area occupied by the Antipolo CADC. **Figure EL-10** shows the location of the Montalban CADT and Antipolo CADC relative to the project site.

Social Forestry Projects

Social forestry is the management and protection of forests and the reforestation of bare areas for the purpose of environmental, social and rural development. It encourages rural participation in the management of natural resources and enables communities to take an active role in managing their forests to prevent further deforestation. In the Philippines, social forestry comes in the form of the Community Based Forestry Management or CBFM. The Community Based Forest Management Agreement (CBFMA) is a production sharing agreement between the DENR and a people's organization (PO) for a period of 25 years and is renewable for another 25 years. The agreement provides tenurial security and incentives to develop, utilize and manage specific portions of forestlands.

Prior to the CBFM strategy, social forestry was through the Integrated Social Forestry Program or ISFP, a national program that started in 1982. Its major initiative was in upland development and was designed to maximize land productivity, enhance ecological stability and improve socio-economic conditions of forest occupants and communities. The ISFP offered two forms of stewardship agreement: The Certificate of Stewardship Contract (CSC) for households and Certificate of Community Forestry Stewardship (CCFS) for community organizations. The agreements were for a period of 25 years and required the retention or establishment of 20% of the awarded area as permanent forest cover. The responsibility of ISFP was transferred from the DENR to the LGUs in 1994 and the DENR subsequently encouraged ISFP sites to integrate with CBFM areas.

Key informant interview with the PENRO staff in charge of UMRBPL on 04 September 2020 indicates that CBFM sites within the protected area are located within Barangays Calawis and San Juan of Antipolo City. National Greening Program (NGP) sites are also located within Sitio Amianan of Barangay Pintong Bukawe (Antipolo) and Sitio Anipa of Barangay San Rafael (Rodriguez). The NGP site in Sitio Anipa is located on the riverbank and was planted with bamboo. Records from the NGP Office of DENR[1] indicate that there are several NGP projects in Barangay Puray in the Municipality of Rodriguez and in several barangays of Antipolo City including San Jose, Pintong Bukawe, Calawis, Laiban, etc. (see **Figure EL-11**) Consultations with DENR and local communities will be undertaken prior to commencement of any project activity to determine the extent of the NGP planting sites and other forestry tenurial instruments in the area.

[1] Source: https://ngp.denr.gov.ph/index.php/11-hidden-articles/35-accomplishment-by-site

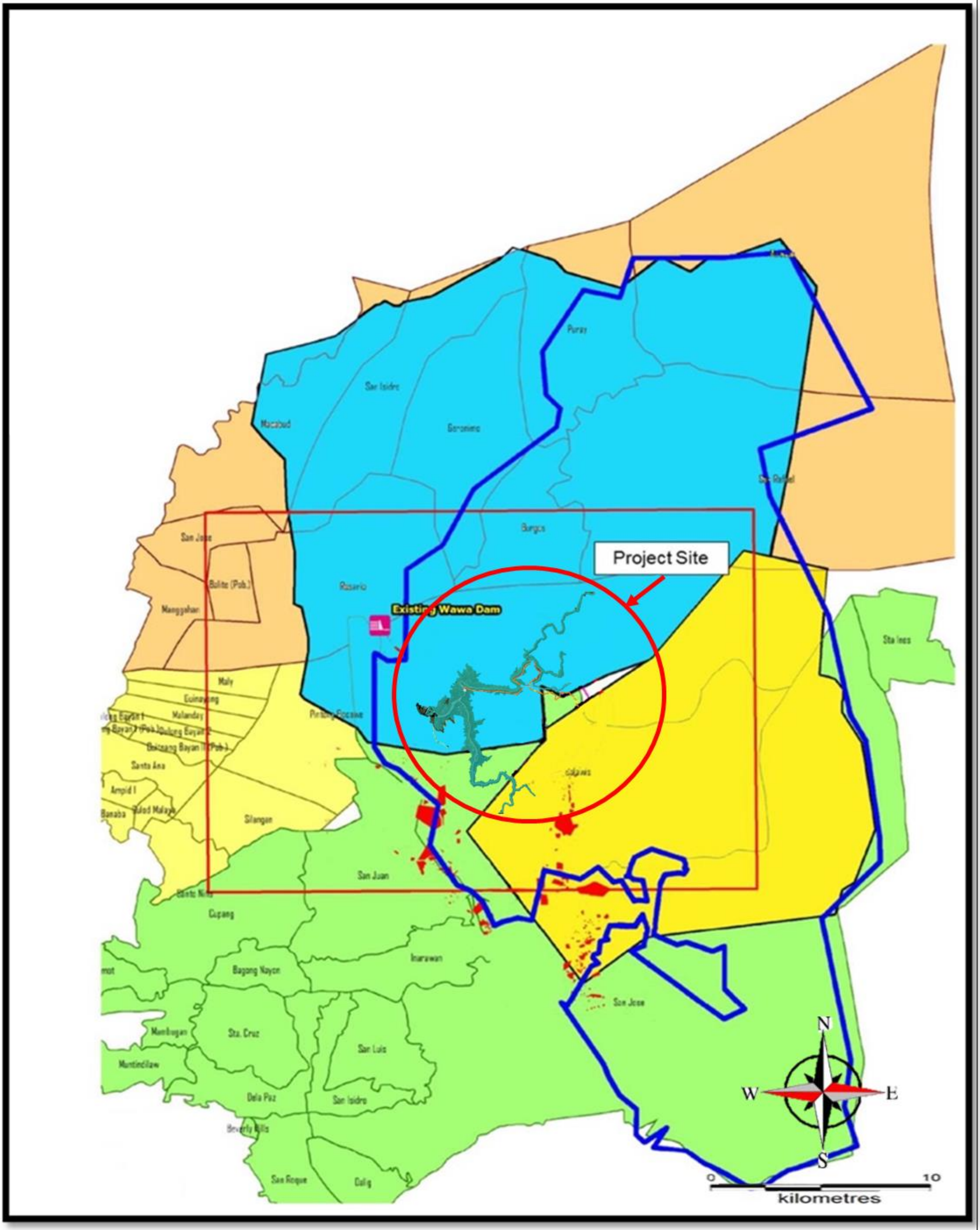

Figure EL-10. Location of ancestral domains relative to the project site	Legend: Montalban CADT; Antipolo CADC; Service Contract Area; Antipolo; San Mateo; Rodriguez; Settlements; Wawa River Basin	DATA INFORMATION/SOURCE:	WawaJVCo INC. apercu CONSULTANTS INC.	
ENVIRONMENTAL IMPACT STATEMENT LAND MODULE Wawa Bulk Water Supply Project – Upper Wawa Dam		Source Map: **OVPI (2015)** Modified by: **Apercu Consultants Inc. (2020)**	SCALE: 1:100,000	PAGE 82

Overlap with ancestral domains and social forestry projects including NGP projects within the project site should be verified with the appropriate government agency (NCIP and DENR-FMB, respectively). Agreements with concerned IP groups and social forestry project implementers should be secured in order to ensure the harmonious co-existence of the proposed bulk water supply project with the existing tenurial instruments.

1.1.3.4 Impairment of Visual Aesthetics

The proposed project will be built on areas with existing natural vegetation, mostly grassland, shrubland and some forested areas. Introducing any type of development into this landscape, particularly large concrete structures such as dams and water supply project facilities, will change the visual character of the area. Pre-construction and construction activities that will contribute to visual impacts include:

- Removal of existing vegetation for construction of access roads, temporary facilities (bunkhouses, construction offices, storage and stockpile areas, etc.);
- Presence and use of heavy equipment, machinery and vehicles on site;
- Development of various stockpiles and excavated areas; and
- Construction of roads and other large project structures.

Removal of existing vegetation and introduction of permanent structures such as roads and large project structures will result to change in the visual and aesthetic character of the area as the large concrete structures will be highly visible and prominent from long distances. However, presence of heavy equipment, machinery, excavated areas, and various stockpiles are short term impacts that are expected to persist only during project construction.

The Google Earth satellite imagery in **Figure EL-12** shows the location of natural landforms (caves, waterfalls) within the vicinity of the proposed dam site. As shown on the figure, the closest natural landforms include Karugo Falls, Wawa Dam and Pamitinan Cave located about 3km northwest of the proposed dam site and Bunsuran Falls located about 5m southeast of the proposed dam site. Other natural landforms within the general area of the project site include Puray Falls and Kinabuan Falls to the northeast, Kay-ibon Falls to the southeast, Mystical Cave to the south, and Hinulugang Taktak Falls to the southwest. The construction and operation of the proposed Upper Wawa Dam is not expected to impact these natural landforms.

Visual impairment during the pre-construction and construction phases is an unavoidable but temporary impact. The proponent and contractor will designate a specific spoils dump area to prevent the occurrence of several stockpile areas that are potential eyesores. Spoil tip areas will also be selected to minimize visual impact. Other measures that the proponent and contractor will employ to reduce the visual impacts during the construction phase include:

- **Create greenery in exposed areas**
- **Ensure maximum utilization of spoils/debris and muck for construction purposes, thereby decreasing the amount that needs to be stockpiled**
- **Develop exposed areas in line with the landscape**
- **Disposal of rock from both surface and underground excavation works will be undertaken with careful consideration of the following key criteria:**
  - **Spoils area layout will maximize the storage volume while minimizing geographical extent**
  - **Slope height, angle, and stability**
  - **Spoil area filling sequence and compaction of waste material**

Upon completion of construction activities, all exposed areas will be re-vegetated using indigenous species as part of the Catchment Area Treatment (CAT).

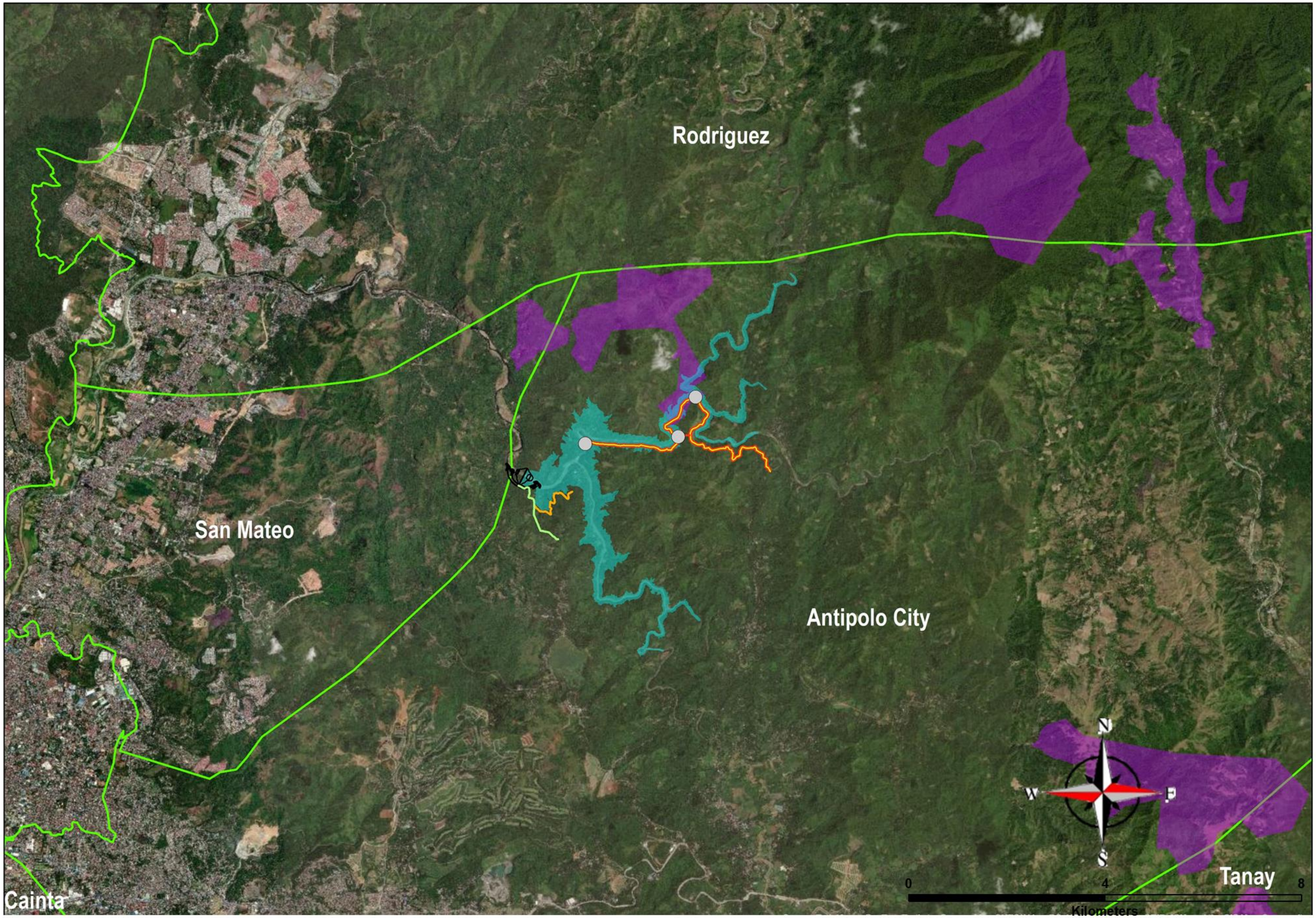

Figure EL-11. Location of NGP sites in Antipolo City

ENVIRONMENTAL IMPACT STATEMENT
LAND MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

Legend
- NGP Sites
- Municipal Boundary
- Pump Station
- Transmission Pipeline via Tunnel Optional
- UWD Optional Access Road (New)
- UWD Access Road (Original)
- Access Road to WTP / Transmission Pipe
- UWD Dam and Diversion Tunnel
- Transmission / Water Conveyance Pipeline
- UWD Reservoir

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCO, Inc. (2020)
Source Map: CENRO Antipolo (2015)
Created by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.

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SCALE: 1:62,500

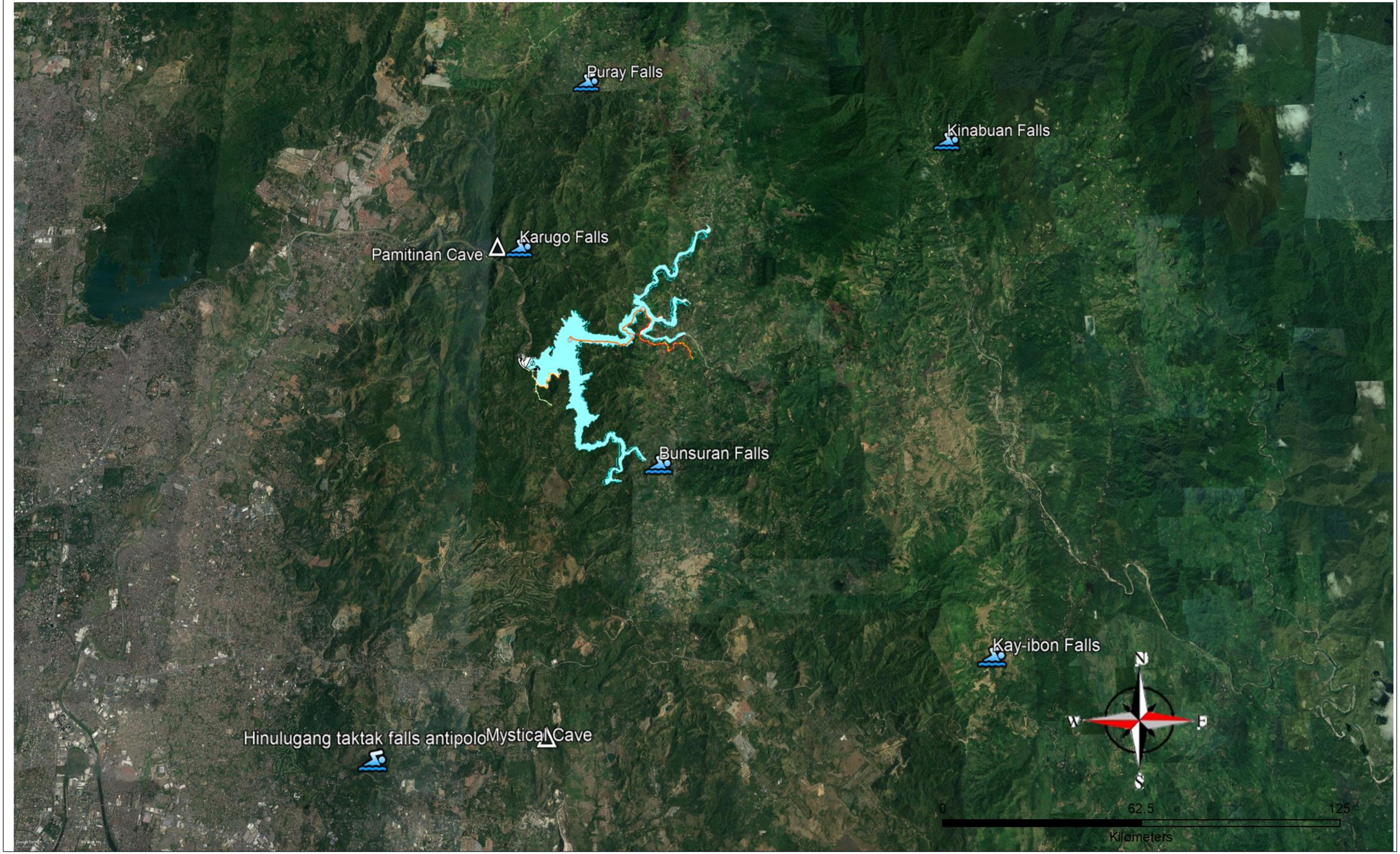

Figure EL-12. Location of Natural Landforms within the vicinity map of the proposed Upper Wawa Dam

ENVIRONMENTAL IMPACT STATEMENT
LAND MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

Legend
- Pump Station
- Transmission Pipeline via Tunnel Optional
- UWD Optional Access Road (New)
- UWD Access Road (Original)
- Access Road to WTP / Transmission Pipe
- UWD Dam and Diversion Tunnel
- Transmission / Water Conveyance Pipeline
- UWD Reservoir

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCO, Inc. (2020)
Base Map: Google Earth Imagery (2020)
Created by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.
aperçu CONSULTANTS INC.

SCALE: 1:1,000,000

During the operation phase, the reservoirs of the dams will be potential tourist attractions particularly if access roads to these sites will be constructed. This is a positive impact and will increase the land value of the area. If the sites become tourist destinations, it can create a positive impact to the local economy by creating opportunities for locals to set up transportation services and food establishments. Proper management of these establishments will have to be done to ensure that these areas remain free of solid wastes and other unsightly materials.

1.1.3.5 Devaluation of Land Value as Result of Improper Solid Waste Management

The generation of various solid waste streams is an associated impact of construction activities. Sources of construction wastes include:

- The removal of vegetation, which represents a solid waste stream that needs to be disposed of properly;
- Waste materials generated from the daily activities of construction workers (paper, plastics and biodegradable wastes);
- Generation of construction waste such as wooden crates (from equipment packaging), various steel pieces (pipes, plates, cables, etc.), and concrete;
- Waste generated from offices (paper, plastics, cartons, bulbs, etc.);
- Hazardous waste including used engine oils and lubricants, hydraulic fluids, spent batteries, used paint, soiled rugs, etc.; and
- Silt-laden runoff from active construction sites and stockpiles of construction materials

The nearest sanitary landfill to the proposed project site is the San Mateo Landfill located about 3.8km west of the proposed dam site. The San Mateo Sanitary Landfill is a 19-hectare facility located in Barangay Pintong Bukawe, San Mateo, Rizal. This landfill has been in operation since February 1990 and services several cities of Metro Manila and neighboring municipalities of Rizal Province. However, the expected life of this landfill is only until 2022 due to the increasing waste volume it receives from the cities of Metro Manila[2].

Although no specific assessment of the municipal waste management network was done, it is assumed that any additional waste generated by the project will impose additional stress on the existing LGU waste management services. Improper storage of these waste streams on site may result in corollary impacts that include impacts to the health and safety of workers and residents due to contamination of drinking water or food. This may also result to accidental spills and leaks of hazardous materials that could potentially impact surface waters and surrounding soils.

The impacts of improper disposal of solid wastes can be mitigated by proper solid waste management; the use of silt and erosion traps and sedimentation ponds in active construction areas; and the use of bund walls for stockpile of construction materials so the materials will not be washed away by rains or streamflow. Other measures to mitigate the identified impacts include:

- Coordination with the LGU to determine the capacity to absorb new waste streams;
- Develop a Solid Waste Management Plan (SWMP) at work areas and worker's camps that includes practices to manage, reduce and reuse waste and the establishment of a Materials Recovery Facility;
- Implement strict rules on proper solid waste management that are to be complied with by all personnel engaged or associated with the project;
- Provide waste disposal bins/ facilities (with appropriate signages) throughout the construction site;
- Engage third party collectors if the local LGU network cannot accommodate the additional waste; and
- Appoint a licensed waste contractor for transfer of any hazardous waste from the construction site.

1.1.4 Land Use Monitoring Plan

The monitoring activities to address land use concerns include:

[2] https://cnnphilippines.com/news/2017/10/19/Landfill-recycling-trash.html

- Visual inspection of presence of solid waste in the active construction sites and on Montalban /Wawa River.
- Visual monitoring or regular inspection of the stockpiles of construction materials. Interviews with local residents regularly passing along the riverbank can also be done to find out whether they have issues and concerns on the on-going construction activities particularly on wastes washed down from active construction areas.

1.2 Geology/ Geomorphology

1.2.1 Regional Tectonic Setting

Luzon is located in the northern part of what is known as the Philippine Mobile Belt, an actively deforming zone created from the complex system of subduction zones, collision zones and marginal sea basin openings on the western and eastern sides of the Philippine Archipelago (Aurelio and Peña (eds.), 2004). The Philippine Mobile Belt is wedged between the colliding Philippine Sea Plate and the Eurasian Plate and is bounded to the east and west by opposing subduction zones.

The subduction systems to the east of the Philippine Mobile Belt include the East Luzon Trough and the Philippine Trench which extends from the eastern seaboard of Luzon down to Mindanao. The East Luzon Trough is a young subduction zone located north of the Philippine Trench that has no corresponding compressive structures and an undeveloped corresponding volcanic arc. The Philippine Trench is the morphological expression of the westward subduction of the Philippine Sea Plate beneath the eastern Philippine Arc and its corresponding volcanic arc can be traced from Bicol to Leyte, but it becomes unclear in Mindanao (Aurelio and Peña (eds), 2004).

The subduction systems to the west of the Philippine Mobile Belt include: (1) the Manila Trench that represents the subduction of the South China Sea oceanic crust beneath the Luzon Arc and a corresponding active volcanic chain known as the Luzon Volcanic Arc; (2) the Negros Trench where the Sulu Sea Basin oceanic crust subducts beneath Negros and Panay Islands with a corresponding active volcanic chain in Negros Island; and (3) the Sulu-Cotabato Trench that extends beneath western and southern Mindanao with a corresponding active volcanic arc located on the western margin of Mindanao.

The Philippine Fault Zone (PFZ) is a major tectonic feature of the Philippine Mobile Belt that resulted from the tectonic forces compressing the Philippine Archipelago. The PFZ is related to the subduction of the Philippine Sea Plate beneath the Philippine island arc. The Philippine Fault is a strike slip fault that cuts almost the entire length of the Philippine Archipelago and runs for almost 1,200 km from northwestern Luzon to southeastern Mindanao. The Philippine Fault Zone is one of the most seismically active regions in the Philippines with the biggest earthquakes (e.g. Ms 7.0 Ragay earthquake in 1973, Ms 7.7 Luzon earthquake in 1990, and Ms 6.7 Surigao earthquake in 2017) attributed to movements along the Philippine Fault. The PFZ Infanta Segment is one of the seismic generators that can affect the project site and vicinity.

The East Valley Fault is the nearest geologic structure to the project site. It is a 10-km long structure that extends from Rodriguez to San Mateo in the province of Rizal. It is estimated to generate a magnitude 6.2 earthquake (PHIVOLCS). Barangays along the fault alignment include Ampid I, Dulongbayan II, Guinayang, Guitnangbayan II, Malanday, Malay and Santa Ana in the Municipality of San Mateo; and Burgos, Macabud, San Jose, San Isidro and San Rafael in the Municipality of Rodriguez.

Located about 10km west of the project site is the West Valley Fault that forms the western boundary of the Marikina Valley. The West Valley Fault is a 100km long structure that traverses the cities of Metro Manila namely Taguig, Muntinlupa, Paranaque, Quezon City, Pasig, Makati and Marikina as well as portions of the provinces of Rizal, Laguna, Cavite and Bulacan. This fault is believed to move every 200-400 years with its last movement recorded in 1658. The West Valley Fault can generate an earthquake magnitude of 7.2.

The Montalban Fault is another geologic structure located east of the project site. It is interpreted to have resulted from recent movement along the Philippine Fault Zone. The Montalban Fault trends northwest-southeast and exhibits a dextral strike slip character. It is presumed to follow a parallel line along the Boso-Boso Valley. The seismic behavior and probable intensity of the Montalban Fault is unknown at present.

The geologic structures that affect the seismicity of southern Luzon are shown in **Figure EL-13**.

1.2.2 Regional Stratigraphy

Rocks in the project site and vicinity belong to the Southern Sierra Madre Stratigraphic Grouping (SG6). The rock units in Southern Sierra Madre are briefly described below (after Aurelio and Pena (Eds.), 2004).

Montalban Ophiolitic Complex – These are the oldest rocks in Southern Sierra Madre and consist of an incomplete ophiolite sequence consisting of layered and massive gabbro, sheeted diabase dike complex, pillow basalts, pelagic sedimentary rocks and plagio-granite. The unit was previously called the Angat Ophiolite but was renamed since the best-known exposures are found in the Montalban area. The Montalban Ophiolitic Complex define a nearly north-south belt from Montalban, Rizal through Eastern Bulacan to Nueva Ecija just south of the Laur-Dingalan segment of the Philippine Fault. The unit is dated early Late Cretaceous.

Kinabuan Formation – This unit consists of sedimentary rocks such as calcareous sandstones, thinly interbedded silty shales, limestone, calcarenites and calcilutites comprising the sedimentary cover of the Montalban Ophiolitic Complex. The basal part of the sedimentary sequence is associated with underlying pillow basalts and basaltic breccias that represent the volcanic carapace of the ophiolite. The unit is dated early Late Cretaceous based on radiolarians and pelagic foraminifera.

Maybangain Formation – This unit conformably overlies the Kinabuan Formation and consists of the Masungi Limestone member and a clastic volcanic member (volcanic breccia, sandstones, siltstones, mudstones and conglomerates). The formation crops out along Umiray, Limutan and Makalya Rivers, at Alas-asin, Macaira and along the Tanay-Daraitan Road. The unit is dated Middle Paleocene to Middle Eocene and is probably equivalent to the Eocene Formation of Antonio (1967) in Sta. Ines, Antipolo, Rizal and the Bayabas Formation of Revilla and Malaca (1987) on the eastern part of the Central Luzon Basin.

Sta. Ines Diorite – This unit intrudes the Kinabuan and Maybangain Formations along the Antipolo-Teresa Road, Mt. Masarat in Sta. Ines, Tanay Rizal and in tributaries of Madlum and Angat Rivers. The hornblende diorite and minor quartz diorite intrudes limestone and clastic rocks and is associated with deposits of iron ore. The rock unit is dated Early Oligocene.

Binangonan Formation – This unit consists of the Lower Teresa Siltstone member consisting of siltstones and marl and an Upper Limestone member. It is unconformable over the Maybangain Formation and is distributed in Binangonan, Teresa and Antipolo, and in Coronel River and Mt. Dalumpa west of Ligaya and Gabaldon in Nueva Ecija. The unit is dated Late Oligocene to Early Miocene.

Angat Formation – This unit consists of a Lower clastic member (shale, sandstone, sandy limestone) and an Upper limestone member. It overlies the Barenas Baito-Formation, Bayabas and Binangonan formations and the Sta. Ines Diorite and is conformably overlain by the Madlum Formation. The rocks are distributed in Angat River and Camachile River in Bulacan. The clastic member is made up of thin beds of calcareous shale and clayey sandstone with occasional lenses of sandy limestone while the limestone member is made up of a lower bedded reef-flank deposit and an upper biohermal mass. The unit is dated Early Miocene.

Madlum Formation – The Madlum Formation consists of a Lower Clastic member (sandstones, shale, conglomerate), the Middle Alagao Volcanics and the Upper Buenacop Limestone member. It is conformable over the Angat Formation.

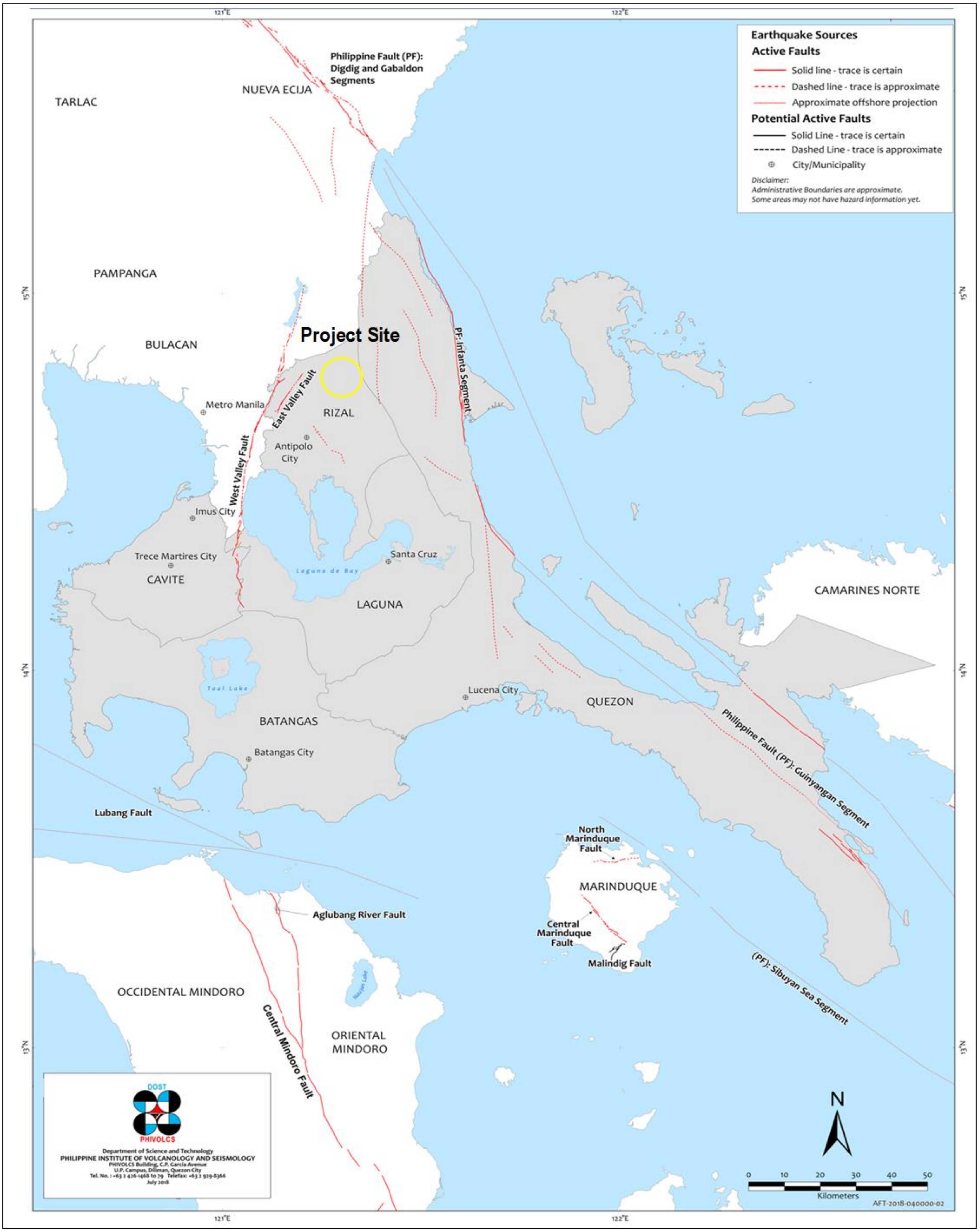

Figure EL-13. Location of active faults and trenches in Region IV-A

DATA INFORMATION/SOURCE:

Source Map: **PHIVOLCS (2018)**
Modified by: **Apercu Consultants Inc. (2020)**

ENVIRONMENTAL IMPACT STATEMENT
LAND MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

WawaJVCo INC.
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SCALE: 1: 1,000,000

The clastic member is extensively distributed in an almost continuously exposed belt between Angat and Penaranda Rivers and consist of a thick sequence of sandstone and silty shale with minor basal conglomerate and occasional limy sandstone interbeds. The Alagao Volcanics are exposed in Alagao, San Ildefonso, Bulacan and consist of a sequence of pyroclastic breccia, tuffs, argillites, indurated graywacke and andesite flows. The Buenacop Limestone is exposed in Barrio Buenacop, San Ildefonso, Bulacan and occurs as narrow discontinuous strips formed by a series of almost north-south aligned ridges and several small patches between Sta. Maria and Sumacbao Rivers. The limestone in the lower part is thin to medium bedded while the upper part is massive and cavernous. The formation is dated Middle Miocene.

Guadalupe Formation – The Guadalupe Formation consists of the Alat Conglomerate and the Diliman Tuff. It is unconformable over the Miocene rocks and distributed in Quezon City, Pasig, Makati, southern Rizal, eastern Bulacan and southeastern Nueva Ecija. The Alat Conglomerate consists of massive conglomerate, deeply weathered silty mudstone and tuffaceous sandstone that are exposed along Sapang Alat about 3km north of the Novaliches Reservoir. The Diliman Tuff is exposed in Diliman, Quezon City and in large portions of Makati, Pasig, Paranaque and nearby areas. It consists of volcanic ejecta with some amounts of tuffaceous, fine to medium-grained sandstone. It also underlies areas between Sta. Maria and Bulu rivers in Bulacan. Fossil plant leaves indicate a Pleistocene age for this formation.

Antipolo Basalt – This unit was named for the basalts exposed on the hills around Antipolo and in surrounding areas such as Binangonan, Morong, Angat-Novaliches area and Talim Island. The age of the basalt is believed to be Miocene although it could be as late as Pleistocene due to the low degree of erosion despite its location in an elevated plateau in the Antipolo hills. Remnants of wasting in the basalt terrain are manifested as scattered columns of basalts in Antipolo and vicinity, which suggests that the basalts were subjected to columnar jointing.

Figure EL-14 presents the stratigraphic column of northern and southern Sierra Madre.

The general area of the project site has rock outcrops belonging to the Kinabuan, Angat and Madlum Formations. These are discussed in detail in the section on Site Geology.

1.2.3 Geomorphology, Topography and Slope

The project site is located on the southern part of the Sierra Madre Mountains and borders the hills of Antipolo Plateau and shores of Laguna de Bay on the south, the mountainous coastal areas to the east, and the lower elevations of Metro Manila to the west. The project site is located along the narrow channels of the Wawa, Montalban, Tayabasan and Boso-Boso Rivers while the steep slopes of Mt. Purro are located to the east of the project site. The river channels are bounded by steep slopes except in areas where the two rivers converge and in areas with lower relief particularly on the adjoining hills. The steep slopes are sustained on the flanks of Mt. Purro but the terrain becomes gentler as the summit is approached.

The sub-river basins making up the Upper Marikina River Basin have narrow channels that are deeply incised into the surrounding hilly terrain, except Boso-Boso River that has a defined wide valley floodplain surrounded by the ridges of Antipolo, San Isidro and Binangonan-Baras. The Tayabasan, Wawa and Montalban Rivers converge at the junction located at the footslopes of Mt. Compananan and Mt. Tayabasan.

The channels of Tayabasan, similar to other tributaries of Wawa River, curve sharply around the hills and peaks and change direction abruptly in many places, which may indicate the possible presence of a geologic structure (Ramos, 2016). The overall relief of the channel is not very high with only 150m elevation difference between the Wawa Dam in Rodriguez, Rizal to its channel about 20km away before reaching the steep slopes of its headwaters to the east. Waterfalls and steep rapids are very rare along this river channel.

STRATIGRAPHY OF NORTHERN AND SOUTHERN SIERRA MADRE

PERIOD	EPOCH	STAGE	Ma	POLILIO GROUP OF IS.	BALER - PALANAN STRIP	SOUTHERN SIERRA MADRE
QUATERNARY	HOLOCENE				NORTHERN SIERRA MADRE	Quaternary Alluvium
			0.01			
	PLEISTOCENE					Guadalupe Formation
			1.80			
TERTIARY	PLIOCENE	2		Karlagan Formation		
			3.4			
		1				
			5.3			
	MIOCENE	3	6.7	Patnanongan Formation	Palanan Formation	
			10.4			
		2	14.2			Madlum Formation
			16.3	Langoyen Limestone	Kanaipang Limestone	
		1	21.5			Angat Formation
			23.0	Bordeos Formation	Disubini Formation	
	OLIGOCENE	2				Binangonan Formation
			29.3			
		1		Polillio Diorite		Antipolo Diorite
			36.5			
	EOCENE	3		Babacolan Formation		
			38.6			
		2	42.1			
				Anawan Formation		Maybangain Formation
			50.0			
		1				
			53.0			
	PALEOCENE	2		? ? ? ? ? ? ? ? ?		
			60.5			
		1				Kinabuan Formation
			65.0			
CRETACEOUS				Quidadanom Schist	Dibuakag Volcanic Complex	
			97.0			
				Buhang Point Meta-Ophiolite	Casiguran Ophiolite, Dibut Bay Meta-Ophiolite	Angat Ophiolite

Figure EL-14. Stratigraphic column of northern and southern Sierra Madre

DATA INFORMATION/SOURCE:

Source Map: Mines and Geo-sciences Bureau (MBG), 2004
Modified by: APERCU CONSULTANTS, INC (2020)

The project area has generally rugged topography set over the elevated terrain known as the Antipolo Plateau. The ridges and valleys generally trend northerly, creating an undulating landscape with elevations ranging from 100m in the valleys to around 600m on the ridges. The drainage systems generally flow westward and merge with other rivers as they discharge towards Manila Bay.

The elevation profile of the project site and vicinity is shown on **Figure EL-15**.

Figure EL-15. Elevation profile of project site and vicinity
Source: Google Earth, 2019

The proposed Wawa Bulk Water Supply Project will be located along Upper Wawa River, a tributary of the Marikina River System. The confluence of Tayabasan River, Wawa River, Montalban River and Boso-boso River is located upstream of the existing Wawa Dam. The hills and ridges south of the Montalban River are generally mid-altitude with elevations ranging from 250m to around 700m. Further north and east, the headwaters of Montalban and Tayabasan Rivers reach the peaks of the Southern Sierra Madre where elevations range from 800m to 1,300m and serve as boundaries of the watershed.

The topographic map of the project site is shown on **Figure PD-2** while the slope map is shown on **Figure EL-16**.

The geomorphology of the four sub-river basins making up the Upper Marikina River Basin is discussed below (AECOM, 2012).

1.2.3.1 Montalban Sub-river Basin

Mt. Irid (1,469 masl) and Mt. Domire (874 masl) form the eastern ridge boundary of the Montalban sub-river basin, while the western boundary is formed by the ridge at Mt. Puray that extend to the south towards Wawa River and Mt. Compananan (**Plate EL-3**). Montalban River is described as an actively eroding river as shown by the presence of pocket alluvial fans and deeply incised tributary channels in various sections bounding the ridges. The slopes of the ridges are steep to very steep. The river terraces are typically made up of boulder to gravelly material that grades into finer particles towards the depositional surface. Coarse sediment fragments mixed with finer particles along the river are indicative of active episodes of erosion and deposition during flooding events (AECOM, 2012).

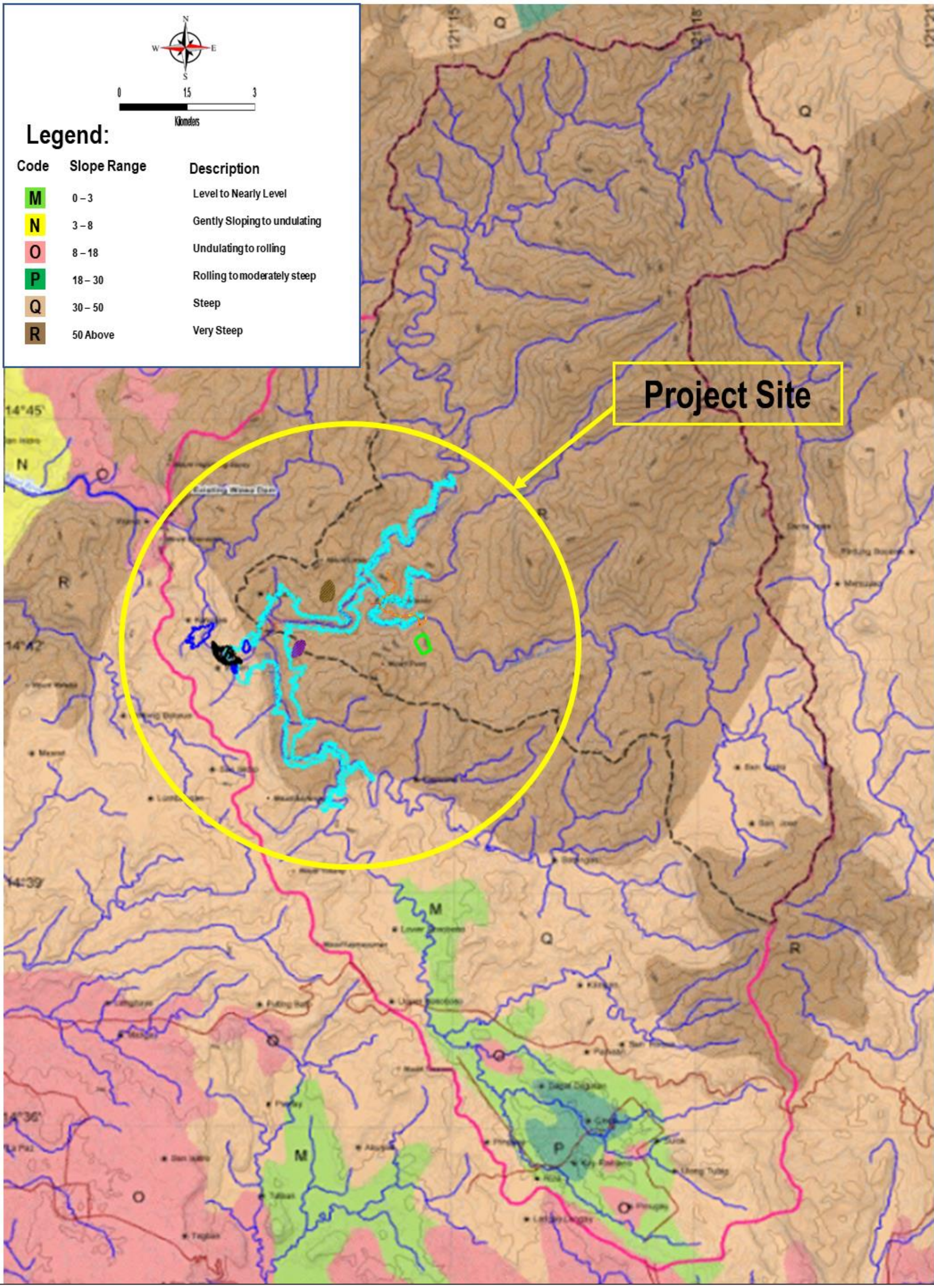

Figure EL-16. Slope map

ENVIRONMENTAL IMPACT STATEMENT
LAND MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

DATA INFORMATION/SOURCE:

Source Map: **NAMRIA (2020)**
Modified by: **Apercu Consultants Inc. (2020)**

WawaJVCo INC.
aperçu CONSULTANTS INC

SCALE: 1:130,000

Plate EL-3. View of Montalban River from the western divide
Source: AECOM 2012

1.2.3.2 Wawa Sub-river Basin

The Wawa subriver basin is bound on the north by the divide between Mt. Limila, the hills towards Mt. Puray and Mt. Compananan; on the west by Mt. Haponang Baboy; on the south by the divide beginning from the hills of Pintong Bukawe and the divide that separates Wawa river valley from the San Mateo subriver basin; and on the east by Mt. Compananan and Mt. Tayabasan, where the Wawa River joins the Montalban and Boso-Boso rivers. The Wawa subriver basin serves as the smallest catchment among the four subriver basins of the Upper Marikina River Basin. It also serves as principal collecting basin of the old Wawa Dam when it was operational until it was decommissioned in the 1970s. The slopes surrounding the Wawa subriver basin are moderately steep to very steep (see **Plate EL-4**) and appears to be affected by slope failure in some places (Aecom, 2012). Mass movement along the slopes is expected to occur during severe rainfall events as well as during strong earthquakes.

The narrow river valley traversed by Wawa River has pocket river terrace plains mostly located in the upstream section and occasionally submerged during flood events. Wider and relatively higher terraces occur within the two kilometre distance to Wawa Dam. The upper layers consist of sandy soil and tend to be gravelly at the deeper subsurface. Pebbly to gravelly particles make up the riverbed of the active river channel.

Plate EL-4. Slopes forming the west-northwest boundary of Wawa Sub-river Basin.
Source: AECOM, 2012

1.2.3.3 Tayabasan Sub-river Basin

The Tayabasan Sub-river Basin is bound on the northeast by Mt. Domire and the lower slopes of Mt. Irid, on the northwest by the divide shared by the Tayabasan and Montalban sub-river basins with Mt. Compananan as the highest peak (**Plate EL-5**), and on the west-northwest by Mt. Tayabsan (Aecom, 2012). The Tayabasan River provides the stream discharge to Wawa River with flows coming from the southern slopes of Mt. Domire and part of Mt. Irid. Most of the subriver basin is described as undulating with steep ridges and incised narrow upstream river channels and tributaries that tightly meander towards the lower section of the main Tayabasan River channel. The river basin widens at Sitio Apia in Barangay Calawis and pocket river terraces occur within the community center. Downstream of Sitio Apia, the subriver basin transitions into a narrow channel until its confluence with Montalban River.

Plate EL-5. Northwest boundary of Tayabasan sub-river basin shared with the southeastern boundary divide of Montalban sub-river basin.
Source: AECOM, 2012

1.2.3.4 Boso-Boso Sub-river Basin

The Boso-Boso subriver basin is bound on the northeast by the extensive range of Mt. Tayabasan, on the northwest by the hills of Sitio Casili extending towards the entire western divide marked by the extensive Antipolo Ridge, and on the east by the hills formed by the Binangonan Limestone. The subriver basin is drained by Boso-Boso River that originates from the southeast and flows northwesterly, passing the northwestern section of the valley where Sitios Cabading, Kaysakat, San Joseph and Tanza are located, and enters the undulating terrain of Sitio Binayoyo and Sitio Casili until it merges with Wawa River. Boso-Boso River has a typical meandering channel and evolves into an incised river valley as it reaches the undulating terrain of Sitio Binayoyo. Mainly fine-grained sediments are found in the upstream section while coarser sediments to large boulders are found as the river flows downstream.

1.2.4 Site Geology

The project site is located on rugged, mountainous terrain that is on the southern edge of the Sierra Madre Mountain Ranges where some of the older rocks of Luzon are found. The proposed dam site will be located along Wawa River which is the accepted nomenclature after the northwest-trending Boso-Boso River merges with the west-southwest trending Montalban-Sapa Bute-Bute-Tayabasan Rivers. This river system becomes the west-trending Marikina River about 20km downstream.

The region where the project site is located is experiencing ongoing geologic processes such as faulting, erosion and a small degree of tectonic deformation. The subduction process along the Manila Trench on the west offshore of Zambales and the subduction along the East Luzon Trough offshore of Aurora Province are considered unrelated to the origin of rocks in the area.

The proposed Upper Wawa Dam is underlain by Madlum Formation that consists of a lower clastic member (sandstone, shale and conglomerate), middle volcanic/pyroclastic member (breccias, tuff, argillite, indurated greywacke and andesite flows), and upper carbonate member (limestone). Outcrops of the lower clastic member were observed in the project site and vicinity. Clastic rocks in the proposed dam site along Wawa River include sandstone, siltstone/shale and conglomerates. Along Boso-Boso river located southeast of the dam site, outcrops of thickly bedded to massive conglomerates and sandstone-siltstone alternations belonging to the Madlum Formation are found while outcrops of rocks belonging to Kinabuan Formation and Angat Formation are found along Tayabasan River located northeast of the dam site.

Figure EL-17 shows the geologic map of the Montalban Quadrangle while **Plate EL-6** shows representative photographs of rock units observed in the vicinity of the proposed dam site. A brief description of the geology in the location of the proposed project structures is provided in succeeding sections.

Plate EL-6. Sandstone outcrops were observed on the slopes adjoining the riverbanks (a, b) while alluvial materials capping these rocks were observed on the riverside & riverbed (c, d).

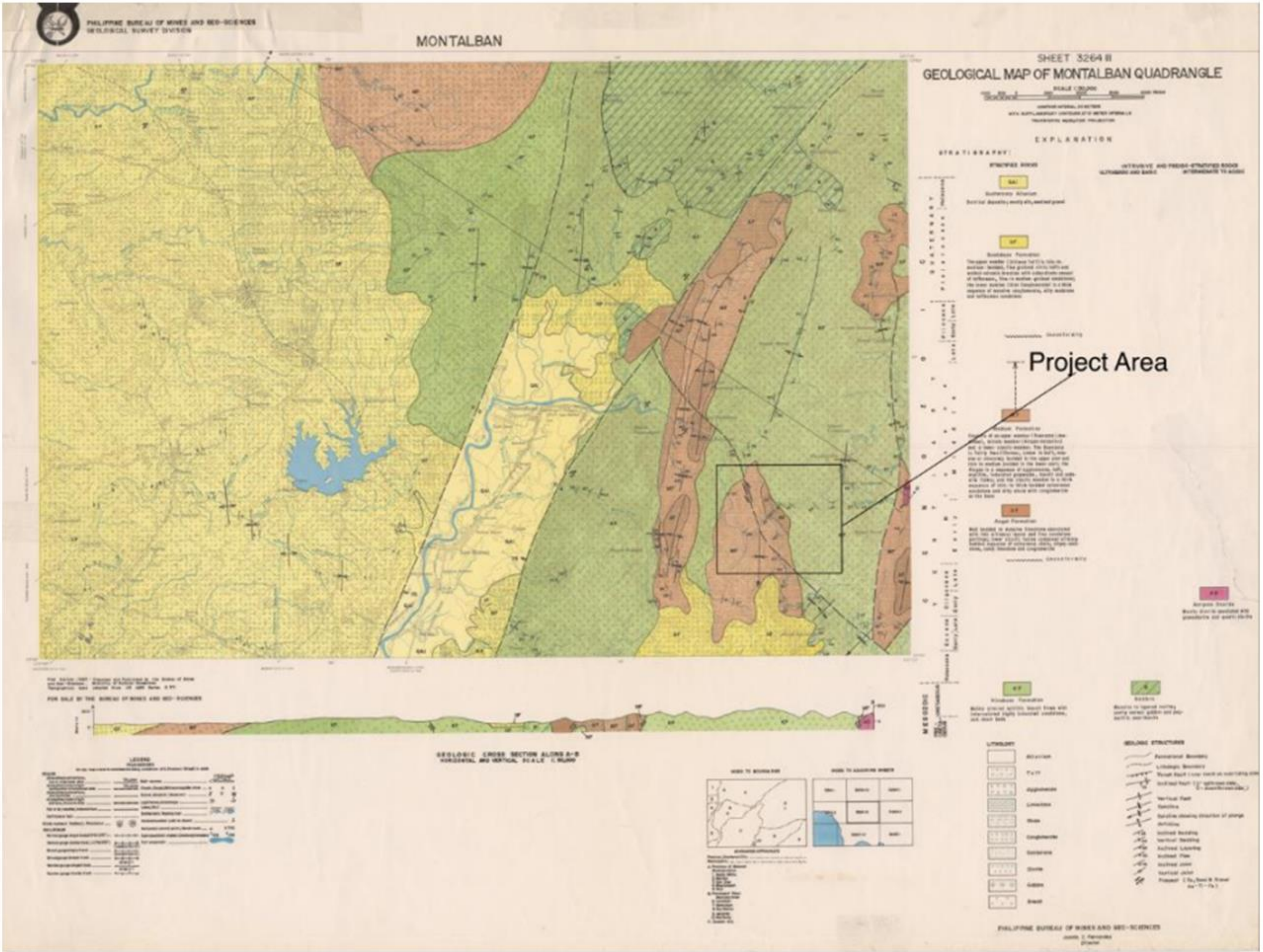

Figure EL-17. Geologic map of the general vicinity of Wawa Basin.	**DATA INFORMATION/SOURCE:** **Source Map:** Prime Infra (2020) **Modified by:** Apercu Consultants, Inc. (2020)	**WawaJVCo INC.** aperçu CONSULTANTS INC.
ENVIRONMENTAL IMPACT STATEMENT **LAND MODULE** **Wawa Bulk Water Supply Project – Upper Wawa Dam**		**SCALE: Not to Scale** / **PAGE 97**

1.2.4.1 Geology at the Dam, Spillway and Diversion Tunnel Area in Upper Wawa River

The proposed dam structure will be set across a relatively narrow gorge of Wawa River **(Figure EL-18).** The slopes on both sides of the valley are generally steep at about 45-50 degrees from the horizontal while the riverbed elevation is about 61m asl. The left side or left abutment is part of a small ridge with peak elevation at 375m while the right abutment is part of a bigger ridge that has an intermediate peak at 200m and continues to rise north-eastward until it reaches Mt. Limila at 542m, Mt. Compananan at 590m and Mt. Malemod at 606m.

The proposed dam shall be founded on sedimentary bedrock predominantly consisting of sandstone with interbedded siltstone/shale and mudstone and occasional conglomerate layers (**Figure EL-19, Figure EL-20 and Figure EL-21**). The color of the sedimentary rocks ranges from light gray to dark gray/black. The sandstone on the riverbank looks like basalt at first glance due to spheroidal weathering. The observed rocks are slightly weathered, slightly jointed, and medium hard to hard as a whole. These rocks are considered good to very good anchorage materials (SMEC, 2019). Optical and acoustic scanning in boreholes at the dam site indicates good Rock Quality Designation that is greater than 75 (Tractebel, 2019). Soil cover in the dam site ranges from 0.95-9.5m and consists of silty sands and sandy, clayey silts. The soil cover consists of loose angular to subrounded rock blocks at the slopes. The soil layer will be removed including the underlying broken rock fragments since the dam foundation will be on competent bedrock at 20m depth.

Figure EL-18. Proposed dam site facing downstream with the axis indicated by the red line
Source: SMEC, 2019

The soil cover at the inlet and outlet structures of Diversion Tunnel 1 is about 4-8m thick and consists of sandy gravels, clayey silts, and silty clays. Mudstone, sandstone, and local conglomerates are found along the tunnel alignment. Soil cover at Diversion Tunnel 2 is about 2-8m thick and underlain with bedrock consisting of mudstone, sandstone, and local conglomerates. The mudstones have alternating sequences with the sandstones. Moderately to highly weathered rock are found in the upper sections of the bedrock. Tunnel excavation is expected to be done primarily on fresh to slightly weathered rock.

The spillway will be located on the right bank of Wawa River. The hills in the spillway area are covered by dense vegetation and rocky outcrops are rare. The bedrock is generally covered by colluvial deposits or highly weathered rocks. The bedrock in the spillway area consists of sandstone and mudstone with some conglomerate. The sandstone sometimes exhibits alternating sequences with the mudstone. Soil cover ranges from 2.95m to 5.9m and consists of silty sands and clayey silts underlain by sandstones and mudstones.

Permeability tests conducted in the boreholes along the dam site, diversion tunnel and spillway location indicate that the rock mass can be regarded as low permeable in many sections and will thus require low grout volume when using standard grouting techniques (Tractebel, 2019).

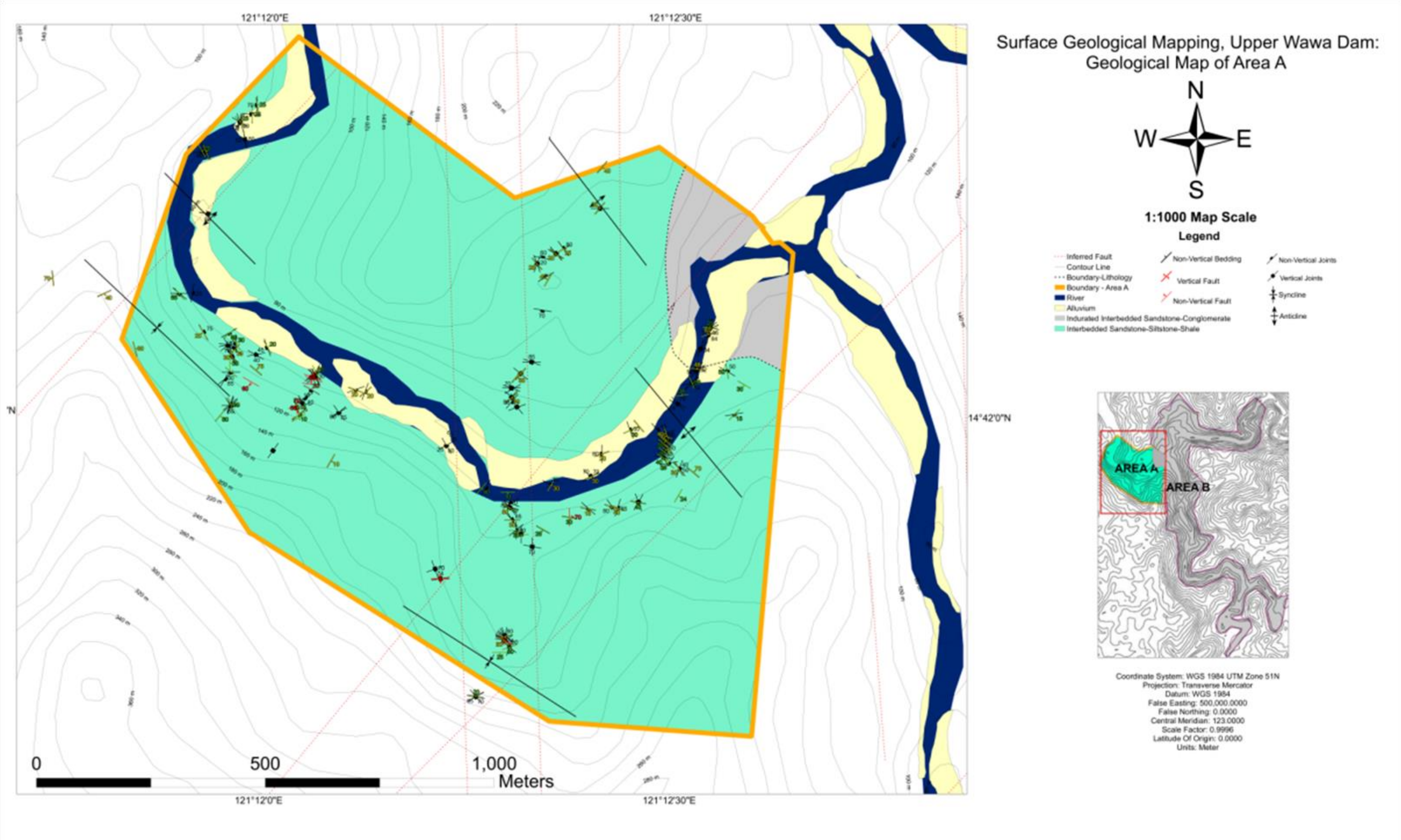

Figure EL-19. Geologic map of Upper Wawa Dam Area	**DATA INFORMATION/SOURCE:**	**WawaJVCo INC.** apercu CONSULTANTS INC.
ENVIRONMENTAL IMPACT STATEMENT **LAND MODULE** **Wawa Bulk Water Supply Project – Upper Wawa Dam**	**Source Map:** Prime Infra (2020) **Created by:** Apercu Consultants, Inc. (2020)	**SCALE: 1:1,000** **PAGE 99**

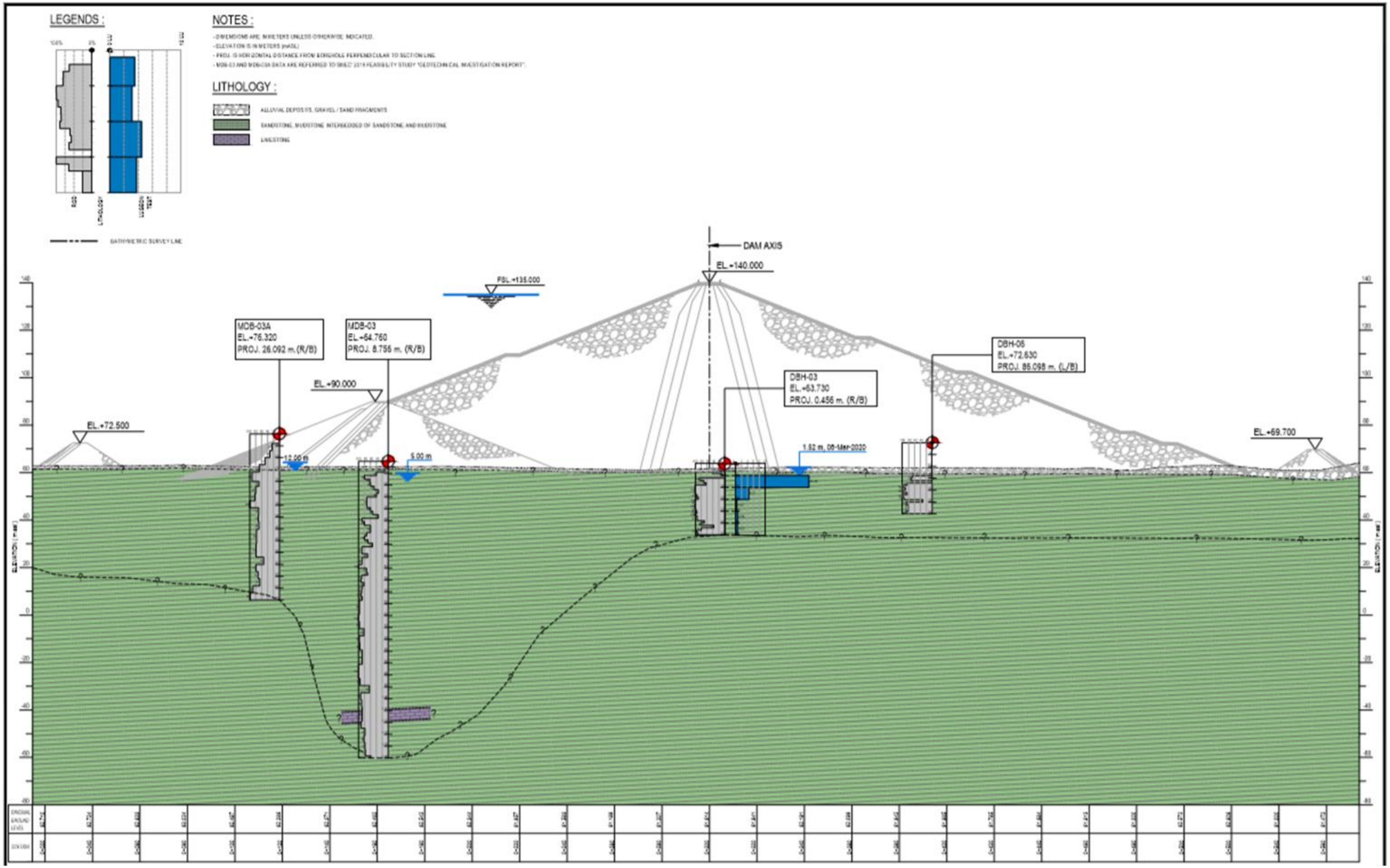

Figure EL-20. Geological cross section at the proposed dam site

ENVIRONMENTAL IMPACT STATEMENT
LAND MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

DATA INFORMATION/SOURCE:

Source Map: Tractebel (2019)
Modified by: Apercu Consultants, Inc. (2020)

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SCALE: Not to Scale

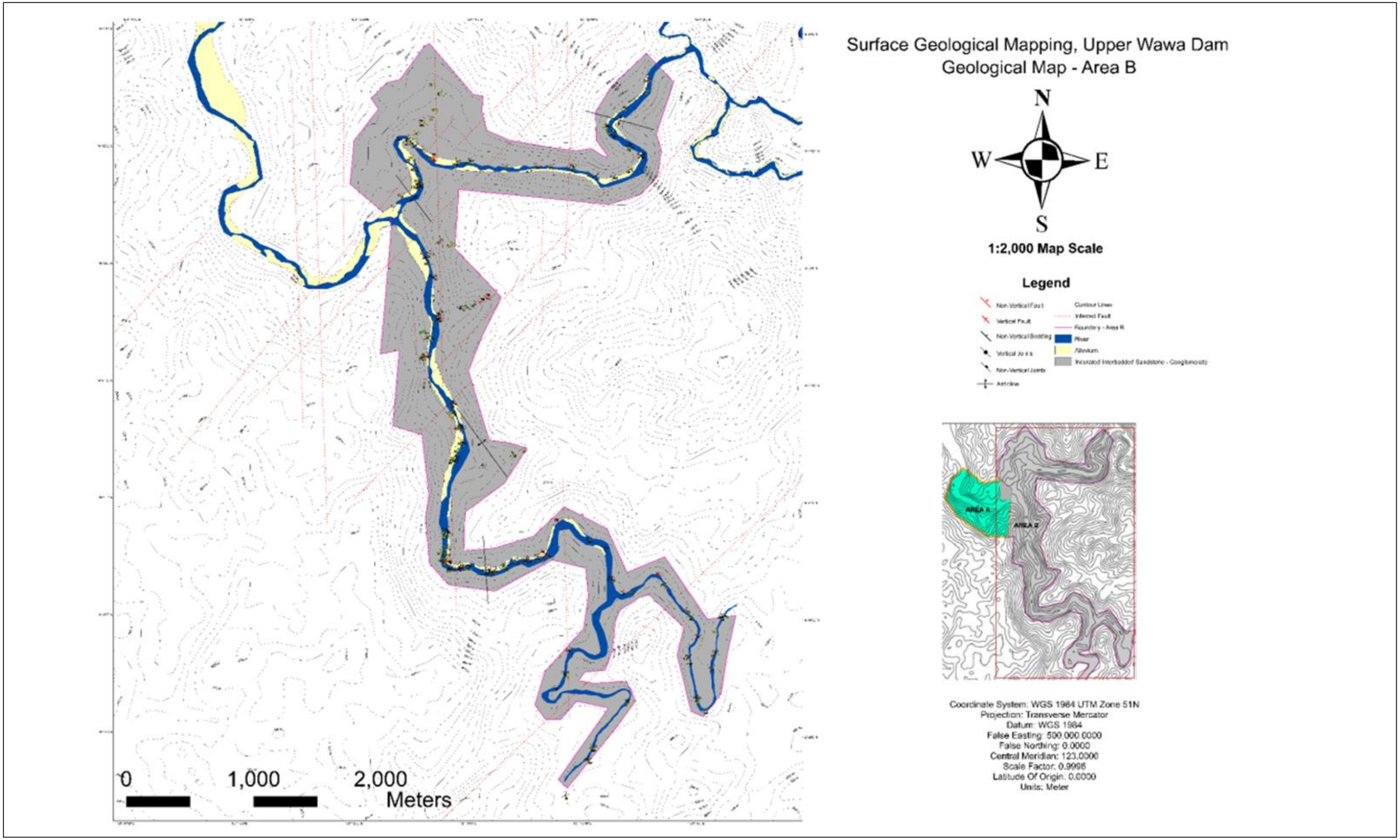


Figure EL-21. Geologic map of areas along Boso Boso and Tayabasan Rivers

ENVIRONMENTAL IMPACT STATEMENT
LAND MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

DATA INFORMATION/SOURCE:

Source Map: Prime Infra (2020)
Modified by: Apercu Consultants, Inc. (2020)

1.2.4.2 Geology at the Reservoir Site

The reservoir has a maximum crest elevation of 151m with the tailwater extending to about 10km upstream of the dam site. Riverbanks in the reservoir area are mostly underlain by intercalated rocks of volcanic/pyroclastic origin and few meta-sedimentary rocks belonging to the Madlum Formation and Kinabuan Formation of Miocene and Cretaceous age, respectively (SMEC, 2019). However, the tailend of the reservoir may reach part of the Guadalupe Formation upstream of Boso-Boso River (SMEC, 2019). A local fault runs almost parallel to Wawa River on its right flank and intersects it about 2km upstream near Sitio Casili and farther upstream of Boso-Boso River. This structure is known as the Montalban Fault and its seismic behaviour and probable intensity is known at present. Additionally, this structure is not expected to be a conduit of subterranean flow since it is blocked by massive, continuous and practically impervious walls of rock (SMEC, 2019).

1.2.4.3 Geology in areas along Tayabasan and Boso-Boso Rivers

This area consists predominantly of clastic sedimentary rocks such as conglomerates and sandstone-siltstone alternations that are moderately to heavily jointed (**Plate EL-7**). The sandstone occurs as thin to thick beds and alternated with siltstones. The sandstones are heavily jointed and fractured with infillings of either calcite or quartz (Prime Infra, 2020). Siltstone and shale frequently occur with sandstone as interbeds. Conglomerates were also observed to be interbedded with sandstones and are thickly bedded to massive, very hard and indurated. The conglomerates are believed to overlie the pillow basalts along Tayabasan River (Pena, 2008).

Plate EL-7. Outcrops of sandstone (left) and conglomerates (right) along Tayabasan and Boso Boso Rivers
Source: Prime Infra, 2020

1.2.4.4 Results of Subsurface Investigation

The project proponent commissioned ESH Drilling Services to conduct geotechnical investigation at the proposed locations of project structures from December 2019 to June 2020 and RDCL to conduct borehole scanning, quality control and reporting. A total of 20 boreholes were drilled at these locations:

- Seven within the dam site (DBH)
- Seven within the tunnel site (TBH)
- Two within the spillway site (SBH)
- Two within the quarry site (QBH)
- Two within the pumping station site (PBH)

Table EL-11 presents the list of rocks encountered at the boreholes while the location of the boreholes was shown in **Figure PD-23**. As maybe gleaned from the table, rocks in the project site generally consist of sandstone, mudstone, siltstone and conglomerate with some interbeds of sandstone-mudstone and sandstone-siltstone.

Table EL-11
Rocks encountered at the boreholes drilled in various sites within the project site

Borehole ID	Borehole depth (m)	Subsurface description
DBH-01	80	Soils with low plasticity encountered until 1.9m depth; Layers of (1) sandstone and siltstone, (2) interbeds of sandstone and mudstone, (3) sandstone, (4) mudstone, (5) conglomerate below the soil
DBH-02	70	10m thick strong soil that is a mixture of weathering products of sandstone, siltstone, mudstone and minor conglomerate; Layers of moderately weathered conglomerate, slightly weathered sandstone, slightly weathered mudstone and interbeds of sandstone and mudstone encountered at depth.
DBH-03	30	1.7m thick soil layer consists of silty sand with some gravel; Layers of sandstone and sandstone-mudstone interbeds were encountered at depth
DBH-04	70	Soil layer is 1m thick and consists of silty sand with traces of gravel and clay; Layers of sandstone, mudstone, conglomerate, and interbeds of sandstone and mudstone were encountered at depth
DBH-05	80	6m thick soil layer consists of sandy silt with minor clay and traces of gravel and clayey silt with minor sand; Layers of mudstone, interbeds of sandstone and mudstone, sandstone, and conglomerate were encountered at depth
DBH-06	30	12m soil layer consists of silty sand with gravel, sandy gravel with silt and clay silty sand with gravel and some clay, and clayey silt with high amounts of fine medium sand; Layers of sandstone and mudstone were encountered below the soils
DBH-07	30	Soils consist of 4.5m thick layer of silty sand with clay and gravel and 0.7m thick sandy gravel with residual soil; Sandstone and sandstone with siltstone were found below the soils
PBH-01	40	Soils consist of 1m thick layer of medium grained sand with traces of clay; Sandstone and mudstone were encountered at depth
PBH-02	40	Soils consist of about 8m alternating layers of clayey sand and silty sand; Sandstone, mudstone and sandstone-mudstone interbeds were found below
QBH-01	30	Soils consist of 9m thick layers of sandy clay, silty clay and clayey silt; Moderately weathered sandstone encountered at depth
QBH-02	80	Soils consist of 3m thick layer of clayey silt with traces of sand and sandy silt with traces of gravel; Sandstone, interbeds of sandstone and mudstone, and mudstone were encountered at depth
SBH-01	90	Soils consist of 5m thick layer of silty sand with some gravel and traces of clay and clayey silt with minor sand; Bedrock consists of interbeds of sandstone and mudstone, sandstone, mudstone, conglomerate
SBH-02	50	Soils consist of 5.8m thick layers of silty sand with some gravel and traces of clay and gravelly sand; Underlying rocks consist of sandstone and siltstone
TBH-01	80	Soils consist of 4m thick alternating layers of silty sand with minor clay and clayey sand with traces of silt and gravel; Underlying rocks consist of sandstone with minor conglomerate
TBH-02	60	Soils are 4m thick and consist of clayey silt with some clay and traces of sand and gravel and silty clay with traces of gravel and some sand; Rocks include sandstone with siltstone and mudstone, and layers of conglomerate, sandstone, mudstone, interbeds of mudstone and sandstone
TBH-03	40	Soils are about 8m thick and consist of clayey silt with sand, gravel with sand, silt and clay; Underlying rocks consist of sandstone, mudstone, conglomerate and some interbeds of sandstone-mudstone and sandstone-siltstone
TBH-04	40	Soils are 8m thick and consist of layers of clayey sand with minor silt and traces of gravel, silty clay with minor sand and traces of fine-grained gravel, and silty sand with some clay; Rocks consist of sandstone and mudstone

Borehole ID	Borehole depth (m)	Subsurface description
TBH-05	110	Soils are 5m thick and consist of layers of sandy silt with minor clay and traces of gravel, clayey silt with minor sand, sandy silt and sand with traces of clay; Underlying bedrock consist of sandstone, interbeds of sandstone and mudstone, mudstone, and conglomerate
TBH-06	60	Sandy gravels with silt and residual soil, non-plastic and blocky
TBH-07	60	About 4m thick soil layer consists of clayey silt with high amounts of sand, and sandy fine to boulder sized gravel with mix of highly weathered and fresh volcanics; Underlying rocks consist of sandstone, interbeds of sandstone and mudstone, mudstone, and conglomerate

Source: RDCL (2020)

1.2.5 Geologic Hazards

The geologic hazards discussed in this section include seismic hazards, volcanic hazards, mass movement hazards and flooding or hydrologic hazards.

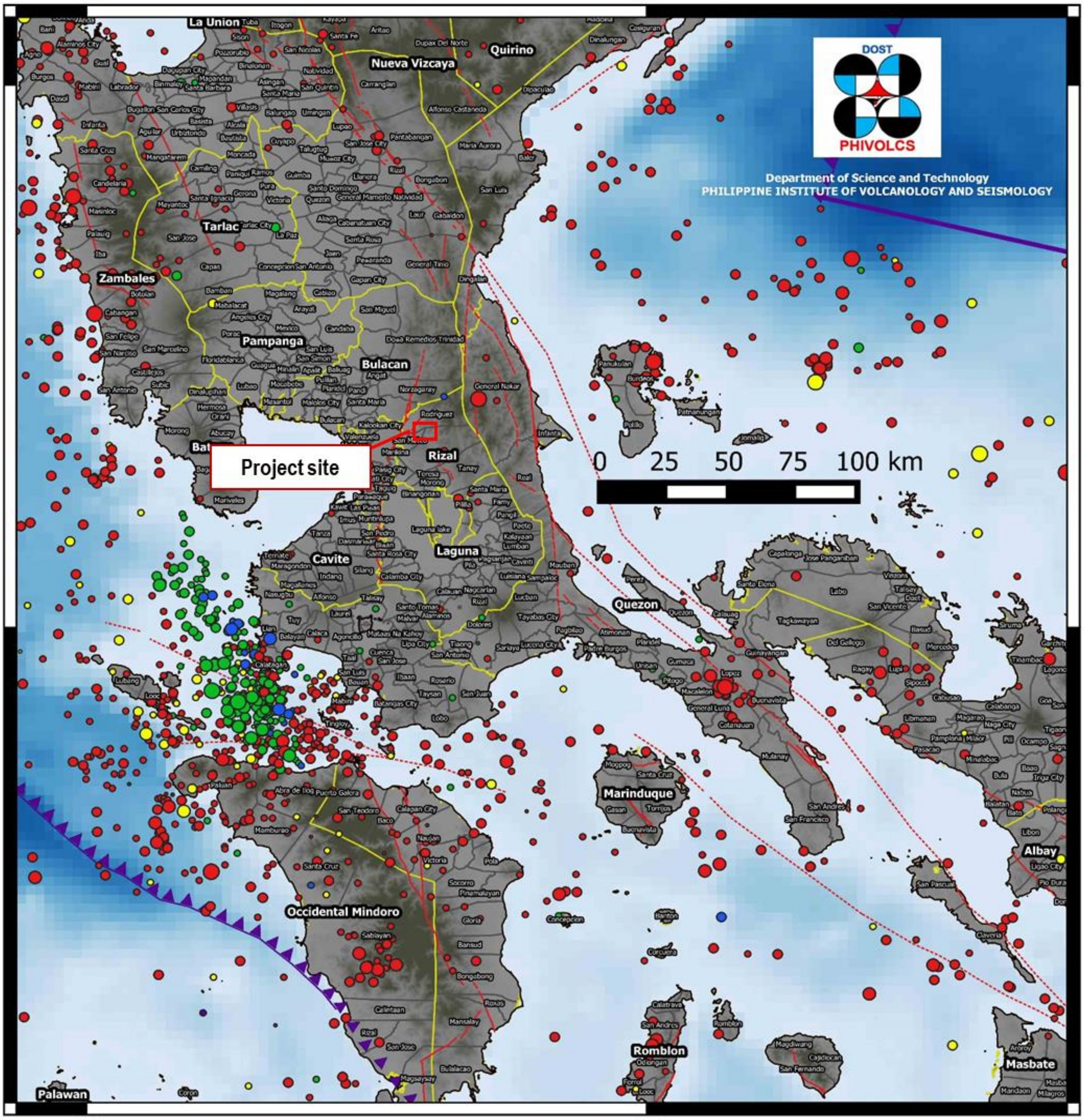
1.2.5.1 Seismic Hazards

Seismic hazard is the probability that an earthquake will occur and is determined by the presence of active geologic structures such as faults and trenches in a geographic region. Earthquake hazards include ground shaking, tsunami, landslides and rockfalls, subsidence, and liquefaction. Seismicity map of Region IV-A in 2016 (**Figure EL-22**) shows the distribution of earthquake events and the most seismically active regions in the country, such as the eastern shores of Mindanao and northwestern Luzon which are influenced by the subduction processes along the Philippine Trench and Manila Trench, respectively. Other seismically active zones are areas along the Philippine Fault Zone where most of the shallow to moderate depth, low to high magnitude earthquakes occurred. **Figure EL-23** shows the distance of the project site to the nearest active fault based on the PHIVOLCS fault finder web application. As shown on the map, the East Valley Fault is located about 5.3 km from the proposed dam site while the West Valley Fault is located about 10km west of the dam site.

The distance of the project site to major geologic structures is summarized below. It may be gleaned from the table that the project site is located about 5.3km southeast of the East Valley Fault while the Infanta Fault segment of the Philippine Fault Zone is located about 46km northeast of the project site (**Table EL-12**).

Table EL-12
Distance of Project Site to Potential Seismic Generators

Earthquake-causing Structure	Potential Maximum Earthquake Magnitude	Distance to Project Site (km)
Philippine Fault	8.6	46
Manila Trench	8.2	180
Lubang Fault	7.5	140
Casiguran Fault	7.3	115
East Valley Fault	6.2	5.3
West Valley Fault	7.6	10



Legend

Earthquake Sources

Active Faults

- Solid Line - Certain
- Dashed Line - Approximate
- Approximate offshore projection
- Transform Fault

Depth

- 0 - 35
- 35 - 70
- 70 - 150
- 150 - 350
- 350 - 800

Magnitude

- 7
- 6
- 5
- 4
- 3
- 2
- 1

Convergence Zone

- Trench
- Collision Zone

Figure EL-22. Seismicity map of Region IV-A	DATA INFORMATION/SOURCE:	WawaJVCo INC. / apercu CONSULTANTS INC.	
ENVIRONMENTAL IMPACT STATEMENT LAND MODULE Wawa Bulk Water Supply Project – Upper Wawa Dam	Source Map: **DOST-PHIVOLCS (2016)** Modified by: **Apercu Consultants Inc. (2020)**	SCALE: 1:1,000,000	PAGE 105

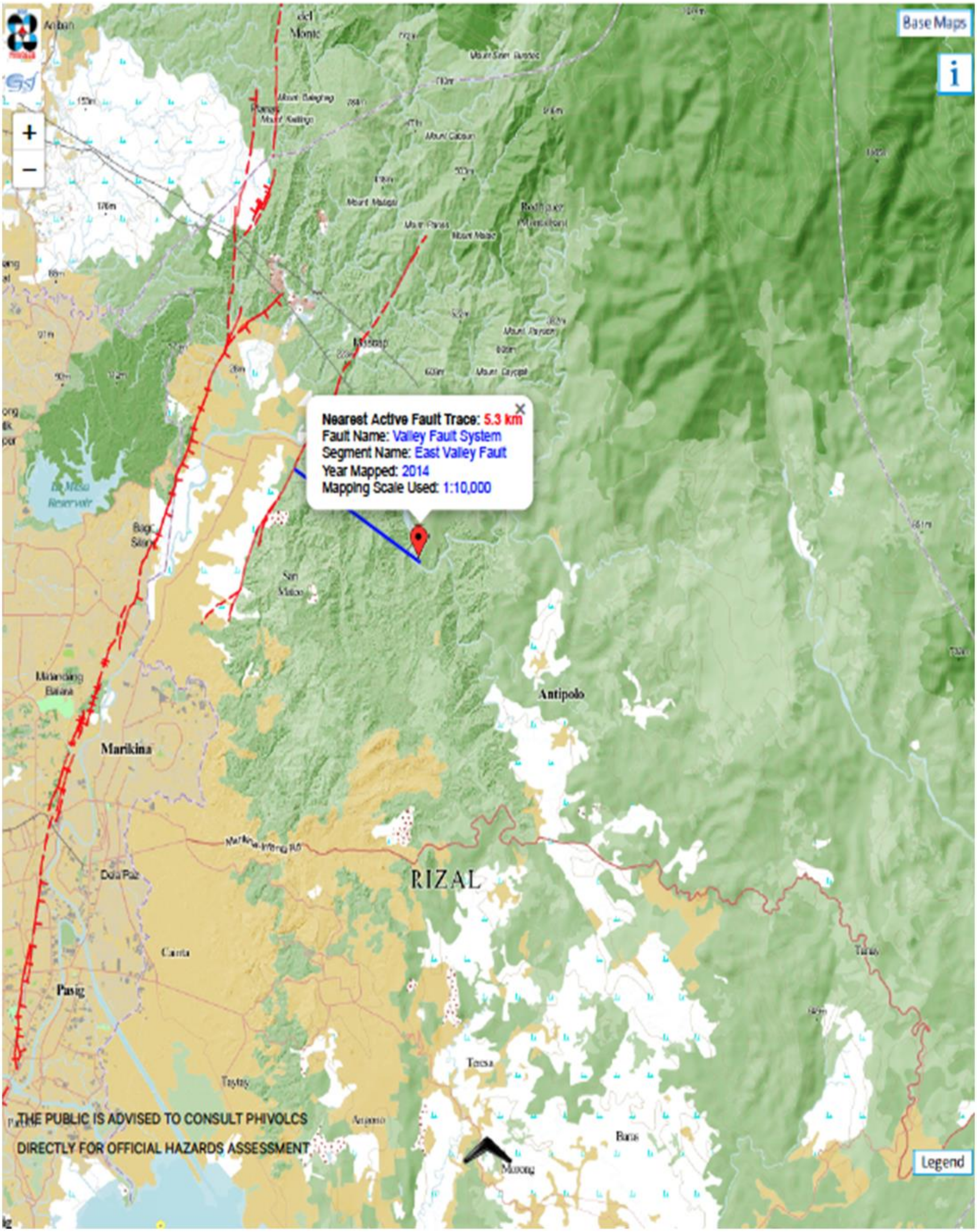


Figure EL-23. Approximate distance of nearest active fault to the project site	DATA INFORMATION/SOURCE:	WawaJVCo INC. aperçu CONSULTANTS INC.
ENVIRONMENTAL IMPACT STATEMENT LAND MODULE Wawa Bulk Water Supply Project – Upper Wawa Dam	Source Map: **DOST-PHIVOLCS (2014)** Modified by: **Apercu Consultants Inc. (2020)**	SCALE: 1:10,000 — PAGE 106

Ground Shaking and Acceleration

Ground shaking is the most familiar effect of earthquakes and is the result of the passage of seismic waves through the ground. Strong ground shaking can result to damage or destruction of buildings and other structures. Ground shaking is expressed in terms of peak ground acceleration (PGA), which is an important parameter for earthquake engineering. Thenhaus et. al. (1994) provided the probabilistic zonation maps of estimated PGA values for various soil and rock conditions in the Philippines. The PGA maps developed by Thenhaus et al (1994) indicate that peak horizontal accelerations in the project site will be around 0.7g for soft soil (**Figure EL-24**), 0.4g for medium soil (**Figure EL-25**), and 0.2g for rock conditions (**Figure EL-26**).

Table EL-13 presents the various earthquake intensity scales (Philippine Earthquake Intensity Scale (PEIS), Modified Mercalli, and United States Geologic Survey (USGS) earthquake intensity scale) in relation to PGA values, perceived shaking and potential earthquake damage. It may be gleaned from **Table EL-13** that the expected PEIS equivalent of ground shaking on soft soil will be Intensity IX while that for medium soil and rock will be Intensity VIII and Intensity VII, respectively. The site is expected to experience moderate to heavy damage during strong earthquakes.

Table EL-13
Various Intensity Scales in Relation to Acceleration, Ground Shaking and Potential Damage

PEIS	Modified Mercalli	USGS	Acceleration (g)	Perceived Shaking	Potential Damage
I	I	I	<0.0017	Not felt	None
II	II	II-III	0.0017 – 0.014	Weak	None
III	III				None
IV	IV	IV	0.014 – 0.039	Light	None
V	V	V	0.039 – 0.092	Moderate	Very light
VI	VI	VI	0.092 – 0.18	Strong	Light
VII	VII	VII	0.18 – 0.34	Very strong	Moderate
VIII	VIII, IX	VIII	0.34 – 0.65	Severe	Moderate to heavy
IX	X, XI	IX	0.65 – 1.24	Violent	Heavy
X	XII	X+	>1.24	Extreme	Very heavy

Probabilistic estimates of peak ground acceleration (PGA) values in the project site presented in Fugro (2019)[3] are provided in **Table EL-14**. Estimated PGA values range from 0.3g to 0.62g with an average of 0.4g.

Figure EL-27 is a PGA map of the Philippines for a 500-year return period (i.e., probability of exceedance in 50 years).

Table EL-14
Probabilistic Estimates of Peak Ground Acceleration Values in the Upper Wawa Dam Site

Study / Author	Year	Return Period (yrs)	PGA Estimate
Global Seismic Hazard Assessment Program	1992 - 1999	475	0.3 to 0.4g
Wong et al.	2007	475	0.62g
Koo et al.	2009	475	0.4g
Philippines Earthquake Model	2017	500	0.4g
Global Earthquake Model	2018	475	0.35 to 0,55g

Source: Fugro (2019)

[3] Fugro, 2019. Site Specific Seismic Hazard Assessment for the Upper Wawa Dam Project.

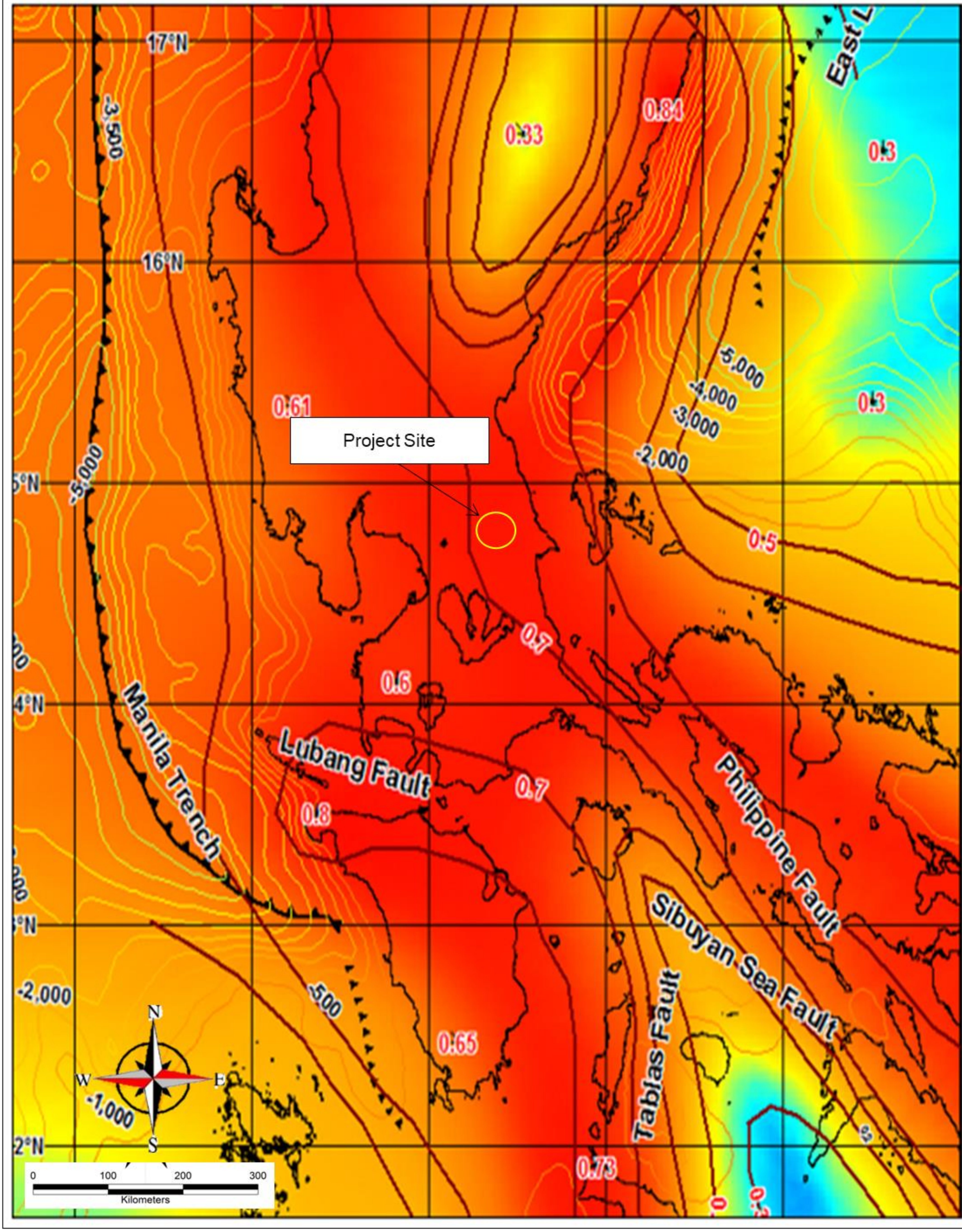


Figure EL-24. PGA Map for the soft soil conditions	DATA INFORMATION/SOURCE:	WawaJVCo INC. apercu CONSULTANTS INC.
ENVIRONMENTAL IMPACT STATEMENT LAND MODULE Wawa Bulk Water Supply Project – Upper Wawa Dam	Source Map: **Thenhaus et. Al, 1994** Modified by: **Apercu Consultants Inc (2020)**	SCALE: Not to Scale / PAGE 108

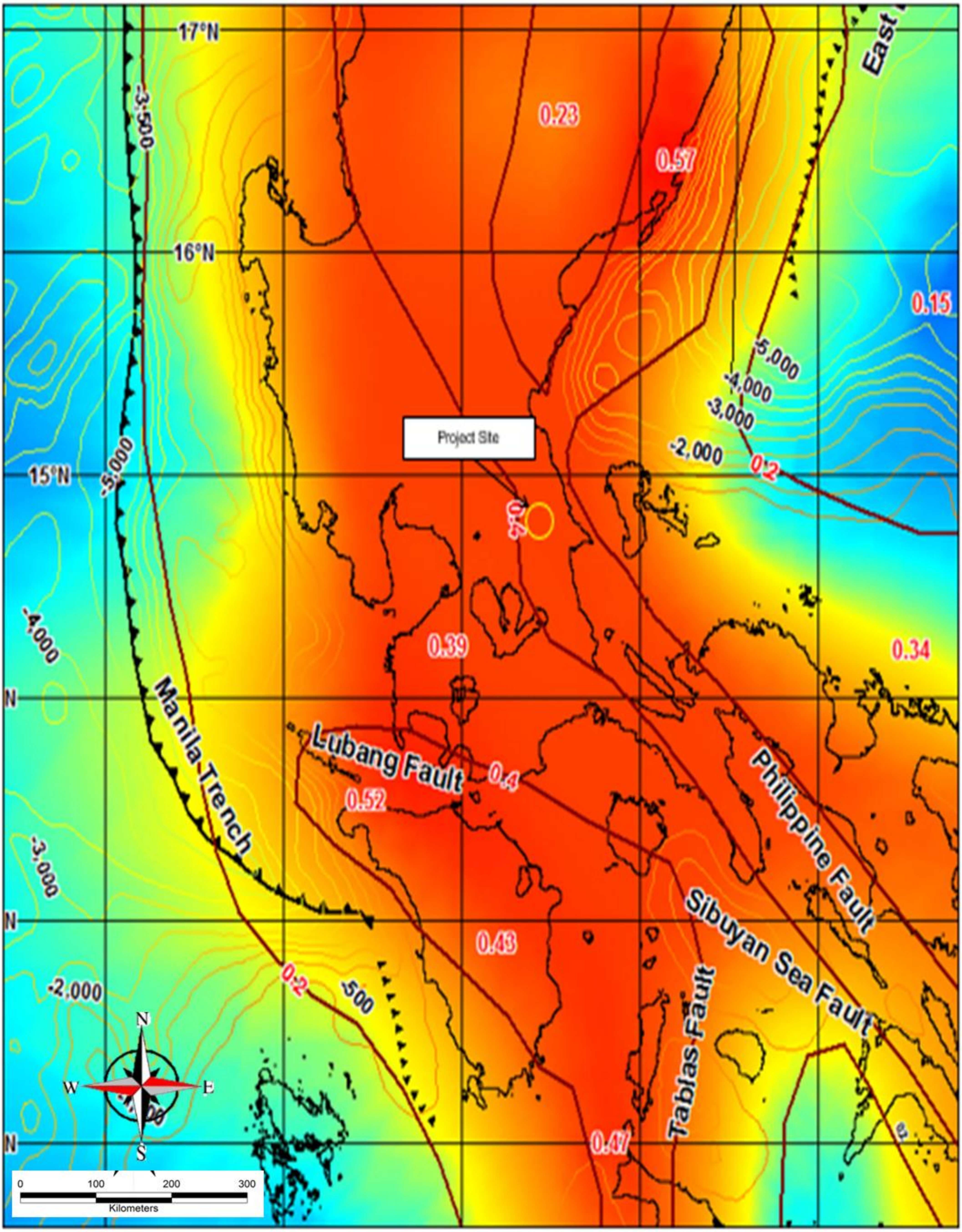


Figure EL-25. PGA Map for Medium Soil Conditions

ENVIRONMENTAL IMPACT STATEMENT
LAND MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

DATA INFORMATION/SOURCE:

Source Map: **Thenhaus et. Al, 1994**
Modified by: **Apercu Consultants Inc (2020)**

WawaJVCo INC.
aperçu CONSULTANTS INC.

SCALE: Not to Scale

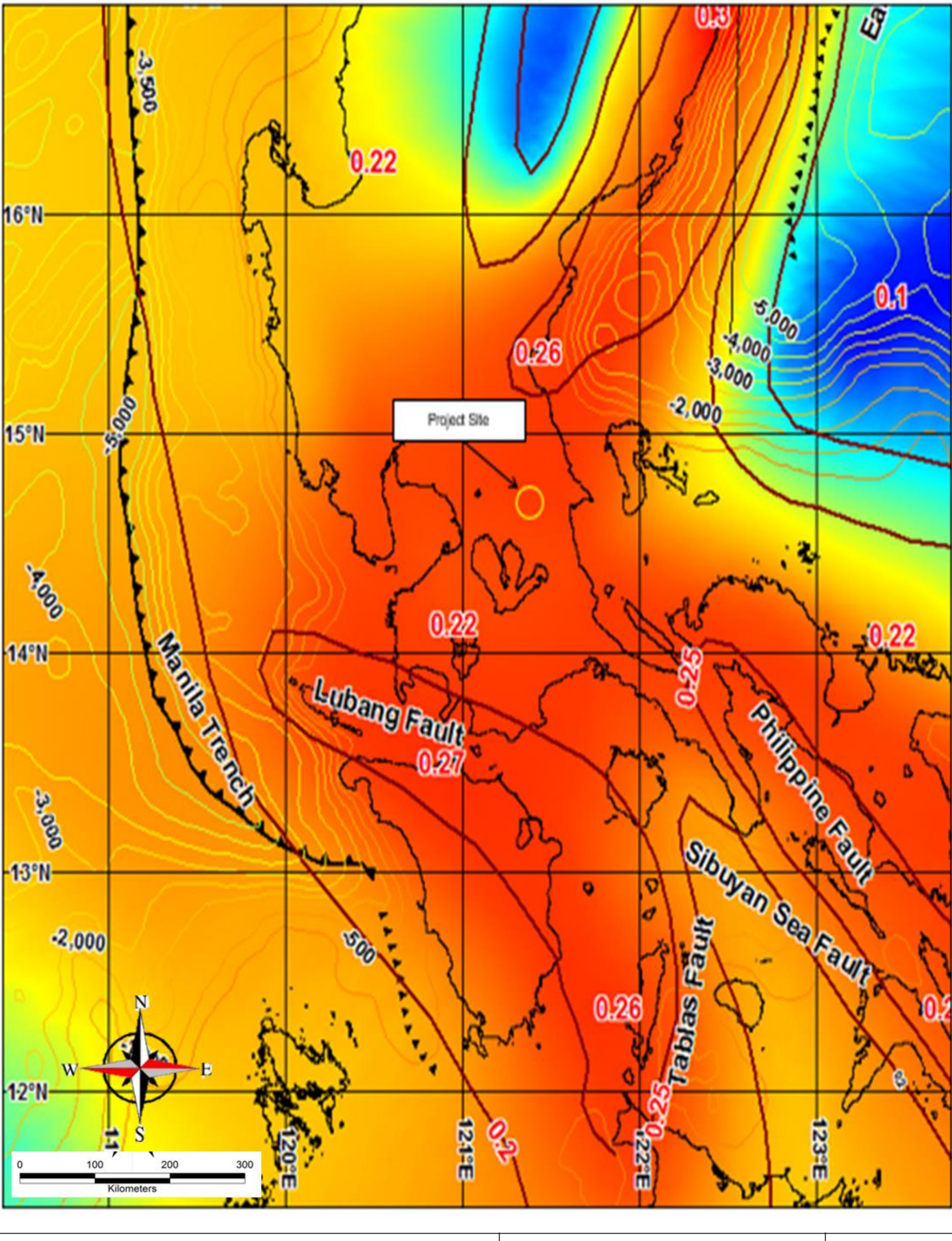


Figure EL-26. PGA Map for rock conditions	DATA INFORMATION/SOURCE:	WawaJVCo INC. aperçu CONSULTANTS INC.	
ENVIRONMENTAL IMPACT STATEMENT LAND MODULE Wawa Bulk Water Supply Project – Upper Wawa Dam	Source Map: **Thenhaus et. Al, 1994** Modified by: **Apercu Consultants Inc (2020)**	SCALE: Not to Scale	PAGE 110

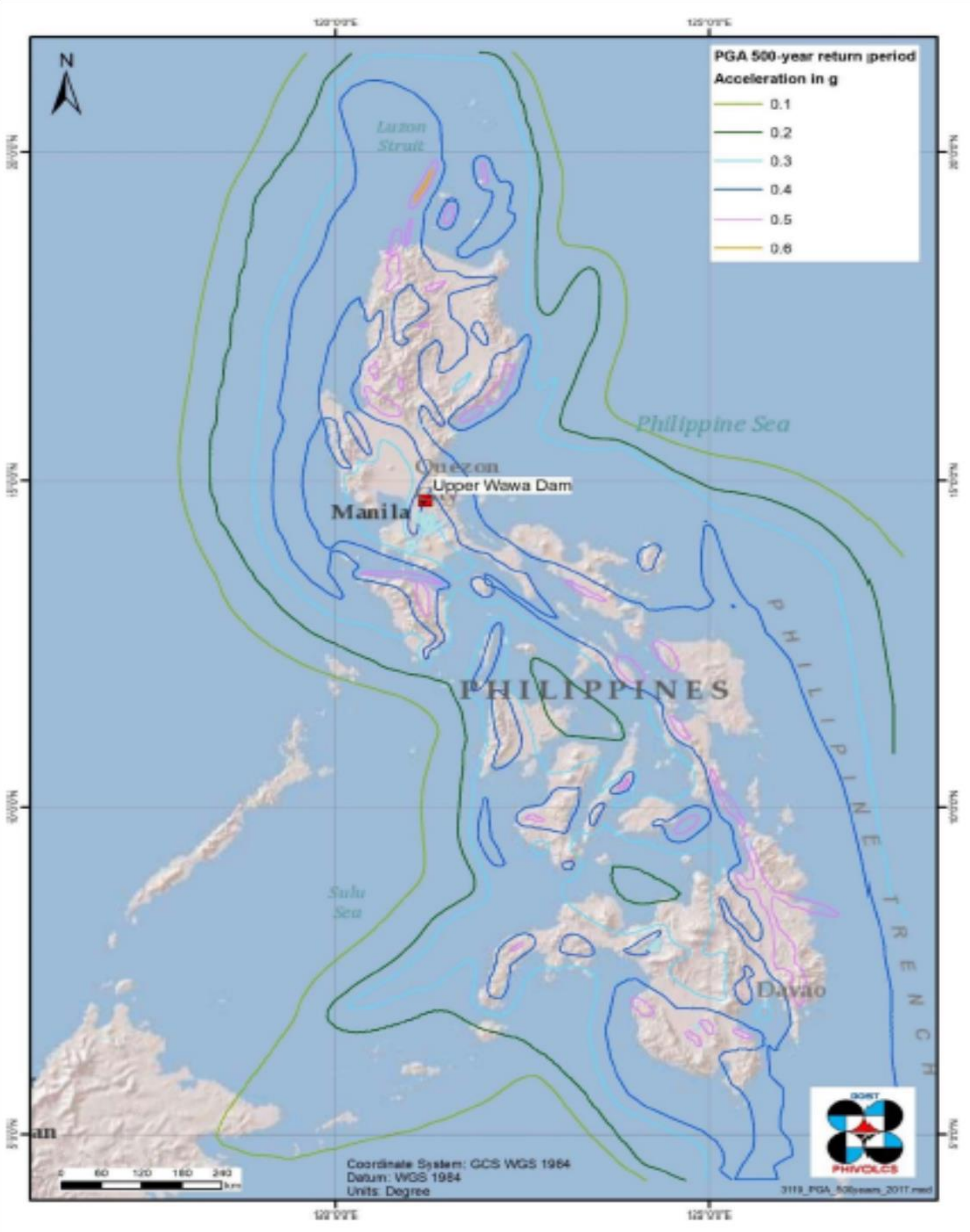


Figure EL-27. PGA map of the Philippines at 500-yr return period

ENVIRONMENTAL IMPACT STATEMENT
LAND MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

DATA INFORMATION/SOURCE:

Source Map: **PHIVOLCS (2017)**
Modified by: **Apercu Consultants Inc. (2020)**

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SCALE: 1:5,000,000

Meanwhile, computed mean horizontal PGA for the proposed structures in the project site are presented in **Table EL-15**.

Table EL-15
Mean Horizontal PGA Values for the Upper Wawa Dam Site, TPS 2 Site and Weir 2 Site

Return Period (Years)	Mean Horizontal PGA		
	Upper Wawa Dam	TPS 2	Weir 2
145	0.22g	0.22g	0.22g
475	0.38g	0.375g	0.37g
2,475	0.70g	0.68g	0.66g
10,000	1	1.02g	0.99g

Source: Fugro (2019)

Ground Rupture

Ground rupture occurs when earthquake movement along a fault breaks the earth's surface and shows a visible offset of the ground surface. This normally poses a risk to structures built across active fault zones. Ground rupture hazard is not expected at the project site considering that the nearest active fault is located 5.3 km from the project site. PHIVOLCS recommends a distance of at least 5m from both sides of active faults to avoid ground rupture hazard.

Liquefaction

Liquefaction occurs when saturated or partially saturated soil substantially loses strength and stiffness due to applied stress such as ground shaking during an earthquake. It can also result from sudden change in stress condition wherein a material that is originally solid behaves like a liquid. Tremendous amounts of damage during historical earthquakes have been attributed to liquefaction and related phenomena. Considering that the project site is underlain by hard rock (basalts), the threat of liquefaction in the project site is low. **Figure EL-28** shows the liquefaction hazard map of Rizal Province. As shown on the map, areas with moderate to high susceptibility to liquefaction (purple and red shaded areas, respectively) are found along the shores of Laguna Lake and along the banks of Marikina River. Areas with low susceptibility to liquefaction are found along riverbanks underlain by liquefiable materials. The project site is not susceptible to liquefaction.

Differential Settlement

Settlement can occur if sediments undergo expansion, contraction or movement. Changes in soil condition may result from drought, flooding, earthquake or vibration. Threat of differential settlement in the project site is low.

Earthquake induced landslides

The possibility of occurrence of earthquake induced landslides in the project site is moderate to high considering the terrain and slope in the project site and vicinity.

Tsunami

The project site is located inland far from the coast and therefore has low susceptibility to tsunami hazard.

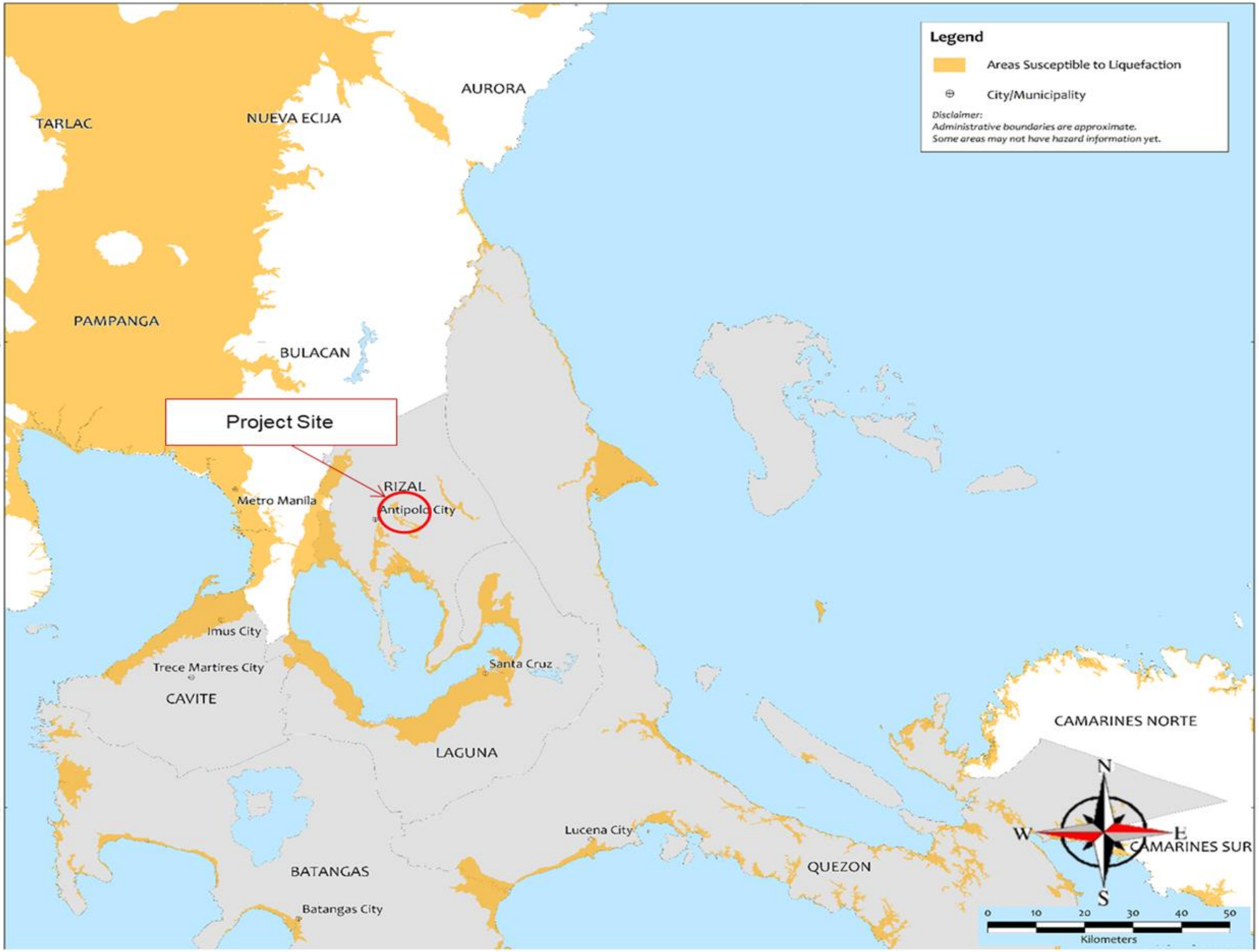

Figure EL-28. Liquefaction Hazard Map of Rizal Province

ENVIRONMENTAL IMPACT STATEMENT
LAND MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

DATA INFORMATION/SOURCE:

Source Map: **PHIVOLCS**
Modified by: **Apercu Consultants Inc. (2020)**

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SCALE: 1:1,000,000

1.2.5.2 Mass Movements

Figure EL-29 shows the flood and landslide hazard map of the project site and vicinity. As shown on the map, the project site has moderate to high susceptibility to slope instability hazards due to the moderate to steep slopes on the hillsides as well as the thick layer of soil that can potentially move downslope during heavy rains. Stream bank erosion, excavation for road construction, and agricultural activities on the hillsides also contribute to the slope instability susceptibility of the slopes. Several slope instabilities mostly due to heavy rains brought by Typhoon Ondoy in 2009 and subsequent strong typhoons are observed on the hillsides. Although the slopes of Mount Purro are steep, very few recent slope instabilities associated with heavy rains and strong typhoons can be observed on the slopes.

1.2.5.3 Flooding

Flooding normally occurs in Wawa and Marikina rivers through flashfloods that occur from the rapid accumulation of runoff during heavy rains; through riverine flood that occurs when water exceeds the riverbank capacity; or through standing floods due to the accumulation of water in concreted areas during heavy rains. The channels of Montalban River reportedly flooded during Typhoon Ondoy in 2009. About 15m deep floods were reported on steep channels during the Ondoy flood. Due to the high elevation of the project site, **Figure EL-29** shows that the upstream section of Wawa River is not susceptible to flooding.

1.2.5.4 Volcanic hazards

The project site is located far from active volcanoes such as Taal and Pinatubo to be directly affected by volcanic activities. Tephra or ashfall may reach the project site during large volcanic eruptions.

1.2.5.5 Summary of Site Susceptibility to Geologic Hazards

The susceptibility of the project site to geologic hazards is summarized in **Table EL-16**.

Table EL-16
Summary of susceptibility of project site to geologic hazards

Seismic Hazards	Susceptibility	Remarks
Faulting	None	No active or potentially active fault
Fault creep	None	No active or potentially active fault
Ground motion	Moderate	Estimated PGAs in the order of 0.2-0.3g
Liquefaction	None	Bedrock not susceptible to settlement
Settlement	None	Bedrock not susceptible to settlement
EQ induced landslides	Moderate	Moderate slopes
Tsunami	None	Not located in coastal area
Seiche	None	No large reservoir in the project site
Volcanic hazards		
Lava flow	None	Project site located far from active volcanoes
Pyroclastic flow	None	Project site located far from active volcanoes
Lahar	None	Project site located far from active volcanoes
Debris flow	None	Project site located far from active volcanoes
Mudflow	None	Project site located far from active volcanoes
Ashfall	None	Project site located far from active volcanoes
Ballistic projectiles	None	Project site located far from active volcanoes
Debris avalanche	None	Project site located far from active volcanoes
Phreatic explosion	None	Project site located far from active volcanoes
Volcanic quakes	None	Project site located far from active volcanoes
Rockfalls	None	Project site located far from active volcanoes
Gases	None	Project site located far from active volcanoes

Seismic Hazards	Susceptibility	Remarks
Mass movement hazards		
Landslides	Moderate	Moderate slopes
Rockfall	Moderate	Moderate slopes
Sinkhole collapse	None	Site is not underlain by limestone
Fluvial hazards		
Inundation	None	Project site is not located on floodplain
Flashfloods	High	Based on MGB geohazard map
Bank erosion & channel migration	Low	Dam axis is not located along erosive meander bend
Scouring	Low	No river deposits observed on site

Source: after SMEC (2019)

1.2.6 Impact Assessment and Mitigation Measures for Geology and Geomorphology

1.2.6.1 Change in Surface Landform/ Topography/ Terrain/ Slope

Change in surface landform is expected as a result of excavation, drilling, filling, controlled blasting and other earthmoving activities. These will create long-term adverse impacts since the terrain will be modified by concrete structures ranging from 0-90m high and stripping/excavation depth for dam foundation of about 20m. The proposed Upper Wawa Dam will have an effective height above bed level of 84m and effective height above foundation of 110m. Crest length will be about 425m. The dam height of 84m considered allocations for water supply as well as flood mitigation and surcharge surplus for a 100-year probable maximum flood and sediment load.

Although the dam height will be lower than the peaks at the left and right abutments, at 375m and 200-606m, respectively, the sheer size of the dam structure will impact the appearance of the surface landform in the area. Topographic changes are mostly visual and aesthetic and will become prominent from certain vantage points (see **Figure EL-30** and **Figure EL-31**).

The design of the proposed Upper Wawa Dam is shown on **Figure EL-30** while the cross section is shown on **Section 1.0 of Project Description Report, Figure PD-11**. The perspective view vis-à-vis the existing condition/site elevation at the proposed dam site is shown on **Figure EL-31**.

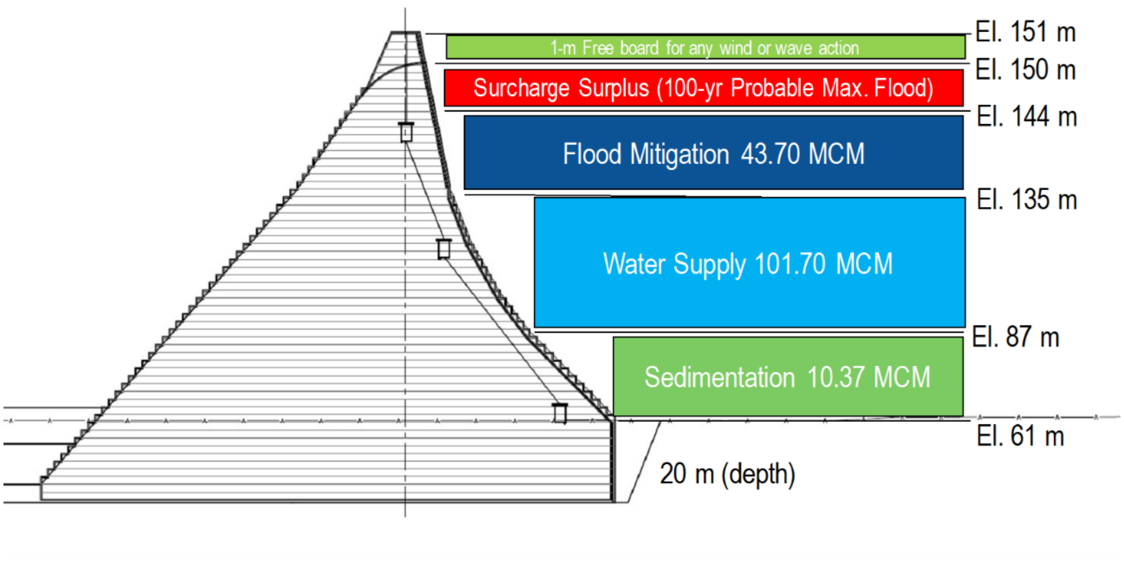

Figure EL-30. Design of the proposed Upper Wawa Dam
Source: SMEC, 2019

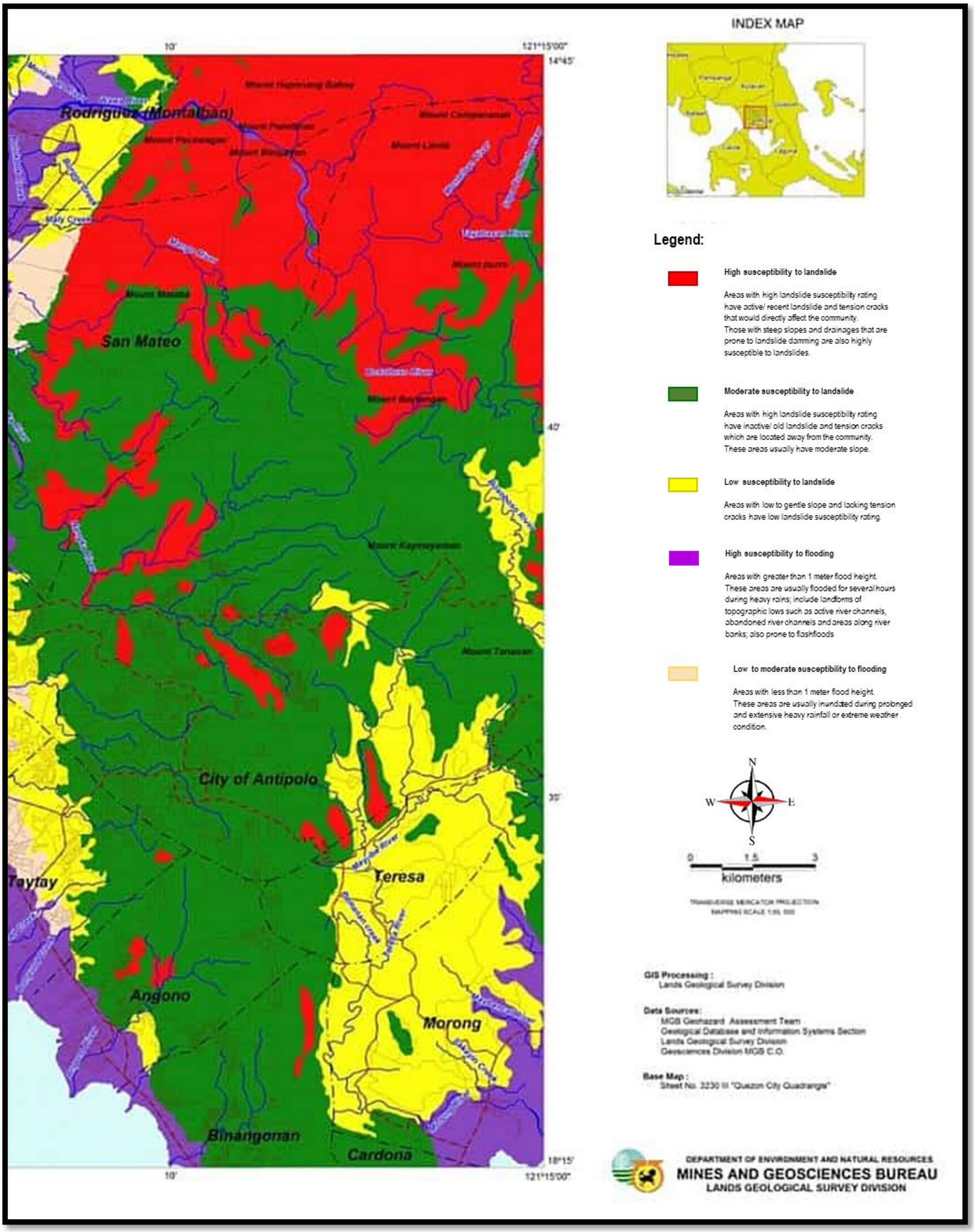

Figure EL-29. Landslide and flood hazard map of the project site and vicinity.

ENVIRONMENTAL IMPACT STATEMENT
LAND MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

DATA INFORMATION/SOURCE:

Source Map: **Mines and Geosciences Bureau (MGB)**
Modified by: **Apercu Consultants Inc. (2020)**

WawaJVCo INC.
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SCALE: 1:30,000

Figure EL-31. Left photo shows existing site condition facing downstream with the dam axis represented by the red line vis-à-vis the perspective view of proposed Upper Wawa Dam facing upstream.
Source: SMEC, 2019

An estimated 8.5MCM of excavated materials will be generated during site preparation for the access roads, dam and reservoir, spillway, and diversion tunnel. About 20% of this volume is expected to be used as fill and construction materials onsite. The remaining 80% will be placed in spoil dumps that will be identified in succeeding stages of project development. Excavation methods will also be determined in succeeding project stages.

Construction of the dam structure for the bulk water supply project will create new water bodies that will become new landform features. The estimated inundation area at minimum operating level is 74.33 hectares while the inundation area at full supply level is estimated at 414.28 hectares as shown in **Section 1.0 of Project Description Report**, **Figure PD-15**.

Construction of the dam will also create a new steep artificial slope that will be concreted and engineered. Lower slopes will result in some areas such as at road alignments and reservoir areas since these will be modified to facilitate access and will be subject to constant human activity.

The identified optional quarry locations is located on the east bank of Upper Wawa River about 200m to 300m to east of the spillway location (refer to **Section 1.0 of Project Description Report**, **Figure PD-21**). This area is underlain mainly by sandstone and mudstone that need further testing to determine their suitability as rockfill material since riprap needs rock strength higher than 100MPa.

Spillway and tunnel excavation materials are also intended to be used as construction materials. However, the rocks from these areas have been determined to be of low strength and cannot be used as rockfill. Alternative sources for rockfill and location of stockpile/disposal area of excavated materials will be identified in succeeding project phases. Silty sands and sandy silts from stripping/excavations within the project site can be used for cofferdam construction (Tractebel, 2019).

The mitigating measures will address both the stability of modified slopes and engineered structures and the aesthetic value of the new landscape features. During project development, geotechnical studies, engineering design and innovative construction methods will be employed to minimize the threat of collapse and to prevent the enhancement of destructive geologic processes such as erosion, slope instability and flooding.

Slope stability is a major issue for projects located in hilly and mountainous areas. A detailed slope stability assessment be done for construction at slopes exceeding 22%. Slopes exceeding 60% and

extending more than 200m in vertical slope distance will be assessed for potential slope instability hazard, particularly around the water impoundment. To avoid the risk of induced weaknesses in the steep slopes, water infiltration into natural fractures will be minimized with the use of grout in sections where seepages may occur.

Re-vegetation of cleared out areas will be done during project operation to visually assimilate the old terrain and to maintain slope stability. Water level fluctuations will be managed to prevent uncontrolled flow in and outside of designed drainages.

The following are the recommendations for foundation works for the various project structures (Tractebel, 2019):

Main Dam Site

Soil cover at the main dam site consists of colluvial and alluvial deposits as well as highly to completely weathered bedrock. Soils include silty sands and sandy to clayey silts with thickness ranging from 0.95 to 10.8m. The soil cover is underlain by transitional rock zone in depths of 5.5-20m forming the upper section of the bedrock. The rock mass in this zone is highly to completely weathered, fractured and with loose sections. RQD of the transition zone indicated very poor rock qualities although there are sections with better rock quality consisting of slightly weathered rock. Good quality slightly weathered to fresh bedrock is found below the transition zone. The following are recommendations for the excavation of the main dam site:

- **Completely remove soil cover for the foundation of the main dam.**
- **Loose or highly fractured parts in the upper sections of the bedrock need to be removed until rock quality of adequate strength and compressibility is encountered that can support the embankment.**
- **Consolidation grouting needs to be done to improve the foundation surface.**
- **Additional testing is recommended to determine rock permeability.**
- **Slope protection measures are required to avoid slope failures into the construction area or on the dam site structure.**

Diversion Tunnels

The bedrock at the proposed location of the diversion tunnels generally provides good rock qualities. However, in the roof sections close to the inlet and outlet structures, unfavorable rock conditions exist which will require stronger rock support. The following are recommendations for excavation of the diversion tunnels (Tractebel, 2019):

- **Slope support measures are required at the inlet and outlet structures.**
- **Strong rock support measures are required at the first meters of tunnel excavation. This may include shotcrete of a higher thickness, lattice girders, rock bolts, etc.**
- **Excavation should not be carried out in full face and short controlled blasting rounds when bad rock qualities are encountered at the portals.**
- **Optimal controlled blasting schemes should be developed at the beginning of tunnel excavation to minimize overbreak, mucking time and future grouting volumes.**
- **A dewatering system is required during tunnel excavation from the direction of the inlet structures. To avoid overflooding of the tunnel invert, a drainage trench is required.**

Spillway

The following are the recommendations for spillway foundation (Tractebel, 2019):

- **Remove soil cover that reaches a thickness of 2.95m to 5.8m.**

- **Install slope protection measures for the soil cover at the edge of the construction pit such as berms, steel wire nets, bioengineering measures, etc.**
- **Install a protection fence on top of the slope to protect the construction pit against rock fall.**
- **Excavation of the uppermost section of the bedrock consisting of loose and fractured sections can be removed by an excavator but slightly weathered or fresh rock has to be excavated by controlled blasting.**
- **Berms with drainage trenches should be constructed on the slopes with bedrock.**
- **Shotcrete and rock bolts are recommended for slope rock support and drainage holes should be drilled into the shotcrete cover.**

Pumping Station

Good foundation conditions were identified in the pumping station location. Weathered outcrop should be removed. The rock slope will need slope protection measures such as shotcrete and rock bolts. Berms should also be part of slope design.

Reservoir Rim

Slope failures might occur during earthquakes and heavy rains. Detailed mapping and stability assessment should be done to determine the stability of the reservoir rim. Occurrence of limestone in the general vicinity of Tayabasan-Boso-Boso Rivers with possible karst phenomena should also be investigated in succeeding project phases to determine if the integrity of the reservoir will be affected by higher permeabilities due to weathering of the limestone (Tractebel, 2019).

1.2.6.2 Change in Subsurface/ Underground Geomorphology

The most significant disturbance to the subsurface is the creation of diversion tunnels for water conveyance (**Figure PD-19**) and human access. There will be two diversion tunnels to isolate the dam during construction.

The two diversion tunnels will be located on the left bank of Wawa River. The excavation of the tunnels will be executed by the drill and controlled blasting tunnelling method. The tunnel will be horseshoe-shaped and primary rock support will consist of steel fiber shotcrete with fully cemented rock bolts. In sections with poor rock quality, steel ribs or lattice girders will be installed. Permanent concrete lining will be installed once tunnel excavation is completed. The maximum cover of the tunnels will be about 90m.

The excavation of the tunnels will require the removal of rock and soil materials and the protection of the void by using steel and/or concrete shells for both structural stability and water leakage control. This will cause a minor shift in geological stresses as voids take form inside the mountain. These stresses are expected to be stabilized as soon as the tunnels and chambers are anchored or lined with concrete or steel. The stockpile area for excavated materials will be strategically located to reduce impacts on the surface and reduce the potential for increased erosion and slope instability.

Geotechnical studies will help determine areas with the potential for having any tensional fault or potentially open faults or fractures in the reservoir that could be intruded by pressurized water. Geological and geotechnical studies will also identify any potential instability in the subsurface structures of the rocks. The use of linings, grouting or any other method for preventing leakage of water into open fractures will be considered whenever appropriate. Rock bolts, steel support and linings will be considered to prevent collapse of any tunnel or chamber.

1.2.6.3 Changes in Rate of Erosion and Sedimentation

Distributed erosion processes in a river basin are reflected as sediment transportation that is a slow process of degradation and sequential loss of topsoil. The total amount of erosional debris transported in a river basin is known as its sediment yield or sediment load. The total natural sediment load for the Upper Wawa River is estimated at 252,000 tons/yr (Tractebel, 2019) while that in upstream tributaries where weirs will be constructed range from 19,000 tons/yr to 75,000 tons/yr. With the introduction of the Upper Wawa Dam and three temporary weirs while the UWD is under construction, the created reservoir is expected to trap some of the sediments transported from the upstream sections of the river basin. The expected sedimentation volume from the operation of the Upper Wawa Dam is presented in **Table EL-17**. Sedimentation at the three weirs is computed for five years since the weirs will no longer be necessary once the UWD is constructed.

Table EL-17
Estimated Sedimentation Volume at the Upper Wawa Dam[4].

Location	Period (Years)	Total Reservoir Sedimentation Volume (MCM)	River Basin Annual Sediment Load (MCM/yr)	Estimated Reservoir Annual Sedimentation Volume (m^3/yr)
Upper Wawa Dam	50	9.6	252	192,000
Weir 1	5	0.2	75	40,000
Weir 2	5	0.2	49	40,000
Weir 3	5	0.1	19	20,000

In the absence of information on grain size distribution, sediment composition in the reservoir is assumed as follows: 30% suspended sand; 30% suspended silt and 40% suspended clay (Tractebel, 2019).

Erosion is expected to increase during the construction phase as excavation and earthmoving activities are ongoing. This impact is temporary and is expected to drastically decrease as soon as the project is completed and becomes operational. The presence of the dam is also expected to reduce erosion and sedimentation since dams normally impede the downstream flow of sediments.

Reforestation and other watershed management activities are expected to contribute to the management of erosion in the area during the construction and operation phases.

1.2.6.4 Inducement of Subsidence, Liquefaction, Landslides, Mud/Debris Flow, etc.

As discussed in the section on Geologic Hazard Assessment, the nearest seismic generators to the project site are the East Valley Fault that is located about 5.3km northwest of the project site and the West Valley Fault located about 10km away. The East Valley Fault has a potential maximum credible earthquake (MCE) magnitude of 6.2 while the West Valley Fault has an MCE of 7.6. The other seismic generators that can affect the project site include the Philippine Fault located (Ms8.6) 46km away, the Lubang Fault (Ms 7.5) located 140km away, the Casiguran Fault (Ms 7.3) located 115 km away, and the Manila Trench (Ms 8.2) located about 180 away. Although the potential maximum earthquake magnitudes of these geologic structures are higher, the expected impact to the proposed project in terms of ground shaking and other seismic hazards is expected to be lower compared to the East Valley Fault and West Valley Fault. The expected peak ground acceleration in the project site ranges from 0.7g for soft soil condition, 0.4g for medium soil condition, and 0.22g for rock condition.

Liquefaction has a low probability of occurrence since the site is underlain by relatively competent bedrock. In areas along riverbanks and stockpiles of excavated materials where unconsolidated materials are expected to be present, the possibility of the occurrence of liquefaction will be mitigated by placing excavated materials in a designated spoils area. The provision of enclosures for stockpiles of sand and gravel will be established to minimize transport of sediments during heavy rains. The probability of occurrence of differential settlement is also low due to the relatively competent nature of the bedrock.

[4] Source: Hydrological Assessment and Engineering Design of Upper Wawa Dam and Tayabasan Multi-Basin conducted by Tractebel Engineering Ltd. For Wawa KVCO, Inc. (2019)

The project site has moderate to high susceptibility to rain-induced landslides due to moderate to steep slopes on the hillside and the thick layer of soil that can potentially move downslope during heavy rains. The occurrence of rain-induced landslide is expected to be aggravated by increased rainfall resulting from climate change.

The impact of prevailing seismic and mass movement hazards to the proposed project can be mitigated by the appropriate seismic design of the proposed structures. The seismic design should consider the maximum credible earthquake that can affect the project site and vicinity.

1.2.7 Monitoring Plan for Geology

Environmental monitoring for geology will include:

- Micro-seismic monitoring for induced earthquakes during filling up of the upper reservoir
- Monitoring of perceptible earthquakes and response of the structures to strong earthquakes using strong motion accelerographs
- Monitoring of erosion rates on the hillsides adjacent to the project site monthly during the rainy season
- Monitoring of occurrence of slope instability during the rainy season

1.3 Pedology

1.3.1 Soils in the Upper Marikina River Basin

Three soil series are found to cover the Upper Marikina River Basin, including Antipolo Series, Binangonan Series and Marikina Series. These are briefly described below (after Aecom, 2012).

Antipolo Series - This comprises of red and reddish brown soils developed from igneous and other volcanic rocks, notably basalt of various degrees of weathering. Two soil types comprise the series, namely clay and clay loam.

- The Antipolo Clay is well developed in the vicinities of Antipolo and in the upland areas of Rodriguez. Corn and rice are normally planted in this soil type, with some areas planted to cashew, duhat trees and pineapples.
- The Antipolo Clay Loam occurs in isolated patches within the Boso-Boso and Montalban subriver basins. Upland and lowland rice is normally planted in this soil type.

Binangonan Series - The Binangonan soils are normally dark brown to nearly black and covers the limestone areas in the mountainous region. This series consist of two soil types, namely clay and clay-lowland phase.

- The Binangonan Clay is dark brown to black in color and has calcareous subsoil. This soil type is found from Binangonan to Rodriguez and normally planted with rice and corn.
- The Binangonan Clay Lowland Phase is found in the lacustrine valley of Teresa and nearby valleys along the headwaters of Morong River. Rice is normally grown in this soil type.

Marikina Series – The Marikina Series consists of typical recent alluvial soil that is normally medium or light brown to brown in color. This soil type is underlain by tuffaceous material of varying degrees of weathering and occupies the Marikina Valley from Montalban to Pateros. This soil series has three types, namely loam, clay loam and silt loam.

- The Marikina Loam is found between Marikina and Antipolo series in the Montalban-San Mateo area and normally planted to corn and vegetables.
- The Marikina Clay Loam is found on the western side of Marikina Valley along the fault line and also in the Taytay and Pateros areas and headwaters of Pasig River. This soil type is mostly planted with rice, corn and sugarcane.
- The Marikina Silt Loam is the principal soil type in the Marikina Valley with the subsoil consisting of highly weathered and disintegrated tuffaceous material. It occurs in the middle portion of the valley from Montalban to Pasig and devoted entirely to rice production.

The typical soil profile of the three soil series found in the Upper Marikina River Basin is presented in **Table EL-18** while the photographs and soil map are shown on **Plate EL-8** and **Figure EL-32,** respectively.

Table EL-18
Typical Soil Profile of Soil Series found in the Upper Marikina River Basin

Depth (cm)	Characteristics
Antipolo Series	
0 – 27	Slightly compact, light reddish brown, friable and finely granular clay with presence of tuffaceous concretions
27 – 65	Slightly compact, dark reddish brown, granular to friable clay with concretions
65 – 85	Slightly compact soil, bright reddish brown granular and friable clay loam; weathered tuff is found below the lower part of the soil horizon
85 – 120	Zone of highly weathered tuffaceous material; the soil is finely granular with slightly friable clay loam; concretions are present
120 – 150	Coarse granular, dark reddish brown clay loam and very friable; soft concretions are present
Binangonan Series	
0 – 20	Very dark brown to nearly black clay, coarse granular and cloddy when dry and sticky when wet, stiff when seemingly dry
20 – 40	Clay lighter in color than abouve, granular when dry and sticky when wet
40 – 55	Light brown to nearly white in color, highly weathered limestone found on lower horizon
55 – 100	Highly decomposed and weathered soft rock limestone
Marikina Series	
0 – 15	Medium brown silt loam with brick-red streaks, almost compact but friable
15 – 35	Dark brown to light gray clay loam, finely granular and very friable
35 – 60	Light brown clay loam with light gray mixture, almost compacted but granular
60+	Light brown clay loam with slight mottling of light gray and brown clay loam, almost compact but friable

Source: AECOM (2012)

40cm soil profile of Antipolo Clay taken from Barangay Pintong Bukawe, San Mateo, Rizal

40cm soil profile of Binangonan Clay taken from Sitio Inigan, Barangay San Rafael, Rodriguez, Rizal

40cm soil profile of Marikina Loam taken from Sitio Kayropa, Barangay San Rafael, Rodriguez, Rizal

Plate EL-8. Typical soil profile of soils found in the Upper Marikina River Basin.
Source: AECOM, 2012.

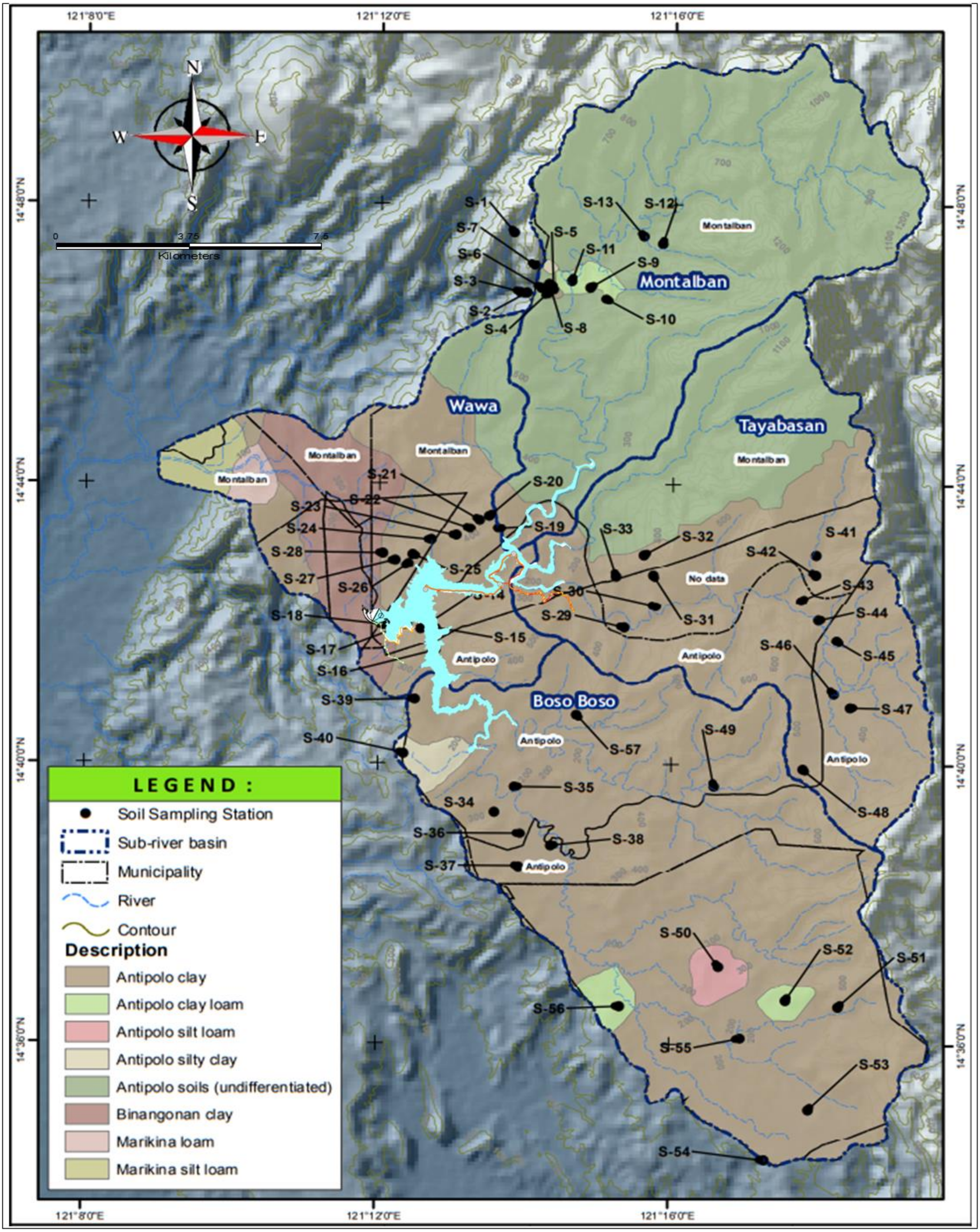

Figure EL-32. Soil map of the Upper Marikina River Basin

ENVIRONMENTAL IMPACT STATEMENT
LAND MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

Legend
- Pump Station
- UWD Reservoir
- Transmission Pipeline via Tunnel Optional
- UWD Optional Access Road (New)
- UWD Access Road (Original)
- Access Road to WTP / Transmission Pipe
- UWD Dam and Diversion Tunnel
- Transmission / Water Conveyance Pipeline

DATA INFORMATION/SOURCE:

Source Map: **AECOM (2012)**
Modified by: **Apercu Consultants Inc. (2020)**

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aperçu CONSULTANTS INC.

SCALE: As above

1.3.1.1 Soils of Antipolo City

Table EL-19 lists the soil mapping units in Antipolo City. The table shows that Dystropept-Tropudalf-Tropudult Association (19.17%) covers the largest land area, followed by Antipolo Clay (17.17%), escarpment (12.22%) and Pinugay clay (9.54%). San Manuel clay loam (0.03%), Teresa clay (0.06%), Baras clay (0.37%) and Tulay clay (0.71%) constitute the smallest land areas.

Table EL-19
Soil Mapping Units in Antipolo City

Soil Mapping Unit	Area (Has)	Percentage
Dystropept-Tropudalf-Tropudult Association	7,383.08	19.17
Antipolo clay	6,610.97	17.17
Escarpment (Misc land types)	4,706.92	12.22
Pinugay clay	3,672.11	9.54
Inarawan clay	3,347.90	8.69
Dystropept-Tropporthent Association	3,340.49	8.68
Lumbangan clay	2,383.26	6.19
Philcomsat clay	1,335.46	3.47
San Luis clay	1,303.17	3.38
Tropudalf-Eutropept Association	1,247.55	3.24
Marikina clay	873.47	2.27
Inceptisol-Riverwash Association	779.96	2.03
Binangonan clay	534.99	1.39
Limestone Rockland (Misc land types)	531.80	1.38
Tulay clay	274.39	0.71
Baras clay	142.54	0.37
Teresa clay	23.31	0.06
San Manuel clay loam	13.07	0.03
Total	**38,504.44**	**100.00**

Four of the 18 soil mapping units, soil associations and miscellaneous soil types listed above occur in the general area of the project site. These include the Dystropept-Tropudalf-Tropudult Association, Pinugay Clay, Dystropept-Troporthent Association and Lumbangan Clay.

The Dystropept-Tropudalf-Tropudult Association occurs in 45 to 65% slope including the project site and are characterized as shallow to deep, well drained and occur in very steep and highly dissected mountain ridges with sharp crests at about 400m asl. Soils are of basaltic origin and vegetated with shrubs, bushes and secondary forest.

The Pinugay Clay occurs in 15 to 65% slightly to moderately eroded slopes in Barangay Calawis and San Jose and originated from shale. The soil is moderately deep to deep and occurs on the upper rounded volcanic hills and ridges covered with cogon, grass and shrubs.

The Dystropept-Troporthent Association occurs in >45% slope and extensively distributed in Barangay Calawis and San Jose. The soils are shallow to deep, well drained and of basaltic origin. It is covered with shrubs and bushes and secondary forest.

The Lumbangan Clay occurs in 25 to 45% slope and observed in Barangay Calawis, San Juan and San Jose. This is a moderately deep to deep, well-drained soil that has dark red, dark yellowish brown or dark grayish brown clay horizon. The soil series is moderately affected by erosion due to the steep slope. It is covered mainly with cogon, other grass and shrubs.

Plate EL-9 shows representative photographs of soils encountered at the soil sampling stations in Rodriguez and Antipolo. Soils are mostly brown to dark brown, sandy silt with clay and some gravel. Hillsides near the project site are cultivated for annual and perennial crops indicating the suitability of the soils for agricultural production.

Plate EL-9. Representative photographs of soils encountered at the project site. Left photo shows Station 2 located south of proposed dam site (14.7006N, 121.2006E) while right photo shows Station 5 located at proposed pump station (14.7159N, 121.2321E).

1.3.1.2 Summary of Soil Investigation Report on Soil Type and Quality

The project proponent commissioned RDCL to conduct geotechnical soil investigation at the proposed locations of project structures from December 2019 to June 2020. A total of 20 boreholes were drilled at these locations:

- Seven within the dam site (DBH)
- Seven within the tunnel site (TBH)
- Two within the spillway site (SBH)
- Two within the quarry site (QBH)
- Two within the pumping station site (PBH)

The boreholes were drilled to a depth of 30-110m and core samples were collected for laboratory analysis. Soil types encountered at the boreholes are briefly described in **Table EL-20** while the borehole location map is shown on **Section 1.0 of Project Description Report, Figure PD-25**. Soils encountered in the boreholes include sandy silt, silty sand, clayey silt, sandy clay, and clayey sand.

Table EL-20
Soils encountered at boreholes drilled in various sites within the project site

Borehole ID	Depth of soil layer (m)	N(SPT)	Soil description
DBH-01	1.9	>50	Sandy silt with minor clay and traces of gravel, soils are light yellowish brown and with low plasticity
DBH-02	10.0	8 - >50	Mixture of sandstone, siltstone, mudstone and minor conglomerate with dark yellowish brown to dark brownish gray residual soil / transported material-colluvium and loose blocks of angular to sub-rounded gravels – Strong Soil
DBH-03	1.7		Silty sand with some gravel, residual soil, light yellowish brown in color and with low plasticity; found between layers of moderately weathered sandstone
DBH-04	1.0	>50	Silty sand with traces of gravel and clay, residual soil that is light yellowish brown in color and has low plasticity
DBH-05	6.0	22 - >50	Sandy silt with minor clay and traces of gravel until 2m depth; Clayey silt with minor sand from 2.0-2.5m depth; Sandy silt with traces of gravel from 2.5-3.0m depth; Clayey silt with minor sand from 3.0-6.0m depth
DBH-06	12.0	15-39	Silty sand with gravel that is generally brown in color (2.6m thick);

Borehole ID	Depth of soil layer (m)	N(SPT)	Soil description
			Sandy gravel with silt and clay (2.5m thick); Silty sand with gravel, medium dense to dense (3.6m thick); Silty sand with clay and gravel, loose to medium dense (2.5m); Dark brown clayey silt with high amounts of fine medium sand (0.8m)
DBH-07	5.2	38 - >50	Silty sand with clay and gravel, dense to very dense (4.5m thick); Sandy gravel with residual soil (0.7m thick)
PBH-01	1.0	>50	Fine to medium grained sand with traces of clay
PBH-02	8.0	15 - >50	Alternating layers of medium dense reddish to dark brown clayey sand and medium dense light to yellowish brown silty sand
QBH-01	9.0	12 - >50	Layers of sandy clay, silty clay and clayey silt with low plasticity
QBH-02	3.0	15 - >50	Light yellowish brown clayey silt with traces of sand (1m thick) and light yellowish brown sandy silt with traces of gravel
SBH-01	5.0	15 - >50	Silty sand with some gravel and traces of clay (4m thick) and clayey silt with minor sand, firm to very stiff (1m thick)
SBH-02	5.8	16 - >50	Silty sand with some gravel and traces of clay, medium dense and non-plastic (4.6m thick) and gravelly sand, dense to very dense, non plastic
TBH-01	2.1	15 - >50	Alternating layers of silty sand with minor clay and clayey sand with traces of silt and gravel, both of medium plasticity
TBH-02	4.0	8 - >50	Clayey silt with some clay and traces of sand and gravel, stiff and with low to medium plasticity (1.7m depth) and silty clay with traces of gravel and some sand, low to high plasticity
TBH-03	8.0	11 - >50	Clayey silt with sand (topsoil), moderately stiff and with low plasticity (5m thick); gravel with sand, silt and clay (2.6m thick)
TBH-04	8.0	13 - >50	Layers of clayey sand with minor silt and traces of gravel; silty clay with minor sand and traces of fine-grained gravel; and silty sand with some clay; soil layers of low to medium plasticity
TBH-05	5.0	9 - >50	Layers of sandy silt with minor clay and traces of gravel (1m thick); clayey silt with minor sand (0.6m thick); sandy silt with very low plasticity (1.5m thick); and sand with traces of clay with very low plasticity
TBH-06	4.0	14 - >50	Sandy gravels with silt and residual soil, non-plastic and blocky
TBH-07	5.0	9 - >50	Clayey silt with high amounts of sand, medium dense and with low plasticity and a 2.1m thick layer of sandy fine to boulder sized gravel with mix of highly weathered and fresh volcanics

Source: RDCL (2020)

As seen from **Table EL-20**, soils in the dam site are found at 0 to 12m depth and consist of sandy silt, silty sand, clayey silt, and sandy gravel. Since the dam foundation will be at 20m depth, the structure is expected to be constructed on top of competent rocks including indurated sandstone with interbeds of siltstone/shale and layers of minor conglomerate. Soils at the dam site exhibit high cohesive content typical for colluvial deposits and highly to completely weathered bedrock. The soil materials in the dam site can be used for the construction of the cofferdams or for backfilling (Tractebel, 2019).

Soils at the pumping station area are found at 0-8m depth and consist of fine to medium grained sand with traces of clay and alternating layers of clayey sand and silty sand.

Soils at the spillway area are found from 0-5.8m depth and consist of silty sand with some gravel and traces of clay. The spillway is expected to be lined with impermeable material and appropriately designed considering the geophysical characteristics of the area.

Soils in the diversion tunnel area are found at 0-8m depth and consist of silty sand, clayey sand, clayey silt, sandy silt and sandy gravels, which are typical colluvial deposits. The tunnel is expected to be bored on competent rock to ensure the structural stability of the structure.

1.3.1.3 Soil Quality Analysis

Soil samples were collected from nine identified soil sampling stations within the project site (**Figure EL-34**) on November 2019 and September 2020 corresponding to the dry and wet seasons, respectively. Soil samples were collected from Stations 1-5 during both sampling periods while Stations 6-9 are additional sampling stations along the proposed alignment of the transmission pipeline. Soil samples from the additional stations were collected on September 2020 only.

Soil samples were collected near the surface and at 0.5m to 1m depth. The soil samples were placed in labeled re-sealable plastic containers and were submitted to CRL Environmental Laboratory for analysis of physico-chemical parameters (i.e., pH, total organic matter, nitrogen, phosphorus, potassium, copper, iron, manganese, zinc, arsenic, cadmium, lead, molybdenum, mercury, hexavalent chromium, boron and chloride). Results of the laboratory analysis of soil samples are provided in **Table EL-21** and lab results for each season is in **Annex E.**

The pH values recorded in Station 1, Station 2, Station 4 and Station 6 indicate that soils are slightly acidic with values ranging from 5.3 to 5.9. Soils in Station 3, Station 5, Station 7, Station 8 and Station 9 are within the normal pH range of 6-8. Total organic matter (TOM) values range from 0.33% to 5.22%. There is no Canadian Soil Quality Guideline value for TOM. The plot of pH and TOM is shown on **Figure EL-33**.

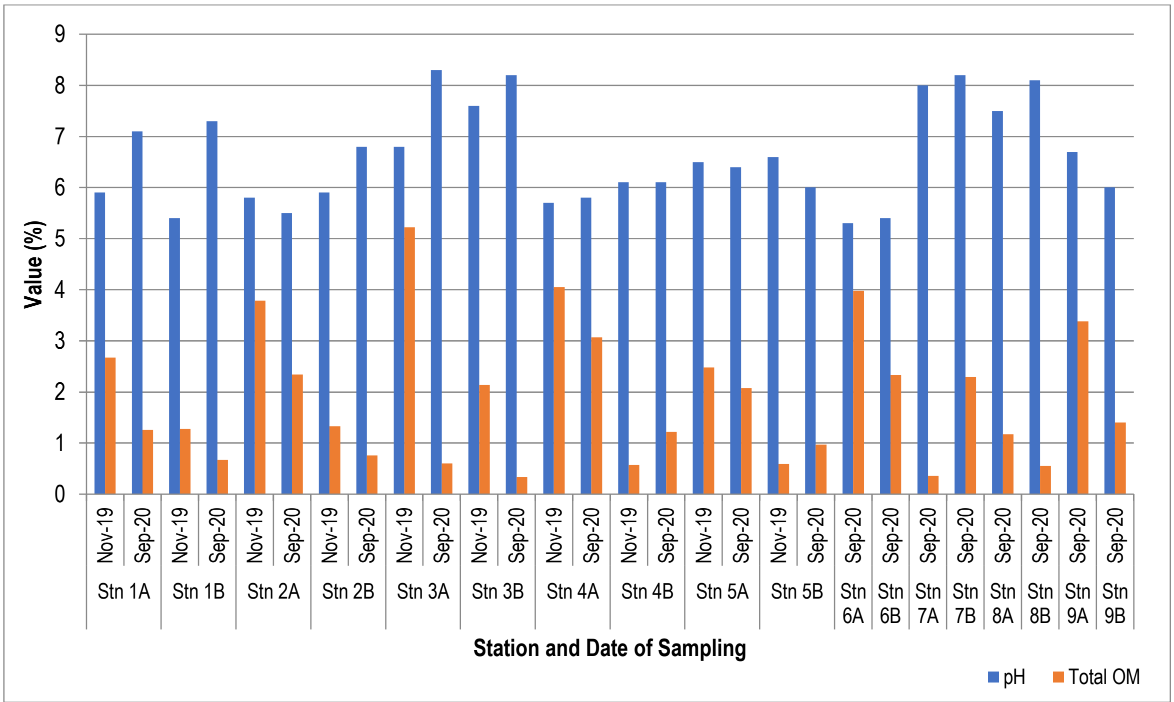

Figure EL- 33. Plot of pH and Total Organic Matter Values Obtained in the Soil Sampling Stations

Nitrogen values range from 143 mg/kg to 469 mg/kg while phosphorus values range from 270 mg/kg to 1,180 mg/kg. There is no standard value for nitrogen while phosphorus should not be detected in sample solutions. Considering that soil samples were obtained from non-agricultural land, it is assumed that the phosphorus detected in the soil samples are naturally occurring through the decomposition of organic material and can be correlated to soil pH since stations with acidic soils have high phosphorus content.

Table EL-21
Laboratory results of soil quality analysis (November 2019 and September 2020)

Station	Geographic Coordinates	Date of Sampling	pH	Total OM	N	P	K	Cu	Fe	Mn	Zn	As	Cd	Pb	Mo	Hg	Cr^{+6}	B	Cl
Station 1A	14°42'6.79"N 121°12'7.09"E	Nov 2019	5.9	2.67	209	736	1,240	48	18,400	1,570	53	-	-	-	-	-	-	-	-
		Sep 2020	7.1	1.26	216	616	1,890	81	64,000	1,240	120	1.5	0.8	17	ND	ND	-	-	-
Station 1B		Nov 2019	5.4	1.28	206	662	541	47	15,400	884	38	-	-	-	-	-	-	-	-
		Sep 2020	7.3	0.67	213	645	567	56	53,900	818	84	1.5	1.0	9.7	ND	ND	-	-	-
Station 2A	14°41'58.49"N 121°12'2.82"E	Nov 2019	5.8	3.79	304	1,180	1,680	39	11,100	818	59	-	-	-	-	-	-	-	-
		Sep 2020	5.5	2.34	373	535	1,060	42	51,600	1,620	46	2.3	1.0	18	ND	ND	-	-	-
Station 2B		Nov 2019	5.9	1.33	202	1,140	1,480	47	13,700	894	58	-	-	-	-	-	-	-	-
		Sep 2020	6.8	0.76	316	450	1,110	63	65,000	693	52	2.1	1.0	17	ND	ND	-	-	-
Station 3A	14°42'25.32"N 121°12'45.11"E	Nov 2019	6.8	5.22	344	284	978	17	12,600	657	69	-	-	-	-	-	-	-	-
		Sep 2020	8.3	0.60	209	581	746	60	69,600	924	88	2.2	1.3	15	ND	ND	ND	0.5	ND
Station 3B		Nov 2019	7.6	2.14	241	270	565	22	14,300	957	59	-	-	-	-	-	-	-	-
		Sep 2020	8.2	0.33	211	587	641	51	68,200	734	72	1.9	0.9	14	ND	ND	ND	0.4	ND
Station 4A	14°42'24.12"N 121°14'48.72"E	Nov 2019	5.7	4.05	259	489	502	35	12,600	835	55	-	-	-	-	-	-	-	-
		Sep 2020	5.8	3.07	397	455	1,790	42	54,200	1,060	78	1.7	0.8	12	ND	ND	ND	0.5	ND
Station 4B		Nov 2019	6.1	0.57	155	444	597	44	9,620	1,000	59	-	-	-	-	-	-	-	-
		Sep 2020	6.1	1.22	266	423	811	53	63,900	1,210	69	1.3	1.1	15	ND	ND	ND	0.4	ND
Station 5A	14°42'16.17"N 121°11'43.57"E	Nov 2019	6.5	2.48	361	591	886	32	10,900	724	48	-	-	-	-	-	-	-	-
		Sep 2020	6.4	2.07	375	561	2,520	40	46,500	1,240	58	2.2	0.9	17	ND	ND	ND	ND	ND
Station 5B		Nov 2019	6.6	0.59	143	464	558	40	11,500	658	45	-	-	-	-	-	-	-	-
		Sep 2020	6.0	0.97	260	490	2,090	39	45,800	810	46	1.1	0.7	12	ND	ND	ND	ND	37
Station 6A	14°41'50.13"N 121°12'31.73"E	Sep 2020	5.3	3.98	469	708	421	47	61,100	2,590	68	6.2	1.2	25	ND	ND	ND	0.3	ND
Station 6B		Sep 2020	5.4	2.33	422	627	397	53	47,800	1,070	47	5.7	1.0	17	ND	ND	ND	0.3	ND
Station 7A	14°42'29.53"N 121°13'42.39"E	Sep 2020	8.0	0.36	210	464	893	57	63,600	994	82	2.0	1.6	16	ND	ND	ND	0.3	ND
Station 7B		Sep 2020	8.2	2.29	266	542	568	57	55,700	948	78	2.5	1.4	15	ND	ND	ND	0.3	ND
Station 8A	14°42'54.54"N 121°13'55.73"E	Sep 2020	7.5	1.17	266	746	929	61	53,600	1,070	74	2.0	1.3	15	ND	ND	ND	0.3	ND
Station 8B		Sep 2020	8.1	0.55	212	479	706	55	49,400	859	74	2.3	1.5	15	ND	ND	ND	0.3	ND
Station 9A	14°42'19.84"N 121°14'22.61"E	Sep 2020	6.7	3.38	375	1,110	1,720	64	60,200	1,300	90	1.8	1.0	18	ND	ND	ND	0.3	ND
Station 9B		Sep 2020	6.0	1.40	265	946	1,400	64	44,600	1,240	85	1.4	1.2	18	ND	ND	ND	0.4	ND
CSQG[5]			**6-8**	**-**	**-**	**ND**	**-**	**91**	**-**	**-**	**360**	**12**	**22**	**600**	**40**	**50**	**1.4**	**-**	**-**

[5]Canadian Soil Quality Guidelines. http://esdat.net/Environmental%20Standards/Canada/SOIL/rev_soil_summary_tbl_7.0_e.pdf
Note: All values are in mg/kg except pH and total organic matter (expressed in % w/w)

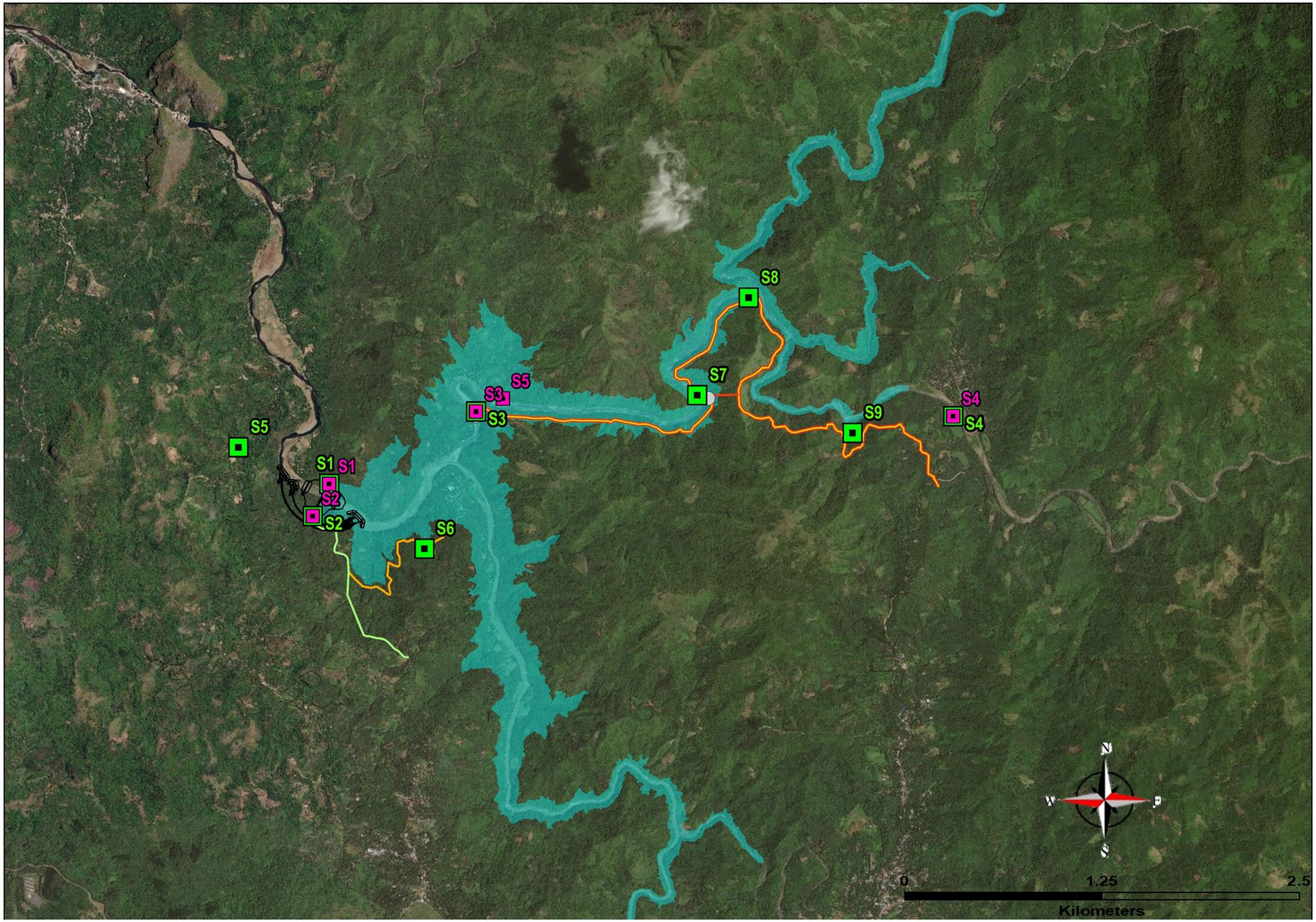

Figure EL-34. Soil Quality Sampling Stations	Legend Dam and Diversion Tunnels UWD Reservoir Dry Season Wet Season Pump Station Transmission Pipeline via Tunnel Optional UWD Optional Access Road (New) UWD Access Road (Original) Access Road to WTP / Transmission Pipe UWD Dam and Diversion Tunnel Transmission / Water Conveyance Pipeline	DATA INFORMATION/SOURCE: **Project Components:** Wawa JVCO, Inc. (2020) **Basemap:** ArcGIS Imagery, 2020 **Created by:** APERCU CONSULTANTS, INC (2020)
ENVIRONMENTAL IMPACT STATEMENT LAND MODULE Wawa Bulk Water Supply Project – Upper Wawa Dam		WawaJVCo INC. aperçu CONSULTANTS INC. SCALE: 1: 25,000 PAGE 129

Potassium values range from 397 mg/kg to 2,520 mg/kg. Principal sources of potassium in soil are minerals such as feldspars and micas which release the element as the minerals are weathered. Feldspars are common rock forming minerals often found in extrusive and intrusive igneous rocks and also found in many types of metamorphic and sedimentary rocks. Considering that the project site is largely made of sedimentary rocks, potassium is expected to be present in the soils which are weathering products of the underlying bedrock.

Figure EL-35 shows a graph of the nitrogen, phosphorus and potassium values reported in the soil sampling stations.

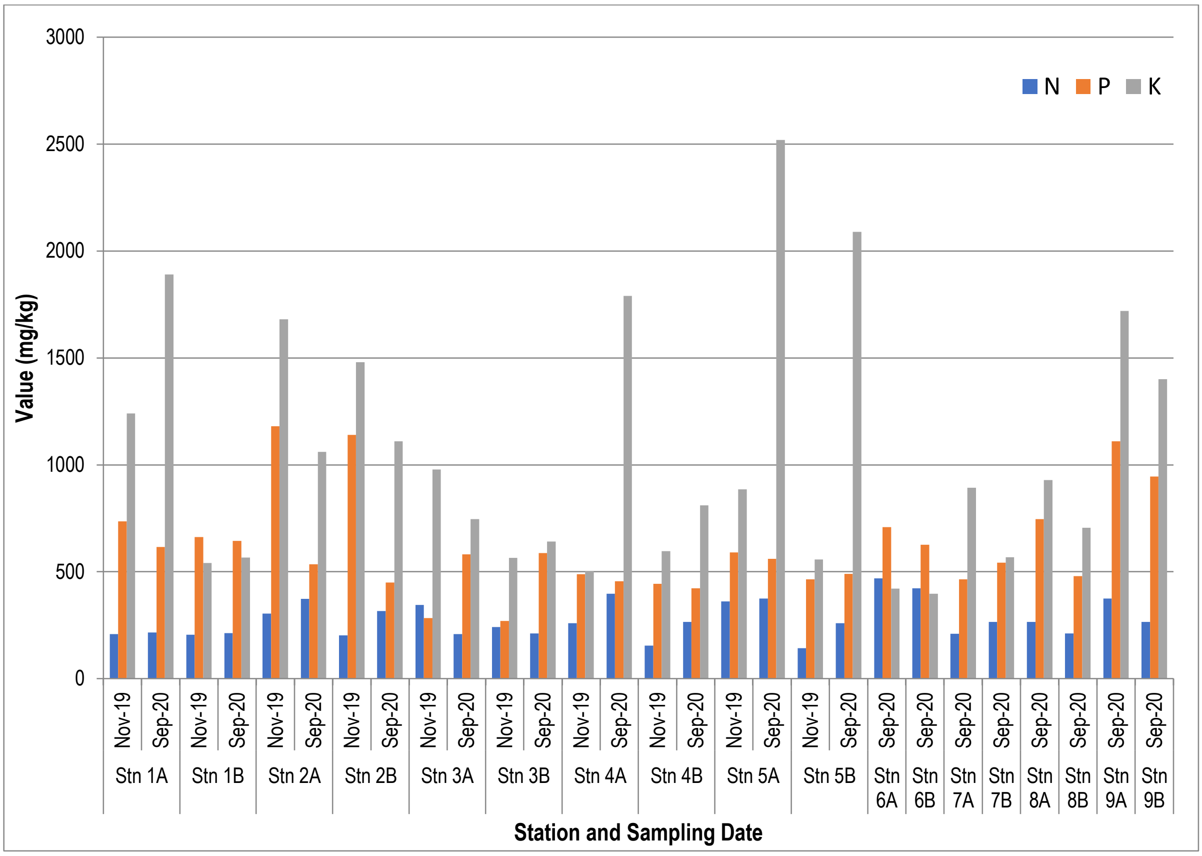

Figure EL-35. Nitrogen, Phosphorus and Potassium Values Reported in the Soil Sampling Stations

Copper values range from 17 mg/kg to 64 mg/kg and is within the Canadian Soil Quality Guidelines value of 91 mg/kg. Copper is naturally occurring in the earth's crust. The mean concentration of copper in soil ranges from 5 to 70 mg/kg.

Iron values range from 9,620 mg/kg to 68,200 mg/kg. Iron is one of the most abundant elements on the earth's crust and occurs mostly as ferromagnesium silicates. Most of the iron in soil is found in silicate minerals or iron oxides and hydroxides, which are commonly found in the rocks found in the project site.

Manganese values range from 657 mg/kg to 2,590 mg/kg. Manganese is a naturally occurring element with crustal rock as a major source of manganese. Manganese in soils come from crustal sources, direct atmospheric deposition, leaching from plant tissues and shedding or excretion from leaves, dead plant or animal excreta.

Zinc values range from 38 mg/kg to 120 mg/kg and are well within the Canadian Soil Quality Guideline value of 360 mg/kg. Zinc is a naturally occurring element but unnatural increase in zinc concentrations in soil is attributed to anthropogenic activities such as mining, waste combustion and steel processing. In the absence of these activities at the project site and the relatively low zinc concentration in soils, it is assumed that zinc found in the soil samples are naturally occurring.

Arsenic, cadmium, lead and boron values are low and within the Canadian Soil Quality Guideline values while molybdenum, mercury and hexavalent chromium were mostly not detected in the soil samples.

Figure EL-36 shows the graph of copper, iron, manganese, zinc, arsenic, cadmium and lead values reported at the soil sampling stations.

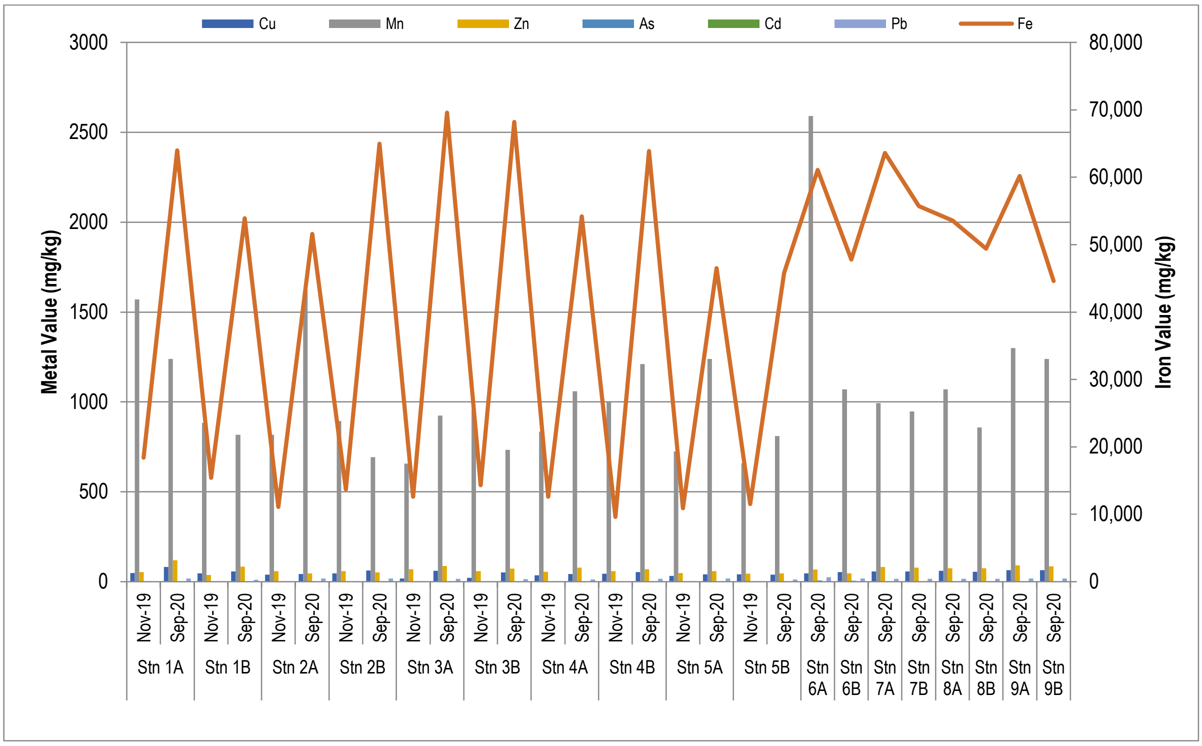

Figure EL-36. Plot of Trace Metal Values Reported in the Soil Sampling Stations

1.3.2 Soil Erosion Susceptibility

Soil erosion susceptibility is a function of soil type, slope and vegetation cover. Areas located in >30% slope, particularly the sloping grassland areas, are highly susceptible to erosion. Some steeply sloping areas observed near Montalban River are cultivated for annual crops (i.e. corn and cassava). The slopes are highly susceptible to erosion (**Plate EL-10**). Natural erosion rates are also aggravated by the uncontrolled and unsustainable farming practices in upland areas (i.e. swidden farming/kaingin). Charcoal making, which requires the cutting of trees, also contributes to increased erosion rates in steeply sloping areas. The National Greening Program of the DENR in coordination with the LGUs and concerned stakeholders aims to address the erosion problem in addition to rehabilitating the forestlands. The location of NGP projects in the vicinity of the proposed project site is shown on **Figure EL-11.**

Plate EL-10. Slope instability were observed on the hillsides adjacent to Tayabasan River.

Figure EL-37 shows the potential soil erosion map of the Philippines which indicates that the project site has slight erosion potential.

1.3.3 Sediment Sources and Riverbank Stability

The riverbed on the downstream section consists mostly of sandy material with some gravel and cobble-sized sediments while the riverbed upstream of the dam site consists mostly of cobble to boulder-sized sediments (**Plate EL-11**). These represent eroded materials from upstream and the hillsides adjacent to Wawa/Tayabasan and Montalban Rivers. The riverbanks are mostly lined with boulders; thus, the banks are stable and have minimal erosion potential.

Plate EL-11. Boulders and rock outcrops are found on both sides of the Wawa riverbank while alluvial materials are found on the riverbed.

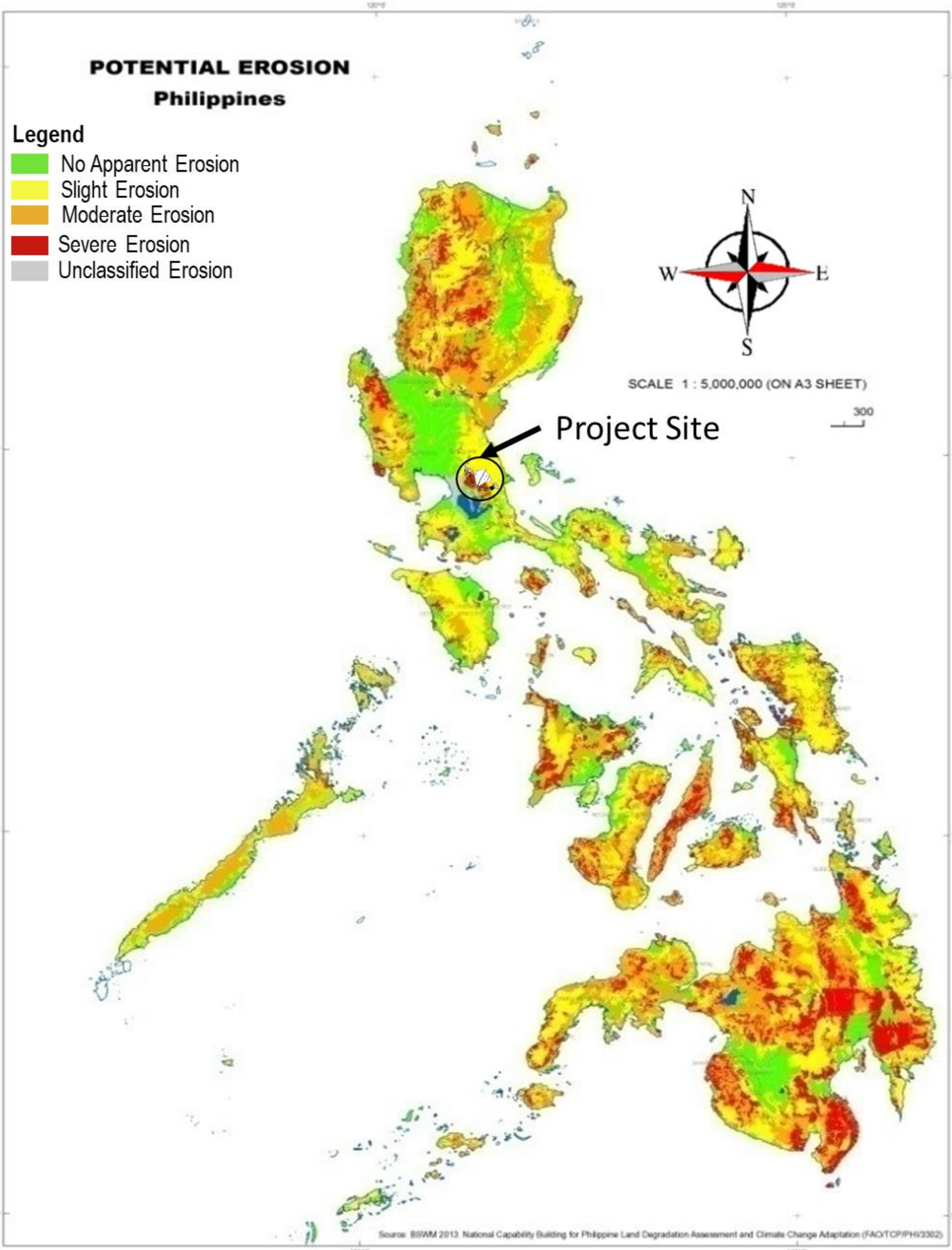

Figure EL-37. Potential soil erosion map of the Philippines

ENVIRONMENTAL IMPACT STATEMENT
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Wawa Bulk Water Supply Project – Upper Wawa Dam

DATA INFORMATION/SOURCE:

Source Map: **Bureau of Soils and Water Management, BSWM (2013)**
Modified by: **Apercu Consultants Inc. (2020)**

WawaJVCo INC.
aperçu CONSULTANTS INC.

SCALE: 1:5,000,000

1.3.4 Impact Assessment and Mitigation Measures for Pedology

1.3.4.1 Soil Erosion/Loss of Topsoil/Overburden and Bank Stability

Sediment build up occurs in dams or reservoirs due to the reduced flow velocity of the river. Areas located upstream of the dam structure become more susceptible to flooding. Large magnitude and frequent fluctuation in water levels in a reservoir can cause bank erosion and add to sediment deposition upstream of the dam.

Increased erosion of riverbanks and riverbeds can result from the loss or reduction in sediment load downstream of the dam structure. It can also lead to loss of floodplains through erosion and increased overbank accretion. Loss of topsoil on the riverbanks and adjacent areas can also occur due to the erosional impacts of a reservoir upstream and downstream of the dam.

Another possible impact is vegetation encroachment due to the decrease in flood flows and provision of stable low flows. This can stabilize new deposits, trap additional sediments and reduce bank erosion.

To minimize risks of erosion, the execution of major earthworks will be restricted as far as possible to the dry season. Temporary drainage structures will be installed if construction activities will extend into the rainy season so that stormwater will be directed and managed appropriately during the construction phase.

Bank erosion control and maintaining a natural reserve around the reservoir will help limit erosion and sediment deposition in the reservoir.

Erosion can also be reduced through the addition of sediments downstream of the dam. This will also maintain channel morphology. Installation of riprap or other bank protection structures and regeneration of a buffer zone of riparian woodland will also reduce rates of bank erosion.

Watershed management and implementation of soil-water conservation programs will help limit soil erosion. The project's watershed management plan will thus contribute to mitigating erosion within the project site and the watershed in general.

Diversion of sediment-laden flows upstream of the reservoir will also be done. As the very fine sediments are normally rich in nutrients, this will create fertile farmland upstream of the dam. Sediment flow into the reservoir will also be greatly reduced.

1.3.4.2 Change in Soil Quality/Fertility

Oil spills or leaks from construction equipment and machinery can lead to negative impacts on soil quality. However, this is expected to be a short-term impact that will persist only during the construction phase.

Soils in the floodplain downstream of the dam structure can become infertile due to reduced supply of nutrient-rich sediments from upstream, which are trapped in the reservoir due to the presence of the dam.

Proper and regular maintenance of construction equipment and machinery will reduce the possibility of oil spills or leaks. Designation of cemented machine and equipment maintenance area equipped with proper drainage canals and oil absorbing material will minimize soil contamination that will result in degradation of soil quality, during construction phase. The fuel storage area will likewise be equipped with absorbing materials for spilled and leaked fuel.

Sediment flushing every few weeks can ensure the maintenance of the reservoir capacity and at the same time provide nutrient rich sediments downstream of the dam.

1.3.5 Monitoring Plan for Pedology

Soil quality monitoring is recommended during both the construction and operation phases. Monitoring can be done annually during the rainy season.

Visual inspection of sedimentation in natural and man-made drainage channels will be done to determine if soil erosion is occurring on site. Appropriate measures will be instituted if occurrence of soil erosion is identified such as placement of silt traps and construction of siltation ponds where silt and sediments will be allowed to settle before run-off is allowed to drain into the canals. Monitoring can be done monthly downstream of active construction areas during the rainy season.

1.4 Terrestrial Ecology

1.4.1 Flora

The Wawa River Basin is an important subwatershed of the Marikina Watershed Reservation. Similar with the Tanay Watershed (LLDA, 2005), it, at present, is predominantly covered by shrubs and bamboo with some perennial woody vegetation. Literature indicates that buho (*Schizostachyum lumampao*), a cluster-forming bamboo, is a common vegetation in the Wawa River Basin. Yet, small intermittent patches of early secondary forests contain species of dipterocarps (LLDA, 2005; Nicer, 2004). Kaingin farming, according to Nicer (2004), has rendered most of the basin's land bare and agricultural activity has halted the natural forest cover's regeneration. The root cause of the basin's current condition was the implementation of conflicting laws in the whole Marikina Watershed Reservation which intended to commercialize most of its land area.

Continuous disturbance in the area, as revealed by the presence of extensive banana farms all over the watershed and the unabated charcoal production, especially within the impact zone of the proposed Upper Wawa Dam, has caused tremendous loss of native forest trees. The dipterocarps and some other premium and lesser-used species, which were recorded during the floristic inventory of Apercu Consultant's Inc. in 2016, were not observed during the conduct of the EIA for this project. The complete list in the floral inventory report of SMEC, conducted in May 2019, also delisted some previously common native forest trees in the area. Biodiversity of the Upper Wawa Watershed may have been affected by the cultural management regime applied by the upland residents for years until this date.

1.4.1.1 Historical Occurrences of Pest Infestation, Forest/Grass Fire and/or Similar Incidences

Extensive literature search using freeware and licensed search engines revealed no historical records of pest infestation in the UWD Project Site. In addition, ocular inspection during the field surveys, presented no unusual disease occurrences and pest infestation problems. Only leafspots, blights, cankers and butt rots were noted, which are among the typical disease-related symptoms in forested landscapes. Moreover, forest and grass fires are common and intentionally performed to open up space for banana, vegetable and upland rice production. Evidences of intentional fire are ashes and charcoal on the agricultural farms of the community residents.

1.4.1.2 Methodology

Sampling Stations

The field data collection was done on November 16 to 20, 2019 for the wet season sampling. The study done by SMEC on May 2019 for the dry season was used in this study. The purposive quadrat sampling technique was used during wet season. This field data collection technique was chosen with the intention of recording as many plant species as possible in all major vegetation types within wide accessible areas of the impact zone. The plots [also known as quadrats] in two different dimensions (10m x 10m and 2m x 2m) were laid one by one as new plant species were encountered at the stations. **Table EL-22** shows the sampling sites covered in the latest survey. During dry season, stratified random sampling was used by SMEC to establish two different dimensions of plots

(40m x 40m for trees and 4m x 4m for regenerants). In this method, each sampling point is located by taking a random number of 100m and 200m distance plots along riparian areas extending to around 40-50m from the edge of the river, to give a global positioning system (GPS) coordinates, coupled with observation as to change of vegetation to be taken in the said direction.

Table EL-22
Vegetation Sampling Sites

Site ID	Location
Site 1	Sitio Casili, Barangay San Rafael
Site 2	Ilog Baho, Sitio Casili and Boso-boso, Barangay San Rafael
Site 3	Sitio Anipa, Barangay San Rafael
Site 4	Sitio Lantawan, Barangay San Rafael
Site 5	Sitio Pagsabangan, Barangay San Rafael and Sitio Apia, Barangay Calawis

A total of 304 plots or quadrats were established all over the project area consisting of about 138 standard-sized plots (10m x 10m) and 166 smaller plots (2m x 2m) during wet season. The standard (10m x 10m) plot was intended to facilitate recording of trees and other erect plants with a diameter at breast height (DBH) of more than 1 centimeter. The smaller nested (2m X 2m) plot at the center of each plot, on the other hand, was purposely utilized to facilitate listing of ground vegetation and understory plants with less than 1cm DBH. The 2mx 2m plots were also established on grass-dominated and floodplain areas where vegetation formations are dominated by low stature plants. Other associated plant species not recorded in both plots but seen in the vicinity were also noted. The locations of all these plots are shown in **Figure EL-38**, while the record of coordinates of these plots are presented in **Annex F-1.** On the other hand, a total of 178 plots with a dimension of 40m x 40m for trees and 4m x 4m for regenerants were established during dry season (**Figure EL-39**).

Apart from listing down of plant names, bio-measurements such as diameter at breast height (DBH in cm), total height (TH in m), and crown cover (CC in %) were noted for each plot. For the undergrowth and understory plants, only the number of individuals and percent crown cover were recorded.

1.4.1.3 Ecological Measurements

Data gathered were subjected to various formula to determine ecological indices that include species dominance, diversity and evenness. The threatened status of the encountered species was also determined using IUCN and DAO listings.

Species Dominance

Species dominance in each vegetation type was determined by computing the species importance value (IV). For this study, importance value is considered as the sum of the relative frequency, relative density and relative dominance combined as one.

The dominance indices and their corresponding formulas to derive the importance value [IV] (based on Brower, 1989 as cited by Fernando *et al*., 1998) are provided below:

For Large Plants (trees, shrubs and erect large herbs):

$$\text{Density} = \text{total number of individuals of a species/unit area}$$

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

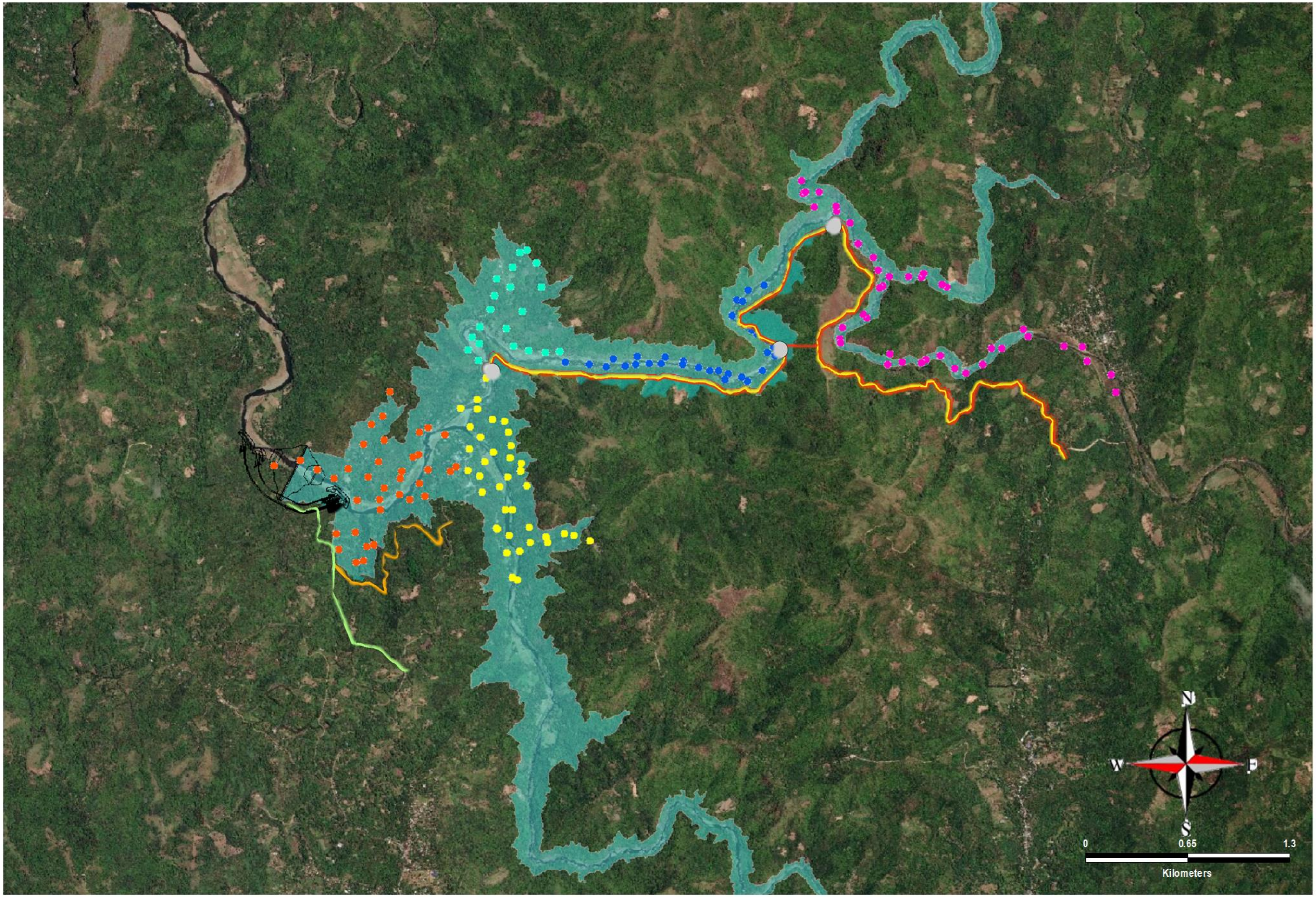

Figure EL-38. Terrestrial Ecology – Flora Sampling Stations (Wet Season)

ENVIRONMENTAL IMPACT STATEMENT
LAND MODULE
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LEGEND

Vegetatoion Plots
- Site 1
- Site 2
- Site 3
- Site 4
- Site 5

- Pump Station
- Transmission Pipeline via Tunnel Optional
- UWD Optional Access Road (New)
- UWD Optional Access Road (New)
- UWD Access Road (Original)
- Access Road to WTP / Transmission Pipe
- UWD Dam and Diversion Tunnel
- Transmission / Water Conveyance Pipeline
- UWD Reservoir

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCO, Inc. (2020)
Basemap: Google Earth Pro (2020)
Created by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.
aperçu CONSULTANTS INC.

SCALE: 1: 28,000

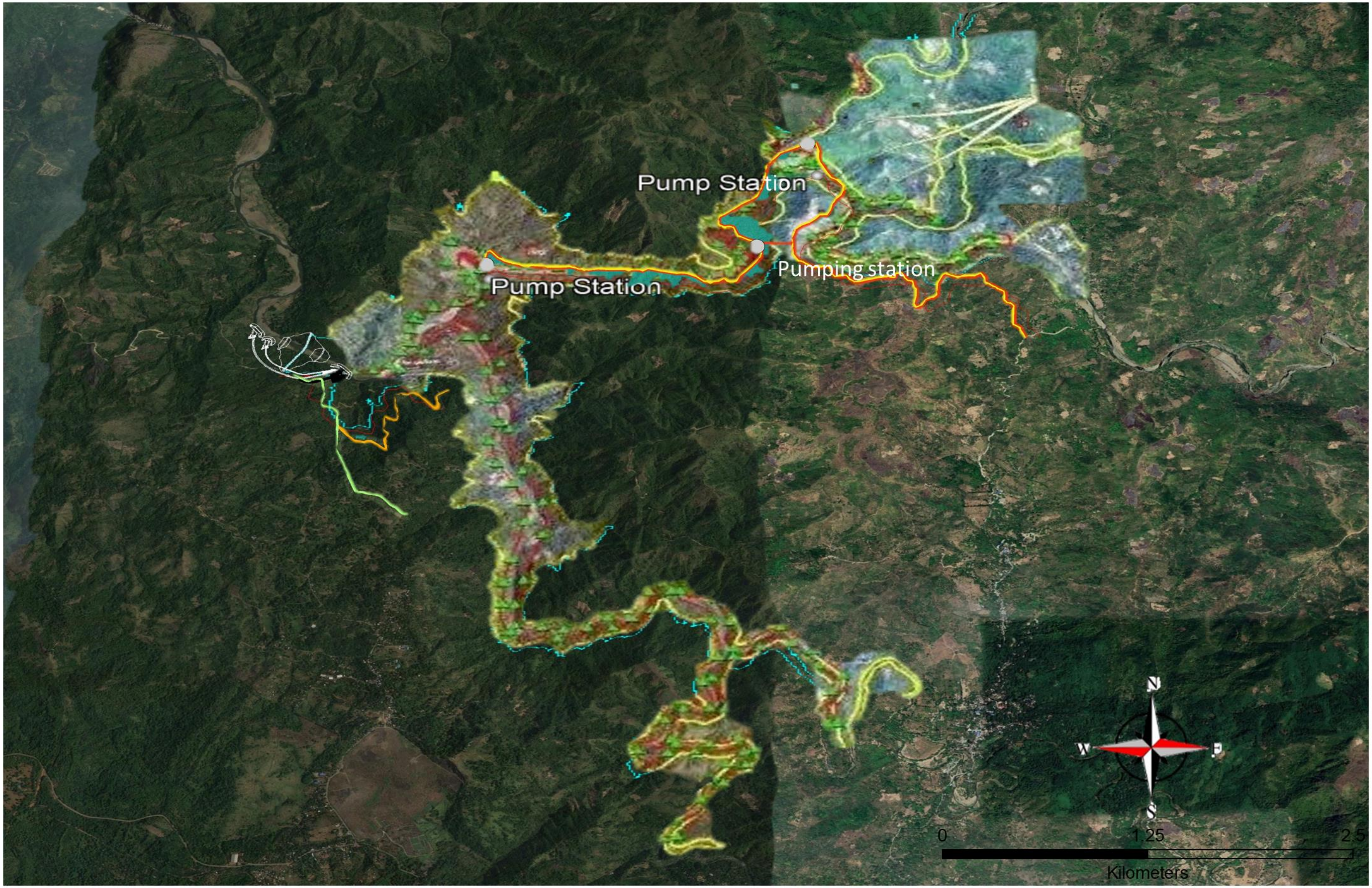

Figure EL-39. Terrestrial Ecology – Flora Sampling Stations (Dry Season)

ENVIRONMENTAL IMPACT STATEMENT
LAND MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

Legend

- Pump Station
- UWD Dam and Diversion Tunnel
- Transmission / Water Conveyance Pipeline
- UWD Reservoir
- Sampling points
- Transmission Pipeline via Tunnel Optional
- UWD Optional Access Road (New)
- UWD Access Road (Original)
- Access Road to WTP / Transmission Pipe

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCO, Inc. (2020)
Source Map: SMEC (2019)
Basemap: ArcGIS Imagery (2020)
Modified by: APERCU CONSULTANTS, INC (2020)

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SCALE: 1: 30,000

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

$$\text{Relative Dominance} = \frac{\text{Dominance of a species}}{\text{Total dominance of all species}} \times 100$$

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

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

$$\text{Relative Frequency} = \frac{\text{Frequency of a species}}{\text{Total summation of all frequencies}} \times 100$$

Importance Value = Relative Density + Relative Dominance + Relative Frequency

For Low Stature Plants (ground vegetation and understory plants with DBH less than 1 cm):

Density = *total number of individuals of a species/unit area*

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

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

$$\text{Relative Dominance} = \frac{\text{Dominance of a species}}{\text{Total dominance of all species}} \times 100$$

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

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

$$\text{Relative Frequency} = \frac{\text{Frequency of a species}}{\text{Total summation of all frequencies}} \times 100$$

Importance Value = *Relative Density* + *Relative Dominance* + *Relative Frequency*

Summary tables are presented in the main body of this report and the complete lists of plant species, all arranged in descending order of importance values, are provided in the appendices.

Diversity and Evenness Indices

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-Weiner 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. This diversity index is supported by Simpson's Diversity and Gini-Simpson's Indices.

Evenness (E), which is a measure of overall evenness, is the ratio of observed diversity to maximum diversity.

The diversity indices were all assessed using the following equations:

Shannon-Weiner Diversity (H') = $-\sum pi * (LNpi)$

For Tree and Shrub Layer:

$$\text{where: } pi = \frac{\text{IV of a species}}{\text{Total IV's of all species}}$$

Simpson's Diversity Index (D) = $1 - \sum pi^2$

Gini-Simpson's Index (1/D) = $1/\sum pi^2$

Evenness Index (E) = $H'/LN(s)$

where: s = number of species

The species diversity index 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). Fernando *et al*. (1998) has provided an ordinal classification of species richness and dominance indices for easy interpretation. **Table EL-23** shows the relative value rating for a specific range of diversity and dominance indices.

Table EL-23
Ordinal Classification of Species Richness and Dominance 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

Threatened Status

The global threatened status of each species was determined from the IUCN Red List of Threatened Species 2019 website using the link "http://www.iucnredlist.org/search" and from DAO 2017-11 which is the updated national list of threatened Philippine plants and their categories.

1.4.1.4 Existing Habitat Types within the Study Area

Several major vegetation types were surveyed and assessed in the proposed project site. These include brush and shrubby areas; natural bamboo stands; floodplain and riparian vegetation; and agricultural farms (banana and other perennial crops).

However, the latest ecosystem types used by the SMEC study (2019) for this project were adopted for the purpose of comparison. These include the following: (a) natural bamboo stands and karst vegetation; (b) banana farms; and (c) other agricultural farms.

The natural bamboo stands and karst vegetation in this new study covers brush and shrubby areas and natural bamboo stands. Banana farms, on the other hand, was considered a separate agro-ecosystem type since among all other agrifarms it has the most extensive cover in the area. Other agricultural farms include tree farms of edible fruit-bearing trees and timber species. There was no upland rice farm established within the impact zone during the wet season survey, thus it is not included in the succeeding discussions

Natural Bamboo Stands and Karst Vegetation

This ecosystem type covers the largest component (more than 50%) of the whole area. It is abundantly dominated by several species of bamboo such as buho (*Schizostachyum lumampao*), bikal (*Dinochloa acutiflora*), bolo (*Gigantochloa levis*), bayog (*Dendrocalamus merrillianus*), and kawayan (*Bambusa sp.*) (**Plate EL-12, Plate EL-13, Plate EL-14 and Plate EL-15**). The last two species are suspected to be introduced in the area. Only a small number of large lesser-used trees such as taluto (*Pterocymbium tinctorium*), baleteng salisi (*Ficus benjamina*), dita (*Alstonia scholaris*), and batino (*Alstonia macrophylla*) are now observed in this type of land use. Juvenile and mature narra (*Pterocarpus indicus*), teak (*Tectona grandis*), auri (*Acacia auriculiformis*) and mahogany (*Swietenia macrophylla*) trees were also found planted as boundary trees. According to the field guides who joined the survey, the remnants of rare premium trees like molave (*Vitex parviflora*) and juvenile dipterocarp trees (i.e. palosapis, white lauan, and guijo) are now only seen in inaccessible areas (not part of the impact zone) particularly in the steep mountains along Montalban river in Sitio Pagsabangan.

Historically, according to the communities of *Dumagats* and migrant *Aklanons* in the area, the whole basin was once thickly vegetated by dipterocarp forests and the main reasons of destruction were the slash-and-burn farming and unabated illegal cutting of trees for lumber and charcoal. They also added that common trees lushly growing all over the forested landscapes of the Wawa River Basin decades ago belonged to the group of premium trees. These trees, include white lauan (*Shorea contorta*), palosapis (*Anisoptera thurifera*), guijo (*S. guiso*), narig (*Vatica mangachapoi*), narra (*P. indicus*), molave (*V. parviflora*), kamagong (*Diospyros blancoi*), panau (*Dipterocarpus gracilis*), mayapis (*S. palosapis*), red lauan (*S. negrosensis*), gatasan (*Garcinia venulosa*), and the majestic apitong (*Dipterocarpus grandiflorus*) trees. All these trees are, no longer present in the impact zone of the proposed project based on the latest survey.

As observed in the field, the establishment of banana farms and harvesting of pole-sized trees for charcoal production are still rampant, apart from the slash-and-burn farming (kaingin) which has totally changed the original vegetation and species composition in the area.


Plate EL-12. A typical brush and shrubby vegetation formation in the Wawa River Basin


Plate EL-13. *Schizostachyum sp.* (Buho)


Plate EL-14. *Dinochloa sp.* (Bikal)


Plate EL-15. *Gigantochloa sp.* (Bolo)

Banana Farms

Banana, among other agri-crops, is the most commonly cultivated agri-commodity in the area. Thus, banana farms are seen in all stations, in flat to relatively steep slopes (**Plate EL-16 and Plate EL-17**).


Plate EL-16. Banana farms on flat slope in the Wawa River Basin


Plate EL-17. Banana farms on steep slopes in the Wawa River Basin

Other Agricultural Farms

The annual and perennial farms, referred to in this report as "other agricultural farms", are seen as distinct patches of vegetation in the watershed. Swidden farming (also known as kaingin) is commonly practiced all over the area. Annual crops raised include upland rice, vegetables and occasionally corn, while perennial crops are comprised of coconut, nangka, caimito, citrus, kape, cacao and other edible fruits, other than banana. Most of the farms are established near residential areas in Sitio Casili and Sitio Anipa. Other farms are also seen in other sitios where access to water is somehow available. Common agricultural farms (annual and perennial crops) in Sitio Casili and Sitio Anipa are shown in **Plates EL-18, EL-19, EL-20 & EL-21**.

The upland rice and vegetables farms are currently established far from the border of the impact zones and were not included in the sampling.

Plate EL-18. Agrifarm of Multiple crops – Fruit Trees

Plate EL-19. Agrifarm of Timber Species

Plate EL-20. Agrifarm of Upland Rice and Vegetables

Plate EL-21. Agrifarm of Coconut and Citrus

Riparian Strips and Floodplain Areas

Riparian strips and intermittent floodplain areas that are situated along the river stretch of the Upper Wawa River Basin (**Figure EL-40 and Figure EL-41**) from the branching streams in Sitio Pagsabangan, Barangay San Rafael and Sitio Apia, Barangay Calawis down to Sitio Casili in Barangay San Rafael. Floodplains are intermittent relatively flat areas along the river which are occasionally flooded for a couple of months during rainy season, while riparian strips are distinct vegetation formation on both sides along the stretch of the river.

Among the few common species found unique in both habitat types include mayagos (*Homonoia riparia*), kalubkob lalaki or kalogkog (*Syzygium calcicola*), kalubkob (*Syzygium calubcob*), and kakauateng ilog (*Fordia brachybotrys*).

Mayagos (*Homonoia riparia*)

Hagonoy (*Chromolaena odorata)*

Talahib (*Saccharum spontaneum*)

Multiple species of weeds

Figure EL-40. Typical floodplains in the Wawa River Basin (red circle)

Some other species of tall grasses, climbing bamboo and broadleaf herbs are common in both areas. These include, among others, the following: napier (*Pinnesetum purpureum*), talahib (*Saccharum spontaneum*), bikal (*Dinochloa levis*) and hagonoi (*Chromolaena odorata*).

Napier (*Pinnesetum purpureum*)

Bikal (*Dinochloa*) and Kakauateng Ilog (*Fordia*)

Multiple species of shrubs & weeds	**Kalubkob and Kalogkog (*Syzygium*)**

Figure EL-41. Riparian vegetation along the stretch of the Wawa River (red arrow)

1.4.1.5 Regional Description of Flora in Rizal

The Wawa River Basin is an important subwatershed of the Marikina Watershed Reservation. Similar with the Tanay Watershed (LLDA, 2005), at present, it is predominantly covered by shrubs and bamboo with some perennial woody vegetation. Literature says that buho (*Schizostachyum lumampao*), a cluster-forming bamboo, is common vegetation. Yet, small intermittent patches of early secondary forests contain species of dipterocarps (LLDA, 2005; Nicer, 2004). Kaingin farming, according to Nicer (2004), has rendered most of the basin's land bare and agricultural activity has halted the regeneration of the natural forest cover. The root cause of the basin's current condition was the implementation of conflicting laws in the whole Marikina Watershed Reservation, which intended to commercialize most of its land area (Nicer, 2004).

1.4.1.6 Project Sites Species Composition

Three (3) major ecosystem types were surveyed including natural bamboo stands, karst vegetation, bamboo farms, and other agricultural farms. A total of 315 species of plants were recorded during wet season in the 414.28 hectares proposed study area for Wawa Bulk Water Supply project (**Annex F-2**). These belong to 239 genera and 83 families. During dry season, a total of 107 species of regenerants (103 species of trees and 4 species of bamboo) and 89 mature tree species were recorded. Regenerants refer to any naturally established woody species, including seedlings, saplings and coppicing tree stumps. As shown in **Table EL-24 and Figure EL-42**, trees dominate in terms of the number of species, followed by herbs and shrubs, among all other plant types. The family with the most number of species were Fabaceae (legumes), Moraceae (mulberries), Euphorbiaceae (euphorbs), Lamiaceae (mints), Poaceae (grasses), Malvaceae (gumamela-related group), Moraceae (figs), Rubiaceae and Asteraceae during wet and dry season (**Table EL-25**). **Annex F-2** shows the complete list of plants encountered in the proposed study area.

Table EL-24
Number of Species based on Plant Type

Plant Type and Habit	Number of Species
Tree	151
Herb	87
Shrub	44
Vine	19
Fern	11
Climbing palm	2
Strangling fig	1
Total	**315**

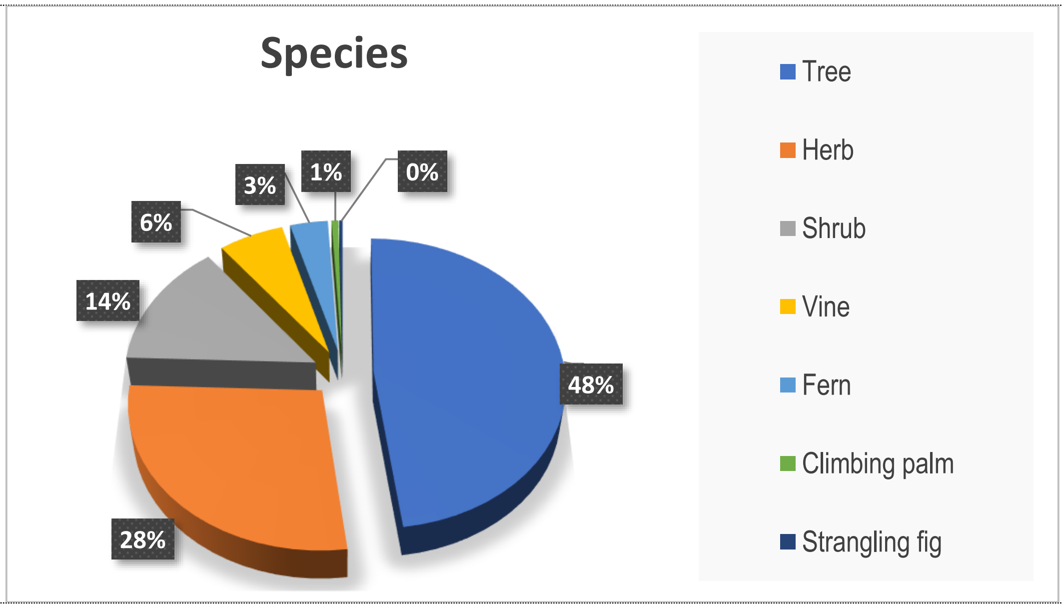

Figure EL-42. Percent distribution of species per plant type

Table EL-25
Common Plant Families based on the number of Species and Genera

Family	Species		Genera	
	Dry	Wet	Dry	Wet
Amaranthaceae	-	6	-	4
Anacardiaceae	6	7	3	5
Annonaceae	5	5	3	4
Apocynaceae	6	5	4	4
Araceae	-	6	-	5
Araliaceae	1		1	
Arecaceae	3	7	2	6
Astraceae	-	10	-	10
Boraginaceae	2	-	1	-
Burseraceae	6	-	1	-
Cannabaceae	2	-	2	-
Clusiaceae	2	-	2	-
Combretaceae	3	-	2	-
Cornaceae	1	-	1	-
Cyatheaceae	1	-	1	-
Dipterocarpaceae	1	-	1	-
Ebenaceae	3	-	1	-
Euphorbiaceae	11	23	6	17
Fabaceae	23	36	12	25
Lamiaceae	15	7	5	6
Lauraceae	4	5	2	4
Lecythidaceae	2	-	1	-
Leeaceae	2	-	1	-
Lythraceae	2	-	1	-
Malvaceae	10	18	7	14
Meliaceae	7	7	5	5
Moraceae	28	18	4	4
Myrtaceae	7	8	2	3
Lythraceae	2	-	1	-

Family	Species		Genera	
	Dry	Wet		Dry
Oxalidaceae	2	-	1	-
Phyllanthaceae	4	-	3	-
Poaceae	1	22	1	17
Polygonaceae	1	-	1	-
Rubiaceae	9	13	6	9
Rutaceae	6	7	3	5
Salicaceae	2	-	2	-
Sapindaceae	3	-	2	-
Sapotaceae	7	-	4	-
Simaroubaceae	3	-	1	-
Stemunoraceae	1	-	1	-
Urticaceae	1	-	1	-

Plant Species Abundance

Computation of importance value, an indicator of species abundance, was done separately for larger plants (≥ 1cm DBH) and low stature plants (ground vegetation and understory plants <1cm DBH). Summary results are provided in the tables below.

❖ Large Plants

The table below presents the most common large plants in the impact zone of the proposed project site during wet and dry season. Out of 177 species, saging (*Musa sapientum*), buho (*Schizostachyum lumampao*), ipil-ipil (*Leucaena leucocephala*), bolo (*Gigantochloa laevis*) and tibig (*Ficus nota*) had high importance values of more than 10% during wet season (**Table EL-26**). *M. sapientum* (banana) is the most cultivated agri-perennial crop in the area. A marked change in this vegetation was observed from 2015 to 2019. Banana farms estimated to have expanded to about 50 hectares in Sitio Casili and Sitio Anipa from 20-30 hectares in 2014. *S. lumampao*, *L. leucocephala*, *G. laevis* and *F. nota* are the common species in idle farms and brush areas. *Schizostachyum* covers more than 50% of the whole landscape, while *Leucaena*, *Gigantochloa* and *Ficus nota* are seen forming their own clusters. *F. nota*, in particular, dominates along forest edges and in open gaps.

Table EL-26
Dominant large plants (erect herbs, shrubs and trees)

Season	Common Name	Scientific Name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Wet	Saging	*Musa sapientum* L.	17.32	3.72	14.42	35.47
	Buho	*Schizostachyum lumampao* (Blanco) Merr.	1.37	1.58	21.36	24.30
	Ipil-ipil	*Leucaena leucocephala* (Lam.) de Wit	7.66	6.16	4.24	18.05
	Bolo	*Gigantochloa laevis* (Blanco) Merr.	2.00	3.71	11.33	17.04
	Tibig	*Ficus nota* (Blanco) Merr.	5.16	5.21	2.92	13.29
Dry	Yemane	*Gmelina arborea* Roxb.	11.228	0.493	263.343	263.836
	Caimito	*Chrysophyllum cainito* L.	8.383	0.473	196.629	197.103
	Tibig	*Ficus nota* (Blanco) Merr.	4.790	0.533	112.36	112.892
	Niyog	*Cocos nucifera* L.	4.790	0.335	112.36	112.695
	Mango	*Mangifera indica* L.	4.790	0.296	112.36	112.655

Out of 89 mature tree species, Yemane (*Gmelina arborea*), Caimito (*Chrysophyllum cainito*), Tibig (*Ficus nota*), Niyog (*Cocos nucifera*) and Mango (*Mangifera indica*) had a very high importance values more than 100% during dry season. This high importance value during dry season may attributed to the large dimension of plots established by SMEC (40m x 40m and 4m x 4m) compared to the survey done during wet season (10m x 10m and 2m x 2m). Yemane is a fast-growing species that usually used as construction materials, furniture, and musical instruments.

The complete list of large plants in the impact zone of the proposed project site is provided in **Annex F-3**.

- **Low Stature Plants**

There are about 213 low stature plants, saplings and seedlings noted in the proposed project site during wet season. Hagonoi (*Chromolaena odorata*) is seen in open areas extending in brush and shrubby vegetation and in abandoned timber and fruit-tree farms. Commonly recorded dominant associates were kudzu (*Pueraria montana*) and large crabgrass (*Digitaria sanguinalis*) (**Table EL-27**).

During dry season, Ipil-ipil (*Leucaena leucocephala*) has the highest importance among 107 species recorded with 499.6. It was followed by Mahogany (*Swietenia macrophylla*), Hauili (*Ficus septica*), Bogus (*Acalypha amentacea*), Kawayan killing (*Bambusa vulgaris*) and Tibic (*Ficus nota*) having 364.17, 295.95, 221.21, 202.15, and 174.56, respectively. This high importance value during dry season may attributed also to the large dimension of plots established by SMEC (40m x 40m and 4m x 4m) compared to the survey done during wet season (10m x 10m and 2m x 2m).

The complete list of low stature plants, saplings, and seedlings in the impact zone of the proposed project site is provided in **Annex F-4.**

Table EL-27
Dominant smaller plants (ground vegetation and other erect plants with less than 1cm DBH)

Season	Common Name	Scientific Name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Wet	Hagonoi	*Chromolaena odorata* (L.) R.M. King & M. Robinson	6.69	0.31	8.81	15.81
	Kudzu	*Pueraria montana* var. *lobata* (Willd.) Maes. & S. Almeida	5.46	0.80	5.86	12.13
	Large crabgrass	*Digitaria sanguinalis* (L.) Scop.	3.99	0.12	6.12	10.23
Dry	Ipil-ipil	*Leucaena leucocephala (Lam.) de Wit*	11.01	92.3	407.3	499.6
	Mahogany	*Swietenia macrophylla King*	9.30	20.06	344.1	364.17
	Hauili	*Ficus septica Burm. f.*	6.64	50.16	245.79	295.95
	Bogus	*Acalypha amentacea Roxb.*	4.84	42.13	179.07	221.21
Dry	Kawayan kiling	*Bambusa vulgaris Schrad.*	5.41	2.01	200.14	202.15
	Tibig	*Ficus nota (Blanco) Merr.*	3.42	48.15	126.4	174.56

Plant Species Composition per Site

Species composition was also determined, and species abundances were computed per station by plant group. The complete lists of plants by station per plant group are all provided in **Annex F-5 to Annex F-14**. The summary results, on the other hand, are provided one-by-one below.

Site 1 (Casili)

Recorded large plants (erect herbs, shrubs and trees) in Station 1 reached a total of 72 species (**Annex F-5).** Among the most commonly observed species are: saging (*M. sapientum*), buho (*S. lumampao*), bolo (*G. laevis*), ipil-ipil (*L. leucocephala*), caimito (*Chrysophyllum cainito*), and Tibig (*F. nota*) (**Table EL-28)**.

C. cainito survives competition as it is also observed in all vegetation/ecosystem types, apart from *Schizostachyum*, *Gigantochloa*, *Leucaena* and *Ficus*. It is also believed to have been commonly cultivated decades ago for home consumption for its sweet-edible juicy and pulpy fruit. Sitio Casili is where most of the residents are and thus has the greatest number of *Musa* and *Chrysophyllum*.

Table EL-28
Dominant large plants (erect herbs, shrubs and trees) in Site 1

Species Name	Scientific Name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Saging	*Musa sapientum* L.	40.47	8.94	22.27	71.67
Buho	*Schizostachyum lumampao* (Blanco) Merr.	0.15	0.43	27.23	27.80
Bolo	*Gigantochloa leavis* (Blanco) Merr.	0.74	2.13	22.93	25.80
Ipil-ipil	*Leucaena leucocephala* (Lam.) de Wit	4.14	6.38	1.37	11.89
Caimito	*Chrysophyllum cainito* L.	3.84	4.68	2.45	10.97
Tibig	*Ficus nota* (Blanco) Merr.	3.69	5.53	1.30	10.53

About 108 low stature plant species are listed in Site 1 (**Annex F-6**). *D. sanguinalis, Clitoria sp., Chromolaena odorata, P. montana, Colocasia esculenta, Commelina benghalensis* and *Mimosa pudica* are the most observed plants (**Table EL-29**). *Digitaria* is common under the shades of moderate to heavy tree canopies, while the rest are sun-loving plants.

Table EL-29
Dominant low stature plants (ground vegetation and other erect plants with less than 1 cm DBH) in Site 1

Species	Scientific Name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Large crabgrass	*Digitaria sanguinalis* (L.) Scop.	6.61	6.63	11.05	24.30
Butterfly pea	*Clitoria* sp.	6.88	6.90	6.52	20.29
Hagonoi	*Chromolaena odorata* (L.) R.M. King & M. Robinson	5.56	5.57	7.03	18.16
Kudzu	*Pueraria montana* var. *lobata* (Willd.) Maes. & S. Almeida	5.03	5.04	5.18	15.24
Gabi	*Colocasia esculentum* (L.) Schott	4.76	4.77	3.17	12.70
Landrina	*Commelina benghalensis* L.	3.70	3.45	4.60	11.75
Makahiya	*Mimosa pudica* L.	3.70	3.71	3.71	11.13

Site 2 (Boso-Boso)

The dominant plants in Site 1 were also commonly observed in Site 2 (**Annex F-7** and **Annex F-8**) with the addition of niog (*Cocos nucifera*) and hauili (*Ficus septica*) (**Table EL-30**). Coconut farm areas in Site 2 are a much larger than other stations, thus making coconut one of the dominant species in this station. *F. septica*, is a pioneer tree that grows in areas where sunlight is adequately available

Table EL-30
Dominant large plants (erect herbs, shrubs and trees) in Site 2

Species	Scientific Name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Saging	*Musa sapientum* L.	27.36	4.94	26.85	59.15
Buho	*Schizostachyum lumampao* (Blanco) Merr.	7.84	6.10	26.11	40.05
Ipil-ipil	*Leucaena leucocephala* (Lam.) de Wit	7.84	6.10	6.11	20.05
Tibig	*Ficus nota* (Blanco) Merr.	6.22	6.69	5.42	18.32
Niog	*Cocos nucifera* L.	4.48	3.49	8.69	16.66
Hauili	*Ficus septica* Burm. f.	4.48	6.40	3.94	14.81
Caimito	*Chrysophyllum cainito* L.	3.36	3.78	4.39	11.53

In addition to the list of most common low stature plants in the previous station, Site 2 has *Alternanthera sessilis, Oplismenus compositus, Triumfeta rhomboidei, Synedrella nodiflora,* and *Mimosa pudica* (**Table EL-31**)

All of these plants are sun-loving species commonly seen in coconut farms. However, *Oplismenus* gains more abundance in partly shaded portions of the farm.

Table EL-31
Dominant low stature plants (ground vegetation and other erect plants with less than 1 cm DBH) in Site 2

Species	Scientific Name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Kudzu	*Pueraria montana* var. *lobata* (Willd.) Maes. & S. Almeida	7.74	7.79	8.34	23.87
Hagonoi	*Chromolaena odorata* (L.) R.M. King & M. Robinson	6.50	6.54	9.19	22.24
Large crabgrass	*Digitaria sanguinalis* (L.) Scop.	5.57	5.61	7.33	18.51
Dilang butiki	*Centrosema pubescens* (DC.) Benth.	5.88	5.92	6.70	18.50
Alternanthera	*Alternanthera sessilis* (L.) R. Br. Ex DC.	4.64	4.67	6.48	15.79
Oplismenus grass	*Oplismenus compositus* (L.) Beauv.	4.33	4.36	5.81	14.51
Kulot-kulot	*Triumfeta rhomboidea* Jacq.	4.33	4.36	3.95	12.65
Tuhod manok	*Synedrella nodiflora* (L.) Gaertn.	3.72	3.74	5.02	12.48
Makahiya	*Mimosa pudica* L.	4.33	4.36	3.44	12.14

Site 3 (Anipa)

Station 3 has 70 recorded large plants in total (**Annex F-9**). *Dumagats* and *Aklanons* are the common residents of Sitio Anipa. Most of them used to cultivate timber species apart from banana, upland rice and vegetables. The inclusion of big-leaf mahogany (*S. macrophylla*) and yemane (*G. arborea*) is a proof of their preference to timber species as well, apart from the usual agri-crops (**Table EL-32**).

Both mahogany and yemane are naturalized-introduced trees from Southern America in the 50's. These are commonly used reforestation species in the Philippines and are cultivated in private farms for lumber.

Table EL-32
Dominant large plants (erect herbs, shrubs and trees) in Site 3

Species	Scientific Name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Saging	*Musa sapientum* L.	16.38	2.86	14.65	33.88
Buho	*Schizostachyum lumampao* (Blanco) Merr.	3.47	3.43	22.54	29.43
Big-leaf mahogany	*Swietenia macrophylla* King	13.29	4.57	10.22	28.08
Bolo	*Gigantochloa leavis* (Blanco) Merr.	3.28	2.86	15.00	21.14
Tibig	*Ficus nota* (Blanco) Merr.	9.06	6.29	4.45	19.79
Yemane	*Gmelina arborea* Roxb. ex Sm.	5.20	3.43	4.34	12.97

There are 88 species of low stature plants in Station 3 (**Annex F-10**). Listed in **Table EL-33** below, are common ground vegetation which are also found in the two previous stations.

Table EL-33
Dominant low stature plants (ground vegetation and other erect plants with less than 1 cm DBH) in Site 3

Species	Scientific Name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Hagonoi	*Chromolaena odorata* (L.) R.M. King & M. Robinson	5.43	1.14	10.25	16.82
Large crabgrass	*Digitaria sanguinalis* (L.) Scop.	4.35	1.14	7.45	12.93

Species	Scientific Name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Kudzu	*Pueraria montana* var. *lobata* (Willd.) Maes. & S. Almeida	4.71	1.14	6.25	12.10
Kulot-kulot	*Triumfeta rhomboidea* Jacq.	5.07	1.14	3.85	10.06

Site 4 (Lantawan)

Since both Stations 4 and 5 have intermittent steep mountain walls along both sides of the meandering river in Sitio Lantawan and Sitio Pagsabangan sampling was conducted along the riverbanks and plains of these areas.

Apart from the usual common plants also observed in Stations 1 to 3 *(L. leucocephala, S. lumampao, G. laevis*), kakauateng ilog (*Fordia brachybotrys*), malabuho (*Sterculia oblongata*), bogus (*Acalypha amentacea*), putat (*Barringtonia racemosa*) and tan-ag (*Kleinhovia hospita*) were also commonly recorded in Station 4 (**Table EL-34**). A total of 74 large plant species were noted in Station 4 (**Annex F-11)**.

Table EL-34
Dominant large plants (erect herbs, shrubs and trees) in Site 4

Species	Scientific Name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Ipil-ipil	*Leucaena leucocephala* (Lam.) de Wit	20.00	9.68	14.18	43.86
Buho	*Schizostachyum lumampao* (Blanco) Merr.	3.80	2.30	15.46	21.56
Bolo	*Gigantochloa leavis* (Blanco) Merr.	4.30	7.83	6.33	18.47
Kakauateng ilog	*Fordia brachybotrys* Merr.	8.10	4.15	3.34	15.59
Malabuho	*Sterculia oblongata* R. Br.	3.29	4.15	6.71	14.15
Bogus	*Acalypha amentacea* Roxb.	5.32	4.61	2.53	12.45
Tibig	*Ficus nota* (Blanco) Merr.	4.56	3.69	3.65	11.89
Putat	*Barringtonia racemosa* (L.) Blume ex DC	4.30	4.61	2.45	11.37
Tan-ag	*Kleinhovia hospita* Linn.	4.30	3.23	2.57	10.10

Low stature plants in Station 4 reached a total of 94 (**Annex F-12)**. **Table EL-35** shows that talahib (*S. spontaneum*) stood out as the most dominant, followed by *Chromolaena sp.* and *Mimosa sp*.

Dilang butiki (*Centrosema pubescens*) and *P. montana*, both creeping vines, are also common associates.

Table EL-35
Dominant low stature plants (ground vegetation and other erect plants with less than 1 cm DBH) in Site 4

Species	Scientific Name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Talahib	*Saccharum spontaneum* L.	6.06	6.06	10.98	23.10
Hagonoi	*Chromolaena odorata* (L.) R.M. King & M. Robinson	7.41	7.41	7.54	22.35
Makahiya	*Mimosa pudica* L.	5.39	5.39	6.16	16.93
Dilang butiki	*Centrosema pubescens* (DC.) Benth.	6.06	6.06	4.17	16.29
Kudzu	*Pueraria montana* var. *lobata* (Willd.) Maes. & S. Almeida	5.39	5.39	4.90	15.67

Site 5 (Apia and Pagsabangan)

There are about 64 species of large plants in Station 5 (**Annex F-13**). Among the most noticeable common dominants, apart from *Leucaena, Musa, Kleinhovia*, and *Gigatochloa*, are kakauateng ilog (*F. brachybotrys*), molave (*V. parviflora*) and malagos/miagos (*Homonaia riparia*) (**Table EL-36**).

Fordia and *Homonaia* are natural riparian flora. Both are commonly seen along the riverbanks and floodplains of Wawa and Montalban rivers, along with talahib (*Saccharum spontaneum*). The relative inaccessibility of the area is a good reason why a few mother trees and saplings of Molave (*Vitex parviflora)* still grow in the area.

Table EL-36
Dominant large plants (erect herbs, shrubs and trees) in Site 5

Species	Scientific Name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Ipil-ipil	*Leucaena leucocephala* (Lam.) de Wit	7.87	6.25	6.49	20.61
Saging	*Musa sapientum* L.	9.11	1.56	8.57	19.24
Tan ag	*Kleinhovia hospita* Linn.	5.80	5.47	6.86	18.13
Kakauateng ilog	*Fordia brachybotrys* Merr.	7.04	3.91	6.74	17.68
Bolo	*Gigantochloa leavis* (Blanco) Merr.	3.93	7.03	6.31	17.28
Molave	*Vitex parviflora* Juss.	5.18	5.86	5.61	16.64
Malabuho	*Sterculia oblongata* R. Br.	4.35	3.91	4.93	13.18
Bogus	*Acalypha amentacea* Roxb.	4.35	3.13	3.12	10.59
Malagos/Miagos	*Homonaia riparia* Lour.	3.52	3.13	3.60	10.25

There are 102 species of ground vegetation in Site 5 (**Annex F-14**). The common plants found in Site 4 are also evident in Site 5 although *C. odorata* is more abundant than *S. spontaneum* in Site 5 (**Table EL-37**).

Table EL-37
Dominant low stature plants (ground vegetation and other erect plants with less than 1 cm DBH) in Site 5

Species	Scientific Name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Hagonoi	*Chromolaena odorata* (L.) R.M. King & M. Robinson	8.45	8.47	10.24	27.17
Kulot-kulot	*Triumfeta rhomboidea* Jacq.	5.07	5.08	4.56	14.71
Kudzu	*Pueraria montana* var. *lobata* (Willd.) Maes. & S. Almeida	4.51	4.52	4.78	13.81
Dilang butiki	*Centrosema pubescens* (DC.) Benth.	4.51	4.52	4.47	13.50
Talahib	*Saccharum spontaneum* L.	3.10	3.11	4.64	10.85

Plant Species Composition per Vegetation Type

One of the objectives of this report is to purposely compare the previous flora assessments (APERCU 2015 and SMEC 2019) and the latest flora inventory and assessment. Thus, comparison on species composition and abundance per ecosystem/vegetation type was performed.

❖ Natural Bamboo Stands and Karst Vegetation

The natural bamboo stands and karst vegetation is the most species rich among the three ecosystem types. A total of 160 species of large plants have been recorded during wet season and 139 species during dry season (**Annex F-15**).

The most common large plants, based on importance value index, are *S. lumampao, L. leucocephala, G. laevis* and *F. nota* (**Table EL-38**). These same plants are among the most abundant species and are found in most of the stations.

Table EL-38
Dominant large plants (erect herbs, shrubs and trees) in natural bamboo stands and karst vegetation

Species	Scientific Name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Buho	*Schizostachyum lumampao* (Blanco) Merr.	1.79	7.15	19.38	28.32
Ipil-ipil	*Leucaena leucocephala* (Lam.) de Wit	10.75	6.74	6.64	24.13
Bolo	*Gigantochloa leavis* (Blanco) Merr.	2.77	4.39	14.92	22.08
Tibig	*Ficus nota* (Blanco) Merr.	6.73	5.11	4.21	16.05

The low stature plants in this vegetation type are also species rich, with a total of 182 (**Annex F-16**). The most dominants ones are: *C. odorata, P. montana, D. sanguinalis, C. pubescens, S. spontaneum, M. pudica* and *T. rhomboidei* (**Table EL-39**).

Table EL-39
Dominant low stature plants (ground vegetation and other erect plants with less than 1cm DBH) in natural bamboo stands and karst vegetation of the UWD area arranged in descending order of importance value

Species	Scientific Name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Hagonoi	*Chromolaena odorata* (L.) R.M. King & M. Robinson	7.91	6.79	8.59	23.29
Kudzu	*Pueraria montana* var. *lobata* (Willd.) Maes. & S. Almeida	5.76	5.27	5.31	16.34
Large crabgrass	*Digitaria sanguinalis* (L.) Scop.	5.96	3.31	5.09	14.35
Dilang butiki	*Centrosema pubescens* (DC.) Benth.	4.20	4.56	4.13	12.88
Talahib	*Saccharum spontaneum* L.	4.42	2.68	4.67	11.77
Makahiya	*Mimosa pudica* L.	4.21	3.57	3.62	11.40
Kulot-kulot	*Triumfeta rhomboidea* Jacq.	3.48	3.93	3.38	10.80

❖ Banana Farms

Banana (*M. sapientum*) has been the primary source of income of farmers in the study area by selling their produce in Antipolo City. Some of the upland residential farmers own hectares of banana farms within the impact zone.

Adjacent or along the boundary of agricultural farms are lines of mahogany trees used as live fences or monumental/ lot-mark trees. Most of the banana farms are planted with coconuts as well.

A total of 51 species of plants were recorded during wet season and 27 species during dry season in banana farms within the impact zone (**Table EL-40**) and (**Annex F-17**).

Table EL-40
Dominant large plants (erect herbs, shrubs and trees) in banana farms of the UWD area arranged in descending order of importance value

Species	Scientific Name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Saging	*Musa sapientum* L.	38.52	14.58	39.88	92.99
Big-leaf mahogany	*Swietenia macrophylla* King	3.20	4.27	3.01	10.48
Niog	*Cocos nucifera* L.	2.00	4.88	3.50	10.37

Common low stature plants in banana-mahogany-coconut farms are the following: *D. sanguinalis, C. odorata, P. montana, M. pudica* and others (**Table EL-41**).

Table EL-41
Dominant low stature plants (ground vegetation and other erect plants with less than 1cm DBH) in banana farms of the UWD area arranged in descending order of importance value

Species	Scientific Name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Large crabgrass	*Digitaria sanguinalis* (L.) Scop.	12.82	7.31	11.61	31.74
Hagonoi	*Chromolaena odorata* (L.) R.M. King & M. Robinson	10.37	7.31	10.80	28.48
Kudzu	*Pueraria montana* var. *lobata* (Willd.) Maes. & S. Almeida	7.06	5.65	6.93	19.65
Makahiya	*Mimosa pudica* L.	4.99	4.65	4.87	14.51
Cogon	*Imperata cylindrica* (L.) Beauv.	6.30	2.99	5.13	14.42
Butterfly pea	*Clitoria* sp.	3.69	4.32	3.56	11.57
Oplismenus grass	*Oplismenus compositus* (L.) Beauv.	4.07	2.66	4.33	11.06
Kulot-kulot	*Triumfeta rhomboidea* Jacq.	2.96	4.32	2.84	10.11
Kulape	*Paspalum conjugatum* Berg.	4.49	2.66	2.95	10.10

❖ Other Agricultural Farms (Fruit Trees)

Table EL-42 shows that even in other agricultural farms in the study area *Musa* dominates in density and dominance. Some other commonly cultivated perennial crops are *C. caimito, C. nucifera, S. macrophylla, P. indicus, M. indica, C. maxima,* and *Artocarpus heterophyllus*.

The presence of *F. nota* and *L. leucocephala* – perennial weeds, means that most of the farms are not properly managed or have been abandoned for months or years.

Table EL-42
Dominant large plants (erect herbs, shrubs and trees) in fruit-tree farms of the UWD area arranged in descending order of importance value

Species	Scientific Name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Saging	*Musa sapientum* L.	16.83	4.44	16.73	38.00
Caimito	*Chrysophyllum cainito* L.	10.73	8.33	12.57	31.63
Niog	*Cocos nucifera* L.	7.07	5.00	13.16	25.23
Big-leaf mahogany	*Swietenia macrophylla* King	5.37	4.44	8.80	18.61
Narra	*Pterocarpus indicus* Willd.	3.90	3.89	4.84	12.63
Mangga	*Mangifera indica* L.	2.93	3.89	5.67	12.48
Tibig	*Ficus nota* (Blanco) Merr.	4.39	5.56	2.27	12.22
Lukban	*Citrus maxima* Burm.	3.17	5.00	3.78	11.95
Ipil-ipil	*Leucaena leucocephala* (Lam.) de Wit	5.85	2.22	3.16	11.23
Nangka	*Artocarpus heterophyllus* Lam.	3.17	4.44	2.99	10.61

Associated weeds, on the other hand, include among others, the following: *P. montana, C. odorata, M. pudica, S. nodiflora, A. sessilis, P. conjugatum,* and *T. rhomboidea*.

Table EL-43
Dominant low stature plants (ground vegetation and other erect plants with less than 1cm DBH) in fruit-tree farms of the UWD area arranged in descending order of importance value

Species	Scientific Name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Kudzu	*Pueraria montana* var. *lobata* (Willd.) Maes. & S. Almeida	8.09	6.44	7.46	21.98
Hagonoi	*Chromolaena odorata* (L.) R.M. King & M. Robinson	7.53	4.46	7.18	19.16

Species	Scientific Name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Makahiya	*Mimosa pudica* L.	4.38	5.45	4.49	14.31
Tuhod manok	*Synedrella nodiflora* (L.) Gaertn.	5.00	3.47	5.50	13.96
Alternanthera	*Alternanthera sessilis* (L.) R. Br. Ex DC.	5.84	2.97	3.93	12.74
Kulape	*Paspalum conjugatum* Berg.	4.10	2.97	4.21	11.28
Gabi	*Colocasia esculentum* (L.) Schott	3.65	3.96	3.48	11.09
Paminta	*Piper nigrum* Linn.	3.54	1.49	5.05	10.07
Kulot-kulot	*Triumfeta rhomboidea* Jacq.	3.65	3.47	2.92	10.03

1.4.1.7 Diversity and Evenness

The tables (**Tables EL-44, EL-45 & EL-46**) below reveal diversity and evenness values in different categories. Most of the computed diversity (H' > 3.0; D > 0.9; 1/D > 11) and evenness (E > 0.75) values reflected in the tables show that the impact zone, even anthropogenically disturbed, have high to very high diversity and evenness indices, with the exemption of banana farms which exhibited only moderate diversity (2.62).

❖ Overall Species Diversity and Evenness

Table EL-44
Diversity and evenness values in the whole Upper Wawa Watershed

Plant Group	H'		D		1/D		E	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Large Plants (trees, shrubs and erect woody plants and herbs)	3.98	3.72	0.96	0.038	27.39	26.27	0.77	0.83
Small Plants (ground vegetation)	4.74	3.81	0.99	0.389	70.43	25.85	0.89	0.82

❖ Species Diversity and Evenness per Station

Table EL-45
Diversity and evenness values computed per station

Station	Plant Group	H'	D	1/D	E
1	Large Plants	3.29	0.92	11.99	0.77
	Small Plants	4.02	0.97	33.61	0.86
2	Large Plants	3.64	0.94	16.59	0.79
	Small Plants	3.78	0.96	28.03	0.85
3	Large Plants	3.53	0.95	20.16	0.83
	Small Plants	4.23	0.98	52.58	0.95
4	Large Plants	3.64	0.95	21.61	0.84
	Small Plants	4.02	0.97	34.76	0.89
5	Large Plants	3.68	0.97	28.61	0.87
	Small Plants	4.13	0.97	39.26	0.89

❖ Species Diversity per Vegetation/Ecosystem Type

Table EL-46
Diversity and evenness values computed per vegetation/ecosystem type

Vegetation Type	Plant Group	H'	D	1/D	E
Natural bamboo stand and karst vegetation	Large Plants	4.06	0.97	29.90	0.80
	Small Plants	4.34	0.98	42.84	0.83
Banana farms	Large Plants	2.62	0.91	10.85	0.67
	Small Plants	3.71	0.96	24.65	0.83
Other agricultural farms (fruit trees and timber species)	Large Plants	3.43	0.95	19.00	0.82
	Small Plants	3.87	0.97	34.06	0.88

1.4.1.8 Threatened Species and Endemism

Threatened Species

There are 23 species of trees recorded to have threatened conservation status during wet season while 17 species during dry season as shown in **Table EL-47**. Kamagong (*Diospyros blancoi*) is noted as the most threatened species being endangered internationally and critically endangered in the Philippines. This species is known to produce edible fruits and the lumber from its durable trunk, roots and branches can be utilized as hand tools and raw materials for tables, chairs, and other novelty items.

Table EL-47
List of threatened plant species in either of or both IUCN 2019 and DAO 11-2017

Common Name	Scientific Name	Family Name	Conservation Status	
			IUCN 2019	DAO 11, S2017
Kamagong	*Diospyros blancoi* A DC	Ebenaceae	EN	CR
Narra	*Pterocarpus indicus* Willd.	Fabaceae	EN	VU
Ebony	*Diospyros ferrea* (Willd.) Bakh.	Ebenaceae	EN	VU
Tindalo	*Afzelia rhomboidea* (Blanco.) Vid	Fabaceae	VU	EN
Molave	*Vitex parviflora* A.Juss.	Lamiaceae	VU	EN
Anubing	*Ficus ovatus* Blanco	Moraceae	VU	NE
Aplas	*Ficus ampelas*	Moraceae	VU	NE
Balete	*Ficus balete*	Moraceae	VU	NE
Big-leaf mahogany	*Swietenia macrophylla* King	Meliaceae	VU	NE
Is-is	*Ficus ulmifolia* Lam.	Moraceae	VU	NE
Kamansi	*Artocarpus altilis*	Moraceae	VU	NE
Katmon	*Dillenia philippinensis* Rolfe	Dilleniaceae	VU	VU
Nangka	*Artocarpus heterophyllus*	Moraceae	VU	NE
Niog-niogan	*Ficus pseudopalma*	Moraceae	VU	NE
Pakiling	*Ficus odoratissimus*	Moraceae	VU	NE
Malakape	*Canthium dicoccum* (Gaertn.) Merr.	Rubiaceae	VU	NE
Bagawak morado	*Clerodendrum minahassae* Teijsm. & Binn.	Lamiaceae	NE	VU
Bolong eta	*Diospyros pilosanthera* Blanco	Ebenaceae	NE	VU
Pahutan	*Mangifera altissima* Blanco	Anacardiaceae	NE	VU
Anislag	*Securinega flexuosa* Muell.-Arg.	Euphorbiaceae	NE	OTS
Kalomata	*Clausena brevistyla* Oliv.	Rutaceae	NE	OTS
Lanutan	*Mitrephora lanotan* (Blanco) Merr.	Annonaceae	NE	OTS
Malasaging	*Aglaia diffusa*	Meliaceae	LR/NT	OTS
Philippine teak	*Tectona philippinensis*	Lamiaceae	EN	EN
Anang	*Diospyros pyrrhocarpa*	Ebenaceae	LC	VU
Betis	*Madhuca betis*	Sapotaceae	VU	EN
Piling liitan	*Canarium luzonicom*	Burseraceae	NT	OTS
Tanglin	*Adenanthera intermedia*	Fabaceae	VU	OTS

Note: CR = critically endangered; EN = endangered; VU = vulnerable; OTS = other threatened species; NE = not evaluated; IUCN 2019 = International red list of threatened species of flora and fauna; DAO 11, S 2017 = Updated National List of Threatened Philippine plants and their categories

Narra (*Pterocarpus indicus*) and ebony (*Diospyros ferrea*) are both endangered internationally, however categorized as vulnerable in the country. Narra is a common reforestation species since it adapts to many types of soils and can be mass-produced sexually (thru seeds) and asexually (clones/cuttings). Ebony, on the other hand, adapts to rocky areas, under the shade of intermediate-sized trees. It is also an endemic species very common in limestone areas.

Tindalo (*Afzelia rthomboidea*) and molave (*Vitex parviflora*) are both endangered in the country. Both are now being used as reforestation species being sun-loving that can easily adapt in open areas if planted in a proper substrate or if soil is ameliorated. They are also used for heavy construction since lumber harvested from these trees are highly durable. Tindalo, in particular, is reddish and fine-textured, while molave is heavy and grayish in color.

Other species listed in table below are mostly classified internationally under vulnerable category except for anislag (*Securinega flexuosa*), kalomata (*Clausena brevistyla*), lanutan (*Mitrephora lanotan*) and malasaging (*Aglaia diffusa*), which are considered under other threatened species in the country. All of these tree species are recommended to be part of the priority species for earthballing.

Some other non-tree species which are classified threatened are: gabing tigre (*Alocasia zebrina* C. Koch & Viecth.), tagbak (*Alpinia elegans* [Presl.] K. Schum.) and palasan (*Calamus merrillii* Becc.).

Endemism

About 24 species of plants in the UWD project site are found to be native to the country during wet season while 95 species during dry season. Among all the listed species in **Table EL-48**, gabing tigre, katmon, tagbak and palasan are also threatened and need immediate protection.

Table EL-48
List of endemic species recorded in UWD Project Site

Common Name	Scientific Name	Family Name
Hemigraphis/ Red Flame	*Hemigraphis longipetiolata*	Acanthaceae
Gabing tigre	*Alocasia zebrina* C. Koch & Viecth.	Araceae
Galamay amo	*Schefflera odorata* (Blanco) Merr. & Rolfe	Araliaceae
Palasan	*Calamus merrillii* var. *merrillii* Becc.	Arecaceae
Binukaw	*Garcinia binucao*	Clusiaceae
Kamandiis	*Garcinia rubra*	Clusiaceae
Katmon	*Dillenia philippinensis* Rolfe.	Dilleniaceae
Hamindang	*Macaranga bicolor*	Euphorbiaceae
Balete	*Ficus balete*	Moraceae
Pakiling	*Ficus odorata*	Moraceae
Niog-niogan	*Ficus pseudopalma*	Moraceae
Antipolo	Artocarpus blancoi	Moraceae
Is-is	*Ficus ulmifolia* Lam.	Moraceae
Ficus	*Trophis philippinensis* (Burm.) Corner	Moraceae
Saging matsing	*Musa balbisiana* Colla, Mem	Musaceae
Lit-lit	*Piper interruptum* Opiz var. loheri (C.D.C.) Quis.	Piperaceae
Baret	*Weinlandia luzonica*	Rubiaceae
Langin	*Micromelum caudatum* Merr.	Rutaceae
Tulibas tilos	*Micromelum compressum*	Rutaceae
Oonog	*Osmelia philippina* (Turcz.) Benth.	Salicaceae
Alahan	*Guioa koelreuteria*	Sapindaceae
Alagasi	*Leucosyke capitellata*	Urticaceae
Amamali	*Leea philippinensis*	Vitaceae
Tagbak	*Alpinia elegans* [Presl.] K. Schum.	Zingiberaceae
Alagau	*Premna odorata*	Lamiaceae
Anang	*Diospyros pyrrhocarpa*	Ebenaceae
Anislag	*Securinega flexuosa*	Euphorbiaceae
Bagauak	*Clerodendrum minahassae*	Lamiaceae
Bagawak morado	*Clerodendrum minahassae* Teijsm. & Binn.	Lamiaceae
Balobo	*Diplodiscus paniculatus*	Malvaceae
Betis	*Madhuca betis*	Sapotaceae
Kubi	*Artocarpus nitida*	Moraceae
Narra	*Pterocarpus indicus*	Fabacaee
Philippine teak	*Tectona philippinensis*	Lamiaceae
Molave	*Vitex parviflora*	Lamiaceae

It is therefore suggested that all species listed in **Table EL-47** and **Table EL-48** be included in the priority species for rehabilitation. The proponent will establish a permanent nursery and these listed species will be included for mass propagation.

1.4.1.9 Economic Uses and Importance of Significant Flora

Important plant species are often selected in terms of their ecological and economic contributions to the environment and society. **Table EL-49** presents the list of 22 significantly important plants in the UWD impact areas. Uses vary from heavy and light construction material, raw materials for handicrafts and novelty items, food for man and wildlife, and as medicines. Most of the species are used in reforestation programs of the government.

Table EL-49
Significant flora and their corresponding ecological, medicinal and economic uses and importance

Common Name	Scientific Name	Uses
Anislag	*Securinega flexuosa* Muell.-Arg.	For hand tools, farm armaments, handicraft and novelty items; fruits edible birds
Anubing	*Ficus ovatus* Blanco	For light construction
Bagawak morado	*Clerodendrum minahassae* Teijsm. & Binn.	For landscaping; leaves and flowers medicinal
Balete	*Ficus balete*	Fruits edible to birds and other wildlife; for landscaping
Big-leaf mahogany	*Swietenia macrophylla* King	Planted for timber, lumber and posts; common reforestation species for it adapts in almost all types of soil; seeds medicinal
Bolong eta	*Diospyros pilosanthera* Blanco	Fruits edible to birds and other wildlife; used in landscaping
Ebony	*Diospyros ferrea* (Willd.) Bakh.	For landscaping; fruits edible to birds and other wildlife
Gabing tigre	*Alocasia zebrina* C. Koch & Viecth.	For landscaping, in and outdoor
Galamay amo	*Schefflera odorata* (Blanco) Merr. & Rolfe	For landscaping, in and outdoor
Is-is	*Ficus ulmifolia* Lam.	For landscaping; fruits edible to birds and other wildlife
Kamagong	*Diospyros blancoi* A DC	For rehabilitation/reforestation; edible fruits; timber, lumber, posts; novelty; roots and leaves medicinal
Kamansi	*Artocarpus altilis*	Fruits used as vegetable; gummy sap used as trap for birds in rice farms
Katmon	*Dillenia philippinensis* Rolfe	Fruits edible; lumber for handicraft and novelty; fruits, leaves and
Lanutan	*Mitrephora lanotan* (Blanco) Merr.	For landscaping
Molave	*Vitex parviflora* A.Juss.	Known reforestation species; for heavy construction; railroad ties, handicraft and novelty items
Nangka	*Artocarpus heterophyllus*	Fruits edible and valued high in the market; for light construction; leaves, bark and roots medicinal
Narra	*Pterocarpus indicus* Willd.	Well-known reforestation species; timber, lumber, posts; for construction; floorings and walls; source of dyes; roots and leaves medicinal
Pahutan	*Mangifera altissima* Blanco	For light construction
Palasan	*Calamus merrillii* var. *merrillii* Becc.	Raw material for handicrafts and novelty items
Tagbak	*Alpinia elegans* [Presl.] K. Schum.	For landscaping, in and outdoor
Tindalo	*Afzelia rhomboidea* (Blanco.) Vid	Known reforestation species; for construction, handicraft and novelty items
Yemane	*Gmelina arborea*	Plantation and reforestation species

1.4.1.10 Ecologically Sensitive Areas based on the distribution of Threatened Plants

Figure EL-43 below shows the location of identified threatened plants. The whole area which will be inundated by water upon project operation is considered ecologically sensitive based on the distribution of threatened species. However, most ecologically sensitive areas are the riparian ecosystem, easements and the thickets of tall vegetation in the karst landscape.

It is noticeable that narra (*Pterocarpus indicus*) and molave (*Vitex parviflora*) are widely distributed either as medium to large-sized trees, saplings, wild regenerations and planted seedlings through the National Greening Program of the DENR.

Mahogany (*Swietenia macrophylla*), though commonly seen in the area as reforestation species and cultivated for timber in the Philippines, is included since it is categorized as Vulnerable internationally. Other species with similar conservation status, however, still common in the area are the following: nangka (*Artocarpus heterophyllus*), is-is (*Ficus ulmifolia*), niog-niogan (*Ficus pseudopalma*), and pakiling (*Ficus odoratissimus*). Nangka is cultivated in tree farms and in the backyard of residents while the last three species are quite common in abandoned coconut farms as pioneer trees.

The threatened plants (listed in **Table EL-47**) will be the priority vegetation species in all earth balling and future rehabilitation activities.

1.4.1.11 Comparison of Past and Present Studies of Flora in Wawa Area

<u>**Apercu 2015 and Apercu 2019**</u>

Similar plant species have been recorded in both 2015 and 2019 surveys, however, it was observed in the latest inventory and assessment that most (if not all) of the listed premium trees in the 2015 inventory such as narig (*V. mangachapoi*), palosapis (*A. thurifera*), white lauan (*S. contorta*) and guijo (*S. guiso*) were harvested either perhaps for lumber or charcoal and conversion of their habitats to agricultural farms (banana and other perennial crops). Some of the native trees still prominent, though markedly reduced in numbers, were: molave (*V. parviflora*), narra (*P. indicus*), pahutan (*Mangifera altissima*), lanutan (*Mitrephora lanotan*), katmon (*Dillenia philippinensis*), kamagong (*Diospyros blancoi*), bolong eta (*Diospyros pilosanthera*), anislag (*Securinega flexuosa*), and lingo-lingo (*V. turczaninowii*), among others.

These plants may serve as future sources of seeds and seedlings which can be used in rehabilitation program of the proponent.

<u>**SMEC 2019 and Apercu 2019**</u>

There are very slight differences in the species listing of the SMEC and APERCU inventory. This could be due to the expert opinion of the specialist in both groups. However, majority of the recorded plants are alike.
Some of the species noted in the SMEC 2019 list, however not recorded in the latest inventory, are the following:

1. Philippine teak (Tectona philippinensis) – endemic or native only in Ilin Island and Batangas province
2. Amugis (Koordersiondendron pinnatum) – may be present but not observed in the latest survey
3. Betis (Madhuca betis) – may also be present but not observed in the latest survey
4. Dungon late (Heritiera littoralis) – naturally grows in mangroves and beach areas
5. Akle (Albizzia acle) – may be present but not observed in the latest survey
6. Kalantas (Toona calantas) – may be present but not observed in the latest survey

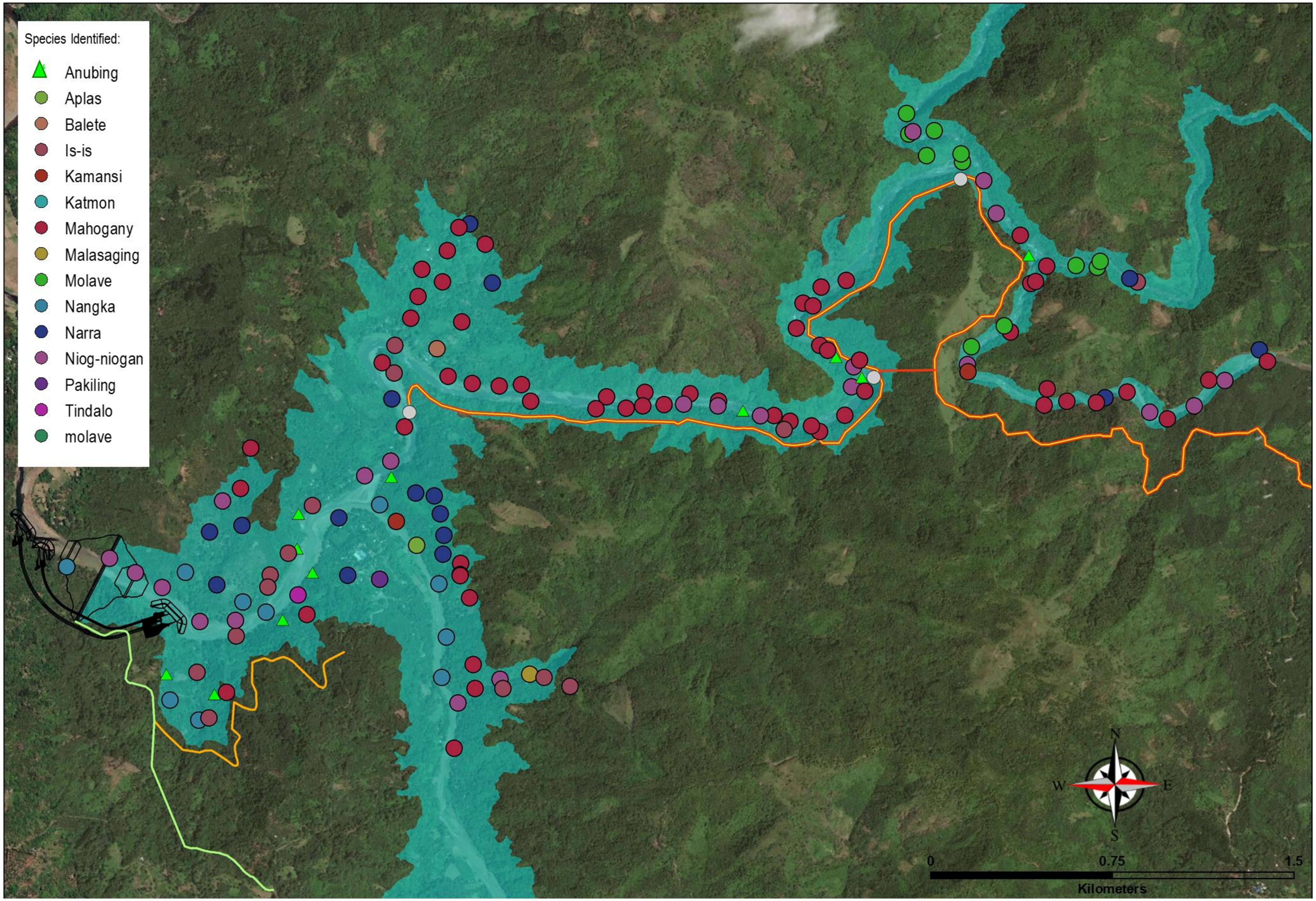

Figure 43. Location Map of Threatened Plant Species and Ecologically Sensitive Areas

ENVIRONMENTAL IMPACT STATEMENT
LAND MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

Legend

- Pump Station
- UWD Dam and Diversion Tunnel
- Transmission / Water Conveyance Pipeline
- UWD Reservoir
- Transmission Pipeline via Tunnel Optional
- UWD Optional Access Road (New)
- UWD Access Road (Original)
- Access Road to WTP / Transmission Pipe

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCO, Inc. (2020)
Basemap: ArcGIS Imagery(2020)
Created by: APERCU CONSULTANTS, INC (2019)

WawaJVCo INC.

aperçu CONSULTANTS INC.

SCALE: 1: 12,500

Anang (*Diospyros pyrrocarpa*) and Mt. Tapinag (*Sterculia cordata*) may have been identified in the latest survey as bolong eta (*Diospyros pilosanthera*) and malabuho (*Sterculia montana*). Confirmation of the real ID may only be finalized until flowers and fruits are evident.

Differences in species abundances or importance values may have been contributed to the choice of sampling locations. In the case of SMEC, plant species with high importance values were: yemane (with IV = 263%), caimito (197%), tibig (112%), manga (112%), niog (112%), and hagimit (102%).

It is sad to note that the total importance values should not exceed 300%, but obviously by looking at the values presented above, it seems that SMEC was not able to use the right formula in the computation of species abundance (IV).

The latest APERCU 2019 survey presents complete tables of relative abundance and importance values in the appendices for cross validation.

1.4.1.12 Impact Assessment and Mitigation Measures for Terrestrial Flora

Pre-Construction Phase

At this stage, a complete inventory of the vegetation that will be affected during the construction and operation phases of the project will be undertaken and a permit to cut trees secured in coordination with the DENR and the Philippine Coconut Authority (PCA). The inventory is intended to determine the number of seedlings to be cultivated as replacements for those which will be cut or submerged in water.

Upon completion of the inventory, nurseries will be established in strategic locations where water is available all year-round. Collection of seeds and wildlings will focus on the identified threatened plants listed in **Annex F-1**. Sources of planting stocks will be the project site and its vicinities as well as nearby watersheds with thick forests, which are also good sources of seeds.

The proponent will collect the required number and quality of planting stocks (seeds and seedlings) to be raised in the nurseries for reforestation and rehabilitation activities. Pursuant to DENR Memorandum Order No. 2012-02, the number of seedlings (*replacement ratio for cut/relocated trees will be 1:50 for trees planted in private and forestlands while 1:100 for naturally growing trees*) to be raised will depend on the anticipated areas which will be damaged during the construction phase and inundated by water during the project operation.

Construction Phase

To minimize loss and disturbance to various habitat types, active construction areas will be limited to what is needed, as much as possible. A Catchment Area Treatment (CAT) that will include buffer zone establishment thru assisted natural regeneration and enrichment planting will be crafted and implemented. The framework will also include the detailed plan on the construction of "vengineering" structures (retaining structures) to control siltation; earthballing activity on threatened and ecologically important flora; and protection of existing thick vegetation which will serve as sources of seeds and seedlings.

Rehabilitation of temporarily disturbed areas will be done as soon as practicable. The proponent will require contractors to provide clear demarcations of areas to be cleared and layouts of the work areas will be carefully planned. In the reservoir area, however, all vegetation will be cleared to minimize the impacts associated with eutrophication and greenhouse gas contributions during the operations phase. The threatened plants (**Annex F-1**) that will be affected during the construction phase will be the focus of the rehabilitation and conservation programs of the proponent. When necessary, earth balling of threatened and ecologically important plants will be enforced.

Operation Phase

The inundation area will result in the permanent loss of riparian and floodplain vegetation as well as of threatened species situated in these areas. Once inundation is complete, the operation of the dam will define minimum and maximum water levels, which in turn will create new vegetation zones that may form. In this case, assisted natural regeneration (ANR) and enrichment planting using identified species common in both vegetation types will be conducted to fast track the creation of this new riparian zone. This new riparian zone will serve as the buffer zone around the dam that will prevent river flow scouring, soil erosion, dam siltation and slope instability. ANR is a simple, low-cost forest restoration method that can effectively convert degraded lands to more productive forest (Shono, K. et al. 2007). This method aims to accelerate, rather than replace, natural successional processes by removing or reducing barriers to natural forest regeneration such as soil degradation, competition with weedy species, and recurring disturbance. Enrichment planting, on the other hand, is the planting of desirable tree species to enrich the forest species stocks with the goal of increasing diversity.

Abandonment Phase

Should abandonment occur, right after dismantling all the structures, assisted natural regeneration (ANR) will be performed to extend the growth of plants on the impact zone. Seeds of cover crops will be broadcasted all over the area to enrich the soil's chemical and physical properties. Readily available planting stocks of indigenous timber and fruit trees will also be raised and planted in open spaces.

Vegetation Removal and Habitat Loss

Vegetation removal and habitat loss will have an adverse negative impact to all economically and ecologically important plants and wildlife in the area. Before any vegetation removal is done in the proposed project site, the proponent will see to it that 100% inventory has been conducted in all impact areas. Also, the buffer zones of thick vegetation surrounding the proposed dam will be established and maintained intact and protected. These zones will serve as alternative habitats for biodiversity, particularly wildlife, that will be later displaced in impact areas during dam operation. Open disturbed gaps in these buffer zones will be enriched through planting by those identified endangered, endemic and economically important plant species. All endemic, rare and endangered plant species situated in areas which will be submerged in dam water will be earth-balled and transferred in identified near-by relocation sites.

Threat to Existence and/or Loss of Important Local Species

Important local/endemic plants are priority species for production and protection. So apart from those listed threatened plants, local (endemic) species will be considered in the nursery seedling production and earth-balling activities. Seedling production and earth-balling will be done during rainy seasons to ensure high survival of seedlings and earth-balled saplings and pole-size trees.

Threat to Abundance, Frequency and Distribution of Important Species

The proponent will conduct regular inventory and monitoring activities in buffer zones and protection areas. This is to ensure that frequency, abundance and distribution of economically and ecologically important species are monitored periodically.

Hindrance to Wildlife Species

Wildlife living in impact areas which will be submerged in dam water will definitely be displaced from their natural habitats. Provision of new habitats (in buffer zones) will be the priority of the proponent. Full protection will be imposed in these buffer zones to ensure that the wildlife will find comfort in their new environment. Regular foot patrol will also be arranged by the proponent, together with the locals and DENR personnel, to avert poaching of wildlife in the area.

1.4.1.13 Sustainable Watershed Management Framework

The proponent will adopt and implement the watershed management framework as shown in **Figure EL-44** primarily to abate the negative impacts of the Wawa Bulk Water Supply Project.

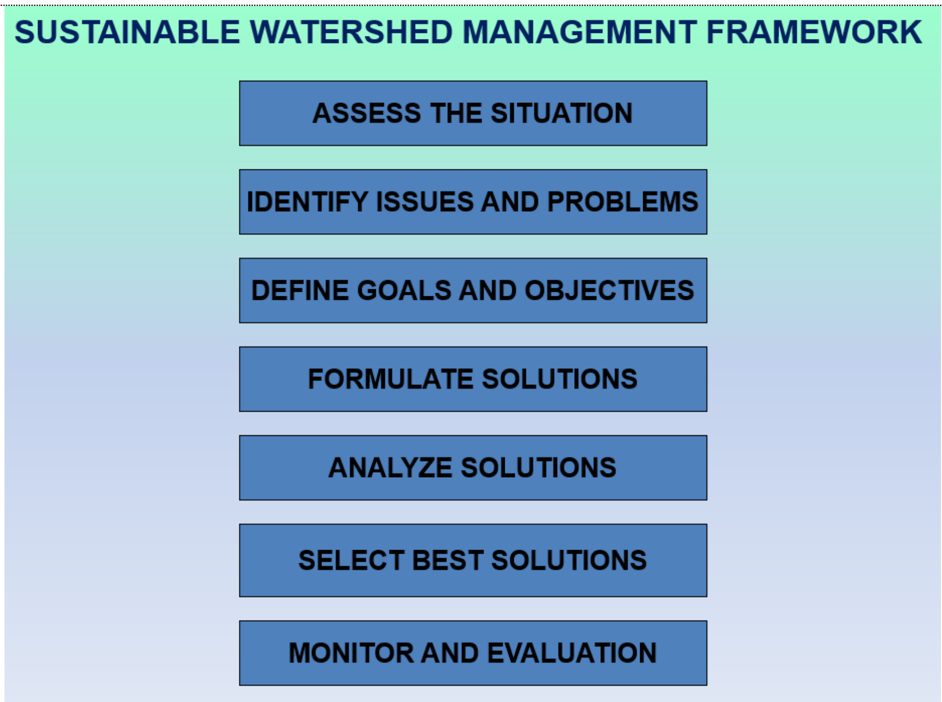

Figure EL-44. Watershed management framework for the UWD Project

The sustainable watershed management framework that will be adopted will serve as the management framework in the implementation of the sustainable watershed management framework.

Series of activities that are essential in attaining sustainability of the Upper Wawa Watershed are the following:

Assessment of Current Situation

Also known as environmental scanning, this process is the preliminary step towards determining watershed related issues and problems. This can be done through reconnaissance survey (ocular inspection), reading of secondary data and talking with the concerned people.

The proponent will see to it that all activities in relation to determining the current situation in the Upper Wawa Watershed will be implemented. The baseline data, as a result of the previous and present environmental impact assessments (EIAs) thru public scoping, socio-economic assessment, flora and fauna inventories, soil, geological and hydrological studies, and the like, will be used to determine the present situation in the area, including the decline in flora and fauna species diversity brought by anthropogenic and natural disturbances.

Identification of Issues and Problems

This process includes determination of issues, problems, constraints and opportunities. The usual tool used to determine the current situation in the project site is the "problem tree". Apart from ocular observation, focus group discussions can be administered to determine relevant issues and problems in the area, including potential opportunities, constraints and externalities.

Problems identified related to UWD expansion are the following: (a) potential siltation due to soil erosion; (b) damage to vegetation; (c) habitat loss; (d) displacement of wildlife, among others.

Goal and Objective Formulation

Any management strategy is anchored on the end goal and objectives of the operations. If the goal is a sustainable watershed, then all processes to make the watershed sustainable should be part of a set of targets and strategies to achieve this goal. The objectives should be defined in a way that they are SMART: simple, measurable, attainable, realistic and time-bounded.

For this purpose, the proponent's goal is to increase the vegetation around the dam which will serve as buffer to prevent/control sedimentation/siltation in the dam and implement reforestation and rehabilitation activities in relation to increasing the vegetation in nearby open areas as exchange of those vegetation which will be submerged due to water impounding in dam.

Formulation of Solutions

When the issues and problems are identified and a goal to address the issues and problems are supported by clear and concrete objectives and well-planned strategies, then robust solutions can easily be implemented. The UWD project will be experiencing problems on siltation due to construction related soil erosion, habitat destruction, loss of habitat due to dam water impoundment and many more.

Possible solutions to reduce these negative impacts brought by this Upper Wawa Dam Project are the following:

a. 100% inventory of plants on impact areas for immediate replacement in rehabilitation sites and bufferzones;
b. establishment and implementation of Catchment Area Treatment (CAT);
c. construction of retaining structures or "vengineering" structures to control siltation especially in steep areas;
d. enforcement of earth-balling activity for threatened and ecologically important plants;
e. re-establish, thru assisted natural regeneration (ANR) and enrichment planting, of any disturbed areas that need immediate rehabilitation; and
f. retain thick vegetation near impact areas as alternative habitat or corridor for displaced wildlife.

Analysis of Solutions

Providing solutions is not enough, of course this set of solutions has to be analyzed whether can be achieved given limited resources.

Selection of Best Solution

The best solutions are always the most realistic ones. Since the suggested possible solutions are achievable given the resources within the project site and budget of the proponent, it is expected these identified solutions will be implemented as expected.

So far, the proponent has identified the following as the best solutions to achieve the watershed management goals.

a. 100% inventory of plants on impact areas for immediate replacement in rehabilitation sites and bufferzones;
b. establishment and implementation of Catchment Area Treatment (CAT);
c. construction of retaining structures or "vengineering" structures to control siltation especially in steep areas;
d. enforcement of earth-balling activity for threatened and ecologically important plants;

e. re-establish, thru assisted natural regeneration (ANR) and enrichment planting, of any disturbed areas that need immediate rehabilitation; and
f. retain thick vegetation near impact areas as alternative habitat or corridor for displaced wildlife.

Monitoring and Evaluation

The key to the success of sustainable watershed management is on monitoring and evaluation. For the purpose of monitoring and assurance of rehabilitation and conservation programs, permanent monitoring plots will be established all over the rehabilitation sites including the buffer zones. There will be M&E in all stages of project development including the implementation of reforestation and rehabilitation activities

1.4.1.14 Monitoring Plan for 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 at the rehabilitation, nursery and earth ball 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.

For the purpose of monitoring and assurance of rehabilitation and conservation programs, permanent monitoring plots will be established all over the rehabilitation sites including the buffer zones. Buffer zones are thick vegetation strips to be established at a distance along the boundaries of the dam.

In addition, 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 programs will be implemented.

1.4.2 Fauna

The general objective of this study was to assess the diversity of terrestrial animals present in the proposed project site located at the forest ecosystem of Upper Marikina River Basin Protected Landscape (UMRBPL).The terrestrial fauna surveys, which ran from August 10 to 13, 2019 (wet season) and November 27, 2019 (dry season), were conducted to determine the terrestrial wildlife organisms inhabiting within the proposed project area. Specifically, the objectives of this study were to study and enumerate terrestrial wildlife animals occurring within the study area; to compare the relative abundance of terrestrial wildlife animals among 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. With the existing environmental problems of the local communities of the province of Rizal and the numerous and conflicting development goals, it is imperative that decision makers have a sound basis such as science-based and measured parameters. The results of the study would be relevant to the Wawa Bulk Water Supply Project for they will be able to plan the development scientifically, environmentally sound and effective.

1.4.2.1 Threats and Historical Environmental Degradation in Marikina River Basin and its Effect to Wildlife Species Richness

Land use conversion is rapidly occurring in response to land development or urbanization, industrialization and increasing demand for certain agricultural produce. Forest areas are being encroached and converted to plantation or agricultural lands that cause vegetation degradation thus minimizing interception capacity which is the amount of rain captured by forest canopy and ground cover (Brebante, 2017). Due to shifting of vegetation structures in the forest, wildlife diversity and distribution is also affected. Wildlife such as rodents and mammals are being driven away from their natural habitats and encroach human settlements and agricultural areas. Urbanization, on the other hand involves construction of hard surfaces such as houses, paved roads, infrastructure development and congestion of drainage systems which reduce infiltration and increase overland flow. These, in effect may result to aggravation of flooding occurrences in the future (Suriya & Mudgal, 2012). Extreme flooding also affects the diversity and distribution of wildlife species in the area particularly amphibians and reptiles, who are mostly prone to drowning.

In Marikina River Basin, major threats that were identified are mining as a source of livelihood; logging of the highly sought after dipterocarp representatives found in the site, and on steep slopes which are prone to erosion; slope instability and flooding; two geological fault lines bordering the Boso-Boso and Tayabasan subwatersheds are considered earthquake prone; population growth rate in barangays Calawis and San Jose (7.6%) is much higher than the national average (2.04%) as of 2010, partly attributed to migration from other provinces. This in turn puts increasing pressure on the area's natural resource base (Foundation for the Philippine Environment, 2014). Recently, forest fire was recorded in unprotected mountain areas in Antipolo and Tanay in Rizal, this was reported by an official from Masungi Georeserve last April 2020. It was suspected that fires are man-made, either caused by kaingin, charcoal production, or unintentionally through negligence. The biggest effect wildfire has on wildlife habitat is by altering the three things animals need most: food, water and shelter. Tender understory plants and shrubs that provide food are lost and this loss often results in wildlife moving away to areas where food, water and shelter are more readily available. Wildlife with limited mobility living above ground is most vulnerable to fire caused injury and mortality, whereas animals that live in moist habitats are least likely to be affected. Amphibians and reptiles avoid the direct effects of fire by either moving away from it or burrowing into the soil. Smaller mammals and most birds leave their habitat; as a consequence, distribution and diversity in the area will decrease and change. Meanwhile, logging operations directly leads to many negative consequences for wildlife and in the ecological integrity of the forest. Massive activity of logging both legal and illegal involves the felling of trees on such a large that it is one of the major forms of deforestation. When forest is logged, species lose their habitat, food sources and shelter that could lead to changes in distribution and decrease in diversity of wildlife species in the area. In the case of Marikina River Basin, logging has been one of the major problems in the area, however, most cases in the area were unreported; this is because most of the loggers are Indigenous People (IPs).

Recent study shows that illegal hunting may be a bigger threat to mammals and ground dwelling birds than forest degradation in Southeast Asia. A personal interview with local people in the study area was conducted during the sampling period, and we have learned that hunting was mostly done by Indigenous People (IPs) because hunting was one of their main sources of food. Hunting is an integral part of the traditional Indigenous lifestyle and it can normally occur within protected areas.

Identified major threats in Marikina River Basins, if not addressed immediately, will result to long term impact to sustain the earth's resources. To protect the forest environment of Marikina River Basins, proactive steps must be devised by concern local government and agencies.

1.4.2.2 Methodology

A 414.28 hectares proposed study area for Wawa Bulk Water Supply project was delineated and digitally mapped to assess the wildlife terrestrial biodiversity. The four (4) major invertebrates namely avifauna/birds, mammals (Volant and non- Volant), amphibians and reptiles were surveyed, monitored and recorded in the plot. The animals were recorded by monitoring the number of catch and sightings.

Collection of representative wildlife in the project site were conducted through the use of mist nets and transect method for flying mammals and birds; improvised traps for reptiles and amphibians; cast nest of small mesh size for small animals; and hand-picking for some small wildlife. Animals that are considered endangered were not collected but instead were photographed in their natural habitat. Pertinent information regarding their habitat, sex, behavior, economic and ecological importance was noted. All surveyed animals were identified and classified based on available standard taxonomic keys for each type.

Comprehensive methodology on the collection of four (4) major invertebrates was discussed in the succeeding sections and map presenting the location of each sampling site is presented in **Figure EL-45.**

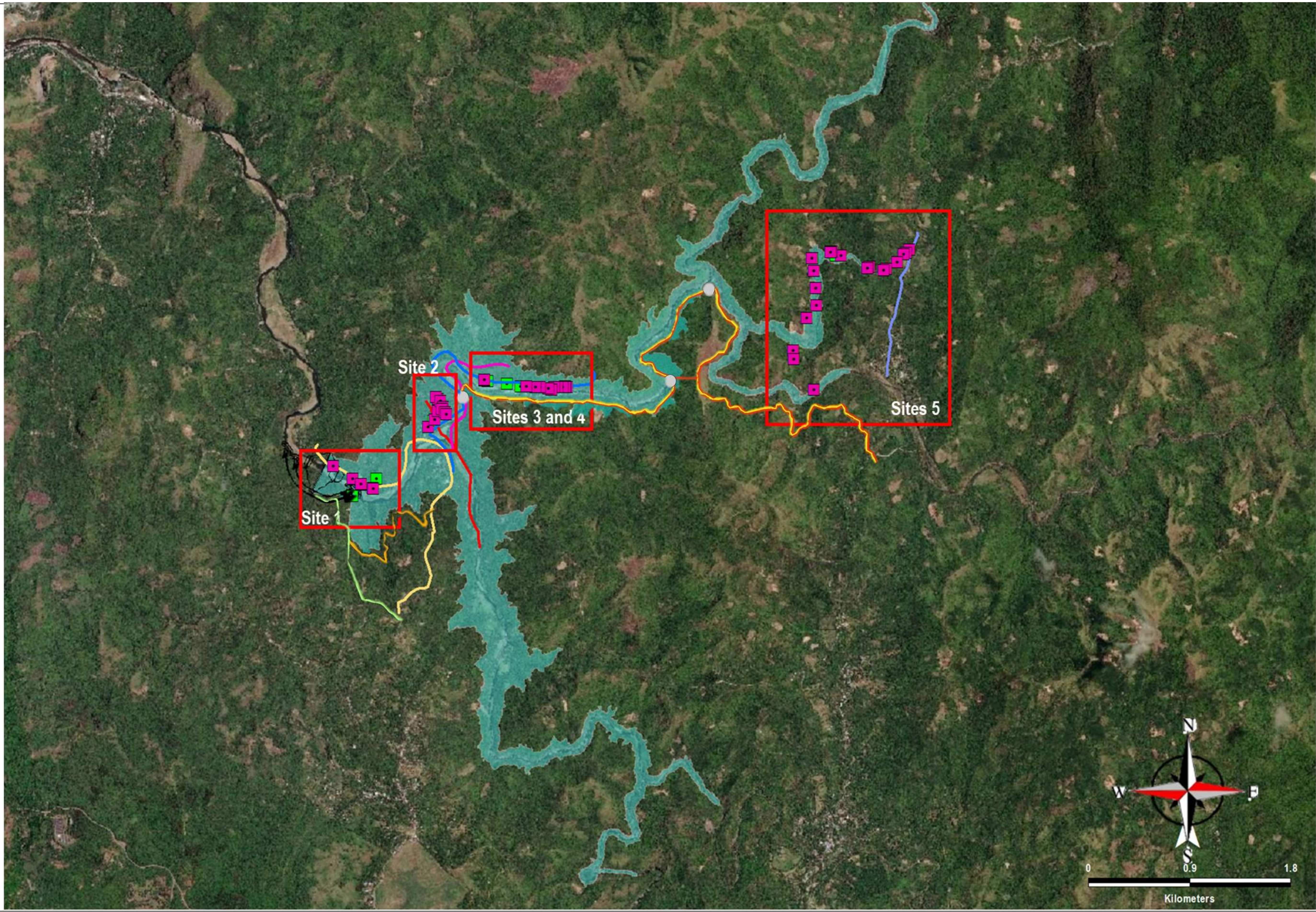

Figure EL-45. Terrestrial Ecology – Fauna Sampling Stations

ENVIRONMENTAL IMPACT STATEMENT
LAND MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

LEGEND

- Dam and Diversion Tunnel
- Transmission Pipe and Access Road to Calawis WTP
- Reservoir
- Pump Stations
- Transect 1
- Transect 2
- Transect 3
- Transect 4
- Transect 5
- Mist Netting
- Live Trapping

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCO, Inc. (2020)
Basemap: ArcGIS Imagery, 2020
Created by: APERCU CONSULTANTS, INC (2020)

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SCALE: 1: 28,000

Transect Method

Trails that were 5 to10 km long traversing different elevations, habitats and forest types' stations were established. In every station, alternating transects perpendicular to the trail were established. A 100m radius plot in every site was then marked from the transect (with consideration for slope and safety). GPS points for all the sites and transects were recorded and photographs of each plot were taken (**Figure EL-46**)

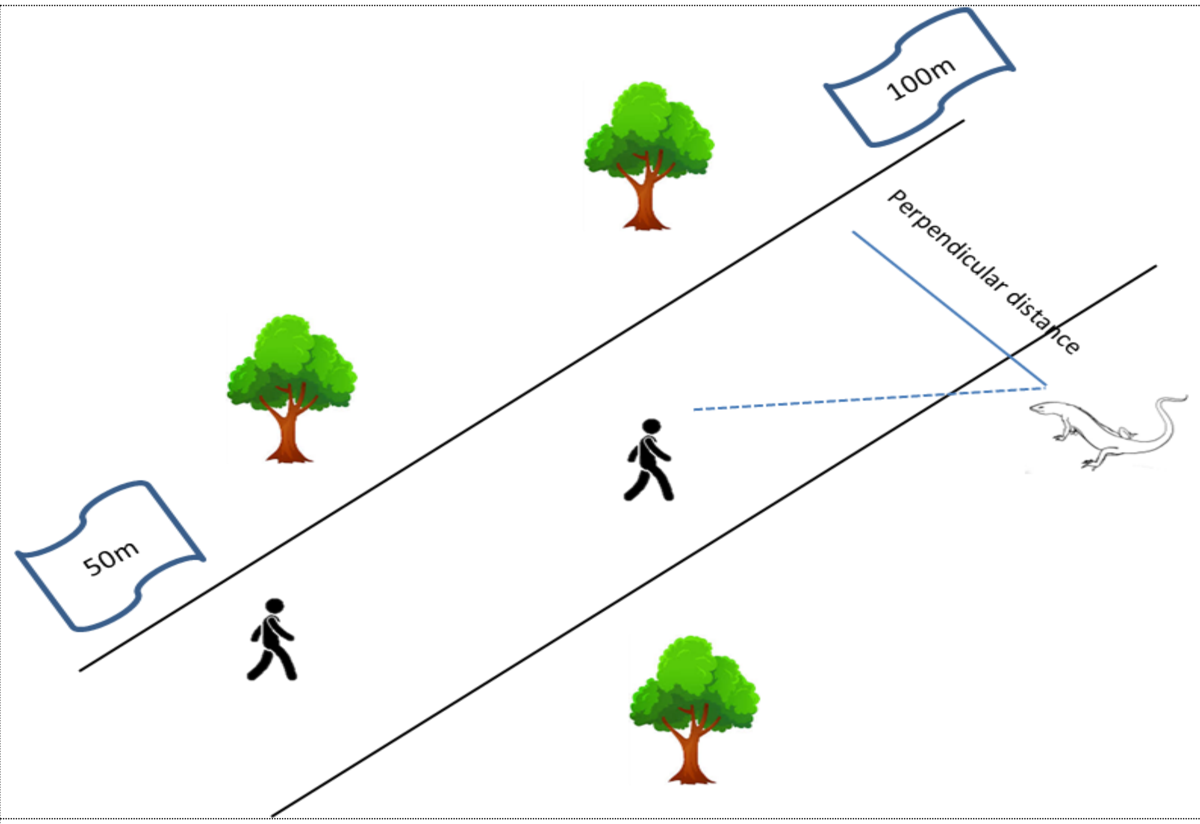


Figure EL-46. Diagram showing 100-meter radius plot and perpendicular distance

Avian Survey

The composition and distribution of avian species were assessed using transect survey and mist-netting methods. During the transect walk, the observer recorded the following information for the bird census: species name, number of individuals, and type of habitat and species association (single, pairs, flock, feeding groups or mixed flock). Transect survey was done during early morning (5:30-10:00 AM) and during afternoon (3:00-5:00 PM). Sound recorder was used to record bird calls and songs and identified up to species level using birds' song and call archives online.

The mist-netting method involved setting up mist nets in strategic locations with the nets were set singly (single net) or in series (consisting of 2 or more nets stacked on top of one another) and operated for days. Strategic locations included ridges, cliffs, clearings, areas along streams, rivers or near bodies of water. One single and one series (1) mist nets were employed per station. Each net has an average 36 mm mesh size, is 6x12m long and with 4 shelves. Nets were set 2-3 meters high with a ground clearance of approximately 0.3 meters. Nets were checked several times. Captured birds were identified up to species level and basic biometric data was recorded. Nomenclature and classification were based on available taxonomic identification guides and books. Population and threatened status were followed using the IUCN Red List of Threatened Species (**Table EL-50** and **Table EL-51**).

Table EL-50
Identified Avifauna Sampling Sites – Transect survey

Stations	Northing	Easting		Northing	Easting
Transect 1-Site 1	14°41'22.69" N	121°12'27.30" E	to	14°42'10.27" N	121°12'3.85" E
Transect 2- Site 2	14°41'41.77" N	121°12'50.18" E	to	14°42'22.02" N	121°12'35.20" E
Transect 3- Site 3	14°42'8.54" N	121°12'42.44" E	to	14°42'32.54" N	121°12'58.66" E
Transect 4- Site 4	14°42'2.91" N	121°12'42.75" E	to	14°42'30.39" N	121°13'22.92" E
Transect 5- Site 5	14°42'29.12" N	121°14'46.88" E	to	14°43'8.08" N	121°14'55.91" E

Table EL-51
Identified Avifauna Sampling Sites – Mist netting

Stations	Latitude	Longitude
Station 1	14°41'34.81" N	121°12'34.99" E
	14°41'55.95" N	121°12'13.82" E
Station 2	14°42'17.21" N	121°12'37.18" E
	14°42'22.81" N	121°12'38.65" E
Station 3	14°42'28.21" N	121°12'52.68" E
	14°42'27.61" N	121°12'58.23" E
Station 4	14°42'26.94" N	121°13'2.31" E
	14°42'26.53" N	121°13'15.42" E
Station 5	14°43'4.07" N	121°14'53.13" E
	14°43'3.35" N	121°14'32.81" E
	14°43'2.72" N	121°14'26.22" E
	14°42'34.43" N	121°14'20.99" E

Mammalian Survey

Two methods were used to survey volant mammals and non-volant mammals. Population and threatened status were determined using the IUCN Red List of Threatened Species. The same mist-netting stations set up for the bird sampling were used to capture bats (**Table EL-52**). Captured animals were carefully removed from the nets, identified, and released back to the forest. Basic information such as sex, reproductive condition, ear length, forearm length, hind foot length and total length were recorded to help for the identification of bats up to species level.

Non-volant mammals such as mice 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. Captured mammals were identified up to species level (**Table EL-53**).

Table EL-52
Identified Volant Mammal Sampling Sites – Live Trapping

Stations	Latitude	Longitude
Station 1		121°12'34.99" E
	14°41'55.95" N	121°12'13.82" E
Station 2	14°42'17.21" N	121°12'37.18" E
	14°42'22.81" N	121°12'38.65" E
Station 3	14°42'28.21" N	121°12'52.68" E
	14°42'27.61" N	121°12'58.23" E
Station 4	14°42'26.94" N	121°13'2.31" E
	14°42'26.53" N	121°13'15.42" E
Station 5	14°43'4.07" N	121°14'53.13" E
	14°43'3.35" N	121°14'32.81" E
	14°43'2.72" N	121°14'26.22" E
	14°42'34.43" N	121°14'20.99" E

Table EL-53
Identified Non-Volant Mammal Sampling Sites – Live Trapping

Stations	Latitude	Longitude
Station 1	14°42'4.46" N	121°12'8.45" E
	14°42'0.74" N	121°12'14.00" E
	14°42'0.80" N	121°12'13.86" E
	14°41'59.33" N	121°12'16.36" E
	14°41'59.48" N	121°12'16.41" E
	14°41'58.21" N	121°12'19.59" E
	14°41'58.07" N	121°12'19.90" E
Station 2	14°42'15.38" N	121°12'35.75" E
	14°42'17.45" N	121°12'37.58" E
	14°42'19.95" N	121°12'38.57" E
	14°42'23.07" N	121°12'38.54" E
	14°42'23.97" N	121°12'37.85" E
	14°42'22.67" N	121°12'39.25" E
	14°42'21.19" N	121°12'39.96" E
	14°42'20.32" N	121°12'39.73" E
	14°42'19.42" N	121°12'40.54" E
	14°42'19.07" N	121°12'40.87" E
Station 3	14°42'28.50" N	121°12'51.96" E
	14°42'28.60" N	121°12'51.83" E
Station 4	14°42'26.60" N	121°13'15.54" E
	14°42'26.85" N	121°13'15.16" E
	14°42'26.59" N	121°13'15.04" E
	14°42'26.52" N	121°13'14.45" E
	14°42'26.60" N	121°13'12.84" E
	14°42'26.68" N	121°13'11.98" E
	14°42'26.00" N	121°13'11.30" E
	14°42'26.20" N	121°13'10.26" E
	14°42'26.59" N	121°13'7.80" E
	14°42'26.71" N	121°13'6.61" E
	14°42'26.91" N	121°13'3.90" E
Station 5	14°43'5.14" N	121°14'54.01" E
	14°43'4.05" N	121°14'53.12" E
	14°43'3.86" N	121°14'52.50" E
	14°43'1.60" N	121°14'50.68" E
	14°42'59.73" N	121°14'47.50" E
	14°42'59.25" N	121°14'46.77" E
	14°43'0.20" N	121°14'42.45" E
	14°42'59.99" N	121°14'42.11" E
	14°43'0.04" N	121°14'41.99" E
	14°43'3.48" N	121°14'34.58" E
	14°43'4.48" N	121°14'31.73" E
	14°43'4.49" N	121°14'31.61" E
	14°43'4.39" N	121°14'31.53" E
	14°43'2.64" N	121°14'26.06" E
	14°42'59.03" N	121°14'26.65" E
	14°42'54.14" N	121°14'27.22" E
	14°42'49.29" N	121°14'27.42" E
	14°42'45.87" N	121°14'24.50" E
	14°42'36.68" N	121°14'20.70" E
	14°42'34.41" N	121°14'20.98" E
	14°42'25.84" N	121°14'26.65" E
	14°42'25.93" N	121°14'26.64" E

Amphibians and Reptiles

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, tree ferns and bodies of water. Sampling was conducted all day, starting early in the morning until daylight was available (4:00 am- 5:00pm). The identification of amphibians and reptiles was based on Brown et al. (2000), Diesmos et al. (2002), Brown et al. (2012), and Brown et al. (2013) (**Table EL-54**).

Table EL-54.
Amphibians and Reptiles Sampling Sites

Stations	Northing	Easting		Northing	Easting
Transect 1-Site 1	14°41'22.69" N	121°12'27.30" E	to	14°42'10.27" N	121°12'3.85" E
Transect 2- Site 2	14°41'41.77" N	121°12'50.18" E	to	14°42'22.02" N	121°12'35.20" E
Transect 3- Site 3	14°42'8.54" N	121°12'42.44" E	to	14°42'32.54" N	121°12'58.66" E
Transect 4- Site 4	14°42'2.91" N	121°12'42.75" E	to	14°42'30.39" N	121°13'22.92" E
Transect 5- Site 5	14°42'29.12" N	121°14'46.88" E	to	14°43'8.08" N	121°14'55.91" E

1.4.2.3 Ecological Measurements and Biodiversity Indices

The ecological parameters of the results were then computed and included the total number of individuals per species, species richness, abundance, Evenness, Hill's number and Shannon's Diversity Index (**Table EL-55**).

Table EL-55
Criteria for the level species of diversity (Fernando, 1998)

Relative Values	Shannon Index (H')
Very High	3.5 and above
High	3.0 – 3.49
Moderate	2.5 – 2.99
Low	2.0 – 2.49
Very Low	1.9 and Below

Biodiversity indices that consider 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

Sources of Environmental Degradation of the Forest Ecosystems

To assess the present condition of the forest ecosystem, the sources of environmental degradation in the forest ecosystems were also recorded.

1.4.2.4 Description of Sampling Stations

Selection of study sites was based on (2) two criteria: 1) location of the main project components; and 2) areas with the highest probability that a substantial number of wildlife species would be observed. **Table EL-56** shows the sampling sites covered within the project area.

Table EL-56
Wildlife Sampling Sites

Site ID	Site Description	Municipality/city	Sampling Method
Transect Walk			
Transect 1	Wawa Upper Dam	Municipality of Rodriguez	Transect walk method; ocular inspection
Transect 2	Wawa Upper Dam Reservoir	Municipality of Rodriguez	Transect walk method; ocular inspection
Transect 3	Upstream of Wawa upper dam reservoir	Municipality of Rodriguez	Transect walk method; ocular inspection
Transect 4	Wawa PSP Reservoir	Municipality of Rodriguez	Transect walk method; ocular inspection
Transect 5	Inundated area at Sitio Apia near Pipeline area	Municipality of Rodriguez and Antipolo City	Transect walk method; ocular inspection
Mist-Netting and Trapping			
Site 1	Wawa Upper Dam	Municipality of Rodriguez	Live traps and Mist nets
Site 2	Wawa Upper Dam Reservoir	Municipality of Rodriguez	Live traps and Mist nets
Site 3	Up stream of Wawa upper dam reservoir	Municipality of Rodriguez	Live traps and Mist nets
Site 4	Wawa PSP Reservoir	Municipality of Rodriguez	Live traps and Mist nets
Site 5	Inundated area at Sitio Apia near Pipeline area	Municipality of Rodriguez and Antipolo City	Live traps and Mist nets

Site 1: Wawa Upper Dam (Sitio Anipa)

The sampling site is located at the westernmost of the project site (**Plate EL-22**). This site has substantial portions of brushland, agricultural and grassland area. It was observed that there were some fruit bearing trees that were planted in the area namely; rambutan (*Nephelium lappaceum*), banana (*Musa* sp.) and santol or cotton fruit *(Sandoricum koetjape)*; gabi or taro *(Colocasia esculenta)* was also observed in the area. This area is characterized by shallow river during dry season.

Plate 22. Site 1 (Upper Wawa Dam)

Site 2: Wawa Upper Dam Reservoir

The sampling site is located near the upper Wawa dam (**Plate EL-23**). This sampling site was composed of brushland area and grassland area. Trees such as gmelina (*Gmelina arborea*), bamboo (*Bambusoideae* sp.) and mahogany (*Swietenia* sp.) were observed in the area. Also, fig trees were notably seen in the area.

Plate EL-23. Site 2 (Upper Wawa Dam Reservoir)

Site 3: Upstream of Wawa upper Dam Reservoir

Site 3 (**Plate EL-24**) is located near the river and composed of bamboo *(Bambusoideae sp), kamias (Averrhoa bilimbi), gmelina (Gmelina arborea) and mahogany trees (Swietenia* sp.*)*

Plate EL-24. Site 3 (Upstream of Wawa upper dam reservoir)

Site 4: Wawa PSP Reservoir

This area has substantial portion of brushland and located near the river (**Plate EL-25**). However, the actual proposed area for site 4 was inaccessible due to deep and strong river flow, the team decided to place the traps and mist nets to the nearest area approximately 0.77 km away from the actual proposed area for site 4.

Plate EL-25. Site 4 (Wawa PSP Reservoir)

Site 5: Inundated area near proposed pipeline

This area is composed of numerous fruit bearing trees namely banana, santol, cacao, and guava. Also, plantation of okra and eggplant was found in the area. The placement of traps and mist nets were near the river, open area and near plantation (**Plate EL-26**).

Plate EL-26. Near the proposed area for the pipeline

1.4.2.5 Regional Fauna in the province of Rizal

The Marikina Watershed Reservation (MWR), presently known as the Upper Marikina River Basin Protected Landscape (UMRBPL), had an original total cover of almost 28,000 hectares and has now been considerably reduced by at least 9,000 hectares, after several Proclamations reduced the forestlands and removed portions of the reservation as resettlement sites or as alienable and disposable lands (Haribon, 2012). In November 24, 2011, about 26,125 hectares of the watershed was proclaimed as a protected area to be known as the Upper Marikina River Basin Protected Landscape (UMRBPL) (Proclamation no. 269 ser 2011). The UMRBPL is originally of mountain forest and tropical forest. Logging was prevalent prior to its designation as watershed reserve resulting in only 30 percent forest cover remaining in the area[6].

The Foundation for the Philippine Environment (FPE) (2012), AECOM (2011) and United Coconut Planters Bank-Coconut Industry Investment (UCPB-FII) (2009) conducted a biological survey together with Haribon Foundation. The study area of FPE and AECOM was located in the Boso-Boso and Tayabasan sub-watersheds in the Marikina Watershed reservation while the UCPB-FII conducted their survey in Sitio Boso-Boso, Brgy. San Jose.

The FPE and UCPB-FII gathered and assessed the conditions of the fauna from two of the largest watersheds (Boso- Boso and Tayabasan) in the UMRBPL where the 500MW PS hydropower project is located. According to Haribon and FPE six (6) of the ninety-five (95) bird species observed in the area are globally threatened or near threatened while ten (10) of the twenty five (25) reptiles and amphibian species recorded are endemic to the Philippines, four (4) of which can only be found in Luzon. In addition, four (4) out of fifteen (15) species of mammals observed to occur in the sub-watersheds are endemic to the Philippines. From the UCPB-FII findings there were 53 birds, 6 mammals and 3 species of herptofauna, observed in Brgy. San Jose. The study area was described as lowland secondary forest type of which the highest elevation was 416 meters above sea level. The geographic feature of the area was generally sloping and mostly steep ridges with minimal forests observed, mostly on ridge tops.

Haribon (2009) and AECOM (2011) recorded a total of 95 avifaual species, majority (52% or 49 species) of these are resident species or species that breed or are suspected of breeding in the country and normally found in the study sites throughout the year. Endemic species comprised 41% (39 species) of the total number of bird species. Six percent (6%) of the 95 species were listed as threatened or near threatened by IUCN. The IUCN Red List classifies the Flame-breasted Fruit Dove (*Ptinilopus marchei*), the Philippine Eagle Owl (*Bubo philippinesis*) and the Ashy Thrush (*Zoothera cinera*) as vulnerable while the Rufous Hornbill (*Buceros hydrocorax*), the Luzon Scops Owl (*Otus longicornis*) and the Rufous Coucal (*Centropus unifufus*) are classified as near threatened.

[6] Retrieved at calabarzon.denr.gov.ph on November 9, 2015

However, these species identified by Haribon and AECOM were not observed in the study area during the sampling period, probably because the project area is more disturbed and there may be degradation or loss of some of their habitats. Additionally, the species that Haribon and AECOM observed have limited distribution, which is the major threat to their population. The only near threatened bird species that was observed in the project site is the Mountain shrike (*Lanius cristatus*), which was not observed by the Haribon during their survey.

The biological survey of Haribon in the Tayabasan watershed area yielded four (4) bats, namely the Dagger-toothed long-tongued fruit bat (*Macroglossus minimus*); the Philippine pygmy fruit bat (*Haplonycteris fischeri*); the Horseshoe bat (*Rhinolophus* sp.) and the flying fox (*Pteropus* sp.). Of the bats in Tayabasan, only the Philippine Pygmy fruit bat (*Haplonycteris fischeri*) is endemic to the Philippines. These species were not observed during the project survey. However, the bamboo bat (*Tylonecteris* sp.) and the Philippine nectar bat (*Eonycteris robusta Miller*) were recorded in the project site as vulnerable and near threatened, respectively, by the IUCN Red List. Palm civet (*Paradoxorus hermaphroditus*) droppings were identified both by the Haribon and Apercu wildlife teams in the study site. Compared to the survey in the Boso-Boso sub-watershed (UCPB 2009 and AECOM 2011), more mammal species were either netted or identified from droppings and general observations in the Tayabasan area. The species richness in Tayabasan may be higher because of its proximity to the natural and old growth forests whereas the Boso-Boso sub-watershed site was situated in a reforested area.

Haribon identified 23 species of reptiles and amphibians in Tayabasan. Ten (10) species (43%) are endemic to the Philippines while six (6) of them (26%) are Luzon endemics. Three (3) species (13%) are introduced species while the rest are resident species. One species is globally under the category of vulnerable. In the project area 15 herptofauna were identified, two (2) of which were categorized by IUCN as near threatened, the Luzon Fanged frog (*Limnonectes macrocephalus*) and as vulnerable the Chinese soft-shelled turtle (*Pelodiscus sinensis* (Weigmann)).

Interviews with local residents were conducted by Haribon during the biological survey in Tayabasan and reported three mammal species. Two of the species mentioned, i.e. the Southern Luzon Giant Cloud rat (*Phloeomys cumingi*) and the Philippine Warty Pig (*Sus philippensis*), were also noted in the Wawa project site.

Apercu Consultants Inc. (2015) conducted a study in the same area for the proposed 500MW Pumped Storage in the Municipality of San Mateo, Antipolo and Rodriguez. The study resulted to a total of 96 species of terrestrial wildlife were observed at 13 sampling locations within the project site consisting of 72 birds species, nine (9) species of mammals, 7 species of reptiles (two of which were endemics) and 8 species of amphibians (three are endemic).

1.4.2.6 Project Site Species Composition

A total of 33 species of terrestrial vertebrate fauna representing 30 families were recorded from the five (5) sampling sites during wet season. Thirteen (13) species were Philippine endemics, while the rest are native, migrant or introduced species. Birds were the most abundant species, with 22 species, followed by reptiles (9 species), mammals (7 species) and amphibians (5 species) (**Table EL-57**). During dry season, a total of 42 species of terrestrial vertebrate fauna representing 31 families were recorded from which thirteen (13) species were endemic and the rest are native, migrant or introduced species. Birds still the most abundant species with 30 representative species, followed by reptiles and mammals with 5 species and 2 species, respectively (**Table EL-58)**.

In contrast with the study done in 2015, the total number of species recorded then was 96 from 13 sampling locations consisting of 72 bird species, nine (9) species of mammals, 7 species of reptiles and 8 species of amphibians. The difference in the findings is due to the fact that the sampling effort and area in the 2015 survey was bigger than the current study area.

Herpetofauna (Amphibians and Reptiles)

Only two amphibians were observed during wet season (*Rhinella marina* and *Platymantis dorsalis*) but the croaks of three other species (*P. mimulus, Limnonectes woodworthi* and *Polypedates leucomystax*) were recognized while traversing the trails during the early morning hours (**Plate EL-27**). Froglets of *Rhinella marina* (Figure 7) were recorded from the river banks near the residential areas during dry season. These introduced species is widely distributed and often seen in polluted river in the area where they feed on insects. They also able to tolerate human disturbances. The endemic and common *Platymantis dorsalis* was recorded in the forested area in Site 1. The diversity of amphibians is likely underrepresented in this survey since no night sampling was conducted, a time when most frog species are more active.

Three species of frogs which were previously recorded during the wet season sampling were not recorded during the dry season sampling. These are *P. mimulus, Limnonectes woodworthi* and *Polypedates leucomystax*. Calls from these species were not recorded during the dry season sampling. This could be attributed to the change in the season of sampling, with most frogs being more active during the rainy season which coincides with their mating cycle. Although there is a river where frogs may lay-egg all year round, most frog species prefer laying-eggs in slow flowing water bodies where the tadpoles can grow and develop.

Regionally, 27 amphibian species have been recorded in the southern Sierra Madre region which includes parts of Bulacan, Laguna and Quezon provinces, all of which are adjacent to Rizal province (Gojo Cruz and Afuang, 2018). The Angat watershed in Bulacan, which is the closest watershed to the area sampled, records a total of 19 species of frogs (McLeod et al., 2011). A more thorough night survey of the waterways, the rivers and the forest may reveal a higher number of species, but this the survey team was unable to do due to security reasons. Three of the 5 species of frogs recorded were endemic. All the amphibians recorded during this sampling period were listed as least concern (IUCN, 2019).

Plate EL-27. *Rhinella marina*

In the present study, lizards, turtles and snakes represent the reptiles recorded in the area. Of the 9 species listed in **Table EL-57**, only three species were observed during the sampling. The six (6) other species were reported to be present in the area based on interviews with residents and local guides. Fewer reptile species were recorded during dry season with only five (5) species from which only one species (*Parvoscincus* cf. *decipiens*) were observed during the sampling. The four (4) other species were reported to be present in the area based on interview with residents and local guides. One of the species, (*Pelodiscus sinensis*) is an introduced species which thrives even in polluted habitat. Other large bodied species (*Varanus* sp. and *Malayopython reticulatus*) are often found in areas with minimal human presence.

The number of reptile species recorded in the area is very low compared to the number of species recorded from the southern part of Sierra Madre and from the previous study conducted by Apercu Consultants Inc. (2015). Gojo Cruz and Afuang (2018) listed 52 species of reptiles documented from the Southern Sierra Madre. McLeod et al (2011) reported 44 species of reptiles from the Angat watershed. Since no night sampling was done, some species of reptiles may have been over-looked. One species (*N. philippinensis*) is listed as near threatened while 3 species (*H. pustulatus, C. amboinensis* and *P. sinensis*) are listed as vulnerable. Furthermore, recent biodiversity assessment was conducted by Apercu Inc. (2015) in the same project location wherein seven (7) species of reptiles and eight (8) amphibians were recorded.

Overall, number of species herpetofauna (amphibian and reptiles) recorded during this survey is almost similar to the number of species recorded in 2015. Additional species recorded in the area include *Limnonectes macrocephalus and Platymantis mimulus* for the amphibians; and *Eutropis multifasciata, Parvoscincus decipiens, Ahaetulla prasina, Hydrosaurus pustulatus, Malayopython reticulatus, Naja philippinensis* and *Cuora amboinensis.* The last four species were not observed during the survey, but locals and guides reported the presence of these species in the area. However, the decrease in species from the study conducted on year 2015 and at present is noticeable; this is attributed to the sampling effort done because there was no night sampling conducted in the present study due to unfavorable weather conditions and safety.

Avifauna

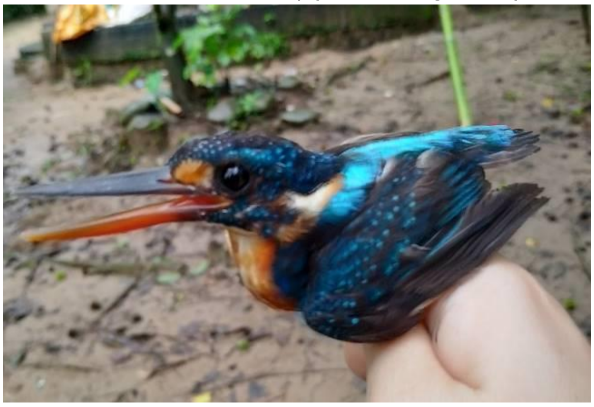
Twenty-two (22) species of birds were recorded from the area. Most species were recorded during the transect walks, with only two species Luzon bleeding heart (*Gallicolumba luzonica)* and Yellow vented bulbul (*Pycnonotus goiavier*) being captured in the mist nets (**Figure EL-47**). One species, red jungle fowl (*Gallus gallus),* was reported by local guides. The high number of bird species in the area may be attributed to the large number of fruiting trees santol (*Sandoricum koetjape), Banana (Musa paradisiaca), Kaimito (Chrysophyllum cainito*). The presence of fish in the river also explains the presence of several species of fish-eating birds such as kingfishers and egrets. Forest-associated species such as Philippine bulbul (*Hypsipetes philippinus), Mountain white eye (Zosterops montanus), Blue headed fantail (Rhipidura cyaniceps), Yellow vented bulbul (Pycnonotus goiavier)* were often seen flying in mixed-species flocks. The associated grassy area harbors species such as Stirated grass bird (*Megalurus palustris)* and Common bottonquial (*Turnix sylvatica).* The endemic Luzon bleeding heart (*G. luzonica)* is listed as near threatened in the IUCN (2019) while Philippine hanging parrot (*Loriculus philippensis)* is listed as critically endangered (DENR DAO-2018).

Dry season sampling revealed the presence of 30 bird species compared to the previous record of 22 bird species during the wet season sampling. G*. sulphurea, A. purpurea, A. leucorhynchos, G. striata, S. tranquebarica, C. viridis, L. atricapilla, L. cristatus, M. tschutschensis, S. caprata, C. jugularis, M. funebris, and A. hypoleucos* were recorded during the dry season sampling but were not recorded during the wet season sampling. On the other hand, *E. eulophotes, G. luzonica,* and *L. philippinensis* which were recorded during the wet season were not recorded during the dry season sampling. Seasonal variation in microclimatic condition and the presence of food items may explain the presence or absence of particular species. Moreover, the presence of migrant species of birds in the area coincides with the time when migratory birds are arriving in the Philippines. This shows that the river ecosystem in the area is an important waterway for these migratory species.

Luzon bleeding-heart (*Gallicolumba luzonica)*

Yellow vented bulbul (*Pycnonotus goiavier)*

Philippine Bulbul (*Hypsipetes philippinus)*



Common kingfisher (*Alcedo atthis)*

Figure EL-47. Avifauna species observed in the five (5) stations

Previous study conducted in the year 2015 revealed the presence of 72 species of birds and mostly were not recorded this year. Eight (8) species of birds that were recorded this year were not observed on the previous study these include Common kingfisher (Alcedo atthis), Chinese egret (Egretta eulophotes), White-breasted woodswallow (Artamus leucorhynchos), Luzon bleeding-heart (G. luzonica), White-eared brown dove (Phapitreron leucotis), Philippine pied fantail (Rhipidura nigritorquis), and Blue-headed fantail (R. cyaniceps).

Mammals (Non-Volant and Volant)

Bats are the most represented mammalian order in the study area with 5 species of fruit bats recorded during wet season while 3 species of fruits bats during dry season (**Figure EL-48**). Two (2) introduced murid rodents were also recorded: Asian house rat (*Rattus tanezumi)* and Brown Rat (*Rattus norvegicus)* in **Figure EL-49**. The introduced rodents were caught in areas dominantly vegetated with banana. All mammal species recorded during this survey are listed in the IUCN (2019) as least concern. The presence of fruiting trees in the area explains the presence of several fruit eating bats.

All the recorded mammals in the present survey were recorded in the previous wildlife assessment in the year 2015. However, in this present study, the team was unable to detect the presence of Philippine dawn bat (*Eonycteri robusta),* Lesser bamboo bat *(Tylonycteris pachypus),* Philippine forest rat *(Rattus everetti)* and Asian Palm civet (*Paradoxorus hermaphrodites).* Meanwhile, *R. tanezumi* which was not observed previously in the area was recorded in Sites 1 and 2; this could be due to the presence of several agricultural crops and human habitations near the sites.

Cynopterus brachyotis

Eonycteris spelaea

Macroglossus minimus

Ptenochirus jagori

Rousettus amplexicaudatus

Figure EL-48. Volant Mammals observed in the five (5) stations

Brown Rat *(Rattus norvegicus)*

Asian House Rat (*Rattus tanezumi*)

Figure EL-49. Non-volant Mammals observed in the five (5) stations

Table EL-57
List of fauna and observed in the forest ecosystems of Upper Wawa Dam Project Area during Wet Season

Species	Family	Common Name	Distribution Status	Mode of Detection	IUCN Red List Threat and Conservation Status	DAO 2017-11 Status	Economic and Ecological Importance	Site 1	Site 2	Site 3	Site 4	Site 5	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5
Amphibians																	
Rhinella marina	Bufonidae	Cane toad	Introduced	Visual	Least concern, stable	Not listed	play a vital ***role*** in the food chain						x	x			
Platymantis dorsalis	Ceratobatrachidae	Leaf litter frog	Endemic	Visual	Least concern	Not listed	play a vital ***role*** in the food chain							x		x	
Platymantis mimulus	Ceratobatrachidae	Leaf litter frog	Endemic	Acoustic	Least concern, stable	Not listed	play a vital ***role*** in the food chain							x			
Limnonectes woodworthii	Dicroglossidae	Woodworth's wart frog	Endemic	Acoustic	Least concern, stable	Not listed	play a vital ***role*** in the food chain							x		x	
Polypedates leucomystax	Rhacophoridae	Common tree frog	Native	Acoustic	Least concern, stable	Not listed	play a vital ***role*** in the food chain							x		x	
Reptiles																	
Lizards																	
Hydrosaurus pustulatus	Agamidae	Philippine sailfin lizard	Endemic	Reported by locals	Vulnerable, decreasing	Other threatened species	No information										
Eutropis multifasciata	Scincidae	Common mabuya	Native	Visual	Least concern, stable	Not listed	Collection for trading and medicinal purposes						x			x	
Parvoscincus cf. decipiens	Scincidae	Forest skink	Endemic	Visual	Not evaluated	Not listed	No information							x	x		
Varanus sp.	Varanidae	Monitor lizard	Native	Reported by locals	Least concern	Other threatened species	Source of food by many locals							x			
Snakes																	
Ahaetulla prasina	Colubridae	Green vine snake	Native	Visual	Least concern, stable	Not listed	play a vital ***role*** in the food chain								x		
Naja philippinensis	Elapidae	Philippine cobra	Endemic	Reported by locals	Near threatened, decreasing	Other threatened species	play a vital ***role*** in the food chain										
Malayopython reticulatus	Pythonidae	Reticulated python	Native	Reported by locals	Least concern, unknown	Other threatened species	play a vital ***role*** in the food chain										
Turtles																	
Cuora amboinensis	Geoemydidae	Malaysian pond turtle	Native	Reported by locals	Vulnerable, unknown	Other threatened species	play a vital ***role*** in the food chain										
Pelodiscus sinensis	Trionychidae	Chinese softshell turtle	Introduced	Reported by locals	Vulnerable, decreasing	Not listed	Collection for food such as turtle soup										
Birds (Avifauna)																	
Alcedo atthis	Alcedinidae	Common Kingfisher	Migrant	Visual	Vulnerable, unknown	Not listed	Common kingfishers are important members of ecosystems and good indicators of freshwater community health										
Halcyon smyrnensis	Alcedinidae	White-throated Kingfisher	Resident	Visual, Acoustic	Least concern, increasing	Not listed	eat domestic and agriculutral pests, including both mammalian and insect pests.										
Collocalia sp.	Apodidae	Swift	Resident	Visual	--	Not listed	***important*** component in maintaining ***ecosystem*** balance							*x*	*x*		*x*
Bubulcus coromandus	Ardeidae	Eastern Cattle Egret	Resident	Visual	Least concern, unknown	Not listed	Cattle egrets may transmit parasites and other disease organisms to livestock and people		x					x			
Nycticorax nycticorax	Ardeidae	Black-crowned Night Heron	Resident	Visual	Least concern, decreasing	Not listed	Have been hunted for food, though they are hunted for this purpose much less frequently now.								x		x
Egretta eulophotes	Ardeidae	Chinese Egret	Migrant	Visual	Vulnerable, decreasing	Not listed	the hunting of waterbirds has long been a source of food as well as a commercial activity										
Artamus leucorynchus	Artamidae	White-breasted Woodswallow	Resident	Visual	Least concern, stable	Not listed	Although woodswallows are primarily aerial foragers, sweeping flying insects from the canopy and above, they also are proficient ground pouncers, dropping from tree limbs to capture a grasshopper or caterpillar from open ground. These versatile foragers also take nectar and pollen								x		x
Gallicolumba luzonica	Columbidae	Luzon bleeding heart	Endemic	Caught in net	Near threatened	Vulnerable	These birds play an *important role* in biodiversity and local *ecology*					x					
Phapitreron leucotis	Columbidae	White-eared Brown Dove	Endemic	Visual, Acoustic	Least concern, stable	Not listed	They play useful **role** in the control of insect pests of agricultural crops, as predators of rodents, as scavengers, as seed dispersers, and as pollinating agents							x		x	
Corvus macrorhynchos	Corvidae	Large-billed Crow	Resident	Visual, Acoustic	Least concern, stable	Not listed	It is very adaptable and can survive on a wide range of food sources, making it capable of colonizing new areas, due to which it is often considered a nuisance, especially on islands								x	x	

Species	Family	Common Name	Distribution Status	Mode of Detection	IUCN Red List Threat and Conservation Status	DAO 2017-11 Status	Economic and Ecological Importance	Site 1	Site 2	Site 3	Site 4	Site 5	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5
Lanius schach	Laniidae	Long-tailed Shrike	Resident	Visual	Least concern, unknown	Not listed	This bird has a characteristic upright "shrike" attitude when perched on a bush, from which it glides down at an angle to take lizards, large insects, small birds and rodents.						x	x	x		
Megalurus palustris	Locustellidae	Tawny-grassbird	Resident	Visual, Acoustic	Least concern, unknown	Not listed	Arthropods and other invertebrates; some seeds also eaten. Feeds almost entirely on small insects, chiefly larvae of moths									x	x
Cinnyris jugularis	Nectariniidae	Olive-backed Sunbird	Resident	Visual, Acoustic	Least concern, stable	Not listed	prey to various predatory birds and it has been recorded to be a victim of the Oriental Whip Snake (*Ahaetulla prasina*)							x		x	
Oriolus chinensis	Oriolidae	Black-naped Oriole	Resident	Visual, Acoustic	Least concern, decreasing	Not listed	have been recorded to feed on a range of berries including *Trema orientalis*, *Ficus* and others apart from insects. It has been suggested that they may have aided in the dispersal of *Ficus* species							x			x
Gallus gallus	Phasianidae	Red Junglefowl	Resident	Reported by locals	Least concern, decreasing	Not listed	Used mainly for eggs a meat production, used for cock fighting or chicken competitions							x		x	
Loriculus philippensis	Psittaculidae	Philippine Hanging Parrot/Colasisi	Endemic	Visual, Acoustic	Least concern, decreasing	Critically endangered	Being hunted by people to sell as pet								x		x
Hypsipetes philippinus	Pycnonotidae	Philippine Bulbul	Endemic	Visual, Acoustic	Least concern, stable	Not listed	A common and adaptable bird as long as sufficient forest remains							x		x	
Pycnonotus goiavier	Pycnonotidae	Yellow-vented Bulbul	Resident	Visual, Caught in net	Least concern, increasing	Not listed	Seed dispersers					x			x		
Rhipidura nigritorquis	Rhipiduridae	Philippine Pied Fantail	Endemic	Acoustic	Least concern, stable	Not listed	Seed disperser			x				x		x	
Rhipidura cyaniceps	Rhipiduridae	Blue-headed Fantail	Endemic	Visual, Acoustic	Least concern, stable	Not listed	Seed disperser					x			x		
Turnix sylvaticus	Turnicidae	Common Buttonquail	Resident	Visual	Least concern, decreasing	Not listed	This species has been bred in captivity and may be found in aviaries								x		x
Zosterops montanus	Zosteropidae	Mountain White-eye	Resident	Visual, Acoustic	Least concern, unknown	Not listed	No specific information						x	x		x	
Rhipidura nigritorquis	Rhipiduridae	Philippine Pied Fantail	Endemic	Acoustic	Least concern, stable	Not listed	Seed disperser			x				x		x	
Rhipidura cyaniceps	Rhipiduridae	Blue-headed Fantail	Endemic	Visual, Acoustic	Least concern, stable	Not listed	Seed disperser					x			x		
Turnix sylvaticus	Turnicidae	Common Buttonquail	Resident	Visual	Least concern, decreasing	Not listed	This species has been bred in captivity and may be found in aviaries								x		x
Zosterops montanus	Zosteropidae	Mountain White-eye	Resident	Visual, Acoustic	Least concern, unknown	Not listed	No specific information						x	x		x	
Mammals																	
Non-Volant																	
Rattus norvegicus	Muridae	Brown rat	Introduced	Caught in trap	Least concern, stable	Not listed	Considered as agricultural and industrial pest	x	x			x					
Rattus tanezumi	Muridae	Oriental house rat	Introduced	Caught in trap	Least concern, increasing	Not listed	Considered as agricultural and industrial pest	x	x			x					
Volant																	
Cynopterus brachyotis	Pteropodidae	Common short-nosed fruit bat	Native	Caught in net	Least concern, unknown	Not listed	Seed disperser	x	x	x	x	X					
Eonycteris spelaea	Pteropodidae	Common nectar bat	Native	Caught in net	Least concern, stable	Not listed	Important pollinator of major crops					X					
Macroglossus minimus	Pteropodidae	Dagger-toothed flower bat	Native	Caught in net	Least concern, stable	Not listed	plays a major role as pollinator of many trees, including the families Bignoniaceae, Bombacaceae, Leguminosae, Musaceae				X	x					
Ptenochirus jagori	Pteropodidae	Musky fruit bat	Endemic	Caught in net	Least concern, stable	Not listed	Seed disperser	x	x	x	x	X					
Rousettus amplexicaudatus	Pteropodidae	Common rousette	Native	Caught in net	Least concern, unknown	Not listed	In the Philippines and Indochina, it is subject to intense hunting at some cave roosts (IUCN).	x	x	x		X					

Table EL-58
List of fauna and observed in the forest ecosystems of Upper Wawa Dam Project Area during Dry Season

Species	Family	Common Name	Residency	IUCN Red List Threat and Population Status	DAO 2017-11 Status	Economic and Ecological Importance	Site 1	Site 2	Site 3	Site 4	Site 5	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5
Amphibians																
Rhinella marina	Bufonidae	Cane Toad	Introduced	Lc, Stable	not listed	Prey for snakes						x		x	x	
Platymantis dorsalis	Ceratobatrachidae	Wrinkled Ground Frog	Endemic	Lc, Decreasing	not listed	Prey for snakes							x		x	
Reptiles																
Lizards																
Parvoscincus cf. decipiens	Scincidae	Forest Skink	Endemic	Not Evaluated	not listed	n/a							x		x	
Gekko gecko	Gekkonidae	Tokay Gecko	Native	Lc, Unknown	ots	Medicine, sold in market									x	
Varanus sp.	Varanidae	Monitor Lizard	Native	--	ots	For food consumption by locals						local reports				
Snakes																
Malayopython reticulatus	Pythonidae	Reticulated Python	Native	Lc, Unknown	ots	For food consumption by locals; biological control for rodent pest										
Turtles																
Pelodiscus sinensis	Trionychidae	Chinese Softshell Turtle	Introduced	Vu, Decreasing	not listed	Sold in the market						local reports				
Birds																
Gerygone sulphurea	Acanthizidae	Golden-Bellied Gerygone	Resident	Lc, Decreasing	not listed	Seed dispersal						x	x	x	x	x
Alcedo atthis	Alcedinidae	Common Kingfisher	Migrant	Vu, Unknown	not listed	Eat invertebrates						x	x			
Halcyon smyrnensis	Alcedinidae	White-Throated Kingfisher	Resident	Lc, Increasing	not listed	Eat invertebrates							x			
Collocalia marginata	Apodidae	Swift	Endemic	Not Evaluated	not listed	n/a						x	x	x	x	x
Ardea purpurea	Ardeidae	Purple Heron	Resident	Lc, Decreasing	not listed	Migratory bird						x			x	
Bubulcus coromandus	Ardeidae	Eastern Cattle Egret	Resident	Lc, Unknown	not listed	Migratory bird						x	x	x	x	x
Nycticorax nycticorax	Ardeidae	Black-Crowned Night Heron	Resident	Lc, Decreasing	not listed	Migratory bird						x	x			
Artamus leucorynchus	Artamidae	White-Breasted Woodswallow	Resident	Lc, Stable	not listed	n/a								x	x	
Geopelia striata	Columbidae	Zebra Dove	Resident	Lc, Stable	not listed	n/a									x	x
Phapitreron leucotis	Columbidae	White-Eared Brown Dove	Endemic	Lc, Stable	not listed	n/a						x				
Streptopelia tranquebarica	Columbidae	Red Turtle Dove	Resident	Lc, Decreasing	not listed	Food for other locals						x		x	x	
Corvus macrorhynchos	Corvidae	Large-Billed Crow	Resident	Lc, Stable	not listed	predator							x			x
Centropus viridis	Cuculidae	Philippine Coucal	Endemic	Lc, Stable	not listed	Seed dispersal			x					x	x	
Lonchura atricapilla	Estrildidae	Chestnut Munia	Resident	Lc, Stable	not listed	n/a							x		x	
Lanius cristatus	Laniidae	Brown Shrike	Migrant	Lc, Decreasing	not listed	n/a								x		
Lanius schach	Laniidae	Long-Tailed Shrike	Resident	Lc, Unknown	not listed	n/a		x						x		x
Megalurus palustris	Locustellidae	Tawny-Grassbird	Resident	Lc, Unknown	not listed	n/a								x		
Motacilla tschutschensis	Moracillidae	Eastern Yellow Wagtail	Migrant	Lc, Decreasing	not listed	Migratory birds							x			
Saxicola caprata	Muscicapidae	Pied Bush Chat	Resident	Lc, Stable	not listed	n/a									x	
Cinnyris jugularis	Nectariniidae	Olive-Backed Sunbird	Resident	Lc, Stable	not listed	Seed dispersal									x	
Oriolus chinensis	Oriolidae	Black-Naped Oriole	Resident	Lc, Decreasing	not listed	Being hunt by locals for market								x		
Gallus gallus	Phasianidae	Red Junglefowl	Resident	Lc, Decreasing	not listed	For food consumption								x		
Mulleripicus funebris	Picidae	Sooty Woodpecker	Endemic		not listed	Being hunt and sold in the market									x	x
Hypsipetes philippinus	Pycnonotidae	Philippine Bulbul	Endemic	Lc, Stable	not listed	n/a							x			x
Pycnonotus goiavier	Pycnonotidae	Yellow-Vented Bulbul	Resident	Lc, Increasing	not listed	n/a			x				x		x	
Rhipidura nigritorquis	Rhipiduridae	Philippine Pied Fantail	Endemic	Lc, Stable	not listed	n/a								x	x	
Rhipidura cyaniceps	Rhipiduridae	Blue-Headed Fantail	Endemic	Lc, Stable	not listed	n/a							x			
Actitis hypoleucos	Scolopacidae	Common Sandpiper	Migrant		not listed	n/a								x		
----	Strigidae	Owl	----	----	----							species not verified, reports by local only				
Zosterops montanus	Zosteropidae	Mountain White-Eye	Resident	Lc, Unknown	not listed	Seed dispersal								x		
Mammals																
Rattus norvegicus	Muridae	Brown Rat	Introduced	Lc, Stable	not listed	Pest, prey for snakes	x	x	x							
Rattus tanezumi	Muridae	Oriental House Rat	Introduced	Lc, Increasing	not listed	Pest, prey for snakes						Reported by locals				
Cynopterus brachyotis	Pteropodidae	Common Short-Nosed Fruit Bat	Native	Lc, Unknown	not listed	pollinators	x	x	x	x	x					
Ptenochirus jagori	Pteropodidae	Musky Fruit Bat	Endemic	Lc, Stable	not listed	pollinators	x	x	x	x	x					
Rousettus amplexicaudatus	Pteropodidae	Common Rousette	Native	Lc, Unknown	not listed	pollinators	x	x	x	x	x					

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 Annex X I but be of "least concern" on the IUCN Red List.

- Annex X I = species considered threatened with extinction
- Annex X 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

1.4.2.7 Species Richness and Abundance

Table EL-55 presents the computed ecological parameters per sampling site during wet and dry season. During wet season, Site 2 recorded the highest number of individuals and species (70 recorded individuals representing 16 species). The high number of species in Site 2 is attributed to the large number of fruiting trees in the area, mostly banana (*M. paradisiaca*), santol (*C. koetjape*) and guava (*P. guajava*). Site 5 recorded the next highest number of individuals but the lowest number of species (60 individuals representing only 5 species). Species encountered during transect walks totaled 19 species. Species were often encountered along paths, trails, the river and in the ecotones between the forest and plantations. During dry season, Site 1 and Site 2 recorded the highest number of species (18 species each), with Site 1 recording the highest number of individuals (126 individuals). The high number of species and individuals in these sites is attributed to the large number of fruiting trees in the area, mostly banana (*M. paradisiaca*), santol (*C. koetjape*) and guava (*P. guajava*) which is eaten by the animals. Site 3 and 4 follows with 9 and 10 species, respectively. These areas are along the river, with mostly grasses and bamboo as dominant plants. Site 5 recorded the lowest number of species (33 individuals representing only 6 species). The low number of species recorded is due to limited sampling of the site due to security reasons. Species encountered during transect walks totaled to 13 species, lower than the previous number of species recorded during the wet season sampling. Overall, more species and individuals were encountered during the dry season sampling than the wet season sampling.

Among the observed amphibians, *R. marina* recorded the highest number of individuals (2 individuals) encountered with 2 individuals during wet season and 6 individuals during dry season, most of which are still in froglet stage. *E. multifasciata* was the most common reptile encountered with 3 adult individuals seen along the river during wet season while *Varanus* sp during dry season with 3 adult individuals seen basking in the river. Among birds, *Zosterops montanus* was the most numerous (32 individuals) travelling in mixed-species flocks. *P. jagori* and *C. brachyotis* were the common mammals, with 74 and 65 individuals, respectively. The large number of fruit-eating bats in the area is supported by the presence of numerous fruit-bearing trees.

During wet season, Site 3 recorded the highest diversity index (2.22) and Hill's number (9.21) (**Table EL-59**). Despite having the highest number of species, Site 2 only came in third in terms of Shannon's diversity index (1.94) and Hill's number (6.96). The reason for this is that 48% of the individuals recorded in Site 2 belong to only one species, *C. brachyotis.* Site 1 and Site 3 has a more heterogenous population of species (evenness of 0.9 and 0.89, respectively) compared to the evenness value of Site 2 (0.7). Site 5 on the other hand recorded the lowest value in all parameters.

Table EL-59
Computed ecological parameters per station in the forest ecosystems of Upper Marikina Watershed Protected Landscape

Site No.	Species Richness		No. of individuals		Shannon's Diversity Index		Hill's Number		Evenness		Abundance
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	
Site 1	11	18	47	126	2.15	2.36	8.58	10.59	0.90	0.82	0.23
Site 2	16	18	70	57	1.94	2.32	6.96	10.18	0.70	0.80	0.23
Site 3	12	9	24	42	2.22	1.78	9.21	5.93	0.89	0.81	0.50
Site No.	Species Richness		No. of individuals		Shannon's Diversity Index		Hill's Number		Evenness		Abundance
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	
Site 4	7	10	42	40	1.39	1.87	4.01	6.49	0.71	0.81	0.17
Site 5	5	6	60	33	1.02	1.56	2.77	4.76	0.63	0.87	0.08
Transects 1 to 5	19	13	63	33	2.30	2.49	9.97	12.06	0.78	0.97	0.30

Among the sites, Site 1 recorded the highest diversity index (2.36) and Hill's number (10.51) during the dry season. The computed value was higher compared to the computed value for the site during the wet season sampling (H'=2.15, N1=8.48). Site 2 closely follows the computed value in terms of Shannon's diversity index (2.32) and Hill's number (10.18). This is also higher compared to the previous recorded values for the site (H'=1.94, N1=6.96). Site 3 previously recorded the highest computed value during the wet season sampling (H'=2.22, N1=9.21) but recorded a lower value for the dry season sampling (H'=1.78, N1=5.93). Overall, there is a marked increase in the number of species and individuals in all sites, except for Site 3. Seasonal variation in species composition may be attributed to changes in food availability, migration, microclimatic conditions, and reproductive cycle of species which may influence the observed diversity of a particular habitat.

Diversity Indices

As shown in **Table EL-59**, Site 3 recorded the highest diversity index (2.22) and Hill's number (9.21) during the wet season. Despite having the highest number of species, Site 2 only came in third in terms of Shannon's diversity index (1.94) and Hill's number (6.96). The reason for this is that 48% of the individuals recorded in Site 2 belonged to only one species, *C. brachyotis.* Site 1 and Site 3 have a more heterogenous population of species (evenness of 0.9 and 0.89, respectively) compared to the evenness value of Site 2 (0.7). Site 5 on the other hand recorded the lowest values for all parameters. For dry season, Site 1 recorded the highest diversity index (2.36) and Hill's number (10.59). Site 5 has the lowest diversity index (1.56) and has a more heterogenous population of species based on the computed evenness (0.87). On the other hand, transect walk observations also shows low faunal diversity with 2.49.

Noteworthy Species

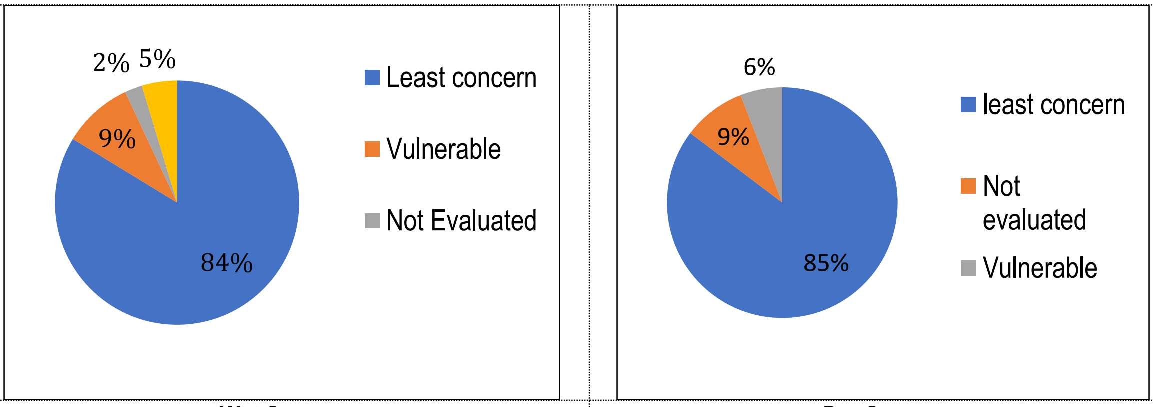
There are four species present in the project area that are considered noteworthy by virtue of several characteristics: (1) listed as globally threatened or the population is decreasing by IUCN, and (2) heavily exploited for food or pets. Two species of birds, the *Gullicolumba luzonica* (Luzon Bleeding Heart) is considered as nearly threatened and the other one is *Gallus gallus* (Red Junglefowl) which is decreasing in population. One species of mammals, the Common Rousette (*Rosettus amplexicaudatus*) is heavily hunted for food. Lastly, the *Naja philippinensis* and *Varanus* sp. (Monitor lizard), which is also heavily hunted for food consumption by the locals, are classified as a nearly threatened species

Culturally Significant Fauna

There is no culturally significant fauna identified in the project site. Dumagats (IPs) 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 traditional or cultural manner. It was reported that they hunt deer, wild boar and monitor lizards. This is also a possible reason for the current absence of deer and wild boar in the project area. Based on local interviews with the IPs and other local people in the area, there used to be numerous deer and wild pigs in the vicinity of the proposed project area and nearby forests. But due to excessive hunting, the population of deer and wild boar has declined.

1.4.2.8 Summary of Endemicity/Conservation Status

Of the observed overall wildlife population status during the wet season (based on IUCN assessment), 84% (64% for amphibians and reptiles, 91% for birds and 100% for mammals) are of least concern, 5% (7% for amphibians and reptiles and 5% for birds) are near threatened; 9% (22% for amphibians and reptiles and 4% for birds) are vulnerable and 2% of the amphibians and reptiles are not evaluated (**Figure EL-50**). During the dry season, 85% (57% for amphibians and reptiles, 92% for birds and 100% for mammals) are of least concern, 6% (14% for amphibians and reptiles and 4% for birds) are vulnerable and 9% (29% for amphibians and reptiles, 4% for birds) are not evaluated or not listed. In contrast with the assessment conducted in the year 2015, 92% are recorded as least concern these includes 99% for birds, 78% for mammals and 67% for amphibians and reptiles. And 3% was recorded as near threatened species.



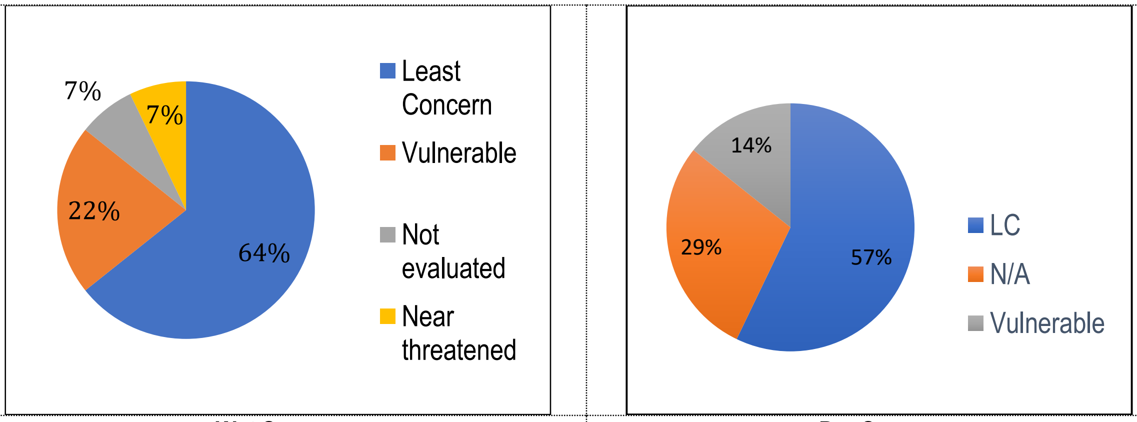
Wet Season	Dry Season

Figure EL-50. Population status of Wildlife species recorded in the site
Note: Conservation status is based on IUCN categories

Herpetofauna (Amphibians and Reptiles)

Among the reptiles and amphibians (herpetofauna) observed in the project site, most are listed as Least Concern (9 species or 64%), three (3) are Vulnerable (22%) and one (1) is Near Threatened (7%) (**Figure EL-51**). The other 7% or one (1) of the herpetofauna species is recorded as data deficient or not evaluated. The latter means that there is insufficient information for a proper assessment of conservation status to be made. However, this does not necessarily indicate that this one (1) species has not been extensively studied; but it does indicate that little or no information is available on the abundance and distribution of the species. Likewise, most of the reptiles and amphibians observed in the project site are listed as Least Concern (57%) while 14% are vulnerable. The remaining 29% of herpetofauna are recorded as data deficient or not evaluated.

The Chinese softshell turtle (*Pelodiscus sinensis* Weigmann) was introduced into China, Taiwan, Vietnam and in Thailand. It was also introduced in the United States and in the Philippines. The population trend of this species is decreasing worldwide (**Table EL-53**). The native range of the Chinese softshell turtle is difficult to determine due to the long tradition of use as a food and tonic and the subsequent spread by migrating people (Ernst, C.H et al). According to IUCN the status assessment was made with respect to natural populations only. The taxonomic and genetic diversity of this taxon has been confused and compromised by the mixing of animals of different origins in farms, and the escape of farmed animals into wild populations. While this species is commercially farmed in vast numbers for food trade, the wild population continues to be exploited for food and possibly farm founder stock, resulting in a decline in abundance throughout its wide range. This species of turtle was also recorded during the previous study but *Cuora amboinensis* (Malaysian pond turtle) that was recorded during this current assessment was not observed on the year 2015 valuation.

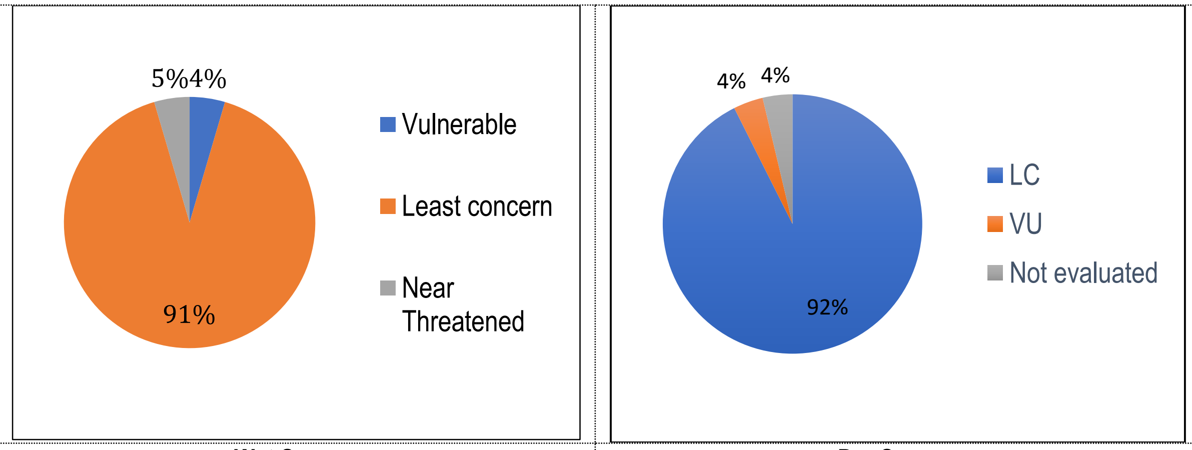


Wet Season	Dry Season

Figure EL-51. Conservation Status of Collected Herpetofauna (Reptiles and Amphibians) in the Study Area

Avifauna (Birds)

Out of 22 species observed during wet season, only one near threatened (5%) avifauna was recorded in the project site and the rest are listed as Least Concern (91%) (**Figure EL-52).** This species is the *Gallicolumba luzonica* (Luzon Bleeding heart) which was endemic to the Philippines and mostly observed in the mountains of southern Luzon. The Luzon bleeding heart is the species in which the “blood” feature is most pronounced, with the reddish hue extending down the belly, furthering the illusion of blood having run down the bird’s breast. It lives in primary or secondary forests and can be found at altitudes varying from up to 1400 meters above sea level. They eat seeds, berries and grubs. They are shy and secretive, and very quiet, and rarely leave the ground except when nesting. Unlike the other bleeding-hearts, they usually lay two eggs in each clutch. This species was not recorded on the previous assessment. This could be due to fragmentation through deforestation for timber extraction and agricultural lands and through “kaingin” activity that were observed during the last assessment in 2015. During dry season, 92% of bird species were listed as Least Concern while vulnerable and not evaluated species comprised 4% each.

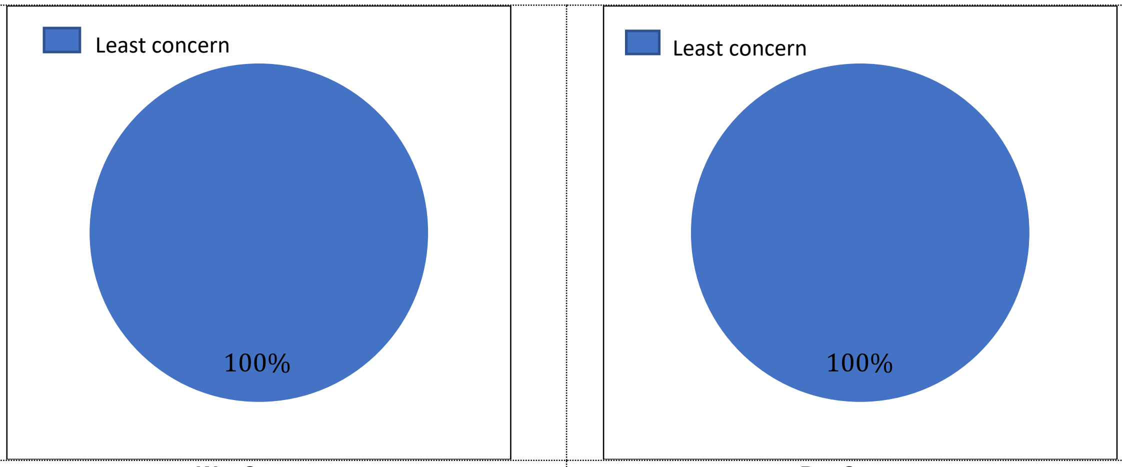


Wet Season | Dry Season

Figure EL-52. Conservation Status of Avifauna Collected in the study area

Mammals (Non-volant and volant)

In the present study, all species that were recorded during wet and dry season are listed as least concerns under the IUCN category (**Figure EL-53)**. This is comparable to the result that was gather in the year 2015, wherein 78% were recorded as least concern and 11% each for vulnerable and near threatened species.



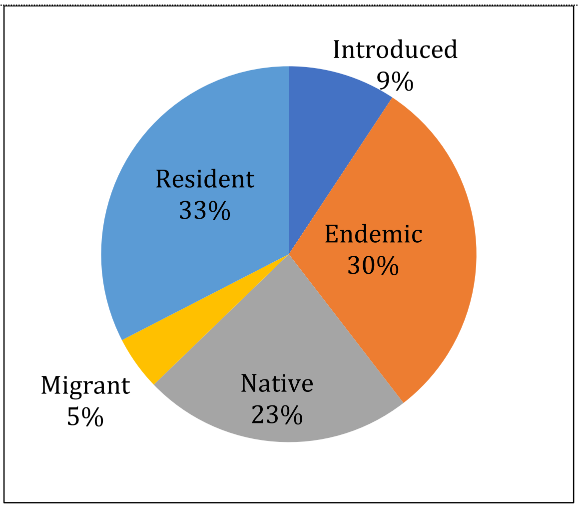
Wet Season | Dry Season

Figure EL-53. Conservation Status of Mammals (Non-volant and volant) collected in the study area

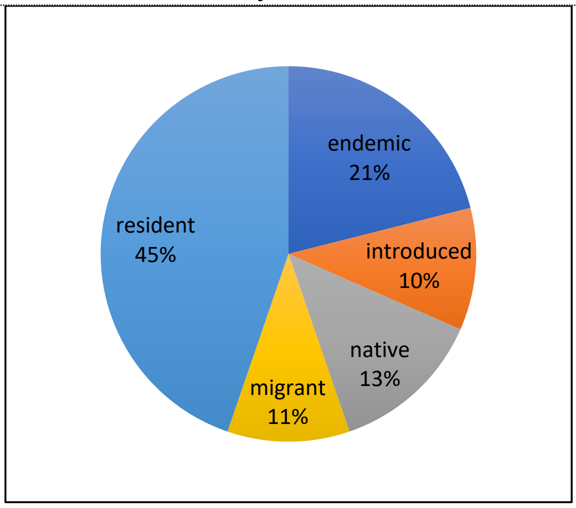
Distribution Status

In terms of percentage population distribution of all wildlife species recorded in all sites during wet season, 33% (64% of all bird species) are resident and 30% (27% for birds, 22% for mammals, 14% for amphibians and reptiles) are endemic. Migrant birds comprised 5% (9% of all bird species), while introduced species (all herpetofauna) comprised 9% (29% for mammals and 14 % of all herpetofauna) (**Figure EL-54**). During dry season, 45% (66% of all bird species) are resident and 21% (27% for birds, 22% for mammals, 50% for amphibians and 20% reptiles) are endemic. Migrant birds comprised 11% (15% of all bird species), while introduced species comprised 10% (40% for mammals and 20% for reptiles and 50% amphibians.

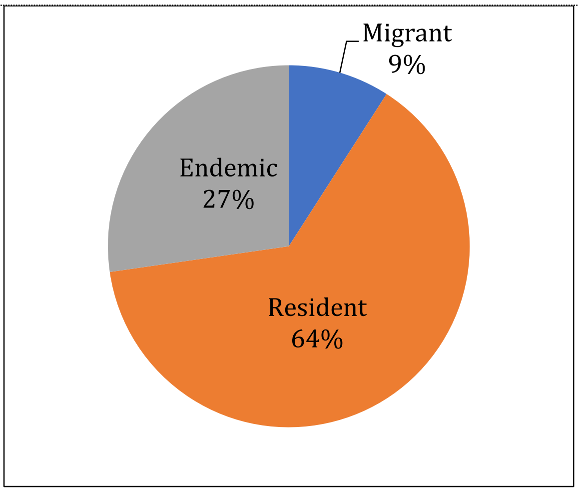
Wet Season

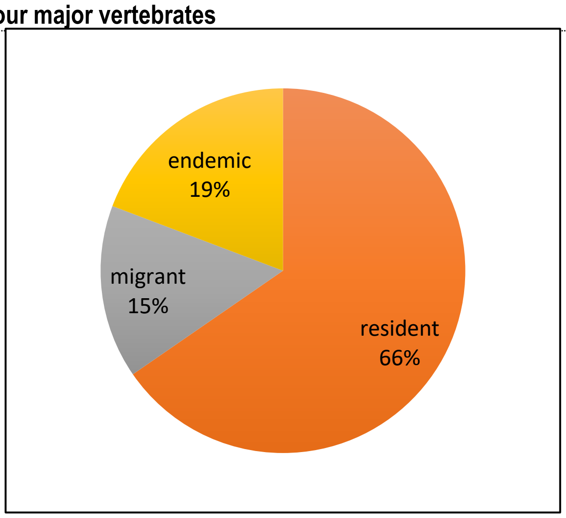


Dry Season

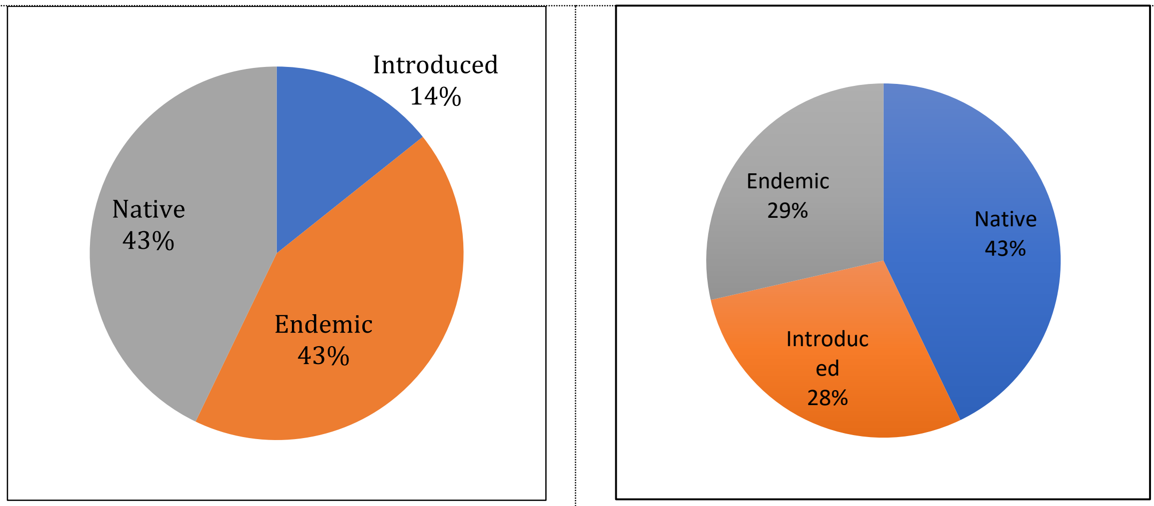


Overall Distribution of four major vertebrates

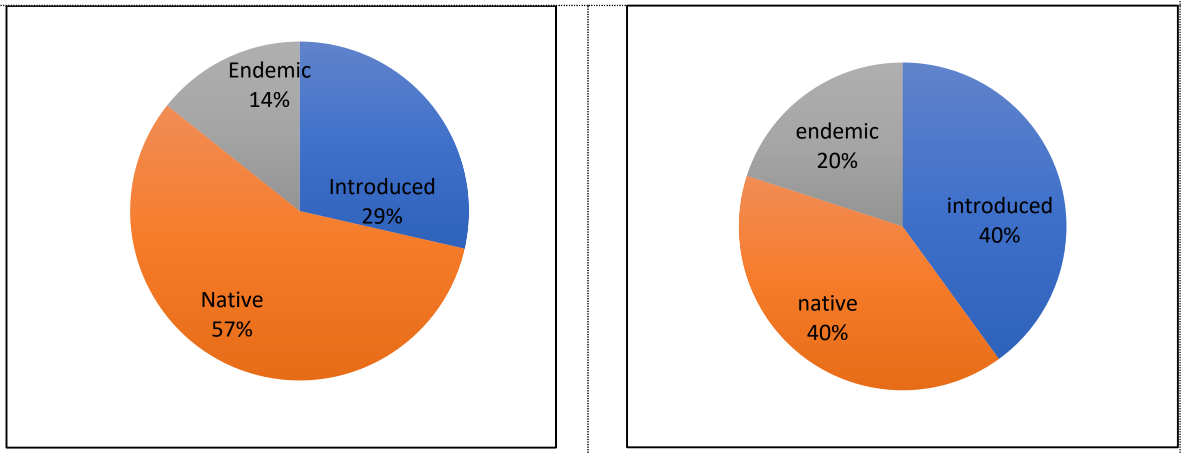




Avifauna (Birds)



Herpetofauna (Reptiles and Amphibians)



Mammals (Non-volant and volant)

Figure EL-54. Distribution of the four major vertebrate groups collected from the study area

1.4.2.9 Distribution and Species Richness of Important Species in Ecologically Sensitive Areas

Many natural habitats are being converted into different land uses, which include agriculture, forestry and aquaculture which yield greater productivity to humans. The natural value of several areas is considered significant that needed to be converted with great caution or sometimes much better to leave in their present natural state. This area of great substantial value in a natural state is what we called Ecological Sensitive Areas (ESAs). This area has unique features, maintain key natural processes, support rare animals or/and plants and their habitats or even provide important breeding areas for various wildlife species. The Upper Marikina River Basin Protected Landscape, where the proposed project is located, has been proclaimed a protected area by the Department of Environment and Natural Resources (DENR). Despite of being declared as the Marikina Watershed Reservation by virtue of Executive Order No. 33 dated 26 July 1904, the upstream Marikina River is still intended for Fishery water, recreation water class II, and industrial water supply class 1. Hence, the proposed Upper Water Dam is still allowed to be constructed with strict compliance with rules and regulations of DENR/PAMB since the location of the proposed project is noted to be within Multiple Use Zone with some areas designated for Assisted Natural Revegetation, reforestation/ rainforestation and agroforestry areas. These are consistent with the findings on site, as detailed in the land use and terrestrial flora section of this report.

Important species that were identified in the study area are native, endemic and threatened. There were thirteen (13) species of important species recorded. This includes two (2) species of mammals' namely *C. brachyotis* and *P. jagori*; three (3) species of avifauna namely *A. atthis, C. marginata,* and *M. funebris* for dry season. Meanwhile for the wet season sampling, there were ten (10) including three (3) species of mammals namely *P. jagori, C. brachyotis,* and *R. amplexicaudatus*; four (4) species of avifauna namely *H. philippinus, R. cyaniceps, L. philippinensis,* and *G. luzonica;* and three (3) species of herpetofauna namely *Varanus sp, P. cf. decipiens,* and *P. mimulus*. Species richness of wildlife during wet season is higher compared to dry season, this is probably due to the abundance of food types, presence of dense vegetation and stable hydrological period. It was also noted that the during wet season amphibians and reptiles were more diverse and randomly distributed in the area because rivers overflow their banks and amphibians and reptiles retreat to higher ground that made easier for us to directly observed their movement. Clump distribution of the species in the area were observed, probable reason for this is that the food resources of numerous wildlife in the area is also patchy or concentrated in one area (**Figure EL-55** and **Figure EL-56**).

1.4.2.10 Effects of Infrastructure projects in the Distribution and Species Richness of Important Species

Marikina river is a tributary of Pasig river with headwaters located in the Sierra Madre Mountains in Rodriguez, Rizal. The river is located east of the Metro Manila region with an approximately length of 31km that drains the 582 km^2 Marikina River Basin towards the Pasig River (Abon et al., 2011 as cited by Berkman Inc, retrieved from riverbasin.denr.gov.ph). Industrialization at the upstream portion of Marikina River Basin is concentrated mainly on agricultural business sector. Major poultry and piggery farms of Universal Robina, Foremost and GMC are in Antipolo. The livestock farms are the primary source of wastewater going to Marikina River. Deforestation and subsequent erosion of the mountainous area at the headwaters of Marikina River is another source of pollution of the basin. Due to a relatively flat valley and easy accessibility, particularly within the NCR, several large industries were being established in the vicinity of the Marikina River System (MWSS MP, 2012 as cited by Berkman Inc, retrieved from riverbasin.denr.gov.ph). As a major source of water, the National Water Resources Board (NWRB) has issued water permits for tapping some tributaries of Marikina River at the upstream portion in Rodriguez, San Mateo down to Antipolo City. The tributaries that are being used as source of water include Tayabasan, Boso Boso, Wawa, Nangka and Puray rivers.

According to the infrastructure map provided by the DENR and Berkman Inc. dated September 2014, the study area has four infrastructures; two of these are proposed and another two were already competed. The Renewable Energy Law being implemented by the Department of Energy is providing incentives to the private sector for the development of renewable energy sources which include the hydropower. On the other hand, the Calabarzon Regional Development Plan 2011-2016 identifies the construction of Micro-Hydropower projects in Marikina City and San Mateo, Rizal as possible projects to enhance the region’s competitiveness as a global business hub. Further, Hydrotec Renewables Inc. has pending application for renewable energy services contracts which will allow the company to pursue the feasibility study for its proposed hydropower projects. In the year 2015- 2016 a 500MW Wawa Pumped Storage was also proposed in the area for energy development. Most of the proposed hydropower projects will be using the Marikina River or its tributaries. Meanwhile, The MWSS mater plan indicates utilizing Wawa Dam to supply potable water up to 50 MLD. According to their ocular inspection and water quality assessment, an in-depth study may be required to determine the suitability and sustainability of re-opening Wawa Dam as source of water supply. Table 1 shows the list of the proposed plans, projects and projects for water resources.

Table EL-60
Proposed projects identified in the Marikina Watershed

Plan/ Project/Programs	Lead Agency
Updating of water body classification of Marikina River	DENR
Hydropower	Private sector
Water supply	Private sector

Source: https://riverbasin.denr.gov.ph/masterplans/marikinaexecutivesummary.pdf

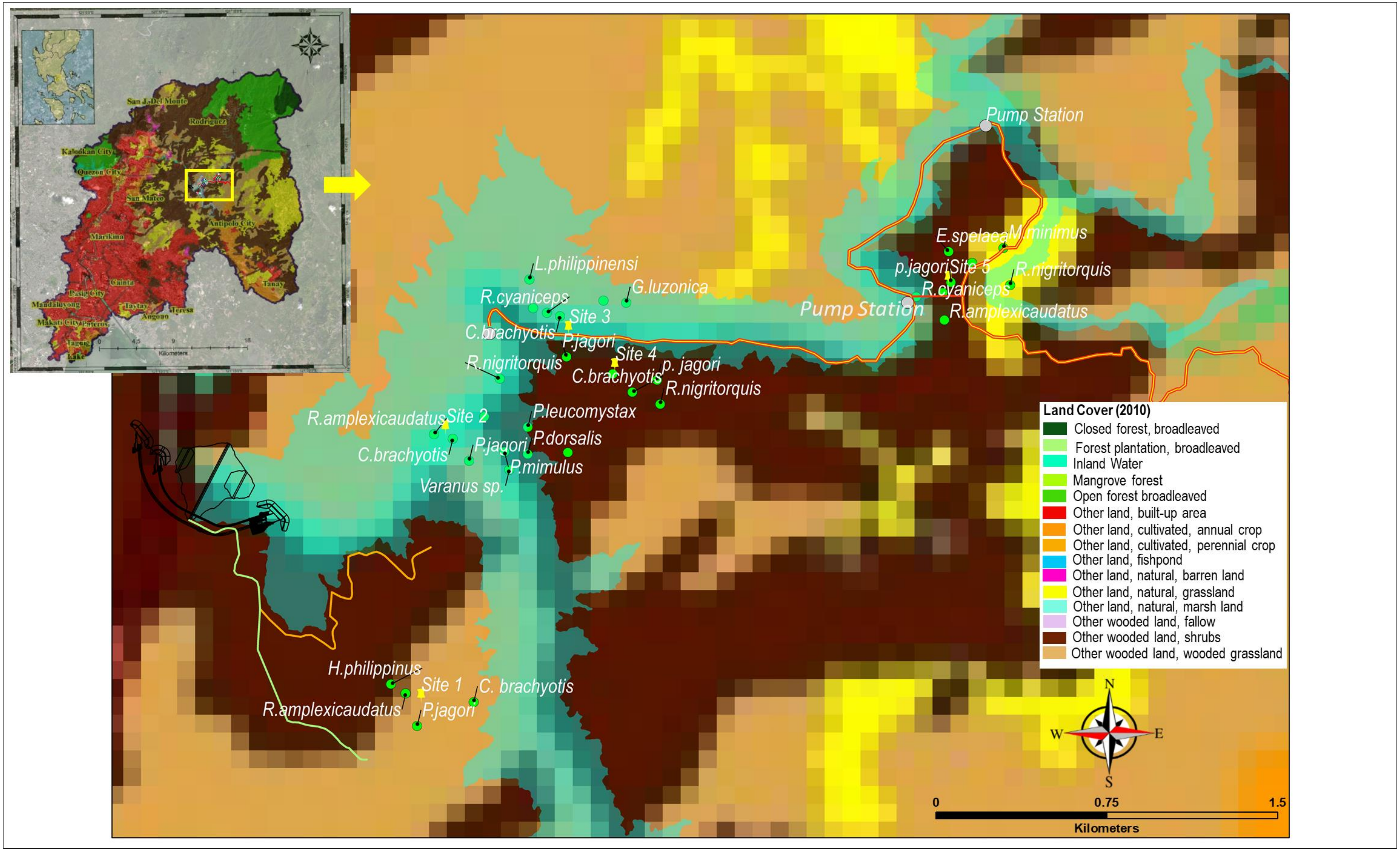


Figure EL-55. Ecological Sensitive Areas and Important Species (Wet Season)

ENVIRONMENTAL IMPACT STATEMENT
LAND MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

Legend
- Sampling points
- Important species
- Pump Station
- Transmission Pipeline via Tunnel Optional
- UWD Optional Access Road (New)
- UWD Access Road (Original)
- Access Road to WTP / Transmission Pipe
- UWD Dam and Diversion Tunnel
- Transmission / Water Conveyance Pipeline
- UWD Reservoir

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCO, Inc. (2020)
Source: Department of Agriculture's - Bureau of Agricultural Research (2014)
Basemap: ArcGIS Imagery, 2020
Created by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.

aperçu CONSULTANTS INC.

SCALE: 1: 12,500

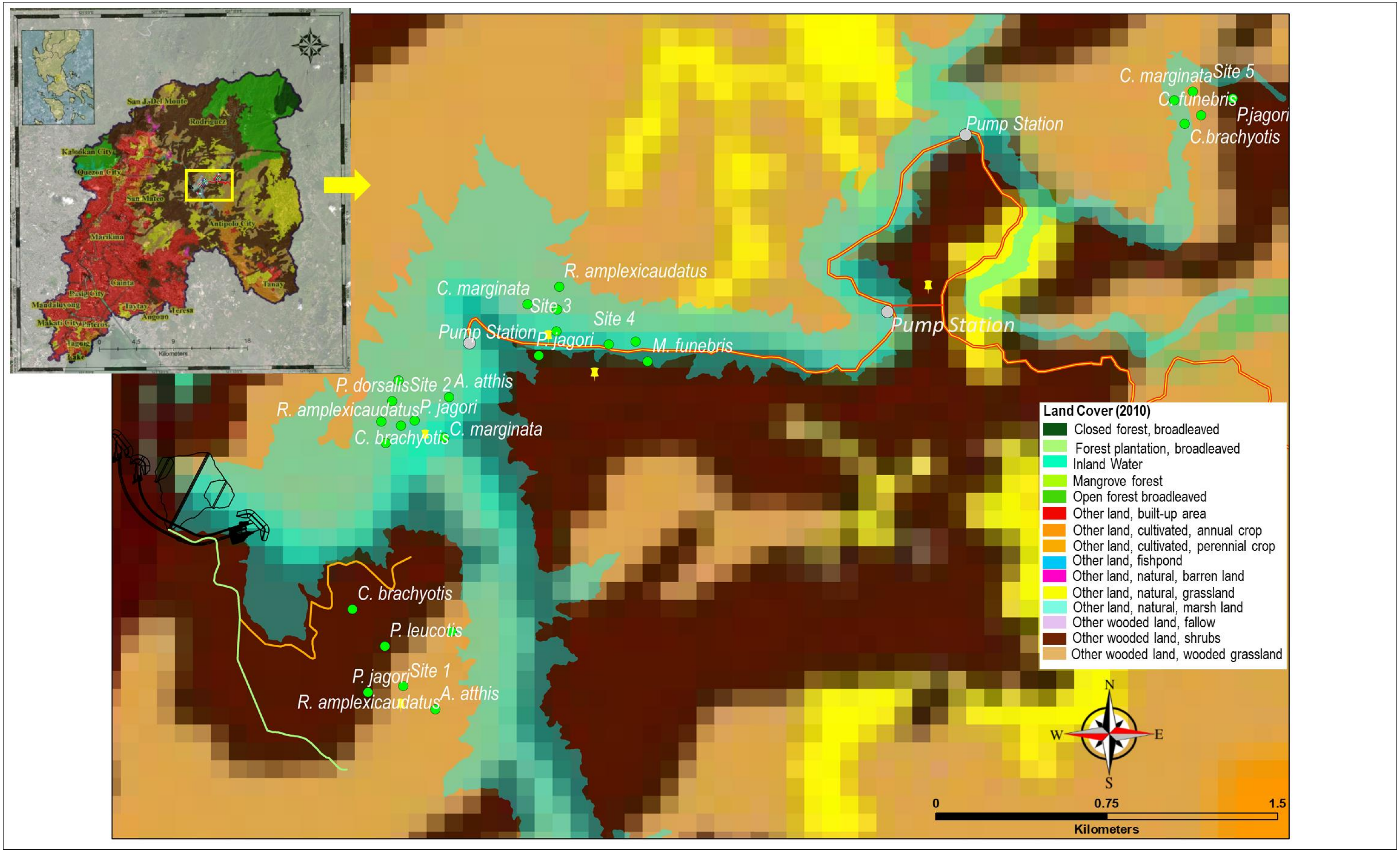


Figure EL-56. Ecological Sensitive Areas and Important Species (Dry Season)

ENVIRONMENTAL IMPACT STATEMENT
LAND MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

Legend
- Sampling points
- Important species
- Pump Station
- Transmission Pipeline via Tunnel Optional
- UWD Optional Access Road (New)
- UWD Access Road (Original)
- Access Road to WTP / Transmission Pipe
- UWD Dam and Diversion Tunnel
- Transmission / Water Conveyance Pipeline
- UWD Reservoir

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCO, Inc. (2020)
Source: Department of Agriculture's - Bureau of Agricultural Research (2014)
Basemap: ArcGIS Imagery, 2020
Created by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.

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SCALE: 1: 12,500

Effects of infrastructure on wildlife refer to primary effects measured at a local scale. Primary ecological effects are caused by the physical presence of the project components as well as an increased traffic due to these projects. The impacts of these are habitat loss, disturbance/edge effects, mortality, and barrier effects as negative impacts. However, corridor habitats along infrastructure can be seen as either positive or negative in natural well conserved landscapes where the invasion of non-native, sometimes pest species can be facilitated. For the construction of the Upper Water Bulk Supply, direct impacts will be to biological, chemical and physical properties of rivers and riparian environments particularly during construction phase. During the operational phase dams have some beneficial impacts such as the creation of reservoirs that can benefit local wildlife during drought, and can provide habitats for wetland creatures, especially wetland bird species. In terms of the distribution and dispersal of wildlife species, Cowan and Van Reit (1998) stated that it has a major effect on the distribution and numbers of wildlife especially with waterfowl, their study in South Africa evidently observed that waterfowl has greatly increased in numbers because of the presence of reservoirs. However, in contrast with the positive impact stated by Cowan and Van Reit, 1998; Nilsson and Dynesius 1994, emphasize that the most negative downstream consequence of river regulation on mammals and birds is the disruption of the seasonal flood regime along the river. In the long term, reduced flooding can alter vegetation communities that may be important for a wide range of mammals, herpetofauna and bird species. If the flooding is altered, changes in vegetation may place at risk the birds and animals that depend on it. Simply put, if there will be changes in the vegetation structure of the forest distribution and dispersal of wildlife species will also be affected. In **Figures EL-57 and Figure EL-58**, distribution of the important species identified in the site will probably affect its dispersal and distribution however, this impact in their distribution will just be short term, changes in the distribution of the species is expected to be observed during construction phase only.

1.4.2.11 Comparison of Past and Present Studies of Fauna in Wawa Area

The Wawa River area have been extensively studied for the past years. In 2015, Apercu Consultant Inc. conducted a study to assess the impacts of the proposed 500MW pumped storage to the fauna in the area. A total of 96 species were recorded from 13 sampling locations consisting of 72 bird species, 9 mammal species, 7 reptile species and 8 amphibian species. The total species recorded in 2015 study was higher than the present study. This is attributed to the relatively greater sampling effort and area in 2015 study than the present (only five stations). SMEC Consultancy firm studied the composition of fauna in the same area last May 2019 for the preparation of the feasibility study for the proposed Water Bulk Supply. The study showed less composition compared both to the 2015 and the present studies. Throughout the transect lines, observations by SMEC were made by listing and counting of species seen or heard. For mammals, traps were set up and distributed in the areas. However, SMEC did not mention in the report whether mist nets were set up for volant mammals, unlike the 2015 and present studies that utilizes mist nets to capture volant mammals and bird species. This could account for the low composition of species recorded by SMEC (sampling stations were not mentioned in the report).

For herpetofauna, Apercu in 2015 recorded 7 reptile and 8 amphibian species, including the endemic species Cuming's Sphenomorphus and Philippine Water Monitor. The number of herpetofauna species recorded during the present survey is almost similar to the number of species recorded in 2015. Additional species recorded in the area in 2015 include *Limnonectes macrocephalus* and *Platymantis mimulus* for the amphibians; and *Eutropis multifasciata, Parvoscincus decipiens, Ahaetulla prasina, Hydrosaurus pustulatus, Malayopython reticulatus, Naja philippinensis* and *Cuora amboinensis* for the reptiles. The last four species were not observed during the survey, but locals and guides reported the presence of these in the area. The decrease in species from the study conducted in 2015 and at present is noticeable. This is attributed to the sampling effort done in the present study because there was no night sampling conducted due to the conditions brought by monsoon rains. The mentioned turtle species were also recorded in the previous Apercu study except *Cuora amboinensis* (Malaysian pond turtle). On the other hand, SMEC only reported two species of turtles namely Philippine forest turtle and Asian softshell turtle, which were not recorded in the present and 2016 studies.

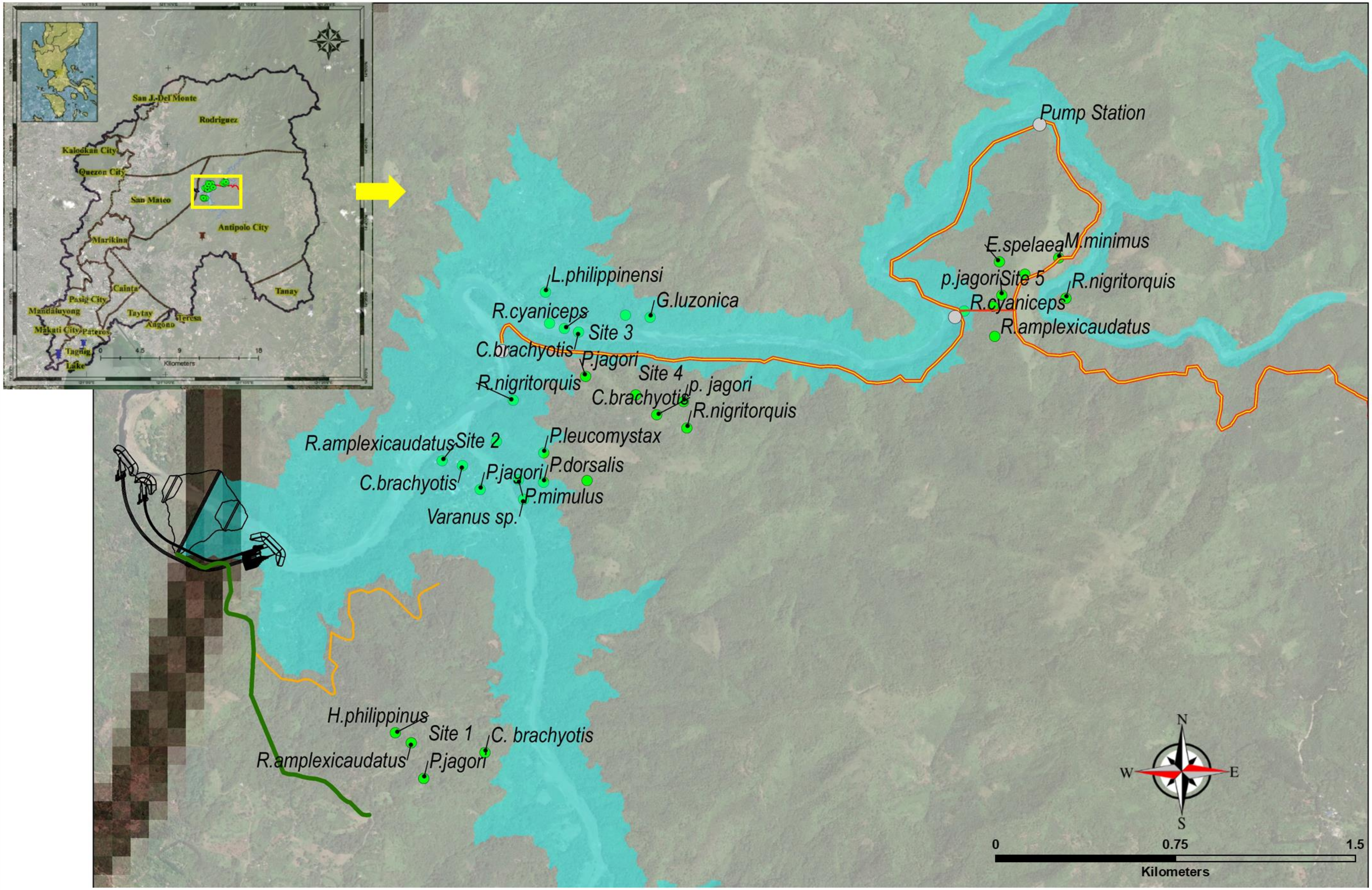

Figure EL-57. Infrastructure Map and Important Species (Wet Season)

ENVIRONMENTAL IMPACT STATEMENT
LAND MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

Legend
- Sampling points
- Important species
- Pump Station
- Transmission Pipeline via Tunnel Optional
- UWD Optional Access Road (New)
- UWD Access Road (Original)
- Access Road to WTP / Transmission Pipe
- UWD Dam and Diversion Tunnel
- Transmission / Water Conveyance Pipeline
- UWD Reservoir

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCO, Inc. (2020)
Source: Department of Agriculture's - Bureau of Agricultural Research (2014)
Basemap: ArcGIS Imagery, 2020
Created by: APERCU CONSULTANTS, INC (2020)

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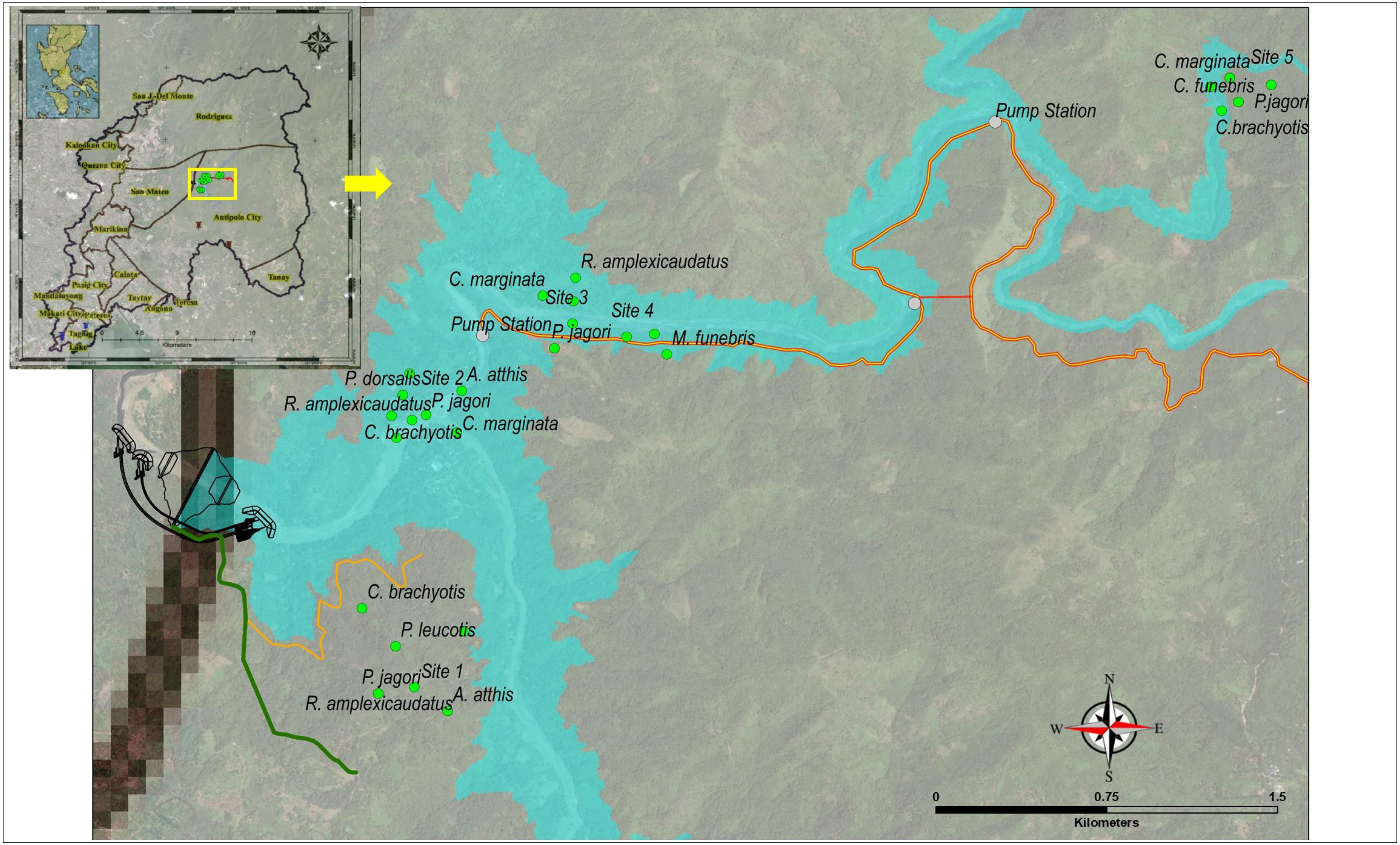

Figure EL-58. Infrastructure Map and Important Species (Dry Season)

ENVIRONMENTAL IMPACT STATEMENT
LAND MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

Legend
- Sampling points
- Important species
- Pump Station
- Transmission Pipeline via Tunnel Optional
- UWD Optional Access Road (New)
- UWD Access Road (Original)
- Access Road to WTP / Transmission Pipe
- UWD Dam and Diversion Tunnel
- Transmission / Water Conveyance Pipeline
- UWD Reservoir

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCO, Inc. (2020)
Source: Department of Agriculture's - Bureau of Agricultural Research (2014)
Basemap: ArcGIS Imagery, 2020
Created by: APERCU CONSULTANTS, INC (2020)

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SCALE: 1: 12,500

For avifauna, the 2015 study revealed the presence of 72 species of birds and mostly were not recorded this year. However, eight (8) species of birds that were recorded this year were not observed in the previous study, including *Alcedo atthis*, *Egretta eulophotes*, *Artamus leucorhynchos*, *G. luzonica*, *Phapitreron leucotis, Rhipidura nigritorquis*, and *R. cyaniceps*. The absence of the Luzon bleeding heart (*G. luzonica*) in the previous study could be due to fragmentation from deforestation for timber extraction and agricultural lands, as well as "kaingin" activities that were observed during the assessment conducted in 2015. Meanwhile, a total of 29 species of birds with a total of 444 individuals were listed in the study made by SMEC.

Lastly, all the recorded mammals in the present survey were recorded in the previous wildlife assessment in 2016; meanwhile no mammals were reported by SMEC. However, in this present study, the team was unable to detect the presence of *Eonycteris robusta, Tylonycteris pachypus, Rattus everetti* and *Paradoxorus hermaphroditus*. Whereas *R. tanezumi* which was not observed previously in the area was recorded in Sites 1 and 2, which could be due to the presence of several agricultural crops and human habitations near the sites.

In terms of diversity, it is apparent that the species recorded in 2015 were more diverse and abundant compared to the 2019 studies. This could be attributed to the sampling effort and stations of three different reports. The 2015 study has 13 sampling stations and both seasons were assessed. Although both seasons were also assessed in the present study, there were fewer sampling stations (only five stations) compared to the 2015 study. Meanwhile, no sampling effort and stations mentioned in the report from the study conducted by SMEC.

The differences in number and type of detected species are attributed to temporal and spatial distribution of the species and differences in the area surveyed, with fewer areas being surveyed in the recent assessment. Habitat changes may have also resulted in some species moving to newer areas. Also, number of sampling stations could be one major factor why there is a difference in the observed species.

1.4.2.12 Impact Assessment and Mitigation Plan for Fauna

Disturbance or Loss of Species due to Habitat Loss

Construction of the proposed Wawa Water Bulk Supply will involve some clearance of vegetation at the dam site. The construction of workers' camps will result in further vegetation clearance that will lead to disturbance or loss of wildlife species in the area. Those terrestrial species that have minimal dispersal capabilities may be drowned during the dam filling. Submergence of terrestrial natural habitats risk the drowning of wildlife species is also anticipated however this will only occur at the time that the dam will fail or breach since during normal working conditions, flow will always be regulated as soon as the water bulk supply commence.

Construction will involve noise and vibration that may cause short term (lasting during the construction phase) disturbance to wildlife that occupy adjacent habitats. The primary causes of noise and vibration would come from traffic and equipment operation and movement, clearing and excavation, rock breaking and construction.

During the operation phase, the accessibility to the area will improve due to construction of roads, which in turn may increase human interferences leading to marginal adverse impacts on the terrestrial ecosystem.

Sources of Environmental Threats in the Forest Ecosystems of Upper Wawa Dam Project Area

There were many observed sources of environmental degradation in or near the forest ecosystems surveyed. These environmental problems may pose threats to the forest ecosystems in Upper Wawa dam project area. Ecotourism, kaingin farming, solid wastes and wildlife hunting were observed and recorded in the study area.

Upper Wawa Dam Project Area is an ecotourism area where development such as road construction and trekking/hiking, motorcycling activities already occur. Wildlife hunting in the forest ecosystems was also practiced by the locals and indigenous people residing near the area. Some of the residents stated that they hunt wild deer, wild boar and other animals in the forest for their consumption. Lands near the base of the mountain as well as in higher areas are used for cultivating fruit trees such as rambutan, banana and corn. The soils of these areas are often exposed after harvesting season making them vulnerable to soil erosion and soil instability during rainy season.

Environmental degradation could result to damage in faunal composition of the forest ecosystem, destruction of wildlife habitat and water quality, soil erosion and loss of biodiversity. The degradation of environment may lead to a more permanent loss of biological productivity (Alberto, 2005).

Only the necessary roads will be constructed. The proponent will ensure compliance with all regulations relevant to minimizing noise generated from construction of the Wawa Water Bulk Supply reduce impacts on wildlife.

Wildlife rescue efforts will be taken up, wild animals rescued or captured to be relocated or released to suitable habitats during reservoir filling. Material placement processes need to be carefully managed to ensure any adverse effects are prevented or confined to active work areas.

Threat to Existence and/ or Loss of Important Local Species

Endemic wildlife in the project site especially those species (amphibians, reptiles and small non-volant mammals) that have limited dispersal abilities will be forced to stay in the area and may result in their injury or even death. Since there are only few important local species recorded within the project area this impact is expected to be minimal.

Personnel temporarily staying within the construction camp site may affect wildlife population in different ways: hunting, collection of trees for firewood and irresponsible disposal of waste materials. If personnel to be stationed are numerous, the impacts might be compounded and could lead to substantial disturbance. If hunting will ensue, several species might be affected, such as large and conspicuous wildlife species.

Wildlife rescue efforts will be taken up, wildlife animals rescued or captured will be relocated to a suitable habitat.

Ensure compliance with all regulations relevant to minimizing noise generated from construction site of the Wawa Water Bulk Supply hence monitoring of vibration and noise will be carried out at construction sites and access roads in order to access the effectiveness of noise and vibration mitigation measures.

Threat to Abundance, Frequency and Distribution of Important Species

Important wildlife species, including threatened species, will be displaced once the habitat is converted. Displacement will decrease the abundance of the local population. Reduction in number of migratory birds is also expected since the total number of available habitats will decrease during the construction phase due to additional impacts from noise, lights and humans. This will also result in increased competition among individuals and species; however, this impact however is expected to be minimal since there is very few threatened wildlife species recorded in the site.

Ensure compliance with all regulations relevant to minimizing noise generated from construction. Only the necessary roads and project area will be constructed. For offset purposes, to mitigate the removal and/or modification of native vegetation that will occur within the construction footprint. Wildlife rescue efforts will be taken up by the proponent once the project commences.

Hindrance to Wildlife Access

This impact is expected to be minimal since the forest in the project area is already patchy. However, the development of roads and other facilities may affect wildlife by altering and isolating habitat and populations, deterring the movement of wildlife and may result in wildlife mortality.

An activity such as reforestation will be done by the proponent to minimize fragmentation and retention of vegetated areas through which wildlife may use as areas corridors. Further, financial support to enhance ranger patrol operations and reserve boundary must be considered by the proponent.

Impacts of Habitat Fragmentation

Fragmentation can have a severed impact on wildlife. Reductions in habitat may lead to increased competition among species and more limited resources. Landscape development, roads, fences, power line corridors and other structures in the proposed project can serve as obstacles for the movement of wildlife. This can lead to increased mortality to wildlife especially for species that require large continuous habitat; fragmentation reduces the success of the species. Detailed effects of habitat fragmentation to wildlife are as follow:

Patch size effects caused by road and project facility construction of the proposed project

Fragmentation can negatively impact large bodied or wide-ranging species in the area that are depend on large areas of favorable forest habitat to survive by reducing landscape patch size and increasing movement barriers.

Edge Effects due to construction of proposed project

Fragmentation in the area might increase the amount of edge in a landscape, which can negatively impact wildlife by causing changes in abiotic and biotic conditions, making habitat unsuitable for some native species.

Isolation Effects due to Construction of Project Facility

Isolation of habitats can negatively impact species of wild in the area those species require access to multiple small habitat patches to survive by reducing their access to resources. Increased isolation of habitats can lead to inbreeding which may cause genetic abnormalities and weaknesses.

Development of wildlife corridors that connect at least two significant habitat areas by natural habitat; the proponent must create or preserve lands of similar quality and size to that which they impact. Riparian areas are important corridors with many wildlife species because this can be used by them to move through landscape. Moreover, maintain and restore habitat connectivity for wildlife throughout the project area by working with conservation lands as well as lands that may be managed primarily for other values such as agriculture, roadways, residential/offices development. Maintain riparian areas whenever possible and plant them with native plants to provide food and cover.

Impacts of Pollution Effects in Terrestrial Wildlife Species

Possible pollution that may affect wildlife species in the proposed project are noise and air pollution, impacts are detailed below:

Noise Pollution

Birds seem to be especially sensitive to noise as it directly interferes with their vocal communication and consequently their territorial behaviors and mating success. Chronic noise exposure is especially disruptive for species that rely on sound for communication or hunting. Animals that use noise for hunting such as bats and owls and prey species that rely on noise to detect predators may have decreased patterns of foraging, reducing growth and survivability (Kight and Swaddle, 2011). Reduction of birds in the study area due to noise pollution during construction phase can in turn negatively impact seed dispersion, affecting ecosystem services and diversity in the project area.

To mitigate the noise pollution, proponent will ensure the softening of the noise using appropriate silencers, to levels lower than the pain threshold of human ear (120dB in the frequency range 2,000-4,000Hz), particularly during construction phase. During operational phase of the project, increased green space/ tree belt in the area to reduce noise; width of vegetation belts can absorb sound and dissipation with larger acoustic pathway. It is also recommended to the proponent to invest with Nanofibre nonwovens, this is a lightweight, porous, have a high surface area to volume ratio to maximize the reflection of noise waves and can absorb high, medium and low frequencies. Khan et al. (2012) have shown that nanofibres within 200nmn to 5um enabled a significant loss of sound transmission.

Air Pollution

Air pollutants can poison wildlife through the disruption of endocrine function, organ injury, and increase vulnerability to stresses and diseases, lower reproductive success and possible death. Changes in the diversity of species in the area due to air pollution during the construction phase and in road areas can dramatically influence the abundance, distribution and health of species.

During construction, use of modern well-maintained machinery and vehicles meeting applicable emission performance standards would minimize emissions. Use of dust abatement techniques such as wetting soils, covering storage piles and limiting operations during windy periods on unpaved, un-vegetated surfaces would reduce airborne dust and resulting impacts.

1.4.2.13 Monitoring Plan for Fauna

Monitoring of vibration and noise must be carried out at construction sites and access roads in order to assess the effectiveness of noise and vibration mitigation measures. Monitoring wildlife species in the area should take place before clearing, after clearing and then every six to three years during operation. Thereafter the schedule is to be reviewed based on the results.

Monitoring of the reptile species will take place at intervals of months, starting a week immediately after water fills the dam and then 6 months, and thereafter on a yearly basis.

II. BASELINE KEY ENVIRONMENTAL IMPACTS

2.0 Water

This section covers the description of the existing environment, assessment of potential impacts and proposed mitigation measures for the following water-related environmental aspects:

- Hydrology and Hydrogeology (**Section 2.1);**
- Water Quality (**Section 2.2**); and,
- Freshwater Ecology (**Section 2.3**)

2.1 Hydrology and Hydrogeology

2.1.1 Scope

The proposed Upper Wawa Dam catchment covers watersheds of six (6) rivers namely: (1) Boso Boso River, (2) Montalban River, (3) Payagwan River, (4) Sapa Bute Bute River, (5) Tayabasan River and (6) Wawa River, where the proposed UWD Project will be located. This section provides a description of the physical characteristics and flows of the six (6) rivers mentioned above based on the drainage system and delineated watersheds. This is followed by an assessment of potential impacts arising due to the construction and operation of the project in terms of changes in drainage morphology, potential for flooding, reduction in river volumetric flow, and depletion of water resources or water use competition. Based on these assessments, measures to manage and mitigate potential adverse impacts are recommended.

As per feasibility study conducted for the project, the following major work items will be constructed:

(i) Conveyance system from Basin 1 and Basin 2 to the Calawis WTP

Raw water from Basin 1 will be conveyed to the Calawis WTP by pumping thru a 3.5 km steel pipe from the intake structure. On the other hand, from the intake structure raw water from Basin 2 will be transferred to the WTP by gravity thru a 1 km steel pipe.

(ii) Intake structures at Basins 1 and 2

Before raw water is delivered thru the conveyance system, it will be collected in intake structures located in the vicinity of each weir. These intake structures' function is to help in safely withdrawing water from the source over predetermined water levels. Intake structures for both weir 1 and 2 will be located upstream of the weirs where the opening level elevation of intakes are positioned where it can draw water even during the driest period.

In summary, a. Basin 1 to Calawis WTP, one (1) 3.5-km long steel from intake structure; b. Basin 2 to Calawis WTP, one (1) 1-km long steel pipe from intake structure; c. Intake structures are located upstream of weir 1 and weir 2; at the elevation where the intakes "can still draw water even during the driest period."

The study gives the proposed key features of the Upper Wawa Dam and to emphasize, the diversion works include the diversion tunnel of 13m in diameter and 375m in length.

2.1.2 Methodology

The overall methodology to describe the hydrological and hydrogeological conditions of the project area as well as to assess potential impacts associated with the project are summarized below. Each of these methods and findings are discussed in detail in subsequent respective sub-sections:

- **Determination of hydrological setting:** Reference was made to topographic maps to determine the hydrological setting and the drainage system.
- **Delineation and characterization of the Wawa River Basin:** Reference was made to topographic maps which were obtained from NAMRIA and SRTM-DEM data.
- **Determination of the hydrogeological setting:** Reference was made to the General Geology and Mineral Resources of the Philippines, Volume 1-2004 by the Philippine Bureau of Mines and Geosciences.
- **Determination of historical rainfall and streamflow records:** Reference was made to secondary rainfall and climatologic data of relevant synoptic/rainfall stations acquired from the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA). Rainfall data was also obtained from the Effective Flood Control Operations System (EFCOS) under the Department of Public Works and Highways (DPWH). Streamflow data was retrieved from the Philippine Water Data Summary (1980) published by the National Water Resources Council (now National Water Resources Board or NWRB).
- **Spring and well inventory:** The wet and dry season field surveys were undertaken on August 3-6 and November 15-16, 2019, respectively, aiming to: (1) identify the potential groundwater (springs and wells) and surface water (rivers and tributaries) sources, (2) determine the existing water use and water users of the sources, (3) estimate the available flows from these sources at the time of observation, (4) estimate the water consumption of the water users, and (5) investigate the hydrologic condition of the study area. The flow measurements for piped springs were carried out using the volumetric method while stream flow measurements were estimated by both float method and with the use of a flow meter. The specific locations of all the stations in latitude-longitude coordinates were observed using a GPS instrument.
- **Determination of current water users:** Reference was made to water permit records available from the National Water Resources Board (NWRB).
- **Water availability and dependability analysis:** Reference was made to daily streamflow data of the DPWH-Sabo Engineering from year 1992 to 2002.
- **Water balance study:** A monthly water balance model was utilized to estimate the actual evapotranspiration (losses), direct runoff, and the groundwater recharge of the Wawa River Basin.
- **Proof of coordination:** A coordination between DPWH and WawaJVCo was conducted on 2018 to obtain support from the said government agency for the Upper Wawa Dam Project (**Annex G)**

2.1.3 Existing Conditions

2.1.3.1 Hydrological Setting and Drainage System

The proposed Upper Wawa Dam Project and the catchment of the dam will be in the City of Antipolo and Municipalities of Rodriguez and San Mateo, Rizal. The Project concept is to utilize Wawa River as a bulk water source by constructing a reservoir along the river and delivering water to the Metropolitan Waterworks and Sewerage System (MWSS) for distribution to their service areas. The center of the Upper Wawa Dam is approximately located at 14° 42' 3.25"N and 121° 12' 7.38" E and is about 4km distance upstream of the existing Wawa Dam. It will use a 80-meter high dam with a storage capacity of 101.7 million cubic meters (MCM) for water supply. Raw water from the dam will be pumped to the Calawis Water Treatment Plant located at 14° 42' 11.78"N and 121°14'46.61"E which will be developed by Manila Water. The Project has a proposed flood control component that can hold 43.7MCM of flood water.

As shown in **Figure EW-1**, majority of the infrastructures is within the drainage area of Wawa River. The Upper Wawa Dam has an estimated catchment of 242km^2. The Project concept is to utilize Wawa River as a bulk water source by constructing a reservoir along the river and delivering water to the Metropolitan Waterworks and Sewerage System (MWSS) for distribution to their service areas. Additionally, the Upper Wawa Dam project has a flood control component to mitigate flooding at the downstream areas of Wawa River.

Wawa River Basin

Wawa River is composed of 280 km^2 of drainage area and a dendritic river system with around 45km of main river that stretches from the peak of Mt. Palagyo to the confluence located in Balite, Rodriguez, Rizal. It is one of the major tributaries of Marikina River. The highest elevations (above 1000 but less than 1500 masl) of the watershed can be found in the ridges of the basin where the headwaters are located and in the portions of the Sierra Madre Mountains. The lower elevations are in the downstream near the confluence in Balite, Rodriguez, Rizal and in the urban areas of the basin. **Figure EW-1** depicts the topographic map of the drainage area of Wawa River and majority of the infrastructure is within the drainage area of the wawa river basin.

The Upper Wawa Dam will be located along Wawa River approximately 4km upstream of the existing Wawa Dam. Delineation of the Upper Wawa Dam catchment using 1:50,000 NAMRIA topographic maps is shown in **Figure EW-2**

The watershed receives an average annual rainfall of approximately 2500 mm and exhibits a Type I climate based on the Modified Coronas Climate Classification System. The area has a pronounced dry period in the first four months of the year and a wet period occurring from June to October. May, November and December are season transition months. (This is further discussed in the section **5.0 Air and Noise Module**).

2.1.3.2 Watershed Delineation and Characterization of Basin Parameters

In delineating the Wawa river basin four (4) sheets of 1:50,000-scale topographic maps were obtained from NAMRIA and assembled electronically to cover the entire study area. The collated maps include Quezon City, Angat, Baras and Mt. Irid.

The catchment of the Upper Wawa Dam is measured at approximately 242km^2 which is subdivided into 28 sub-basins. **Figure EW-3** shows the delineated catchment sub-divided into several hydrologic units (sub-basins, main reaches, and main tributaries) while the generated slope map of the Wawa River catchment using the STRM-DEM 90m x 90m resolution data as also discussed in the **1.0 Land Module** section (**Figure EL-16)**. The figure shows that majority of the Wawa River catchment has steep slopes.

Table EW-1 presents the summary of the hydrologic parameters (drainage area, river length, river slope, accumulated drainage area).

Table EW-1
Summary of Hydrologic Parameters

Sub-basin	Catchment Area, km^2	River Length, km	River Slope
SB 1	12.58	5.29	0.168
SB 2	13.48	7.24	0.014
SB 3	12.77	3.90	0.020
SB 4	13.34	11.57	0.007
SB 5	6.10	6.90	0.183
SB 6	2.72	1.75	0.011
SB 7	17.96	11.64	0.114
SB 8	4.42	3.82	0.012
SB 9	4.80	4.07	0.010
SB 10	0.21	0.49	0.010
SB 11	15.39	7.90	0.015
SB 12	1.70	1.54	0.045
SB 13	10.76	5.48	0.051
SB 14	2.21	1.17	0.004
SB 15	8.96	4.90	0.013
SB 16	2.37	3.57	0.010

Sub-basin	Catchment Area, km^2	River Length, km	River Slope
SB 17	6.44	5.54	0.088
SB 18	3.70	2.83	0.183
SB 19	5.95	2.87	0.035
SB 20	7.28	7.36	0.008
SB 21	4.66	4.00	0.099
SB 22	13.44	5.75	0.070
SB 23	9.39	6.63	0.117
SB 24	18.77	12.17	0.005
SB 25	13.77	12.12	0.065
SB 26	4.27	2.21	0.009
SB 27	16.65	8.49	0.058
SB 28	7.82	7.68	0.027
Total	**241.89**		

2.1.3.3 Hydrogeological Setting and Identification of Aquifer

The Wawa River Basin is part of the Southern Sierra Madre geological province of Luzon. The area is generally rugged to mountainous. The region is affected by active geologic structures such as the Philippine Fault, the Philippine Trench and the Manila Trench, all of which are main sources of earthquakes. The nearest active fault is the West Valley Fault of Marikina. This fault has moved in historic times unlike the Philippine Fault, the Manila Trench, and the Philippine Trench. (**Figure EW-4**).

The project area is generally underlain by different rock formations consisting of various rock types such as gabbro, diorite, pillow basalt, sandstone, shale, conglomerate and volcanic pyroclastics which are covered by alluvium in river courses and valleys. The general characteristics and rock types of the different formations from oldest to youngest age and emplacement are described below. The disposition of these rock formations is presented in the General Geologic Map of Boso Boso River Basin in **Figure EW-5**. The general lithologic description is based on the General Geology and Mineral Resources of the Philippines, Volume 1-2004 by MGB. These and the succeeding information are furthermore discussed in the **1.0 Land Module** section.

The study area, based on the Regional Hydrogeological Map or Groundwater Availability Map in **Figure EW-6** is located in a local groundwater region underlain by impermeable rocks generally without significant groundwater, except in residuum, sufficiently leached and/or fractured zone. There were limited number of deep wells in the study area and a number of springs which are manifestations of aquifers.

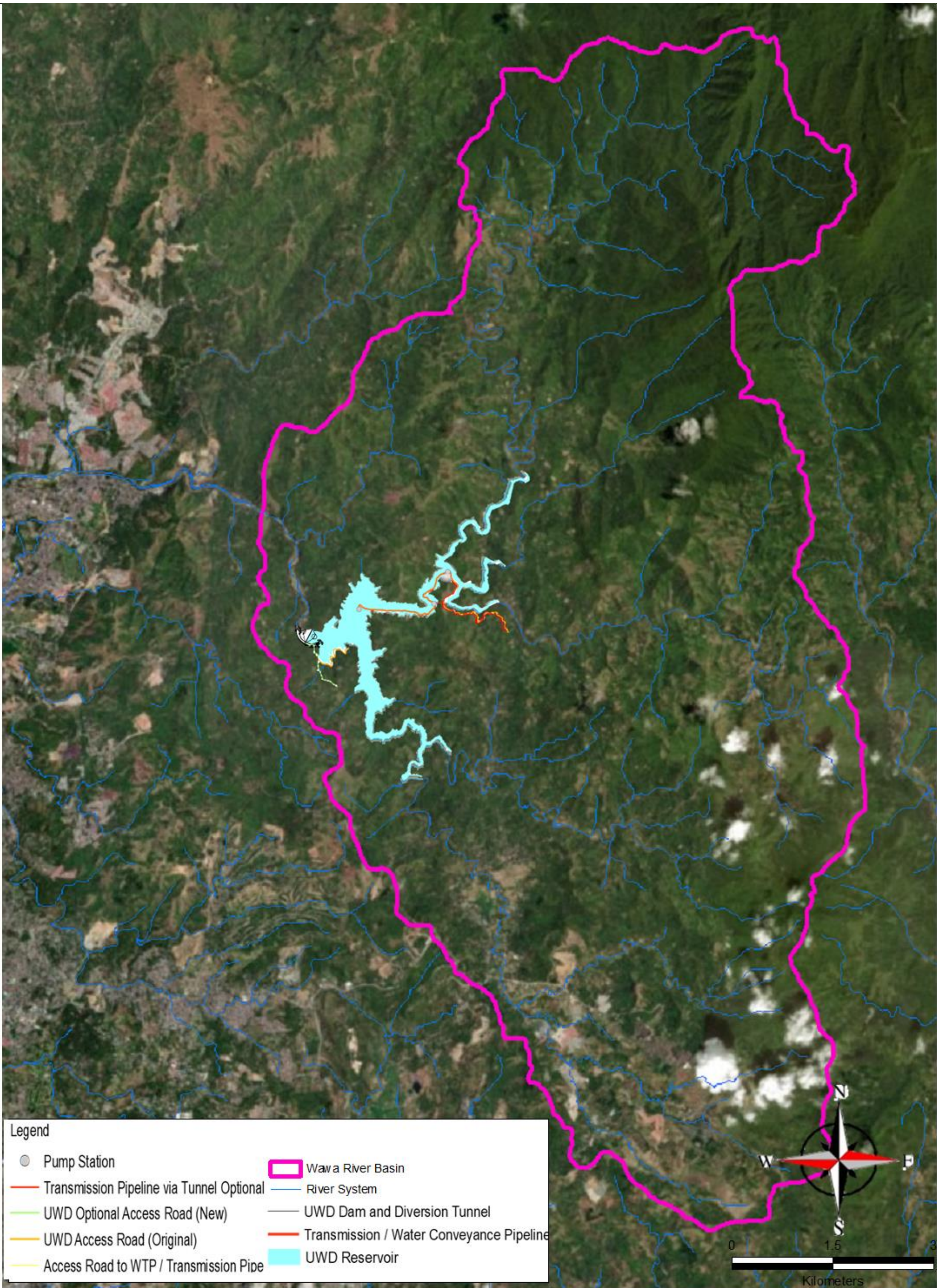


Figure EW-1 Wawa River Basin

ENVIRONMENTAL IMPACT STATEMENT
WATER MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

DATA INFORMATION/SOURCE:

Project Components: WawaJVCo, INC. (2020)
Basemap: ArcGIS Imagery, 2020
Created by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.
aperçu CONSULTANTS INC.

SCALE: 1: 110,000

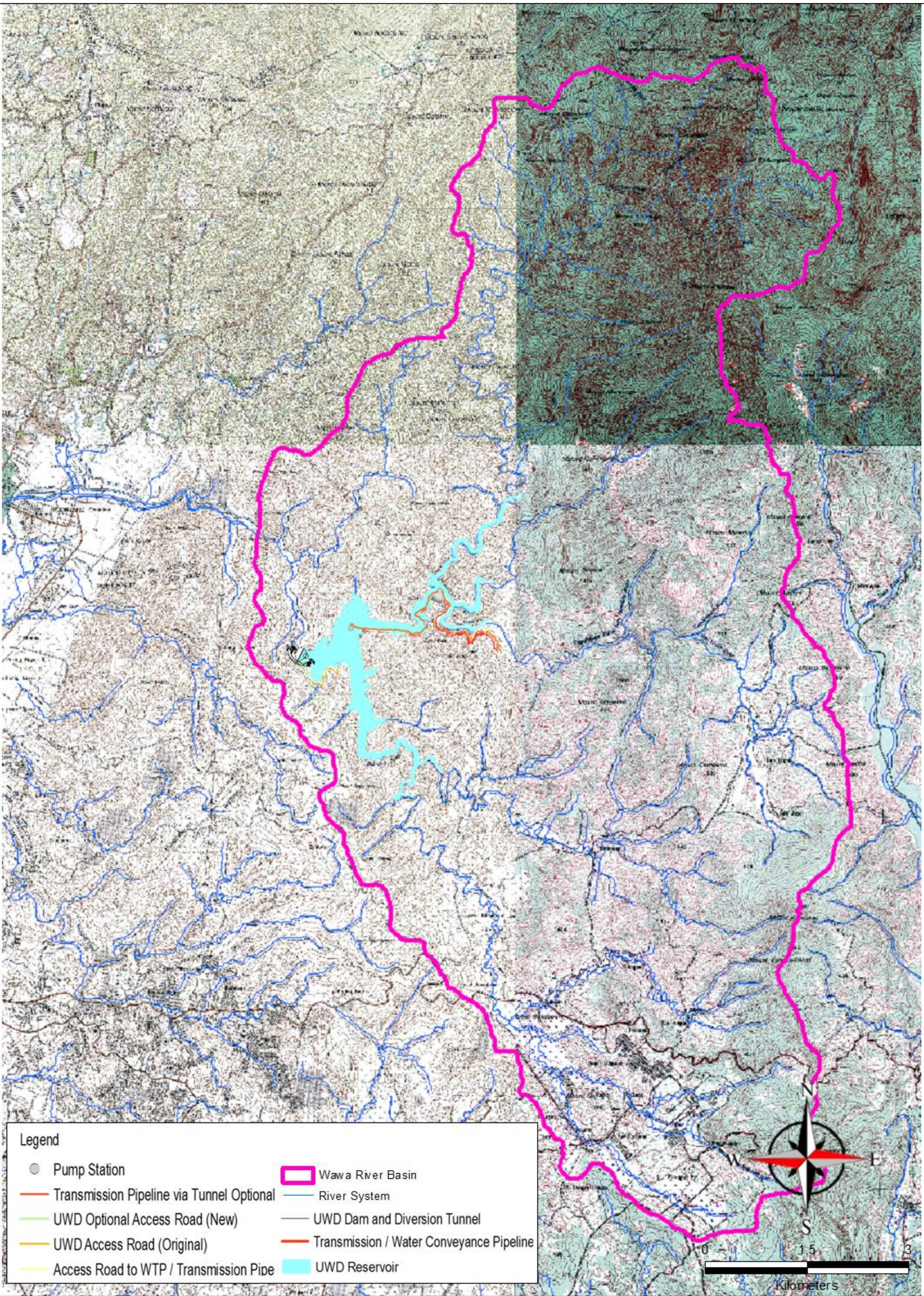


Figure EW-2. NAMRIA Topographic Map of the Wawa River Basin

ENVIRONMENTAL IMPACT STATEMENT
WATER MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

DATA INFORMATION/SOURCE:
Project Components: WawaJVCo, INC. (2020)
Basemap: NAMRIA Topographic Sheets:
3230-III: Quezon City
3230-IV: Angat
7272-II: Baras
7272-I: Mountlrid
Created by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.
aperçu CONSULTANTS INC.

SCALE: 1: 110,000

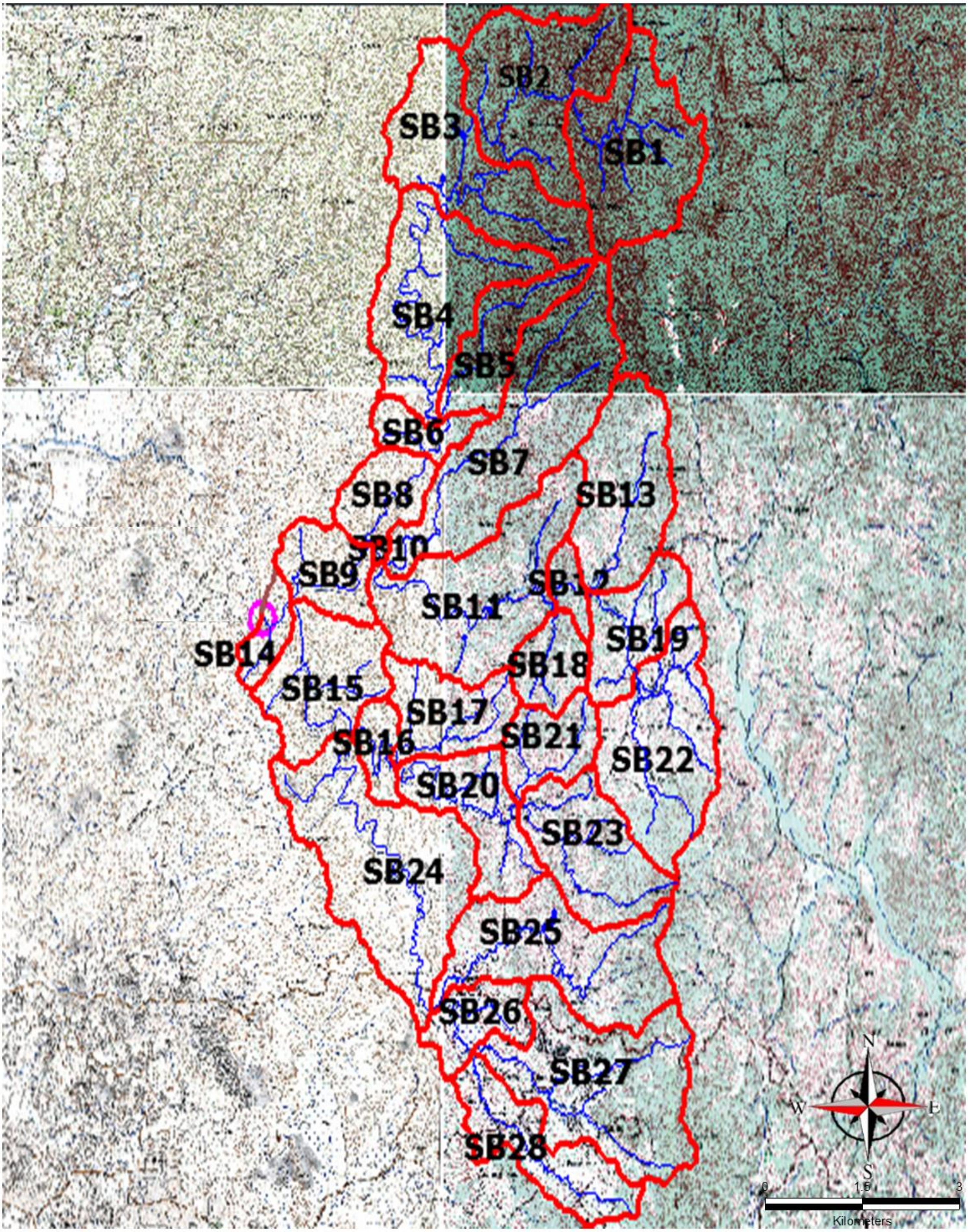


Figure EW-3. Wawa River Catchment Divided Into Sub-Basins	**DATA INFORMATION/SOURCE:** **Basemap:** NAMRIA Topographic Sheets: 3230-III: Quezon City 3230-IV: Angat 7272-II: Baras 7272-I: Mountlrid **Created by:** APERCU CONSULTANTS, INC (2020)	**WawaJVCo INC.** aperçu CONSULTANTS INC.
ENVIRONMENTAL IMPACT STATEMENT **WATER MODULE** **Wawa Bulk Water Supply Project – Upper Wawa Dam**		**SCALE: 1: 110,000** **PAGE: 207**

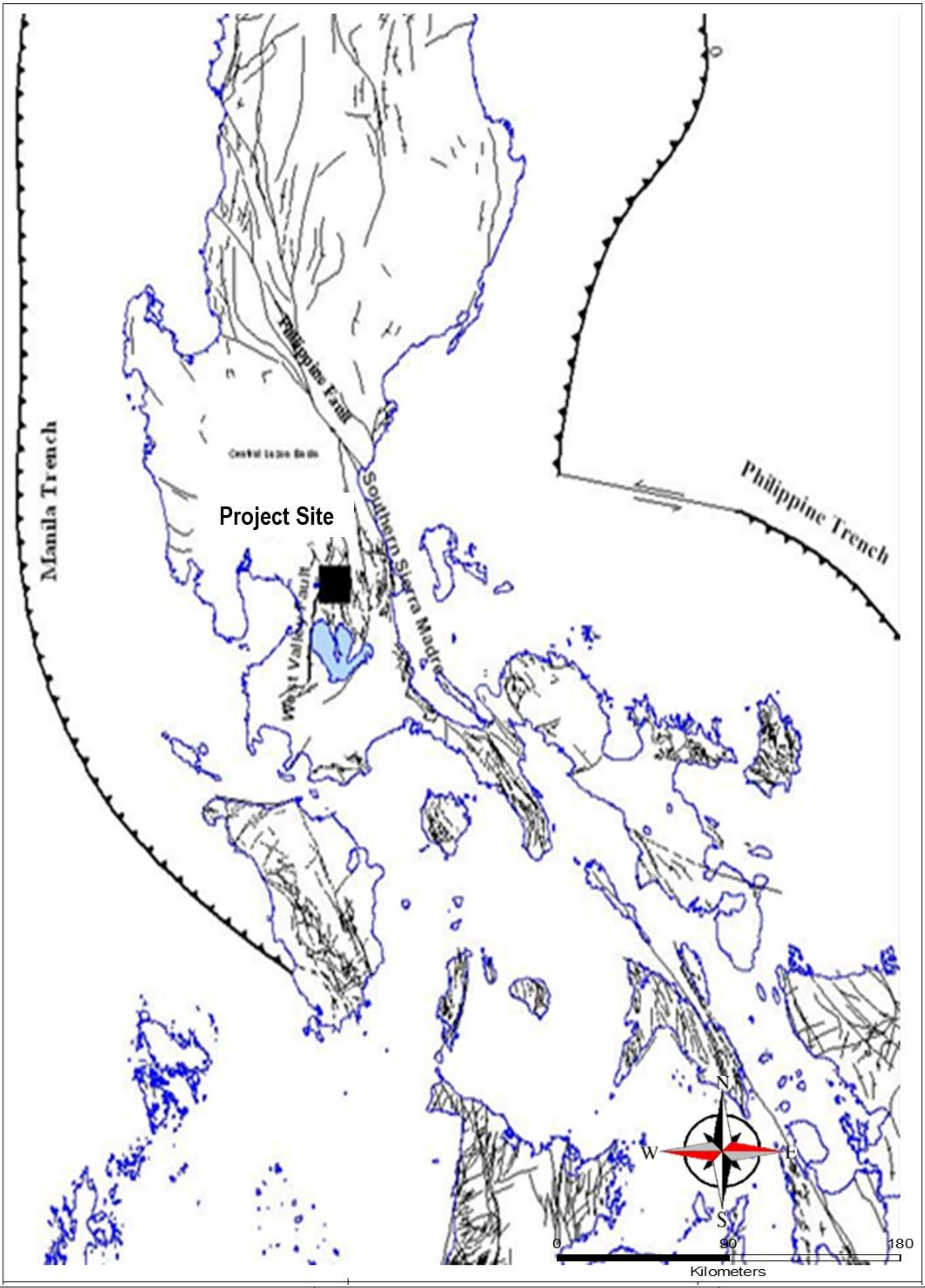


Figure EW-4. Tectonic Map of Luzon showing Earthquake Generating Faults and Geologic Structures

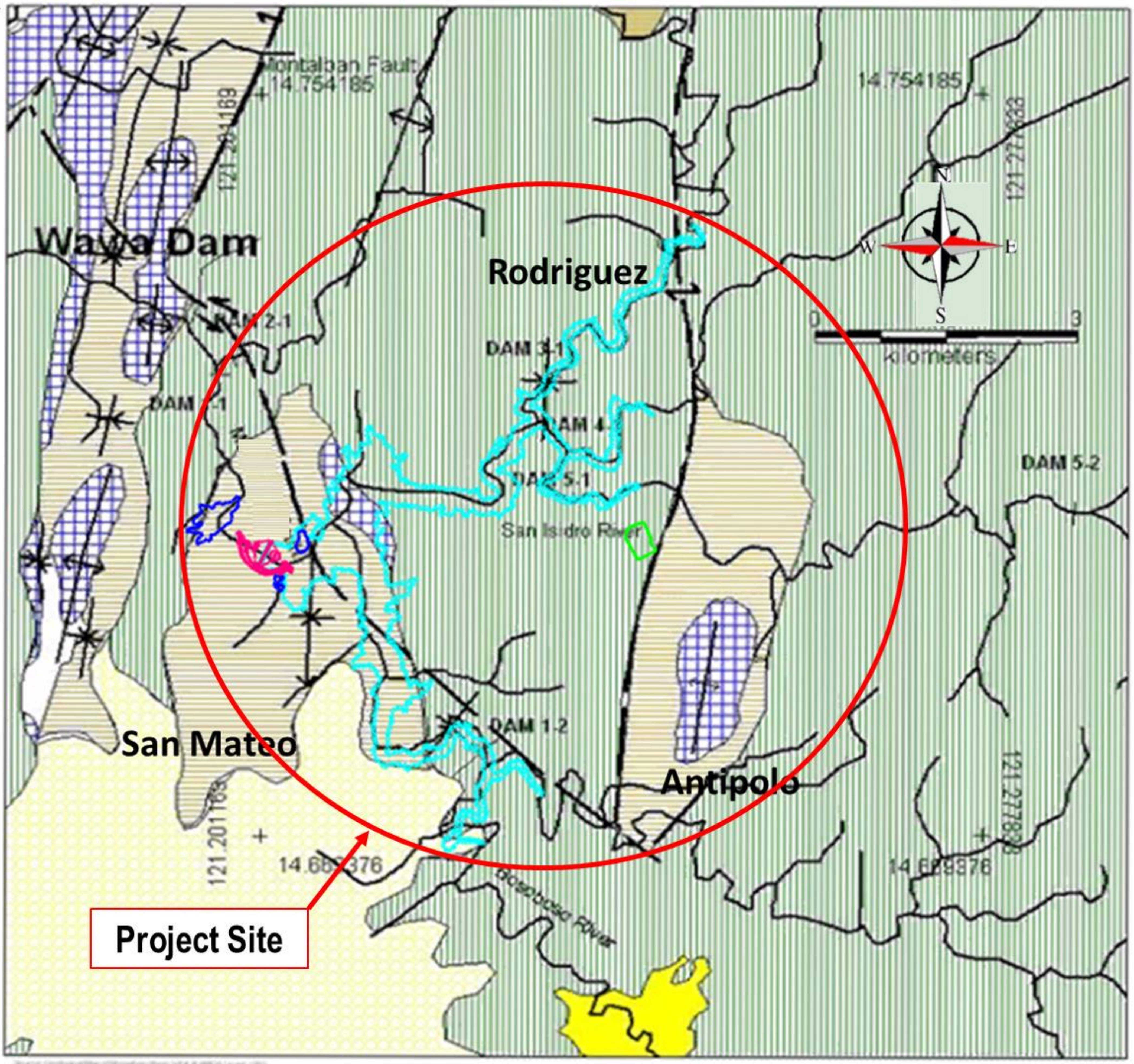
ENVIRONMENTAL IMPACT STATEMENT
WATER MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

DATA INFORMATION/SOURCE:

Source Map: PHIVOLCS
Modified by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.
aperçu CONSULTANTS INC.

SCALE: 1: 2,000,000



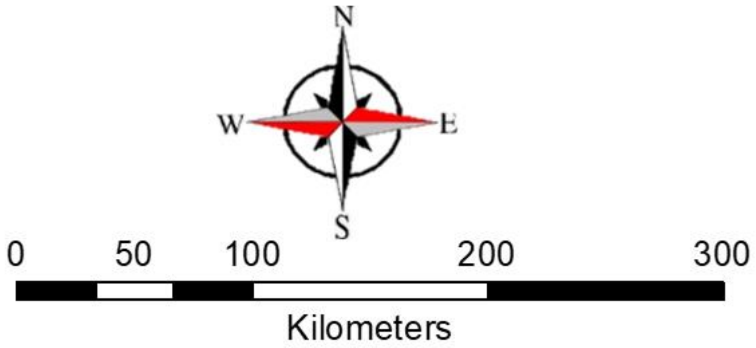
GENERAL GEOLOGIC MAP OF BOSOBOSO RIVER BASIN

Legend:

Explanation Stratigraphy

- Quantenary/ Alluvium
  Sand, Silt, Clay and Gravel
- Guadalupe Formation (Pleistocene)
  Tuff, Welded Tuff, Conglomerate
- Madlum Formation (Middle Miocene)
  Limestone, Volcanic, Sandstone and Shale
- Angat Formation (Early Miocene)
  Limestone, Sandstones, Conglomerate
- Montalban Ophiolite Complex (Cretaceous)
  Gabbro, Sheet Diabase Dike, Pillow Lavas, Turbine Sediments
- Formation Boundary
- Fault (U – Upward Block, D – Downward Block)
- Anticline
- Syncline

Figure EW-5 Geologic Map of Boso Boso River Basin	**DATA INFORMATION/SOURCE:**	WawaJVCo INC. aperçu CONSULTANTS INC.
ENVIRONMENTAL IMPACT STATEMENT WATER MODULE Wawa Bulk Water Supply Project – Upper Wawa Dam	**Project Components:** WawaJVCo, INC. (2020) **Source Map:** PHIVOLCS **Modified by:** APERCU CONSULTANTS, INC (2020)	SCALE: 1: 35,000



LEGEND:

I. ROCKS IN WHICH FLOW IS DOMINANTLY INTERGRANULAR

- (A) EXTENSIVE AND HIGHLY PRODUCTIVE AQUIFERS
- (B) FAIRLY EXTENSIVE AND PRODUCTIVE AQUIFERS
- (C) LOCAL AND LESS PRODUCTIVE AQUIFERS

II. ROCKS IN WHICH FLOW IS DOMINANTLY THROUGH FRACTURES AND/OR SOLUTION OPENINGS

- (A) FAIRLY EXTENSIVE AND PRODUCTIVE AQUIFERS WITH HIGH POTENTIAL RECHARGE
- (B) FAIRLY TO LESS EXTENSIVE AND PRODUCTIVE AQUIFERS WITH LOW TO MODERATE POTENTIAL RECHARGE

III. LOCAL GROUNDWATER REGIONS UNDERLAIN BY IMPERMEABLE ROCKS GENERALLY WITHOUT SIGNIFICANT GROUNDWATER EXCEPT IN, SUFFICIENTLY LEACHED AND/OR FRACTURED ZONE

- (A) ROCKS WITH LIMITED POTENTIAL, LOW TO MODERATE PERMEABLITY
- (B) ROCKS WITHOUT ANY KNOWN SIGNIFICANT GROUNDWATER OBTAINABLE THROUGH DRILLED WELLS LARGELY UNTESTED

Figure EW-6. Regional Hydrogeologic Map (Groundwater Availability Map)

ENVIRONMENTAL IMPACT STATEMENT
WATER MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

DATA INFORMATION/SOURCE:

Project Components: WawaJVCo, INC. (2020)
Basemap: ArcGIS Imagery, 2020
Created by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.
aperçu CONSULTANTS INC.

SCALE: 1:3,500,000

2.1.3.4 Rainfall and Streamflow Records

In this study, secondary rainfall and climatologic data of the relevant synoptic/rainfall stations are acquired from Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA). Rainfall data was also obtained from the Effective Flood Control Operations System (EFCOS) under the Department of Public Works and Highways (DPWH). Streamflow data was retrieved from the Philippine Water Data Summary (1980) published by the National Water Resources Council (now National Water Resources Board or NWRB). Most recent streamflow observations were obtained from the DPWH – Bureau of Research and Standards (BRS). A consultation with NWRB provided a data of Marikina River dating back to 1874 and this was used in the formulation of the agency's historical Flow Duration Curve.

Table EW-2 presents the gauging stations for rainfall and streamflow data that were used in this study while **Figure EW-7** exhibits the location of these rainfall and streamflow gauging stations. **Tables EW-3**, **EW-4**, **EW-5**, and **EW-6** present the average monthly rainfall values for Tanay, Boso Boso, Mt. Oro and Mt. Campana rainfall stations, respectively while **Table EW-7** and **Table EW-8** present the average monthly streamflow records for the Marikina River gauging station, which were monitored by the DPWH-BRS and by the DPWH-Sabo Engineering, respectively. The DPWH-Sabo Engineering data was used in the analysis since it is the most recent and provides data on a daily basis. It will be noted that the rainfall gauging station of Mt. Campana is situated slightly within the borders of the easternmost part of the catchment while the Boso Boso rainfall station is in close proximity to the Upper Wawa Dam.

The average annual rainfall values for the Tanay Station is 2,576.8 mm, 1,956.6mm for the Boso Boso station, 2,735.9mm for the Mt Oro station and 2,699.5mm for the Mt. Campana station.

Table EW-2
Summary of Rainfall and Streamflow Gauging Stations and Data Availability

Station Name	Location (Rizal)	Agency	Latitude	Longitude	Period of Record		No. of Years with Data	Data Available
					From	To		
Rainfall								
Tanay	Tanay	PAGASA	14°34'53.22"	121°22'09.30"	1999	2014	16	Monthly
Boso Boso	Antipolo	PAGASA	14°38'30"	121°14'18"	1976	2014	39	Monthly
Mt. Campana	Antipolo	EFCOS-DPWH	14°40'00"	121°18'00"	2003	2006	4	Monthly
Mt. Oro	Rodriguez	EFCOS-DPWH	14°45'30"	121°09'30"	1994	2006	13	Daily/Monthly
Streamflow								
Marikina River	Rodriguez	BRS-DPWH	14°44'00"	121°10'00"	1956	1969	14	Monthly
Marikina River	Rodriguez	BRS-DPWH	14°44'00"	121°10'00"	1971	1979	9	Monthly
Marikina River	Rodriguez	DPWH-Sabo Engineering	14°44'00"	121°10'00"	1992	2002	10	Daily

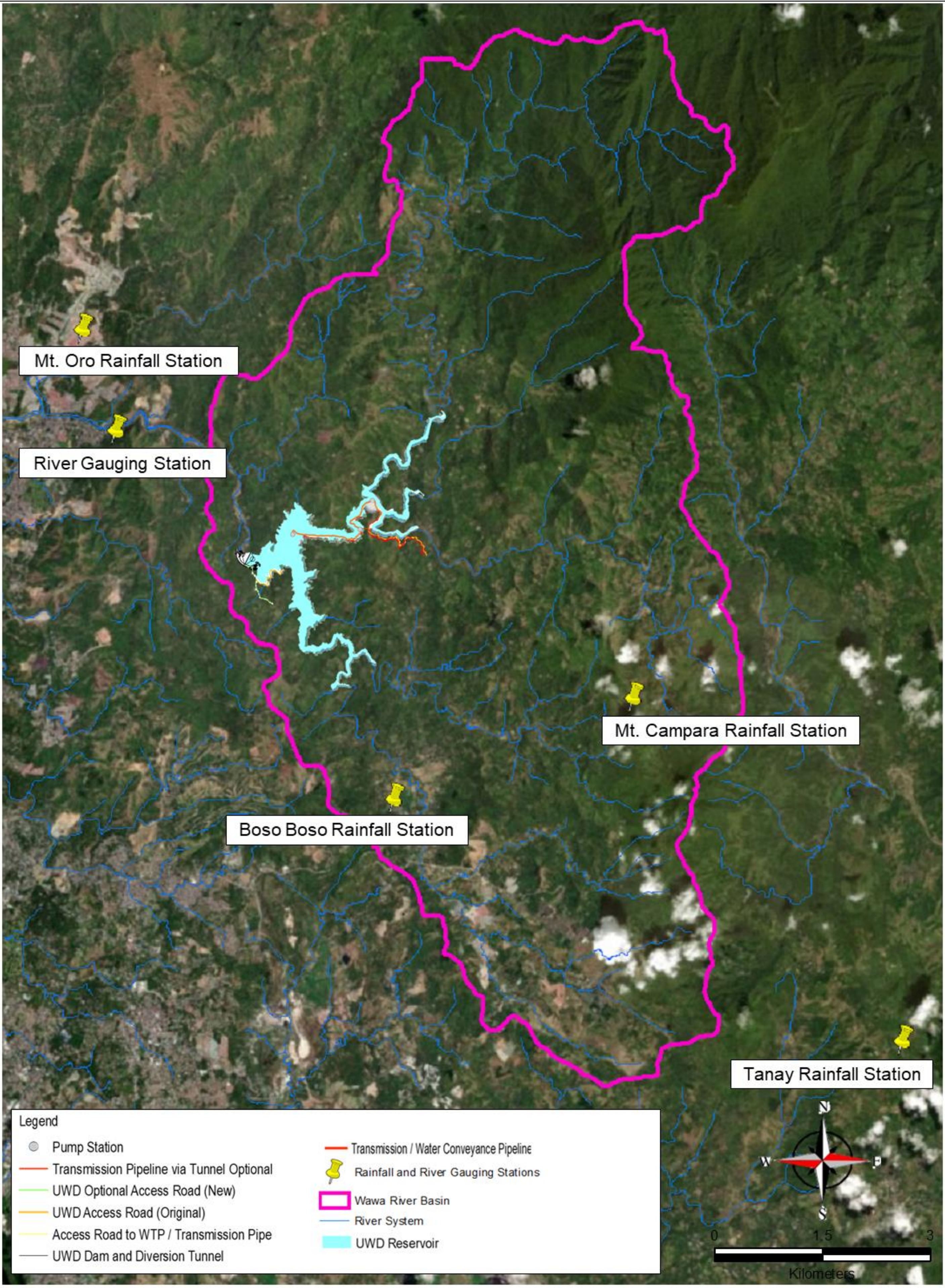


Figure EW-7 - Location of Rainfall and Streamflow Gauging Stations	**DATA INFORMATION/SOURCE:** **Project Components:** WawaJVCo, INC. (2020) **Basemap:** ArcGIS Imagery, 2020 **Created by:** APERCU CONSULTANTS, INC (2020)	**WawaJVCo INC.** aperçu CONSULTANTS INC.
ENVIRONMENTAL IMPACT STATEMENT **WATER MODULE** **Wawa Bulk Water Supply Project – Upper Wawa Dam**		**SCALE: 1: 125,000** — **PAGE: 212**

Table EW-3
Monthly and Annual Rainfall (mm) at Tanay Gauging Station

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1999										367.1	371.9	394.3	1133.3
2000	104.4	135.7	96.3	31	302.2	127.2	852.2	327.8	366	461.7	375.8	375.8	3556.1
2001	15.6	152.9	53.7	78.6	262.9	127.1	442.2	611.3	294.9	235.4	210.8	237.1	2722.5
2002	32.6	60	68.6	27.2	77.3	68	957.5	417.3	464	113.9	372.6	85.5	2744.5
2003	14.5	19.3	18.6	20.1				294.1	469	56.5	186.7	21.6	1100.4
2004	14.6	57.2	6.8	4.2	135.8	281.2				171.8	189.5	174.7	1035.8
2005		33.8			130.9	293.5	267.3	440.8	546.7	305.8			2018.8
2006	107.9	36.9		0	142.5	125.2	671.2	205.2	387	169.2	183.5	145.4	2174.0
2007	42.3	12.6	35.6	19.2	86.1	202.7	187.1	720.7	387.9	292.7	358.5	209.3	2554.7
2008	148.7	77.3	1	59.3	364.2	306.2	373.4	392.8	541.9	368.4	337.8	256.1	3227.1
2009	101.3	44	58.5	307.1	316.7	530.8	655.6	476.6	1076	562.1	118.9	32.2	4279.8
2010	40.4	2.4	17.2	24.6	61.4	132.2	317.7	311.1	223	244.8	311.5	189.9	1876.2
2011	128	12.2	137.3	25.9	243	570.6	304.5	455.2	516.8	228.7	364.1	355.1	3341.4
2012	98.2	174.9	155.6	9.4	232.3	326.9	847.4	1035.8	520.6	292.6	60.4	152.4	3906.5
2013	98.8	153.7	27.1	7	114.6	386.5	263.8	714.9	582.7	236.7	385.9	64.4	3036.1
2014	11.9	4.8	39.8	3.4	46.0	276.9	518.6	312.7	631.7	292.8	117.6	265.8	2522.0
Mean	68.5	65.2	55.1	44.1	179.7	268.2	512.2	479.7	500.6	275.0	263.0	197.3	2576.8
Std. Dev.	48.3	59.9	48.5	78.8	104.7	152.7	258.9	222.4	200.9	126.0	114.1	119.2	983.2
Min	11.9	2.4	1.0	0.0	46.0	68.0	187.1	205.2	223.0	56.5	60.4	21.6	1035.8
Max	148.7	174.9	155.6	307.1	364.2	570.6	957.5	1035.8	1076.0	562.1	385.9	394.3	4279.8

Table EW-4
Monthly and Annual Rainfall (mm) at Boso Boso Gauging Station

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1976			0	0.7	20.5	42.1	53.6	103.8	86.8	19.1	19.3	30	375.9
1977	20.2	17.8	1	0	6.5	11.6	24	20.9	28.7	8.3	3.9	1.6	144.5
1978	1.9	0.8	0	1.8	18.6	12.1	53.6	60.2	81.5	104.2	7.3	11.4	353.4
1979	0	0	0	2.3	36.1	29.8	62.8	48.9	36.8	47.2	6.7	0	270.6
1980	0	0	7.4	0	8.9	13	50.2	21.4	50.5	35.8	29.8		217
1981	0	0	0	1	6.3	51.6	76.1	30.5	54.8	60.7	68.3	21.6	370.9
1982	0	0	2	2	18.2	50.5	112	135.3	110.3	27.2	14.1	2.3	473.9
1983	15.2	0.5	0	0	6.4	14.5	34.2	63.2	32	24.1	0	0	190.1
1984	0	0	0	55.7	88.6	776.3	198.9	1667.8	495.5	513.1	50.4	0	3846.3
1985	0.1	0.1	0	12.4	15.5	282.9	169.9	318.6	444.7	560.7	5.9	9.1	1819.9
1986	0	15.5	0	2	25.6	90.6	414.1	883.7	797.2	492.7	152.1	129	3002.5
1987	0	0	0	15.6	49.9	251.3	51.5	443.8	288	138.6	112.1	42.5	1393.3
1988	25.3	0	0.1	2.3	94.3	459.5	346.8	198.5	278.6	728.2	226.4	0	2360
1989	0	40	88.9	65	191	275.5	373.8	584.9	314.4	219.8	49.6	0	2202.9
1990	0.1	0	0	0	216.3	385.7	435.9	592.3	407.4	261.6	173.9	16.6	2489.8
1991	0	0	0.1	7.5	35.2	234.6	649.8	1089.9	662.4	107.4	26.2	0	2813.1
1992	0	0	5	5.2	55.6	131.9	489.2	818.9	428.4	168.1	49.2	4.5	2156
1993	17.5	0	0	40	0	254.3	511.2	336	462.6	305.3	145.7	220.9	2293.5
1994	95.2	0	0	0.3	224.5	427.6	843.7	365.6	404.4	135.5	18.2	92.6	2607.6
1995	23	0	0	0	140.2	306.3	570.9	452.5	505.4	215.8	159.6	205.6	2579.3
1996	19	0	0	103.8	229.1	117.8	495.9	415.2	325.8	269.7	365.8	0	2342.1
1997	0	0	0	18.1	461.5	245.5	521.2	445.9	310	78.6	11.2	0	2092
1998	5.3	0	5.2	6	243.8	199.8	101.3	304.9	651.1	521.3	103.7	485.6	2628
1999	25	10	111.7	117.7	137.8	294.5	611.8	1037.3	541.1	379.4	143.4	252.5	3662.2

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2000	10.5	70.3	6.1	5.1	525.5	132.6	1177.7	435.8	340	535	290.2	134	3662.8
2001	76.1	83.3	41.1	101.0	234.1	248.7	742.0	823.9	304.4	91.1	152.4	35.1	2933.2
2002	0.0	0.0	7.1	0.0	45.0	120.2	1271.4	583.0	606.1	30.2	59.1	9.0	2731.1
2003	0.0	0.0	0.0	9.0	648.1	203.3	180.5	459.7	536.1	48.1	73.3	18.0	2176.1
2004	0.0	65.1	0.0	25.0	119.3	519.9	188.7	779.2	69.7	23.9	138.4	121.0	2050.2
2005	0.0	0.0	15.0	0.0	80.3	246.3	185.3	323.4	552.2	355.2	75.2	98.6	1931.5
2006	65.2	0.0	14.1	0.0	22.0	50.2	703.5	173.3	190.4	150.0	79.0	45.0	1492.7
2007	0.0	0.0	0.0	0.0	82.0	94.0	215.0	397.0	472.0	520.0	132.0	38.0	1950
2008	39.1	15.0	0.0	27.0	381.0	228.0	370.0	458.8	546.8	257.3	198.8	43.3	2565.1
2009	25.9	9.2	17.5	188.7	0.0	0.0	605.6	0.0	589.0	251.6	15.8	0.0	1703.3
2010		0.0	0.0	18.0	34.6	85.2	222.1	407.5	323.4	250.3	50.2	15.1	1406.4
2011	6.1	0.0		28.1	251.1	517.6	457.1	325.9	621.7	249.2	180.3	122.0	2759.1
2012	45.3	65.4	112.2	4.0	282.4	242.8	654.2	797.3	142.5	111.5	15.2	29.5	2502.3
2013		45.8	34.7	0.0	93.7	196.5	196.1	498.6	472.6	116.8	77.6	32.4	1764.8
2014	0.0	0.0	0.0	15.3	32.5	527.3	206.9	308.8	438.0	182.4	79.3	74.3	1864.8
Mean	14.3	11.5	12.3	22.6	132.4	214.7	375.1	441.3	359.1	220.4	91.3	61.6	1956.6
Std. Dev.	23.4	23.2	28.9	40.8	155.7	177.4	306.5	350.5	210.9	187.5	84.5	96.9	1016.3
Min	0.0	0.0	0.0	0.0	0.0	0.0	24.0	0.0	28.7	8.3	0.0	0.0	144.5
Max	95.2	83.3	112.2	188.7	648.1	776.3	1271.4	1667.8	797.2	728.2	365.8	485.6	3846.3

Table EW-5
Monthly and Annual Rainfall (mm) at Mt. Oro Gauging Station

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1994	59.0	18.0	15.0	18.0	159.0	405.0	653.0	264.0	310.0	260.0	17.0	97.0	2275.0
1995	14.0	0.0	0.0	1.0	211.0	280.0	632.0	101.0	167.0	194.0	168.0	168.0	1936.0
1996	41.0	0.0	6.0	182.0	204.0	123.0	439.0	299.0	448.0	283.0	217.0	42.0	2284.0
1997	0.0	26.0	0.0	60.0	440.0	246.0	296.0	528.0	285.0	67.0	11.0	11.0	1970.0
1998	14.0	0.0	0.0	31.0	207.0	142.0	248.0	320.0	602.0	436.0	147.0	461.0	2608.0
1999	68.0	2.0	140.0	130.0	318.0								658.0
2000	15.0	152.0	22.0	79.0	828.0	407.0	1163.0	56.0	355.0	463.0	244.0	191.0	3975.0
2001	81.0	51.0	67.0	57.0	264.0	375.0	642.0	727.0	222.0	181.0	111.0	87.0	2865.0
2002	26.0	14.0	27.0	3.0	168.0	157.0	951.0	434.0	536.0	186.0	234.0	46.0	2782.0
2003	1.0	1.0	13.0	5.0	590.0	210.0	269.0	409.0	536.0	39.0	97.0	15.0	2185.0
2004	4.0	42.0	5.0	9.0	201.0	248.0	302.0	667.0	278.0	199.0	300.0	104.0	2359.0
2005	0.0	1.0	41.0	21.0	188.0	387.0	418.0	404.0	430.0	327.0	60.0	137.0	2414.0
2006	101.0	3.0	77.0	0.0	146.0	114.0	861.0	465.0	428.0	216.0	120.0	40.0	2571.0
Mean	32.6	37.7	36.0	24.9	340.7	271.1	658.0	451.7	397.9	230.1	166.6	88.6	2735.9
Std. Dev.	41.3	54.3	27.2	30.9	263.3	118.8	345.9	217.3	120.6	132.7	91.1	61.5	595.9
Min	0.0	1.0	5.0	0.0	146.0	114.0	269.0	56.0	222.0	39.0	60.0	15.0	2185.0
Max	101.0	152.0	77.0	79.0	828.0	407.0	1163.0	727.0	536.0	463.0	300.0	191.0	3975.0

Table EW-6
Monthly and Annual Rainfall (mm) at Mt. Campana Gauging Station

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2003	8.0	11.0	31.0	49.0	661.0	190.0	299.0	329.0	567.0	58.0	144.0	32.0	2379.0
2004	9.0	53.0	4.0	19.0	145.0	326.0	292.0	912.0	222.0	160.0	385.0	148.0	2675.0
2005	4.0	525.0	49.0	59.0	146.0	494.0	362.0	460.0	627.0	304.0	122.0	193.0	3345.0
2006	92.0	11.0	46.0	0.0	204.0	134.0	714.0	324.0	448.0	204.0	105.0	117.0	2399.0
Mean	28.3	150.0	32.5	31.8	289.0	286.0	416.8	506.3	466.0	181.5	189.0	122.5	2699.5
Std. Dev.	42.6	250.8	20.6	27.1	249.5	160.4	200.7	277.7	178.9	102.0	131.6	67.9	451.0

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Min	4.0	11.0	4.0	0.0	145.0	134.0	292.0	324.0	222.0	58.0	105.0	32.0	2379.0
Max	92.0	525.0	49.0	59.0	661.0	494.0	714.0	912.0	627.0	304.0	385.0	193.0	3345.0

Table EW-7
Mean Monthly Streamflow (m³/s) at Marikina River Gauging Station (DPWH-BRS)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1956					2.64	1.58	1.34		197.60	16.92	13.45	35.02	38.3643
1957	8.90	2.95	1.43	0.91	0.70	2.98	19.67	65.37	45.89	24.88	12.56	2.00	15.6867
1958	0.72	0.34				12.29	74.61	19.10	71.42	21.30	7.07		25.86
1959	0.93											9.16	5.05
1960	6.23	2.71	0.48			19.08			36.07	57.88	6.70		18.45
1961								44.36	66.77	15.43			42.19
1962	1.22	0.67	0.27	0.16	0.20	5.39	63.32	39.68	59.66	11.77	10.99	4.03	16.45
1963	0.76	0.29	0.13	0.15	0.13	21.12	29.88	27.90	48.82	9.28	3.71	4.04	12.18
1964	1.30	0.48	0.45	0.29	1.22	17.17	26.16	91.56	52.30	20.53	26.12	33.95	22.63
1965	3.81	1.49	0.47	0.45	1.59	10.92	19.52	18.13	25.70	9.71	0.85	0.14	7.73
1966	0.05	0.04	0.03	0.03	7.83	5.04	11.91	12.00	46.82	6.46			9.02
1967	0.72	0.17	0.08	0.07	0.07	66.40	11.70	10.71	26.12	23.76	38.21	5.53	15.30
1968	5.23	5.10	5.56	6.00	6.57	4.95	48.47	164.90	41.10	31.20	0.84	0.42	26.70
1969	0.89	0.50	0.32	0.21	0.18		11.89	12.37	.		1.41	0.59	3.15
1970													
1972	0.70	0.01	0.01	0.00	0.17	23.57	147.44	156.68	88.04	5.75	4.73	5.56	36.06
1973			1.02	1.39	1.00	1.96	5.81	18.03	11.10	25.50	10.62	6.93	8.34
1974	2.98	1.45	1.09	0.96	1.69	9.58	17.50	84.38	2.94	29.60	50.38	7.72	17.52
1975	1.54	0.83	0.61	0.50	0.41	0.93	1.32	24.98	12.59	4.63	4.44	8.99	5.15
1976	1.72	0.68	0.45	0.31	60.88	27.06	15.26	6.46	13.72	1.41	0.80	0.62	10.78
1977	0.38	0.34	0.31	0.24	0.32	0.35	10.15	13.16	12.52	0.42	26.50	0.36	5.42
1978	0.53	0.35	0.17	0.11	0.20	0.74	1.39	29.66	12.58	39.96	2.18	0.44	7.36
1979	0.29	0.20	0.14	0.26	0.88	0.58	4.84	14.83	1.44	4.88	0.48	0.36	2.43
Mean	2.05	1.03	0.72	0.71	4.82	12.19	27.48	44.96	43.66	18.06	11.69	6.99	15.99
Std. Dev.	2.38	1.32	1.27	1.41	14.16	15.70	35.58	47.61	43.73	14.41	13.98	10.49	11.64

Table EW-8
Mean Monthly Streamflow (m³/s) at Marikina River Gauging Station (DPWH-Sabo Engineering)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1992				1.03	0.79	10.77	31.86	69.21	163.27	22.98	14.12	9.03	35.90
1993	5.20	2.99	1.95	1.41	1.25	9.26	31.49	37.36	32.24	24.28	29.95	44.83	18.52
1994	9.17	6.92	12.08	10.04	16.44	12.62		24.95	26.50	21.88	15.96	15.50	15.64
1995	13.06	9.30	12.19	10.58	14.10	16.23	26.89	18.76	19.70	96.87	54.11	16.86	25.72
1996	16.04	6.43	6.63	3.15	14.55	13.54	18.75	38.34	19.51	19.04	33.22	16.10	17.11
1997	12.57	13.82	12.82	13.72	14.83	23.00	25.68			17.15	16.62	14.89	16.51
1998	14.57	11.36	7.21	7.08	6.74		12.74	18.41	41.95	38.13	10.24	172.08	30.96
1999	8.52	6.53	8.06	9.52	14.10	18.61	39.21	30.72	16.14	15.16	14.18	14.19	16.25
2000	11.06	16.36	8.32	7.36	26.70	14.77	72.81	25.24	55.70	60.39	50.36	21.36	30.87
2001	7.15	1.43	2.31	2.37	28.35	17.24	44.97	83.77	32.27	18.56	24.10	16.50	23.25
2002	7.01	8.04	7.40	6.66	8.45	10.45	71.82	43.48					20.41
Mean	10.44	8.32	7.90	6.63	13.30	14.65	37.62	39.03	45.25	33.44	26.28	34.13	22.83
Std. Dev.	3.58	4.59	3.79	4.19	8.88	4.24	20.46	21.68	45.96	26.09	15.54	49.43	7.09

2.1.3.5 Spring and Well Point Inventory

Two seasons (wet and dry season) data gathering and field investigations were conducted in this study to: (1) identify the potential groundwater (springs and wells) and surface water (rivers and tributaries) sources, (2) determine the existing water use and water users of these sources, (3) estimate the available flows from these sources at the time of observation, (4) estimate the water consumption of the water users, and (5) investigate the hydrologic conditions of the study area.

Figure EW-8 shows the locations of the inventoried deep wells and springs and the location of the river stations where actual discharge measurements were measured. In addition, **Annex H** presents the photo highlights of the groundwater and surface water inventory.

Wet Season Sampling

The field investigations and data gathering were conducted on August 3-6, 2019. A total of three (3) springs and one (1) deep well were inventoried within the study area and actual discharge measurements were carried out in six (6) surface water (SW) stations. All stations and the inventoried groundwater sources are within the catchment. **Table EW-9** provides a summary listing of the inventoried groundwater and surface water sources while **Figure EW-11** shows the locations of the inventoried groundwater sources and the surface water stations where actual discharge measurements were taken.

Table EW-9
Wet Season Surface Water and Groundwater Inventory

Station No.	Latitude	Longitude	Type/ SWL	Estimated Flow (m^3/s)	Remarks and Photo Reference
SW1	14°40'7.08"N	121°14'4.68"E	River	3.606	Sampling was done in normal (wet) condition; Water was turbid.
SW2	14°39'47.46"N	121°13'24.96"E	River	34.29	t Sampling was done while raining; Water was very turbid.
SW3	14°43'36.06"N	121°14'28.62"E	River	44.47	Sampling was done in normal (wet) condition.
SW4	14°43'5.22"N	121°14'54.24"E	River	5.67	Sampling was done in normal (wet) condition; Large riverstones are evident.
SW5	14°42'17.39"N	121°12'42.88"E	River	30.18	Sampling was done in a windy (wet) condition with some rainpour.
SW6	14°42'11.15"N	121°12'40.84"E	River	16.85	Sampling was done in (wet) condition with some rain. Water was very turbid and had a bad odor.
GW1	14°39'25.56"N	121°13'54.42"E	Deep Well/ 30.5 m	0.15	Well is provided with EA150 pump (5-8 gpm capacity); Sampling was done while raining; Soil sediments were found in the sampled water.
GW2	14°42'33.48"N	121°14'50.82"E	Boxed Spring	1.06	Spring box of dimension L=3m x W=3m x H=1.5m; Used for cooking, washing, and bathing; Dries out during dry season and overflows during wet season; The source is a spring located upstream.
GW3	14°42'11.05"N	121°12'31.98"E	Open Spring	0.12	An open spring used for all necessities, including as a source of drinking water. Does not dry out even during dry season; Initially provided with a box/enclosure but was already destroyed; discharge observation is only partial.
GW4	14°42'34.73"N	121°12'45.03"E	Open Spring	0.017	An open spring; the flow was negligible during time of observation; the location of the spring water has a nearby stream.

From the groundwater and surface water inventory, it was observed that most of the groundwater sources within the basin are free flowing springs whose flows come from the fractured rocks in the mountains and eventually discharges into the river. This also indicates a major aquifer manifestation in the area. Stream flow measurements for surface water were conducted upstream of the proposed dam site.

The flow measurements for piped springs were carried out using the volumetric method while stream flow measurements were estimated using both the float method and a flow meter. The specific locations of all the stations in latitude-longitude coordinates were observed using a GPS instrument.

Dry Season Sampling

Dry season streamflow measurements and groundwater discharge measurements were carried out on November 15-16, 2019. Changes in river morphology and decreases in the sources' capacities were evident. There were instances where portions of riverbeds that were submerged during the wet season survey were already dry. Seven (7) surface water sources were inventoried, six of which were inventoried during the wet season. Streamflow was measured on the additional station established at the confluence of Montalban and Boso-Boso rivers to estimate the flow of a previous station at Montalban River (SW5) because the consultants were not permitted access to the location of SW5.

Table EW-10 lists the surface water and groundwater sources inventoried.

Table EW-10
Dry Season Surface Water and Groundwater inventory

Station No.	Latitude	Longitude	Type/ SWL	Estimated Flow (m^3/s)	Remarks and Photo Reference
SW1	14°40'7.08"N	121°14'4.68"E	River	0.375	Sampling was done at approximately 50 meters downstream of the station surveyed during the wet season since the flow was more stabilized. Water was clear.
SW2	14°39'47.46"N	121°13'24.96"E	River	1.57	Terrain of the sampling point was very irregular and the riverbed which was previously under water was dry. Water was slightly turbid.
SW3	14°43'36.06"N	121°14'28.62"E	River	1.35	A more stabilized flow was measured at approximately 100 meters downstream of the wet season station. Water was clear.
SW4	14°43'5.22"N	121°14'54.24"E	River	0.26	Measurement was done at approximately 200 meters upstream of the wet season sampling station where flow was more stabilized. Water was clear.
SW5	14°42'17.39"N	121°12'42.88"E	River	3.43	Streamflow in this station was not measured because the consultants were not allowed access the area. Rather, the flow was estimated using measurements done at SW 6 and SW7.
SW6	14°42'11.15"N	121°12'40.84"E	River	2.55	The middle portion of the riverbed which was previously underwater became visible and divided the river into two sections. Streamflow from both sections of the river were measured. Water was turbid.

Station No.	Latitude	Longitude	Type/ SWL	Estimated Flow (m^3/s)	Remarks and Photo Reference
SW7	14°42'11.48"N	121°12'34.31"E	River	5.98	Relatively higher streamflow than the other stations since the sampling point is the confluence of Montalban River and Boso-boso River. Water during the discharge measurement was turbid on one side (water from Boso-boso River) and clear on the other (water from Montalban River) side.
GW1	14°39'25.56"N	121°13'54.42"E	Deep Well/ 30.5 m	0.00015	The well was provided with an EA150 pump (5-8 gpm capacity). The pump was connected to a 2-inch pipe, from where the sampling was done. Water is not used for drinking.
GW2	14°42'33.48"N	121°14'50.82"E	Boxed Spring	0.00012	The spring is boxed. It was provided with two hoses for water delivery to nearby houses. Sampling was done only on one of the hoses to avoid interruption.
GW3	14°42'11.05"N	121°12'31.98"E	Open Spring	0.00017	Flow from the spring was approximated using dried banana leaf for water conveyance. Greater estimated flow than that of the wet season was observed due to the addition of conveyance.
GW4	14°42'34.73"N	121°12'45.03"E	Open Spring	N/A	The flow in this station was not measured because the consultants were not given access to the property. Since it is dry season, the estimated flow is minimum.
GW5	14°42'37.37"N	121°14'48.44"E	Deep Well/ 24.4 m	0.00014	The presence of the deepwell was only noted in November 2019 and was not surveyed during the wet season sampling. Water in the deep well is used for drinking and other domestic purposes. The well during dry period can still supply a little amount of groundwater. It does not dry out.

The table shows significant reductions in flow from the wet season values. All flows were expressed in cms. The streamflow in Station SW5 at Montalban River was estimated using the flows measured at Station SW6 in Boso Boso River which was subtracted from the measured flow at Station SW7 at the confluence of Montalban River and Boso Boso River. Another deepwell (Station GW5) was added to the sources identified. It was not located during the wet season inventory. Springs are manifestations of aquifers and they sourced at locations when the groundwater table or static water level intersects the ground surface. However, the static water levels for deepwells are included in the table.

2.1.3.6 Current and Major Water Users

Based on the records of the National Water Resources Board (NWRB), as of May 2019, 25 water permits were issued within the close proximity of the study area. The list is provided in **Table EW-11**. Of the 25 grantees, 6 grantees draw water from surface sources, two of them indicated the same source of extraction. The remaining 19 grantees draw water from groundwater sources, 8 from deepwell sources and eleven (11) from springs. As shown in **Figure EW-9**, there are sources which are within the catchment of the Upper Wawa Dam.

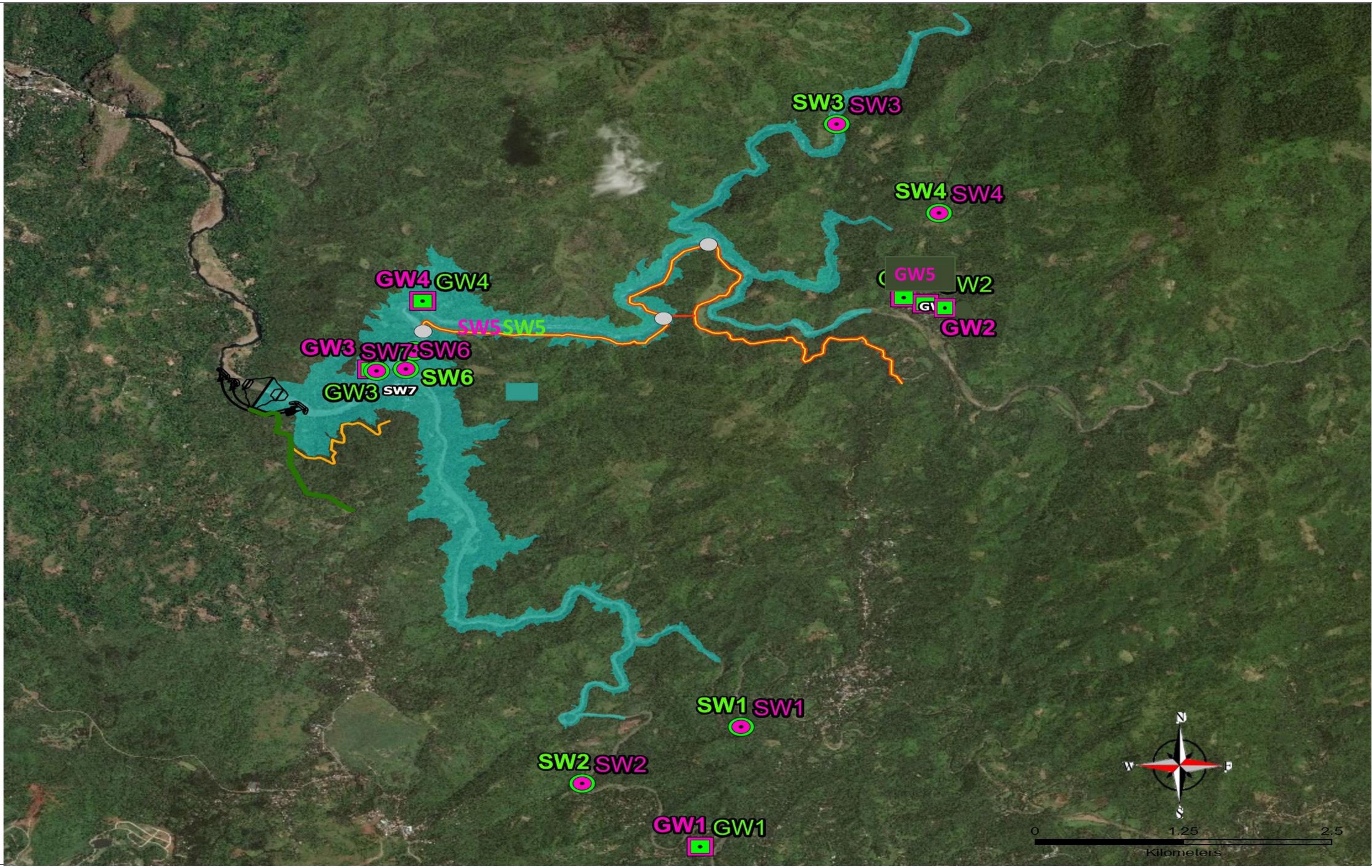


Figure EW-8. Spring and Well Inventory Stations	Legend	DATA INFORMATION/SOURCE:	WawaJVCo INC. apercu CONSULTANTS INC.
ENVIRONMENTAL IMPACT STATEMENT WATER MODULE Wawa Bulk Water Supply Project – Upper Wawa Dam	Pump Station Transmission Pipeline via Tunnel Optional UWD Optional Access Road (New) UWD Access Road (Original) Access Road to WTP / Transmission Pipe UWD Dam and Diversion Tunnel Transmission / Water Conveyance Pipeline UWD Reservoir Wet - SW Stations Wet - Spring/ Well Stations Dry - SW Stations Dry - Spring/ Well Stations	**Project Components:** WawaJVCo, INC. (2020) Basemap: ArcGIS Imagery, 2020 **Created by:** APERCU CONSULTANTS, INC (2020)	SCALE: 1: 32,000 — PAGE: 219

Table EW-11
NWRB's Summary of Existing Water Permits within the Closest Proximity of the Watershed

No.	WPA	Grantee	Location	Source	Latitude	Longitude	Q (lps)	Purpose	Date App
1	006580	M.W.S.S.	MONTALBAN	WAWA R.	14-44-06	121-10-30	348.00	DOMESTIC	12/14/79
2	009368	G. MNGT. INC.	ANTIPOLO	UMAYAS S.	14-37-54	121-12-17	0.04	DOMESTIC	09/17/82
3	009369	G. MNGT. INC.	ANTIPOLO	KAY- SIPOT S.	14-38-03	121-12-24	0.04	DOMESTIC	09/17/82
4	009453	G. MNGT. INC.	ANTIPOLO	S. PALANAS S.	14-38-23	121-12-43	0.04	DOMESTIC	11/29/82
5	009591	BOSO-BOSO FIA	ANTIPOLO	SAPANG BAYAN CK.	14-37-59	121-13-55	66.00	IRRIGATION	07/15/83
6	010290	ESTATE DEV.	ANTIPOLO	SPRING	14-38-12	121-15-04	9.00	DOMESTIC	05/12/85
7	012768	LUBOG IRR. ASS., INC	RODRIGUEZ	MT. AYAAS DW#1	14-45-17	121-12-28	10.00	IRRIGATION	07/09/91
8	012769	LUBOG IRR. ASS., INC	RODRIGUEZ	MT. AYAAS DW #2	14-45-28	121-12-25	10.00	IRRIGATION	07/09/91
9	014941	EMMANUEL C. NACE	ANTIPOLO	NACE SPRING	14-37-42	121-12-26	8.00	DOMESTIC	11/10/95
10	016620	B. B. WATER SUPPLY	ANTIPOLO	UNNAMED SPRING	14-37-32	121-12-21	2.90	COMMERCIAL	12/14/98
11	016621	B. B. WATER SUPPLY	ANTIPOLO	UNNAMED SPRING	14-37-32	121-12-21	5.00	COMMERCIAL	12/14/98
12	016688	PHILJAS CORP.	ANTIPOLO	PUTING BATO SP.	14-37-38	121-12-25	2.52	DOMESTIC	02/08/99
13	016959	E. M. ARELLANO	ANTIPOLO	UNNAMED SPRING	14-37-38	121-13-29	0.29	DOMESTIC	07/22/99
14	018066	N.H.A.	ANTIPOLO	DEEPWELL	14-39-16	121-13-18	9.53	DOMESTIC	07/23/02
15	018067	N.H.A.	ANTIPOLO	DEEPWELL	14-39-00	121-13-54	11.67	DOMESTIC	07/23/02
16	018068	N.H.A.	ANTIPOLO	DEEPWELL	14-39-24	121-13-33	9.53	DOMESTIC	07/23/02
17	018069	N.H.A.	ANTIPOLO	DEEPWELL	14-39-18	121-13-10	6.94	DOMESTIC	07/23/02
18	018964	SAN LORENZO RUIZ	MONTALBAN	WAWA RIVER	14-43-45	121-11-17	3480.00	DOMESTIC	02/19/04
19	019018	MWSS	RODRIGUEZ	MARIKINA RIVER	14-43-45	121-11-17	580.00	MUNICIPAL	04/22/04
20	019101	DENR-DILG-DECS	CUYAMBAY	SPRING #5	14-37-39	121-18-51	14.18	MUNICIPAL	06/15/04
21	020577	J. E. ANGELES	ANTIPOLO	SPRING	14-37-22	121-13-10	5.40	COMMERCIAL	02/06/06
22	021104	FEMAR REALTY	ANTIPOLO	DEEPWELL	14-37-53	121-14-01	1.26	COMMERCIAL	02/27/07
23	021886	MWSS BY MWCI	ANTIPOLO	TAYABASAN RIVER	14-42-57.66	121-13-57.51	1004.02	MUNICIPAL	12/15/09
24	023942	DR. C. B. PAAT	ANTIPOLO	DEEPWELL	14-37-30.09	121-14-19.30	0.38	LIVESTOCK	10/27/16
25	021735	MWSS	MONTALBAN	WAWA RIVER	14-44-13.78	121-09-7.21	115.74	MUNICIPAL	06/18/09

There are three (3) existing surface water rights downstream of the proposed UWD Project. San Lorenzo Ruiz Builders (SLRB) and MWSS have water permits for the same source. Both were granted for domestic and municipal purposes. Downstream of the San Lorenzo Ruiz and MWSS sources are two other locations for the MWSS water permits for domestic and municipal purposes. Upstream of the proposed Upper Wawa Dam is another water right granted for water extraction at Tayabasan River while the remaining water permit for surface water use is in a creek upstream of the proposed project.

As shown in the **Figure EW-9**, seven (7) deep wells and one (1) spring within the catchment of the Upper Wawa Dam have water rights.

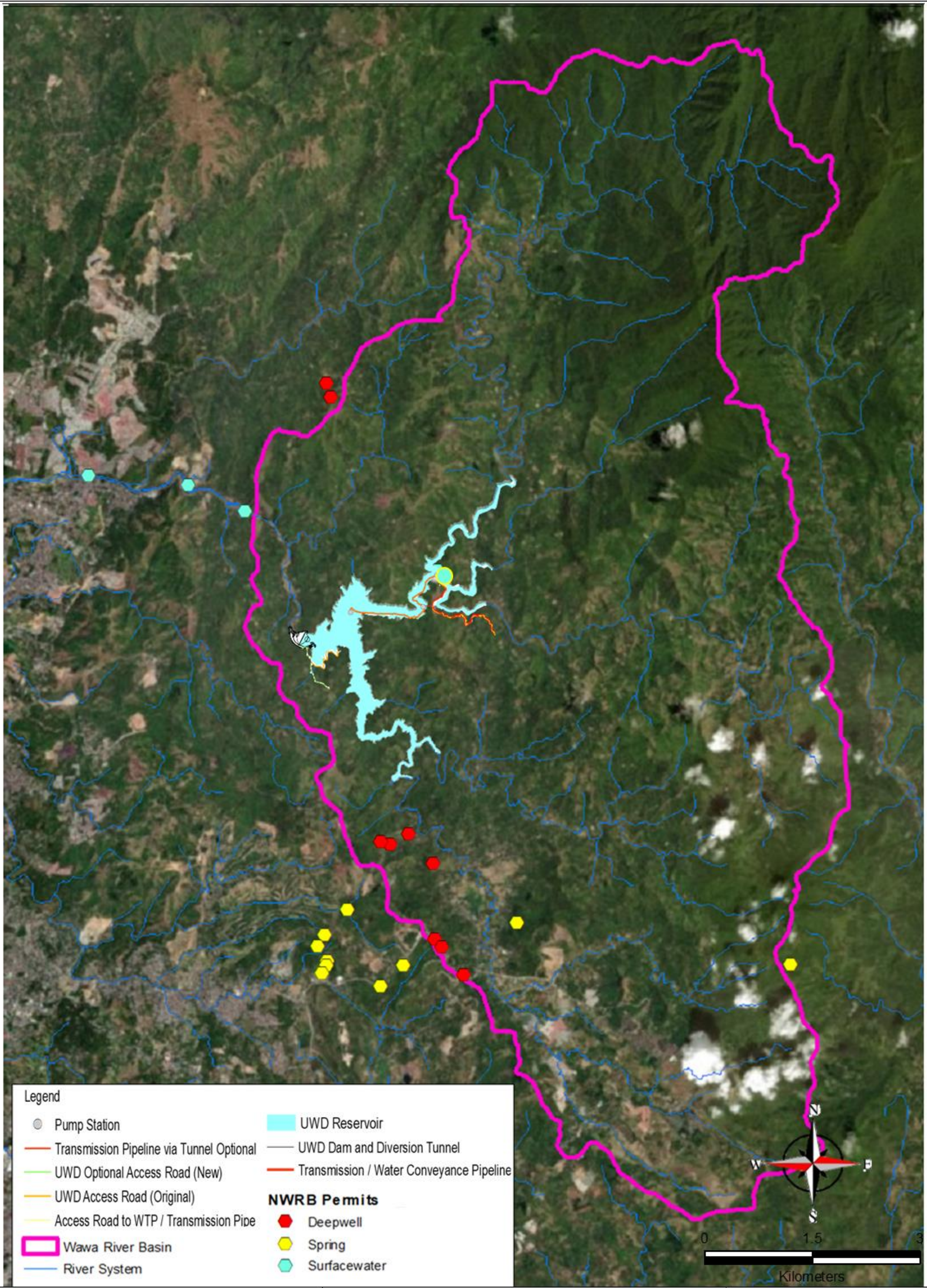


Figure EW-9 - Location of Groundwater and Surface waters Permitees

ENVIRONMENTAL IMPACT STATEMENT
WATER MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

DATA INFORMATION/SOURCE:

Project Components: WawaJVCo, INC. (2020)
Basemap: ArcGIS Imagery, 2020
Created by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.

aperçu CONSULTANTS INC.

SCALE: 1: 110,000

2.1.3.7 Water Availability and Dependability Analysis

The water availability and dependability analysis were conducted in this study to determine the average flows, dependable flows, and required environmental flows for the Upper Wawa Dam

The data from 1992 to 2002 of the DPWH-Sabo Engineering was used in the analysis since it is the most recent and the data is on a daily basis. **Figure EW-10** shows the time-series plot of the flows in Marikina River. The daily streamflow data ranges from 0.30cms to 2,697.58cms with an average flow of approximately 23cms.

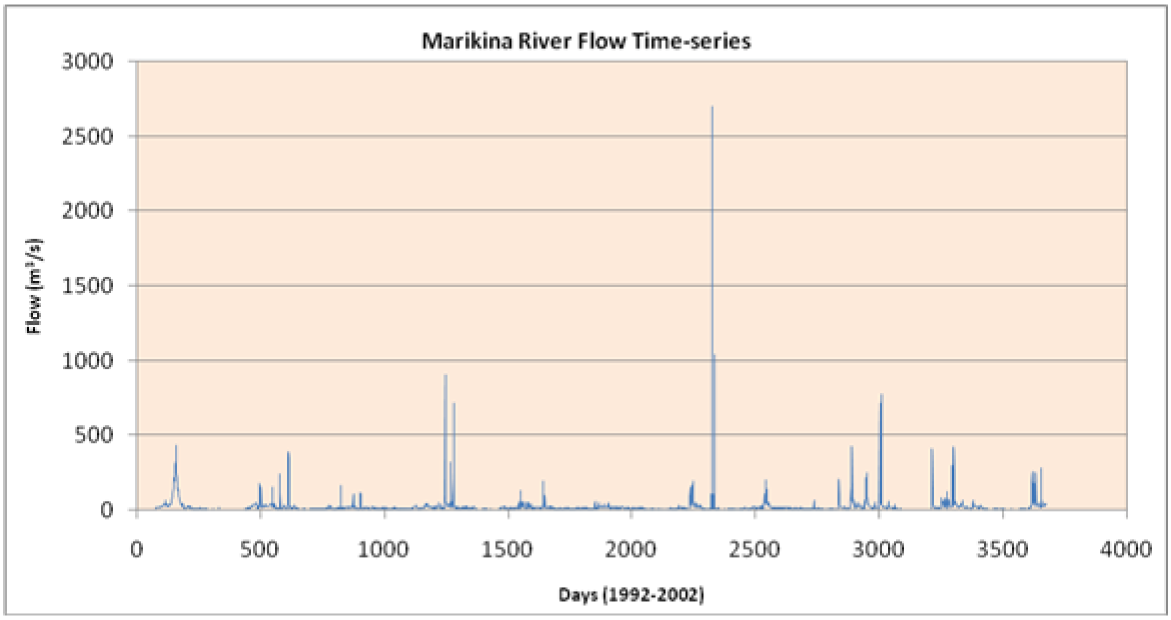


Figure EW-10. Time Series Plot of Average Daily Stream flows for Marikina River

From the daily stream flows, flow duration curves for the entire year and for the wet and dry seasons were generated to determine the dependable flows and the required environmental flows. 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. Further, 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-11, Figure EW-12** and **Figure EW-13** exhibit the flow duration curves for the Upper Wawa dam project site.

Based on the generated flow duration curve for the entire year, the 80% dependable flow of Wawa River is estimated at **7.00 m³/s** while the minimum environmental flow (10% of the dependable flow) is computed as **0.70 m³/s**.

On the other hand, for the wet season (June to November), the 80% dependable flow is estimated at **13.33 m³/s** while the minimum required environmental flow (10% of the dependable flow) is computed as **1.33 m³/s**.

For the dry season (December to May), the 80% dependable flow is estimated at **4.72 m³/s** while the minimum required environmental flow (10% of the dependable flow) is computed as **0.47 m³/s**. The average flows, dependable flows, and minimum environmental flows for the Upper Wawa river are summarized in **Table EW-12.**

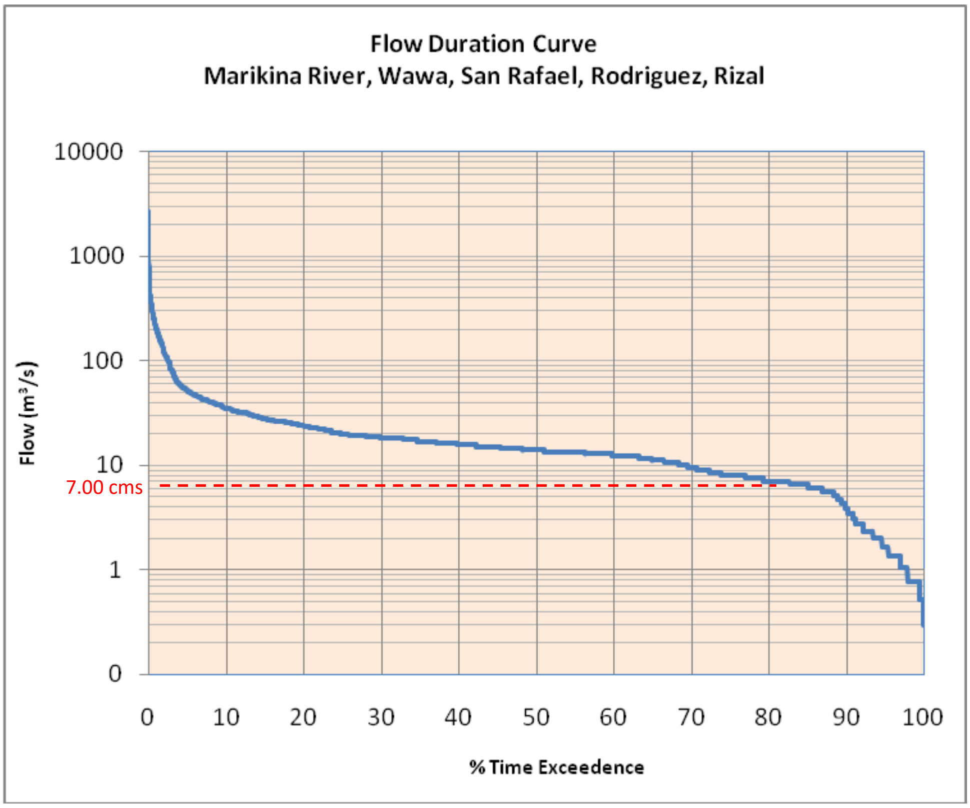


Figure EW-11. Generated Flow Duration Curve for Wawa River

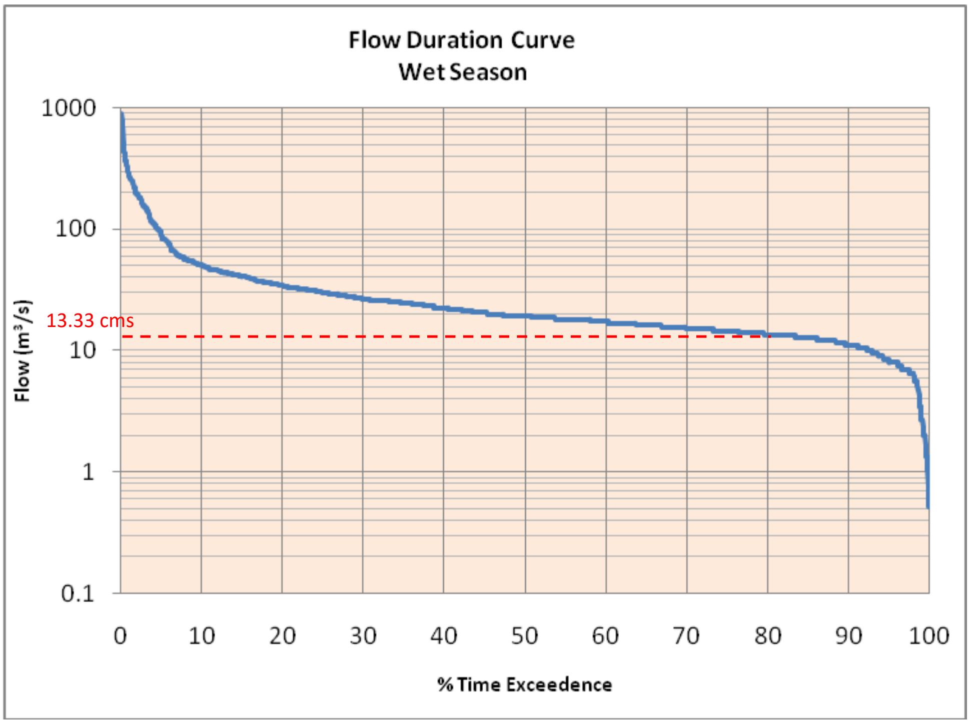


Figure EW-12. Generated Flow Duration Curve for Wawa River During Wet Season

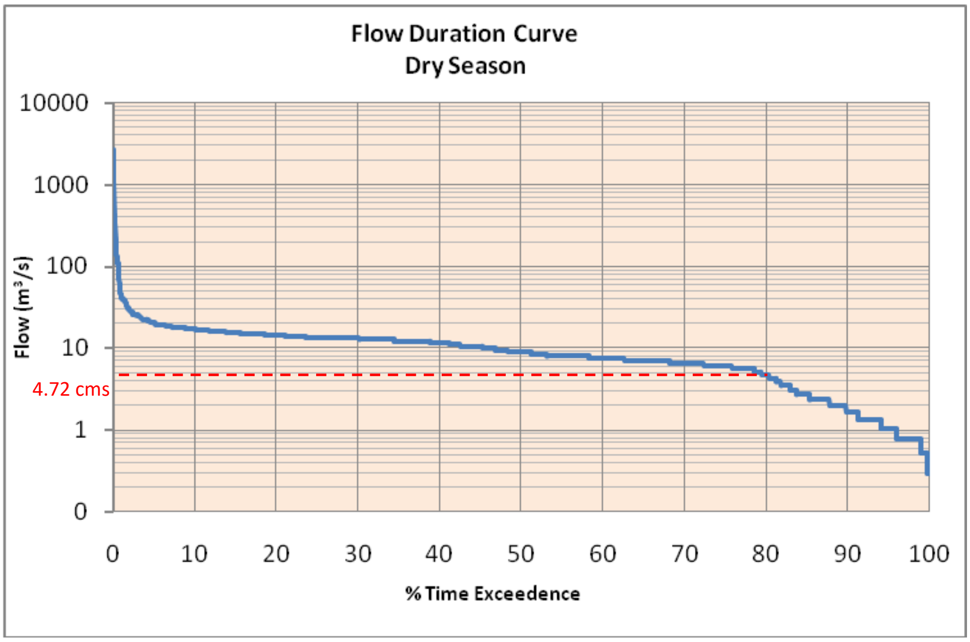


Figure EW-13. Generated Flow Duration Curve for Wawa River During Dry Season

Table EW-12
Average, Dependable and Minimum Environmental flows Wawa River

Flow Type (from Flow Duration Curve)	Throughout the year (m^3/s)	Wet Season (m^3/s)	Dry Season (m^3/s)
Average Flow	22.60	32.57	13.03
10% Dependable	35.21	50.84	17.49
20% Dependable	23.90	34.46	14.49
30% Dependable	18.10	26.62	13.33
40% Dependable	15.67	22.58	11.65
50% Dependable	13.91	19.36	8.99
60% Dependable	12.21	17.49	7.49
70% Dependable	9.51	15.06	6.53
80% Dependable	7.00	13.33	4.72
90% Dependable	3.88	11.11	1.62
Env Flow (0.1 x 80% DF)	0.70	1.33	0.47

Considering that there are water permittees upstream and downstream of the proposed reservoir, the National Water Resources Board decides on the amount of water that is still available for appropriation. An initial assessment shows that during the dry season, there is no more water available for appropriation, hence, only the dependable flow for the wet season can be considered to satisfy the water requirement of this project.

2.1.3.8 Water Balance Study

Water balance models are 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 monthly water balance model is utilized to estimate the actual evapotranspiration (losses), direct runoff, and the groundwater recharge of the Wawa river basin.

The first input parameter in the model is a time series of the estimated monthly rainfall. Rainfall estimation at the study area is done by utilizing the monthly rainfall data obtained from the Tanay and Boso Boso Rainfall Gauging Stations. Rainfall records of Mt. Oro and Mt. Campana were not considered in the estimate of average rainfall because of insufficient records. Only simultaneous year of records were considered in the estimate. Few missing records are first estimated by normal-ratio method and then inverse-distance method of interpolation is employed to generate the monthly rainfall estimates for the Upper Wawa Dam catchment. **Table EW-13** presents the estimated monthly rainfall in the catchment.

The estimated monthly rainfall in the catchment is referred to as P_{RAIN} in the model. 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.

Table EW-13
Estimated Monthly Rainfall at Upper Wawa Dam Catchment

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1999	37.1	24	97.8	99.9	153.3	284.7	591.3	888.3	525.7	376.1	203.9	290	3572.1
2000	35.3	87.6	30	12	466.4	131.2	1091.6	407.2	346.9	515.6	312.8	198	3634.6
2001	60.1	101.7	44.4	95.1	241.7	216.5	662.7	767.7	301.9	129.3	167.9	88.5	2877.5
2002	8.6	15.9	23.4	7.2	53.5	106.4	1188.4	539.2	568.5	52.3	142	29.2	2734.6
2003	3.8	5.1	4.9	11.9	528.6	217.7	274.1	415.9	518.3	50.3	103.3	19	2152.9
2004	3.9	63	1.8	19.5	123.7	456.7	280.1	698.5	179	63	151.9	135.2	2176.3
2005	18.7	8.9	26.6	13.4	93.7	258.8	207	354.5	550.7	342.1	125.4	126	2125.9
2006	76.5	9.8	26	0	53.9	70	695	181.7	242.4	155.1	106.6	71.6	1688.6
2007	11.2	3.3	9.4	5.1	83.1	122.8	207.6	482.6	449.7	459.9	191.9	83.3	2110
2008	68.1	31.5	0.3	35.5	376.6	248.7	370.9	441.3	545.5	286.7	235.6	99.6	2740.2
2009	45.8	18.4	28.3	220	83.8	140.4	618.8	126.1	717.8	333.8	43.1	8.5	2385
2010	26.1	0.6	4.6	19.7	41.7	97.6	247.4	382	296.8	248.8	119.3	61.3	1546.1
2011	38.4	3.2	54	27.5	249	531.6	416.7	360.1	593.9	243.8	228.9	183.7	2930.8
2012	59.3	94.4	123.7	5.4	269.1	265.1	705.3	860.4	242.5	159.4	27.2	62	2873.8
2013	41.5	74.3	32.7	1.9	99.2	246.8	214	555.8	501.7	148.5	159.2	40.9	2116.5
2014	3.1	1.3	10.5	12.2	36.1	461.1	289.4	309.8	489.2	211.6	89.4	125	2038.7
Mean	33.6	33.9	32.4	36.6	184.6	241	503.8	485.7	441.9	236	150.5	101.4	2481.5
Std. Dev.	24.1	36.9	34.6	57.4	156.3	138.5	309.5	222.8	153.8	141.8	73.5	74.3	603.9

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}).

The results of water balance simulation are the time series of computed equivalent water depths (in millimeters) of various components of the hydrologic cycle. The summary results, which are presented in time series plots, are shown in **Figure EW-14**.

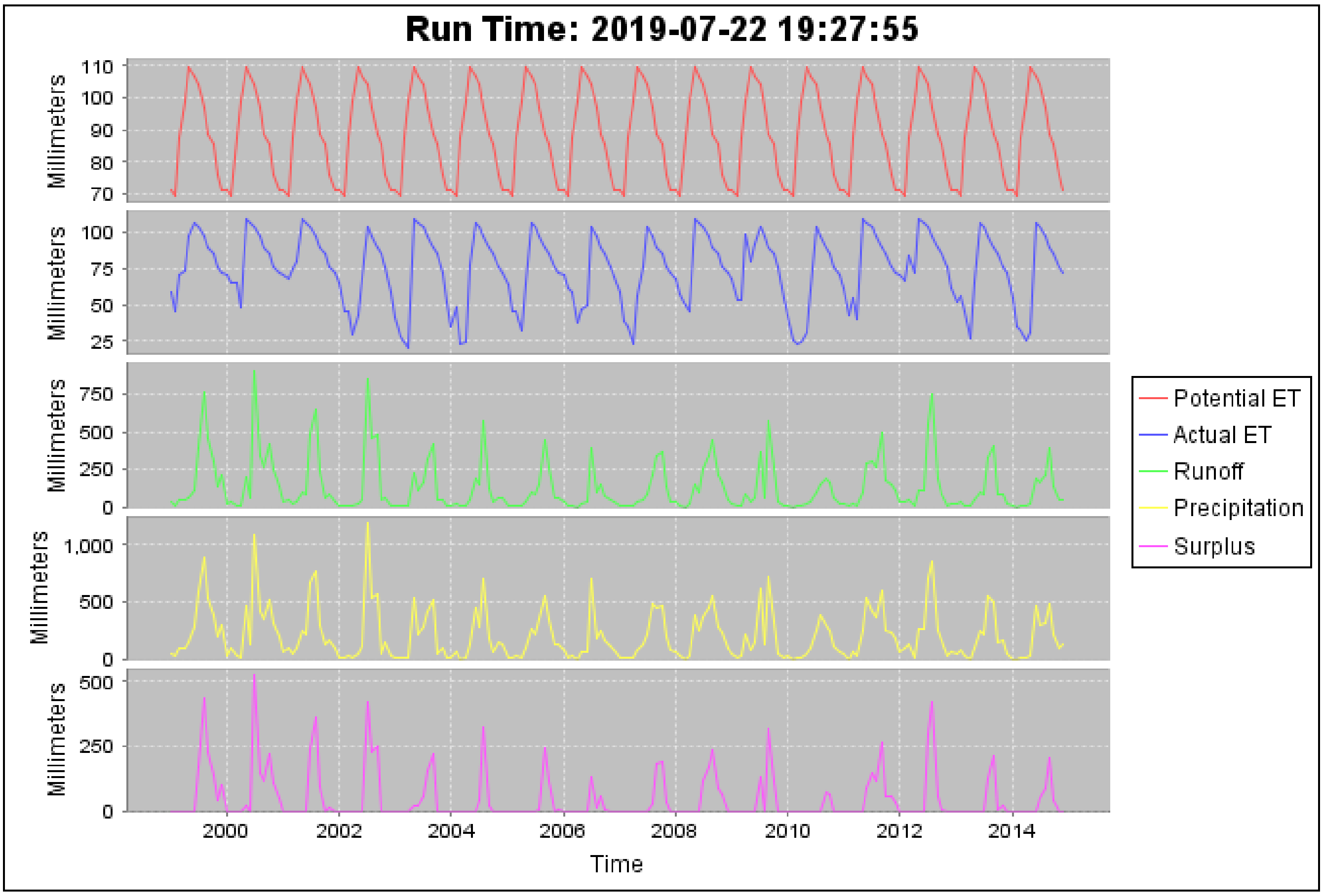


Figure EW-14. Time Series Plots of the Hydrologic Components of Upper Wawa River Basin Generated from the Thornthwaite Monthly Water Balance Model

The monthly averages of rainfall, actual evapotranspiration, runoff, change in soil moisture storage and groundwater recharge from the 16-year water balance simulation for the Upper Wawa river basin are computed and presented in **Table EW-14** and **Figure EW-15**.

Table EW-14
Summary of Monthly Averages of Rainfall, Evapotranspiration, Runoff, Change in Soil Moisture Storage and Groundwater Recharge for Upper Wawa River Basin

Date	Rainfall (mm)	Actual ET (mm)	Soil Moisture	Baseflow (mm)	Runoff (mm)
Jan	33.6	59.9	121.2	0.0	16.2
Feb	33.9	49.0	92.6	0.0	13.9
Mar	32.4	49.2	62.8	0.0	13.0
Apr	36.6	44.0	40.8	0.0	14.7
May	184.6	78.3	70.7	32.7	73.6
Jun	241.0	94.8	113.6	50.3	95.9
Jul	503.8	104.0	166.3	212.2	187.6
Aug	485.7	97.0	197.6	197.6	191.1
Sep	441.9	88.8	200.0	177.8	175.4
Oct	236.0	85.9	189.6	45.1	105.0
Nov	150.5	75.7	181.7	9.2	65.6
Dec	101.4	67.7	162.9	0.0	42.1
Annual	2481.4	894.1	133.3	724.8	994.1

Based from the water balance results, the area has a deficit at the start of the year and a surplus at mid- year as the wet season peaks. The annual groundwater recharge of Upper Wawa river basin is 24% of its mean annual rainfall. Considering the basin drainage area of the Upper Wawa river basin, this groundwater recharge is equivalent to an average daily volume of approximately 14.4 x $10^7 m^3$. Further, approximately 40% of the total rainfall becomes surface runoff, 36% is lost as actual evapotranspiration.

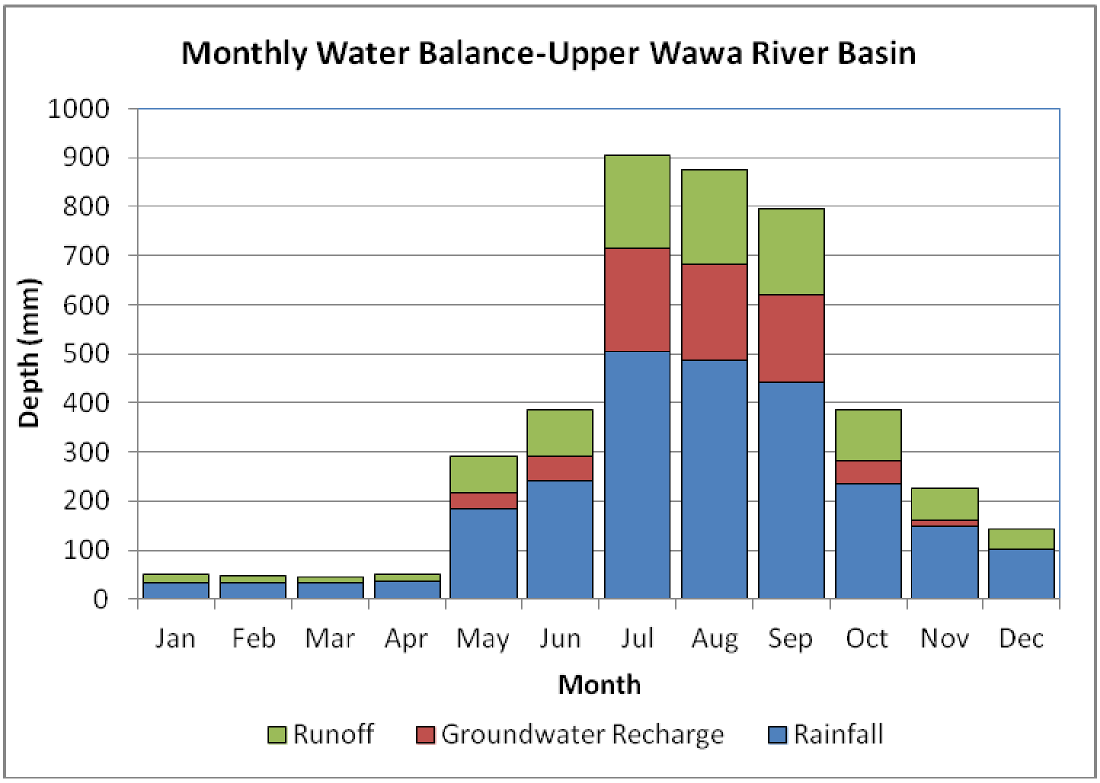


Figure EW-15. Monthly Water Balance of Upper Wawa River Basin (16-year simulation)

Groundwater recharge evidently starts in May and therefore the aquifers are replenished. It is also the season when rainfall starts to increase. From January to April is the time of the year when competition for soil moisture and groundwater for a diversity of uses is highest. It is also the season when rainfall is at its lowest. During this time vegetation stresses occur when there is not enough soil moisture. Runoff varies depending on the season, it is significantly proportional to the rainfall conditions.

2.1.3.9 Flood Frequency Analysis and Probable Maximum Flood

Dams are designed and constructed such that a catastrophic failure is prevented during a large flood. The design flood refers to the flood magnitude for which spillways and energy dissipating structures were designed, with a safety margin provided by the freeboard. Dam failures may also be attributed to overtopping of dams. It is recommended to estimate flood discharge with a return period of 1000 years or more. 100 years return period for the design of spillways and 10,000 years return period for the safety of dams. HEC-HMS is one of the models used to simulate design floods. Other approaches to estimate the probable maximum flood is a common practice nowadays in dam design. Hydrometeorological data are used as inputs to the model for simulation.

The U.S. Water Advisory Committee on Water Data (1982) recommended the Log-Pearson Type 3 (LP3) distribution technique for flood frequency analysis and is hereby used for this analysis. The LP3 method calculates the 200-year flood based on maximum daily streamflow. Using the daily maximum flow of the DPWH-BRS streamflow data in Marikina River located in Wawa, San Rafael, Rodriguez, Rizal resulted to the peak values shown in **Figure EW-16** and given in **Table EW-15** which also includes the transposed values of peak flows at the diversion point of the proposed reservoir.

Streamflow transposition

The RO or streamflow upstream of the proposed dam site is estimated by transposition of the streamflow at the Marikina River gauging station located approximately 1.5 kilometres downstream of the original Wawa Dam. The transposition method is based on the assumption that the specific yield (Q/A) and the rainfall depth and distribution is the same for the gauged and un-gauged basin. In general, to account for the difference in annual rainfall depth, the equation used for the streamflow transposition is

$$Q(i,j) = \frac{A_i P_i}{A_2 P_2} Q_2(j)$$

where

$Q(i,j)$ = estimated flow in m^3/sec of the sub-catchment i for the month j
A_i = area of the sub-catchment i in km^2
P_i = mean annual rainfall in millimetres of the sub-catchment i
$Q_2(j)$ = measured flow of the gauged basin in m^3/sec. for the month j
A_2 = gauged drainage area in km^2
P_2 = mean annual rainfall in millimetres of the reference station of the gauged basin
In the study, the mean annual precipitation is assumed to be the same for all sub-catchments.

Table EW-15
LP3 Estimates of Peak Discharge Values

Rainfall Return Period (years)	Marikina River Peak Discharge (Q m³/sec)	Transposed values for Upper Wawa River (Q m³/sec)
2	350.38	302.83
5	536.59	463.77
10	680.85	588.45
25	889.36	768.66
50	1060.48	916.56
100	1249.01	1079.50
200	1459.20	1261.16

Table EW-15 above shows the peak discharge values obtained using the Log-Pearson Type 3 method and the transposition method for the Upper Wawa diversion point, The 100-year return period peak at the Upper Wawa diversion is estimated at approximately 1,080cms and the 200-year return period peak discharge is approximately 1,260cms. Considering that the proposed Upper Wawa Dam will be located 4km upstream of the original Wawa Dam and is just a few square kilometers short of its area, the values of peak discharge at the location of the original Wawa Dam and the proposed Upper Wawa Dam only vary to a certain extent.

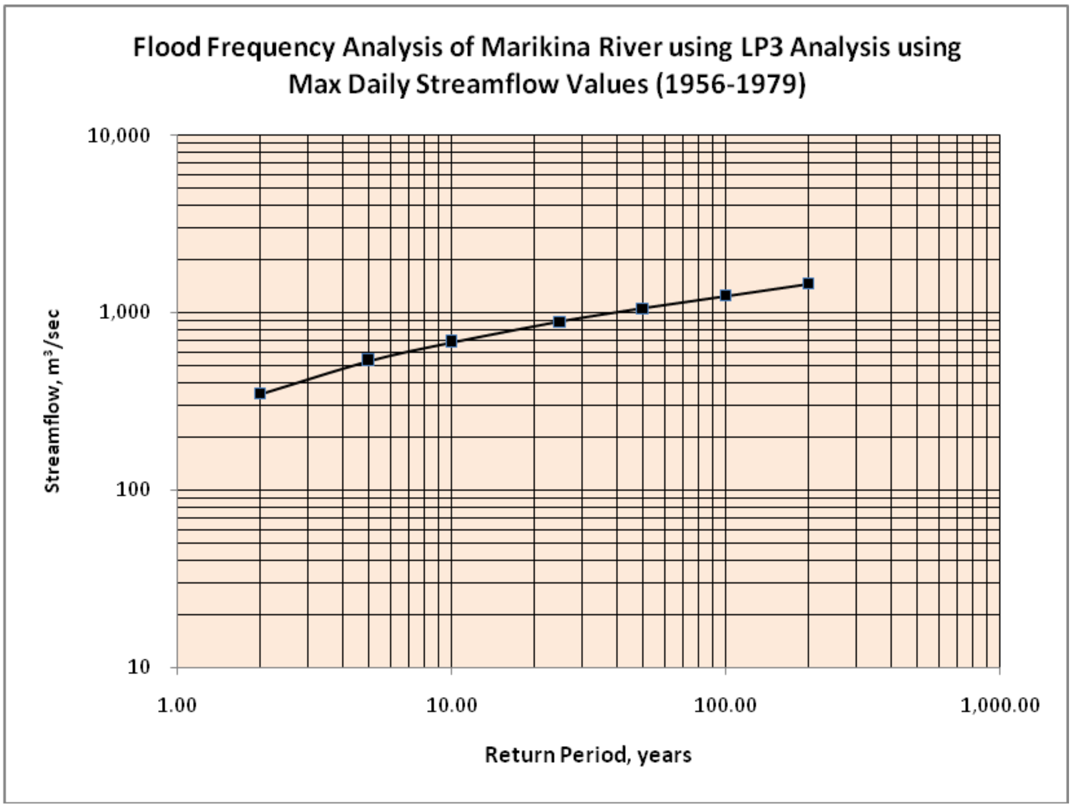


Figure EW-16. Flood Frequency Analysis of Marikina River (Wawa) using LP3 Analysis

The Probable Maximum Flood (PMF) cannot be determined from the available streamflow records using normal frequency analysis methods because the periods of record available are too short to extrapolate with any degree of reliability. Since PMFs are presumed to fall in the 10^4 to 10^{-6} per year frequency range, the streamflow records are of little value for this purpose.

An estimate of the PMF can be determined using empirical formula of the envelop curves for the observed maximum floods in monsoon affected areas in South, Southeast and East Asia and the Pacific. These are the

Creager's formula and the Modified Myers formula with the following equations:

Creager's: $Q_{max} = CA^{(bA^{-n})}$

Modified Myer's: $Q_{max} = CA^{0.5}$

Where Q_{max} is the maximum flood in m^3/sec and A = drainage area in km^2. For Sub-Region C which includes Taiwan, Japan, Korea, Vietnam and the Philippines, the empirical constant C = 364 (Modified Myer's) and C = 87 (Creager's). The values of the other constants in Creager's equation are b = 1.0 and n=0.04. For the Upper Wawa area with a 242 km^2 drainage area, the estimated PMF is 7,135.50 m^3/sec using Creager's formula and 5,662.5 m^3/sec using the Modified Myer's formula.

Rainfall-Runoff Modelling using HEC-HMS

The Hydrologic Engineering Center's Hydrologic Modelling System (HEC-HMS) version 3.5 was used to simulate the rainfall-runoff response of the watershed. The input is a time-series of rainfall increments that was developed from the Rainfall-Intensity-Duration-Frequency (RIDF) data of Boso Boso and Tanay rainfall gauging stations. The RIDF data tables are given in **Table EW-16** and **Table EW-17**.

Table EW-16
RIDF Values at Boso Boso Rainfall Gauging Station

Station	Bosoboso							Antipolo, Rizal			Latitude		14°38'24"	
Agency	PAGASA										Longitude		121°13'23"	
T, years	Time, minutes													
	5	10	15	20	30	45	60	80	100	120	150	180	360	720	1440
2	325.6	205.1	156.5	129.2	98.6	75.3	62.1	51.3	44.2	39.1	33.7	29.9	18.8	11.9	7.5
5	456.0	287.3	219.2	181.0	138.1	105.4	87.0	71.8	61.9	54.8	47.2	41.8	26.4	16.6	10.5
10	543.8	342.6	261.4	215.8	164.7	125.7	103.7	85.6	73.8	65.4	56.3	49.9	31.4	19.8	12.5
20	628.9	396.2	302.3	249.6	190.5	145.3	120.0	99.0	85.4	75.6	65.1	57.7	36.3	22.9	14.4
25	656.1	413.3	315.4	260.4	198.7	151.6	125.2	103.3	89.0	78.9	68.0	60.2	37.9	23.9	15.0
50	740.7	466.6	356.1	293.9	224.3	171.2	141.3	116.7	100.5	89.0	76.7	67.9	42.8	27.0	17.0
100	826.1	520.4	397.1	327.8	250.2	190.9	157.6	130.1	112.1	99.3	85.6	75.8	47.7	30.1	18.9

Table EW-17
RIDF Values at Mt. Campana Rainfall Gauging Station

Station	Mt. Campana							Antipolo, Rizal			Latitude		14°40'06"	
Agency	PAGASA										Longitude		121°17'29"	
T, years	Time, minutes													
	5	10	15	20	30	45	60	80	100	120	150	180	360	720	1440
2	243.6	153.5	117.1	96.7	73.8	56.3	46.5	38.4	33.1	29.3	25.2	22.3	14.1	8.9	5.6
5	352.2	221.8	169.3	139.8	106.7	81.4	67.2	55.5	47.8	42.3	36.5	32.3	20.4	12.8	8.1
10	424.0	267.1	203.9	168.3	128.4	98.0	80.9	66.8	57.6	51.0	43.9	38.9	24.5	15.4	9.7
20	493.0	310.6	237.0	195.6	149.3	113.9	94.1	77.6	66.9	59.3	51.1	45.2	28.5	17.9	11.3
25	514.9	324.3	247.5	204.3	155.9	119.0	98.2	81.1	69.9	61.9	53.3	47.2	29.8	18.7	11.8
50	582.2	366.8	279.9	231.1	176.3	134.6	111.1	91.7	79.0	70.0	60.3	53.4	33.6	21.2	13.4
100	649.1	408.9	312.1	257.6	196.6	150.0	123.8	102.2	88.1	78.0	67.2	59.5	37.5	23.6	14.9

Aside from the RIDF, other inputs to the HEC-HMS simulation include the Curve Number (CN) which describes the amount of extraction from rainfall. The sub-basins are assumed to have either poor or fair land cover conditions. The percentage of the impervious area for each sub-basin was assumed to be equal to 5% of the sub-basin's total area except for SB-27 and SB-28 (**Figure EW-3**) which are evidently residential and/or commercial areas. For SB-27 and SB-28, the impervious area was set to 8%.

In the calculation of lag time of the stream for each sub-basin, the Manning's roughness coefficient (n) of 0.04 was applied, describing the main channels as "clean, winding, some pools and shoals".

The probable maximum flood with 10,000-year return period based on the HEC-HMS simulation is at 7,839cms. This is close to the value calculated using Creager's Method. While the 100-year return period streamflow was estimated to be 4,238cms.

2.1.3.10 PAGASA Climate Change Projection and Impacts on Hydrology

Climate change has a considerable impact to water resources. Some key information on the climate change in the Philippines includes seasonal mean temperature variations, seasonal rainfall changes and occurrence of extreme events. Temperature will consistently increase in all provinces.

In the case of seasonal rainfall change, there will be a reduction in rainfall in most provinces during the summer months (MAM) and rainfall increases are likely in most areas of Luzon and Visayas during the southwest monsoon (JJA) and the SON seasons. During the southwest monsoon season (JJA), larger increases in rainfall are expected in provinces in Luzon (0.9% to 63%) and Visayas (2% to 22%) but generally decreasing trends in most of the provinces in Mindanao in 2050.

Projections for extreme events in 2020 and 2050 reflects that hot temperatures (indicated by the number of days with maximum temperature exceeding 35^{o}C) will continue to become more frequent; the number of dry days (days with less than 2.5mm of rain) will increase in all parts of the country; and heavy daily rainfall (exceeding 200mm) events will also continue to increase in number in Luzon and Visayas.

The PAGASA Climate Change Projection indicates that the part of Rizal province will have a decrease amount of rainfall from September to May every year and an increase in rainfall during every wet season or the months of June July and August. This phenomenon is directly proportional to the increase and decrease of water resources. The concern is addressed by the government agency mandated to regulate and manage water resources in the country.

The projected seasonal temperature increase, seasonal rainfall change and frequency of extreme events in 2020 and 2050 under the medium range emission scenario in the provinces in Region 4-A are presented in **Table EW-18**, **Table EW-19** and **Table EW-20**, respectively.

Table EW-18
Seasonal Temperature Increases in 2020 and 2050 under Medium-Range Emission Scenario in Region 4A

	Observed Baseline (1971-2000)				Change In 2020 (2006-2035)				Change In 2050 (2036-2065)			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
Region 4A												
Batangas	24.2	26.5	25.9	25.6	1	1.2	0.9	1	1.9	2.2	1.8	1.9
Cavite	25.7	28.2	27.3	26.9	1	1.2	0.9	1	2	2.2	1.8	1.9
Laguna	25	27.5	27.5	26.7	0.9	1.1	1.1	0.9	1.8	2.1	1.9	1.9
Quezon	25.1	27.2	27.6	26.7	0.9	1.1	1.1	0.9	1.8	2.1	2	1.8
Rizal	25.4	27.9	27.6	26.8	0.9	1.1	0.9	1	1.9	2.1	1.8	1.9

Table EW-19
Seasonal Rainfall Changes in 2020 and 2050 under Medium-Range Emission Scenario in Region 4A

	Observed Baseline (1971-2000)				Change In 2020 (2006-2035)				Change In 2050 (2036-2065)			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
Region 4A												
Batangas	231	280.4	856.5	746.4	-29.9	-24.1	9.1	0.5	-11.1	-23.1	17.2	6.3
Cavite	124.9	242.8	985.7	579	-26.1	-28.2	13.1	0.4	-19.1	-30.5	24.2	5.9
Laguna	629.2	386.8	845	1067	-20.2	-31.5	2.9	2.9	0.1	-34.8	6.8	0.4
Quezon	827.7	382.7	670	1229	-6.5	-18.6	2.9	5.2	6.6	-20.6	6.5	0.9
Rizal	262.4	241.5	1001	821.8	-13.1	-30.7	12.4	-0.9	-11.5	-39.8	24.8	-0.8

Table EW-20
Frequency of Extreme Events in 2020 and 2050 under Medium-Range Emission Scenario in Region 4A

Provinces	Stations	No. of Days w/ Tmax>35°C			No. of Dry Days			No. of Days w/ Rainfall >200mm		
		OBS (1971-2000)	2020	2050	OBS	2020	2050	OBS	2020	2050
Batangas	Ambulong	928	8010	8016	8226	6081	6049	6	14	9
Cavite	Sangley	630	1697	2733	7352	6635	6565	6	9	9
Quezon	Alabat	53	132	733	6629	7025	7042	20	58	70
	Tayabas	22	791	1434	6771	4717	4668	17	9	12
	Casiguran	575	1720	2768	6893	4520	4887	23	54	57
	Infanta	350	378	1112	5903	4006	4015	22	39	34

The projections for the normal and extreme values of temperature and rainfall will mean an increase in the evapotranspiration amount in the water balance that may reduce the amount of groundwater recharge and total runoff in the study area.

For possible drought occurrences, **Table EW-20** does not give specifics for Rizal but considering the proximity of Rizal to Cavite, it is not alarming since the number of dry days will decrease under the 2020 and 2050 scenarios. On the contrary, for possible flood events, there is a slight increase in the number of days with rainfall greater than 200mm. It is thus important that the flood mitigation concept of this project take this into consideration.

2.1.3.2 Flooding and Drought in the Study Area

Floods, considered a man-made as well as a natural disaster, are perennial problems in the metro. The low-lying areas downstream of the study area's watershed are no exception. The upstream portion of Marikina River which is the portion of Wawa River contributes greatly to flooding but since there is no gauging station to measure water levels located within the proximity of Upper Wawa, the Marikina River gauging station in Sto Nino, Marikina City is normally considered for record purposes.

In 2017, the Philippine Journal of Science published a study on Marikina Flood Hazard Models Using Historical Data of Water Levels of Marikina River. It used recorded water levels at the gauging station in Sto. Nino, Marikina City. The study shows that there are distinguished events that caused considerable water level increase in Marikina River from 2002 to 2012. Information regarding these floods are given in **Table EW-21**.

Table EW-21.
Record of floods in Marikina River

Date	Event	Max. River Height Recorded (m)
Sep. 26-27, 2009	Monsoon rain plus Typhoon Ondoy	23.6
Sep. 27, 2011	Typhoon Pedring	20.1
Aug. 7, 2012	Southwest monsoon enhanced by Typhoon Haikui	20.6
Aug. 20, 2013	Monsoon rain plusTropical Storm Maring	19
Sep. 19-20, 2014	Monsoon rain plus Typhoon Mario	19.9
July 17, 2018	Monsoon rain	16.7
August 11-12, 2018	Monsoon rain plus Typhoon Karding	20.6

From **Table EW-21**, the flood that resulted from Typhoon Ondoy is still the most destructive. Its rainfall was a record-high of 448.5 mm in 12 hours and it flooded the central part of Luzon. In particular, the centroid of Typhoon Haikui was kilometers away from the Philippines explaining why it was not given a local name but it enhanced the monsoon rains that flooded Marikina.

Several water level and monitoring stations are in place in the Marikina River Basin and along the Marikina River that can provide an up-to-date status of water levels at selected sections of the main river and of rainfall depth at different locations within Marikina River Basin. **Figure EW-17** shows the locations of these monitoring stations.

It appeared that although there were several stations to monitor water level at different sections of Marikina River, this was not enough to provide near-real time information on the status of water levels in the river. To achieve this, the flood extent monitoring system was developed for the section of Marikina River starting from San Jose Bridge in Rodriguez (Montalban), Rizal and at Rosario Junction in Pasig City. This is shown in **Figure EW-18**. At these locations are water level monitoring stations of the Enhanced Flood Control and Operation Warning System (EFCOS) namely Station Montalban, Station Sto. Nino (in Marikina City) and Station Rosario.

Drought, on the other hand, is the prolonged dry spell and it is also a natural disaster of significant concern in the Philippines. Although the onset is slow, it can last for a considerable period and can cause severe damage. The country has an average annual rainfall of 2400 mm, a drop from the normal can trigger water shortage.

The occurrence of drought is heavily influenced by the El Nino Southern Oscillation (ENSO) and its warm and dry phase. According to the National Drought Plan of the Philippines (2019) there has been 11 droughts recorded since 1968 but not all these droughts have particularly affected the study area. The drought episodes that might have affected the study area are:

- the 1968-1969 drought that affected most of the Philippines
- the October 1982 to September 1983 drought when moderate to severe drought affected most of Luzon
- the October 1986 to September 1987 drought that affected mainland Luzon
- the 1991-1992 drought which severely affected Manila
- the 1997-1998 drought episode when the most severe El Nino episode occurred and 70% of the Philippines was severely affected, and
- the May 2002 to March 2003 drought which moderately affected Southern Tagalog

Mindanao has experienced more severe episodes of drought compared to other regions of the country.

Figure EW-17. Marikina River Basin showing water level stations and warning posts	DATA INFORMATION/SOURCE:	WawaJVCo INC. apercu CONSULTANTS INC.
ENVIRONMENTAL IMPACT STATEMENT WATER MODULE Wawa Bulk Water Supply Project – Upper Wawa Dam	**Project Components:** Wawa JVCO, Inc. (2020) **Source:** PAGASA (2020) **Created by:** APERCU CONSULTANTS, INC (2020)	SCALE: Not to Scale — PAGE 234

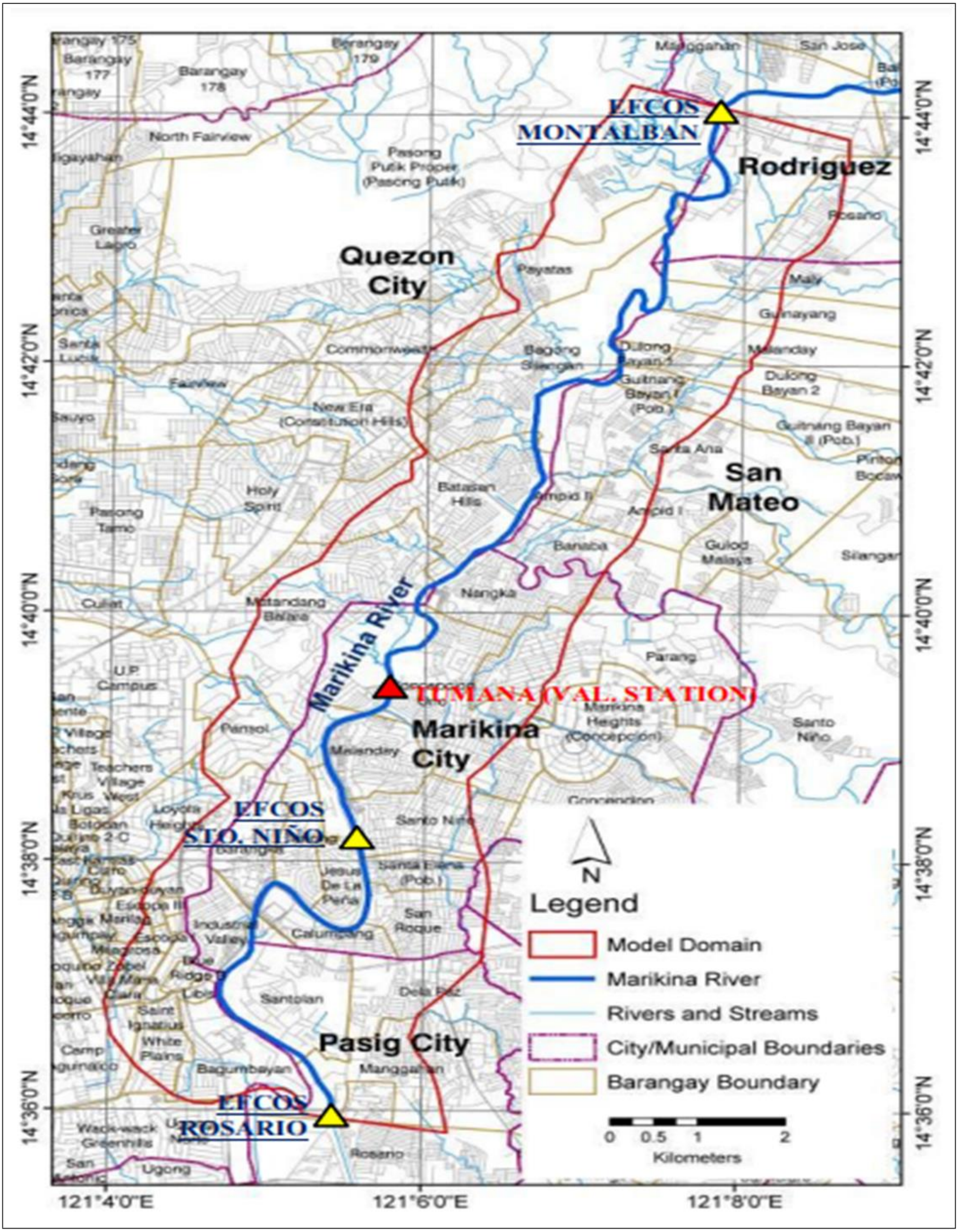


Figure EW-18. Locations of EFCOS Stations along Marikina River	DATA INFORMATION/SOURCE: **Source Map:** PhilGEOS (2012) **Modified by:** Apercu Consultants Inc. (2020)	WawaJVCo INC. apercu CONSULTANTS INC.	
ENVIRONMENTAL IMPACT STATEMENT WATER MODULE Wawa Bulk Water Supply Project – Upper Wawa Dam		SCALE: As above	PAGE: 235

2.1.4 Impact Assessment and Mitigation Measures for Hydrology

2.1.4.1 Pre-construction Phase

The pre-construction phase, which covers planning activities, feasibility studies, permits, and ocular or reconnaissance surveys in the study area, will have a minimal impact on the hydrology, surface water, groundwater and drainage conditions in the proposed site of the project.

2.1.4.2 Construction Phase

Change in Drainage Morphology

To ascertain dry working conditions at the proposed dam during its construction, cofferdams will be built upstream and downstream of the proposed dam. This will block the flow along the river and cause the water to rise significantly which may flood the upstream area.. To mitigate this, river diversions with sufficient capacity (designed for 20-year return period) will be constructed to convey the natural flow upstream of the proposed dam to downstream during the construction of the dam.

For the construction of river diversions, cofferdams for river diversions, will be built along the river so as not to constrict the flow in the river significantly. This will still allow the design flood to pass thru the river during the construction of the dam.

Change in River/ Water Depth

During clearing and construction of the dam, access/service roads and water treatment plant, construction sediments may reach the waterways during rainfall events. The construction of river diversion requires tunneling/excavation that may result in the production of large amount of sediments that may come into the water. These may cause decrease in water depth. To avoid this, sediment/silt traps should be provided properly around the construction sites.

Cofferdams are to be built upstream and downstream of the diversion to ensure a dry working condition while tunelling/excavation is done. Drilled or excavated sediments should be properly conveyed and maybe used as construction material for the proposed dam. Cofferdams should be constructed with sufficient height (based on 20-yr return period) and in such a way that it will not impede the flow in the river so as not to induce flooding during the constructon period.

During the construction of the main dam, the working area should be equipped with cofferdams to prevent water from entering the site thus making the area dry and not allowing the excavated and construction sediments from the site to come into the water. The river diversion in this stage should be fully functional to convey the water upstream of the proposed dam to downstream throughout the construction of the main dam.

For the spillway, cutting or excavation is done to meet the required spilling level of the proposed reservoir. During the excavation, excavated materials should be properly conveyed to the dam site and maybe used as construction material in building the main dam. In this case excavated materials will be kept from coming into the water.

Depletion of Water Resources/ Competition in Water use

Based from the records of National Water Resources Board (NWRB), 25 water permits are issued within the closest proximity of the study area. The list is provided in **Table EW-10** and are shown in **Figure EW-9**. Of the 25 grantees, 6 grantees draw water from surface sources, two (2) of them indicated the same source of extraction. The remaining 19 grantees draw water from groundwater sources, 8 from deepwell sources and 11 from springs. As shown in the **Figure EW-9**, there are sources which are within the catchment of the Upper Wawa Dam.

In particular, there are four (4) existing surface water rights downstream of the proposed project in Wawa River. San Lorenzo Ruiz Builders and MWSS have water permits at the same source. Both were granted for domestic and municipal purposes. Downstream of the San Lorenzo Ruiz and MWSS source are two other locations for the MWSS water permits for domestic and municipal purposes. Upstream of the proposed Upper Wawa Dam is another water right granted for water extraction at Tayabasan River while the remaining water permit for surface water use is in a creek upstream of the proposed project.

As shown in **Figure EW-9**, 6 deepwells and 2 springs that are within the catchment of the Upper Wawa Dam catchment have water rights.

Considering the above data from NWRB and the available water at the source, the use of water during construction will have an effect on the competition in water use during dry season. It is hence recommended to tap other sources of water during construction, i.e. spring water that can be found within the vicinity of the project or a deepwell that can be constructed specifically intended for the project but can be donated to the locals upon the completion of the project.

Reduction in Volumetric Flow

The water requirement during the construction of the proposed dam and other infrastructures is mainly for concreting, equipment use, washing, and for the water demands of construction personnel. The potential source of the water requirements of construction personnel would be the springs that are close to the construction site. Water requirements for concreting and equipment use may be directly tapped from available springs near the site and/or from Wawa river but may need to undergo conventional water treatment methods to pass the water quality standards for concrete use. At this stage, the exact amount of water required for the construction phase is not yet determined.

Sediments Reaching the Waterways due to Construction of Support Facilities and Tunnelling/Excavation Activities

During clearing and construction of the dam, access/service roads and water treatment plant, construction sediments may reach the waterways during rainfall events. The construction of river diversion requires tunneling/excavation that may result in the production of large amount of sediments that may come into the water. To avoid this, sediment/silt traps should be provided properly around the construction sites.

Cofferdams are to be built upstream and downstream of the diversion to ensure a dry working condition while tunneling/excavation is done. Drilled or excavated sediments should be properly conveyed and maybe used as construction material for the proposed dam.

Other sediments that may come from clearing, tunneling and excavations during construction of the main dam and spillways should be properly conveyed and maybe used as construction materials.

Occurrence or Aggravation of Flooding in nearby Areas

During construction, cofferdams will be built upstream and downstream of the proposed dam which may block the flow along the river around the construction site. This will cause the water upstream to rise significantly and hence may flood portions of the upstream area during the construction of the proposed dam. To mitigate this, the river diversion will be constructed with sufficient capacity (designed for 20-year return period) and will be fully functional to convey the natural flow from upstream of the proposed dam to downstream.

2.1.4.3 Operation Phase

Change in Drainage Morphology

During the operation phase, the natural flow along Wawa River at the dam site will be altered permanently. There will be a permanent inundation in some areas on the upstream side of the dam. Those areas will be identified prior to construction and relocation of those who will be affected should be done.

To mitigate any adverse impact of the diversion in the downstream rivers, the required minimum environmental flows should be released downstream of the rivers. As per Water Code of the Philippines, 10% of the available flow in the river should be maintaned as environmental flow that will support the lives of flora and fauna in the body of water.

During typhoons or high rainfall events, the spillways will be designed properly (based from the probable maximum flood or 10,000-Yr Return Period) to accommodate or convey practically all excess inflows into the reservoir so as to prevent flooding upstream or avoid any dambreak failure.

The estimated probable maximum flood which will be used in the design of the spillway will be enough to accommodate excess runoff at any climatic condition.

Reduction in Volumetric Flow

The alteration of the river flow downstream of a dam is a significant impact of dam construction. It also alters the ecosystem. Flora and fauna in the river depend on the quantity of river flow Disrupted and altered river flows can be as severe as losing the living organisms in the river. Maintaining the environmental flow in the river will address this concern.

The project will compete with the use of water especially during dry season based on the calculation of 80% dependable flow. To support the flora and fauna in the river, environmental flows of 1.33 m3/s during wet season and 0.47 m3/s during dry season should be maintaiined in the river.

Change in Stream/ Water Depth

To prevent damages upstream of the dam because of the permanent inundation, locals living within the identified areas to be inundated will be relocated.

Any significant change in stream or water depths during operation should be noted and the approved operation rule curve should always be followed. Spillways should be operated in such a way that it prevents upstream and downstream flooding during unwarranted peak flows. reservoir water level should be considered in the operation to maintain the elevation between minimum and maximum pool level.

To ensure ecological sustainability, a flow at least equal to the minimum environmental flow amounting to 1.33 m3/s during wet season and 0.47 m3/s during dry season has to be released all the time to the downstream reach of the diversion point.

Depletion of Water Resources/ Competition in Water use

Aside from the dependable flows, NWRB is considering all water users within the basin in granting water rights for applicants of surfacewater for hydropower project. **Table EW-10** in **Section 2.1.3.5** presents the major and current water users within the study area. These will be regarded in this study to account the competition in water use. It is also worth noting that the major and current water users within the Wawa River basin are located downstream of the diversion point.

The project will not compete with water use during wet season, however, there will be no water available for extraction during dry season. Ensuring ecological sustainability should be considered at all times by maintaining environmental flows in the river.

Occurrence or Aggravation of Flooding in nearby Areas

Even if flood control is an intended consequence of the project, flooding in addition to the expected inundation upstream of the dam may still occur when the spillway is unable to discharge excess water during unwarranted peak flows. To mitigate this, the spillways should be designed based from the probable maximum flood to accommodate and convey all excess inflows into the reservoir so as to prevent flooding upstream or failure by dambreak.

There will be a very small chance of inundation downstream if the dam will be properly designed for flood control.

Sedimentation behind the Dam

Sedimentation affects the safety of dams and reduces energy production (if used for hydropower), storage, discharge capacity and flood attenuation capabilities. It increases loads on the dam and gates, damages mechanical equipment and creates other environmental impacts.

Many watershed experience increased erosion rates due to land use and other practices. Watershed management is the most widely used recommendation to address this environmental impact. Vegetative erosion control takes advantage of plants' natural ability to limit erosion. Also, agricultural practices that minimize sediment yield are also effective in providing adequate protection to the reservoir/riverbank.

Larger and heavier particles are deposited behind the dam duiring operation. Extraction of deposited coarse materials from the riverbed can be done from time to time to avoid excessive sedimentation.

Dredging can be efficient to remove sediment deposits but providing sediment trapping devices could be prioritized to avoid sediments depositing behind the dam.

Flushing sediments that involves the use of gated structures while maintaining river regime will be a good technique to mitigate sedimentation impact.

2.1.5 Monitoring Plan for Hydrology

Based on the assessment of the project impacts and concerns on the hydrology and water resources, there are only two significant impacts on the surface water due to the project. These major possible impacts are on flooding and drainage morphology.

The major impact on flooding during the construction stage is mitigated by the construction of cofferdams and river diversions which are designed the with adequate capacity (designed based on the 20-yr Return Period) to convey peak flows. On the other hand, the major impact on flooding during the operation stage is mitigated by the construction of spillway that can discharge excess water based on the design of probable maximum flood.

The project will be beneficial to control flooding since there is a flood control component. This way, the dam will impound floodwaters and then either release them under control to the downstream side of the dam or store or divert the water for other beneficial uses. It is a known fact that dams are built to help control devastating floods. It will therefore be very useful on the part of the community who were devastated by the previous floods like the floods caused by typhoon Ondoy in 2009 since it will be the first ever dam to be constructed in the Upper Marikina River that has a flood control component. And since there is a flood control component, it would be a standard to establish a flood warning system.

It should be beneficial to the whole community in every aspect and to do this, its existence and objectives should be linked with all government agencies that are operating the current disaster management system. The project should be coordinated to augment existing procedures/facilities/development to promote improvement of the existing system.

The major impact on river and drainage morphology is mitigated by the provision of sediment traps during the construction stage of the hydropower plant and its appurtenant structures, release of the minimum environmental flows, and proper operation of the facility.

The impact on the surface water requirement during operation and depletion of water resources are assessed and will be based on the requirements of NWRB.

Summary of the environmental monitoring plan for hydrology consists of the following:

- Construction Phase – water level will be monitored daily at the diversion point using water level meter in order to comply in water requirements. The discharge of springs and current of the river at the diversion point will be checked daily through the use current meter and rating curve.
- Operation Phase – a water level meter will be used every day to determine and monitor the water levels at the upstream and downstream of the diversion point in the reservoir. A current meter and rating curve will be used every day to monitor the discharge of springs and current of water at the upstream and downstream of the diversion point in the reservoir. An automatic recording rain gauge will be used to record the amount of rainfall around the diversion point.

2.2 Water Quality

2.2.1 Scope

This section describes the physical and chemical characteristics of the water quality in the Boso Boso, Montalban, Payagwan, Sapa Bute Bute, Tayabasan and Wawa rivers. The objective of the survey was to provide baseline information regarding the conditions of the watercourses using the DENR standard methods and procedures for sampling and analysis. The impact assessment will determine the potential impacts from the project and its activities to surface water and groundwater quality.

2.2.2 Methodology

Samples from surface water and groundwater were taken at various locations to obtain the baseline date for the existing water quality in the proposed project area. Considering the location of sampling stations and the general conditions of the project site, the water quality survey were carried out in two (2) occasions – the first set of water samples was collected during wet season in June, July, August 2019 and September 2020, and the second set of water samples was collected in November and December 2019, during dry season.

2.2.2.1 Surface Water Sampling Stations

A total of eighteen (18) sampling stations were established during wet season and eleven (11) stations during dry season at the proposed project site.

Rivers	No. of Stations (Wet Season)	No of Stations (Dry Season)
Boso Boso River	3	2
Montalban River	6	2
Payagwan River	1	1
Sapa Bute Bute River	2	1
Tayabasan River	3	2
Wawa River	3	3

Eleven (11) stations were covered during dry season because the accessibility of the stations that were not covered was determined to be risky during the sampling period in wet season, which was conducted beforehand. To ensure the water quality that will be delivered by the UWD Project, the Manila Water will be in-charge for water treatment before distributing to its consumers.

The locations of the surface water stations were selected taking into consideration the location of the structures and the upstream and downstream sections of these structures. **Table EW-22** provides the geographical coordinates and description of the sampling stations and **Figure EW-19** presents the stations with their site photographs.

Table EW-22
Description of Surface Water Sampling Stations

Sampling Station	Geographic Coordinates	Location Description	Site Photographs
SW1	14°40'10.66"N 121°14'4.76"E	Located at Payagwan river, a small river channel upstream of the Upper Wawa Dam (UWD) reservoir and approximately 4.81 kilometers southeast of the proposed UWD. Riparian vegetation was present in the area.	
SW2	14°39'44.76"N 121°13'26.10"E	Located at the upstream section of the Boso Boso river and upstream of the Upper Wawa Dam (UWD) reservoir. The location is approximately 4.76 kilometers southeast of the proposed UWD. Small rocks and vegetation were present in the area. An upleasant smell was also observed in the river.	
SW3	14°43'53.34"N 121°14'45.48"E	Located at the upstream section of the Montalban river and upstream of the Upper Wawa Dam (UWD) reservoir. The location is approximately 5.79 kilometers northeast of the proposed UWD. Small boulders and vegetation were present in the area.	
SW4	14°43'4.50"N 121°14'53.46"E	Located at the upstream section of the Sapa Bute Bute river and upstream of the Upper Wawa Dam (UWD) reservoir. The location is approximately 5.22 kilometers northeast of the proposed UWD. Small rocks and vegetation were observed in the area.	

Sampling Station	Geographic Coordinates	Location Description	Site Photographs
SW5	14°43'30.24"N 121°14'6.96"E	Located upstream of the confluence of the Montalban and Tayabasan rivers and part of the Upper Wawa Dam (UWD) reservoir. The location is approximately 4.41 kilometers northeast of the proposed UWD. Boulders and vegetation were observed in the area.	
SW6	14°42'7.58"N 121°11'59.67"E	Located in the proposed reservoir area and approximately 286 meters downstream of the proposed Upper Wawa Dam. The river is used for navigation and fishing. Small rocks and vegetation were observed in the area.	
SW7	14°42'5.79"N 121°12'31.99"E	Located in the Upper Wawa Dam (UWD) reservoir and approximately 726 meters upstream of the proposed UWD. The station is near Sitio Casili community	
SW8	14°42'25.80"N 121°13'2.95"E	Located 650 meters southeast of Sitio Anipa and located approximately 1.79 kilometers northeast of the proposed Upper Wawa Dam. The river is used for fishing and domestic purposes.	
SW9	14°42'37.92"N 121°11'54.66"E	Located at the Wawa river and approximately 1.2km northeast and downstream of the proposed Upper Wawa Dam. Small pebbles and vegetation were observed in the area.	

Sampling Station	Geographic Coordinates	Location Description	Site Photographs
SW10	14°42’28.90”N 121°12’40.47”E	Located approximately 207 meters southwest of Sitio Anipa and approximately 1.26 kilometers northeast of the proposed Upper Wawa Dam. The river is used for fishing and domestic purposes.	
SW11	14°41’55.46”N 121°12’48.47”E	Located downstream of the Boso Boso river and approximately 1.22 kilometers southeast of the proposed Upper Wawa Dam. The river has an unpleasant odor. Small pebbles and vegetation were observed in the area.	
SW12	14°41’21.91”N 121°12’56.10”E	Located in the middle portion of Boso Boso river and approximately 1.87 kilometers southeast of the proposed Upper Wawa Dam. Fishing was observed during the sampling.	
SW13	14°42’39.43”N 121°14’27.04”E	Located in the downstream section of the Sapa Bute Bute river and approximately 4.30 kilometers northeast of the proposed Upper Wawa Dam. Small boulders and vegetation were observed in the area.	
MON1	14°43'11.28"N 121°13'58.56"E	Located in the upstream section of the Montalban river and part of the inundated area of the Project. It is approximately 4.05 kilometers northeast of the proposed UWD. The water is used for fishing and domestic purposes.	

Sampling Station	Geographic Coordinates	Location Description	Site Photographs
MON2	14°42'45.06"N 121°13'44.46"E	Located in the upstream section of the Montalban River and part of the inundated area of the Project. It is approximately 3.32 kilometers northeast of the proposed UWD. The water is used for fishing and domestic purposes. Small rocks and vegetation were observed in the area.	
TAY1	14°42'47.87"N 121°14'3.43"E	Located in the downstream section of the Tayabasan River and part of the inundated area of the Project. It is approximately 3.83 kilometers northeast of the proposed UWD. The water is used for fishing and domestic purposes.	
TAY2	14°42'27.19" N 121°14'17.59" E	Located in the downstream section of the Tayabasan River and part of the inundated area of the Project. It is approximately 3.94 kilometers northeast of the proposed UWD. Boulders, pebbles and vegetation were observed in the area.	
TAY3	14°41'58.05" N 121°15'5.64" E	Located in the downstream section of the Tayabasan River and part of the inundated area of the Project. It is approximately 5.30 kilometers southeast of the proposed UWD. The water was used for fishing and domestic purposes. Riparian vegetation was present in the area.	

2.2.1.2 Surface Water Sampling Methods

Apercu engaged the services of DENR accredited CRL Environmental Corporation Laboratory and Ostrea Mineral Laboratories, Inc. in analyzing the samples collected on site. Laboratory certificates are presented as **Annex E**. Parameters and methods of analysis for water samples are presented in **Table EW-23**.

Kindly note that the Station SW9 dry season lab result is labeled as SW13 and Stations TAY 1, TAY 2, TAY3, MON1 and MON2 wet season lab results is labeled as FW3, FW4, FW5, FW1 and FW2, respectively, in the official lab certificates.

Table EW-23
Analytical Methods for Surface Water Samples

Parameters	Equipment/ Method of Analysis
In Situ Parameters	
pH	pH Meter
Temperature	YSI550A DO meter
DO	YSI550A DO meter
Turbidity	Turbidity Meter
Conductivity	pH Meter
Laboratory Analyzed Parameters	
Biological Oxygen Demand (BOD)	Azide Modification Winkler (SM 5210 B)
Chemical Oxygen Demand (COD)	Open Reflux Method (SM 5220 B)
Total Dissolved Solids (TDS)	Gravimetric (SM2540 C)
Total Suspended Solids (TSS)	Gravimetric (SM2540 D)
Oil and Grease	Gravimetric (n-Hexane Extraction) (SM 5220 B)
Chloride	Argentometric Method (SM4500 Cl-B)
Fluoride	SPADNS Method (SM4500-F D)
Fecal Coliform	Multiple Tube Fermentation Technique (SM9221 E)
Total Coliform	Multiple Tube Fermentation Technique (SM9221 B)
Iron	ICP - OES
Phosphate	Stannous Chloride Method (SM 4500 P D)
Nitrate	Colorimetry – Brucine (EPA 352.1)

In situ measurements for temperature, DO, pH, turbidity and conductivity were taken and done with three (3) trials in each of the stations to average the result.

Boso Boso River, Montalban River, Payagwan River, Sapa Bute Bute River, Tayabasan River and Wawa River (Project site location) are categorized as Class C under the DENR List of Water Bodies[1] since these rivers are used for fishing and domestic purposes such as washing clothes, cleaning dishes and gardening. These activities were confirmed as being undertaken by the residents during the site visit. The recorded water depth during the wet season was more than 6ft while during the dry season, it was about 3ft.

Careful sampling procedures were followed to avoid cross contamination of the samples. All samples were stored in a closed container and cooled to about 6˚C with ice. Samples were picked up by the laboratory, taking into consideration the holding time of each parameter.

[1] http://water.emb.gov.ph/?page_id=761

Results of *in situ* measurements and laboratory analyses of water samples collected were compared with the DENR Administrative Order No. 2016-08 (DAO 2016-08) Clean Water Act standard for Class C waters (**Table EW-24).**

Table EW-24
DENR Class C Standards for Surface Water Parameters

Parameters	Unit	DENR Class C Standards
pH		6.5 – 9.0
Temperature	°C	25.0 – 31.0
DO (minimum)	mg/L	5.0
Turbidity	NTU	-
Conductivity	µS/cm	-
Biological Oxygen Demand (BOD)	mg/L	7.0
Chemical Oxygen Demand	mg/L	-
Total Dissolved Solids (TDS)	mg/L	-
Total Suspended Solids (TSS)	mg/L	80
Oil and Grease	mg/L	2.0
Chloride	mg/L	350
Fluoride	mg/L	1
Fecal Coliform	MPN/100mL	200
Total Coliform	MPN/100mL	-
Iron	mg/L	1.5
Phosphate	mg/L	0.5
Nitrate	mg/L	7

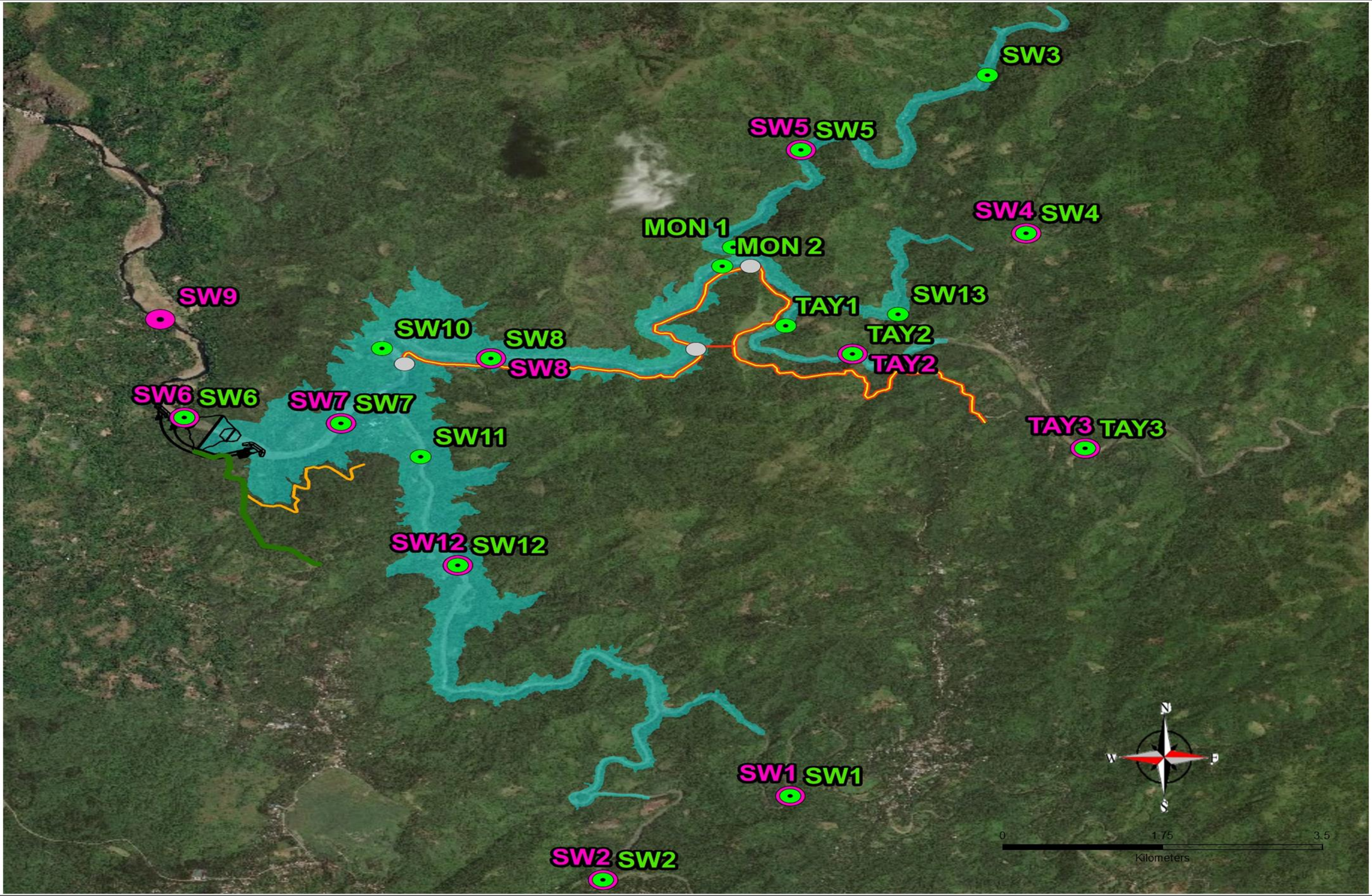


Figure EW-19. Surface Water Quality Stations

ENVIRONMENTAL IMPACT STATEMENT
WATER MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

Legend
- Pump Station
- Transmission Pipeline via Tunnel Optional
- UWD Optional Access Road (New)
- UWD Access Road (Original)
- Access Road to WTP / Transmission Pipe
- UWD Dam and Diversion Tunnel
- Transmission / Water Conveyance Pipeline
- UWD Reservoir
- Dry Season Stations
- Wet Season Stations

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCO, Inc. (2020)
Basemap: ArcGIS Imagery, 2020
Created by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.
aperçu CONSULTANTS INC.

SCALE: 1: 30,000 | PAGE: 247

2.2.1.3 Groundwater Sampling Stations

Four (4) sampling stations were established for groundwater quality during the wet and dry seasons. Groundwater samples were collected from identified springs and deep well pumps in the vicinity of the Project site.

Table EW-25 provides a description of the sampling stations with site photographs and **Figure EW-20** presents the location in relation to the project facilities.

Table EW-25
Description of Groundwater Sampling Stations

Sampling Station	Geographic Coordinates	Location Description	Site Photos
GW1	14°39'25.56"N 121°13'54.42"E	Located in the Binayoyo Elementary School. An electronic pump that is used for washing clothes, dishes, gardening etc.	
GW2	14°42'31.56"N 121°14'49.98"E	Located in Sitio Apia, Barangay Calawis. Water is used for washing, cooking and drinking.	
GW3	14°42'11.16"N 121°12'31.80"E	A spring water located in Sitio Casili, Barangay Pintong Bukawe. Water is mainly used for drinking by the residents.	
GW4	14°42'34.74"N 121°12'45.00"E	A spring water located in Sitio Anipa, Barangay San Rafael. Water is mainly used for drinking by the residents.	

2.2.1.4 Groundwater Sampling Methods

Groundwater samples were collected and analyzed by CRL Laboratory for BOD, COD, TDS, TSS, Oil & Grease, chloride, fluoride, fecal and total coliform, iron, phosphate and nitrate while *in situ* testing was done for pH, temperature, DO, turbidity and conductivity. Laboratory certificates are presented as **Annex E**.

Results were then compared to the 2007 Philippine National Standards for Drinking Water (PNSDW) Guidelines for Drinking Water listed in **Table EW-26**.

Table EW-26
Standard Values for Physical and Chemical Quality of Groundwater Samples

Parameters	PNSDW Standards	Equipment/ Method of Analysis
pH	6.5 – 8.5	pH meter
Temperature	-	YSI550A DO Meter
BOD	-	Azide Modification Winkler (SM 5210 B)
COD	-	Open Reflux Method (SM 5220 B)
TDS	500mg/L	Gravimetric (SM2540 C)
TSS	-	Gravimetric (SM2540 D)
Oil and Grease	-	Gravimetric (n-Hexane Extraction) (SM 5520 B)
Chloride	250mg/L	Argentometric Method (SM4500 Cl-B)
Fluoride	1mg/L	SPADNS Method (SM4500-F D)
Fecal Coliform	-	Multiple Tube Fermentation Technique (SM9221 E)
Total Coliform	-	Multiple Tube Fermentation Technique (SM9221 B)
Iron	1mg/L	ICP - OES
Phosphate	0.5mg/L	Stannous Chloride Method (SM 4500 P D)
Nitrate	50mg/L	Cadmium Reduction Method

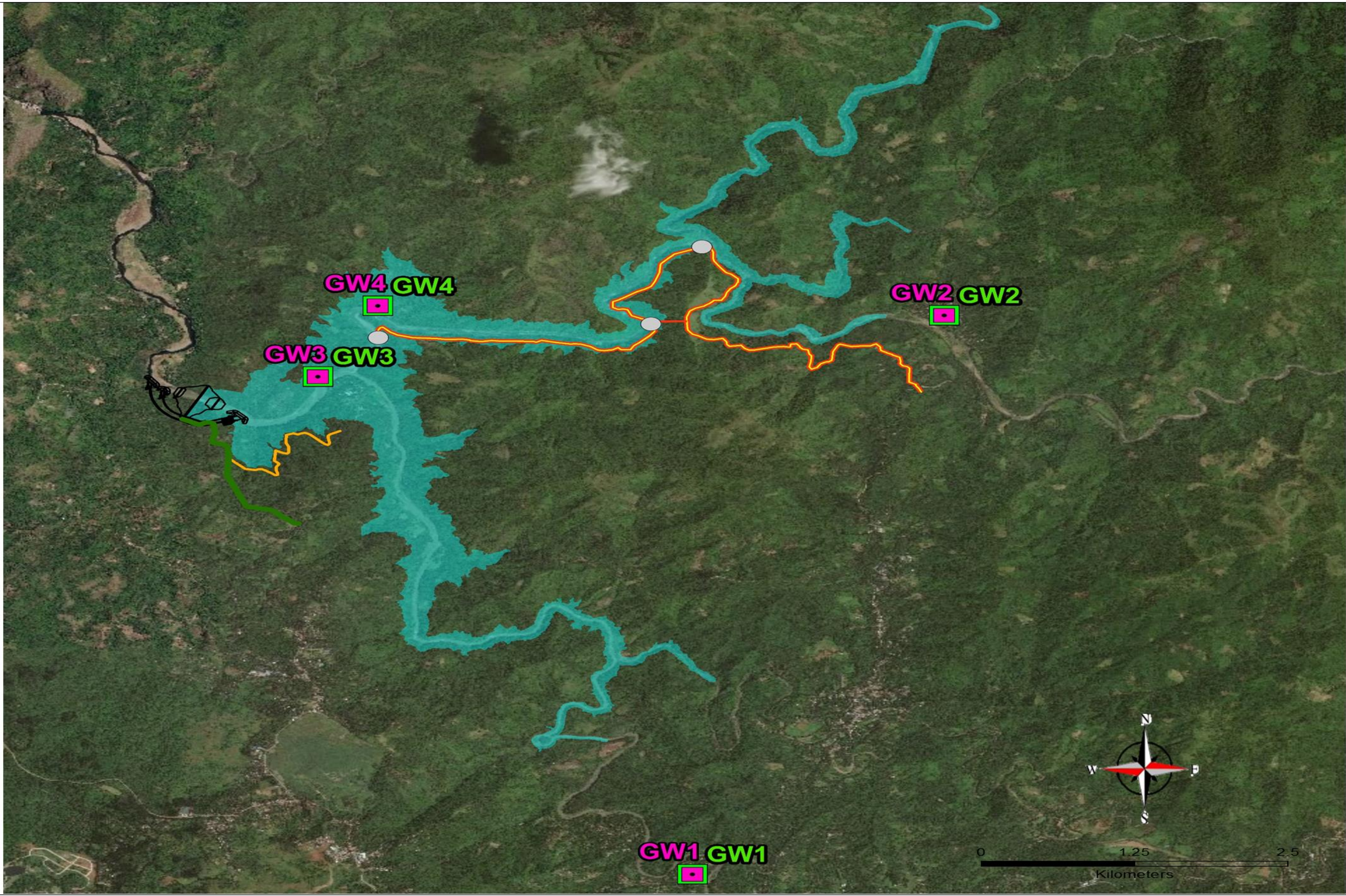


Figure EW-20. Groundwater Quality Stations

ENVIRONMENTAL IMPACT STATEMENT
WATER MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

Legend
- Pump Station
- Transmission Pipeline via Tunnel Optional
- UWD Optional Access Road (New)
- UWD Access Road (Original)
- Access Road to WTP / Transmission Pipe
- UWD Dam and Diversion Tunnel
- Transmission / Water Conveyance Pipeline
- UWD Reservoir
- Dry Season Stations
- Wet Season Stations

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCO, Inc. (2020)
Basemap: ArcGIS Imagery, 2020
Created by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.
aperçu CONSULTANTS INC.

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2.2.3 Existing Conditions

2.2.3.1 Surface Water Quality Results

The results of the *in-situ* measurements are presented in **Table EW-27,** while the results of samples analyzed at the laboratory are provided in **Table EW-28**.

Table EW-27
Results of In-situ Testing (Surface Water)

Sampling Stations	River	Season	pH	Temperature (°C)	DO (mg/L)	Turbidity (NTU)	Conductivity (µS/m)
SW1	P River	Wet	7	25.27	7.61	5.84	0.25
		Dry	7.7	26.80	12.09	3.3	0.22
SW2	BS River	Wet	7.3	26.03	7.02	12.01	0.49
		Dry	7.6	27.30	10.36	7	0.56
SW3	M River	Wet	7.3	23.9	9.01	2.94	0.2
		Dry	-	-	-	-	-
SW4	SB River	Wet	8.35	25.23	7.8	8.97	0.21
		Dry	7.5	23.9	21.06	0	0.23
SW5	M River	Wet	8.39	24.77	7.6	2.9	0.25
		Dry	7.6	23.60	27.73	0	0.20
SW6	W River	Wet	8.27	24.4	9.5	23.91	0.16
		Dry	7.5	27.80	9.29	3	0.24
SW7	W River	Wet	8.41	24.3	8.5	0	0.21
		Dry	7.8	26.50	12.77	1.5	0.24
SW8	M River	Wet	7.4	24.5	8.72	0	0.17
		Dry	7.7	25.30	12.63	2.5	0.21
SW9*	W River	Wet	7.55	27.1	8.9	332	8.23
		Dry	7.8	27.10	12.2	1.60	0.26
SW10	M River	Wet	7.3	23.93	8.54	4.46	0.21
		Dry	-	-	-	-	-
SW11	BS River	Wet	7.2	24.13	8.48	43.66	0.21
		Dry	-	-	-	-	-
SW12	BS River	Wet	8.2	25	8.8	58.33	0.26
		Dry	7.5	27.50	12.19	3.9	0.39
SW13	SB River	Wet	8.28	24.33	7.29	0	0.21
		Dry	-	-	-	-	-
MON1*	M River	Wet	8.18	28.80	8.1	13.28	0.25
		Dry	-	-	-	-	-
MON2*	M River	Wet	8.23	29.01	8.26	7.90	0.22
		Dry	-	-	-	-	-
TAY1*	T River	Wet	8.4	28.67	7.8	3.47	0.24
		Dry	-	-	-	-	-
TAY2*	T River	Wet	8.31	26.63	8.5	7.10	0.25
		Dry	7.6	24.10	12.92	2.9	0.22
TAY3*	T River	Wet	7	29.20	7.64	7.93	0.33
		Dry	7.8	24.90	11.7	1.9	0.21
DENR Standard Class C			**6.5 – 9.0**	**25.0 – 31.0**	**Min. of 5.0**	**-**	**-**

Note: BS = Boso boso River SB = Sapa Bute bute River P = Payagwan River W = Wawa River
M = Montalban River T = Tayabasan River

**Kindly note that the Station SW9 dry season lab result is labeled as SW13 and Stations TAY 1, TAY 2, TAY3, MON1 and MON2 wet season lab results is labeled as FW3, FW4, FW5, FW1 and FW2, respectively, in the official lab certificates.*

pH

Levels of pH in all stations ranged from 7 to 8.41 during the wet season and 7.50 to 7.80 during the dry season. pH levels during wet season were slightly higher than that during the dry season and slightly alkaline. The values recorded in all stations conformed to the prescribed DENR range of 6.5 to 9.0 (**Figure EW-21**).

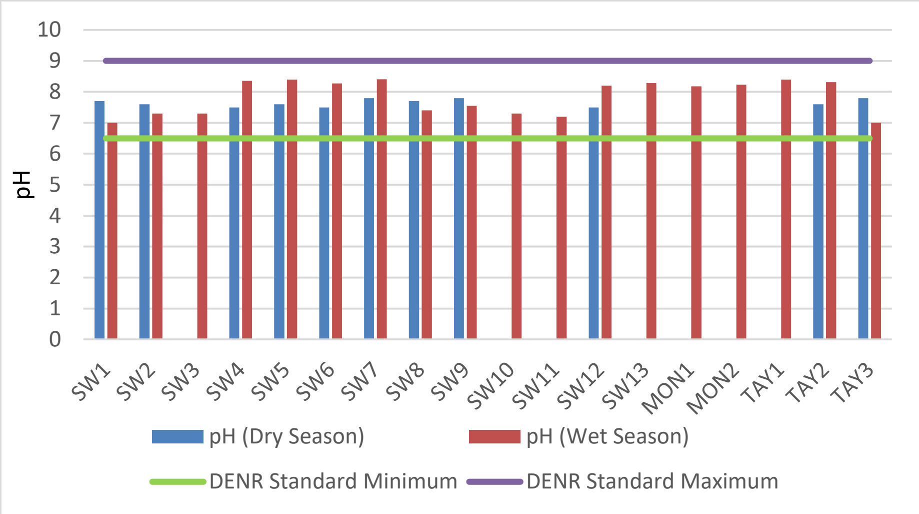


Figure EW-21. pH Levels during the Dry and Wet Seasons in all Stations

Water Temperature

Water temperatures ranged from 23.6°C to 27.80°C during the dry season and 23.90°C to 29.20°C during the wet season (**Figure EW-22**). During the dry season, Stations SW4 (Sapa Bute bute river), SW5 (Montalban river), TAY2 and TAY3 (Tayabasan river) were below with the DENR minimum standard of 25°C with values 23.90°C, 23.60°C. 24.10°C and 24.90°C, respectively. For the wet season, stations with temperatures below the DENR Standards were Stations SW3, SW5, SW8, SW10 (Montalban river), SW6, SW7 (Wawa river), SW11 (Boso Boso river) and SW13 (Sapa Bute Bute river) with values 23.90°C, 24.77°C, 24.50°C, 23.93°C, 24.40°C, 24.30°C, 24.13°C and 24.33°C, respectively.

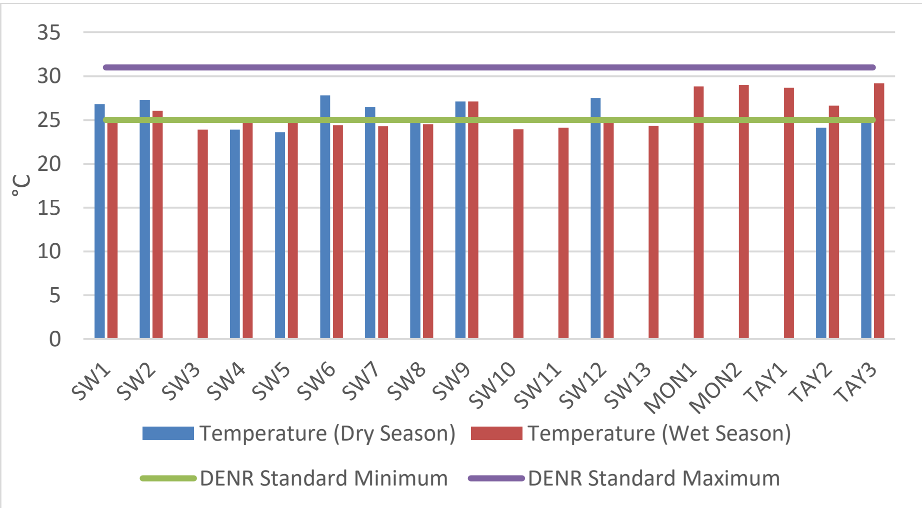


Figure EW-22. Temperature Values During the Dry and Wet Seasons in all Stations

Dissolved Oxygen

DO levels ranged from 7.02mg/L to 9.5m/L during the wet season and 9.29mg/L to 27.73mg/L during the dry season. The lowest DO reading was recorded during the wet season at 7.02mg/L in Station SW2 (Boso Boso river) but still conforms with the DENR Standard of the min. 5mg/L **Figure EW-23** presents the trend of DO levels in all the stations.

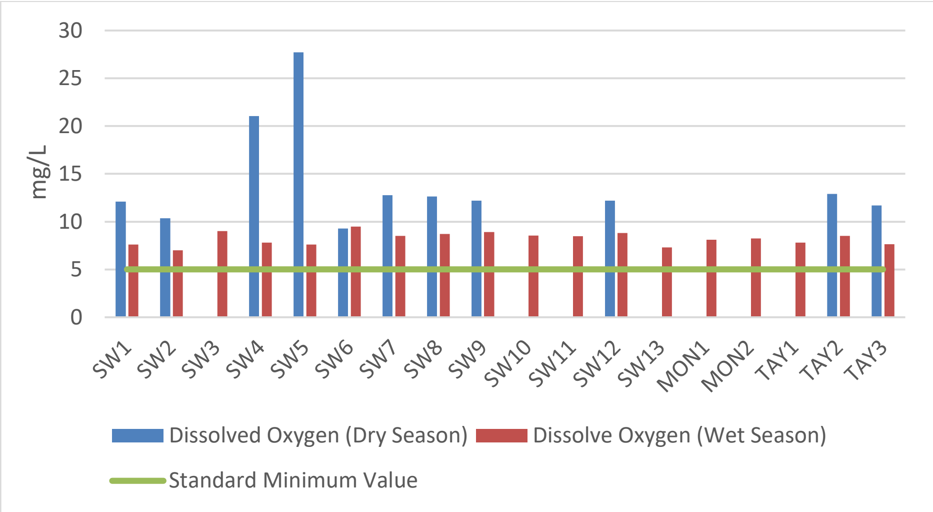


Figure EW-23. DO Levels During the Dry and Wet Seasons in all Stations

Turbidity

Turbidity levels recorded during the dry season ranged from 0 NTU to 3.90 NTU and 0 NTU to 332 NTU during the wet season (**Figure EW-24**). The highest value recorded during the dry season was in Station SW12 (Boso Boso river) and the lowest were in Stations SW4 (Sapa Bute Bute river) and SW5 (Montalban river). For the wet season, the highest value recorded was in Station SW9 (Wawa river) and the lowest were recorded in Stations SW7 (Wawa river), SW8 (Montalban river) and SW13 (Sapa Bute Bute river). There is no DENR standard for turbidity.

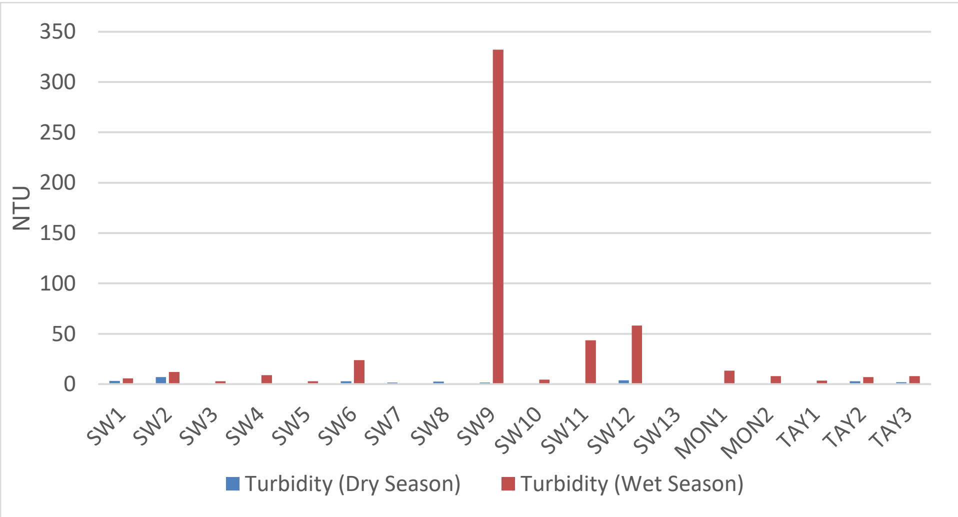


Figure EW-24. Turbidity Levels During the Dry and Wet Seasons in all Stations

Conductivity

Conductivity levels recorded during the dry season ranged from 0.20 μS/m to 0.56 μS/m and from 0.16μS/m to 8.23μS/m during the wet season. The highest value recorded during the dry season was in Station SW2 Station (Boso Boso river and the lowest was recorded in Station SW5 (Montalban river). For the wet season, SW9 (Wawa river) also had the highest value similar to the dry season results. The lowest was recorded in Station SW6 (Wawa river). There is likewise no DENR standard for conductivity. Variations in the conductivity levels of all the stations are shown in **Figure EW-25**.

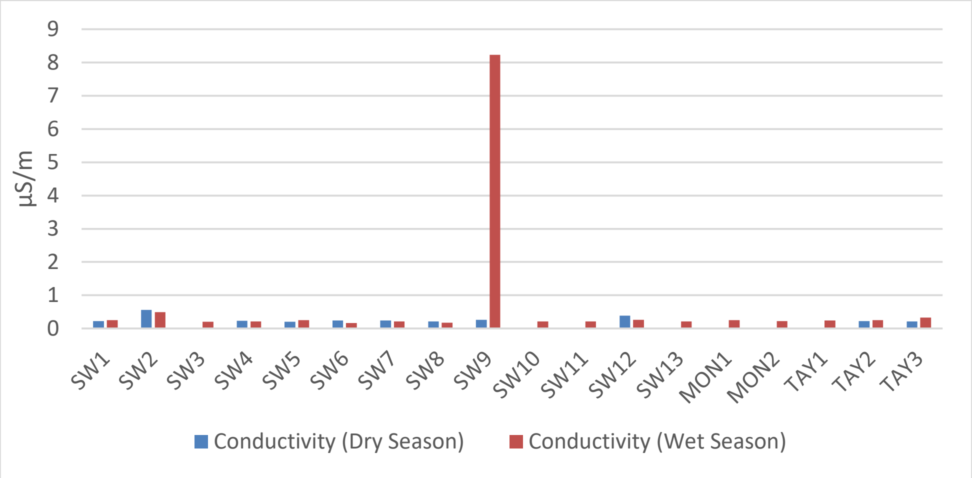


Figure EW-25 Conductivity Levels During Dry and Wet Seasons in all Stations

Table EW-28
Water Quality Laboratory Results

Sampling Stations	River	Season	BOD, mg/L	Iron mg/L	Phosphate mg/L	Nitrate mg/L	TDS, mg/L	TSS, mg/L	Oil & Grease, mg/L	Fluoride, mg/L	Fecal Coliform, MPN/100mL
SW1	P River	Wet	1	0.05	0.04	0.09	164	6	0.51	<0.02	2,400
		Dry	1	-	-	-	155	6.5	0.52	0.06	170
SW2	BS River	Wet	3	0.4	6.2	1.0	325	28	0.61	<0.02	3,500
		Dry	11	-	-	-	350	13	3.1	0.3	240
SW3	M River	Wet	2	0.06	0.02	0.1	145	3	0.41	<0.02	79
		Dry	-	-	-	-	-	-	-	-	-
SW4	SB River	Wet	1	0.04	0.04	<0.017	152	4	0.41	<0.02	2,400
		Dry	<1	-	-	-	172	5.5	0.51	<0.02	540
SW5	M River	Wet	1	0.04	0.02	0.2	146	<2.5	0.42	<0.02	49
		Dry	<1	-	-	-	139	7	0.61	<0.02	240
SW6	W River	Wet	1	0.04	0.3	0.2	139	30	0.61	0.02	240,000
		Dry	3	-	-	-	191	7	0.51	0.03	540
SW7	W River	Wet	1	0.03	0.3	0.2	126	25	0.71	0.1	24,000
		Dry	3	-	-	-	185	3.5	0.61	0.03	920
SW8	M River	Wet	2	0.03	<0.0064	<0.017	120	12	0.52	<0.02	3,500
		Dry	1	-	-	-	148	17	0.61	<0.02	2,400
SW9	W River	Wet	13	0.04	0.3	<0.017	149	367	0.65	0.08	54,000,000
		Dry	1	-	-	-	182	8	0.61	<0.02	2,400
SW10	M River	Wet	1	0.03	<0.0064	<0.017	132	11	1.5	0.3	24,000
		Dry	-	-	-	-	-	-	-	-	-
SW11	BS River	Wet	4	0.2	2.5	1.7	163	58	0.82	0.5	24,000
		Dry	-	-	-	-	-	-	-	-	-
SW12	BS River	Wet	5	0.2	2.6	2.1	166	110	0.6	0.7	35,000
		Dry	9	-	-	-	265	11	0.83	0.03	130

Sampling Stations	River	Season	BOD, mg/L	Iron mg/L	Phosphate mg/L	Nitrate mg/L	TDS, mg/L	TSS, mg/L	Oil & Grease, mg/L	Fluoride, mg/L	Fecal Coliform, MPN/100mL
SW13	SB River	Wet	1	0.04	0.03	<0.017	160	<2.5	0.51	<0.02	920
		Dry	-	-	-	-	-	-	-	-	-
MON1	M River	Wet	1	0.1	0.02	0.08	149	7	<1.0	0.1	350
		Dry	-	-	-	-	-	-	-	-	-
MON2	M River	Wet	1	0.06	0.02	0.9	155	8	<1.0	0.1	1,600
		Dry	-	-	-	-	-	-	-	-	-
TAY1	T River	Wet	1	0.04	0.008	<0.017	165	2	<1.0	0.1	920
		Dry	-	-	-	-	-	-	-	-	-
TAY2	T River	Wet	1	0.04	<0.0064	<0.017	158	6	<1.0	0.1	3,500
		Dry	<1	-	-	-	154	4.5	0.52	<0.02	68
TAY3	T River	Wet	2	0.05	0.01	0.2	164	6	<1.0	0.1	540
		Dry	<1	-	-	-	164	3.5	0.62	0.5	23
DENR Standard Class C			**7**	**1.5**	**0.5**	**7**	**-**	**80**	**2**	**1**	**200**

Note: BS = Boso boso River; M = Montalban River; P = Payagwan River; SB = Sapa Bute bute River; T = Tayabasan River; W = Wawa River

Biological Oxygen Demand (BOD)

BOD levels during the dry season ranged from less than 1.0mg/L to 11mg/L and from 1.0mg/L to 13mg/L during the wet season. The highest readings were recorded in Stations SW2 and SW12 (Boso Boso River), during dry season at 11mg/L and 9mg/L, respectively and Station SW9 (Wawa River), during wet season at 13mg/L (**Figure EW-26**). Exceedances to the DENR limit of 7.0mg/L is caused by the piggery located along the Boso Boso river that discharges effluents in the river while exceedance along Wawa River is caused by the runoffs of discharges effluents from Boso Boso River. A moderate precipitation was occurring during the sampling period in wet season. Also, Boso Boso river flows downstream to the Wawa river which may have contributed to the recorded levels of BOD levels in the Station SW9 during wet season. Also, moderate precipitation may also contribute to the high concentration level in the stations as it increases runoffs.

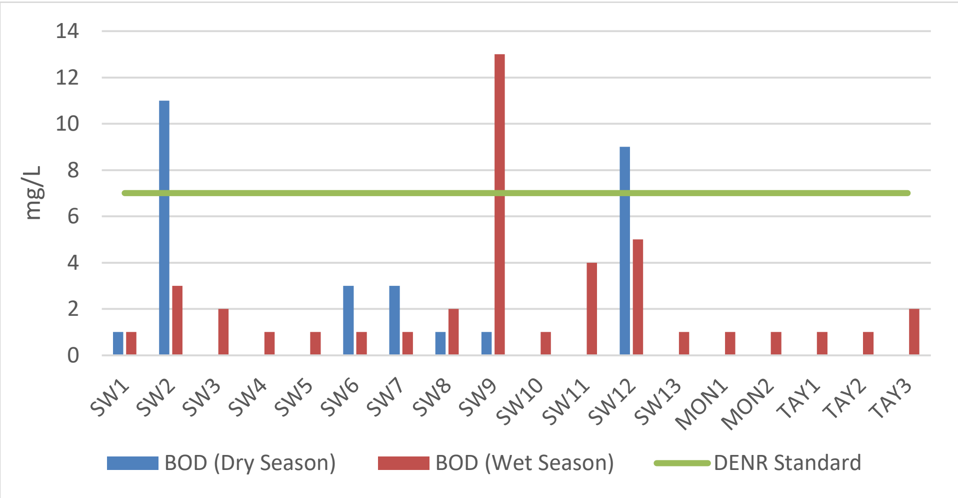


Figure EW-26. BOD Levels During the Dry and Wet Seasons in all Stations

Total Dissolved Solids (TDS)

Recorded TDS levels during the dry season ranged from 139mg/L to 350mg/L and from 120mg/L to 325mg/L during the wet season (**Figure EW-27**). The highest TDS level during the dry season was recorded in Station SW2, which is located in Boso Boso river and the lowest was recorded in Station SW5 which is located in Montalban river. For wet season, Station SW2 also had the highest TDS level reading while the lowest was recorded in Station SW12 which is also located in Montalban river. There is no DENR standard for TDS.

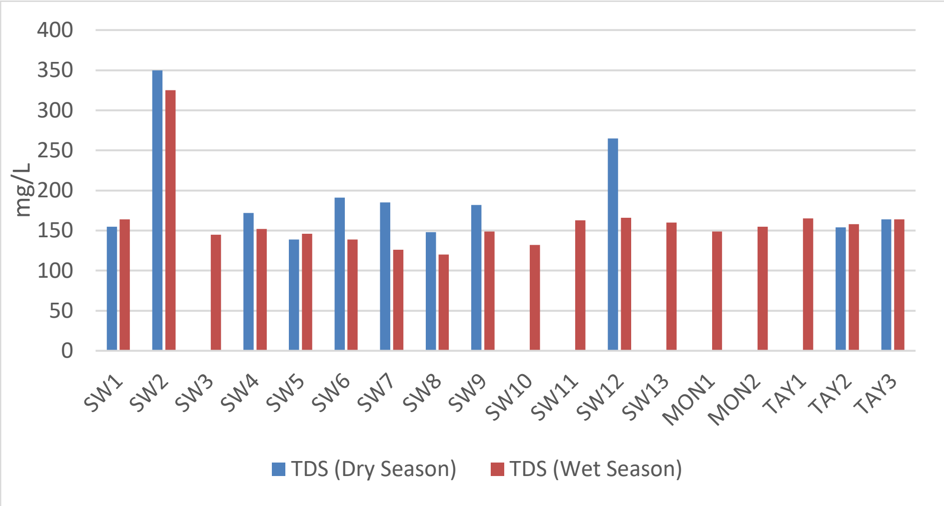


Figure EW-27. TDS Levels During the Dry and Wet Seasons in all Stations

Oil & Grease

Oil & grease levels during the dry season ranged from 0.51mg/L to 3.10 mg/L and from 0.41mg/L to 1.5mg/L during the wet season (**Figure EW-28**). Only one station did not comply with the DENR standard of 2.0mg/L, which is Station SW2 (Boso Boso river) at 3.10mg/L. Observed exceedance is caused by the piggery along the Boso Boso river that discharges wastes into the river.

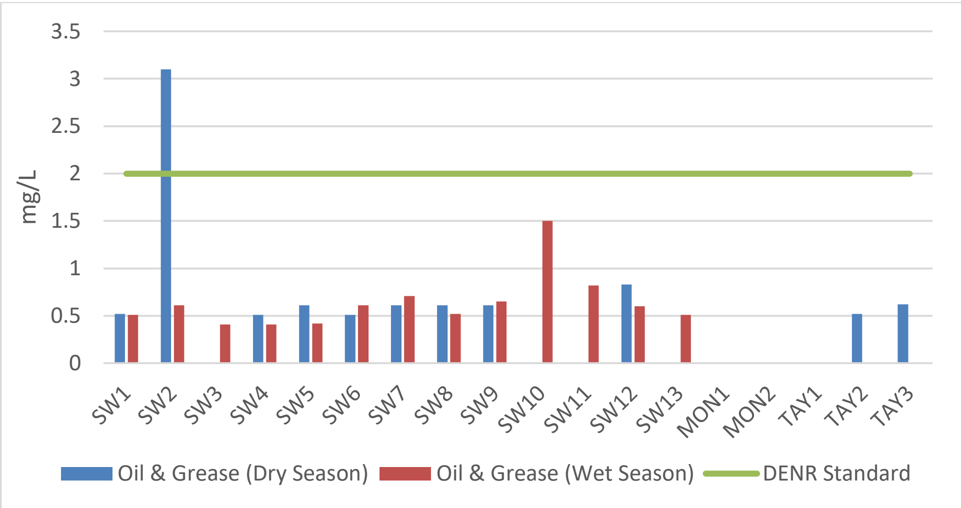


Figure EW-28. Oil & Grease Levels During Dry and Wet Season in all Stations

Total Suspended Solids (TSS)

TSS levels during the dry season ranged from 3.50mg/L to 17.0mg/L while from 2.0mg/L to 367.0mg/L during the wet season (**Figure EW-29**). Two station exceeded the DENR standard of 80.0mg/L, which is Station SW9 (located in Wawa river) and SW12 (located in Boso Boso river) during wet season, with recorded values at 367.0mg/L and 110.0mg/, respectively. The observed exceedance is caused by the nearby piggery that discharges effluents along the Boso Boso river that flows downstream to the Wawa River. Other stations had TSS values below the limit.

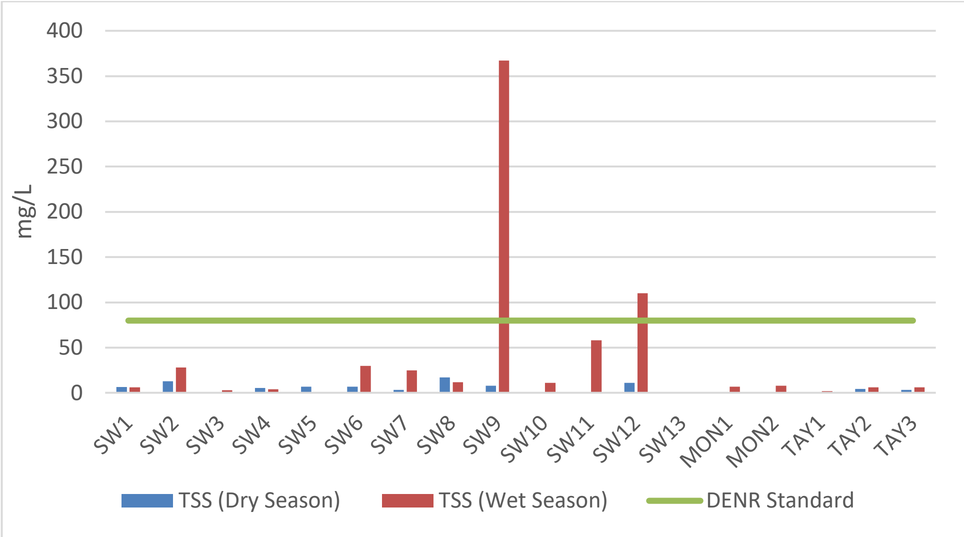


Figure EW-29. TSS Levels During the Dry and Wet Seasons in all Stations

Fluoride

Recorded values of fluoride during the dry and wet seasons were all way below the DENR Standard of 1.0 mg/L, with values ranging from less than 0.02mg/L to 0.50mg/L and from 0.02mg/L to 0.7mg/L, respectively (**Figure EW-30**).

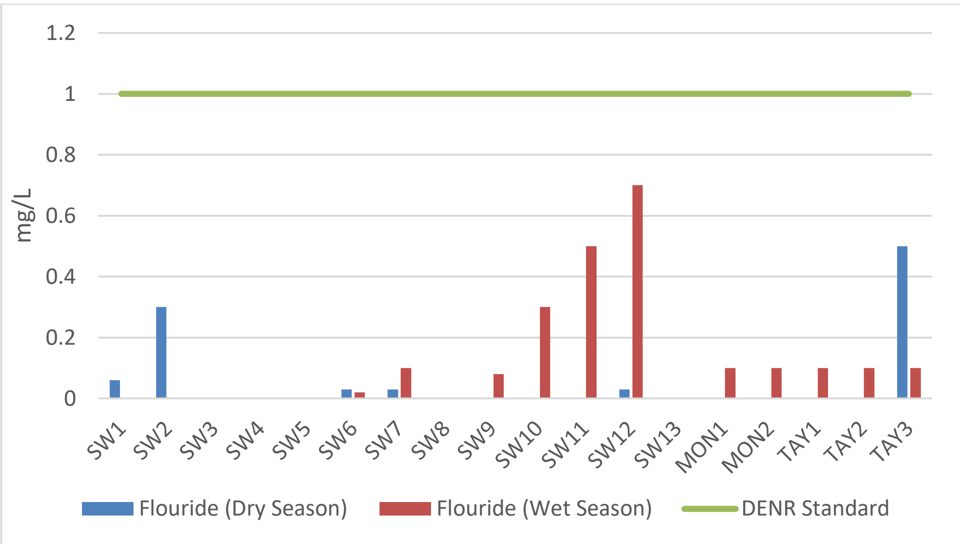


Figure EW-30. Fluoride Values During the Dry and Wet Seasons in all Stations

Fecal Coliform

Fecal coliform levels during the dry season ranged from 23 MPN/100mL to 2,400 MPN/100mL and from 49.0 MPN/100mL to 54,000,000 MPN/100mL during the wet season (**Figure EW-31)**. Only Stations SW1, SW12, TAY2 and TAY3 during the dry season and SW3 and SW5 during the wet season complied with the DENR Standard of 200 MPN/100mL. The highest recorded value was observed in Stations SW8 (Montalban River) and SW9 (Wawa River) with the same value at 2,400 MPN/100mL during dry season and Station SW9 (Wawa River) at 54,000,000 MPN/100mL during the wet season. Recorded exceedances to the stations can be associated with the use of the rivers for domestic purposes such as bathing, washing clothes and washing dishes. There are communities present upstream, Sitio Anipa and Sitio Casili, that probably use the river for waste discharge. Also, a piggery along the Boso Boso river have probably contributed in the significant increase in fecal coliforms levels. Boso Boso river flows downstream to the Wawa river which may have contributed to the recorded levels of fecal coliform in the Station SW6 and SW9.

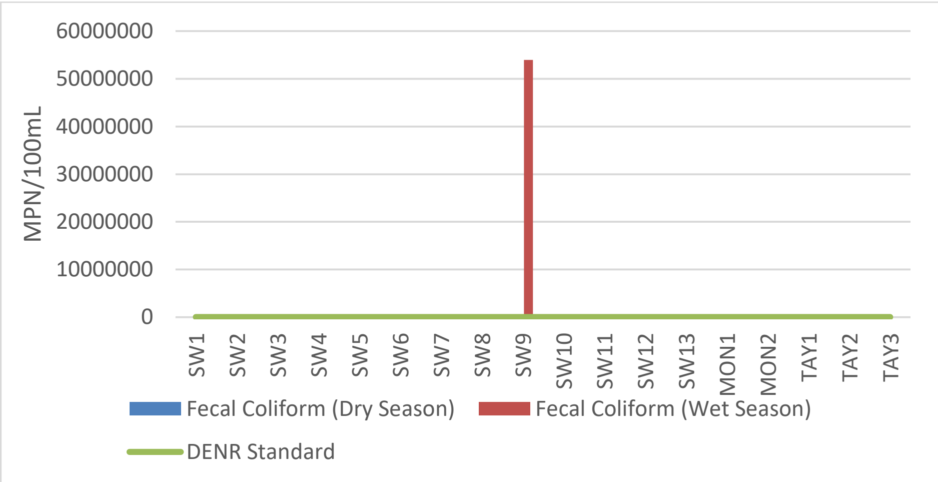


Figure EW-31. Fecal Coliform Levels During Dry and Wet Season in all Stations

Iron

Iron levels during the wet season ranged from 0.03 mg/L to 0.4 mg/L (**Figure EW-32)**. All stations during the wet season complied with the DENR Standard of 1.5 mg/L. Highest recorded Iron was in SW2 which is situated in Boso Boso River. No record for this parameter was established during dry season as the technical scoping was happened on May 2020 and the sampling time for dry season is conducted on December 2019.

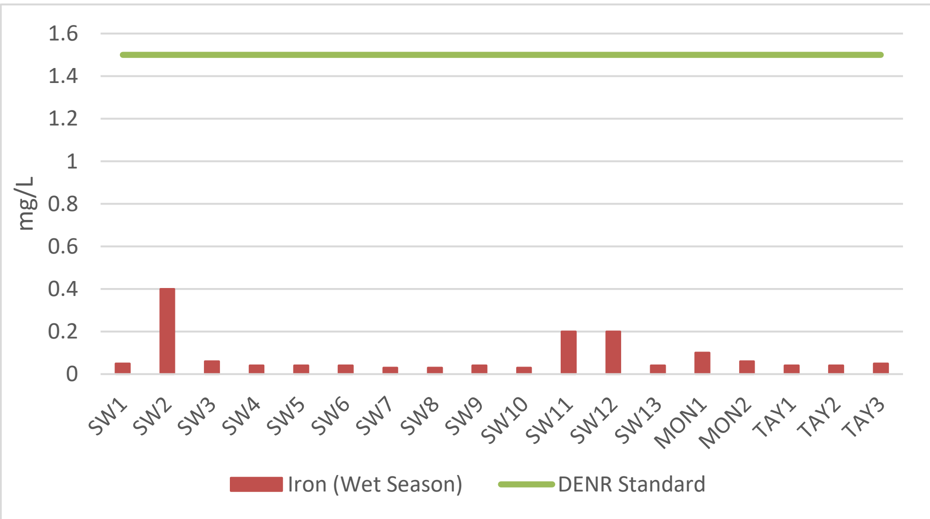


Figure EW-32. Iron Levels During Wet Season in all Stations

Phosphate

Phosphate levels during the wet season ranged from <0.0064 mg/L to 6.2 mg/L (**Figure EW-33)**. All stations except SW2, SW11and SW12 complied with the DENR Standard of 0.5 mg/L. Recorded exceedances to the stations can be associated with the use of the rivers for domestic purposes such as bathing, washing clothes and washing dishes. Also, moderate precipitation may also contribute to the high concentration level in the stations as it increases runoffs. No record for this parameter was established during dry season as the technical scoping was happened on May 2020 and the sampling time for dry season is conducted on December 2019.

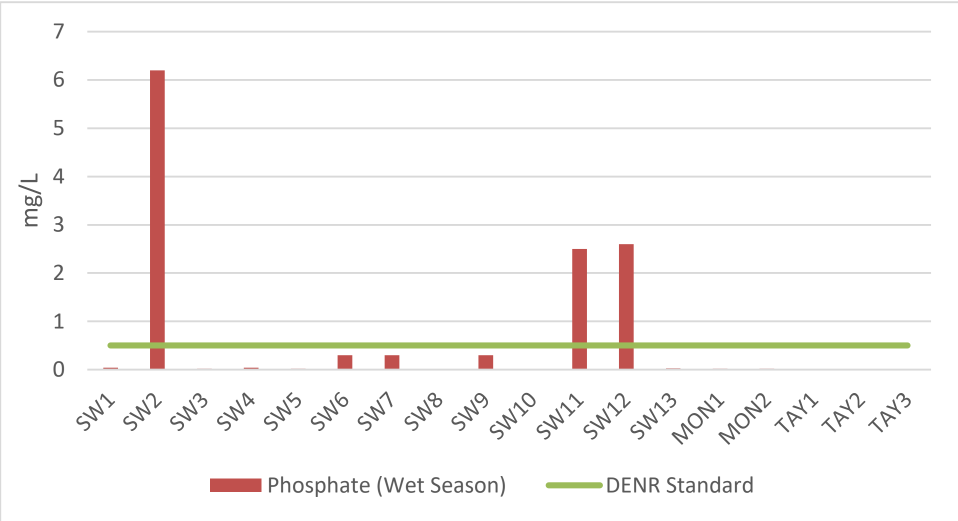


Figure EW-33. Phosphate Levels Wet Season in all Stations

Nitrate

Recorded values of nitrate during the wet season were all way below the DENR Standard of 7.0 mg/L, with values ranging from <0.017 to 2.1 mg/L (**Figure EW-34**). The highest chloride levels for wet season were recorded in Station SW12, which is located in Boso Boso river where there is a nearby piggery in the upstream section. No record for this parameter was established during dry season as the technical scoping was conducted on May 2020 and the sampling time for dry season is conducted on December 2019.

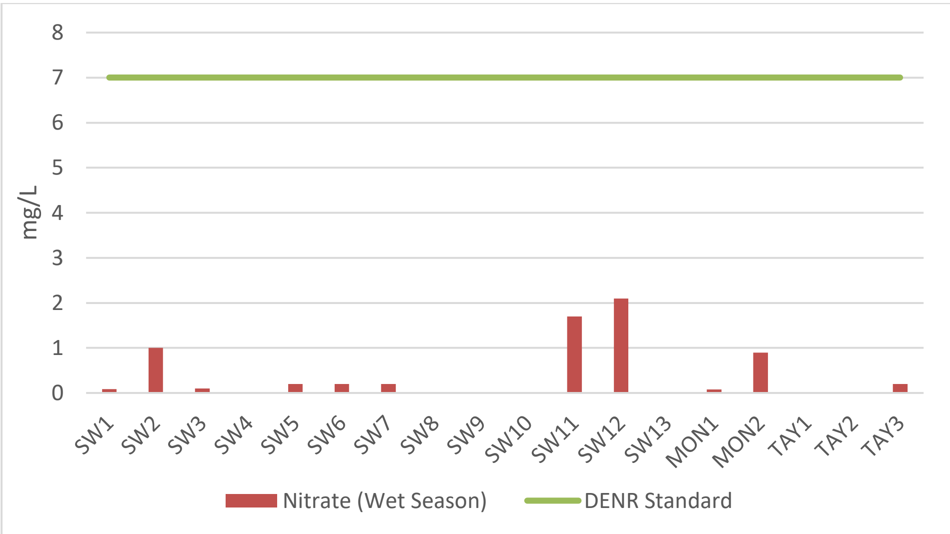


Figure EW-34. Nitrate Concentration During Wet Season in all Stations

2.2.3.2 Groundwater Quality Results

Groundwater quality testing was taken at four (4) stations located in the Sitio Apia, Binayoyo Elementary School, Sitio Casili and Sitio Anipa. The results of the In-situ samples collected are presented in **Table EW-29** while the laboratory results are in **Table EW-30**.

Table EW-29
Results of Groundwater Sampling

Sampling Station	Season	pH	Temp. (°C)	DO (mg/L)	Turbidity	Conductivity (μS/m)
GW1	Wet	7.2	25.23	8.44	0.61	0.18
	Dry	6.2	27.5	11.3	1.94	0.19
GW2	Wet	7.1	25.6	9.51	0.42	0.4
	Dry	6.1	25	11.76	1.86	0.47
GW3	Wet	7.1	25.5	8.6	0.44	0.33
	Dry	7.1	26.9	9.08	0.43	0.31
GW4	Wet	7.2	26.03	11.62	0.52	0.17
	Dry	7.5	27	10.1	0.3	1.31
PNSDW Standard		**6.5 – 8.5**	**-**	**-**	**-**	**-**

pH

Recorded pH levels during the wet season ranged from 7.1 to 7.2 and from 6.1 to 7.5 during the dry season (**Figure EW-35)**. Readings for Stations GW1 and GW2 during the dry season indicates a relatively basic concentration and were below the PNSDW minimum standard of 6.5. Slight low pH levels can be associated with the rustiness or corrosion of metals from the water pipes of the pump.

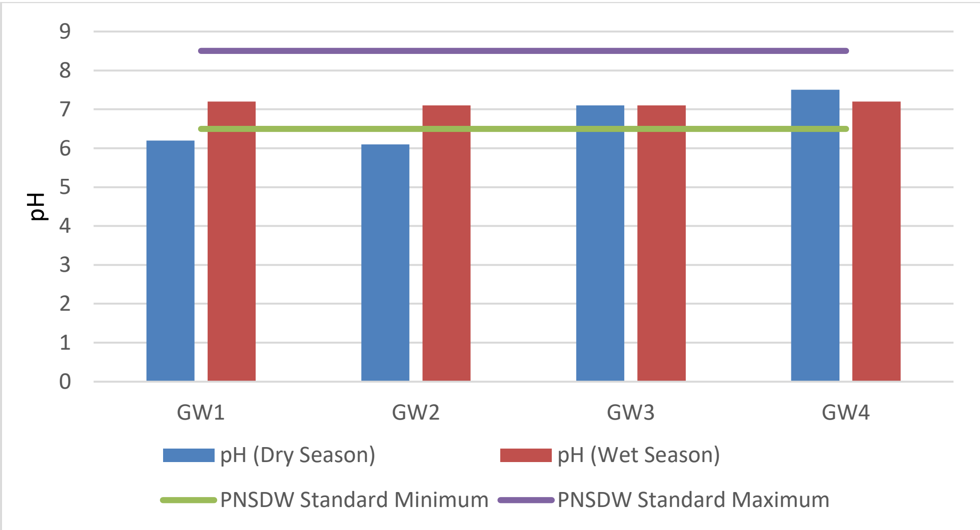


Figure EW-35. pH Levels During Dry and Wet Season in all Stations for Groundwater

Temperature

Temperature values during the dry season ranged from 25°C to 27.50°C and from 25.23°C to 26.03°C during the wet season (**Figure EW-36**). The highest reading was recorded in Station GW1 for the dry season and in Station GW4 for the wet season, both located in Sitio Anipa. There is no PNSDW standard for this parameter in groundwater.

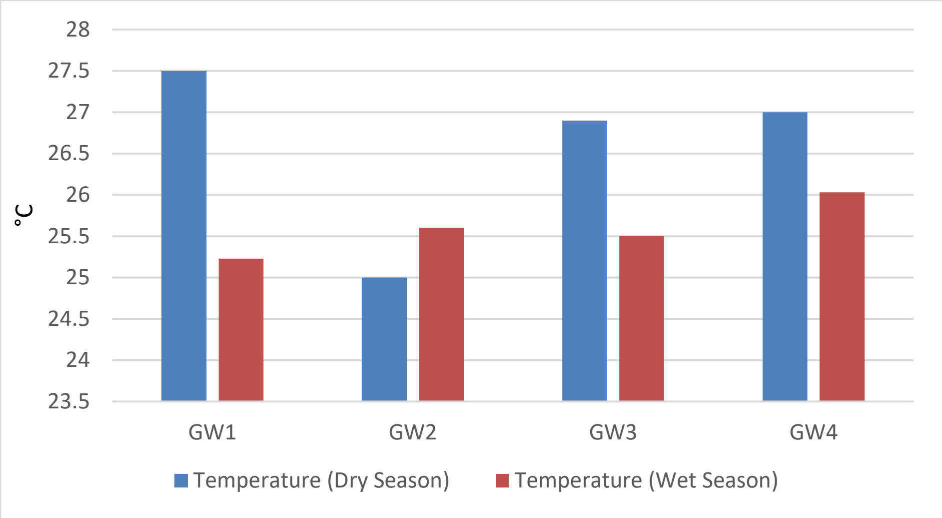


Figure EW-36. Temperature Readings During the Dry and Wet Seasons in all Groundwater Stations

Dissolved Oxygen

Dissolved oxygen levels for the dry season have ranged from 9.08 mg/L to 11.76mg/L with the highest was recorded in Station GW2, also located in Sitio Apia and from 8.44 mg/L to 11.62mg/L during wet season with the highest reading recorded in Station GW4 which is located in Sitio Anipa. (**Figure EW-37**). No standard was set by the PNSDW for this parameter in groundwater.

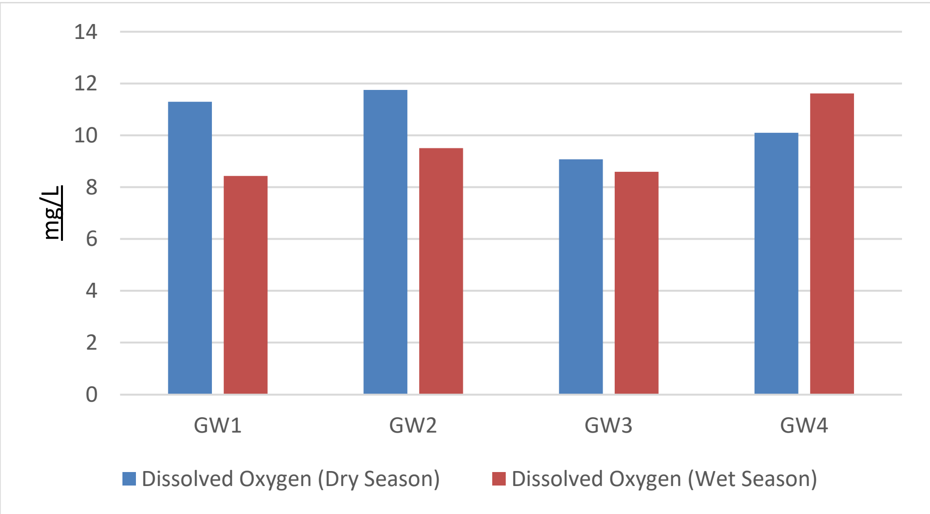


Figure EW-37. Concentrations of Dissolved Oxygen During the Dry and Wet Seasons in all Groundwater Stations

Turbidity

The highest turbidity level during the dry season was observed in Station GW1 (located in Binayoyo Elementary School) at 1.94 NTU while the lowest was in Station GW4 (located in Sitio Anipa) at 0.3 NTU. For the wet season, Station GW1 had the highest turbidity value of 0.61 NTU while the lowest was in Station GW2 (located in Sitio Apia). **Figure EW-38** presents the trend of turbidity levels in all the stations for both seasons. No standard was set by the PNSDW for this parameter in groundwater.

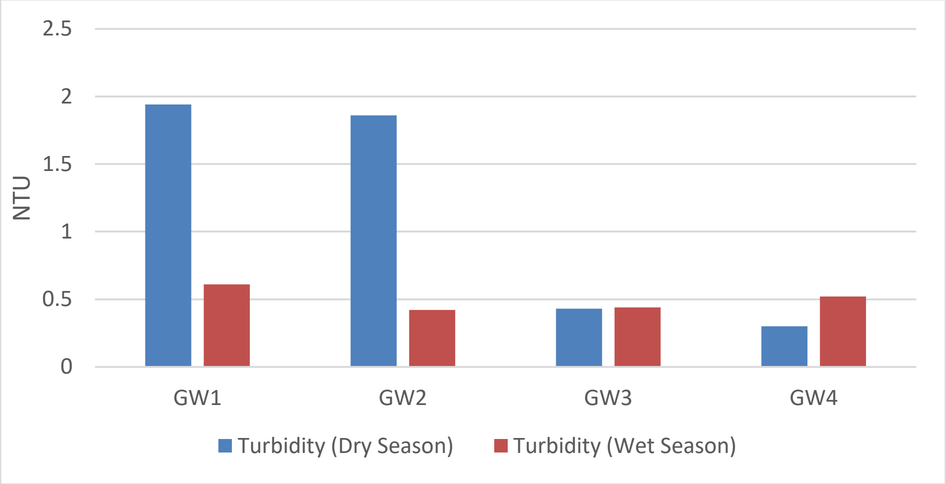


Figure EW-38. Turbidity Levels During the Dry and Wet Seasons in all Groundwater Stations

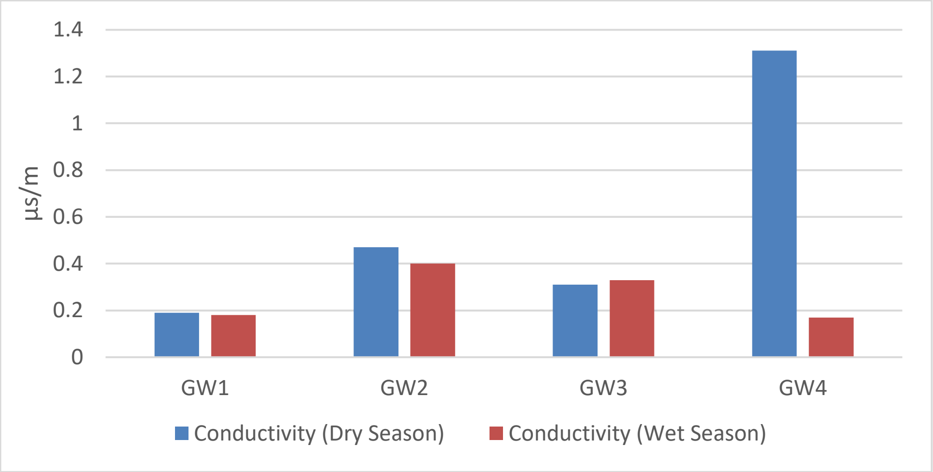


Figure EW-39. Conductivity Levels During Dry and Wet Season in all Stations for Groundwater

Table EW-30
Groundwater Quality Laboratory Results

Sampling Station	Season	BOD (mg/L)	TDS (mg/L)	TSS (mg/L)	Oil & Grease (mg/L)	Iron (mg/L)	Phosphate (mg/L)	Nitrate (mg/L)	Fluoride, mg/L	Fecal Coliform, MPN/100mL
GW1	Wet	3	132	38	0.51	12	0.1	0.6	0.2	<1.1
	Dry	1	109	42	0.51	-	-	-	<0.02	<1.1
GW2	Wet	4	297	<2.5	0.51	-	-	-	0.2	>23
	Dry	<1.0	359	<2.5	0.51	-	-	-	<0.02	<1.1
GW3	Wet	<1.0	215	4	0.52	0.04	0.2	0.3	0.2	16
	Dry	1	202	20	0.51	-	-	-	0.02	>8.0
GW4	Wet	1	116	<2.5	0.52	-	-	-	0.6	<1.1
	Dry	2	848	<2.5	0.61	-	-	-	0.2	>8.0
PNSDW Standard		**-**	**500**	**-**	**-**	**1**	**0.5**	**7**	**1**	**-**

Biological Oxygen Demand

BOD levels for the dry season did not vary much with values ranging only from less than 1.0mg/L to 2.0mg/L with the highest value recorded in Station GW4 at 2.0 mg/L. For the wet season, readings ranged from less than 1.0mg/L to 4.0mg/L wherein Station GW2 recorded the highest value with 4.0mg/L. **Figure EW-40** presents the trend of BOD levels in all the stations for both seasons. No standard was set by the PNSDW for this parameter in groundwater.

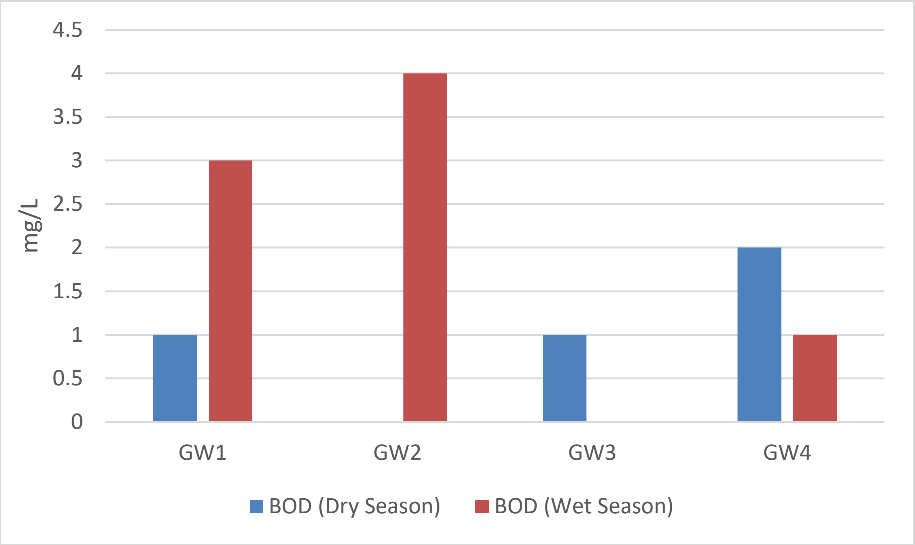


Figure EW-40. Biological Oxygen Demand During the Dry and Wet Seasons in all Groundwater Stations

Total Dissolved Solids

Figure EW-41 shows the readings of total dissolved solids during dry and wet season. Station GW4 (located in Sitio Anipa) during dry season had highest readings among all stations to both season with a value of 848mg/L. This reading significantly exceeded the PNSDW standard of 500mg/L. The remaining stations for both seasons conformed the standards of PNSDW.

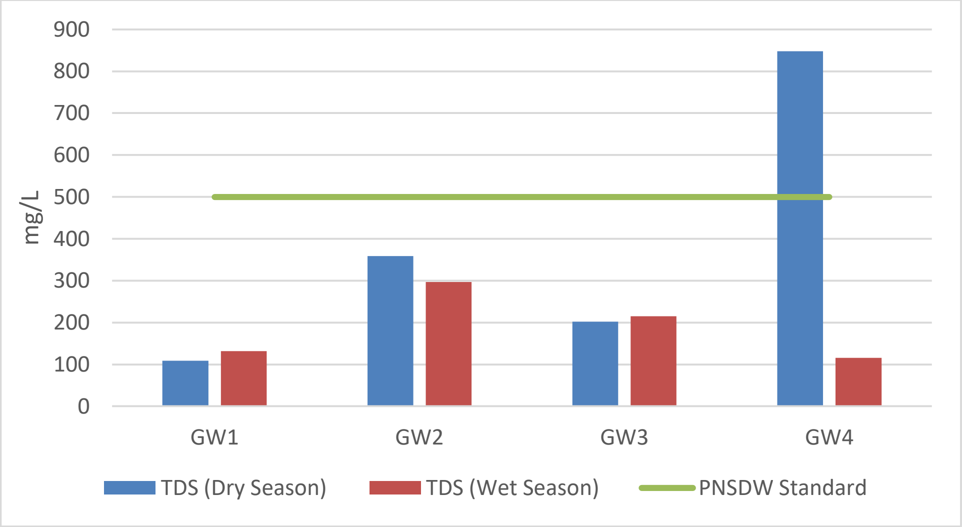


Figure EW-41. Total Dissolved Solids Concentration During dry and Wet Season in all Groundwater Stations

Total Suspended Solids

Total Suspended Solids levels during the dry season ranged from less than 2.5mg/L to 42mg/L with the highest reading observed in Station GW1 (Binayoyo Elementary School). For the wet season, the readings ranged from less than 2.5mg/L to 38mg/L, with the highest reading was also recorded in Station GW1. **Figure EW-42** presents the trend of TSS levels in all the stations for both seasons. No standard was set by the PNSDW for this parameter in groundwater.

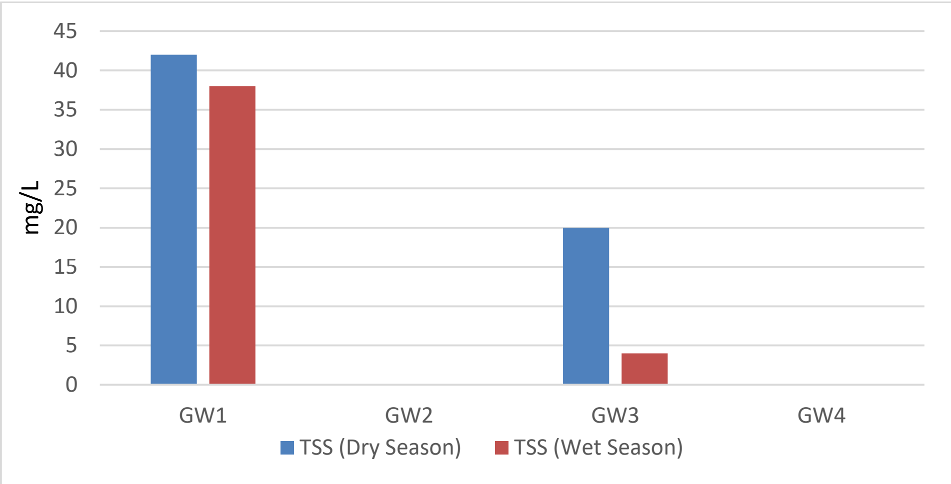


Figure EW-42. Total Suspended Solid Levels During Dry and Wet Season in all Groundwater Stations

Oil & Grease

In terms of oil & grease, the recorded concentrations during the dry and wet seasons showed little variation with values ranging from 0.51mg/L to 0.61mg/L and from 0.51mg/L to 0.52mg/L, respectively. **Figure EW-43** presents the trend of O&G levels in all the stations for both seasons. No standard was set by the PNSDW for this parameter in groundwater.

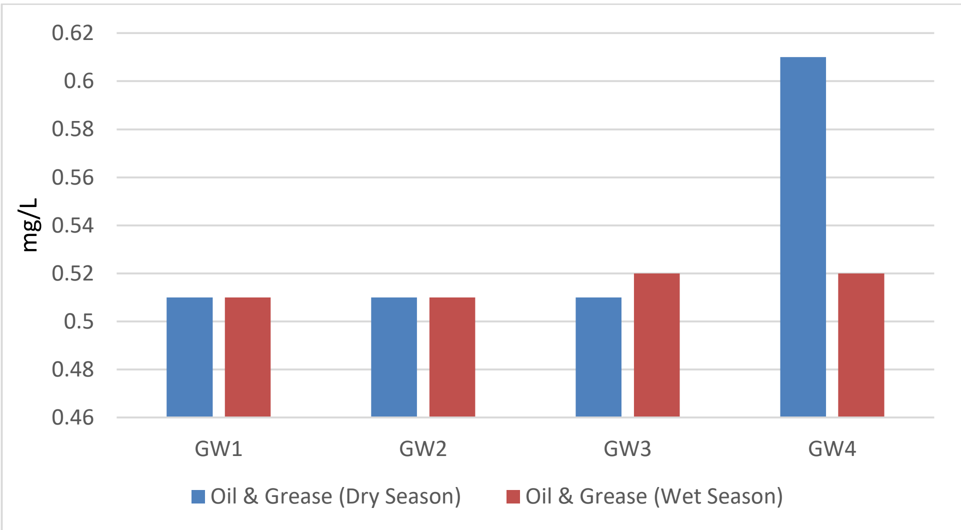


Figure EW-43. Oil & Grease Concentrations During the Dry and Wet Seasons in all Groundwater Stations

Fluoride

Fluoride concentrations during the dry season had a value ranging from less than 0.02mg/L to 0.2mg/L with the highest reading on Station GW4. For wet season, the readings ranged from 0.2 mg/L to 0.6 mg/L. Similar with dry season, the highest value recorded during wet season was in Station GW4. Recorded values were all way below the PNSDW Standard of 1.0 mg/L. **Figure EW-44** presents the trend of Fluoride levels in all the stations for both seasons.

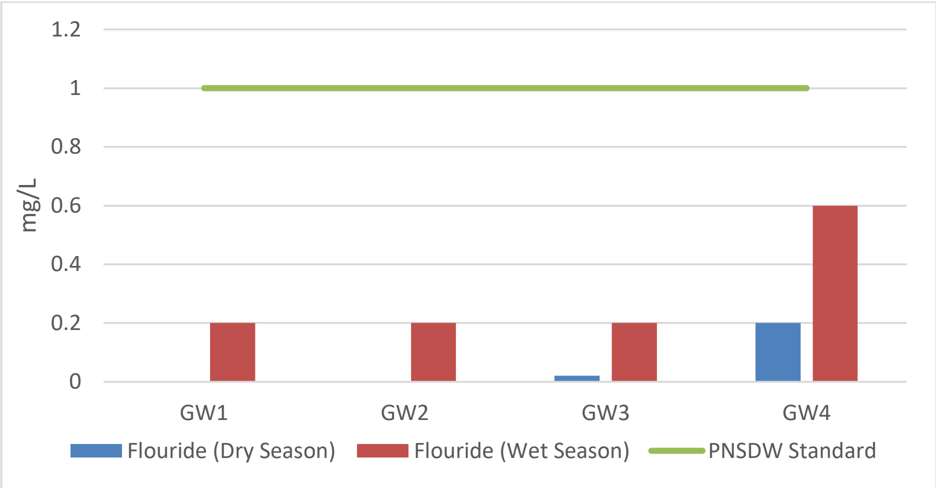


Figure EW-44. Fluoride concentrations During the Dry Seasons in all Groundwater Stations

Fecal Coliform

Fecal coliform levels during the dry season ranged from <1.1 MPN/100mL to >8.0 MPN/100mL with the highest results recorded in Station GW3 and GW4 which is located in Sitio Casili and Sitio Anipa, respectively. Wet season on the other hand had a value ranging from <1.1 MPN/100mL to >23 MPN/100mL, with the highest result recorded in GW2 (located in Sitio Apia). No standard is set by the PNSDW for this parameter (**Figure EW-45)**.

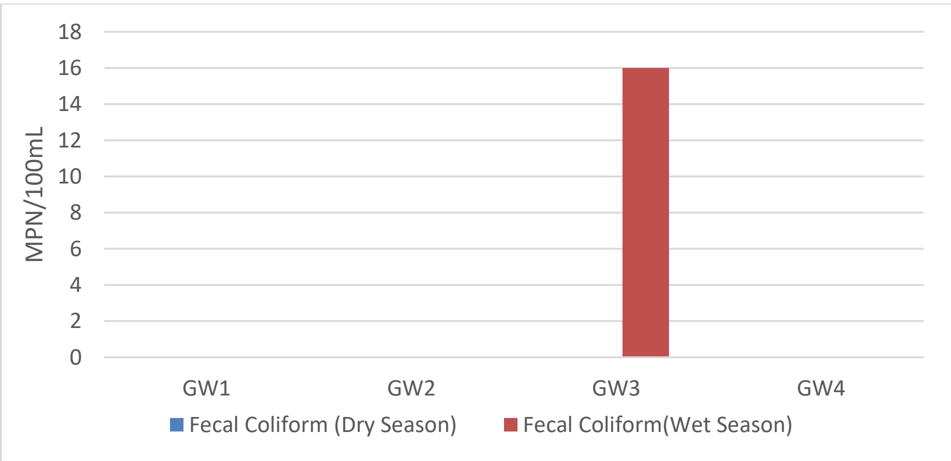


Figure EW-45. Fecal Coliform Levels During the Dry Seasons in all Groundwater Stations

Iron

Figure EW-46 shows the readings of Iron during wet season. Station GW1 (located in Binayoyo elementary school) had highest readings among all stations with a value of 12 mg/L. This reading significantly exceeded the PNSDW standard of 1.0 mg/L. The exceedance was due to the length of time the well was not used. Meanwhile, there were no recorded values for Station GW2 (Sitio Apia) and Station GW4 (Sitio Anipa) during the wet season. According to the residents of Sitio Apia, low level of precipitation in their community is not enough to fill the well and multiple pipe connections to the water tank has caused the Station GW2 to be empty. For Station GW4, residents of Sitio Anipa disconnected the waterline of GW4 since their primary source of water at this time is the river. No record for this parameter was established during dry season as the technical scoping was conducted on May 2020 and the sampling time for dry season is conducted on December 2019.

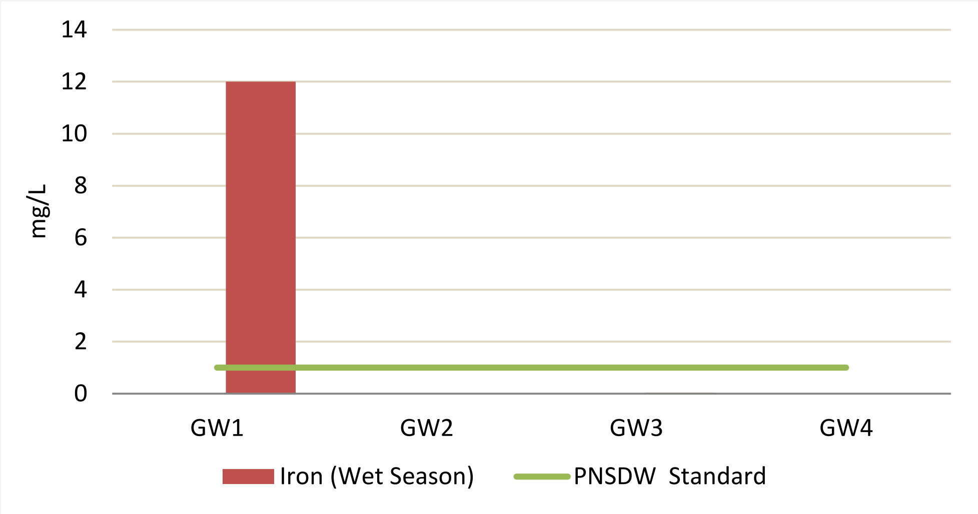


Figure EW-46. Iron Concentrations During the Wet Seasons in all Groundwater Stations

Phosphate

Recorded values of phosphate during wet season were all way below the PNSDW Standard of 0.5mg/L, with values ranging from 0.1 mg/L to 0.2 mg/L respectively (**Figure EW-47**). There were no recorded values for Station GW2 (Sitio Apia) and Station GW4 (Sitio Anipa) during the wet season. According to the residents in Sitio Apia, low level of precipitation in their community is not enough to fill the well and multiple pipe connections to the water tank has caused the Station GW2 to be empty. For Station GW4, residents of Sitio Anipa disconnected the waterline of Station GW4 since their primary source of water at this time is the river. No record for this parameter was established during dry season as the technical scoping was conducted on May 2020 and the sampling time for dry season is conducted on December 2019.

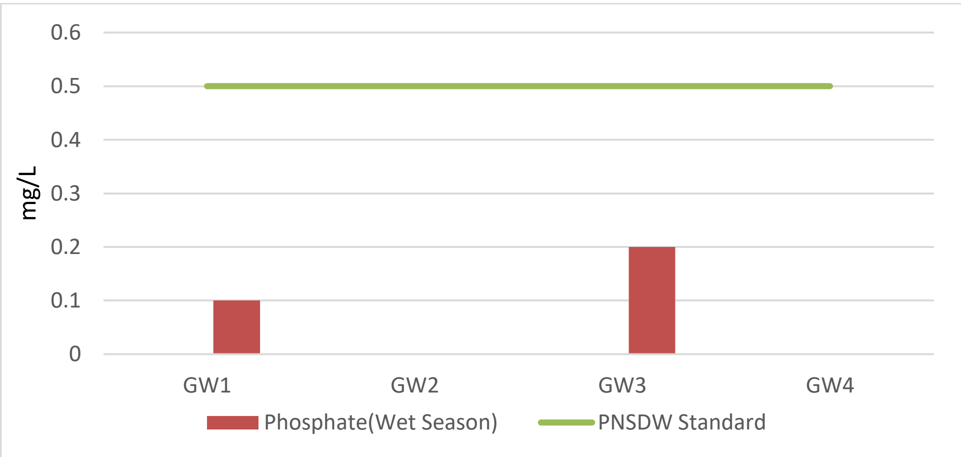


Figure EW-47. Phosphate Concentrations During Wet Seasons in all Groundwater Stations

Nitrate

Recorded values of Nitrate during wet season were all way below the PNSDW Standard of 50 mg/L, with values ranging from 0.3 mg/L to 0.06 mg/L (**Figure EW-48)** There were no recorded values for GW2 (Sitio Apia) and GW4 (Sitio Anipa) during the wet season. M According to the residents in Sitio Apia, low level of precipitation in their community is not enough to fill the well and multiple pipe connections to the water tank has caused the Station GW2 to be empty. For Station GW4, residents of Sitio Anipa disconnected the waterline of Station GW4 since their primary source of water at this time is the river. No record for this parameter was established during dry season as the technical scoping was conducted on May 2020 and the sampling time for dry season is conducted on December 2019.

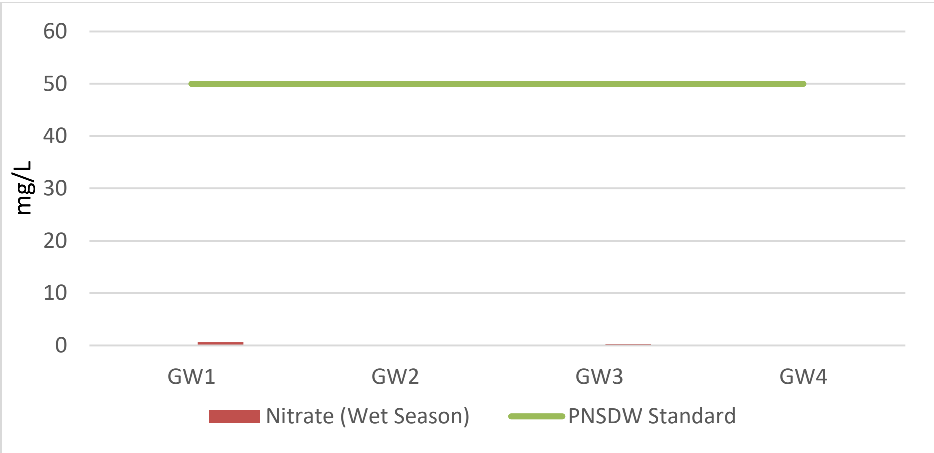


Figure EW-48. Nitrate Concentrations During Wet Seasons in all Groundwater Station

2.2.4 Impact Assessment and Mitigation Measures for Water Quality

2.2.4.1 Construction Phase

The main project construction activities during construction and operation phases may have a potential impact to the water quality within the project vicinity that may result in changes of water flow, temperature, pH and dissolved oxygen concentration; sedimentation and eutrophication.

Project components and other permanent structures during the construction phase of the project will result to excavation of soil, earth moving activities and waste generation. Drilled rocks and soil from construction activities may contribute to sedimentation of rivers within the perimeter of the project, if left unmanaged.

During the course of construction period, temporary houses of the workers may also contribute to degradation of water quality. If an environmental management plan is not established, waste and wastewater from domestic activities, chemical spills and leaks from vehicle maintenance may pollute the water bodies within the vicinity of the project.

Management and Mitigation (Construction Phase)

To mitigate the effects of these impacts, the proponent will make sure that the following mitigation measures will be followed:

1. Construction activities will be scheduled during the dry season (December to May).
2. The equipment, machinery and trucks to be used during the course of work will be on perfect condition and free from oil leaks. If the machinery and vehicles have defects or problems, repair will be conducted in a designated maintenance area that is cemented with proper drainage and oil absorbing material.

3. Sedimentation and erosion plan will be established and implemented. Set up devices to retain sediments and materials that may find its way to the rivers.
4. Excess oils will be properly disposed to prevent leakage of oils into rivers/streams.
5. Establish and maintain drainage canals with settling ponds.
6. Orientation to contractors and workers will be conducted before any activities within the construction sites to ensure the safe environmental practices.
7. Provision of on-site toilets and facilities at work areas.
8. An ecological solid waste management plan will be created and implemented.
9. Emptied construction areas after the construction phase will be re-vegetated to prevent soil erosion.

2.2.4.2 Operation Phase

For the operation phase of the project, the water quality within the reservoir may be degraded due to eutrophication and build-up of organic matter when sufficient of vegetation at the reservoir is not maintained.

Management and Mitigation (Operation Phase)

To mitigate the effects of these impacts, the proponent will make sure that the following mitigation measures will be followed:

1. To avoid eutrophication at the reservoir areas, sufficient clearing of vegetation will be implemented.
2. Release water from the reservoir to downstream to prevent algal bloom and maintain water quality.
3. Daily operational procedures of releasing water and pumping this back to the upper reservoir ensure that there will be no build-up of stagnant water.

2.2.5 Monitoring Plan for Water Quality

The water quality monitoring plan includes activities to be implemented in various surface water and groundwater sources. The parameters for water quality monitoring will include pH, water temperature, dissolved oxygen, turbidity, conductivity, BOD, TSS, TDS, oil and grease, fluoride, fecal coliform, iron, phosphate and nitrate. Quarterly monitoring of the sampling stations established for the baseline study will be undertaken.

2.3 Freshwater Ecology

2.3.1 Scope

Baseline surveys of biological communities were undertaken in the freshwater bodies in the vicinity of the proposed site of the Upper Wawa Dam project in August 2019 for wet season and November and December 2019 for the dry season. The goal of the study is to provide information on general conditions of the freshwater environment and determine how the Upper Wawa Dam: Wawa Bulk Water Supply Project would affect the general use and ecology of the river. It involves an assessment of in-situ water quality and aquatic communities which include phytoplankton, zooplankton, macroinvertebrates and fish. Assessment studies are important since these serve as bases for identification of potential impacts of the proposed project and for formulation of measures to minimize or prevent its detrimental impacts to the overall ecology of aquatic bodies.

The general objective of the study is to establish the community structure characteristics (composition, abundances and functions) of the aquatic biota present in the water bodies. The specific objectives of the study are:

1. To determine composition and densities of phytoplankton, zooplankton, macroinvertebrates and fish at the project site;
2. To determine spatial distribution of these biological communities in the study site;
3. To determine water quality conditions in the project site;

4. To infer from these biological and water quality data conditions of the freshwater systems in the area; and
5. To determine river-use at the vicinity of the project site.

2.3.2 Methodology

2.3.2.1 Description of Study Site

A total of eight (8) sampling stations were established during wet season and ten (10) stations during dry season (eight (8) normal stations plus two (2) additional stations) at the proposed project site focusing on sites where development activities are going to take place. Additional stations were added during dry season to properly study the ecology of freshwater in the project site. The coordinates of the sampling stations were determined using GPS and their relative locations are shown in **Figure EW-49**. The coordinates, name of river and the relative location of the sampling stations in relation to the Upper Wawa Dam Project are shown in **Table EW-31**. Site descriptions are also presented in **Table EW-32**.

Table EW-31
Coordinates, Name of River and Location of Freshwater Ecology Sampling Stations

Station ID	Latitude	Longitude	River	Location in Relation to UWD Project	Remarks
FWE1	14°40'11.26"N	121°14'4.69"E	Payagwan	Upstream of UWD Reservoir	Wet and dry season
FWE2	14°39'47.44"N	121°13'24.95"E	Boso Boso	Upstream of UWD Reservoir	Wet and dry season
FWE3	14°43'36.09"N	121°14'28.63"E	Montalban	Upper limit of UWD Reservoir	Wet and dry season
FWE4	14°43'5.22"N	121°14'54.25"E	Sapa Bute Bute	Upstream of UWD Reservoir	Wet and dry season
FWE5	14°42'7.11"N	121°12'34.91"E	Wawa	UWD Reservoir and upstream of Dam	Wet and dry season
FWE6	14°42'26.40"N	121°13'4.83"E	Montalban	UWD Reservoir	Wet and dry season
FWE7	14°41'57.32"N	121°12'49.17"E	Boso Boso	UWD Reservoir	Wet and dry season
FWE8	14°42'9.63"N	121°11'56.10"E	Wawa	Downstream of Dam	Wet and dry season
FWE9	14°42'30.68"N	121°14'38.58"E	Tayabasan	Upper Limit of UWD Reservoir	Add'tl station (Dry)
FWE10	14°42'40.50"N	121°11'54.82"E	Wawa	Downstream of Dam	Add'tl station (Dry)

All surveyed stations have open canopies, with riparian vegetation comprised of trees (mostly dominated by bamboo and banana), shrubs and grasses. Sampling stations for freshwater ecology are shown in (**Table EW-32**). Majority of the freshwater stations have no periphyton except at Stations FWE1 and FWE10. Aquatic macrophytes were absent at most stations, except at stations FWE7 and FWE9**,** where patches of water hyacinth and *Valissneria,* respectively, were observed. Most surveyed stations had clear to opaque waters, with no odor nor surface oil except at Stations FWE2 and FWE7 (Boso Boso River Upstream and Downstream) where sewage odor was noted and the substrate was primarily muddy and silty.

Watershed areas are comprised of secondary forest and agricultural/ agroforest (such as banana plantations at Stations FWE1 and FWE9). Some watershed activities observed include piggery (Station FWE2), the use of sites as pasture area (Stations FWE1 and FWE10), recreational areas (used for bathing), and site for motorized boat terminal for passengers going to Wawa Dam site (Station FWE5). A number of stations are also located near residential areas/communities such as Stations FWE5, FWE7 and FWE8.

Table EW-32
Descriptions of Freshwater Ecology Sampling Stations

Sampling Station	Location Description	Site Photographs
FWE1	Watershed features: secondary forest, agricultural (banana plantation), pasture area; Riparian vegetation: presence of trees (bamboo), shrubs and grasses. Open canopy; no aquatic plants observed; no odor; oil absent; presence of sand deposits; presence of boulders, cobbles and sand; presence of coarse particulate organic matter (CPOM) and fine particulate organic matter (FPOM); periphyton present	
FWE2	Watershed features: secondary forest, commercial area upstream (Formos farm; piggery); Riparian vegetation: presence of trees, shrubs and grasses (bamboo); Open canopy; no aquatic plants observed; sewage odor; oil absent; presence of black mud deposits; cobble, gravel, sand, silt and mud present; muddy substrate; periphyton absent.	
FWE3	Watershed features: secondary forest, agricultural (agroforest); Riparian vegetation: presence of trees, shrubs and grasses (dominated by bamboo); Open canopy; no aquatic plants observed; no odor, oil absent; presence of sand deposits; boulders, cobbles, sand present; CPOM and FPOM present; periphyton absent	
FWE4	Watershed features: secondary forest, agricultural (agroforest); Riparian vegetation: presence of trees, shrubs and grasses (dominated by bamboo); Open canopy; no aquatic plants observed; no odor nor oil; boulders, cobbles, sand present; presence of sand deposits; presence of CPOM; periphyton absent	

Sampling Station	Location Description	Site Photographs
FWE5	Near hanging bridge; Watershed features: near residential area, secondary forest, recreational area (passenger motorized boat terminal to Wawa dam, bathing area); Riparian vegetation; presence of trees, shrubs and grasses; No aquatic vegetation observed; silt and some mud deposits; cobble, gravel and sand observed; sand muddy and silty substrate; periphyton absent	
FWE6	Near Anipa Community; Watershed features: secondary forest; Riparian vegetation: presence of trees, shrubs and grasses (bamboo); Open canopy; no aquatic plants observed; no odor, clean water; with sand deposits; boulders, cobble, gravel and sand present; FPOM present; periphyton absent	
FWE7	Watershed features: secondary forest, agriculture, small community nearby; Riparian vegetation: presence of trees, shrubs and grasses (bamboo, taro, banana); Open canopy; some patches of water hyacinth observed in the area; sewage odor, silt and mud deposits; cobble, gravel and sand also present; muddy, silty substrate; periphyton absent	
FWE8	Watershed features: near residential area, secondary forest, agroforest; Riparian vegetation: presence of trees, shrubs and grasses; Open canopy; no aquatic vegetation observed; silt and some mud deposit observed; with cobble, gravel and sand; FPOM present; periphyton absent	

Sampling Station	Location Description	Site Photographs
FWE9	Watershed features: secondary forest, agricultural (banana plantation); Riparian vegetation: presence of trees, shrubs and grasses (bamboo); Open canopy; patches of aquatic plants observed (*Vallisneria* sp.); no odor; oil absent; sand deposits present; boulders, cobbles and sand present; presence of CPOM and FPOM; periphyton absent	
FWE10	Near Montalban Area; Watershed feature: pasture, agriculture, agroforest; Riparian vegetation: presence of patches of trees, shrubs and grasses; Open canopy; sand present; no aquatic vegetation observed; with cobble, gravel and sand; FPOM present; periphyton present	

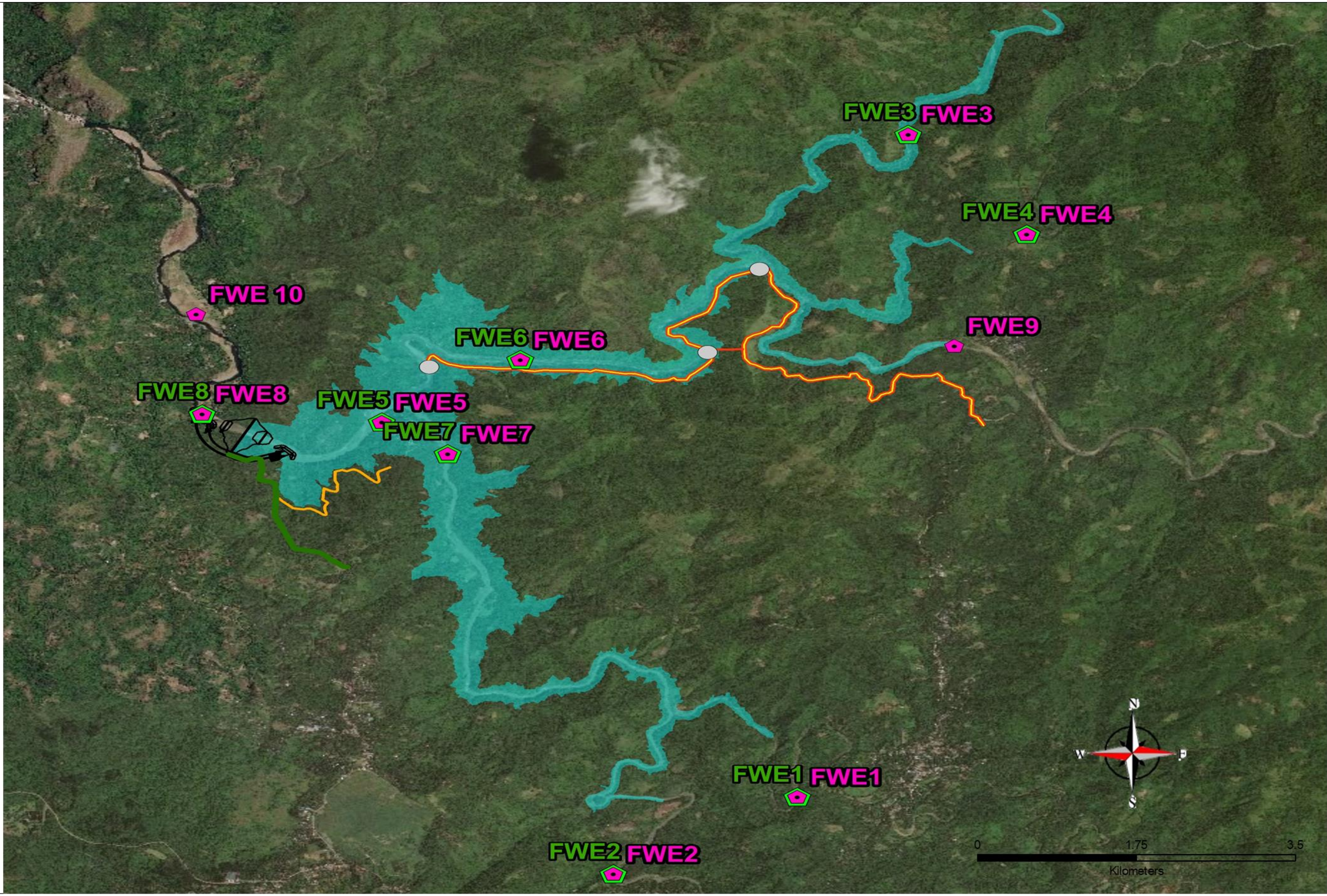


Figure EW-49. Freshwater Ecology Stations

ENVIRONMENTAL IMPACT STATEMENT
WATER MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

Legend
- Pump Station
- Transmission Pipeline via Tunnel Optional
- UWD Optional Access Road (New)
- UWD Access Road (Original)
- Access Road to WTP / Transmission Pipe
- UWD Dam and Diversion Tunnel
- Transmission / Water Conveyance Pipeline
- UWD Reservoir
- Dry Season Stations
- Wet Season Stations

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCO, Inc. (2020)
Basemap: ArcGIS Imagery, 2020
Created by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.
apercu CONSULTANTS INC.

SCALE: 1: 30,000

2.3.2.2 Physical Characterization of Habitat and Measurement of Basic Limnological Variables

Physical features were characterized at each station, such as general land use, bank conditions, stream origin and type, summary of the riparian vegetation features and type of sediment. Instream variables such as average width and depth (Barbour *et al.* 1999) were also measured. Water quality meters were used to obtain on-site measurements of basic limnological variables such as dissolved oxygen (DO), temperature, total dissolved solids (TDS), and pH**.** The average depths and widths of the stations were measured using a meter stick and transect tape, respectively. Flow rate was also determined using the float method (Barbour *et al.* 1999).

2.3.2.3 Biological Communities

Plankton

River plankton sampling was conducted at sampling stations in reaches with open or partly open canopies (>50%) with moderate water velocity (between 10 and 60 cm/sec). Plankton samples were obtained by passing a total volume of 100 liters of water through plankton nets with a mesh size of 26μ and 64μ and a mouth diameter of 0.3m. Three replicate samples each of zooplankton and phytoplankton were collected from each station. Samples were placed in properly labeled plastic containers, immediately fixed in formalin (5% by volume) and brought to the laboratory for processing and further analysis. Plankton enumeration was done using the Sedgewick counting chamber observed under a binocular microscope. Planktonic organisms were identified to the lowest possible taxon using taxonomic keys such as those of Mamaril et al. (1986), Segers (2004; 2007) and Bellinger and Sigee (2010).

Macroinvertebrates

Macroinvertebrate collection was undertaken at three replicate zones of each station. For shallow sites, ten trowelful of sediments were obtained from each replicate zone, which covers an area of about 1m^2. Sediment samples were placed in properly labeled Ziploc plastic bags and preserved in 5% formalin. In addition to sediment collection, the underside of rocks, with an approximate area of 1m^{2,} were also inspected for the presence of insect larvae. Insects were handpicked and placed inside Ziploc plastic bags and preserved with 5% formalin. Samples were brought to the laboratory for further processing.

In the laboratory, sediment samples were passed through a 1-mm mesh-sized sieve and all animals retained in the sieve were collected and sorted. Macroinvertebrates were transferred to plastic containers and preserved with 5% formalin. Macroinvertebrates were identified to the lowest possible taxon using Haynes (2001) and Gapud and Raros (1986). Their abundances were recorded and expressed as number of animals/m^2. Methods of macroinvertebrate collection, preservation, and processing generally followed standard methods such as that of Barbour *et al.* (1999).

Fish

Locals were interviewed on fish catch composition at the rivers in the vicinity of the UWD Project.

River-Use

Locals and fisherfolks residing in the vicinity of the project site were asked general questions on river-use, hydrology, and fisheries in the area.

2.3.3 Survey Results for Freshwater Ecology

2.3.3.1 Phytoplankton Community

Table EW-33
Mean (no. of cells/l) and Relative Densities (%) of Phytoplankton at Eight (8) Sampling Stations (Wet Season)

Taxon	FWE1	FWE2	FWE3	FWE4	FWE5	FWE6	FWE7	FWE8	Overall Mean Density	Relative Density
Cyanobacteria	**0**	**20**	**0**	**0**	**0**	**0**	**0**	**0**	**20**	**6.8**
Oscillatoria	0	20	0	0	0	0	0	0	20	6.8
Diatoms	**426**	**96**	**68**	**44**	**120**	**57**	**152**	**156**	**208**	**71.0**
Cymbella	0	0	21	0	0	0	0	0	21	7.2
Fragilaria	273	28	24	0	25	0	22	40	28	9.5
Navicula	0	36	0	15	35	0	17	36	28	9.5
Nitzschia	74	32	23	29	60	13	26	24	30	10.1
Pinnularia	17	0	0	0	0	0	0	28	28	9.6
Surirella	0	0	0	0	0	0	31	0	31	10.6
Synedra	62	0	0	0	0	44	56	28	43	14.6
Green algae	**13**	**0**	**0**	**0**	**30**	**35**	**0**	**0**	**65**	**22.2**
Planctonema	13	0	0	0	30	0	0	0	30	10.2
Sphaerocystis	0	0	0	0	0	35	0	0	35	12.0
Mean Density	**439**	**116**	**68**	**44**	**120**	**57**	**152**	**156**	**208**	**100.0**
Mean Abundance	**152**									
Number of Taxa	**5**	**4**	**3**	**2**	**4**	**3**	**5**	**5**	**10**	

Table EW-34
Mean (no. of cells/l) and Relative Densities (%) of Phytoplankton at Ten (10) Sampling Stations (Dry Season)

Taxon	FWE1	FWE2	FWE3	FWE4	FWE5	FWE6	FWE7	FWE8	FWE9	FWE10	Overall Mean Density	Relative Density
Bacillariophyta	**297**	**80**	**93**	**44**	**12**	**12**	**18**	**4**	**9**	**13**	**58**	**63.5**
Amphipleura	11	0	0	0	0	0	0	0	0	0	1	1.2
Amphora	16	0	0	0	0	0	0	0	0	0	2	1.7
Aulacoseira	13	5	15	5	0	0	0	0	0	0	4	4.0
Cymbella	10	0	0	0	0	0	0	0	0	0	1	1.1
Fragilaria	41	5	17	6	6	9	5	2	4	4	10	10.6
Gyrosigma	29	18	10	0	0	0	1	0	0	0	6	6.2
Melosira	26	9	19	8	0	0	9	0	0	0	7	7.7
Navicula	10	7	9	4	1	0	0	0	0	0	3	3.4
Nitzschia	22	0	0	7	1	0	0	0	1	3	3	3.7
Pinnularia	16	0	0	0	0	0	0	0	0	0	2	1.7
Rhizosolenia	15	9	0	0	0	0	0	0	0	0	2	2.6
Surirella	30	13	13	6	4	3	0	0	2	2	7	7.8
Synedra	48	15	12	9	0	0	4	2	2	5	10	10.4
Vaucheria	13	0	0	0	0	0	0	0	0	0	1	1.4
Chlorophyta	**23**	**0**	**6**	**14**	**0**	**0**	**2**	**0**	**0**	**5**	**5**	**5.5**
Actinastrum	0	0	0	5	0	0	0	0	0	0	0	0.5
Mougeotia	15	0	0	0	0	0	0	0	0	0	1	1.6
Oocystis	0	0	6	0	0	0	2	0	0	5	1	1.4
Ulothrix	9	0	0	10	0	0	0	0	0	0	2	2.0
Cyanophyta	**228**	**36**	**9**	**0**	**0**	**11**	**0**	**0**	**0**	**0**	**28**	**31.0**
Anabaena	11	10	0	0	0	0	0	0	0	0	2	2.3
Aphanocapsa	0	16	0	0	0	0	0	0	0	0	2	1.7

Taxon	FWE1	FWE2	FWE3	FWE4	FWE5	FWE6	FWE7	FWE8	FWE9	FWE10	Overall Mean Density	Relative Density
Chroococcus	23	0	0	0	0	0	0	0	0	0	2	2.5
Gloeocapsa	0	10	9	0	0	0	0	0	0	0	2	2.1
Merismopedia	128	0	0	0	0	0	0	0	0	0	13	13.9
Oscillatoria	55	0	0	0	0	11	0	0	0	0	7	7.2
Spirulina	12	0	0	0	0	0	0	0	0	0	1	1.3
Mean Density	**548**	**116**	**108**	**58**	**12**	**23**	**20**	**4**	**9**	**18**	**92**	**100.0**
SD	**97**	**10**	**12**	**1**	**2**	**32**	**5**	**2**	**1**	**5**		
Number of Taxa	**21**	**11**	**9**	**9**	**4**	**3**	**5**	**2**	**4**	**5**	**25**	

At least 25 phytoplankton taxa distributed into three algal divisions were recorded at ten surveyed stations combined during the dry season (**Table EW-34**). About 56% of the observed taxa belonged to phylum Bacillariophyta (diatoms), 28% to phylum Cyanophyta (blue-green algae) and 16% to phylum Chlorophyta (green algae). Diatoms also largely dominated the phytoplankton community representing 63.5% of the total count, followed by the blue-green algae, which comprised 31% of the total density.

Phytoplankton mean densities ranged from low to high, with the highest recorded at Station FWE1 (549 cells/l), followed by that recorded at Station FWE2 (116 cells/l), FWE3 (108 cells/l) and at Station FWE4 (58 cells/l) (**Table EW-34**). Low mean densities were recorded at the six remaining stations, with values ranging from 4 cells/l to 23 cells/l. Phytoplankton taxa richness ranged from 2 taxa to 21 taxa, with the highest recorded at Station FWE1 (21 taxa) and the lowest at Station FWE8 (2 taxa).

The dominant algal genera at the surveyed stations were varied. *Merismopedia* was the most abundant algal taxon at Station FWE1 (128 cells/l), followed by *Oscillatoria* (55 cells/l), *Synedra* (48 cells/l) and *Fragilaria* (41 cells/l). Meanwhile, *Gyrosigma* had the highest density at Station FWE2 (18 cells/l), followed by *Aphanocapsa* (16 cells/l), and *Synedra* and *Surirella,* which were observed at almost the same densities with values of 15 cells/l and 13 cells/l, respectively. *Melosira* dominated at Station FWE3 (19 cells/l), followed by *Fragilaria* (17 cells/l). The green algal taxon *Ulothrix* and two diatom taxa, *Synedra* and *Melosira* were recorded at almost equal densities (8-10 cells/l) at Station FWE4. *Fragilaria* dominated at Stations FWE5 and at FWE8. *Oscillatoria* was the most abundant taxon at Station FWE6, closely followed by *Fragilaria*. *Melosira* was the most abundant taxon at Station FWE7, while *Oocystis* and *Synedra,* co-dominated at Station FWE10, which were closely followed by *Fragilaria*. Of the 25 identified phytoplankton taxa, *Merismopedia* had the highest overall relative density, representing 13.9% of the total count, followed by *Fragilaria* (10.6%) and *Synedra* (10.4%). *Surirella*, *Melosira* and *Oscillatoria* each comprised 7% to 8% of the total algal density (**Table EW-34**).

Melosira is common in small, shallow eutrophic waters. Meanwhile, *Fragilaria* spp. are found in mesotrophic to eutrophic waters. Several species of *Oscillatoria* impart odor and taste in drinking water and as a group are known to produce toxins, such as microcystins and anatoxin-a. The dominance and presence at moderate densities of these three algal taxa at majority (about 80%) of the surveyed Stations (FWE1, FWE3, FWE4, FWE5, FWE6, FWE7, FWE8 and FWE10) suggests eutrophic conditions (Bellinger and Sigee, 2010). This could be attributed to domestic activities at the site, such as the use of Station FWE5 as a terminal for passenger boats and for bathing of locals, and the use of Stations FWE1 and FWE2 as bathing areas for carabaos.

Overall composition of phytoplankton was variable across seasons. An increase in the total number of algal taxa was recorded from 9 taxa in the wet season (**Table EW-33**), to 25 taxa in the dry season (**Table EW-34**). Bacillariophyta (diatoms) consistently dominated during the wet and dry season, representing 71% and 63.5%, respectively, of the total count. A shift in the second most abundant algal group was observed from the wet to the dry season. Chlorophyta (green algae) ranked second in terms of overall abundance (22.2%) during the wet season, while Cyanophyta (blue-green algae; 31%) ranked second during the dry season.

2.3.3.2 Zooplankton Community

Table EW-35
Mean (no. of inds./l) and Relative Densities (%) of Zooplankton at Five (5) Sampling Stations (Wet Season)

Taxon	FWE1	FWE2	FWE3	FWE4	FWE5	Mean Density	Relative Density
Adult zooplankton	**43**	**12**	**17**	**32**	**75**	**73**	**73,6**
Arcella sp.	0	0	7	18	25	17	16.9
Difflugia sp.	43	0	0	18	50	34	34.5
Cladoceran	0	12	0	0	0	12	12.2
Keratella sp.	0	0	10	0	0	10	10.1
Larval zooplankton	**0**	**36**	**16**	**0**	**0**	**26**	**26.4**
Nematode larvae	0	36	16	0	0	26	26.4
Mean Density	**43**	**48**	**33**	**36**	**75**	**99**	**100.0**
Mean Abundance	**29**						
Number of Taxa	**1**	**2**	**3**	**2**	**2**		

Table EW-36
Mean (no. of inds./l) and Relative Densities (%) of Zooplankton at Five (5) Sampling Stations (Dry Season)

Taxon	FWE1	FWE3	FWE4	FWE7	FWE8	Mean Density	Relative Density
Arthropoda	**5**	**0**	**1**	**3**	**2**	**2**	**100.0**
Calanoida female	1	0	0	0	1	0	14.3
Copepoda nauplius	4	0	1	3	2	2	85.7
Mean Density	**5**	**0**	**1**	**3**	**2**	**2**	**100.0**
SD	**2**	**0**	**1**	**1**	**0**		
Number of Taxa	**2**	**1**	**1**	**1**	**2**	**2**	

Zooplankton were only observed at five (FWE1, FWE3, FWE4, FWE7 and FWE8) of the ten surveyed stations during the dry season (**Table EW-36**). These stations had low zooplankton taxa richness and densities. Only two zooplankton taxa, which belong to a single animal phylum, Arthropoda, were observed. Copepoda nauplius was recorded at relatively higher proportion than Calanoida female, with overall mean abundances of 85.7% and 14.3%, respectively. Each zooplankton taxon had low mean densities ranging from 1 to 4 inds./l. Copepoda nauplius was recorded at relatively higher mean density at stations FWE1 and FWE7, with values of 4 inds./l and 3 inds./l, respectively. Zooplankton mean densities at surveyed stations were low ranging from 1 to 5 inds./l, with the highest recorded at station FWE1 and the lowest at station FWE3. Low taxa richness and abundances of zooplankton communities observed at surveyed stations can be attributed to good water flow and possibly human disturbances at the stations. Zooplankton are known to thrive and reproduce well in freshwater bodies with stagnant or minimal water movement (**Table EW-36).**

Zooplankton community structure during the wet (**Table EW-35**) and the dry season (**Table EW-36**) was varied. A total of five zooplankton taxa, representing three animal phyla were recorded during the wet season, while only two taxa belonging to a single phylum was observed during the dry season. Protozoans dominated the zooplankton community during the wet season, which comprised 51.4% of the total count, while arthropods represented 100% of the total zooplankton during the dry season. Other phyla recorded during the wet season were Arthropoda, which comprised 12.2% of the total count, and Nematoda representing 26.4% of the total zooplankton.

2.3.3.3 Macroinvertebrate Community

Table EW-37
Mean (no. of animals/m²) and Relative Densities (%) of Macroinvertebrates at Eight (8) Sampling Stations (Wet Season)

Taxa	FWE1	FWE2	FWE3	FWE4	FWE5	FWE6	FWE7	FWE8	Total Density	Relative Density
ANNELIDA	**0**	**0**	**0**	**0**	**0**	**1**	**3**	**0**	**2**	**1.9**
Class Oligochaeta	0	0	0	0	0	1	3	0	2	1.9
MOLLUSCA	**3**	**6**	**155**	**69**	**20**	**27**	**4**	**53**	**74**	**71.5**
Corbicula sp.	0	0	0	0	1	18	0	21	13	13.0
Family Venereidae	0	0	0	0	1	0	0	0	1	1.0
Thiara sp.	0	3	33	21	7	1	0	0	13	12.6
Melanoides maculata	0	0	11	0	0	0	0	8	10	9.2
Tarebia granifera	0	3	111	41	11	8	4	23	29	27.9
Planorbis sp.	0	0	0	1	0	0	0	0	1	1.0
Lymnaeidae	3	0	0	0	0	0	0	1	1	1.0
Neritidae	0	0	0	6	0	0	0	0	6	5.8
ARTHROPODA	**0**	**0**	**9**	**12**	**4**	**16**	**12**	**0**	**27**	**28.6**
Atyidae	0	0	6	4	0	0	0	0	5	4.9
Sesarmidae	0	0	3	8	0	5	0	0	5	5.2
Order Podocopida	0	0	0	0	0	3	0	0	3	2.9
Baetidae	0	0	0	0	0	0	3	0	3	2.9
Libellulidae	0	0	0	0	0	1	1	0	1	1.0
Order Coleoptera	0	0	0	0	0	7	7	0	7	6.8
Gerridae	0	0	0	0	3	0	1	0	2	1.9
Chironomidae	0	0	0	0	1	0	0	0	1	1.0
Mean Abundance	3	6	164	81	24	44	19	53	**103**	**100.0**
SD	49									
Number of Taxa	1	2	5	6	6	8	6	4		

Table EW-38
Mean (no. of animals/m²) and Relative Densities (%) of Macroinvertebrates at Ten (10) Sampling Stations (Dry season)

Taxa	FWE1	FWE2	FWE3	FWE4	FWE5	FWE6	FWE7	FWE8	FWE9	FWE10	Total Density	Relative Density
ANNELIDA	**1**	**142**	**4**	**5**	**0**	**0**	**55**	**6**	**0**	**5**	**217**	**44.5**
Hirudinea	0	0	0	0	0	0	0	5	0	0	5	1.0
Oligochaeta	1	142	4	5	0	0	55	1	0	5	212	43.5
ARTHROPODA	**4**	**16**	**2**	**34**	**44**	**12**	**4**	**22**	**26**	**35**	**200**	**41.1**
Coleoptera	0	0	0	0	0	0	0	0	0	0	1	0.2
beetle larvae	0	0	0	0	0	0	0	0	0	0	0	0.1
Elmidae	0	0	0	0	0	0	0	0	0	0	0	0.1
Psephenidae	0	0	0	0	0	0	0	0	0	0	0	0.1
Diptera	3	16	2	34	18	8	3	21	4	5	114	23.4
Ceratopogonidae	0	0	0	1	0	1	0	0	1	0	3	0.5
Chironomidae	2	16	2	28	18	8	3	21	2	4	104	21.4
Tipulidae	0	0	0	5	0	0	0	0	1	0	7	1.4
Ephemeroptera	1	0	0	0	24	1	0	1	15	23	65	13.3
Baetidae	1	0	0	0	6	0	0	0	1	0	7	1.4
Heptageniidae	0	0	0	0	6	0	0	0	0	0	7	1.4
Leptophlebiidae	0	0	0	0	12	1	0	0	14	23	51	10.5
Hemiptera	0	0	0	0	0	0	0	0	0	0	1	0.1
Aphelocheiridae	0	0	0	0	0	0	0	0	0	0	0	0.1
Veliidae	0	0	0	0	0	0	0	0	0	0	0	0.1

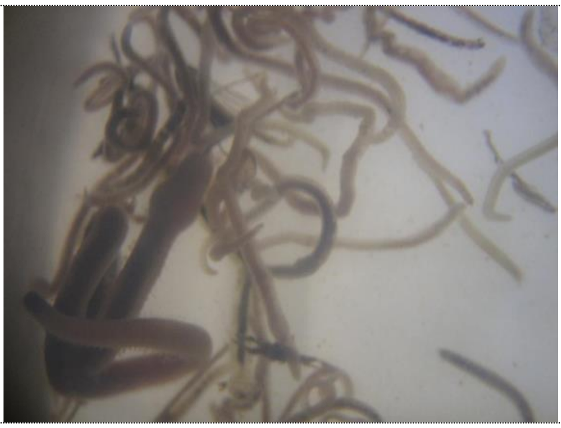
Taxa	FWE1	FWE2	FWE3	FWE4	FWE5	FWE6	FWE7	FWE8	FWE9	FWE10	Total Density	Relative Density
Odonata	0	0	0	1	0	0	0	0	1	0	2	0.3
Anisoptera	0	0	0	1	0	0	0	0	1	0	2	0.3
Plecoptera	0	0	0	0	0	0	0	0	0	1	1	0.2
Perlidae	0	0	0	0	0	0	0	0	0	1	1	0.2
Trichoptera	0	0	0	0	1	2	0	1	7	6	17	3.5
Helicopsychidae	0	0	0	0	0	0	0	0	4	0	4	0.9
Hydropsychidae	0	0	0	0	0	2	0	1	2	1	7	1.5
Hydroptilidae	0	0	0	0	0	0	0	0	0	1	1	0.1
Philopotamidae	0	0	0	0	0	0	0	0	0	4	5	1.0
MOLLUSCA	**30**	**2**	**13**	**6**	**3**	**4**	**0**	**6**	**3**	**2**	**70**	**14.4**
Bivalvia	1	0	0	0	1	0	0	1	0	0	3	0.7
Corbiculidae	1	0	0	0	1	0	0	1	0	0	3	0.7
Gastropoda	28	2	13	6	3	4	0	6	3	1	67	13.8
Hydrobiidae	0	0	0	0	0	0	0	1	1	0	2	0.3
Melanoides	2	0	1	2	0	0	0	0	1	1	8	1.6
Physidae	0	2	0	0	0	0	0	0	0	0	2	0.4
Tarebia granifera	27	0	12	5	3	3	0	4	1	0	55	11.3
Thiara scabra	0	0	0	0	0	0	0	0	0	0	1	0.1
Mean Abundance	**35**	**160**	**19**	**45**	**47**	**16**	**59**	**34**	**29**	**42**	**487**	**100.0**
SD	**20**	**124**	**10**	**27**	**24**	**12**	**38**	**16**	**26**	**43**		
Number of Taxa	**11**	**4**	**5**	**7**	**11**	**8**	**4**	**11**	**13**	**13**	**25**	

At least 25 macroinvertebrate taxa were recorded at the 10 surveyed stations combined in the Upper Wawa Dam project site (**Table EW-38**). Annelida co-dominated with Arthropoda, representing 45% and 41%, respectively of the overall density. Meanwhile, Mollusca was recorded at relatively lower proportion of 14%. About 68% of the identified macroinvertebrate taxa belong to Arthropoda, while 24 % to Mollusca, and only 8% to Annelida. The highest macroinvertebrate density was recorded at Station FWE2, with a mean abundance of 160 animals/m^2, while moderate values were recorded at majority of the surveyed stations, ranging from 29-59 animals/m^2. Relatively lower densities were recorded at Station FWE3 and at Station FWE6 (19 and 16 animals/m^2, respectively). Macroinvertebrate taxa richness were relatively higher at FWE1, FWE5, FWE9 and FWE10 (11-13 taxa), compared with that observed at the remaining stations (4-8 taxa).

Of the 25 recorded taxa, Oligochaeta (segmented worms; **Plate EW-1**) was the most abundant, with an overall relative density of 43.5%, followed by Chironomidae (21.4%; **Plate EW-1**), *Tarebia granifera* (11.3%) and Leptophlebiidae (10.5%) (**Table EW-38**). However, taxa composition, as well as dominant taxa varied among surveyed stations. Oligochaeta dominated at Stations FWE2 and FWE7, while Gastropoda at Stations FWE1 and at FWE3. Diptera (true flies) and Oligochaeta were also recorded at moderate proportions at Station FWE3. Stations FWE4, FWE6 and FWE8 had high relative densities of Diptera, which comprised about 52% to 74% of the total count. Ephemeroptera (mayflies) largely dominated the macroinvertebrate community at Stations FWE9 and FWE10. Moderate proportions of Trichoptera (caddisflies) were also observed at these stations (23% and 13% of the total density). Ephemeroptera, such as Families Leptophlebiidae and Heptageniidae (**Plate EW-1**), was the most abundant group at Station FWE5 which comprised 51% of the total macroinvertebrates, followed by Diptera with a relative density of 39%.

Macroinvertebrate composition suggests that Stations FWE2, FWE4, FWE6, FWE7 and FWE8 are relatively disturbed or polluted with high organic matter. The consistent dominance of Diptera particularly of Family Chironomidae and of Oligochaeta at these stations are indicative of such conditions. These taxa are known bioindicators of eutrophic waters and poor habitat conditions (Barbour *et al*., 1999). This condition can be attributed to the use of these freshwater bodies for domestic purposes such as for bathing of carabaos (FWE2) and as dumping grounds for domestic wastes (FWE7). Meanwhile, Stations FWE5, FWE9 and FWE10 have good habitat conditions as supported by the dominance of Ephemeroptera which is a bioindicator of good water quality condition. The dominance of Gastropoda at Stations FWE1 and FWE3 is suggestive of eutrophic conditions since gastropod taxa observed were mostly algal-grazers (such as *Tarebia granifera* and *Melanoides*). These stations are also used as bathing areas for carabaos, which may somehow explain the observed macroinvertebrate composition.

The number of macroinvertebrate taxa increased, from 17 in the wet season (**Table EW-37**), to 25 taxa in the dry season (**Table EW-38**). Three animal phyla (Annelida, Arthropoda and Mollusca) were consistently observed during both sampling periods. However, the dominant macroinvertebrate phylum varied across seasons. Mollusca was the most abundant phylum during the wet season, which comprised 71.5% of the total count, followed by Arthropoda (26.6%) and Annelida (1.9%). Meanwhile, Annelida dominated during the dry season, representing 44.5% of the total macroinvertebrates, followed by Arthropoda (41.1) and Mollusca (14.4%). A shift in the dominant macroinvertebrate taxon was also recorded, from *Tarebia granifera* in the wet season, to Oligochaeta in the dry season.


Oligochaeta (segmented worms)


Family Chironomidae of Insect Order Diptera


Family Heptageniidae of Order Ephemeroptera (mayflies)

Plate EW-1. Macroinvertebrate Samples

2.3.3.4 Fish Community

There was no significant fishing activity observed at the sites during the survey. Fish collected are not commercially sold but are mainly used for domestic consumption. Based on interview with locals, some of the fish collected at the freshwater bodies include *Oroechromis niloticus* (Nile *tilapia*), *Glossogobius* sp. (gobies or *biya)* and *Hypostomus plecostomus* (janitor fish). According to locals, *tilapia* is the most common fish in the area. Nile tilapia and janitor fish are both introduced species while the reported gobies may be native. The IUCN status of Nile tiapia is least concern while that of janitor fish is not evaluated (Froese and Pauly, 2018).

Six introduced freshwater fish species with least concern status were reported during the wet season: *Clarias batarchus, Gambusia affinis,* one species of Family Gobiidae, *Oreochromis mossambicus* and *O. aureus* and *Poecilia reticulata,* as opposed to three species reported by locals during the dry season. Fish Families Cichlidae and Gobiidae were reported during both monitoring periods. Some fish species observed are used for domestic consumption (such as *Oreochromis* spp. and *Clarias batrachus*) but majority has no commercial value. Some species of Fish Family Gobiidae are also known to migrate at certain stages in their life cycle.

Fish species like gobies which feed on macroinvertebrates and algae, may migrate to upstream areas in search for food, thus, affecting their natural distribution. On the other hand, one species was reported to be migratory species, the river eel (Anguilla sp.), which was gathered from the interviews with locals during the survey. This species was not actually observed or caught during the sampling period. The IUCN status of this species is identified as 'least concern' (IUCN, Ver.2015.2).

The Anguilla sp. (eel) are commercially important and are a fish species with aquaculture potential in the Philippines. There are 18 species and subspecies of Anguillid eels in the world (Ege, 1939; Tesh, 2003). Eels are facultative catadromous fishes: growing in the estuaries or inland freshwater until they become sexually mature, then migrating back to their oceanic spawning grounds to spawn once in their lifetime before dying (Briones et al. 2007). The ability of Anguilla sp. to reside in environments of various salinities may have existed in the ancestral species before the speciation event separating tropical and temperate eels. The Philippine eels are widely distributed in freshwater, estuarine or seawater environments during their growth phase. Selection of the growth habitat may depend on food availability and carrying capacity of the environment (Briones et al. 2007). There is very little literature regarding the migration of the eels in the Philippines and needs further studies to have a better understanding of the life history and movement of the eel species.

2.3.3.5 Water Quality

Table EW-39
Mean Values of Water Quality and Physical Parameters Measured at Eight (8) Freshwater Ecology Sampling Stations (Wet Season)

Parameters	FWE1	FWE2	FWE3	FWE4	FWE5	FWE6	FWE7	FWE8
pH	7	7.3	8.39	8.35	8.41	7.4	7.2	8.27
Temperature (C)	25.27	26.03	24.77	25.23	24.3	24.5	24.13	24.4
Conductivity (uS/cm)	0.25	0.22	0.23	0.21	0.21	0.17	0.21	0.16
DO (mg/l)	7.61	12.09	7.6	7.8	8.5	8.72	43.66	23.91
Flow rate (m/s)	0.22	0.27	0.20	0.30	0.62	0.72	0.21	0.68

Table EW-40
Mean Values of Water Quality and Physical Parameters Measured at Ten (10) Freshwater Ecology Sampling Stations (Dry Season)

Parameters	FWE1	FWE2	FWE3	FWE4	FWE5	FWE6	FWE7	FWE8	FWE9	FWE10
pH	7.70	7.63	7.60	7.57	7.87	7.77	7.03	7.50	7.60	7.83
Temperature (C)	26.77	27.27	23.60	23.97	26.57	25.33	26.43	27.87	24.17	27.10
Conductivity (uS/cm)	0.23	0.56	0.20	0.23	0.24	0.21	0.37	0.25	0.23	0.26
DO (mg/l)	12.09	10.36	27.73	21.07	12.77	12.63	11.07	9.30	12.92	12.20
Flow rate (m/s)	0.10	0.09	0.07	0.23	0.56	0.63	0.05	0.39	0.21	0.92

Levels of four water quality parameters measured at eight (8) stations during wet season and ten surveyed during dry season stations at the vicinity of the proposed site fall within the normal/ usual range of values for freshwater bodies (**Table EW-39 and Table EW-40)**; Lampert and Sommer, 2007). pH regime at majority of the freshwater stations during dry season was slightly basic, ranging from 7.50 to 7.87, except at Station FWE7, where a neutral pH was recorded. For wet season, pH regime at freshwater stations was slightly basic to basic ranging from 7.2 to 8.41, except at Station FWE1 where a neutral pH was recorded. Temperature values ranged from 23.60 °C to 27.87 °C during dry season while 24.3°C to 26.03 °C during wet season, reflecting temporal variations due to variable sampling periods. Conductivity values were low at all stations during dry season ranging from 0.20 uS/cm to 0.56 uS/cm, with the highest recorded at Station FWE2 and the lowest at Station FWE3 while 0.16 uS/cm to 0.25 uS/cm, with the highest recorded at Stations FW1. Dissolved oxygen levels were high at surveyed stations in two occurrences (wet and dry season), exceeding the 5mg/l requirement for optimal functions of aquatic organisms. Flow rate was slow to fast during wet and dry season. Slow water movement was observed at Stations FWE1, FWE2, FWE3, FWE4, FWE7, FWE8 and FWE9 (0.05 m/s to 0.39 m/s) during dry season and Stations FW1, FW2, FW3, FW4 and FW5 (0.21 m/s to 0.30 m/s) during wet season. Moderate flow of water was recorded at Stations FW5 and at FW6 (0.56 m/s and 0.63 m/s) during dry season and Stations FW5, FW6 and FW8 (0.62 m/s to 0.72 m/s). The only fast flow of water was recorded at the additional Station FW10 (0.92m/s) during dry season. Data suggests that overall water quality conditions at the surveyed stations in two seasons are suitable for survival of aquatic organisms.

2.3.3.6 Ambient Air Quality

Table EW-41
Recorded Ambient Air Quality Results at six (6) stations during Air Sampling (One season; Dry season)

Sampling Stations	PM10, µg/Ncm	TSP, µg/Ncm	NO2, µg/Ncm	SO2, µg/Ncm
AQ1	27.8	40.6	0.06	0.04
AQ2	25.8	19.3	0.08	0.61
AQ3	18.6	24.6	0.05	ND
AQ4	9.3	12.4	0.10	ND
AQ5	29.9	22.2	0.09	0.12
AQ6	26.0	25.3	0.09	0.08
NAAQS Values	**150**	**230**	**180**	**150**

*ND – Not Detected

Air quality results showed low to undetectable concentrations of NO_2, SO_2 and particulate matter (PM_{10}) and Total Suspended Particulates (TSP) in all stations. Data suggests that overall air quality conditions at the surveyed stations in one seasons will not affect the survival of aquatic organisms found in the Project site.

River Uses

Surveyed stations at the Upper Wawa Dam Project site are used by locals for minor fishing activity and other domestic activities such as for bathing/ swimming; bathing of carabaos; as a site for passenger and motorized boat terminals to ferry locals along Wawa River; as convenient dumping grounds of wastes; and as pasture areas.

2.3.4 Impact Assessment and Mitigation Plan

2.3.4.1 Construction Phase

a. Threat to existence and/or loss of important local species and habitat

Erosion of sediments and silt. Land clearing activities/ land preparation and excavation works at the dam and reservoir area may damage streambed and may erode silt, which may end up as runoff in nearby sections of rivers, especially during storms and heavy rains. These may increase water turbidity and adversely affect photosynthetic activity of phytoplankton and other algae. Sediment erosion in freshwater bodies may bury and cause localized mortality of macrobenthic organisms. This may have low, minimal and reversible impact at Stations FWE6, FWE7 and FWE9 (all UWD reservoir areas), considering that most of the phytoplankton such as *Melosira* and *Oscillatoria*; and macroinvertebrate taxa representatives from the insect family Chironomidae and Class Oligochaeta observed at these sites are pollution-tolerant and indicators of disturbed conditions. However, siltation may have detrimental impacts at Station FWE5 or the station upstream of Upper Wawa Dam and reservoir area, since the macroinvertebrate assemblage in this area is dominated by Ephemeroptera (mayflies), which are known indicators of good water quality/ habitat conditions. Certain mitigating measures such as the construction of drainage canals, sediment control traps and ditches to prevent siltation should be implemented to prevent alteration of habitat and consequent loss of certain biota, since all have important roles in the overall ecology of rivers.

Pollution from domestic wastes and other toxic materials used during construction. Domestic wastes and other toxic materials generated during construction of the dam and land clearing activities may adversely affect water and sediment quality. Habitat alteration and degradation may affect composition of phytoplankton, zooplankton, macroinvertebrates, fish and decapods, especially at the Upper Wawa Dam and UWD reservoir area at Stations FWE5, FWE6, FWE7 and FWE9. These may generally decrease their overall diversity.

b. Threat to abundance, frequency and distribution of species

Erosion of sediments and silt. This may bury insect families especially at Station FW5 where a number of individuals of Families Baetidae, Leptophlebiidae, and Heptageniidae were recorded, which are known indicators of good water quality, and consequently decrease their abundance**.** Fish species, particularly gobies which feed on macroinvertebrates and algae, may migrate to upstream areas in search for food, thus, affecting their natural distribution.

Pollution from domestic wastes may result in habitat degradation and may have negative impacts on diversity of biological communities. These may generally decrease the frequency and abundances of phytoplankton, zooplankton, macrobenthos, and fish, although as previously mentioned, impact will be localized, low and minimal considering that most algal and macroinvertebrate species recorded at surveyed freshwater stations are pollution-tolerant (except at FW5).

2.3.4.2 Operation Phase

Change in water regime due to the construction of dam may result in unexpected flooding, altering natural structures instream as well as along banks. Conversely, this may result in decrease in water level/ volume during dry periods of the month. Both would alter water quality or may lead to its deterioration, especially during periods of low flow. These may have negative impacts on algal, macroinvertebrate and fish communities in the area, although impacts may be minimal considering that Chironomidae and Oligochaeta dominated most of the surveyed stations. However, a number of aquatic insect individuals belonging to Families of Ephemeroptera (mayflies), which are known indicators of good habitat conditions, was observed at Station FW5. Hence, mitigating measures discussed in the next section will be adapted to minimize adverse effects. Reduction in abundance and frequency, change in distribution of plankton, fish and macroinvertebrates, as well as loss of important macroinvertebrate species such as those belonging to aquatic insect Families Baetidae, Heptageniidae and Leptophlebiidae may occur.

Pollution from domestic wastes may result in habitat degradation and may have negative impacts on diversity of biological communities. These may generally decrease the frequency and abundances of phytoplankton, zooplankton, macroinvertebrates and fish. Impact may be low or minimal since most of the algal and macroinvertebrate species are pollution tolerant. However, some macroinvertebrate families which are known indicators of good water quality were recorded at the study site.

Weirs/ dams may block migration of fish. The construction of weirs/ dams may block migration of some fishes such as gobies and eels. Some species of Fish Family Gobiidae are also known to migrate at certain stages in their life cycle. Also. migratory eels were found to be existing in the project site. One species of river eel (Anguilla sp.) was gathered and recorded from the interviews with locals.

2.3.4.3 Mitigating Measurements

To prevent erosion of sediment and silt into nearby sections of rivers at the Upper Wawa Dam project site, especially during heavy rains, stockpiles should be covered and fully bunded and drainage canals should be constructed to trap and prevent sediment from being washed into the water body.

Implement proper segregation, re-use, recycle and disposal. Adequate number of garbage bins and containers should be strategically located at all construction sites. Prompt and regular collection of wastes as well as removal of non-recyclable wastes from the site will be implemented. Natural organic debris will be gathered and disposed of in a designated area away from the river. Regular monitoring of diversity of aquatic fauna and *in-situ* water quality will also be conducted.

To ensure ecological sustainability, a flow at least equal to the minimum environmental flow amounting to 1.33 m3/s during wet season and 0.47 m^3/s during dry season has to be released all the time to the downstream reach of the diversion point and will be maintained at the project site to minimize detrimental effects on the ecology of the water bodies. Fish passage sites should be provided to allow migratory fish to pass through provision of fish ladders.

2.3.5 Freshwater Ecology Monitoring Plan

Monitoring in the components of freshwater ecology such as composition and abundances of biological communities, as well as water quality will be implemented regularly to ensure the ecological integrity of the rivers. Quarterly monitoring in the same station will be implemented in dominant and abundant species of the plankton community, macroinvertebrates and fish communities. The parameters for freshwater quality monitoring will include pH, temperature, conductivity and dissolved oxygen.

II. BASELINE KEY ENVIRONMENTAL IMPACTS

3.0 Air

3.1 Meteorology

3.1.1 Methodology

This section describes the existing meteorological conditions at the Project area using available primary and secondary data. Emphasis was placed on parameters relevant to the assessment of air pollution impacts and contribution to climate change in terms of greenhouse gas (GHG) emissions.

Regional and Local Meteorology

The regional meteorological conditions were described using secondary data from the PAGASA Science Garden station in Quezon City, the nearest to the Project site. The station is about 17 kilometers west-southwest of the Project (**Figure EA-1**) Records and data used were a) climatological normals and extremes (**Table EA-1**, **Table EA-2**) b) the modified Coronas climate map of the Philippines (**Figure EA-2**); c) windrose analysis data; and d) tropical cyclone risk and frequency maps (**Figure EA-4**).

The local meteorology at the Project site was described using a three-stage prognostic procedure described below. The process generated the required met files for the AERMOD model (surface and profile files).

Stage 1 – Weather Research and Forecasting Model (WRF)

The WRF is a next-generation mesoscale numerical weather prediction system designed for both atmospheric research and operational forecasting applications. It is the most commonly used prognostic model by the USEPA and the modeling community and provides state-of-the-science parameterizations of the atmosphere. The WRF (version 4.1, ARW core) was initialized with the NCEP FNL (Final) Operational Global Analysis Data 3 operationally prepared every 6 hours on a 1x1 degree grid. The model was run at 45 vertical levels, up to 50 mb, with a three-level nested domain with resolutions of 27, nine, and three kilometers. The innermost WRF domain extended about 200 km along both longitude and latitude.

Stage 2 – Mesoscale Model Interface Program (MMIF)

The USEPA MMIF was used to convert the WRF output fields to the parameters and formats required for direct input into AERMET, the meteorological preprocessor of AERMOD. The MMIF has options to produce either input files for AERMET or meteorological input files for AERMOD bypassing AERMET. The MMIF for the MGP study was used to create the required files ONSITE for the AERMET preprocessor.

Stage 3 - AERMET

The AERMOD surface and profile met files with hourly resolution were generated by AERMET. The variables included in the surface file are: sensible heat flux, friction velocity, convective velocity, vertical temperature gradient in the first 500m above the planetary boundary layer, extents of the convective and mechanical boundary layers, the Monin-Obukhov length, surface roughness, Bowen ratio, albedo, wind speed, wind direction, anemometer height, temperature, and thermometer height. Variables included in the vertical profile for each elevation above ground are elevation, wind speed, wind direction, temperature, and standard deviations of wind direction and vertical wind speed.

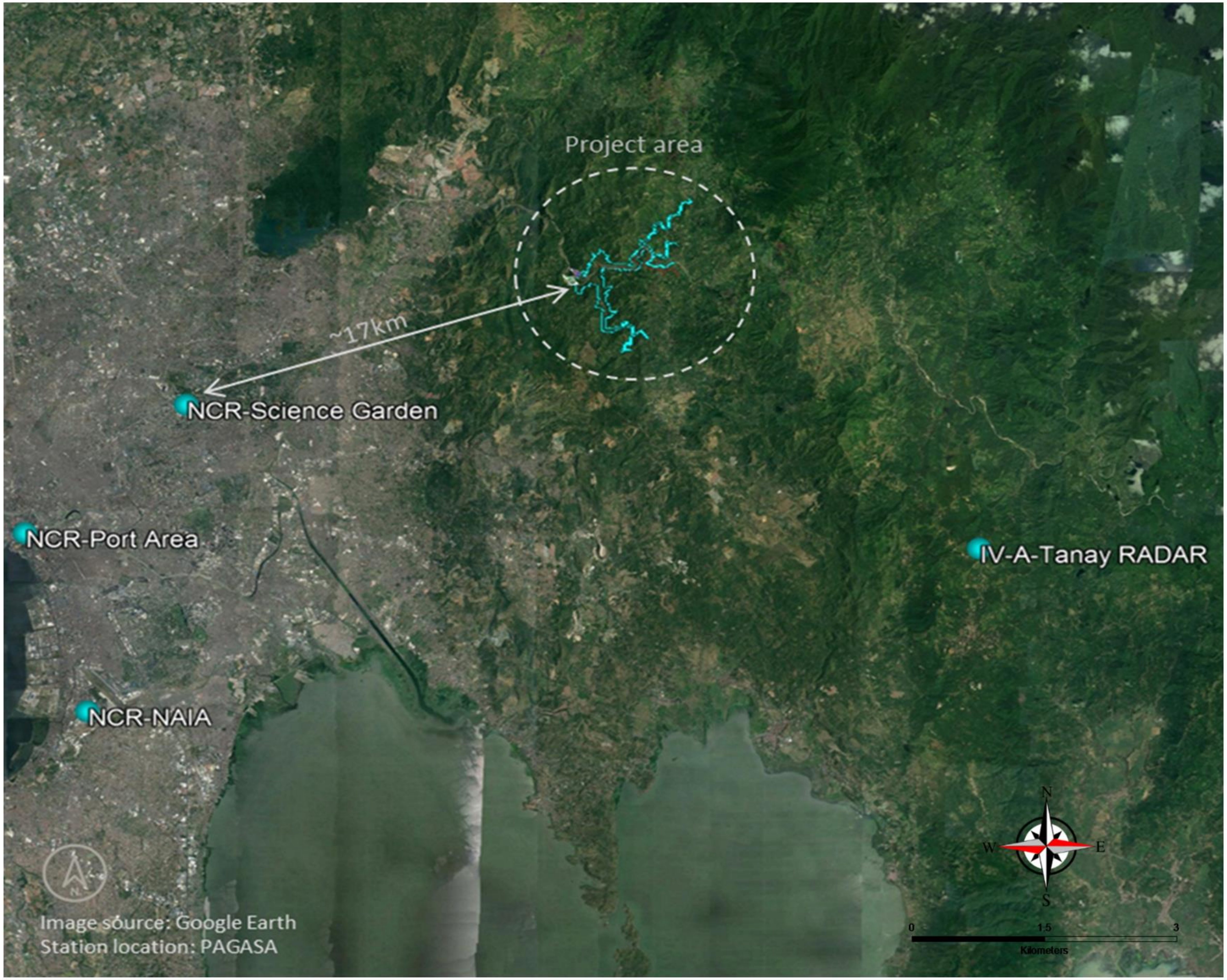


Figure EA-1. Nearest PAGASA station to the Project site	**DATA INFORMATION/SOURCE:** **Source Map:** Google Earth, 2020 **Modified by:** APERCU CONSULTANTS, INC (2020)	**WawaJVCo INC.** aperçu CONSULTANTS INC.
ENVIRONMENTAL IMPACT STATEMENT **AIR MODULE** **Wawa Bulk Water Supply Project – Upper Wawa Dam**		SCALE: 1: 100,000 / **PAGE 286**

Table EA-1
Climatological normal records at the Science Garden PAGASA station (1981-2010)

Month	Rainfall		Temperature						Vapor Pressure	Relative Humidity	MSLP	Wind		Cloud Amount	No. of Days w/	
	Amount	No. of RD	Max	Min	Mean	Dry Bulb	Wet Bulb	Dew Pt.				Direction	Speed		TSTM	LTNG
	mm	#	ºC	ºC	ºC	ºC	ºC	ºC	mbs	%	mbs	16 pt	m/s	okta	#	#
Jan	18.5	4	30.6	20.8	25.7	25.3	22.2	20.9	24.6	76	1012.3	N	1	5	1	0
Feb	14.6	3	31.7	20.9	26.3	26.0	22.3	20.8	24.4	73	1012.0	NE	1	5	0	0
Mar	24.8	4	33.4	22.1	27.8	27.6	23.2	21.5	25.4	69	1011.3	SE	1	4	2	1
Apr	40.4	5	35.0	23.7	29.4	29.2	24.4	22.7	27.2	67	1009.7	SE	1	4	4	2
May	186.7	12	34.7	24.7	29.7	29.3	25.3	23.9	29.5	72	1008.5	S	1	5	12	8
Jun	316.5	18	33.1	24.6	28.8	28.4	25.5	24.5	30.6	79	1008.1	SW	1	6	17	9
Jul	493.3	22	31.9	24.1	28.0	27.5	25.2	24.4	30.5	83	1007.7	SW	2	6	19	9
Aug	504.2	23	31.3	24.2	27.8	27.3	25.2	24.5	30.6	84	1007.4	SW	2	7	17	6
Sep	451.2	22	31.6	24.0	27.8	27.2	25.1	24.4	30.4	84	1010.6	SW	1	6	18	9
Oct	296.6	18	31.6	23.5	27.6	27.0	24.7	23.9	29.5	83	1008.8	N	1	6	11	6
Nov	148.8	14	31.4	22.7	27.1	26.5	24.1	23.2	28.4	82	1010.1	N	1	5	5	1
Dec	78.7	8	30.5	21.6	26.0	25.5	22.8	21.7	25.9	79	1011.5	N	1	5	1	0
Annual	**2574.4**	**153**	**32.2**	**23.1**	**27.7**	**27.2**	**24.2**	**23.0**	**28.1**	**78**	**1009.8**	N	1	5	107	51

Source: PAGASA, 2020; RD – rainy days; MSLP – Mean Sea Level Pressure; SPD- wind speed in meters per second; TSTM – thunderstorm; LTNG - lightning

Table EA-2
Climatological extremes at the Science Garden PAGASA station (as of 2019)

Month	Temperature (°C)				Greatest Daily Rainfall (mm)		Strongest Winds (mps)			Sea Level Pressures (mbs)			
	High	Date	Low	Date	Amount	Date	SPD	DIR	Date	High	Date	Low	Date
Jan	34.7	01-17-1998	15.5	01-27-1987	55.8	01-16-1988	24	ESE	01-17-1972	1021.4	01-21-2005	998.8	01-22-1989
Feb	35.6	02-24-1967	15.1	02-04-1987	61.7	02-22-2013	22	SSE	02-02-1992	1021.7	02-14-2017	1002.3	02-09-1985
Mar	36.8	03-26-1983	14.9	03-01-1963	65.0	03-31-2012	13	S	03-16-1992	1021.0	03-05-2005	997.8	03-28-1988
Apr	38.0	04-25-1998	17.2	04-05-1963	64.8	04-21-2015	26	SSE	04-07-1992	1016.9	04-05-1998	1001.4	04-16-2007
										1016.9	04-03-2017		
May	38.5	05-14-1987	17.8	05-03-1962	166.0	05-20-1966	21	N	05-10-1992	1015.1	05-28-1986	992.4	05-17-1989
June	38.0	06-02-1993	18.1	06-27-1961	334.5	06-07-1967	37	SW	06-25-1972	1014.9	06-07-1997	978.7	06-26-1993
July	36.2	07-20-1998	17.7	07-23-1961	246.4	07-07-2002	36	NNW	07-09-1977	1015.0	07-01-1979	989.2	07-15-1978
Aug	36.1	08-17-2017	17.8	08-23-1964	391.4	08-07-2012	32	N	08-22-2000	1015.3	08-23-2002	994.2	08-24-1978
Sep	35.6	09-10-2017	20.0	09-08-1964	455.0	09-26-2009	35	NE	09-28-2006	1016.0	09-28-1997	987.4	09-30-1995
Oct	35.4	10-09-2003	18.6	10-31-1967	209.3	10-18-1975	30	SE	10-11-1989	1016.0	10-25-1986	978.7	10-23-1988
Nov	35.0	11-01-2001	15.6	11-12-1962	169.9	11-20-1966	50	NNW	11-03-1995	1019.1	11-18-1979	980.6	11-03-1995
Dec	34.9	12-06-2018	15.1	12-13-1988	135.5	12-15-2015	22	SE	12-22-1997	1020.0	12-27-2001	998.1	12-02-2004
Annual	**38.5**	**05-14-1987**	**14.9**	**03-01-1963**	**455.0**	**09-26-2009**	**50**	**NNW**	**11-03-1995**	**1021.7**	**02-14-2017**	**978.7**	**06-26-1993** **10-23-1988**
Period of Record	1961 - 2019				1961 - 2019		1961 - 2019			1961 - 2019			

Source: PAGASA, 2020

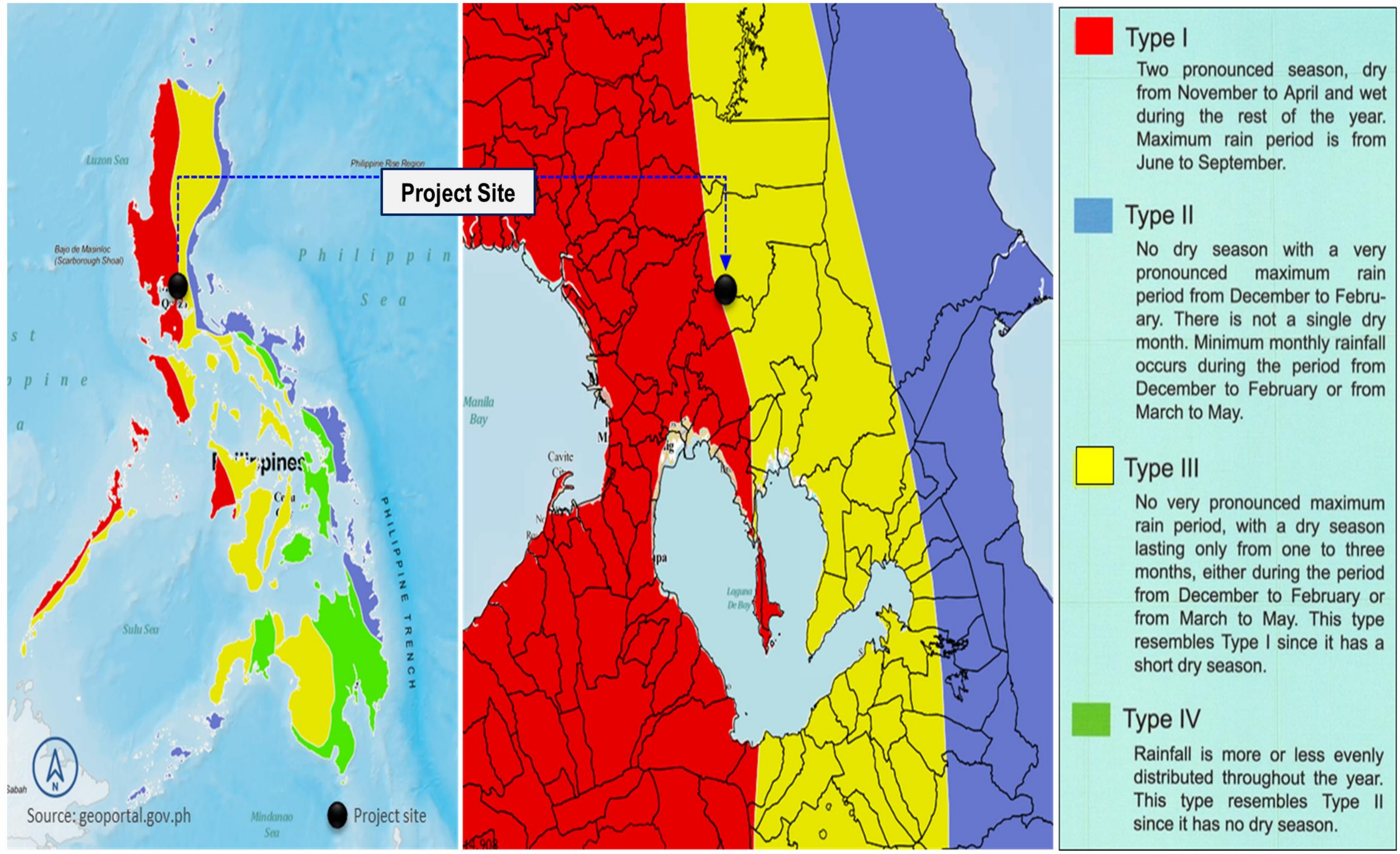


Figure EA-2. Modified Coronas classification of Philippine climate showing the Project Site

ENVIRONMENTAL IMPACT STATEMENT
AIR MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

DATA INFORMATION/SOURCE:

Source Map: Geoportal.gov.ph
Modified by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.
apercu CONSULTANTS INC.

Not to Scale

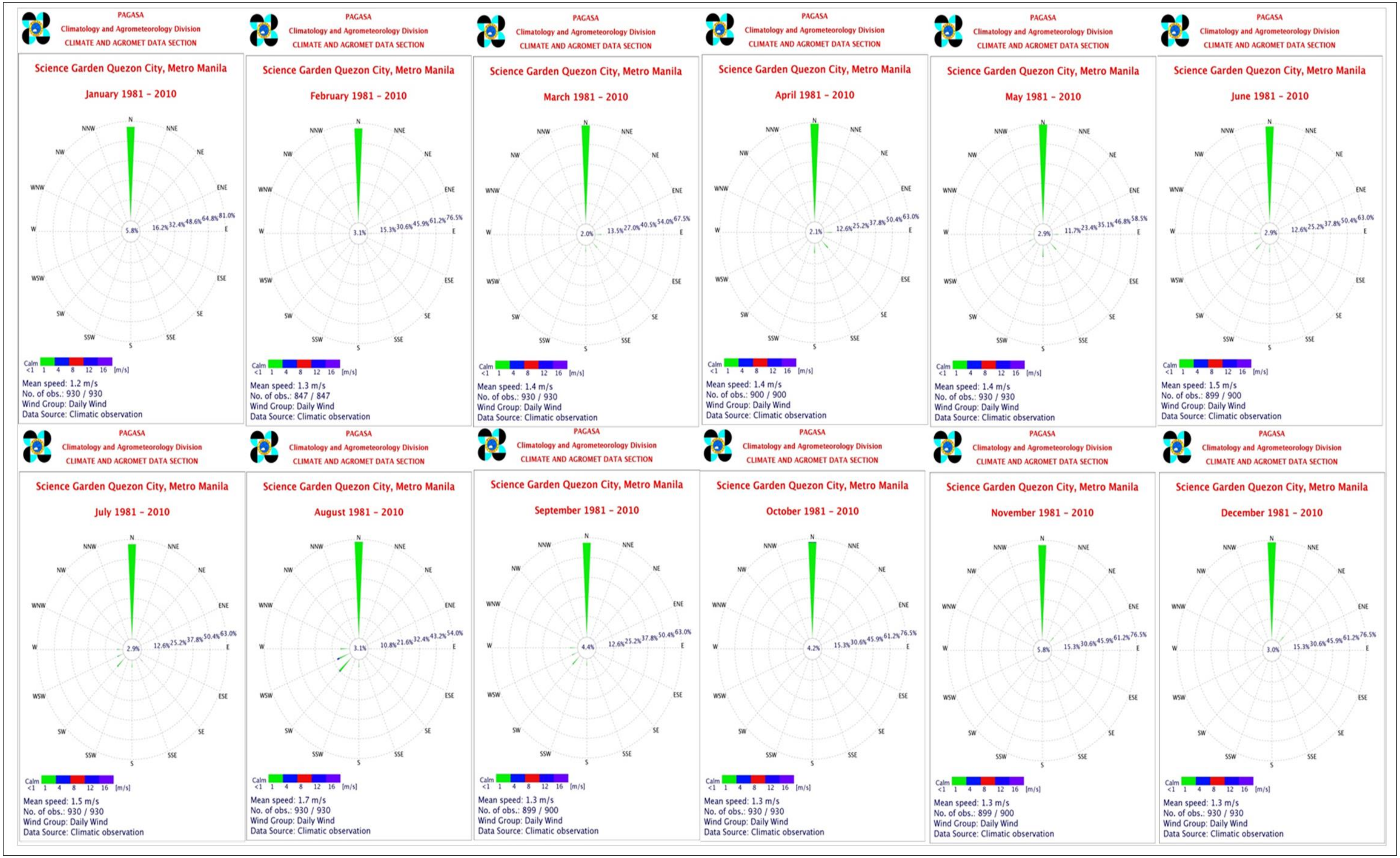


Figure EA-3. Monthly windroses at the Science Garden PAGASA station (1981-2010)

ENVIRONMENTAL IMPACT STATEMENT
AIR MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

DATA INFORMATION/SOURCE:

Source Map: PAGASA, 2020
Modified by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.
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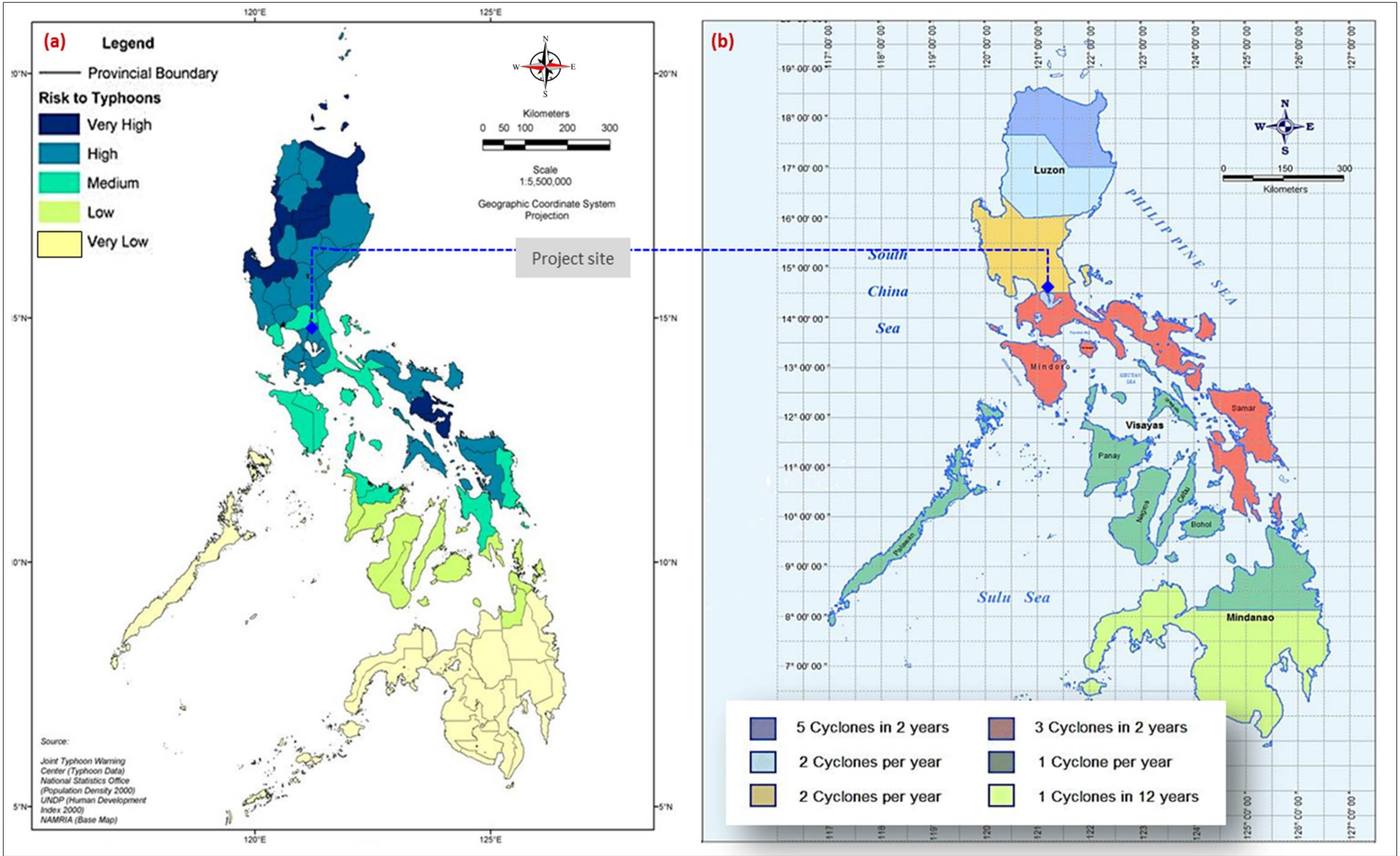

Figure EA-4. Tropical cyclone frequency map of the Philippines

ENVIRONMENTAL IMPACT STATEMENT
AIR MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

DATA INFORMATION/SOURCE:

Source Map: PAGASA, 2020
Modified by: APERCU CONSULTANTS, INC (2020)

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Scale: 1: 5,500,000

3.1.1.1 Impact Assessment

Climate change projections - Climate change projections on rainfall and temperatures in 2020 and 2050 was based on the paper "Climate Change in the Philippines 2011" published by the PAGASA. The projections were based on the normal data 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).*

Greenhouse gas (GHG) emissions - Freshwater reservoirs are a known source of GHG but their quantitative significance is still loosely constrained and uncertain due to the difficulties of measuring highly variable fluxes, and the lack of a clear accounting methodology particularly about what constitutes new emissions and potential new sinks[1].

Estimates of the GHG footprint for reservoirs to date where direct measurements have not been undertaken are generally derived by applying averages obtained from limited flux measurements in nearby systems or from systems thought to be 'comparable'. Because of the several shortcomings associated with this approach, estimating the GHG footprint of a reservoir or group of reservoirs continues to remain a significant scientific challenge[2].

Emission factors proposed by Deemer et al (2016) shown in **Table EA-3** was used to initially estimate the GHG emissions from the Project reservoir. The emissions factors were synthesized from reservoir CH_4, CO_2, and N_2O emission data in their study. Only the GHG from the reservoir was estimated because of unavailability of data from other sources.

Table EA-3
GHG emission factors and GWP used

GHG	EF	GWP*
CH4	120	28
CO2	330	1
N2O	0.30	265

EF – emission factor in mg/m^2/day (Deemer, B.R. et al, 2016); GWP – 100- year Global Warming Potential (IPCC Fifth Assessment Report, 2014)

[1] Prairie, Y.T. et al. (2018)
[2] Prairie, Y.T. et al. (2017)

3.1.2 Assessment of Key Impacts

3.1.2.1 Change in the Local Microclimate

<u>Regional Meteorology</u>

The Project site falls under a Type III climate (**Figure EA-2**). A Type III climate has no very pronounced maximum rainy period. It has a dry season lasting only for one to three months, either from December to February or March to May. This climate type resembles a Type I climate because of its short dry season.

Rainfall **-** The site may experience a monthly rainfall range of 14.6 (February) to 504.2 mm (August) with an annual average of 2574.4 mm. Rainy days may range from three to 23 days in a month with an annual frequency of 41.92 percent. The rainfall normal trend shown in **Figure EA-5a** follows the Type I climate. The site may experience an extreme daily rainfall range of 55.8 to 455.0 mm in January and September respectively (**Table EA-2**).

Surface temperatures - The highest mean temperature at the site may reach 29.7^{o}C in May with a low of 25.7 ^{o}C in January (**Figure EA-5b**) resulting to a normal seasonal difference is about four degrees and an annual mean of 27.7 degrees Celsius. The site may experience an extreme daily temperature range of 14.9 in March to 38.5 degrees Celsius in May (**Table EA-2**).

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 site may experience a relative humidity range of 67 to 84 percent (**Figure EA-5c**). The annual average relative humidity is 78 percent.

Cloud cover - The monthly cloud cover at the site may range from four to seven okta (**Figure EA-5d**). The site may be generally cloudy from June in October (cloud cover ≥ 6 okta) which coincides with the wet season.

Surface winds - The potential prevailing wind speed at the site may range at 1.2 to 1.7 meters per second (average of 1.4) in the North direction prevailing all year round **(Figure EA-3**). The site may experience an extreme wind speed range of 13 to 50 meters per second in March and November respectively (**Table EA-2**).

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 South China Sea or at the western part of the country, having unusual motions, and quite rare with 52 occurrences in 50 years (Perez, 2001). The PAGASA categorized these cyclones as tropical depressions (TD), with wind speeds up to 63 kph; tropical storm (TS) with wind speeds from 64-117 kph, and tropical typhoon (TY), with wind speeds over 117 kph. In general, from 1948-1993, PAGASA has 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.

The Project site is located in an area with high typhoon risk and may be visited by two cyclones every year (**Figure EA-4**).

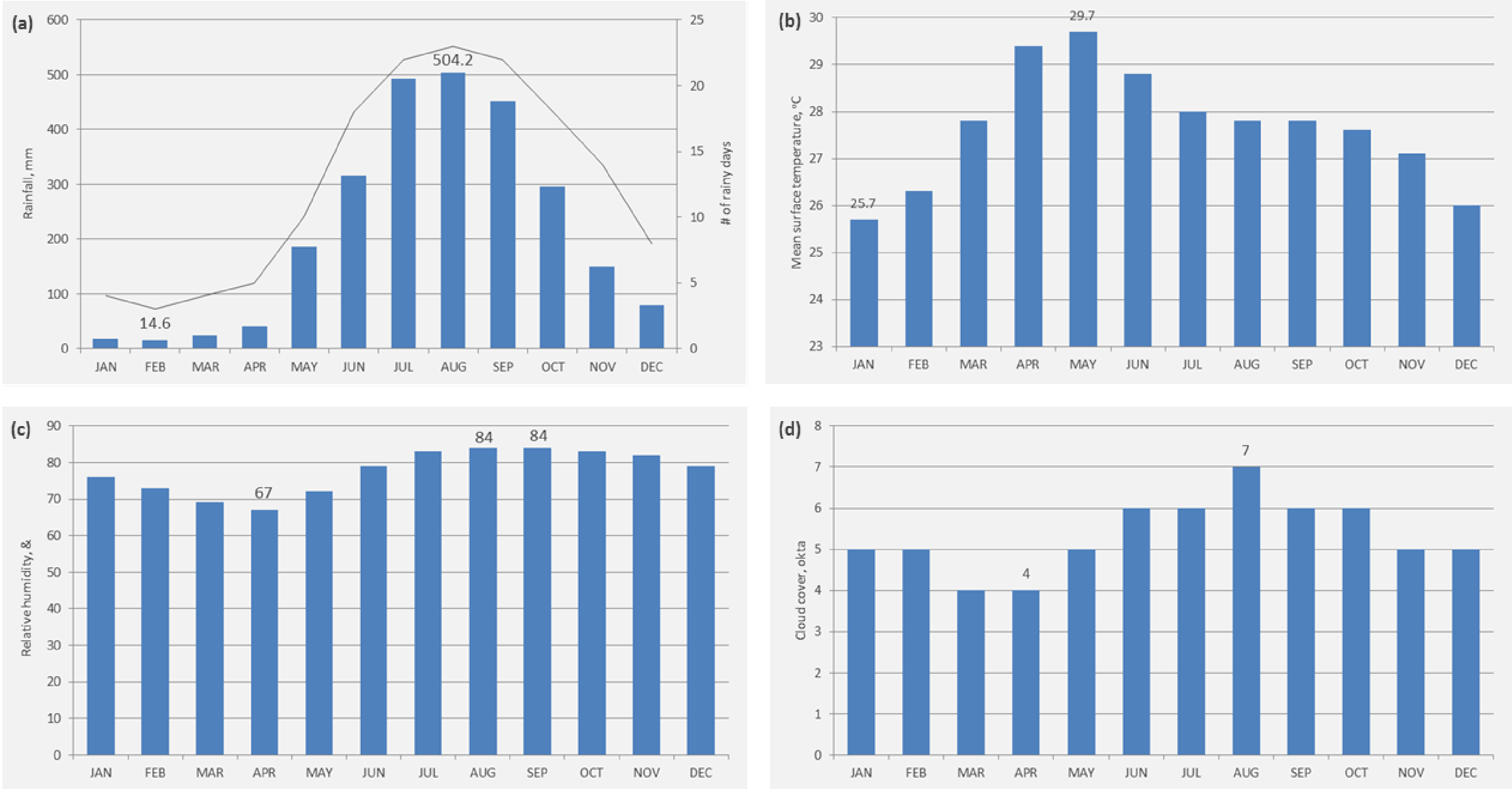

Figure EA-5 (a-d). Regional normal rainfall, temperature, relative humidity, and cloud cover at the Project site

Local Meteorology

In the absence of on-site met records, the meteorology at the Project site and vicinities (model domain) was described by meteorological data derived from prognostic modeling.

The met data at the Project site and its vicinities showed similarity with the Type III PAGASA climate with a dry season from either December to February or March to May (**Figure EA-6**). Although the rainfall trends are similar, predicted local rainfall is greater than the PAGASA record by a factor of three.

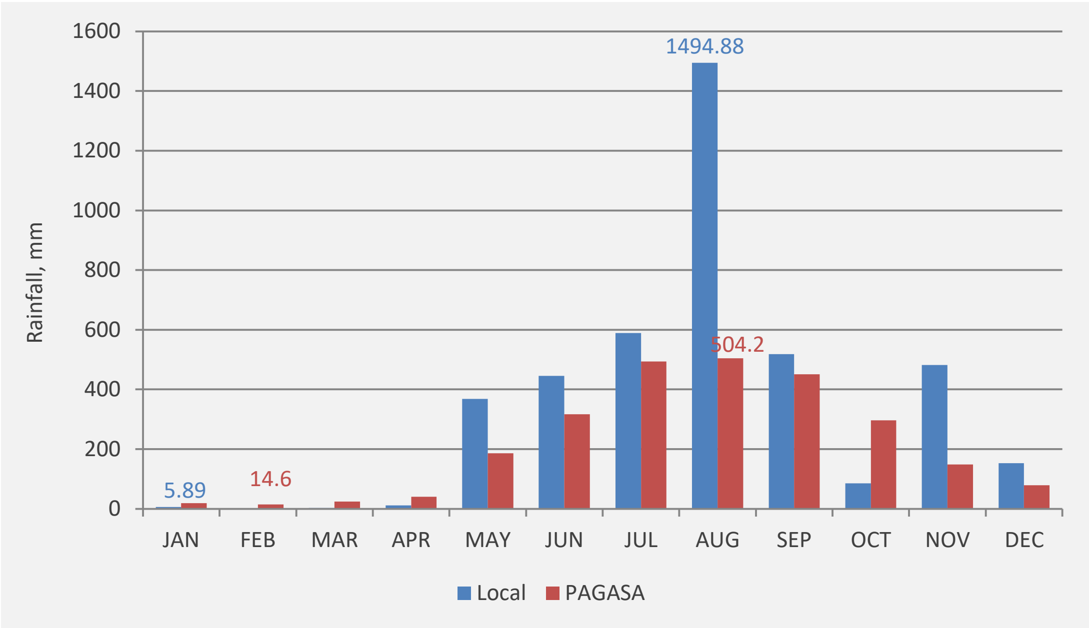

Figure EA-6. Comparison of local and PAGASA rainfall data

Similarly, local surface temperatures and relative humidity also followed the monthly PAGASA trend (**Figure EA-7**,**Figure EA-8**). However, the predicted local temperatures were lower than the lowest and highest PAGASA records by 2.75 and 2.3 degrees respectively.

The prognostic predictions showed a more wind directions at the Project site compared with the regional wind records of PAGASA (**Figure EA-10**, **Figure EA-11**). Local wind profiles are enumerated below and shown in **Figure EA-9**:

a) January to February: East-Northeast direction with wind speeds of 8 to 12 meters per second
b) April and June: Northeast direction with wind speeds of 4 to 8 meters per second
c) May: Northeast direction with wind speeds of 1 to 4 meters per second
d) July: West direction with wind speeds of 1 to 8 meters per second (transition)
e) August and September: West-Southwest direction with wind speeds of 4 to 8 meters per second
f) October to December: East-Northeast direction with wind speeds of 4 to 8 meters per second

The local atmospheric stabilities, determined by converting the Monin-Obukhov Length scalars to the Pasquill-Gifford stability classification, showed that B/C (unstable/slightly unstable) and E/F (slightly stable/stable) stabilities were predicted to be dominant at the Project site (**Figure EA-12**). Unstable atmospheres occur during daytime due to insolation while a stable atmosphere occurs during nighttime. The descriptions of the prevailing stabilities are described below.

a) B stability (unstable): daytime; strong insolation with wind speed between 3 and 5 m/s or moderate insolation with wind speed between 2 and 4 m/s or slight insolation and wind < 2 m/s

b) C stability slightly unstable: daytime; strong insolation and wind speed >5 m/s or moderate insolation with wind between 4 and about 5.5 m/s or slight insolation and wind between 2 and 5 m/s
c) E stability (slightly stable): nighttime; thin overcast or > 50% cloud cover and wind < 3 m/s; < 50% cloud cover and wind between 3 and 5 m/s
d) F stability (stable): nighttime; < 50% cloud cover and wind < 3 m/s

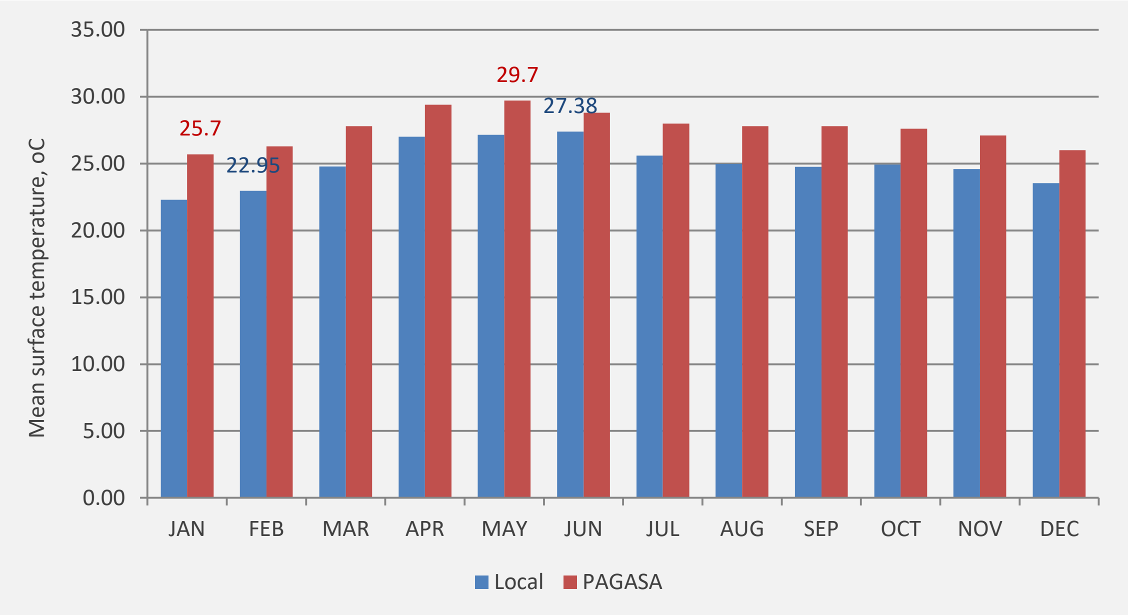

Figure EA-7. Comparison of local and PAGASA surface temperatures

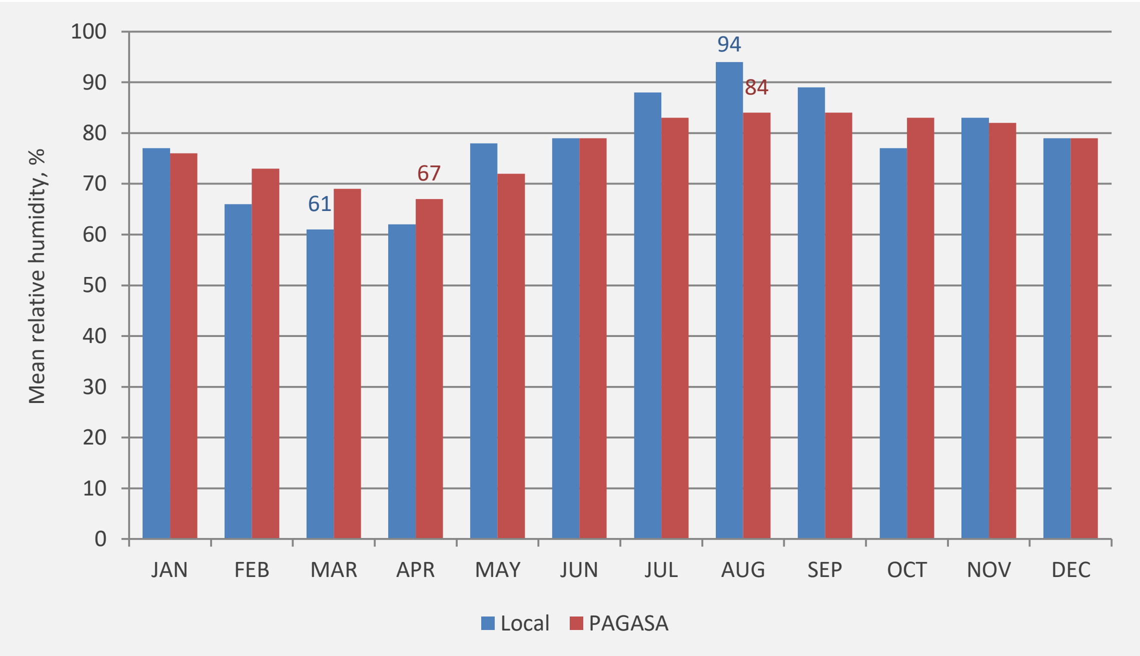

Figure EA-8. Comparison of local and PAGASA humidity values

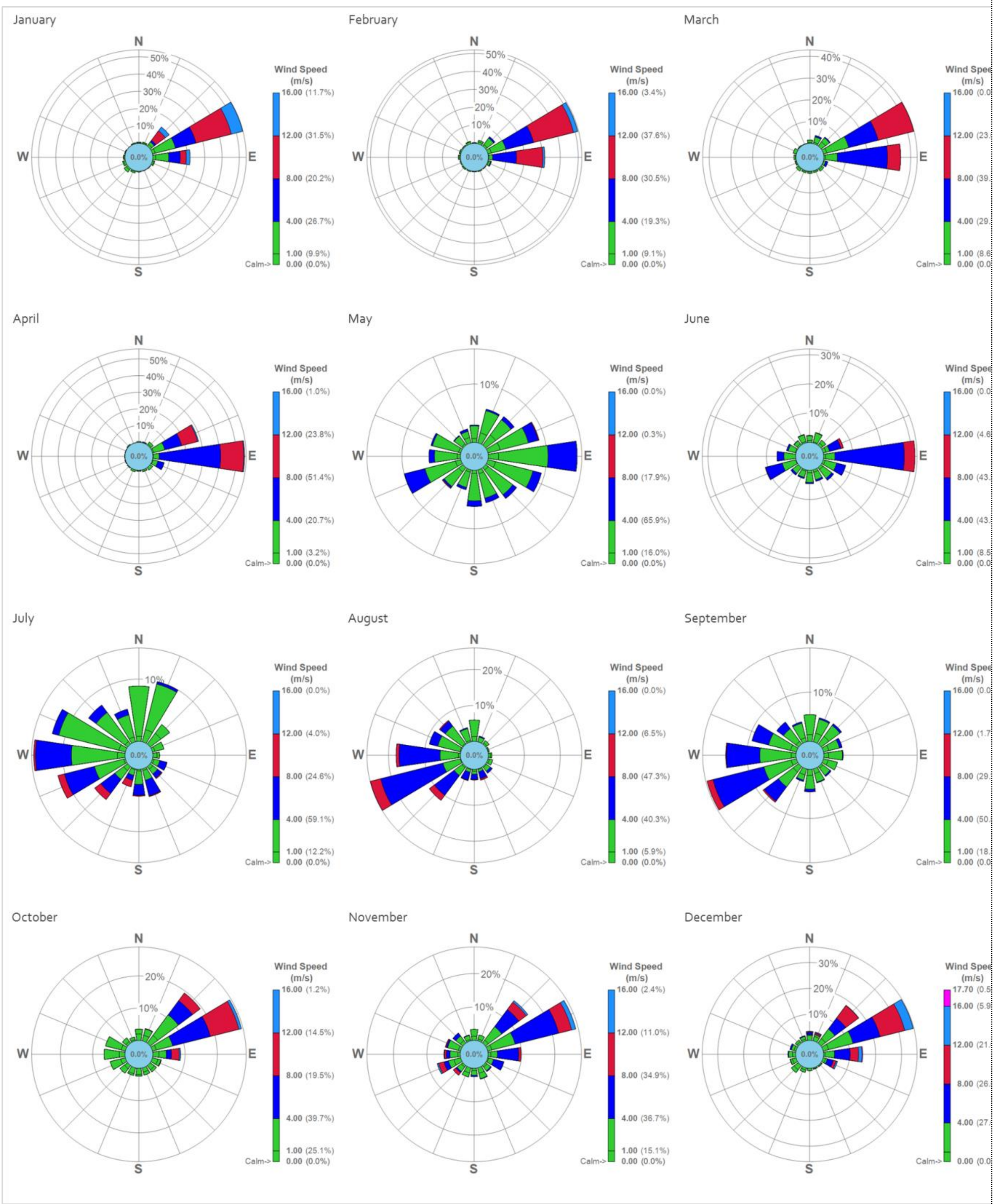

Figure EA-9. Monthly windroses at the at the Project site (2019)

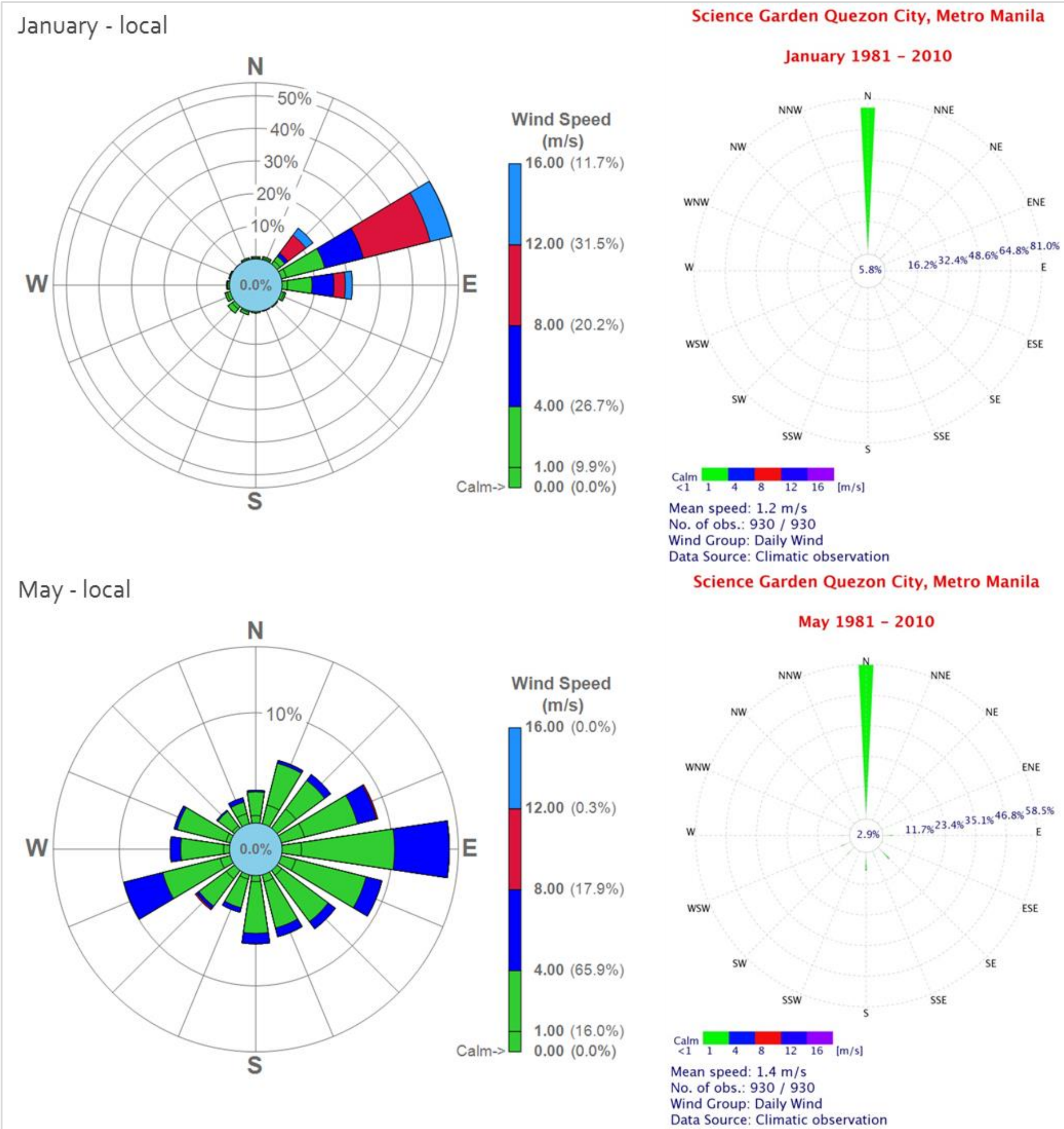

Figure EA-10. Comparison of local and PAGASA wind roses for January and May (1981-2010)

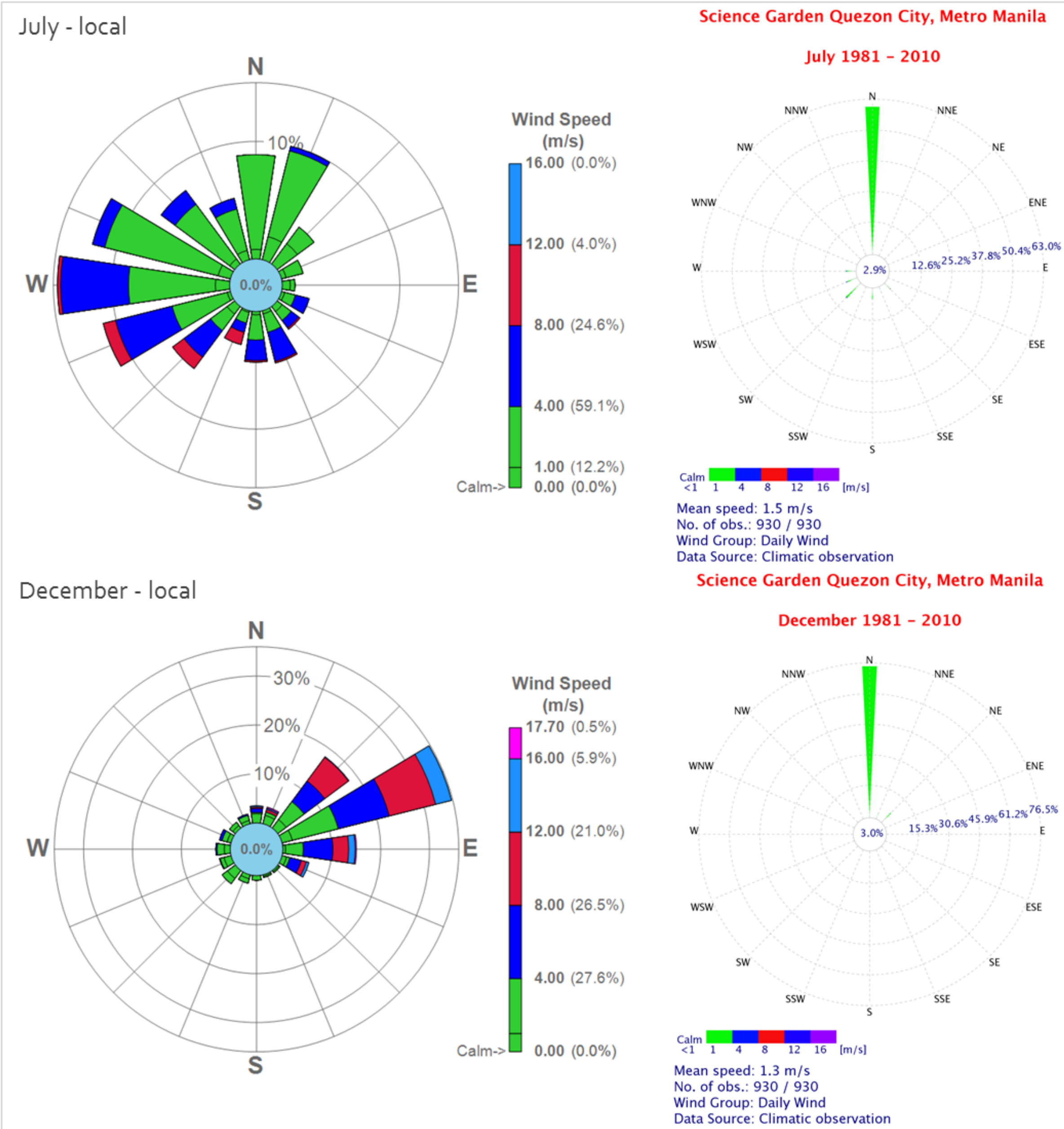

Figure EA-11. Comparison of local and PAGASA wind roses for July and December (1981-2010)

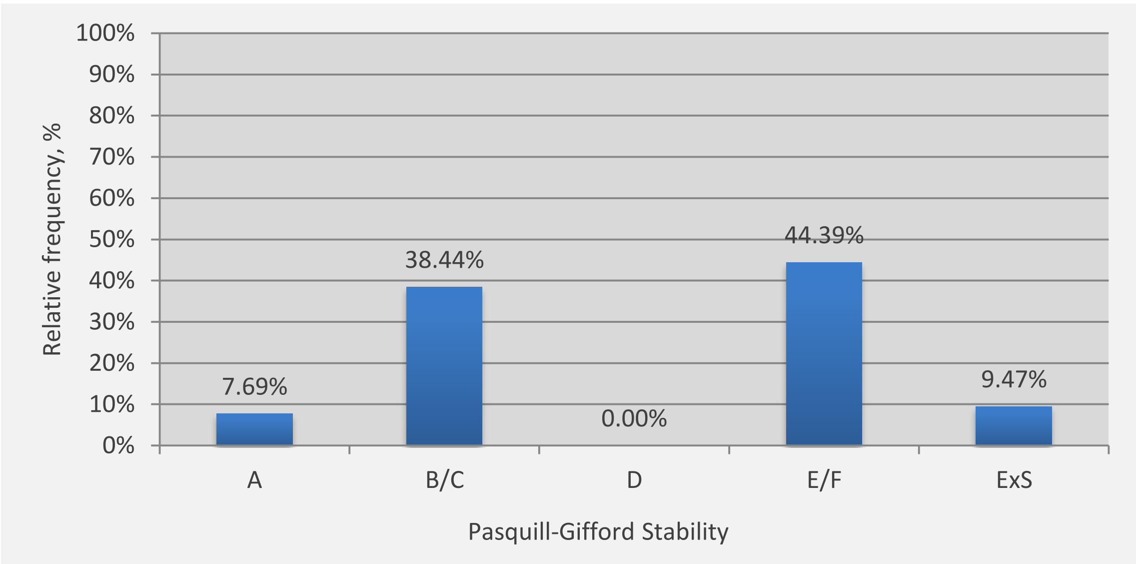

Figure EA-12. Atmospheric stabilities at the Project area

PAGASA Climate Projections

Surface temperatures - 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 Rizal under a medium range scenario showed surface temperature increases of 0.9°C to 1.1°C and 1.8°C to 2.1°C in 2020 and 2050 respectively. With these projections, the Project site may experience seasonal mean surface temperatures from 26.3 to 29.0°C and 27.3 to 30°C in 2020 and 2050 respectively (**Table EA-4**). The projections followed the trend of the baseline temperatures (**Figure EA-13**).

Table EA-4
Annual mean temperature projections in Rizal

Month	Baseline*	2020	2050
DJF	25.40	26.30	27.30
MAM	27.90	29.00	30.00
JJA	27.60	28.50	29.40
SON	26.80	27.80	28.70
Annual Mean	**26.93**	**27.90**	**28.85**

Source: derived from the PAGASA report *Climate Change in the Philippines*;
Notes: *1971-2000; DJF – Dec, Jan, Feb, MAM – Mar, Apr, May, JJA – Jun, Jul, Aug, SON, Sep, Oct, Nov

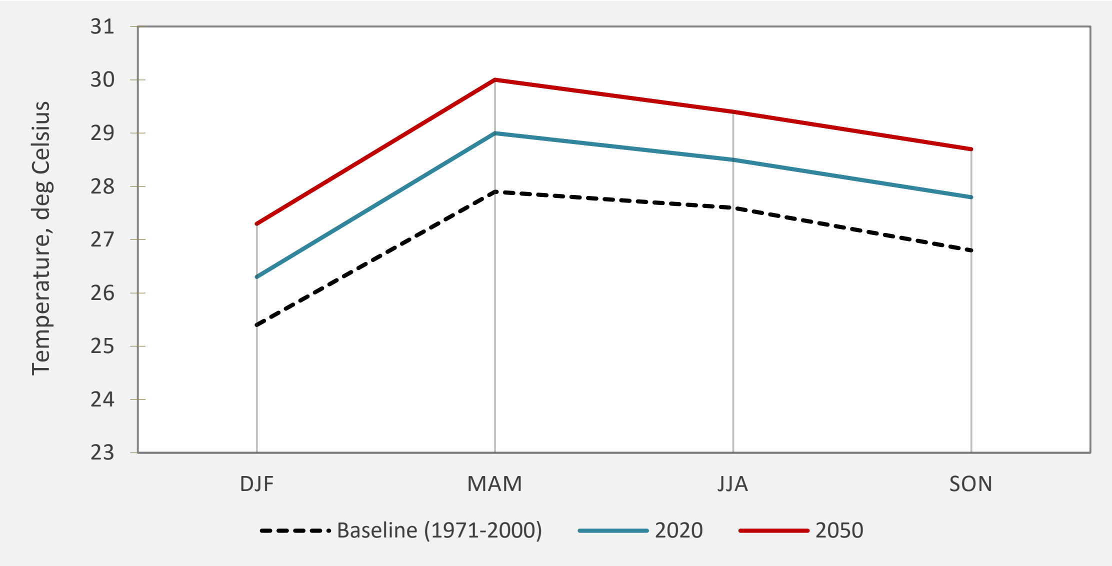

Figure EA-13. Trend of projected temperatures in Rizal

Rainfall **-** In contrast to the projected temperature increase, the mean annual rainfall and the number of rainy days in the country has 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-ranged scenario showed both rainfall decreases and increases in 2020 and 2050 from the observed baseline. The highest increases from the baseline were projected in the months of June, July, and August with an increase of 12.4% (1,125.5mm) and 24.8% (1,249.62mm) in 2020 and 2050 respectively (**Table EA-5**). Similar to projected temperatures, the rainfall projections also followed the baseline trend (**Figure EA-14**).

Table EA-5
Annual mean rainfall projections in Rizal

Month	Baseline*	2020	2050
DJF	262.4	228.0	232.2
MAM	241.5	167.4	145.4
JJA	1,001.3	1,125.5	1,249.6
SON	821.8	814.4	815.2
Annual Total	**2,327.0**	**2,335.3**	**2,442.5**

Source: derived from the PAGASA report *Climate Change in the Philippines*;
Notes: ***1971-2000;** DJF – Dec, Jan, Feb, MAM – Mar, Apr, May, JJA – Jun, Jul, Aug, SON, Sep, Oct, Nov

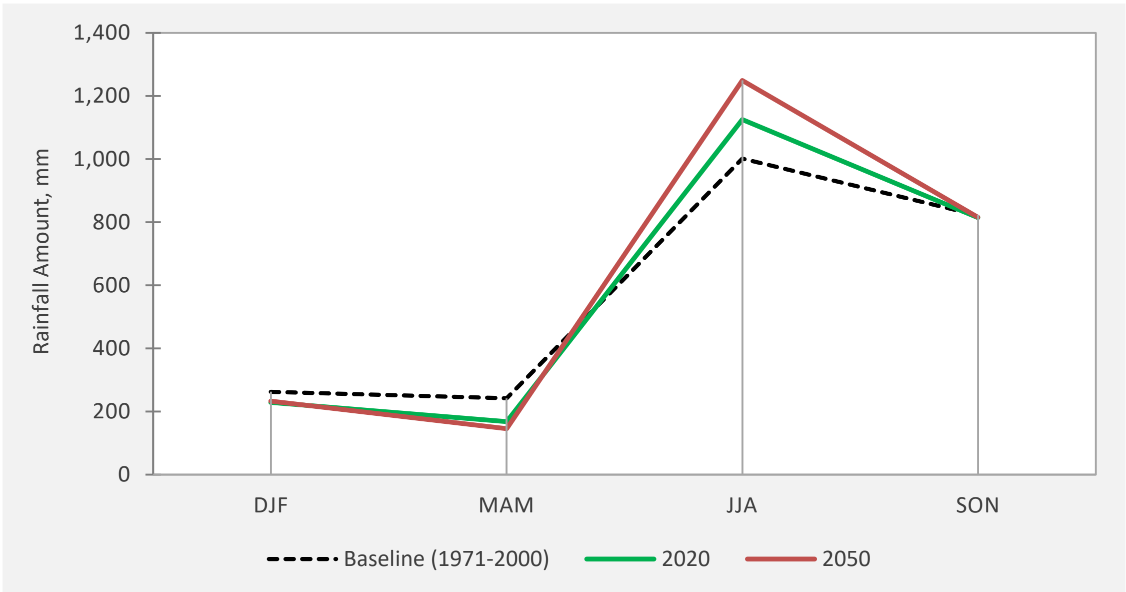

Figure EA-14. Trend of projected rainfall in Rizal

Effect of Meteorological Variability

The global averaged surface temperature according to the IPCC is predicted to increase by 1.4 to 5.8 degrees Celsius over the period 1990 to 2100 resulting to evaporation rate increases and precipitation fluctuations. Consequently, renewable technologies which completely rely on the climate conditions are one of those influenced by the predicted climate variations. The effect of meteorological variability may have the largest impact on hydropower generation and water supply reservoirs because it is sensitive to the amount, timing, and geographical pattern of precipitation as well as temperature (*Skoulikaris Charalampos, Monget Jean-Marie, Ganoulis Jacques*).

Other factors that exacerbate the effects of meteorological variations on the Project operations are a) hydrological cycles altered by climate change means that historic data may no longer be a reliable predictor of future hydrological patterns, and b) the use of historical and present climates may results for the design may expose the dam to rapid shifts in river flows and precipitation. New mechanisms have to be put in place to cope with both the uncertainty of historical climate variability and additional uncertainty of climate change.

3.1.2.2 Contribution in Terms of Greenhouse Gas Emissions

The Project is estimated to emit 5,642 MT of CO_2-equivalents a year with CH_4 comprising about 84 percent of the emissions (**Table EA-6**). The GHG estimates were derived using a reservoir area of 4,100,657 square meters[3].

Table EA-6
Estimated GHG emissions from the Project reservoir

Greenhouse Gas	MT/year	GWP*	CO_2-e	% Distribution
CH_4	179.61	28	5,029.05	89.14%
CO_2	493.92	1	493.92	8.75%
N_2O	0.45	265	118.99	2.11%
TOTAL	673.98		5,641.96	100.00%

*Global Warming Potential, IPCC Fifth Assessment Report (AR5)

[3] Estimated from Google Earth using reservoir footprint provided by Client

Essentially, carbon dioxide (CO_2) and methane (CH_4) are the GHG relevant with large reservoirs (Neumann-Silkow, GTZ). The main sources of CO_2 and CH_4 are the decomposition of inundated vegetation, soils, and organic matter (plants, plankton, algae, etc.) that flows into, and is produced in reservoirs over their lifespan. These gases are released at the reservoir surface, turbines and spillways, and downstream of the dam. Methane is produced by anaerobic decomposition processes occurring in deeper water levels and in shallow warmer waters (respiration). Greenhouse gases are also generated, although small and temporary, during the construction stage.

The GHG emissions in reservoirs vary by time and place; high emissions shortly after flooding (decomposition of flooded biomass) which decline slowly over time until a steady level is reached. Methane emissions can also be higher in shallower waters. A large reservoir area means removal of a carbon sink (flooded vegetation) and generation of methane gas (high GWP).

3.1.3 Proposed Mitigating Measures

The Project's contribution to the enhancement of climate change was described by its potential GHG emissions during operations and reduction of GHG sinks (flooded area). The recommended mitigation to offset these impacts is by carbon sequestration through planting of vegetation. **Table EA-7** shows that tree plantations using fast growing species like *Mahogany, dipterocarps, Gmelina, A. auricoliformis, P. falcataria, T. grandis, Pinus kesia, Acacia, Eucalyptus citrodora, E. cloeziana, E. pellita, E. tereticornis* shows potential for the Project's carbon sequestration program.

The 28 hectares planted with the indicated fast growing tree species to offset GHG emissions of the Project is only indicative at this stage. A more detailed study is needed for the greening program after the detailed engineering design.

Table EA-7
Land cover vegetation matrix for carbon sequestration

Land Cover	C sequestration Rate ($Mgha^{-1}yr^{-1}$)	Area needed for UWD, ha	No. of Trees per ha
Protection Forest	1.5	329.28	66
Second-growth forest	2.2	224.51	97
Tree Plantations	4	123.48	176
Agroforestry	2.7	182.93	119
Tree Plantations (fast growing)*	17.5	28.22	771

Source: Lasco, R.D. et. al., 2000; *Mahogany, dipterocarps, Gmelina, A. auricoliformis, P. falcataria, T. grandis, Pinus kesia, Acacia, Eucalyptus citrodora, E. cloeziana, E. pellita, E. tereticornis

3.2 Ambient Air Quality and Noise

This section presents the existing ambient air quality at the Project area in the context of the applicable Clean Air Act (CAA) ambient air quality standards. Air dispersion modeling was also done to predict the indicative ambient air quality impacts during Project implementation. The criteria for assessing potential ambient air quality impacts during Project implementation are shown in **Table EA-8**.

Table EA-8
Impact assessment criteria during Project implementation

Pollutant	AT	Unit	Value	Source	Analytic Method
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	CAA NAAQSSSAPIS/O	
	24h	μg/ncm	150	CAA NAAQGV	
	Annual	μg/ncm	60	CAA NAAQGV	

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

3.2.1 Methodology

3.2.1.1 Air Quality

The existing ambient air quality was characterized by measuring levels of total suspended particulates (TSP) at six locations at the project site and its vicinities (**Figure EA-15**). Methods for sampling and analysis conformed to methods prescribed in Sec. 1(b) Rule VII Part II of the Clean Air Act Implementing Rules and Regulation (IRR). The results were compared to 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 as an indicative measure of air quality only and not compliance.

The focus of the impact assessment is dispersion of fugitive particulates (TSP and PM10) during the construction and operation phases. The following were done to assess ambient air quality impacts of fugitive particulates:

1. Predicted the 98th percentile ground-level concentrations (GLC) of fugitive TSP and PM10 during construction;
2. Identified air pollution "hotspots", i.e., areas where 98th percentile GLCs were predicted to occur. The identified hotspots will be the priority areas for monitoring especially if sensitive discrete receptors are present;
3. Compared model results with the TSP and PM10 air ambient quality standards and guideline values; and
4. Identified mitigating measures to minimize the potential impacts on the ambient air quality.

Scenarios (or source groupings) were created because there were options during Project planning. Examples are two quarry sites options, an optional access road, and an optional transmission tunnel. The scenarios for the simulations during construction and operation phases are shown in **Table EA-9** and **Table EA-10** respectively.

Table EA-9
Modeling scenarios during construction phase

Scenario	Project components
ALL	▪ Upper Wawa Dam and Spillway (UWDS) ▪ Pump Station 2 (PS2) ▪ Transmission Pipe via tunnel (optional) ▪ Temporary facilities (Camp and Office, Temporary Disposal Area 1, Temporary Disposal Area 2, Facilities during Construction ▪ New Access Roads (Dam to Spillway, UWDS to the existing road, PS2 to the Water Treatment Plant) ▪ Optional New Access Road connecting the UWDS to the existing paved road ▪ Existing Roads ▪ Quarry (two site options)

Scenario	Project components
OP1	▪ Upper Wawa Dam and Spillway (UWDS) ▪ Pump Station 2 (PS2) ▪ Temporary facilities (Camp and Office, Temporary Disposal Area 1, Temporary Disposal Area 2, Facilities during Construction ▪ New Access Roads (Dam to Spillway, existing road, PS2 to the Water Treatment Plant) ▪ Existing Roads ▪ Quarry Option 1
OP2	▪ Upper Wawa Dam and Spillway (UWDS) ▪ Pump Station 2 (PS2) ▪ Temporary facilities (Camp and Office, Temporary Disposal Area 1, Temporary Disposal Area 2, Facilities during Construction ▪ New Access Roads (Dam to Spillway, PS2 to the Water Treatment Plant) ▪ Optional New Access Road connecting the UWDS to the existing paved road ▪ Existing Roads ▪ Quarry Option 1
OP3	▪ Upper Wawa Dam and Spillway (UWDS) ▪ Pump Station 2 (PS2) ▪ Transmission Pipe via tunnel (optional) ▪ Temporary facilities (Camp and Office, Temporary Disposal Area 1, Temporary Disposal Area 2, Facilities during Construction ▪ New Access Roads (Dam to Spillway, UWDS to the existing road, PS2 to the Water Treatment Plant) ▪ Existing Roads ▪ Quarry Option 1
OP4	▪ Upper Wawa Dam and Spillway (UWDS) ▪ Pump Station 2 (PS2) ▪ Transmission Pipe via tunnel (optional) ▪ Temporary facilities (Camp and Office, Temporary Disposal Area 1, Temporary Disposal Area 2, Facilities during Construction ▪ New Access Roads (Dam to Spillway, PS2 to the Water Treatment Plant) ▪ Optional New Access Road connecting the UWDS to the existing paved road ▪ Existing Roads ▪ Quarry Option 1
OP5	▪ Upper Wawa Dam and Spillway (UWDS) ▪ Pump Station 2 (PS2) ▪ Temporary facilities (Camp and Office, Temporary Disposal Area 1, Temporary Disposal Area 2, Facilities during Construction ▪ New Access Roads (Dam to Spillway, existing road, PS2 to the Water Treatment Plant) ▪ Existing Roads ▪ Quarry Option 2
OP6	▪ Upper Wawa Dam and Spillway (UWDS) ▪ Pump Station 2 (PS2) ▪ Temporary facilities (Camp and Office, Temporary Disposal Area 1, Temporary Disposal Area 2, Facilities during Construction ▪ New Access Roads (Dam to Spillway, PS2 to the Water Treatment Plant) ▪ Optional New Access Road connecting the UWDS to the existing paved road ▪ Existing Roads ▪ Quarry Option 2
OP7	▪ Upper Wawa Dam and Spillway (UWDS) ▪ Pump Station 2 (PS2) ▪ Transmission Pipe via tunnel (optional) ▪ Temporary facilities (Camp and Office, Temporary Disposal Area 1, Temporary Disposal Area 2, Facilities during Construction ▪ New Access Roads (Dam to Spillway, UWDS to the existing road, PS2 to the Water Treatment Plant) ▪ Existing Roads ▪ Quarry Option 2

Scenario	Project components
OP8	▪ Upper Wawa Dam and Spillway (UWDS) ▪ Pump Station 2 (PS2) ▪ Transmission Pipe via tunnel (optional) ▪ Temporary facilities (Camp and Office, Temporary Disposal Area 1, Temporary Disposal Area 2, Facilities during Construction ▪ New Access Roads (Dam to Spillway, PS2 to the Water Treatment Plant) ▪ Optional New Access Road connecting the UWDS to the existing paved road ▪ Existing Roads ▪ Quarry Option 2

Table EA-10
Modeling scenarios during operation phase

Scenario	Project components
ALL-ER	▪ New Access Roads (Dam to Spillway, UWDS to the existing road, PS2 to the Water Treatment Plant) ▪ Optional New Access Road connecting the UWDS to the existing paved road ▪ Existing Roads
ALL-ER	All Existing Roads
ALL-NAR1	New Access Roads (Dam to Spillway, UWDS to the existing road, PS2 to the Water Treatment Plant)
ALL-NAR2	▪ New Access Roads (Dam to Spillway, PS2 to the Water Treatment Plant) ▪ Optional New Access Road connecting the UWDS to the existing paved road
OP1	▪ New Access Roads (Dam to Spillway, UWDS to the existing road, PS2 to the Water Treatment Plant) ▪ Existing Roads
OP2	▪ New Access Roads (Dam to Spillway, PS2 to the Water Treatment Plant) ▪ Optional New Access Road connecting the UWDS to the existing paved road ▪ Existing Roads

The EMB Air Dispersion Modeling Guidelines (EMB Memorandum Circular 2008-003) was used to predict the TPS and PM10 GLCs. The Tier 4 approach using the AERMOD model was used to predict the pollutant GLCs. The Breeze™ AERMOD v9.0.0.23 Pro Plus version software using the U.S. EPA AERMOD 19191 executable was used for the simulations.

Description of the ADM model

The AERMOD model is a steady-state plume model that assumes all concentrations at all distances during a modeled hour are governed by the temporally averaged meteorology of the hour. The steady state assumption yields useful results since the statistics of the concentration distribution are of primary concern rather than specific concentrations at particular times and locations. The flow of information implemented by the model is shown in **Figure EA-16** and **Figure EA-17.**

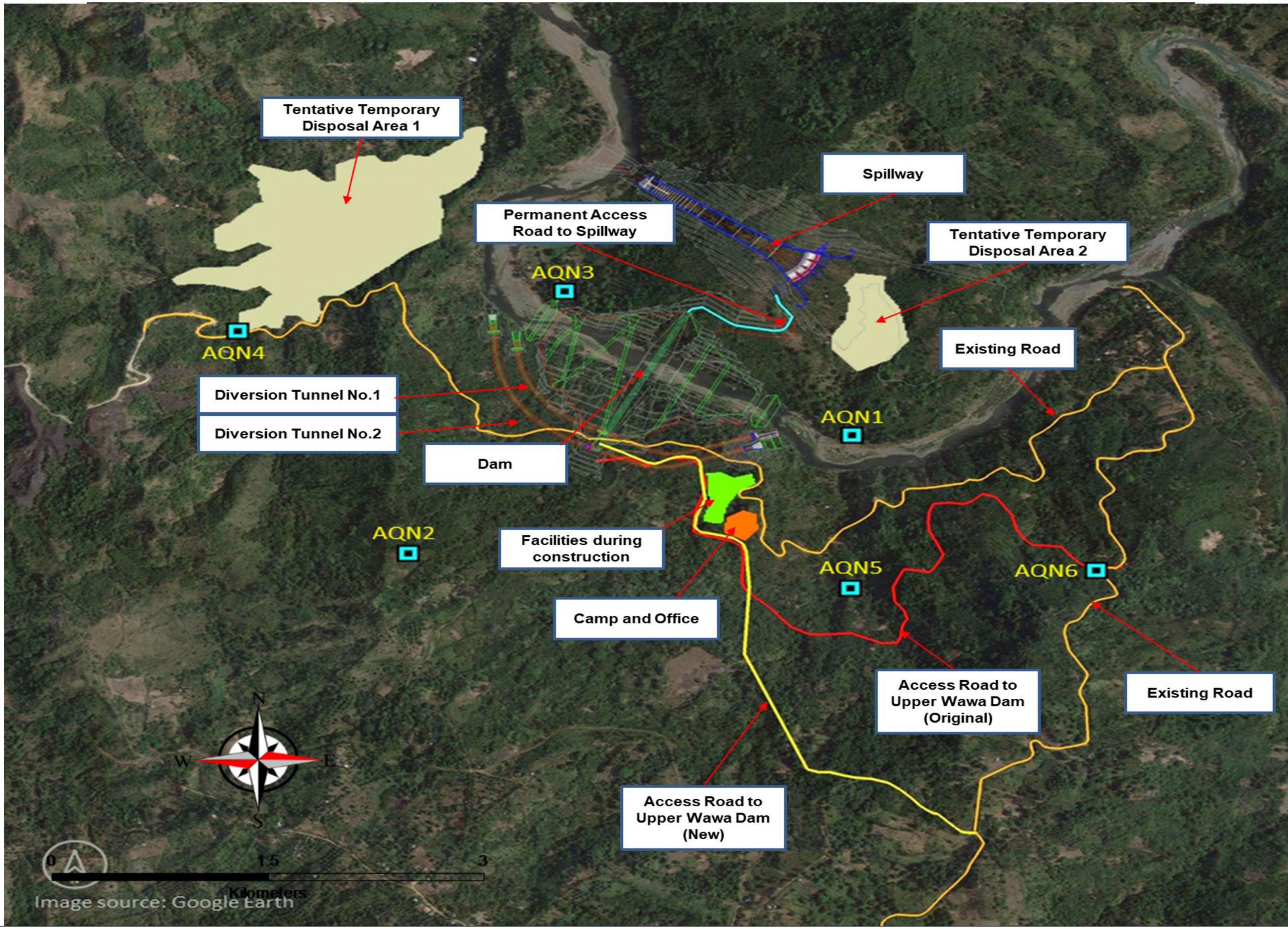

Figure EA-15. Ambient Air Quality and Noise Quality Sampling Stations

ENVIRONMENTAL IMPACT STATEMENT
AIR MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

Legend:
- Air and Noise Quality Stations
- UWD Dam and Diversion Tunnels
- Spillway
- Access Road (Original)
- Access Road (New)
- Temporary Facilities
- Facilities During Construction
- Camp and Office
- Existing Access Road

DATA INFORMATION/SOURCE:

Project Components: WawaJVCo INC. (2020)
Source Map: Google Earth Pro, 2020
Modified by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.
aperçu CONSULTANTS INC.

Scale: 1:10,000

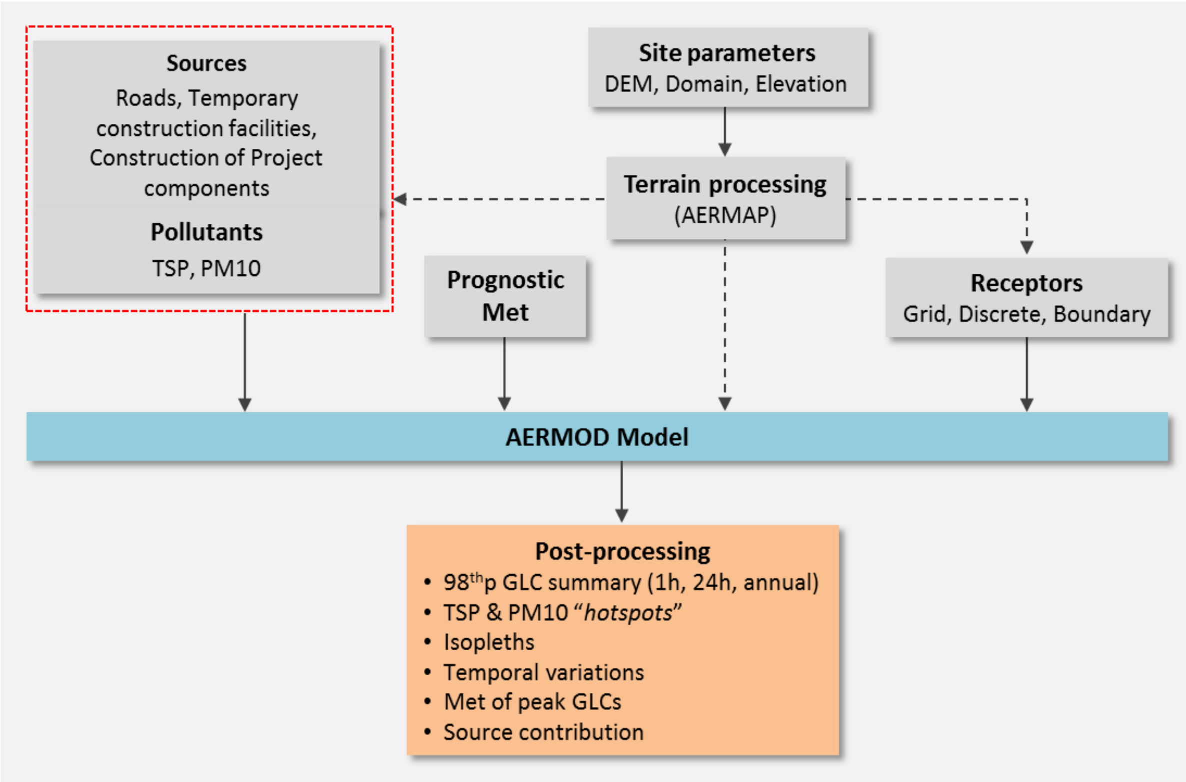

Figure EA-16. The air dispersion modeling logic diagram of the Project

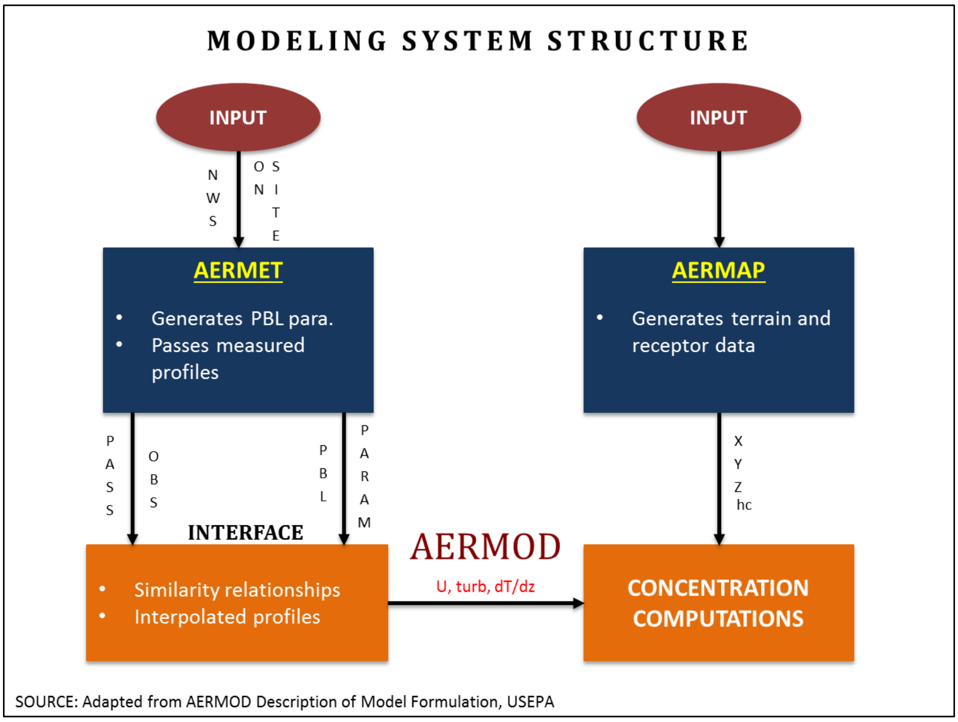

Figure EA-17. Data flow in the AERMOD modeling system

Emission Configuration, Sources and Rates

The model objects grouped by Project phase are enumerated in **Table EA-11**. The configurations of the model objects are shown in **Figure EA-18** and **Figure EA-19**

Table EA-11
Model objects during Project phase

Construction Phase	Operation Phase
1. Construction of Project components - Upper Wawa dam + Spillway - Pump station 2 - Optional transmission pipe via tunnel 2. Construction of roads - New Access Road Dam to Spillway - New Access Road Long - New Access Road from Pumping Station 2 to the Water Treatment Plant - New Access Road (Optional) 3. Use of four existing roads 4. Temporary facilities - Camp and office - Temporary disposal area 1 - Temporary disposal area 2 - Facilities during construction	1. Two existing roads (UNPAVED) 2. One existing road to site (PAVED) 3. New Access Road Dam to Spillway (PAVED) 4. New Access Road from PS2 to WTP (PAVED) 5. New Access Road (PAVED) 6. Optional New Access Road (PAVED)

The sources of the emission factors (**Table EA-12**, **Table EA-13**) used to derive the emissions rates (**Table EA-14, Table EA-15)** are:

1. USEPA AP-42 (Sec. 13.2.3 Heavy construction operations)
2. WRAP Fugitive Dust Handbook, 2006
3. EETM for Aggregated Emissions from Paved and Unpaved Roads, NPI Fugitive Emissions, 2012
4. Open area wind erosion, NPI Fugitive Emissions, 2012

Due to limited information on construction activities at this time, the simulations assumed that 100% of the areas of the major components and roads are emitting particulates during the entire duration of the construction phase as the worst-case scenario. The geographical coordinates and elevations of the different area sources (major components, temporary facilities, and access roads) were determined using Google Earth, ExcelTM formulas, and online tools. The elevations were derived from the Space Shuttle Radar Topography Mission 3 (SRTM3) database.

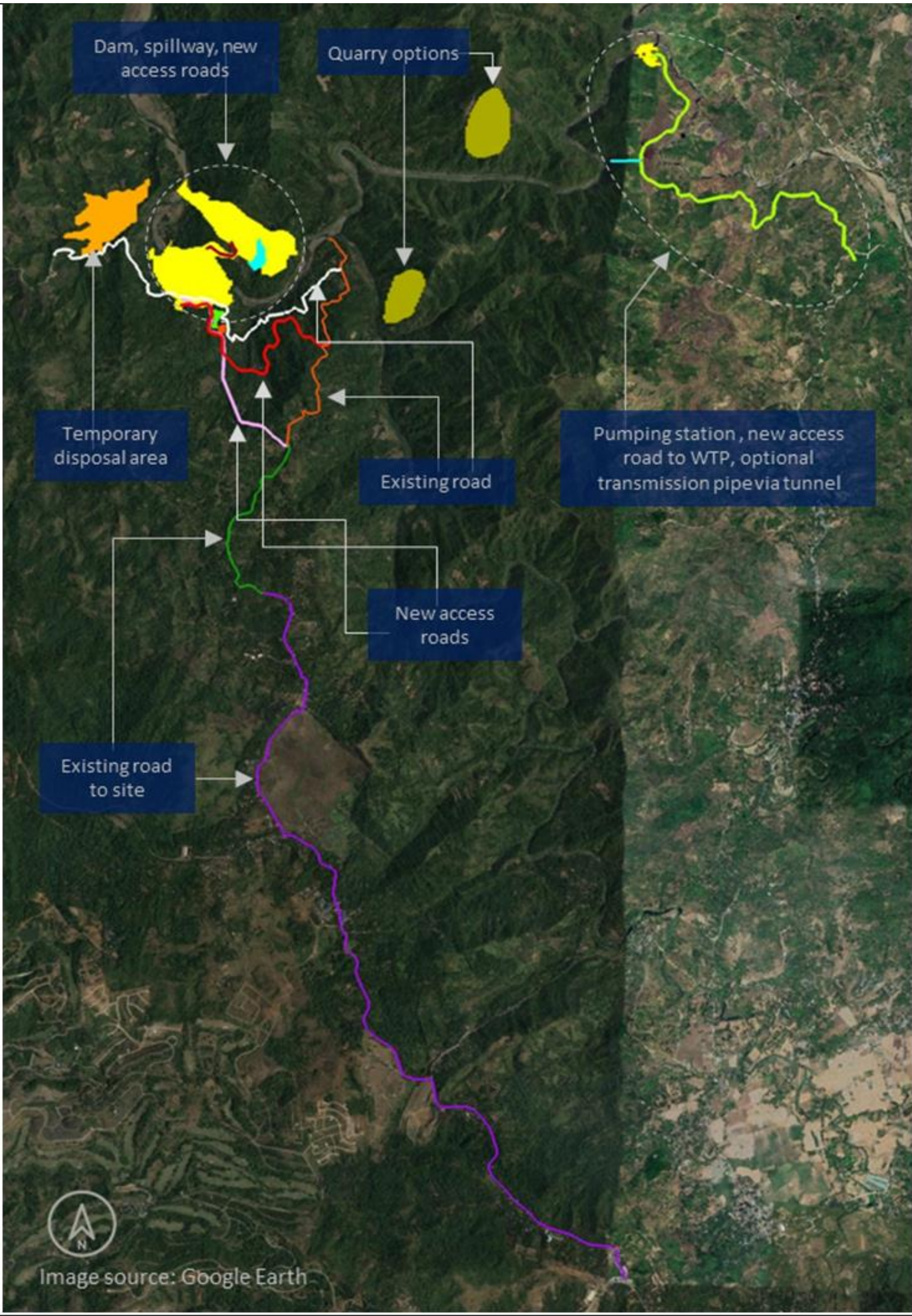

Figure EA-18. Model Objects during Construction Phase

ENVIRONMENTAL IMPACT STATEMENT
AIR MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

DATA INFORMATION/SOURCE:

Project Components: WawaJVCo INC. (2020)
Source Map: Google Earth Pro (2020)
Modified by: Apercu Consultants Inc. (2020)

WawaJVCo INC.
aperçu CONSULTANTS INC

SCALE: Not to Scale

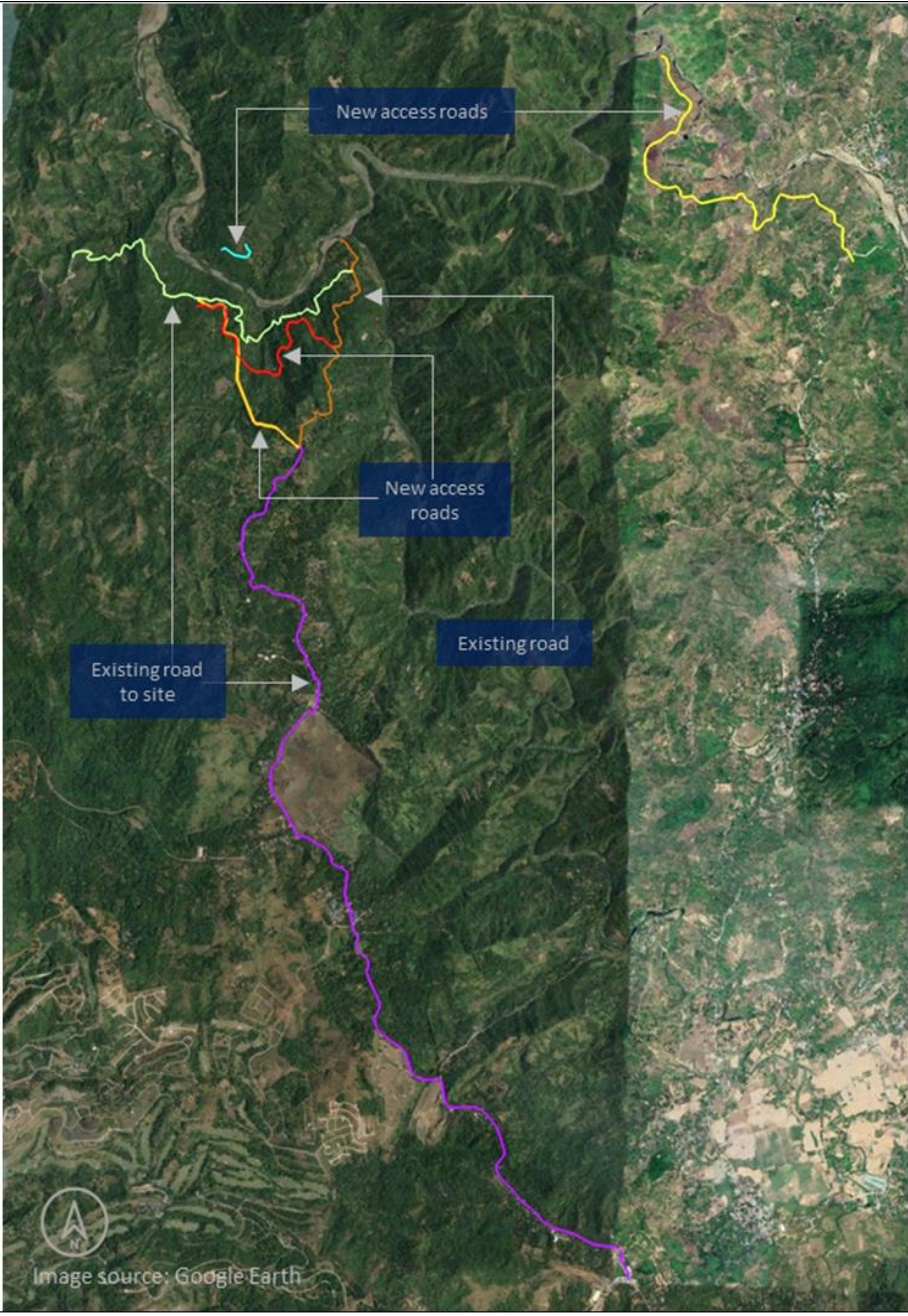

Figure EA-19. Model Objects during Operation Phase	DATA INFORMATION/SOURCE:	WawaJVCo INC. aperçu CONSULTANTS INC	
ENVIRONMENTAL IMPACT STATEMENT AIR MODULE Wawa Bulk Water Supply Project – Upper Wawa Dam	**Project Components:** WawaJVCo INC. (2020) **Source Map:** Google Earth Pro (2020) **Modified by:** Apercu Consultants Inc. (2020)	SCALE: Not to Scale	PAGE: 311

Table EA-12
Emission factors used for deriving particulate emission rates during construction

CONSTRUCTION PHASE MODEL OBJECT	ST	EF type	TSP EF	TSP EF unit	PM10 EF	PM10 EF unit	Source of Emission Factor
1. Construction of Project components							
Upper Wawa dam + Spillway	Area	Heavy construction	2.69	MT/ha/ month	0.11	tonnes/acre-month	TSP - Sec. 13.2.3 Heavy construction operations, AP-42 PM10 - Average conditions Level 1, Table 3-2 WRAP Fugitive Dust Handbook, 2006
Pump station 2	Area	Heavy construction	2.69		0.11		
Transmission Pipe via tunnel (optional)	Area	Heavy construction	2.69		0.11		
2. Construction of roads							
New Access Road Dam to Spillway (PAVED)	Area	Road construction*	2.69	MT/ha/ month	0.42	tonnes/acre-month	PM10 - 3.2.4 Road Construction WRAP Fugitive Dust Handbook, 2006
New Access Road Long (PAVED)	Area	Road construction*	2.69		0.42		
New Access Road from PS2 to WTP (PAVED)	Area	Road construction*	2.69		0.42		
Optional New Access Road (PAVED)	Area	Road construction*	2.69		0.42		
3. Existing roads used							
Blue - Existing road to be used (UNPAVED)	Volume	Veh travel on unpaved roads	2.67	kg/km	2.27	lb/VMT	PM10 - Sec. 6.3.1 WRAP Fugitive Dust Handbook (dust emissions from vehicle travel on unpaved roads) EETM for Aggregated Emissions from Paved and Unpaved Roads
Orange - Existing roads to be used (UNPAVED)	Volume	Veh travel on unpaved roads	2.67	kg/km	2.27	lb/VMT	
Green - existing road to site (PAVED)	Volume	Veh travel on paved roads	0.00886	kg/km	0.00170	kg/km	
Pink - existing road to site (PAVED)	Volume	Veh travel on paved roads	0.00886	kg/km	0.00170	kg/km	
4. Temporary facilities							
Camp and office	Area	Open area wind erosion	0.40	kg /ha/hr	0.20	kg/ha/hr	TSP - Sec. 3.2.5 Open area wind erosion, NPI Fugitive Emissions, 2012 PM10 - Sec. 3.2.5 Open area wind erosion, NPI Fugitive Emissions, 2012
Temporary disposal area 1	Area	Open area wind erosion	0.40	kg /ha/hr	0.20	kg/ha/hr	
Temporary disposal area 2	Area	Open area wind erosion	0.40	kg /ha/hr	0.20	kg/ha/hr	
Facilities during construction	Area	Open area wind erosion	0.40	kg /ha/hr	0.20	kg/ha/hr	
Quarry Option 1	Area	Open area wind erosion	0.40	kg /ha/hr	0.20	kg/ha/hr	
Quarry Option 2	Area	Open area wind erosion	0.40	kg /ha/hr	0.20	kg/ha/hr	

*NOTES: ST – source type; EF – emission factor; veh – vehicle; road color codes referenced to Figure EA-18; *no available EF. Assumed EF of heavy construction*

Table EA-13
Emission factors used for deriving particulate emission rates from roads

				TSP		PM10		
CONSTRUCTION PHASE MODEL OBJECTS	**AERCODE**	**ST**	**EF type**	**EF**	**EF unit**	**EF**	**EF unit**	**Source of Emission Factor**
Existing roads use								
Blue - Existing road to be used (UNPAVED)	ER1U	Volume	Veh travel on unpaved roads	2.67	kg/km	2.27	lb /VMT	▪ PM10 - Sec. 6.3.1 WRAP Fugitive Dust Handbook (dust emissions from vehicle travel on unpaved roads) ▪ EETM for Aggregated Emissions from Paved and Unpaved Roads
Orange - Existing roads to be used (UNPAVED)	ER2U	Volume	Veh travel on unpaved roads	2.67	kg/km	2.27	lb /VMT	
Green - existing road to site (PAVED)	ER3P	Volume	Veh travel on paved roads	0.00886	kg/km	0.00170	kg/km	
Pink - existing road to site (PAVED)	ER4P	Volume	Veh travel on paved roads	0.00886	kg/km	0.00170	kg/km	
OPERATION PHASE MODEL OBJECTS								
Blue - Existing road (UNPAVED)	ER1U	Volume	Veh travel on unpaved roads	2.67	kg/km	2.27	lb /VMT	▪ PM10 - Sec. 6.3.1 WRAP Fugitive Dust Handbook (dust emissions from vehicle travel on unpaved roads) ▪ EETM for Aggregated Emissions from Paved and Unpaved Roads
Brown - Existing road (UNPAVED)	ER2U	Volume	Veh travel on unpaved roads	2.67	kg/km	2.27	lb /VMT	
Pink - existing road to site (PAVED)	ER3P	Volume	Veh travel on paved roads	0.00886	kg/km	0.00170	kg/km	
Black - New Access Road Dam to Spillway (PAVED)	NAR1P	Volume	Veh travel on paved roads	0.00886	kg/km	0.00170	kg/km	
Yellow - New Access Road from PS2 to WTP (PAVED)	NAR2P	Volume	Veh travel on paved roads	0.00886	kg/km	0.00170	kg/km	
Red - New Access Road Long (PAVED)	NAR3P	Volume	Veh travel on paved roads	0.00886	kg/km	0.00170	kg/km	
Optional New Access Road (PAVED)	ONAR	Volume	Veh travel on paved roads	0.00886	kg/km	0.00170	kg/km	

NOTES: ST – source type; EF – emission factor; veh – vehicle; road color codes referenced to **Figure EA-18 and Figure EA-19**; AERCODE – source code in AERMOD software

Table EA-14
Derived particulate emission rates during construction

				Emission rate, g/s-m^2	
CONSTRUCTION PHASE MODEL OBJECTS	AERCODE	ST	EF type	TSP	PM10
1. Construction of Project components					
Upper Wawa dam + Spillway	UWDS	Area	Heavy construction	6.227E-05	5.708E-06
Pump station 2	PS2	Area	Heavy construction	6.227E-05	5.708E-06
Transmission Pipe via tunnel (optional)	TPOP	Area	Heavy construction	6.227E-05	5.708E-06
2. Construction of roads					
New Access Road Dam to Spillway (PAVED)	CNAR1	Area	Road construction*	6.227E-05	2.179E-05
New Access Road Long (PAVED)	CNAR2	Area	Road construction*	6.227E-05	2.179E-05
New Access Road from PS2 to WTP (PAVED)	CNAR3	Area	Road construction*	6.227E-05	2.179E-05
Optional New Access Road	CONAR	Area	Road construction*	6.227E-05	2.179E-05
3. Temporary facilities					
Camp and office	CO	Area	Open area wind erosion	6.72E-06	3.36E-06
Temporary disposal area 1	TDA1	Area	Open area wind erosion	6.72E-06	3.36E-06
Temporary disposal area 2	TDA2	Area	Open area wind erosion	6.72E-06	3.36E-06
Facilities during construction	FDC	Area	Open area wind erosion	6.72E-06	3.36E-06
Quarry Option 1	QU1	Area	Open area wind erosion	6.72E-06	3.36E-06
Quarry Option 2	QU2	Area	Open area wind erosion	6.72E-06	3.36E-06

NOTES: ST – source type; EF – emission factor; AERCODE – source code in AERMOD software;*no available EF. Assumed EF of heavy construction

Table EA-15
Derived particulate emission rates for roads

			Road parameters		Vehicle parameters			Model parameters					Emission rates, g/s	
Project phase	#	AERCODE	RW, m	RL, m	VH, m	VW, m	VL, m	PH, m	PW, m	RH, m	ILD, m	IVD, m	PM10	TSP
Construction	1	ER1U	6.00	3329.00	3.00	3.00	10.00	5.10	12.00	2.55	5.58	2.37	2.13179	8.91286
	2	ER2U	6.00	2065.00	3.00	3.00	10.00	5.10	12.00	2.55	5.58	2.37	2.13179	8.91286
	3	ER3P	6.00	1484.00	3.00	3.00	10.00	5.10	12.00	2.55	5.58	2.37	0.01697	0.08856
	4	ER4P	6.00	6856.00	3.00	3.00	10.00	5.10	12.00	2.55	5.58	2.37	0.01697	0.08856
Operation	1	ER1U	6.00	3329.00	3.00	3.00	10.00	5.10	12.00	2.55	5.58	2.37	2.13179	8.91286
	2	ER2U	6.00	2065.00	3.00	3.00	10.00	5.10	12.00	2.55	5.58	2.37	2.13179	8.91286
	3	ER3P	6.00	8340.00	3.00	3.00	10.00	5.10	12.00	2.55	5.58	2.37	0.01697	0.08856
	4	NAR1P	8.00	327.00	3.00	3.00	10.00	5.10	14.00	2.55	6.51	2.37	0.00566	0.02952
	5	NAR2P	8.00	3549.00	3.00	3.00	10.00	5.10	14.00	2.55	6.51	2.37	0.00566	0.02952
	6	NAR3P	8.00	1986.00	3.00	3.00	10.00	5.10	14.00	2.55	6.51	2.37	0.00566	0.02952
	7	ONARP	8.00	1598.00	3.00	3.00	10.00	5.10	14.00	2.55	6.51	2.37	0.00566	0.02952

NOTES: AERCODE – source code in AERMOD software; RW – road width; RL – road length; VH – default vehicle height; VW - default vehicle width; VL - default vehicle length; RH – release height; ILD – initial lateral dimension; IVD – initial vertical dimension

Modeling Domain and Receptors

The model domain is 9,000m by 14,000m rectangle with a 50-meter resolution grid (**Figure EA-20**). The coordinates and elevations of each node were determined Google Earth, Excel™ formulas, online tools, and data from the Space Shuttle Radar Topography Mission 3 (SRTM3) database. In addition to the grid nodes, a sensitive receptor area with 316 receptors in Sitio Apia was also included.

The technical description of the model domain is shown in **Table EA-16**. The model domain was divided into one fine grid to capture peak GLCs and three coarse grids covering the rest of the domain (**Table EA-17**).

Table EA-16
Technical description of the model domain

Parameter	Axis	Value
Axis length, m	x	9000
	y	14000
SW corner UTM	x	302916
	y	1616615
NE corner UTM	x	311916
	y	1630615
Resolution, m	x	50
	y	50
# of lines	x	181
	y	281
# of nodes	x,y	50861

Table EA-17
Technical description of the model grids

Fine Grid			Coarse Grid 1		
	Ex	Ny		Ex	Ny
SW	302916	1623615	SW	302916	1627615
NE	308916	1627615	NE	311916	1630615
Length, m	6000	4000	Length, m	9000	3000
SE	308916	1623615	SE	311916	1627615
NW	302916	1627615	NW	302916	1630615
Resolution, m	100	100	Resolution, m	200	200
# lines	61	41	# lines	46	16
Coarse Grid 2			**Coarse Grid 3**		
	Ex	Ny		Ex	Ny
SW	308916	1616615	SW	302916	1616615
NE	311916	1627615	NE	308916	1623615
Length, m	3000	11000	Length, m	6000	7000
SE	311916	1616615	SE	308916	1616615
NW	308916	1627615	NW	302916	1623615
Resolution, m	200	200	Resolution, m	200	200
# lines	16	56	# lines	31	36

Digital Elevation Model (DEM)

A DEM was generated to describe the elevations inside the model domain (**Figure EA-21**). Topography inside the DEM domain is characterized by mountainous terrain with elevations ranging from two to 1,509 meters with a mean of 329 meters. Such terrain is called as "complex" in air dispersion modeling and will have effects on the predicted GLCs because these elevations are higher than the modeled sources.

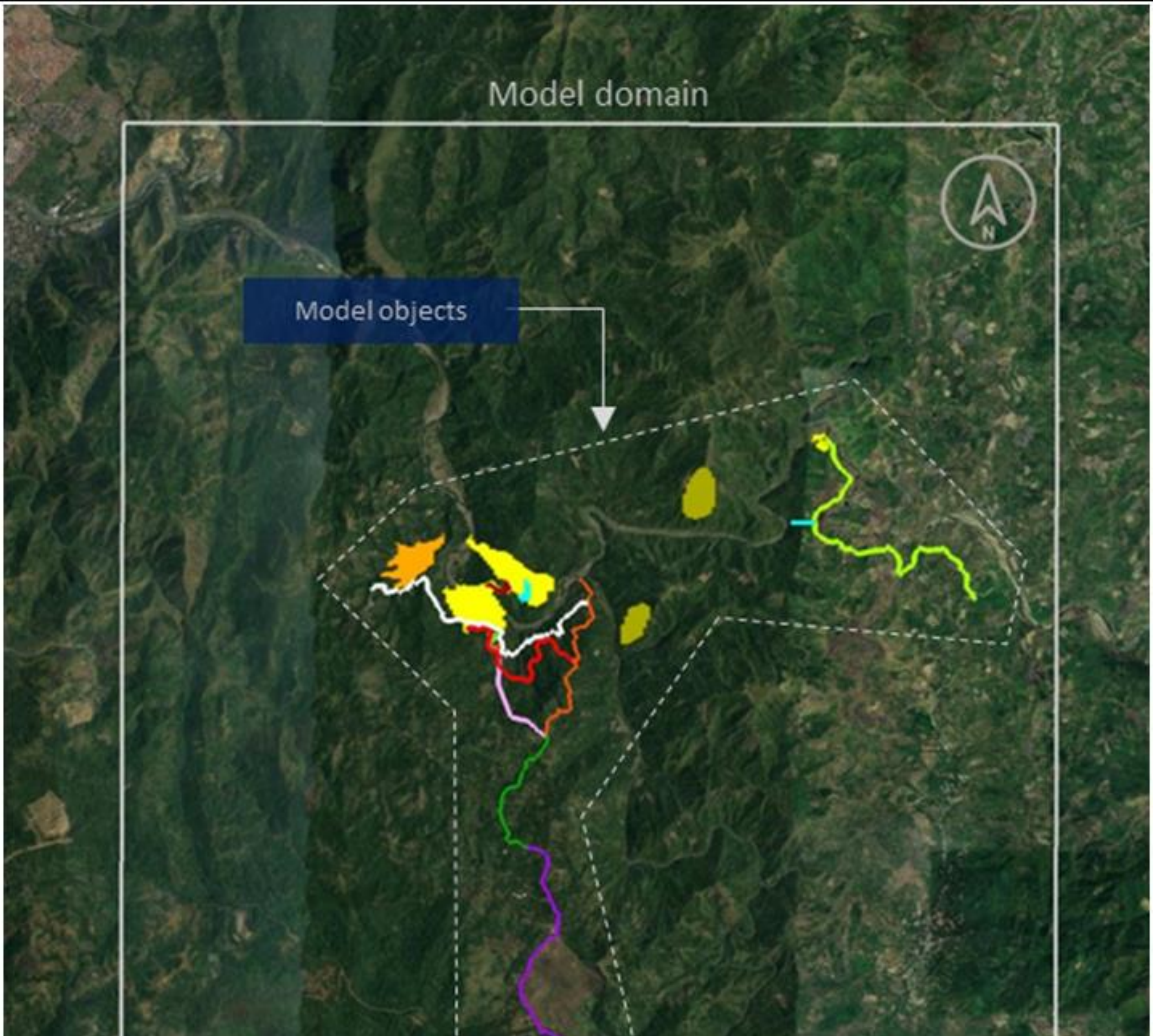

Figure EA-20. Model domain of the Upper Wawa Project	DATA INFORMATION/SOURCE:	WawaJVCo INC. apercu CONSULTANTS INC	
ENVIRONMENTAL IMPACT STATEMENT AIR MODULE Wawa Bulk Water Supply Project – Upper Wawa Dam	**Project Components:** WawaJVCo INC. (2020) **Source Map:** Google Earth Pro (2020) **Modified by:** Apercu Consultants Inc. (2020)	SCALE: Not to Scale	PAGE: 317

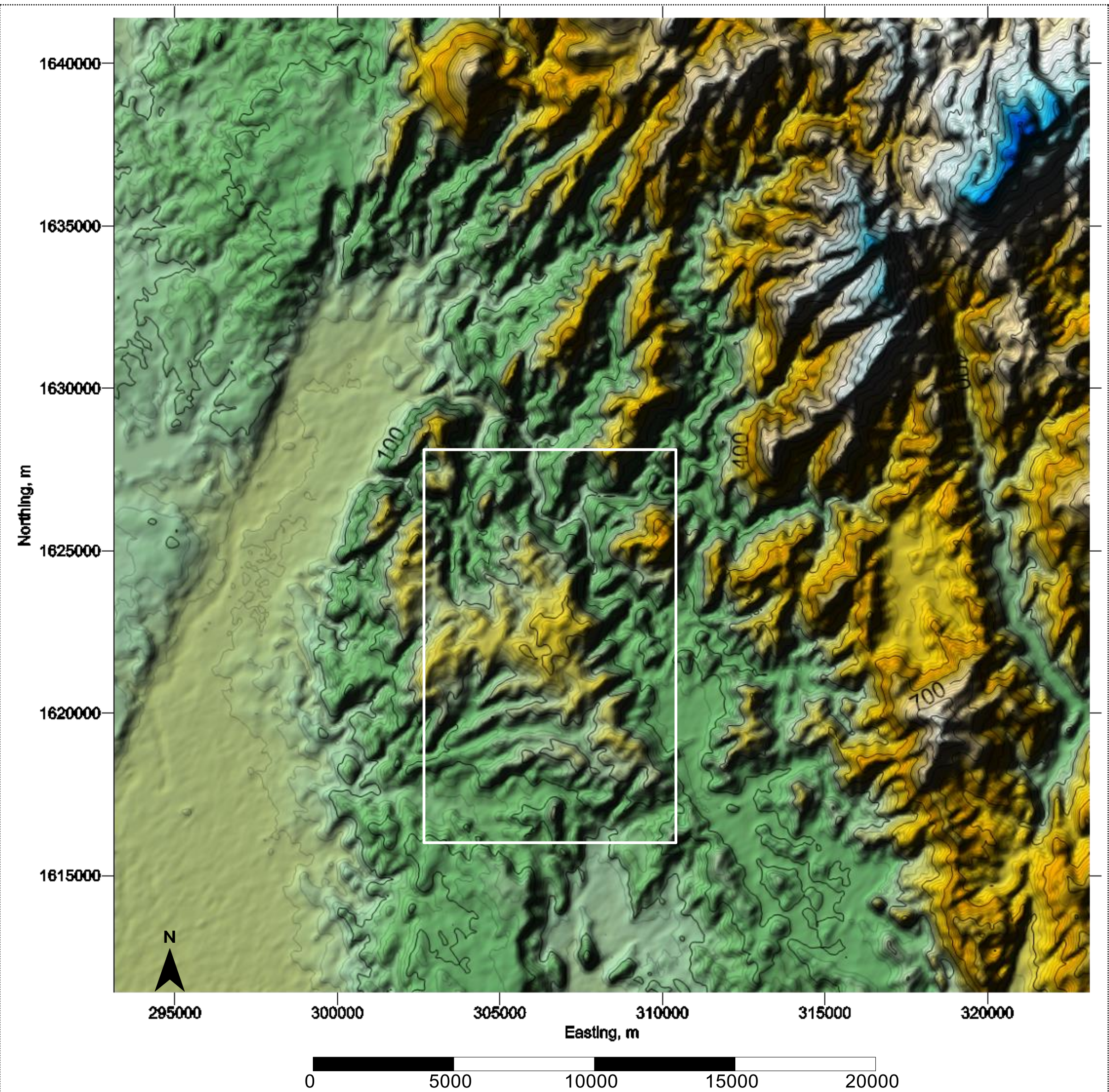

Figure EA-21. Digitized contour map of the DEM showing the model domain

3.2.1.2 Noise

The existing sound profile at the Project area was determined by taking sound measurements every five minutes for 24h at the ambient air quality stations. The noise descriptors shown in **Table EA-18** were derived from the measurements to describe the existing sonic profile at the Project area. The existing noise impacts were determined by comparing the noise descriptors with the DENR Environmental Quality Standards for Noise in General Areas (**Table EA-19**)[4].

Table EA-18
Noise descriptors for describing the existing sonic profile at the Project area

Noise Descriptor	Description
L10	Noise level exceeded 10% of the time of the measurement period.
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 90% of the time and represents the background levels.
Lmax	Highest recorded sound level
Lmin	Lowest recorded sound level

Table EA-19
Environmental Quality Standards for Noise in General Areas (dBa)

Category	Daytime	Morning/Evening	Night-time
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;
Night-time 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

The noise impacts were assessed by predicting the sound propagated by equipment typically used during construction comparing predicted values with the DENR criteria for construction noise (**Table EA-20**). A modeled value to DENR criteria ratio (M/C) was created to facilitate identification of exceedances.

Predicting sound generation from the equipment was done using the point source attenuation rate for geometric spreading. Sound from a small localized source (approximating a point source) radiates uniformly outward as it travels away from the source in a spherical pattern. The sound level attenuates at a rate of six decibels for each doubling of distance. This decrease, due to the geometric spreading of the energy over an increasing area, is referred to as the inverse square law. The law states that the mean-square sound pressure level varies inversely as the square of the distance from the source. The general rule of thumb is that under ideal conditions (no reflecting surfaces or other background sound or interference), sound level drops six decibels for every doubling of the distance from the source. The inverse square law is represented by the formula:

$$\Delta D = 10\log\left(\frac{d_1}{d_2}\right)^2$$

where d_1 and d_2 are the distances and ΔD is the decibel difference.

[4] NPCC Memorandum Circular No. 002 issued May 12, 1980 (amending Section 78 of Presidential Decree 984)

Table EA-20
Maximum noise levels allowed during construction[5]

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

3.2.2 Assessment of Key Impacts

3.2.2.1 Degradation of Air Quality

Sources of Air Emissions

There are very few sources of air residuals within the model domain due to the remote location of the Project. Gaseous pollutants (SO_2, NO_2, CO) and fugitive particulate (TSP, PM10) emitted from motor vehicles travelling the main road to the site and domestic activities like household cooking, backyard waste burning, and occasional burning of agricultural wastes are the dominant air pollution sources.

Existing Ambient Air Quality

The results of the 24h sampling confirmed the absence of significant source of emissions at the Project area (concentrations less than the CAA GV in **Table EA-21**. For example, concentrations of NO_2 and SO_2 were very low with two SO_2 results below the method detection level (orange cells in **Table EA-21**). The particulate detections (TSP and PM10) were likely due to fugitive dust from exposed soil surfaces and roads in the vicinity of the stations. Laboratory certificates for air sampling is shown in **Annex E**.

Table EA-21
Existing ambient pollutant levels in the Project area

Station	AT	UTM coordinates, m		Concentration, ug/ncm			
		Northing	Easting	TSP	PM10	NO_2	SO_2
AQ1	24h	1625848.12	306764.51	40.6	27.8	0.06	0.04
AQ2	24h	1625530.94	305860.19	19.3	25.8	0.08	0.61
AQ3	24h	1626247.64	306183.68	24.6	18.6	0.05	ND
AQ4	24h	1626143.62	305518.42	12.4	9.3	0.10	ND
AQ5	24h	1625428.00	306758.00	22.2	29.9	0.09	0.12
AQ6	24h	1625473.00	307258.00	25.3	26.0	0.09	0.08
CAA Guideline Value				**230**	**150**	**180**	**150**

Notes: AT – averaging time; UTM – Universal Transverse Mercator; CAA – Clean Air Act

Predicted Particulate Levels during Project Implementation

The impacts of particulate emissions during the construction and operation phases were presented by showing statistical summaries of the predicted 98th percentile (*98p*) GLCs at the grid and sensitive receptors. An ***Index***, i.e., ratio of predicted 98p GLCs and the corresponding CAA standard or guideline value and averaging time, was used to determine whether or not the CAA was exceeded.

[5] measured at 30m

The impact assessment was used to determine impact significance and not compliance because there are no explicit provisions in the CAA for non-point sources such as fugitive emissions. In addition, significant air pollution impacts are expected only during construction and will cease during the operation phase. A significant air pollution impact in this context is defined as a predicted 98p TSP or PM10 GLC that exceeds the 24h NAAQGV.

In addition to uncertainties inherent in Gaussian models, the exceedances were expected because of the following assumptions: 1) use of emission rates from literature, and 2) continuous particulate emission from the entire source and at a constant rate; a scenario unlikely to happen during actual conditions. These assumptions were used as the worst-case scenario for the impact assessment. Sample model files and simulation result post-processing are shown in the following annexes:

- **Annex I-1**. Sample AERMOD Meteorological Input File (*.sfc/.pfl*)
- **Annex I-2**. Sample DEM for AERMOD
- **Annex I-3.** Sample AERMAP output file
- **Annex I-4**. Sample AERMOD Input file (*.ami*)
- **Annex I-5.** AERMOD 98th percentile output file (*.pco*)
- **Annex I-6**. Sample Spreadsheet of Predicted 98p GLCs at the Grid Receptors
- **Annex I-7**. Sample Spreadsheet of Predicted GLCs at the Sensitive Receptors

Construction Phase

Predicted TSP at the Grid and Sensitive Receptors - The predicted 98p concentrations of TSP from uncontrolled fugitive emissions during the construction of the major components and access roads and use of existing roads are shown in **Table EA-22**.

The predicted TSP 98p GLCs at the grid receptors exceeded the CAA across averaging times for all scenarios with indices ranging from two to 3.52 (red cells in **Table EA-22**). The exceedances however were predicted at a few grid receptors (green cells in **Table EA-22**). The predicted maximum 98p GLC for the different options were almost the same.

There were no predicted TSP exceedances across averaging times and scenarios at the sensitive receptors located in Sitio Apia, about 500m northeast of the new access road connecting the Pumping Station to the Water Treatment Plant and 5km east-northeast of the dam.

Predicted PM10 at the Grid and Sensitive Receptors – Similar to the TSP GLCs, PM10 exceedances were predicted for all scenarios across averaging times at the grid receptors (red cells in **Table EA-23**). Despite the high PM10 indices, the predicted PM10 GLCs only exceeded the CAA in less than two percent of the total grid receptors (green cells in **Table EA-23**).

The PM10 GLCs were expected to have higher indices and more exceedance occurrences than TSP because its smaller diameter allows it to remain suspended in the air longer and deposited farther from the emission source.

Table EA-22
Predicted 98th percentile TSP GLC at the grid and sensitive receptors (Construction Phase)

AT	Source	CAA	Grid receptors						Sensitive receptors					
			Min	Max	Mean	Index	#Ex	%Ex	Min	Max	Mean	Index	#Ex	%Ex
1h	ALL	300	0.00E+00	1,045.02	4.35	3.48	12	0.21%	2.06	3.27	2.68	1.09E-02	0	0.00%
	OP1	300	0.00E+00	1,044.26	4.25	3.48	12	0.21%	2.05	3.25	2.66	1.08E-02	0	0.00%
	OP2	300	0.00E+00	1,043.31	3.88	3.48	9	0.16%	2.03	3.24	2.65	1.08E-02	0	0.00%
	OP3	300	0.00E+00	1,044.27	4.25	3.48	12	0.21%	2.05	3.25	2.67	1.08E-02	0	0.00%
	OP4	300	0.00E+00	1,043.32	3.89	3.48	9	0.16%	2.04	3.24	2.66	1.08E-02	0	0.00%
	OP5	300	0.00E+00	1,044.22	4.22	3.48	12	0.21%	2.05	3.25	2.66	1.08E-02	0	0.00%
	OP6	300	0.00E+00	1,043.28	3.85	3.48	9	0.16%	2.03	3.24	2.65	1.08E-02	0	0.00%
	OP7	300	0.00E+00	1,044.23	4.22	3.48	12	0.21%	2.05	3.25	2.67	1.08E-02	0	0.00%
	OP8	300	0.00E+00	1,043.28	3.86	3.48	9	0.16%	2.04	3.24	2.66	1.08E-02	0	0.00%
24h	ALL	230	9.23E-05	477.92	2.80	2.08	4	0.07%	0.94	1.42	1.15	6.17E-03	0	0.00%
	OP1	230	0.00E+00	477.57	2.73	2.08	4	0.07%	0.91	1.40	1.13	6.07E-03	0	0.00%
	OP2	230	8.32E-05	477.01	2.52	2.07	4	0.07%	0.88	1.34	1.08	5.83E-03	0	0.00%
	OP3	230	3.09E-06	477.57	2.74	2.08	4	0.07%	0.93	1.41	1.14	6.11E-03	0	0.00%
	OP4	230	9.23E-05	477.02	2.52	2.07	4	0.07%	0.89	1.35	1.09	5.87E-03	0	0.00%
	OP5	230	0.00E+00	477.55	2.72	2.08	4	0.07%	0.91	1.40	1.13	6.07E-03	0	0.00%
	OP6	230	8.32E-05	477.00	2.51	2.07	4	0.07%	0.87	1.34	1.08	5.83E-03	0	0.00%
	OP7	230	3.09E-06	477.55	2.72	2.08	4	0.07%	0.92	1.40	1.14	6.11E-03	0	0.00%
	OP8	230	9.23E-05	477.00	2.51	2.07	4	0.07%	0.89	1.35	1.09	5.86E-03	0	0.00%
Annual	ALL	90	1.59E-05	263.53	1.14	2.93	8	0.14%	0.19	0.27	0.23	3.02E-03	0	0.00%
	OP1	90	3.40E-08	263.49	1.12	2.93	8	0.14%	0.18	0.27	0.23	2.99E-03	0	0.00%
	OP2	90	1.19E-05	263.43	1.05	2.93	7	0.12%	0.18	0.26	0.22	2.94E-03	0	0.00%
	OP3	90	2.13E-06	263.49	1.12	2.93	8	0.14%	0.18	0.27	0.23	3.00E-03	0	0.00%
	OP4	90	1.48E-05	263.43	1.05	2.93	7	0.12%	0.18	0.27	0.22	2.95E-03	0	0.00%
	OP5	90	2.21E-09	263.49	1.12	2.93	8	0.14%	0.18	0.27	0.23	2.99E-03	0	0.00%
	OP6	90	1.20E-05	263.42	1.04	2.93	7	0.12%	0.18	0.26	0.22	2.94E-03	0	0.00%
	OP7	90	1.92E-06	263.49	1.12	2.93	8	0.14%	0.18	0.27	0.23	3.00E-03	0	0.00%
	OP8	90	1.49E-05	263.42	1.04	2.93	7	0.12%	0.18	0.27	0.22	2.95E-03	0	0.00%

AT – averaging time; CAA – Clean Air Act ambient air quality standards or guideline value; ALL – all sources; OP – Options previously defined; Min – minimum; Max – Maximum; Index = ratio of max GLC and CAA; #Ex – number receptors where GLC > CAA; %Ex – percent exceedance of total receptors

Table EA-23
Predicted 98th percentile PM10 GLC at the grid and sensitive receptors (Construction Phase)

AT	Source	CAA	Grid receptors						Sensitive receptors					
			Min	Max	Mean	Index	#Ex	%Ex	Min	Max	Mean	Index	#Ex	%Ex
1h	ALL	200	0.00E+00	3584.07	15.33	17.92	81	1.41%	4.30	9.35	6.84	0.05	0	0.00%
	OP1	200	0.00E+00	3583.01	15.04	17.92	72	1.26%	4.26	9.29	6.78	0.05	0	0.00%
	OP2	200	0.00E+00	3576.15	13.15	17.88	53	0.92%	4.12	9.15	6.66	0.05	0	0.00%
	OP3	200	0.00E+00	3583.02	15.04	17.92	72	1.26%	4.26	9.29	6.79	0.05	0	0.00%
	OP4	200	0.00E+00	3576.17	13.15	17.88	53	0.92%	4.13	9.16	6.66	0.05	0	0.00%
	OP5	200	0.00E+00	3582.96	15.02	17.91	72	1.26%	4.26	9.29	6.79	0.05	0	0.00%
	OP6	200	0.00E+00	3576.11	13.13	17.88	53	0.92%	4.13	9.15	6.66	0.05	0	0.00%
	OP7	200	0.00E+00	3582.98	15.02	17.91	72	1.26%	4.26	9.30	6.79	0.05	0	0.00%
	OP8	200	0.00E+00	3576.13	13.13	17.88	53	0.92%	4.13	9.16	6.66	0.05	0	0.00%
24h	ALL	150	7.16E-03	1232.41	7.82	8.22	40	0.70%	2.94	5.14	4.11	0.03	0	0.00%
	OP1	150	0.00E+00	1229.83	7.65	8.20	40	0.70%	2.88	5.05	4.02	0.03	0	0.00%
	OP2	150	6.89E-03	1223.34	6.62	8.16	31	0.54%	2.38	4.67	3.60	0.03	0	0.00%
	OP3	150	2.40E-04	1229.85	7.65	8.20	40	0.70%	2.88	5.06	4.03	0.03	0	0.00%
	OP4	150	7.16E-03	1223.35	6.62	8.16	31	0.54%	2.39	4.68	3.61	0.03	0	0.00%
	OP5	150	0.00E+00	1229.83	7.64	8.20	40	0.70%	2.88	5.06	4.02	0.03	0	0.00%
	OP6	150	6.89E-03	1223.33	6.60	8.16	31	0.54%	2.39	4.67	3.60	0.03	0	0.00%
	OP7	150	2.40E-04	1229.84	7.64	8.20	40	0.70%	2.88	5.07	4.03	0.03	0	0.00%
	OP8	150	7.16E-03	1223.35	6.61	8.16	31	0.54%	2.39	4.68	3.61	0.03	0	0.00%
Annual	ALL	60	4.90E-04	414.21	1.84	6.90	28	0.49%	0.46	0.95	0.72	0.02	0	0.00%
	OP1	60	7.67E-07	413.96	1.81	6.90	28	0.49%	0.45	0.94	0.71	0.02	0	0.00%
	OP2	60	4.61E-04	413.26	1.61	6.89	23	0.40%	0.42	0.90	0.67	0.02	0	0.00%
	OP3	60	2.89E-05	413.96	1.81	6.90	28	0.49%	0.45	0.94	0.71	0.02	0	0.00%
	OP4	60	4.89E-04	413.26	1.61	6.89	23	0.40%	0.42	0.90	0.67	0.02	0	0.00%
	OP5	60	1.03E-07	413.96	1.81	6.90	28	0.49%	0.45	0.94	0.71	0.02	0	0.00%
	OP6	60	4.56E-04	413.25	1.61	6.89	23	0.40%	0.42	0.90	0.67	0.02	0	0.00%
	OP7	60	2.51E-05	413.96	1.81	6.90	28	0.49%	0.45	0.94	0.71	0.02	0	0.00%
	OP8	60	4.83E-04	413.25	1.61	6.89	23	0.40%	0.42	0.90	0.67	0.02	0	0.00%

AT – averaging time; CAA – Clean Air Act ambient air quality standards or guideline value; ALL – all sources; OP – Options previously defined; Min – minimum; Max – Maximum; Index = ratio of max GLC and CAA; #Ex – number receptors where GLC > CAA; %Ex – percent exceedance of total receptors

Operation Phase

The significant source of air pollution during the operation phase is the existing and new access roads used by vehicles.

Predicted TSP at the Grid and Sensitive Receptors - The summary of simulation results in **Table EA-24** showed no predicted CAA exceedances of TSP 98p GLCs from uncontrolled road fugitive emissions across averaging times, scenarios, and receptors. The predicted highest 98p TSP GLCs from all sources at the grid receptors were 61.3 ug/ncm (1h), 20.7 ug/ncm (24h), and 9.88 ug/ncm (annual) resulting to very low indices.

Predicted PM10 at the Grid and Sensitive Receptors – Similar to TSP, the simulations predicted no CAA exceedances of PM10 GLCs from the uncontrolled road fugitive emissions across averaging times, scenarios, and receptors (**Table EA-25**). The predicted highest 98p PM10 GLCs from all sources at the grid receptors were 29.5 ug/ncm (1h), 12.9 ug/ncm (24h), and 4.7 ug/ncm (annual) resulting to indices less than unity.

Air Pollution Hotspots

The predicted 98p GLCs of TSP and PM10 at the grid receptors were processed to determine the air pollution hotspots, defined as locations within the model domain where a particular CAA standard or guideline value (potential hotspot) was exceeded or where predicted GLCs are greater than 50% of the CAA standard or guideline value with no exceedance (area of concern). Summaries of hotspot evaluation for TSP and PM10 in **Table EA-26** and **Table EA-27** show the potential hotspots at all scenarios for TSP and PM10 during the construction phase only (red cells in **Table EA-26**).

The isopleths of the potential hotspots for TSP and PM10 in **Figure EA-22** and **Figure EA-23** show that the exceedances were inside and in the vicinity of active construction sites, e.g., dam, spillway. There were no sensitive receptors near the dam and spillway. The sensitive receptors are located in Sitio Apia, about 500m northeast of the new access road connecting the Pumping Station to the Water Treatment Plant and 5km east-northeast of the dam.

Table EA-24
Predicted 98th percentile TSP GLC at the grid and sensitive receptors (Operation Phase)

AT	Source	CAA	Grid receptors						Sensitive receptors					
			Min	Max	Mean	Index	#Ex	%Ex	Min	Max	Mean	Index	#Ex	%Ex
1h	ALL-ER	300	0.00E+00	61.33	0.2430	2.04E-01	0	0.00%	0.0335	0.0394	0.0363	1.31E-04	0	0.00%
	ALL-NAR1	300	0.00E+00	0.46	0.0007	1.53E-03	0	0.00%	0.0004	0.0008	0.0006	2.64E-06	0	0.00%
	ALL-NAR2	300	3.34E-07	0.46	0.0008	1.53E-03	0	0.00%	0.0004	0.0008	0.0006	2.63E-06	0	0.00%
	OP1	300	0.00E+00	61.33	0.2435	2.04E-01	0	0.00%	0.0340	0.0399	0.0369	1.33E-04	0	0.00%
	OP2	300	3.34E-07	61.33	0.2438	2.04E-01	0	0.00%	0.0341	0.0400	0.0369	1.33E-04	0	0.00%
24h	ALL-ER	230	0.00E+00	20.67	0.1185	8.99E-02	0	0.00%	0.0202	0.0240	0.0219	1.05E-04	0	0.00%
	ALL-NAR1	230	0.00E+00	0.17	0.0005	7.44E-04	0	0.00%	0.0002	0.0005	0.0004	2.05E-06	0	0.00%
	ALL-NAR2	230	1.01E-06	0.17	0.0005	7.45E-04	0	0.00%	0.0002	0.0005	0.0003	2.00E-06	0	0.00%
	OP1	230	0.00E+00	20.67	0.1187	8.99E-02	0	0.00%	0.0204	0.0244	0.0223	1.06E-04	0	0.00%
	OP2	230	1.01E-06	20.67	0.1189	8.99E-02	0	0.00%	0.0204	0.0244	0.0223	1.06E-04	0	0.00%
Annual	ALL-ER	90	0.00E+00	9.88	0.0370	1.10E-01	0	0.00%	0.0026	0.0031	0.0029	3.42E-05	0	0.00%
	ALL-NAR1	90	0.00E+00	0.06	0.0001	6.42E-04	0	0.00%	0.0000	0.0001	0.0001	1.04E-06	0	0.00%
	ALL-NAR2	90	1.32E-07	0.06	0.0001	6.42E-04	0	0.00%	0.0000	0.0001	0.0001	1.03E-06	0	0.00%
	OP1	90	0.00E+00	9.88	0.0370	1.10E-01	0	0.00%	0.0027	0.0031	0.0029	3.50E-05	0	0.00%
	OP2	90	1.32E-07	9.88	0.0371	1.10E-01	0	0.00%	0.0027	0.0032	0.0029	3.50E-05	0	0.00%

AT – averaging time; CAA – Clean Air Act ambient air quality standard or guideline value; ALL – all sources; ER – existing roads; NAR – new access road; OP – options previously defined; Min – minimum; Max – maximum; Index = ratio of max GLC and CAA; #Ex – number receptors where GLC > CAA; %Ex – percent exceedance of total receptors

Table EA-25
Predicted 98th percentile PM10 GLC at the grid and sensitive receptors (Operation Phase)

AT	Source	CAA	Grid receptors						Sensitive receptors					
			Min	Max	Mean	Index	#Ex	%Ex	Min	Max	Mean	Index	#Ex	%Ex
1h	ALL-ER	200	7.55E-03	29.53	6.85E-01	1.48E-01	0	0.00%	0.00E+00	1.12E-01	5.00E-02	5.61E-04	0	0.00%
	ALL-NAR1	200	1.44E-03	4.73	8.47E-02	2.36E-02	0	0.00%	0.00E+00	1.83E-02	8.18E-03	9.13E-05	0	0.00%
	ALL-NAR2	200	1.44E-03	4.73	8.48E-02	2.36E-02	0	0.00%	1.21E-04	1.81E-02	8.17E-03	9.04E-05	0	0.00%
	OP1	200	8.98E-03	34.26	7.69E-01	1.71E-01	0	0.00%	0.00E+00	1.30E-01	5.81E-02	6.51E-04	0	0.00%
	OP2	200	8.99E-03	34.26	7.70E-01	1.71E-01	0	0.00%	1.21E-04	1.30E-01	5.81E-02	6.51E-04	0	0.00%
24h	ALL-ER	150	1.28E-02	12.90	2.84E-01	8.60E-02	0	0.00%	0.00E+00	8.25E-02	3.73E-02	5.50E-04	0	0.00%
	ALL-NAR1	150	4.59E-05	0.09	1.05E-03	6.18E-04	0	0.00%	0.00E+00	2.14E-03	7.86E-04	1.43E-05	0	0.00%
	ALL-NAR2	150	5.54E-05	0.09	1.11E-03	6.15E-04	0	0.00%	8.40E-05	2.02E-03	7.77E-04	1.35E-05	0	0.00%
	OP1	150	1.28E-02	12.90	2.85E-01	8.60E-02	0	0.00%	0.00E+00	8.45E-02	3.81E-02	5.63E-04	0	0.00%
	OP2	150	1.29E-02	12.91	2.85E-01	8.60E-02	0	0.00%	8.40E-05	8.45E-02	3.81E-02	5.63E-04	0	0.00%
Annual	ALL-ER	60	1.42E-03	4.71	8.24E-02	7.86E-02	0	0.00%	0.00E+00	1.74E-02	7.81E-03	2.89E-04	0	0.00%
	ALL-NAR1	60	5.28E-06	0.03	2.75E-04	5.60E-04	0	0.00%	0.00E+00	5.59E-04	2.11E-04	9.31E-06	0	0.00%
	ALL-NAR2	60	6.53E-06	0.03	2.88E-04	5.59E-04	0	0.00%	1.84E-05	5.33E-04	2.09E-04	8.88E-06	0	0.00%
	OP1	60	1.42E-03	4.72	8.26E-02	7.86E-02	0	0.00%	0.00E+00	1.79E-02	8.01E-03	2.98E-04	0	0.00%
	OP2	60	1.43E-03	4.72	8.27E-02	7.86E-02	0	0.00%	1.84E-05	1.79E-02	8.02E-03	2.98E-04	0	0.00%

AT – averaging time; CAA – Clean Air Act ambient air quality standard or guideline value; ALL – all sources; ER – existing roads; NAR – new access road; OP – options previously defined; Min – minimum; Max – maximum; Index = ratio of max GLC and CAA; #Ex – number receptors where GLC > CAA; %Ex – percent exceedance of total receptors

Table EA-26
Particulate hotpots during Construction Phase

AT	Scenario	TSP				PM10			
		Max	CAA	Index	Hotspot	Max	CAA	Index	Hotspot
1h	ALL	1045.02	300	3.48	PH	3584.07	200	17.92	PH
	OP1	1044.26	300	3.48	PH	3583.01	200	17.92	PH
	OP2	1043.31	300	3.48	PH	3576.15	200	17.88	PH
	OP3	1044.27	300	3.48	PH	3583.02	200	17.92	PH
	OP4	1043.32	300	3.48	PH	3576.17	200	17.88	PH
	OP5	1044.22	300	3.48	PH	3582.96	200	17.91	PH
	OP6	1043.28	300	3.48	PH	3576.11	200	17.88	PH
	OP7	1044.23	300	3.48	PH	3582.98	200	17.91	PH
	OP8	1043.28	300	3.48	PH	3576.13	200	17.88	PH
24h	ALL	477.92	230	2.08	PH	1232.41	150	8.22	PH
	OP1	477.57	230	2.08	PH	1229.83	150	8.20	PH
	OP2	477.01	230	2.07	PH	1223.34	150	8.16	PH
	OP3	477.57	230	2.08	PH	1229.85	150	8.20	PH
	OP4	477.02	230	2.07	PH	1223.35	150	8.16	PH
	OP5	477.55	230	2.08	PH	1229.83	150	8.20	PH
	OP6	477.00	230	2.07	PH	1223.33	150	8.16	PH
	OP7	477.55	230	2.08	PH	1229.84	150	8.20	PH
	OP8	477.00	230	2.07	PH	1223.35	150	8.16	PH
Annual	ALL	263.53	90	2.93	PH	414.21	60	6.90	PH
	OP1	263.49	90	2.93	PH	413.96	60	6.90	PH
	OP2	263.43	90	2.93	PH	413.26	60	6.89	PH
	OP3	263.49	90	2.93	PH	413.96	60	6.90	PH
	OP4	263.43	90	2.93	PH	413.26	60	6.89	PH
	OP5	263.49	90	2.93	PH	413.96	60	6.90	PH
	OP6	263.42	90	2.93	PH	413.25	60	6.89	PH
	OP7	263.49	90	2.93	PH	413.96	60	6.90	PH
	OP8	263.42	90	2.93	PH	413.25	60	6.89	PH

AT – averaging time; CAA – Clean Air Act ambient air quality standard or guideline value; ALL – all sources; OP – options previously defined; Max – maximum; Index = ratio of max GLC and CAA; PH – potential hotspot

Table EA-27
Particulate hotpots during Operation Phase

AT	Source	TSP				PM10			
		Max	CAA	Index	Hotspot	Max	CAA	Index	Hotspot
1h	ALL-ER	61.33	300	0.204	NONE	29.53	200	0.148	NONE
	ALL-NAR1	0.46	300	0.002	NONE	4.73	200	0.024	NONE
	ALL-NAR2	0.46	300	0.002	NONE	4.73	200	0.024	NONE
	OP1	61.33	300	0.204	NONE	34.26	200	0.171	NONE
	OP2	61.33	300	0.204	NONE	34.26	200	0.171	NONE
24h	ALL-ER	20.67	230	0.090	NONE	12.90	150	0.086	NONE
	ALL-NAR1	0.17	230	0.001	NONE	0.09	150	0.001	NONE
	ALL-NAR2	0.17	230	0.001	NONE	0.09	150	0.001	NONE
	OP1	20.67	230	0.090	NONE	12.90	150	0.086	NONE
	OP2	20.67	230	0.090	NONE	12.91	150	0.086	NONE
Annual	ALL-ER	9.88	90	0.110	NONE	4.71	60	0.079	NONE
	ALL-NAR1	0.06	90	0.001	NONE	0.03	60	0.001	NONE
	ALL-NAR2	0.06	90	0.001	NONE	0.03	60	0.001	NONE
	OP1	9.88	90	0.110	NONE	4.72	60	0.079	NONE
	OP2	9.88	90	0.110	NONE	4.72	60	0.079	NONE

AT – averaging time; CAA – Clean Air Act ambient air quality standard or guideline value; ER – existing road; NAR – new access road; OP – options previously defined; Max – maximum; Index = ratio of max GLC and CAA

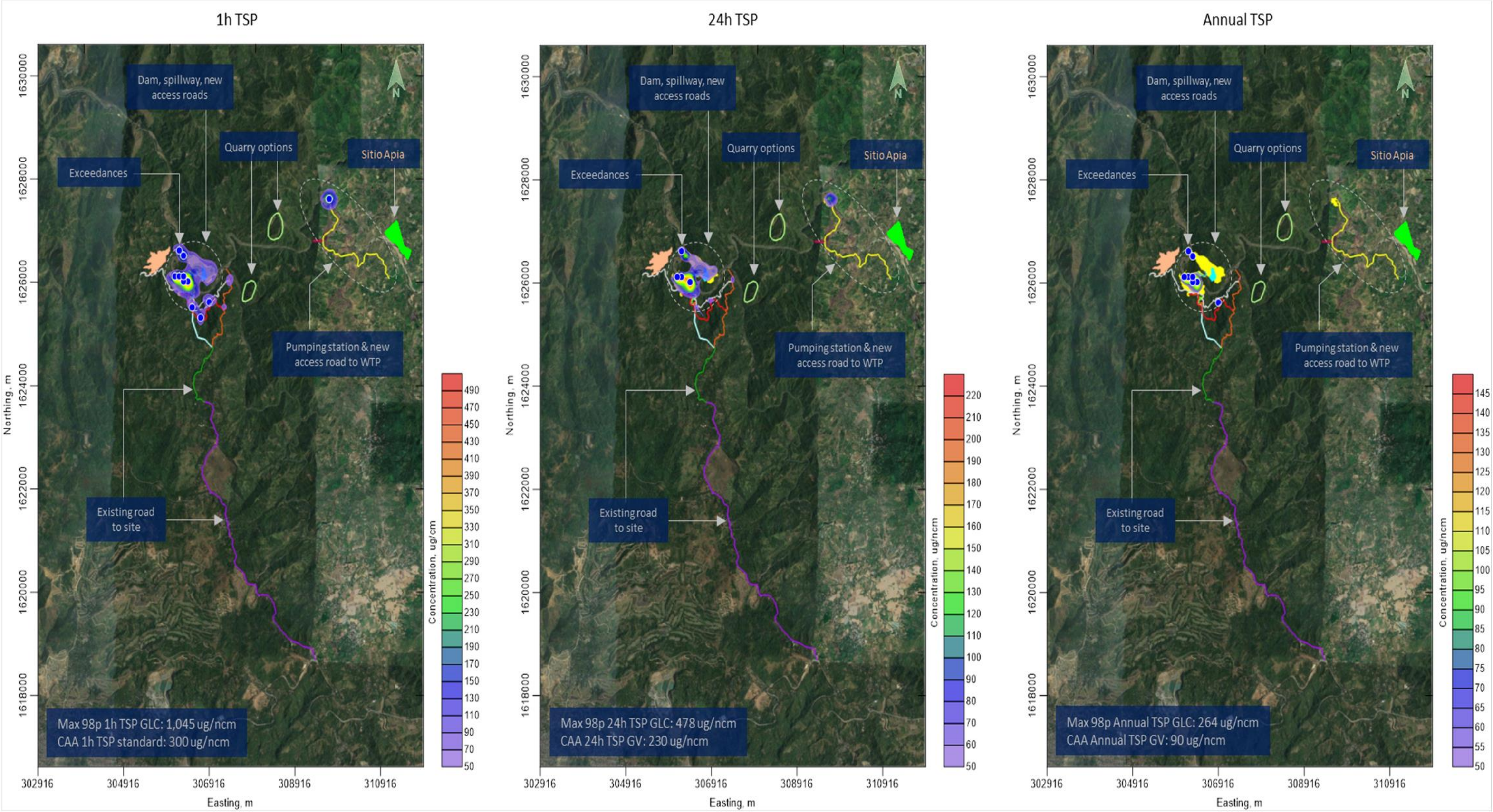

Figure EA-22. Isopleths of TSP potential hotspots during Construction Phase

ENVIRONMENTAL IMPACT STATEMENT
AIR MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

DATA INFORMATION/SOURCE:

Project Components: WawaJVCo INC. (2020)
Source Map: Google Earth Pro (2020)
Modified by: Apercu Consultants Inc. (2020)

WawaJVCo INC.
apercu CONSULTANTS INC.

Not to Scale

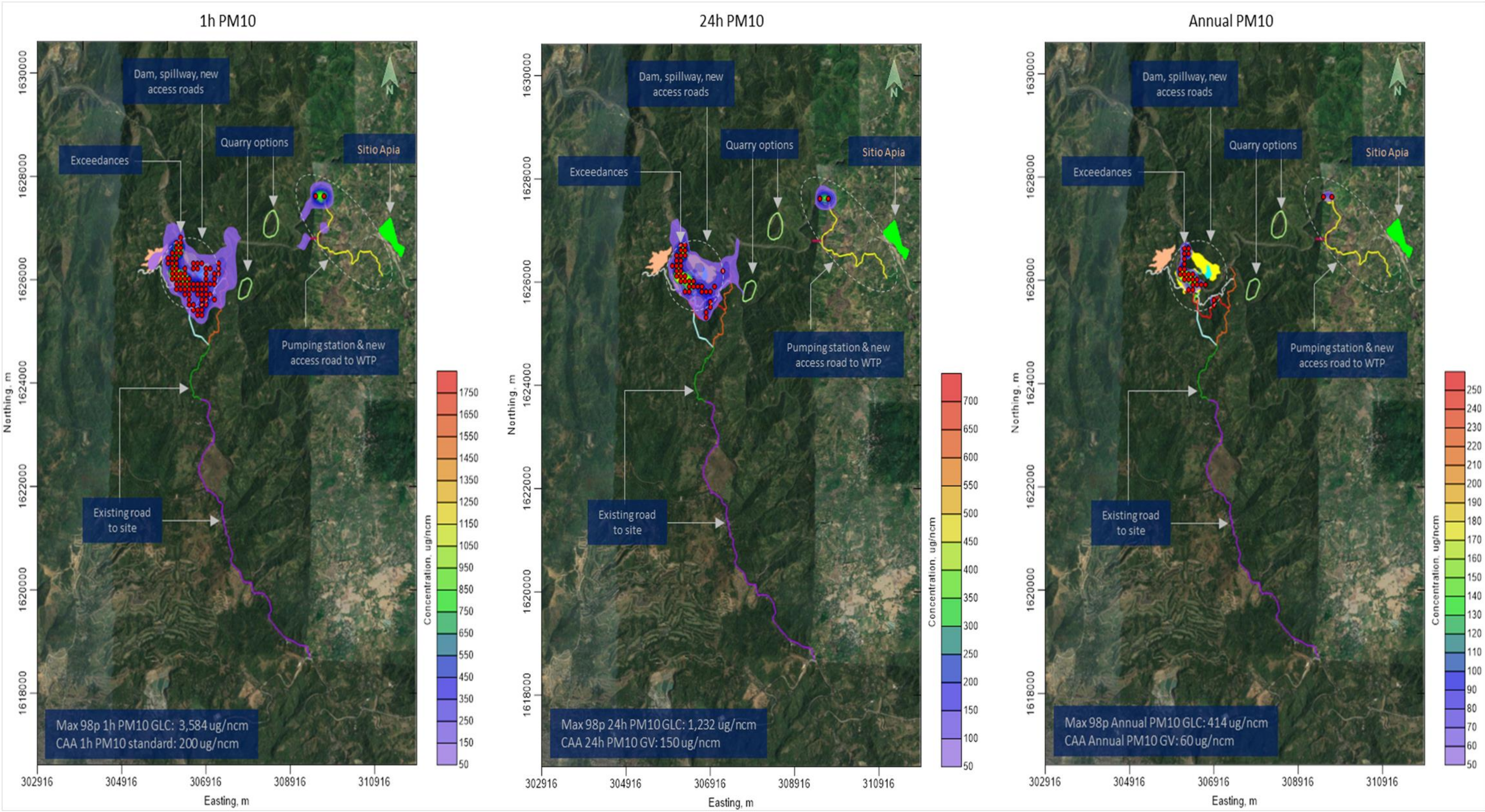

Figure EA-23. Isopleths of PM10 potential hotspots during Construction Phase

ENVIRONMENTAL IMPACT STATEMENT
AIR MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

DATA INFORMATION/SOURCE:

Project Components: WawaJVCo INC. (2020)
Source Map: Google Earth Pro (2020)
Modified by: Apercu Consultants Inc. (2020)

WawaJVCo INC.
apercu CONSULTANTS INC.

Not to Scale

Dust Suppression Measures

The effect of common fugitive dust suppression measures during construction (**Table EA-28**) was applied to the predicted GLCs to demonstrate the effects of these on the predicted TSP and PM10 GLCs.

Table EA-28
Particulate reduction from water suppression and speed restriction

Component	% Red	Mitigation	Data Source
Construction phase	61	Applying water within construction site (3.2-hour interval)	WRAP Fugitive Dust Handbook
	57	Speed restriction	
Roads	55	2x/day water application	
	44	Speed <=40kph	

%Red – Percent reduction

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The TSP and PM10 98p GLCs after the application of dust suppression measures are shown in **Table EA-29**. The simultaneous application of water and speed restriction has significantly reduced the TSP exceedances to less than the CAA standards and guideline values (orange cells in **Table EA-29**). Although the PM10 indices were still greater than unity, simultaneous application of water and speed restriction has shown significant reductions in its ambient concentrations.

Water application and speed restriction is expected to bring particulate levels less than the CAA during the construction phase because the predicted 98p GLCs were overestimates due to the modeling assumptions used, e.g., entire areas of the dam and spillway and roads were constantly emitting particulates during the entire modeling timeframe, use of emission factors. Actual GLCs are expected to be significantly lower than predicted values. In addition, sensitive receptors were absent within 500m of the major Project components and the high concentrations were predicted inside or near the source.

3.2.2.2 Noise Pollution

Existing Sound Level and Noise Impacts

The salient findings of the sound profile processing and noise impacts from the sound measurements done at the Project area are enumerated below. The noise descriptors and impacts and diurnal sound level trends are shown in **Table EA-30** and **Figure EA-24,** respectively.

a) Major sound sources in Stations AQ1 to AQ4 were motorcycles with loud mufflers and workers fixing Manila Water pipelines near Stations AQ5 and AQ6
b) Lowest sound levels ranged from 46 to 59 decibels (*Lmin*)
c) Peak sound levels ranged from 56 to 90 decibels (*Lmax*)
d) Background sound levels ranged from 47 to 60 decibels (*L10*)
e) 24h average sound levels ranged from 49 to 77 decibels (*Laeq*)
f) The following are the noise impact magnitudes assuming the areas at the Stations are residential:
    - Based on background levels: max of 8 decibels
    - Based on peak levels: 6 to 40 decibels
    - Based on 24h average sound levels: max of 27 decibels (morning @ Station AQN6)
g) Noise impacts in all Stations during Morning, Daytime, Evening, and Night time based on peak sound levels. Highest noise impact magnitude of 40 decibels is at Station AQN6 in the Morning.

Table EA-29
Dust uppression on predicted peak 98p particulate GLCs during Construction Phase

AT	Source	TSP 98p concentration, ug/ncm				CAA	TSP Mitigation Index				PM10 98p concentration, ug/ncm				CAA	PM10 Mitigation Index			
		Max GLC	Mitigation								Max GLC	Mitigation							
			Wat	SR	Wat+SR		NM	Wat	SR	Wat+SR		Wat	SR	Wat+SR		NM	Wat	SR	Wat+SR
1h	ALL	1,045.02	407.56	449.36	175.25	300	3.48	1.36	1.50	0.58	3,584.07	1,397.79	1,541.15	601.05	200	17.92	6.99	7.71	3.01
	OP1	1,044.26	407.26	449.03	175.12	300	3.48	1.36	1.50	0.58	3,583.01	1,397.37	1,540.69	600.87	200	17.92	6.99	7.70	3.00
	OP2	1,043.31	406.89	448.62	174.96	300	3.48	1.36	1.50	0.58	3,576.15	1,394.70	1,537.75	599.72	200	17.88	6.97	7.69	3.00
	OP3	1,044.27	407.26	449.03	175.12	300	3.48	1.36	1.50	0.58	3,583.02	1,397.38	1,540.70	600.87	200	17.92	6.99	7.70	3.00
	OP4	1,043.32	406.89	448.63	174.96	300	3.48	1.36	1.50	0.58	3,576.17	1,394.71	1,537.75	599.72	200	17.88	6.97	7.69	3.00
	OP5	1,044.22	407.25	449.02	175.12	300	3.48	1.36	1.50	0.58	3,582.96	1,397.36	1,540.67	600.86	200	17.91	6.99	7.70	3.00
	OP6	1,043.28	406.88	448.61	174.96	300	3.48	1.36	1.50	0.58	3,576.11	1,394.68	1,537.73	599.71	200	17.88	6.97	7.69	3.00
	OP7	1,044.23	407.25	449.02	175.12	300	3.48	1.36	1.50	0.58	3,582.98	1,397.36	1,540.68	600.87	200	17.91	6.99	7.70	3.00
	OP8	1,043.28	406.88	448.61	174.96	300	3.48	1.36	1.50	0.58	3,576.13	1,394.69	1,537.73	599.72	200	17.88	6.97	7.69	3.00
24h	ALL	477.92	186.39	205.50	80.15	230	2.08	0.81	0.89	0.35	1,232.41	480.64	529.94	206.68	150	8.22	3.20	3.53	1.38
	OP1	477.57	186.25	205.35	80.09	230	2.08	0.81	0.89	0.35	1,229.83	479.64	528.83	206.24	150	8.20	3.20	3.53	1.37
	OP2	477.01	186.04	205.12	80.00	230	2.07	0.81	0.89	0.35	1,223.34	477.10	526.04	205.15	150	8.16	3.18	3.51	1.37
	OP3	477.57	186.25	205.36	80.09	230	2.08	0.81	0.89	0.35	1,229.85	479.64	528.84	206.25	150	8.20	3.20	3.53	1.37
	OP4	477.02	186.04	205.12	80.00	230	2.07	0.81	0.89	0.35	1,223.35	477.11	526.04	205.16	150	8.16	3.18	3.51	1.37
	OP5	477.55	186.24	205.35	80.09	230	2.08	0.81	0.89	0.35	1,229.83	479.63	528.83	206.24	150	8.20	3.20	3.53	1.37
	OP6	477.00	186.03	205.11	79.99	230	2.07	0.81	0.89	0.35	1,223.33	477.10	526.03	205.15	150	8.16	3.18	3.51	1.37
	OP7	477.55	186.25	205.35	80.09	230	2.08	0.81	0.89	0.35	1,229.84	479.64	528.83	206.24	150	8.20	3.20	3.53	1.37
	OP8	477.00	186.03	205.11	79.99	230	2.07	0.81	0.89	0.35	1,223.35	477.11	526.04	205.16	150	8.16	3.18	3.51	1.37
Annual	ALL	263.53	102.78	113.32	44.19	90	2.93	1.14	1.26	0.49	414.21	161.54	178.11	69.46	60	6.90	2.69	2.97	1.16
	OP1	263.49	102.76	113.30	44.19	90	2.93	1.14	1.26	0.49	413.96	161.44	178.00	69.42	60	6.90	2.69	2.97	1.16
	OP2	263.43	102.74	113.27	44.18	90	2.93	1.14	1.26	0.49	413.26	161.17	177.70	69.30	60	6.89	2.69	2.96	1.16
	OP3	263.49	102.76	113.30	44.19	90	2.93	1.14	1.26	0.49	413.96	161.45	178.00	69.42	60	6.90	2.69	2.97	1.16
	OP4	263.43	102.74	113.27	44.18	90	2.93	1.14	1.26	0.49	413.26	161.17	177.70	69.30	60	6.89	2.69	2.96	1.16
	OP5	263.49	102.76	113.30	44.19	90	2.93	1.14	1.26	0.49	413.96	161.44	178.00	69.42	60	6.90	2.69	2.97	1.16
	OP6	263.42	102.74	113.27	44.18	90	2.93	1.14	1.26	0.49	413.25	161.17	177.70	69.30	60	6.89	2.69	2.96	1.16
	OP7	263.49	102.76	113.30	44.19	90	2.93	1.14	1.26	0.49	413.96	161.44	178.00	69.42	60	6.90	2.69	2.97	1.16
	OP8	263.42	102.74	113.27	44.18	90	2.93	1.14	1.26	0.49	413.25	161.17	177.70	69.30	60	6.89	2.69	2.96	1.16

AT – averaging time; CAA – Clean Air Act ambient air quality standards or guideline value; ALL – all sources; OP – Option previously defined; Wat – water suppression; SR – speed restriction; Index = ratio of max GLC and CAA; NM – no mitigation; 98p – 98th percentile

Table EA-30
Existing sound levels and noise impacts at the Project area

Station	Coordinates		Category	Timeframe	Noise Descriptor, dBA						DENR	Impact (a)		
	Longitude	Latitude			Lmin	L90	L50	L10	Lmax	Laeq		L90	Lmax	Laeq
AQN1	121.205325	14.699411	A	Morning	51	52	54	58	66	56	50	-2	-16	-6
			A	Daytime	48	49	51	55	74	58	55	6	-19	-3
			A	Evening	48	49	51	54	71	57	50	1	-21	-7
			A	Night time	49	50	52	55	56	53	45	-5	-11	-8
AQN2	121.196953	14.696480	A	Morning	51	52	53	58	66	56	50	-2	-16	-6
			A	Daytime	48	49	51	56	74	58	55	6	-19	-3
			A	Evening	48	49	51	54	71	57	50	1	-21	-7
			A	Night time	48	49	51	55	56	52	45	-4	-11	-7
AQN3	121.199903	14.702980	A	Morning	50	53	56	63	81	65	50	-3	-31	-15
			A	Daytime	59	60	63	66	79	65	55	-5	-24	-10
			A	Evening	48	49	51	56	60	53	50	1	-10	-3
			A	Night time	48	49	50	51	59	51	45	-4	-14	-6
AQN4	121.193734	14.701992	A	Morning	47	47	48	50	56	49	50	3	-6	1
			A	Daytime	47	50	56	60	63	57	55	5	-8	-2
			A	Evening	51	52	53	58	62	55	50	-2	-12	-5
			A	Night time	47	49	51	56	63	53	45	-4	-18	-8
AQN5	121.205296	14.695614	A	Morning	56	58	59	63	68	61	50	-8	-18	-11
			A	Daytime	52	58	62	69	74	65	55	-3	-19	-10
			A	Evening	58	58	60	64	68	62	50	-8	-18	-12
			A	Night time	50	51	53	59	63	55	45	-6	-18	-10
AQN6	121.209935	14.696056	A	Morning	50	50	55	78	90	77	50	0	-40	-27
			A	Daytime	50	51	57	75	89	74	55	4	-34	-19
			A	Evening	50	50	51	56	86	72	50	0	-36	-22
			A	Night time	46	49	50	51	76	57	45	-4	-31	-12

(a) Difference between noise descriptor and DENR Environmental Quality Standards for Noise in General Areas. If (-), value is greater than the noise standard (noise impact), otherwise no impact. Value is the impact magnitude. Lmin – lowest sound level; L90 – background sound levels; L50 – median sound level; L10 – sporadic or intermittent sound level; Lmax – peak sound level; Laeq – 24h averaged sound level; DENR - Environmental Quality Standards for Noise in General Areas

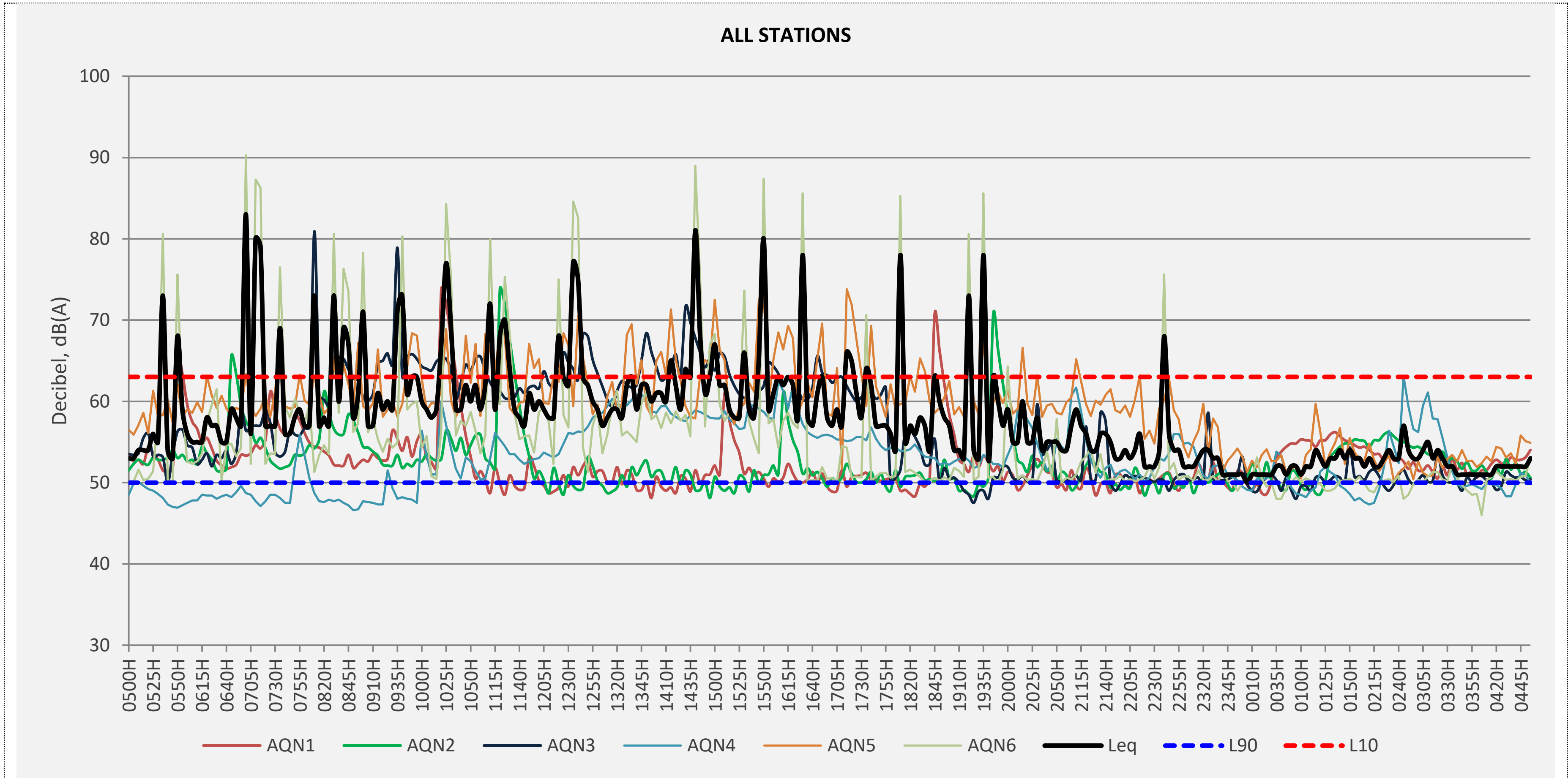

Figure EA-24. Diurnal sound level patterns and noise descriptors at the Project area

Noise Impacts during Construction Phase

Various equipment emit different levels of sound, the degree of disturbance depends on the distance of the source to the receptor, nature of activity, schedule and duration of activity, and type of equipment used. The USEPA defines noise as any sound that is undesirable because it interferes with speech and hearing, and is intense enough to damage hearing, or is otherwise annoying. Another definition of noise is airborne sound that is loud, unpleasant, unexpected or undesired, and may therefore be classified as a more specific group of sounds (California DOT, 2000).

Table EA-31 shows the calculated sound levels from different construction equipment using the inverse square law previously presented.

Table EA-31
Noise impacts from construction equipment[6]

Classification	Equipment	SPL range dB(A)	Predicted Sound levels, dB(A)				
			30m	60m	120m	240m	960m
Earth-moving	Cranes	70-94	64-88	58-82	52-76	46-70	34-58
	Backhoe	74-92	68-86	62-80	56-74	50-68	38-56
	Front loader	77-94	71-88	65-82	59-76	53-70	41-58
	Dozer	70-95	64-89	58-83	52-77	46-71	34-59
	Grader	72-92	66-86	60-80	54-74	48-68	42-62
	Scraper	76-98	70-92	64-86	58-80	52-74	40-62
	Truck	84-93	78-87	72-81	66-75	60-69	48-57
	Compactor	72-74	66-68	60-62	54-56	48-50	36-38
Materials handling	Concrete mixer	75-85	69-79	63-73	57-67	51-61	39-49
	Concrete pump	81-83	74-76	68-70	62-64	56-58	44-46
	Cranes, derrick	88-90	82-84	76-78	70-72	64-66	52-54
	Cranes, movable	75-85	69-79	63-73	57-67	51-61	39-49
Stationary	Pump	69-71	63-65	57-59	51-53	45-47	33-35
	Generator	73-83	67-77	61-71	55-65	49-59	37-47
	Compressor	70-93	64-87	58-81	52-75	46-69	34-57
Impact activities	Jackhammer	82-97	76-91	70-85	64-79	58-73	46-61
	Pile driver	97-105	91-99	85-93	79-87	73-81	61-69

Notes: *SPL – sound pressure level measured at 15m

Table EA-32 shows the noise impacts from the average sound levels emitting from different construction equipment classification. The calculated sound levels at 30 meters exceeded the Classes 1, 2, 3, and 4 limits by a maximum noise impact magnitude of 7, 12, 22, and 22 decibels respectively. The batching plant at the same distance exceeded the Class 4 limit by two decibels.

As previously mentioned, construction activities are only allowed during daytime from 7am to 7pm (12h) for the construction activity classes in Class A areas. However, there are no residential within 30m of the Project components. The nearest residential area is located in Sitio Apia, about 500m northeast of the new access road connecting the Pumping Station to the Water Treatment Plant and 5km east-northeast of the dam.

It is be emphasized that the model results were conservative, i.e., overestimates, because it was assumed that all construction equipment were operating simultaneously at steady state at the boundary of the project components and temporary facilities. The assumption was made as worst-case scenario and because the actual type, usage factors, and location of construction equipment was unavailable at this time. Noise levels during actual construction are likely to be lower than estimated values.

[6] Measured at 15m; Source: Canter, 1996, American Road Builders Association (1973)

Table EA-32
Noise impacts from construction equipment classification

Equipment Classification	SPL	30m	Max Noise Levels*				Noise Impact			
	Ave	Ave	1	2	3	4	1	2	3	4
Earth-moving	95	89	90	85	75	75	1	-4	-14	-14
Materials handling	87.1	81	90	85	75	75	9	4	-6	-6
Stationary	90	84	90	85	75	75	6	1	-9	-9
Impact activities	102	96	90	85	75	75	-6	-11	-21	-21
Concrete batching plant	83	77	90	85	75	75	13	8	-2	-2
Total	**103**	**97**	**90**	**85**	**75**	**75**	**-7**	**-12**	**-22**	**-22**

Notes: SPL – sound pressure level measured at 15m; *per Construction Activity Class

Noise Impacts during Operation phase

Noise impacts in a water resource projects are expected only during the construction phase from site development and structure erection activities such as earth moving, quarrying, blasting, and vehicular movement. Significant impacts during the operation of the Project are not expected.

3.2.3 Proposed Mitigating Measures

3.2.3.1 Degradation of Air Quality

The proposed mitigating measures are shown in **Table EA-33**.

Table EA-33
Proposed mitigating measures for the ambient air quality impacts

Key Impact	Potential Mitigation(s)
Construction Phase	
Air pollution due to fugitive particulates emissions from a) site preparation and b) construction of the project components (dam, spillway, new access roads, pumping station)	▪ Dividing active construction sites into smaller areas if possible; ▪ Dust suppression measures, e.g., water application and speed restriction, in active construction areas and access roads; ▪ Replacement of vegetation in non-structure areas to minimize wind erosion of topsoil; ▪ Compacting of exposed soil surfaces; ▪ Provide tarpaulin cover on trucks loaded with construction materials; and ▪ Hauling of spoils/excavated earth materials immediately after excavation.
Air pollution from SO_2 and NO_2 emissions from heavy equipment and motor vehicles during site preparation and structure erection.	• Regular maintenance of heavy equipment and motor vehicles; and • Use of low-sulfur fuel
Operation Phase *(insignificant impact to ambient air quality)*	

3.2.3.2 Noise Pollution

An important option in construction noise control strategies is controlling sound at the source. Source control techniques may be approached from two ways: (a) muffler requirements and (b) maintenance and operational requirements.

Most construction noise originates from equipment powered by either gasoline or diesel engines. A large part of the noise emitted is due to the intake and exhaust portions of the engine cycle. One remedy for controlling much of the 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.

In addition, poor maintenance of equipment may cause high noise levels, e.g., faulty or damaged mufflers, loose engine parts, rattling screws, bolts, or metal plates, 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 disruptive during leisure hours, sleeping hours, and any time where loud continuous noises affect certain special activities. Construction activities can be avoided at night and limited during daytime. Other measures are a) establishment of barriers and shielding stationary vibrating equipment, and b) provision of buffer zones. The proposed mitigating measures are shown in **Table EA-34**.

Table EA-34
Proposed mitigating measures for the noise impacts

Project Phase	Key Impact	Proposed Mitigating Measure
Construction	Noise from construction activities	▪ Maintenance of motor vehicle mufflers; ▪ Provision of barriers and shielding stationary vibrating equipment; and ▪ If possible, scheduling of noisy activities during day time.
Operation	Noise pollution from equipment	▪ Incorporation of noise criteria in the specifications and selection of equipment ▪ Regular maintenance of mufflers of standby generators and other pertinent equipment; ▪ Use of effective noise-attenuating materials for the structure and walling; and ▪ Planting of the appropriate vegetation as sound attenuation barriers.

3.2.4 Air and Noise Monitoring Plan

During construction phase, particulate matter (TSP and PM10) sound levels in (dB) in the established baseline sampling points will be monitored quarterly by WawaJVCo.

II. BASELINE KEY ENVIRONMENTAL IMPACTS

4.0 People

This module is a multi-level baseline socio-cultural characterization and social impact analysis of the host areas and impact barangays of the proposed project namely: Barangay San Rafael in the Municipality of Rodriguez, Barangay Calawis in the Antipolo City and Barangay Pintong Bukawe in the Municipality of San Mateo. It also contains the resulting social component of the environmental management plan to address the stakeholders' expressed social and economic issues.

An impact assessment is provided, focused on significant impacts to the communities in the area during the pre-construction, construction/development, operation and abandonment stages of the proposed project. An Environmental Management Plan is then presented, specifying the impact mitigation plan, areas of public information, education and communication, social development program proposal, and environmental monitoring plans together with the corresponding institutional and financial requirements/arrangements to implement the plan.

4.1 Methods and Sources of Data

The study made use of secondary data from the provincial, city, municipal and barangay government units and agencies including the Provincial Environment and Natural Resources Office and the Protected Area Management Bureau. Among the documents reviewed were: Comprehensive Land Use Plans, Forest Land Use Plans, Ecological and Socio-Economic Profiles, Situational Analysis Reports, Department Reports and Lists, the Comprehensive Upper Marikina River Basin Protected Landscape Management Plan and internet-based materials.

The Resettlement Action Plan (May 2020) commissioned by the proponent, along with the results of the community consultations and socio-economic survey of project-affected families was carefully studied to gain insight on the perceptions, issues and concerns of the potentially affected families that will go through involuntary settlement for the sake of the project.

Primary data were gathered through IEC sessions and meetings with city/municipal and barangay officials, sectoral and community leaders and residents, and representatives of project affected households (**Table EP-1**) and key informant interviews of local government department heads and staff. The consultations were done either face-to-face with limited number of participants, or via Zoom meetings, in observance of the EMB Memorandum Circular 2020-30 on the Interim Guidelines on Public Participation in the Implementation of Philippine Environmental Impact Statement System (PD 1586) during the State of National Public Health Emergency.

A ride through and ocular inspection of the impact barangays were also done for thorough project site appreciation.

Table EP-1
Schedule of IEC Sessions/Community Consultations with Host LGUs and Impact Barangays

Location	Date	Target Participants	No of Participants
Municipality of Rodriguez	July 22, 2020 (via Zoom)	LGU officials and Department Heads	8
Barangay Pintong Bukawe, San Mateo	September 16, 2020	Barangay Officials, Sectoral Representatives and Residents	27
Barangay Calawis, Antipolo	September 17, 2020	Barangay Officials, Sectoral Representatives and Residents	12
Barangay San Rafael, Rodriguez	September 23, 2020	Barangay Officials, Sectoral Representatives and Residents	11
Municipality of San Mateo	September 29, 2020 (via Zoom)	LGU Officials and Department Heads	6

Location	Date	Target Participants	No of Participants
Antipolo City	October 08, 2020 (via Zoom)	LGU Officials and Departments Heads	11

4.2 Existing Conditions in the Host Province Rizal

Rizal, one of five provinces of Region IV-A or CALABARZON, is a largely a residential area which has absorbed spill-over population from Metro Manila, for several decades, but with its own rapidly growing commerce, trade, manufacturing, industrial, and tourism sectors, alongside a still significant agricultural and fishery base. It is governed by a financially well-off and environment-oriented local government unit.

The province has four (4) congressional districts, thirteen (13) municipalities and one component city. The First District comprises four (4) municipalities with sixty-two (62) barangays while the Second District has nine (9) municipalities with one-hundred ten (110) barangays. The component City of Antipolo, also its capital, is subdivided into two districts with each district comprising of eight (8) barangays.

It is not only first class in income class, but has for several years (2015, 2016, 2017) ranked as the second richest province in the Philippines. In 2019, for instance, the provincial government had P7.928 billion in total receipts from local and external sources (including Internal Revenue Allotment) and non-income receipts[1].

Rizal's poverty incidence among families is also low at 7.5% (2015) compared to the regional figure of 10.4% and the national poverty incidence of 21.1%[2]. Other sources say that the poverty incidence of Rizal is 3.4%.

4.2.1 Location, Boundaries and Area

Rizal is found directly east of Metro Manila. Its northern boundary Bulacan Province, with the provinces of Laguna and Quezon on the east, and Laguna de Bay on the south. The province can be reached from Manila via Ortigas Avenue, and from Quezon City via Marcos Highway and Sumulong Highway.

Rizal's territory measures 130,892 hectares or 1,308.92 square kilometers equivalent to 0.87 percent of Calabarzon's land area. The City of Antipolo and the municipalities of Rodriguez and Tanay have the biggest land areas. The combined land area of the three local government units (LGUs) covers 86,223 hectares corresponding to more than one-half or 66.0 percent of Rizal's total land area. Cainta is the smallest municipality of Rizal with land area of 1,020 hectares comprising only 0.8 percent of the provincial total (**Table EP-2**). The three host areas (Antipolo, Rodriguez and San Mateo) comprise 52.24% of Rizal's land area.

4.2.2 Population

Citizens of the province are mostly Tagalogs plus Visayans, Ilocanos, Bicolanos and other local groups. Data from the National Commission for Indigenous Peoples and the Philippine Task Force for Indigenous Peoples' Rights indicate that Dumagat groups live in several barangays in the towns of Rodriguez and San Mateo.

Rizal is known for its consummate artists and craftsmen. The literacy rate is 100%. The primary dialect is Tagalog with English as the second language

Rizal's population in 2015 was 2,884,227 persons (or 652,605 households) compared to 2,484,840 in 2010. This represents a five-year increase of 13.8% (399,387 persons) or an average yearly growth rate of 2.8%. Household size is 4.4. Population density is 2,439 persons per square kilometer.

Source: [1]Statement of Receipts and Expenditures, Rizal Provincial Government, CY 2019. rizalprovince.ph
Source: [2]2015 First Semester Official Poverty Statistics of the Philippines. psa.gov.ph

With this growth rate of 2.8%, the provincial population will double in 25 years or in 2040. From 1990 to 2000, Rizal's annual growth rate was higher at 5.78%.

The three host areas (Antipolo with the biggest share of 27%, Rodriguez with 12.8% and San Mateo with 8.7%) collectively house 58.5% of the provincial population.

Table EP-2
Land Area by Municipality, Rizal Province, 2008

City/ Municipality	Area (Hectares)1	Percent Distribution	Area (Km.^{2})	Percent Distribution
Angono	2,600	1.99	26.22	2.23
Antipolo City	30,608	23.38	306.10	26.03
Baras	2,340	1.79	84.93	7.22
Binangonan	7,270	5.55	66.34	5.64
Cainta	1,020	0.78	26.81	2.28
Cardona	3,120	2.38	28.56	2.43
Jalajala	4,930	3.77	44.12	3.75
Morong	3,760	2.87	37.58	3.20
Pililla	7,400	5.65	69.95	5.95
Rodriguez	31,278	23.90	172.85	14.70
San Mateo	6,489	4.96	55.09	4.68
Tanay	24,337	18.59	200.00	17.01
Taytay	3,880	2.96	38.80	3.30
Teresa	1,860	1.42	18.61	1.58
Total	130,892	100.00	1,175.96	100.00

Sources: 1) ENR Statistical Profile CY 2005, Rizal Province (PENRO-Rizal) 2) For IRA Allocation
Note: To date, the municipal and city/provincial land areas may not tally and are subject to verification and consultation by the concerned agencies.

Table EP-3
Total Population, Household Population and Number of Households by City/Municipality of Rizal

City/ Municipality	Status	Population Census 1990-05-01	Population Census 2000-05-01	Population Census 2010-05-01	Population Census 2015-08-01
Rizal	Province	977,448	1,707,218	2,484,840	2,884,227
Antipolo	City	207,842	470,866	677,741	776,386
Binangonan	Municipality	127,561	187,691	249,872	282,474
Cainta	Municipality	126,839	261,500	311,845	322,128
Taytay	Municipality	112,403	198,183	288,956	319,104
San Mateo	Municipality	82,310	135,603	205,255	252,527
Rodriguez (Montalban)	Municipality	67,074	115,167	280,904	369,222
Tanay	Municipality	58,410	78,223	98,879	117,830
Angono	Municipality	46,014	74,668	102,407	113,283
Cardona	Municipality	32,962	39,003	47,414	49,034
Pililla	Municipality	32,771	45,275	59,527	64,812
Morong	Municipality	32,165	42,489	52,194	58,118
Teresa	Municipality	20,645	29,745	47,163	57,755
Baras	Municipality	16,880	24,514	32,609	69,300
Jala-Jala	Municipality	16,318	23,280	30,074	32,254

Source: National Statistics Office of the Philippines and National Statistical Coordination Board

4.2.3 Economy

Rizal's economy is a mix of agriculture, fishery, commerce and trade, light and heavy manufacturing, industrial, especially mining and quarrying, and tourism sectors.

4.2.3.1 Agriculture

Agriculture remains significant and takes place in 25% (or 32,2765 hectares) of the provincial land area.

Rice

Rizal Province is very affable for agricultural development in consideration of climatic condition, soil fertility and proximity to markets. Rice farming takes up 5,805 hectares with a production rate of 26,894 cavans or 1,344.7MT per year.

High Value Crops

Slightly larger than rice areas, 6,019.58 hectares are planted with diversified or high value crops like vegetables, fruits and root crops. Among the high value crops are cucumber, cabbage, lettuce, ampalaya, beans, okra, among others. Fruits include mango, banana, cashew, citruses, rambutan, avocado, santol, atis and jackfruit (nangka). Mango is the major produce in the province with an average of 35,000 M.T.per year, supplying almost three fourths of the annual local market demand of the province.

The regional office of the Department of Agriculture reported that in 2016, Rizal's production included 3,532 metric tons of saba and lakatan varieties; 1,402 MT of mango; and 444 MT of pineapple. Said production came from large fruit areas in Tanay, Pililia, Rodriguez and Antipolo City. Many farmers practise natural farming, resulting in sweeter taste of fruit produce and which in turn fetch higher market prices whether fresh or processed[3].

Livestock Production

Rizal is one of the country's top hog raisers. Foremost Farms, for instance, the Philippine's largest and one of Asia's biggest piggery farms was established in the province in 1970. It currently produces an average of 50 tons of hogs for domestic and foreign markets.

Other piggeries and poultry farms supply local market demand. Backyard scale piggeries and poultry farms (native chicken, broiler and ducks) also contribute meat for local consumption. Cattle, goats and carabaos are raised in upland areas. Carabaos are used as draft animals for farming, while goats and cattle are for meat production.

Cutflowers and Ornamental Plants

The Province has a favorable climate for growing cutflowers and ornamental plants. There are thousands of species that are endemic in the province especially in the upland forested areas where most of these are not yet botanically identified. Among the cutflowers, orchid growing is a favorite among cultivators. Resident growers in Rizal Province also grow native and hybrid species of orchids like dendrobiums, cattleyas, vandas, terete vandas, phaelenopsis, cymbidium, renatheras, ascocentrums, among others. These orchid species attract hobbyists and enthusiasts to grow in their own backyards not just as a hobby but as an additional source of income. Bonsai and foliage plant growing are also flourishing businesses in the province.

4.2.4 Aquaculture

Rizal's major resource for aquaculture is the 90,000-hectare Laguna lake. It is the country's largest inland freshwater basin, of which 15,000 hectares are for fish cages and fish pens; 5,000 hectares are for fish sanctuary; and 26,000 hectares are used by marginal fishermen. The province shares around 51,000 hectares or 56.67% of the total area of the lake.

[3]Source: http://prdp.da.gov.ph/rizal

Bangus, tilapia, and big head carp are commonly cultured or commercially harvested from fish pens and fish cages in Laguna de Bay. These species command higher prices compared to other freshwater species. Other freshwater fish species that grow in the lake are the kanduli and hito (belonging to catfish species), biyang tabang (fresh White goby), ayungin (silver perch), dalag (mudfish), gourami, and the other freshwater species like golden kuhol, freshwater clams like paros and tulya, freshwater shrimps, and dulong (starry goby).

4.2.5 Other Industries

4.2.5.1 Tourism Industry

Rizal is known for religious tourism, its historical sites, art venues and galleries by famous local artists, colorful festivities, and scenic natural attractions consisting of waterfalls, natural springs, rock formations, and the panoramic view of Sierra Madre Mountain ranges and Laguna de Bay. It also hosts golf and country clubs, resorts, restaurants, hotels, among others, which further boost the tourism activities in the province.

One of the most interesting tourist destinations in Rizal province is the Petroglyphs in the Angono-Binangonan Boundary. This is a World Heritage Site where there are about 127 drawings of animal and human figures engraved in rock said to be dated back to circa 3000 B.C. It is the most ancient Filipino relic ever discovered.

A new tourist destination in Rizal Province is the Masungi Georeserve, a conservation area located in the Southern Sierra Madre Range in the Municipality of Baras. It centers on the geological formation known as the Masungi Rock, consisting of tower karsts of limestone surrounded by lush montaine rainforests. Masungi Georeserve has several caves including the “Yungib ni Ruben (Ruben’s Cave) wtih stalactites and stalagmites. A popular attraction in the area is the “Sapot” (cobweb) made of metal with wooden steps, allowing visitors to walk on suspended netting above the karst and get a 360-degree view of the Sierra Madre and the Laguna de Bay.

4.2.5.2 Manufacturing Industry

Diverse manufacturing firms producing cement and concrete products, textiles, paints and chemicals, metal and steel products, electrical and electronic products and cars assembly are found in the province. Food processing and manufacturing are also abound there.

Production of garments, leather goods, and wood works, which were institutionalized in 2010, is now among the growing and tax-rich sectors of the provincial economy[4].

4.2.5.3 Mining and Quarrying Industry[5]

Mining and quarrying are major economic drivers of Rizal’s economy.

Rizal is one of three provinces (the two are Batangas and Quezon) in Calabarzon with high metallic and non-metallic mineral deposits with commercial potential. Gold bearing minerals, occurring as vein and placer deposits have been noted in Rodriguez and Tanay. Evidence of copper mineralization have been identified in Barangay Puray in Rodriguez; and magnetite iron deposits were found in the border of Antipolo City and Tanay.

Cement raw materials such as limestone, shale and silica deposits also occur in huge deposits in Antipolo and Teresa. Selected areas in Rizal also abound in construction materials or concrete aggregates consisting of basalt, andesite, sand and gravel. Some limestone resources in Rizal are quarried and marketed as “marble.” Extensive deposits of red-burning clay are also found in Antipolo, San Mateo and Tanay. This can be made into terra cota, ceramics, tiles and bricks. Internet surfing yielded a list of around 20 quarrying outfits and marble contractors in Rizal, mostly located in Antipolo, Rodriguez, Angono, San Mateo, San Isidro and Binangonan.

[4]Source: Mamamayani.wordpress.com
[5]Source: Data were culled from http://www.portal.mediaaccess/com.ph

In 2013, the Portal Philippine Mining Magazine, reported that Rizal had: 18 medium-scale rock aggregates crushing plants (with capital investment of P10 million to P250 million); 1 marble quarry and processing plant; and 1 lime processing plant; and two cement plants: Solid Cement and the RCBM Inc. Teresa Plants. Rizal's share in Calabarzon's annual production output of aggregates/sand and gravel is 43 percent. The cement plants in Rizal contribute 69 percent of the total cement production capacity of the region.

4.2.6 Social Services and Public Utilities

4.2.6.1 Education

Rizal Province has been awarded, First Place in terms of Human Development Index by the United Nations Development Program (UNDP) for being No. 1 in terms of Human Development Index. It has also been recognized by the Human Development Network (HDN) for life expectancy, functional literacy and educational attainment, poverty alleviation, environmental regeneration, women empowerment, jobs creation, and real income per capita.

The literacy rate of the government ranges from 96 - 98% as a result of the full support of all units of governments in the province to achieve and push for higher educational performance rates.

In 2015, of the 2,581,948 population 5 years old and above, only 1.83% were recorded to have not gone to school at all. Those who had a few years of grade school made up 25.47%; those who reached high school constituted 40.74%. High School graduates comprised 27.6%; those who had some years of college education composed 14%. Thirteen percent (13%) were college degree holders and 1% had post graduate education[6].

Internet data indicate that the province has 51 colleges and universities, including their multiple campus locations or branches in the various towns. For example, the University of Rizal System has campuses in Antipolo City, Angono, Cainta, Cardona, Binangonan, Tanay, Taytay, Morong and Pililla.

4.2.6.2 Telecommunication

Historically, Rizal province is the pioneer and foremost in communication technology in the Philippines where the first communication satellite, the "PHILCOMSAT", was established then in the 1970s. This communication facility broke down the barriers and opened up the Philippines to advanced communication systems such as the telephone, broadcasting, fax services, and other satellite communications services.

Currently, PLDT, Smart, Globe Digitel (Sun Cellular) and other facilities are the major service providers for landline telephones, cellular phones, internet connection.

4.2.6.3 Power Generation

Rizal is also a power-generating province with the Malaya Thermal Pumped storage of the NAPOCOR, one of the main sources of energy for Luzon grid, and currently operated by KEPCO Philippines. Rizal is within the service area of MERALCO.

4.2.6.4 Water Supply

The Manila Water Company Inc. provides potable water and used water services to the province. The LGUs that have their own water system are Tanay and Morong.

[6]Source: http://www.psa.gov.ph

4.3 Existing Conditions of the Host City and Municipalities

4.3.1 Antipolo City[7],[8]

Antipolo City is Rizal's major economic, financial and service center. It is a first-class component city which has recently become the provincial capital. It is also categorized as a sub-regional center of Region 4A. Antipolo's revenue in 2016 was P2.134 billion while poverty incidence was recorded at 5.77%.[9]

It is situated in the northern part of the province along the slopes of the Sierra Madre Mountain Range. Much of the city sits on a plateau averaging 150 meters. It has the second largest area in the province with an area of 306.10 km². The northern and southern sections of the city are in the dense forest areas of the Sierra Madre.

In 2015, Antipolo's population was recorded at 776,386 which makes it the most populous in CALABARZON. From 2010, it increased by 98,645 equivalents to 12.7%. With an annual growth rate of 2.62%, the city population is projected to double in 27 years or in 2042.

Residents of the city are mostly Tagalogs. Indigenous Dumagat communities are found in Barangay Calawis and Sitios Old Boso-Boso, San Isidro, San Jose and Kaysakat of Barangay San Jose.

Table EP-4
Population, Antipolo City

CityMunicipality	Population percentage (2015)	Population (2015)	Population (2010)	Change (2010-2015)
Bagong Nayon	5.92%	45,976	45,152	1.82%
Beverly Hills	0.20%	1,562	1,590	-1.76%
Calawis	0.74%	5,709	4,252	34.27%
Cupang	14.63%	113,613	84,187	34.95%
Dalig	6.73%	52,222	45,805	14.01%
Dela Paz	8.88%	68,946	61,281	12.51%
Inarawan	2.95%	22,894	18,026	27.01%
Mambugan	6.76%	52,479	48,247	8.77%
Mayamot	6.49%	50,421	49,073	2.75%
Muntingdilaw	1.50%	11,644	9,824	18.53%
Santa Cruz	8.11%	62,992	55,025	14.48%
San Isidro	8.26%	64,136	57,446	11.65%
San Jose	13.27%	103,051	88,222	16.81%
San Juan	1.12%	8,671	8,488	2.16%
San Luis	6.86%	53,230	48,780	9.12%
San Roque	7.58%	58,840	52,343	12.41%
Total	776,386	677,741	14.55%	2.62%

Antipolo has sixteen (16) barangays, of which four (4) are in the Poblacion namely: Brgy. Dela Paz, San Roque, San Jose and San Isidro. In 2015, the top three barangays in terms of population were Brgy. Cupang (113,613), Brgy. San Jose with 103,051 and Brgy. Dela Paz (68,946). The smallest was Beverly Hills with 1,562.

Calawis, one of the host barangays had 5,709 residents (or 0.7% of the city population). In 2010, 3,978 persons lived in the barangay).

[7]Source: https://en.wikipedia.org/wiki/Antipolo#cite_note-13
[8]Source: Antipolo City Ecological Profile. 2018
[9]Source: En.m.wikipedia.org

4.3.1.1 Economy

The city's economy is dominated by tertiary or service sector activities. Economic contribution from agriculture, livestock production, fishery and forestry has diminished through the years.

In 2018, firms belonging to the tertiary sector accounted for about 93 percent of all registered firms while those in the agriculture, livestock, fishery, and forestry sector comprised only about 0.1 percent. The rest are firms from the secondary sector engaged in mining and quarrying, manufacturing, construction, and electricity, gas and water.

This city grew largely, since the 1970s, due to the real estate industry which developed numerous residential subdivisions, now totaling 689, to absorb the spill-over population of Metro Manila. Alongside, its tourism, commercial and education sectors also flourished. Huge and modern malls, commercial centers, restaurants, banks, hotels and conference sites, and large colleges and universities are visible in different parts of the city.

4.3.1.2 Social Services and Public Utilities

Education

As of 2019, Antipolo City has 270 elementary and high schools: broken down as 46 elementary schools and 23 high schools, all public; and 201 private elementary and high schools. They serve 223,866 learners. The 2 public colleges/universities and 26 private colleges and universities recorded an enrollment of 13,895 college students.[10] Listed number of Day Care Centers in the city is 204.

Housing

The City has 32 socialized housing/resettlement areas where 7,784 families now live. 24 were initiated by the Antipolo government while eight were implemented through the National Housing Authority and the Presidential Commission on the Urban Poor.

Health

Health services in Antipolo City are provided by 2,695 private and public health practitioners (**Table EP-5** and **Figure EP-1**). Majority of health service workers in Antipolo work in private health facilities and around 91% of doctors work in private hospitals and clinics (Antipolo Ecological Profile, 2018). The health personnel ratio in Antipolo is one public health doctor for every 5,456 persons, which much higher than the minimum standard ratio of 1:20,000 population. Public health nurse ratio is at 1:3,398, which is also much higher than the minimum standard of 1:20,000. However, midwife ratio is high at 1:14,4618, which falls below the minimum standard of 1:3,000 to 1:5,000.

Table EP-5
Number of health personnel in public and private health facilities (CHO, 2018)

Health Personnel	Public	Private	Total
Doctors	142	1,513	**1,655**
Nurses	228	638	**866**
Midwives	53	121	**174**
Total	**423**	**2,272**	**2,695**

[10]Source: Antipolo City Ecological Profile. 2018

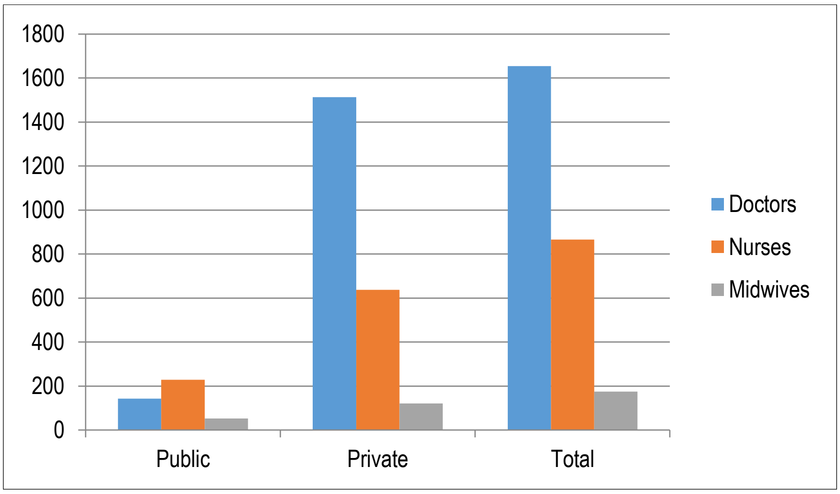

Figure EP-1. Health personnel in Antipolo City (CHO, 2018).

Antipolo City has 325 private and public health facilities, about 85% of which are private hospitals, clinics and diagnostic centers. Government health facilities include barangay health stations, the City Health Center, four public hospitals, rural health units and a Basic Emergency Obstetric and Newborn Care (BEMoNC). All barangays have barangay health stations, with larger barangays provided with 2-5 health stations. The rural health units are located in Barangays Bagong Nayon, Dela Paz, Mayamot and San Jose while the City Health Center is located in Barangay San Roque. Birthing and newborn care centers are located in Barangays San Isidro, Cupang, San Jose and San Luis. Total bed capacity in all health facilities is at 1,177, with private hospitals and clinics accounting for 76% of the total bed capacity (Antipolo Ecological Profile, 2018). The city has 806 public and private hospital beds. The public and private health facilities in Antipolo are listed in **Table EP-6** and presented in **Figure EP-2**.

Table EP-6
Public and private health facilities in Antipolo (CHO, 2018)

Health Facility	Public	Private	Total
Barangay health stations	31	-	**31**
Rural health units	4	-	**4**
BEMoNC	4	-	**4**
City Health Center	1	-	**1**
Hospitals	4	12	**16**
Clinics	-	236	**236**
Diagnostic centers	4	29	**33**
Total	**48**	**277**	**325**

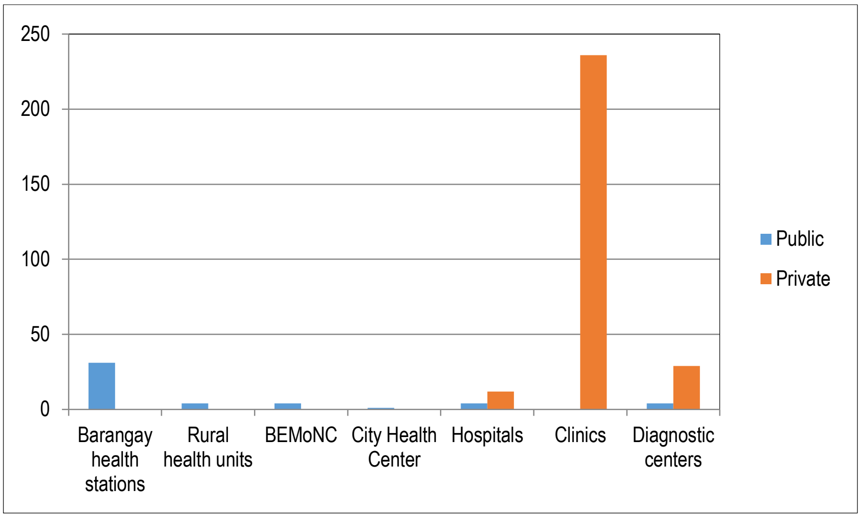

Figure EP-2. Health facilities in Antipolo City (CHO, 2018).

Table EP-7 lists the leading causes of morbidity for all ages from 2016 to 2018. The leading causes of morbidity are acute respiratory infection, cough and cold, acute diarrhea, and hypertension.

Table EP-7
Leading causes of morbidity in Antipolo City (CHO, 2016-2018)

2016	2017	2018
1. Acute respiratory infection	1. Acute respiratory infection	1. Acute upper/lower infection
2. Cough and cold	2. Acute watery diarrhea	2. Acute bloody diarrhea
3. Disorder of the skin	3. Hypertension	3. Hypertension
4. Bronchitis	4. Injury	4. Musculoskeletal disorder
5. Fever	5. Cough and cold	5. Pneumonia
6. Acute watery diarrhea	6. Fever	6. Urinary tract infection
7. Hypertension	7. Musculoskeletal disorder	7. Parasitism
8. Community acquired pneumonia	8. Disorder of the skin	8. Dermatitis
9. Urinary tract infection	9. Community acquired pneumonia	9. Bronchitis
10. Parasitism	10. Urinary tract infection	10. Diabetes

Table EP-8 presents the leading causes of mortality in Antipolo from 2016 to 2018. The leading causes of death are respiratory failure, myocardial infarction and other cerebro-vascular diseases, cancer and multiple organ failure.

Table EP-8
Leading causes of mortality in Antipolo City (CHO, 2016-2018)

2016	2017	2018
1. Respiratory failure	1. Respiratory failure	1. Myocardial infarction
2. Myocardial infarction	2. Myocardial infarction	2. Pneumonia
3. Community acquired pneumonia	3. Community acquired pneumonia	3. Cerebro-vascular accident
4. Cerebro-vascular accident	4. Cerebro-vascular accident	4. Cancer
5. Cardio-pulmonary arrest	5. Cancer	5. Respiratory distress
6. Multiple organ failure	6. Multiple organ failure	6. Pulmonary tuberculosis
7. Septic shock	7. Septic shock	7. Sepsis
8. Herniation syndrome	8. Herniation syndrome	8. Bronchial asthma
9. Pulmonary tuberculosis	9. Pulmonary tuberculosis	9. Acute coronary syndrome
10. Asphyxia	10. Asphyxia	10. Septic shock

Vital health statistics in Antipolo City from 2016 to 2018 is presented in **Table EP-9**. The city recorded 3,478 to 3,654 deaths per year and the crude death rate is estimated at 4.35% to 4.47%. Crude birth rate ranges from 10% to 12.3% while infant mortality rate ranges from 4.37% to 6.37%.

Table EP-9
Vital health statistics in Antipolo City

Vital Health Indicator	2016	2017	2018
Total number of deaths	3,478	3,654	3,646
Crude death rate	4.37	4.47	4.35
Total number of infant deaths	53	43	27
Infant mortality rate	6.37	4.37	3 per 1,000 live births
Total number of neonatal death	32	39	21
Total number of deaths (>50 yrs old)	713	1,650	1,205
Maternal mortality rate	0	30.32	0
Crude birth rate	10.01	12.3	10
Total fertility rate	81.25	99.82	103 per 1,000 live births

Water Supply

Manila Water Company Inc. provides water supply to Antipolo City's 15 barangays, except Barangay Calawis. For reasons of distance and elevation. Calawis is not yet part of Manila Water service area. Most of the barangays have 93-100% coverage with the exception of Barangays Inarawan and San Juan which have only 37% and 24% water service coverage.

Solid Waste Management

The City has regular garbage collection services. It has a "no segregation, no collection" policy as embodied in City Ordinance No. 2008-287 in compliance with the Environmental Compliance Audit for LGUs within the Manila Bay Watershed Area.

To ensure proper solid waste management within the city, the local government has authorized private individuals to engage in the collection, transport, recycling and disposal of solid waste for compensation. The city also has a central MRF in Sitio Kaybagsik in Barangay Inarawan.

4.3.2 Municipality of Rodriguez[11]

Municipal records say that Rodriguez has played an "ancillary role" to regional and provincial development goals, rather than independently pursuing its own development direction according to its physical and environmental attributes. It has served as a receiver of resettlement projects and solid waste from Metro Manila, as it also provides construction materials for the metropolis.

Nevertheless, this may have been beneficial to the municipality as Rodriguez (formerly called Montalban) has turned out into a first-class municipality, with low poverty incidence of 4.5% in 2015[12]. Some sources say that Rodriguez ranks third richest among the municipalities in the country. In 2016, its annual regular income increased to P 532.871 million, a seven-fold leap from its income of P 75.233 million in 2009, only in 7 years. The dramatic rise started in 2015.

[11]Source: Situation Analysis Report. Municipality of Rodriguez
[12]Source: https://en.wikipedia.org/wiki/Rodriguez,_Rizal

Table EP-10
Annual Regular Income. Rodriguez, Rizal (2009 – 2016)

Fiscal Year	Annual Regular Income	Change
2009	75,233,157.70	–
2010	80,479,790.57	6.97%
2011	93,264,720.69	15.89%
2012	100,672,964.29	7.94%
2013	102,036,734.10	1.35%
2014	108,610,212.01	6.44%
2015	486,190,077.99	347.65%
2016	532,871,106.64	9.60%

Annual Regular Income = Locally Sourced Revenue + Internal Revenue Allotment (IRA) Current Year + Other Shares from National Tax Collection *Locally Sourced Revenue* = Real Property Tax (General Fund) + Tax on Business + Other Taxes + Regulatory Fees + Service/User Charges + Receipts from Economic Enterprises

Rodriguez is the northernmost town in the province, nestled on the slopes of the Sierra Madre mountain range. The town borders San Mateo and Antipolo City in the south, Norzagaray and San Jose Del Monte City in the north, Gen. Nakar on the east and Quezon City in the west.

Measuring about 36,307 hectares, Rodriguez is the largest municipality of Rizal Province in land size. It should be noted, however, that almost 3/4 or 72.97% is forestland. Agricultural land is 8.6% and built-up area is 6.4%. Agro-industrial land comprises 0.13%; mining and quarrying 0.84%; and tourism 1.67%.

The 26,496.12 hectares of forestland are part of the watersheds (Angat, Umiray, and Kaliwa Watershed Reservations), and the Upper Marikina RIver Basin Protected Landscape (UMRBPL) formerly called the Marikina Watershed and lands in the municipality covered by Presidential Proclamation 1636, series of 1977, including portions of unclassified public forest. The Upper Marikina River Basin Protected Landscape takes up about 12,704 hectares or 35.00% pf the municipality's forestland area[13]. This means that this big portion of the municipality is co-managed by the LGU and the Department of Environment and Natural Resources, as provided by Proclamation 296 and the NIPAS Act of 1992.

Land area figures of its 11 barangays are shown in **Table EL-11**. Barangay San Rafael, one of four rural barangays, shares 1/6 of the town's land area. The seven others (Balite, Burgos, Geronimo, Manggahan, Rosario, San Isidro, and San Jose) are urban barangays.

Table EL-11
Land Area by Barangays in Municipality of Rodriguez

Barangay	Area (hectares)	% Share
Balite (Poblacion)	53.88	0.15
Burgos	276.00	0.76
Geronimo	36.75	0.10
Macabud	1,886.00	5.19
Manggahan	117.44	0.32
Mascap	7,576.41	20.87
Puray	15,437.70	42.52
Rosario	25.17	0.07
San Isidro	3,792.00	10.44
San Jose	1,045.28	2.88
San Rafael	6,061.45	16.69
Total	**36,307.31**	**100**

[13] Source: Forest Land Use Plan, Municipality of Rodriguez (2019-2023).

The Rodriguez population in 2015 was 369,222, compared to 67,074 persons in 1990. This represents a five-fold jump in 25 years. In the 1990s, the town's growth rate ranged from 3.28 to 4.8% but from 2000 to 2007, the population grew yearly between 8.2 to 9.58%. The high population increases are attributed to national government's move to create housing projects for state employees and resettlement sites for informal settlers from Metro Manila. At a growth rate of 6.4% in 2015, the residents of Rodriguez will double in 11 years or in 2026.

Citing the Indigenous Peoples profile submitted by Virgilio D. Vertudez, NCIP Coordinator for Rodriguez, the FLUP says that municipality is home to the Dumagat-Remontado tribe with a population of 1,037 equivalent to 269 families. They are mostly in Sitio Daapis, Quinao and Sitio Malasya-Uyungan. The population figures per barangay are shown in **Table EP-12**

Table EP-12
Population Distribution by Barangay, 1990-2015

Barangay	1990	1995	2000	2007	2010	2015
Rodriguez	67,074	79,668	115,167	223,594	280,904	369,222
Balite (Pob.)	6,182	6,943	7,849	8,827	9,114	9,983
Burgos	15,483	19,536	25,146	34,032	38,554	44,100
Geronimo	3,365	3,830	4,548	4,450	5,417	5,554
Macabud	2,021	2,327	3,124	6,338	6,605	9,707
Manggahan	5,862	7,031	8,220	11,170	12,557	13,913
Mascap	1,645	2,056	2,089	4,293	4,425	4,699
Puray	1,311	1,746	1,772	2,937	2,941	3,921
Rosario	3,530	4,109	4,558	5,414	5,881	7,244
San Isidro	1,905	2,178	2,618	28,614	62,114	117,277
San Jose	15,222	17,627	40,372	93,567	108,586	124,868
San Rafael	10,548	12,285	14,835	23,952	24,710	27,956

Source: NSO, 2010 Cencus of Population and Housing and PSA, 2015

4.3.2.1 Economy

Rodriguez has a vibrant tertiary sector (wholesale and retail trade, transportation, storage and communication, finance, insurance, real estate and business services and community, social and personal services). Mid-sized shopping malls (such as the existing Montalban Town Center which houses the Robinson's Supermarket, and the Primark Town Center, which is an affiliate of SM Super Malls, and the coming Xentro Mall in San Jose business district) are beginning to line the roadsides. Various food outlets, banks and other financial service outfits, construction and other service establishments abound along major streets and commercial centers given that the municipality hosts 270 housing projects ranging from socialized housing to executive subdivisions. (Inquirer.net. November 2019)

Recent years saw the rise of Micro, Small and Medium Enterprises (MSMEs) engaged in manufacturing of household and holiday decor, and processed food like canned or pickled fruits and vegetables, squash catsup, ginger tea, virgin coconut oil, powdered saluyot and malunggay, pastillas and ice cream made of carabao milk, and taro and rootcrop cookies.

Registered business establishments have multiplied from 782 in 1982 to almost 3075 in 2012

The two sanitary landfills - the 14-hectare Montalban Solid Waste Disposal Facility in Barangay San Isidro, and the 19-hectare Rodriguez Sanitary Landfill - are also big income generators for the municipality. Since the early 2000s, gross revenues reached P700 million yearly from which the municipal government netted a 20% share.

Rodriguez is also referred to as the "quarrying capital" of Rizal.

Agriculture and Forestry

Agriculture in Rodriguez is very limited because of the town's mountainous topography. It is also declining. The FLUP indicates that 8.6% (or 3,122.402 hectares) of the municipality's land area is classified as agricultural land, but it also says that the Rodriguez Comprehensive Development Plan in 1995 had a lower estimate of 1,818 hectares devoted to agriculture. The FLUP further says that in 2010, arable lands decreased to 1,711.40 hectares. This could be lower now because of farmland conversion for residential subdivisions and housing projects.

Swidden agriculture or kaingin is likewise done but this definitely contributes to forestry loss as hardwood species are replaced with shallow-rooted cash crops such as banana, coconut and pineapple. Charcoal making is legally prohibited but it is a source of income for poor upland dwellers and unscrupulous financiers.

There is no updated information on forestry-related economic activities.

Mining and Quarrying

The Municipal Situation Analysis Report attests that mining/quarrying/crushing constitute a major economic activity in Rodriguez. Eight (8) major crushing plants (Pacific Concrete Products, SIRRI, Solid Integrated Construction Inc., Vulcan Industrial and Mining Corp., Viba Aggregates, Millex (Montalban operations), Blue Rock Aggregates, and Oxford Mines, Inc.) reported total rated crushing capacity of 2,250 tons/hour. This translates to about 8.219 million cubic meters of minerals yearly.

Tourism

Prior to the Covid-19 pandemic, the municipality had a well-established and thriving tourism industry patronized by Filipino tourists in the millions. The Municipal Tourist Arrival Report in 2019 recorded 1,475,736 visitors, mostly domestic tourists. Foreigner-visitors reached only 656. A Sustainable Tourism Code is being developed as well as an ordinance to prescribe standard environmental or tourism users' fees.

The main attractions in Rodriguez are the nature-based tourism assets, historical and cultural sites, nature-focused recreational attractions, arts and craft centers, outdoor sports and recreational facilities, various resorts, and souvenir shops. The Municipal Inventory of Tourist Attractions and Destinations lists: 12 mountains such as Mt. Pamitinan Protected Landscape, Mt. Binicayan, Mt. Hapunang Baroy, Mt. Susong Dalaga, Mt. Matamis na Luya, among others); 5 falls (e.g. Puray, Tu-ay, Karugo, etc.); 2 ponds (Pamitinan and Mascap Lagoons); rivers, 4 caves (Pamitinan, Lubog in Mascap and Puray, and Tanglaw); 2 unique land formations (Montalban Gorge and Mt. Lubog Summit Limestone); 5 agro-forestry sites (e.g. Macabud Agri Sites, Puray Agro-forestry, and those in San Rafael, Balagbag, and Mascap); 5 farms/ranches; 5 cycling roads/areas (Puray Mountain Cycling, Mount Paruwagan, Mascap Mountain Cycle Trail, Pamitinan Protected Landscape area); 2 rapelling sites; and the Avilon Zoo in San Isidro.

The historical, religious and cultural destinations include: 3 churches, 2 historical monuments, 2 museums (Eulogio Amang Rodriguez and Liamzon Ancestral Houses); old structures/buildings/monuments (e.g. San Jose Bridge, Wawa Dam, Forest Lawn Jesus Christ Statue, Gen. Licerio Geronimo monument). The Istampang Bato of the Dumagats is found in Sitio Inigan in Barangay San Rafael.

Boating is also enjoyed in certain parts of the Wawa River. About 50 boats are registered in the Wawa Dam Ecotourism site.

4.3.2.2 Social Services and Public Utilities

Education

Rodriguez has 37 elementary schools and 24 high schools; all are under the supervision of the Department of Education (DepEd) schools district. The town also has six tertiary schools subject to the control of the Commission on Higher Education. Out of 37 elementary schools in Rodriguez, 28 are public and 9 are private. Private sector participation in the basic education is significant, particularly for the upper-income classes. Public grade schools cater mostly to middle-income and lower –income brackets.

Health

Primary health care facilities in Rodriguez include a 25-bed infirmary, one rural health unit and a health center for each of the 11 barangays. Other health care services are available in private medical treatment centers, dental clinics, laboratories and lying-in/maternity centers.

The mortality data of Rodriguez in 2018 and 2019 is presented in **Table EP-13**. The total number of deaths was reported at 1,294 in 2018 and 1,390 in 2019. Of the total deaths in 2018, 2 are maternal deaths, 20 are infant deaths, and 30 are neonatal deaths. The 2019 data shows that out of 1,390 deaths, one is a maternal death, 32 are infant deaths while 44 are neonatal deaths.

Table EP-13
Mortality data of Rodriguez from 2018 to 2019 (MHO)

Mortality Statistics	2018	2019
Total number of deaths	1,294	1,390
Maternal deaths	2	1
Infant deaths	20	32
Neonatal deaths	30	44

The leading causes of death in Rodriguez are tabulated in **Table EP-14** and graphically shown on **Figure EP-3**. The leading causes of mortality in 2018 and 2019 are acute myocardial infarction and cardiac arrhythmia followed by acute pulmonary failure, medico-legal cases and multiple organ failure. The top two causes of death in the municipality as well as hypertension are known as lifestyle diseases that are attributed to diet and lack of exercise. Other causes of mortality include pneumonia, other cardio-pulmonary causes and septicimia or severe blood infection.

Table EP-14
Leading causes of mortality in Rodriguez (MHO, 2018-2019)

Disease	2018	2019
Acute myocardial infarction	332	511
Cardiac arrhythmia	121	218
Acute pulmonary failure	114	148
Medico-legal cases	53	61
Multiple organ failure	62	52
Pneumonia	18	35
Cadiogenic shock	29	31
Cardio-pulmonary arrest	45	30
Cerebrovascular attack	-	27
Hypertension	22	22
Septicimia	70	-

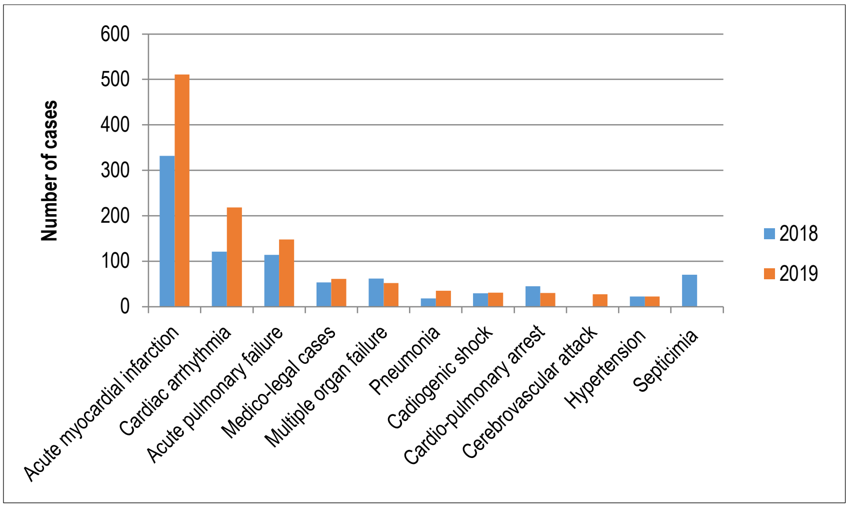

Figure EP-3. Leading causes of mortality in Rodriguez from 2018 to 2019

Leading causes of adult morbidity or sickness in the municipality in 2019 include pulmonary tuberculosis (PTC), hypertension (HPN), upper respiratory tract infection (URTI), pneumonia, diabetes, urinary tract infection (UTI), osteoarthritis, acute otitis media, acute gastroenteritis and severe vascular infection (SVI). **Table EP-15** also presents the leading causes of morbidity in 2000 with the data obtained from Sewerage Master Plan and Feasibility Study of the Marikina River Basin (2008). A marked improvement in upper respiratory tract infections is noted over the 20-year period which decreased significantly from 6,385 cases in 2000 to 370 cases in 2019 (**Figure EP-4**). A significant improvement in acute gastroenteritis cases is also noted, with cases significantly decreasing from 1,348 in 2000 to 52 in 2019. This is attributed to the improvement in water supply distribution in the municipality. However, cases of PTB increased more than three times from 261 in 2000 to 843 in 2019. Slight increase in hypertension and pneumonia cases is likewise noted. Hypertension, along with the inclusion of diabetes as leading cause of morbidity in 2019, is considered as a lifestyle disease that is attributed to incorrect diet and inadequate exercise. Dog bite, measles, dengue and malaria were identified as leading causes of morbidity in 2000 but were not reported in 2019.

Table EP-15
Leading causes of morbidity in Rodriguez in 2010[14] & 2019 (MHO)

Diseases	2000	2019
PTB	261	843
HPN	461	484
URTI	6,385	370
Pneumonia	298	351
Diabetes mellitus	-	200
UTI	299	196
Osteoarthritis	-	56
Acute otitis media	-	54
Acute gastroenteritis	1,348	52
SVI	-	50
Dog bite	221	-
Measles	153	-
Dengue	55	-
Malaria	44	-

[14]Source: The 2000 health data was obtained from the Sewerage Master Plan and Feasibility Study for the Marikina River Basin Interim Report available at https://openjicareport.jica.go.jp/pdf/11948882_21.pdf

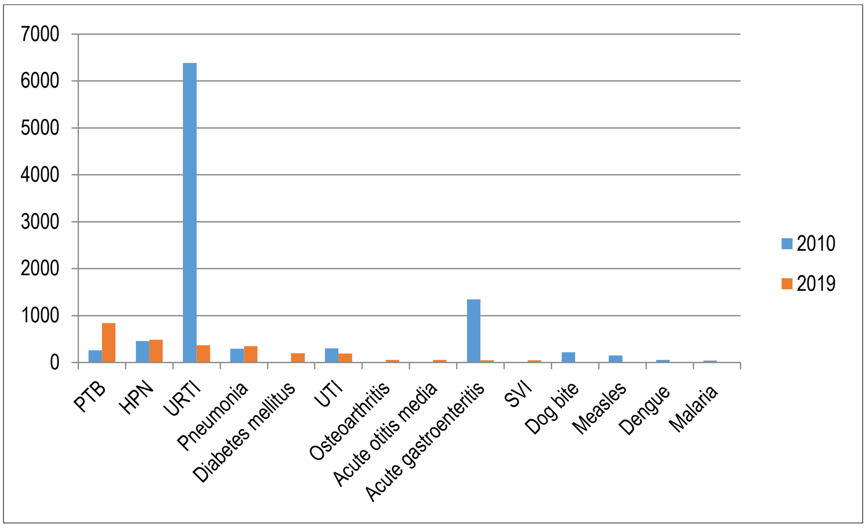

Figure EP-4. Leading causes of morbidity in Rodriguez (MHO, 2010 & 2019)

Leading causes of child morbidity include URTI, PTB, pneumonia, UTI, acute gastroenteritis, impetigo, acute bronchitis and acute otitis media (**Figure EP-5**). Top causes of adult and child morbidity in Rodriguez are tabulated in **Table EP-16** below.

Table EP-16
Leading causes of child morbidity (MHO, 2019)

Diseases	No. of Cases
1. URTI	997
2. PTB	260
3. Pneumonia	238
4. UTI	143
5. ATP	97
6. Acute gastroenteritis	68
7. Impetigo	48
8. SVI	47
9. Acute bronchitis	36
10. Acute otitis media	15

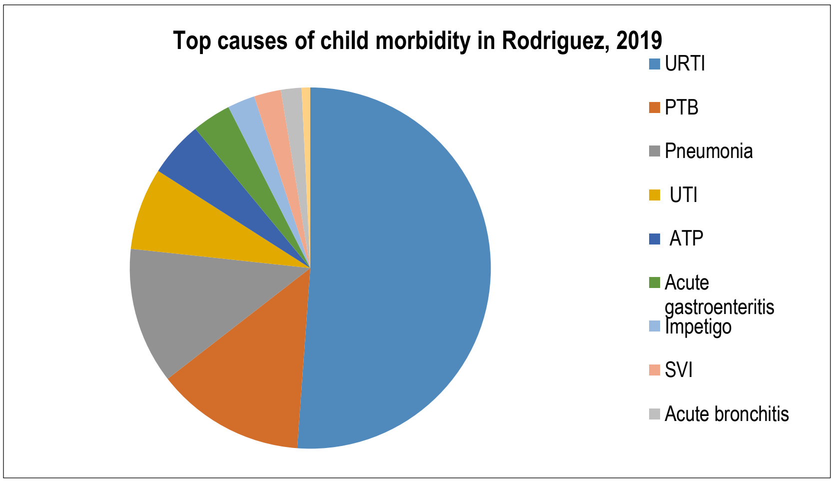

Figure EP-5. Leading causes of child morbidity (MHO, 2019)

Water

There is no updated data on water supply services in the municipality. The FLUP says that in 2012, the Manila Water Company, Inc. operates six deep-well pumping stations to serve 41,567 individual connections covering an estimated 249,402 individuals. Average consumption is 22 cubic meters per month which translates to 119 liters per capita per day. Given that the estimated number of households in 2012 was approximately 83,000, around 40,000 households had no access to piped water distribution or Level 3 service. In 2007, 13, 040 households relied on Level I water supply systems (hand pumps, shallow wells with an average of 15 households within a 250-meter distance) while 2, 912 households had Level 2 water supply (piped water with a communal water source serving 4-6 households within a 25-meter distance).

Power Supply

Meralco provides energy services in Rodriguez. In 2012, around 3,000 households out of the total 83,000 homes had no access to steady power supply. The municipal FLUP and CLUP have no updated data.

4.3.3 Municipality of San Mateo[15]

San Mateo is a first-class municipality that belongs to the second congressional district of Rizal Province. It is one of the fastest growing municipalities in the province and part of the Metro Luzon Urban Beltway (CLUP 2010-2020). San Mateo is located on the western side of Rizal. It is bound on the west by Quezon City, on the south by Marikina City and Antipolo City, on the north by Rodriguez (formerly Montalban) and on the east by the Sierra Madre Mountains. The municipality is located about 24km from Metro Manila and lies within the Marikina Valley. The western side of the municipality is drained by Marikina River while the southern part is drained by Nangka River.

San Mateo has a total land area of 4,825.10 hectares according to the 1976 cadastral survey. The municipality is subdivided into 15 barangays with Guitnangbayan I and II as Poblacion barangays. The largest barangay in terms of land area is Silangan (765.5 has), followed by Pintong Bukawe (753 has) and Guitnangbayan II (614 has). The smallest barangay in terms of land area is Ampid II (24.5 has).

Table EP-17 presents the population of San Mateo from 1960 to 2015. The municipal population has been continuously increasing since the 1960s. From a population of 12,044 in 1960, the population more than doubled in 1970. From 51,910 in 1980, the municipal population reached 135,603 in 2000 and almost doubled to 263,494 over the next 15 years (PSA, 2015). The highest population grown rate was reported between 1960 and 1970 (14.23%) while the average annual growth rate from 1975 to 2015 is 5.52%.

Table EP-17
Population and annual growth rate in San Mateo from 1960 to 2015 (PSA, 2015)

Year	Population	Growth Rate (%)
1960	12,044	-
1970	29,183	14.23
1975	38,955	6.70
1980	51,910	6.65
1990	82,310	5.86
1995	99,217	4.11
2000	135,603	7.33
2007	184,860	5.19
2010	205,255	3.68
2015	252,527	4.61

[15] Source: www.sanmateo.gov.ph

Table EP-18 presents the population by barangay of San Mateo from 1980 to 2015. Missing data in 1980 indicates that these barangays were not yet created at the time of the census conducted by the National Statistics Office, now known as the Philippine Statistics Authority (PSA). The 15 barangays of San Mateo can be classified into two groups in terms of population. Sparsely populated barangays with population not exceeding 10,000 persons in 2015 include Ampid II, Dulongbayan I and II, Guinayang, Gulod Malaya and Pintong Bukawe. Highly populated barangays with population ranging from more than 10,000 to almost 40,000 in 2015 include Ampid I, Banaba, Guitnangbayan I and II, Malanday, Maly, Sta. Ana, Sto. Niño and Silangan. Ampid II had the highest population density of 255 persons/ha based on the 2015 population, followed by Ampid II (219 persons/ha), Banaba (180 persons/ha), Sto. Niño (131 persons/ha) and Sta. Ana (127 persons/ha). Barangay Pintong Bukawe has the lowest population density of around 6 persons/ha. The municipal population density based on 2015 population is 52 persons/ha.

San Mateo reported 56,379 households in 2015 or an average household size of 4.5 persons.

Table EP-18
Land area, population & population density by barangay from 1980- 2015 (PSA census, 1980-2015)

Barangay	Land Area (has)	1980	1990	1995	2000	2007	2010	2015	Popn. Density (2015)
Ampid I	131.60	17,085	11,326	14,533	19,652	26,720	27,365	28,840	219
Ampid II	24.50	-	2,622	2,339	2,750	3,163	3,685	6,242	255
Banaba	138.20	-	7,554	8,630	13,210	20,861	21,553	24,950	181
Dulongbayan I	58.79	3,073	3,308	3,836	4,658	4,295	5,030	6,944	118
Dulongbayan II	430.00	4,168	4,691	4,719	5,164	6,242	6,837	8,777	20
Guinayang	273.00	3,191	4,853	4,540	5,315	6,055	7,167	9,241	34
Guitnangbayan I	412.00	4,492	5,960	10,006	15,071	22,726	24,707	30,598	74
Guitnangbayan II	614.00	3,799	5,490	5,489	8,740	12,246	13,544	17,243	28
Gulod Malaya	139.40	-	2,995	3,989	4,939	7,105	8,564	11,406	82
Malanday	353.00	5,107	9,169	10,229	11,532	12,573	13,544	15,707	44
Maly	565.00	4,851	6,350	8,541	10,536	13,922	14,905	13,865	25
Pintong Bukawe	753.00	-	617	968	1,736	3,494	4,080	4,156	6
Sta. Ana	80.00	6,144	7,418	7,674	8,358	9,107	9,176	10,160	127
Sto, Niño	87.11	-	4,955	6,111	7,233	10,847	11,020	11,402	131
Silangan	765.50	-	5,012	7,613	16,709	25,504	33,942	52,996	69
Total	**4825.10**	**51,910**	**82,310**	**99,217**	**135,603**	**184,860**	**205,255**	**252,527**	**52**

Table EP-19 presents a summary of the municipal population by age group (PSA 2015). As shown on the table, about 65% of the municipal population is of working age (15-64 years old) while 63% is of voting age (>18 years old). The young dependent population represents 40% of the municipal population while the old dependent population represents about 6.6% of the municipal population.

Table EP-19
Total population by age group and sex in San Mateo (PSA, 2015)

Age	Male	Female	Total
0-4	12,837	12,565	25,402
0-14	38,386	37,637	76,023
15-64	82,986	83,954	166,940
18 years and over	79,441	82,096	161,537
60 years and over	7,329	9,279	16,608
65 years and over	4,023	5,541	9,564

4.3.3.1 Economy

The economy of San Mateo is dominated by the tertiary sector consisting of trading, wholesale, retail and financial establishments. Agri-based industries are limited to small poultries and piggeries. A number of small and medium-sized manufacturing industries operate in the municipality. Welding shops, leather craft, and rice mills are among the industrial establishments in the municipality. Manufacturing industries for slippers and footwear are located in Barangay Guitnangbayan II while a Coca-Cola warehouse is located in Barangay Dulong Bayan II.

Commercial establishments are located within population centers. A major commercial area is located in Barangay Guitnangbayan II and includes the public market, financial institutions, restaurants/small eateries, and retail stores. A notable commercial area located in Barangay Ampid I is SM City San Mateo. Puregold San Mateo is located in Barangay Banaba. Various branches of commercial and rural banks conduct business in San Mateo. Fastfood chains such as Jollibee, McDonald's, Greenwich, Chowking, Max's, Tropical Hut, Pizza Hut, and KFC have branches in the municipality.

San Mateo has limited agricultural lands with less than 100 hectares planted to rice in 2000 (CLUP 2010-2020). More recent data on agricultural land in the municipality is not available at the time of writing of this report. Agricultural potential of floodplains and riverbanks is limited by soil type and seasonal flooding; thus, these areas are suitable for short duration crops such as vegetables, corn, peanut and other seasonal crops. Harvested products are normally sold to markets in Marikina City and Divisoria. Tree crops are located on the foothills and mountains of the municipality

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4.3.3.2 Social Services and Public Utilities

Education

San Mateo has 13 public elementary schools and four public high schools (CLUP, 2010-2020). Almost all barangays are served by a public elementary school while public high schools are located in Pintong Bukawe, Silangan, Sto. Niño, and the Poblacion. Private academic institutions in the municipality include Roosevelt College, St. Matthew College in Ampid II, Nuestra Señora de Aranzazu Parochial School located across the municipal hall, Christ the Lord Harvest Academy located in Silangan, Manila Waldorf School is located in Timberland Heights, and Kids World Christian Academy located in Ampid. Other notable educational institutions include Global Career Access Tertiary education and vocational training are provided in Training Institute, ICCT Colleges, Informatics, St. John Bosco Institute of Arts and Sciences, Christian Care Academy, St. Matthew College, and Eastern Star Academy.

Health Facilities

There are no government hospitals in San Mateo. A private hospital, St. Mattheus Medical Hospital, is located in Barangay Banaba. Health services in the municipality are provided by the Rural Health Unit and 17 barangay health stations. A lying-in maternity clinic was established in Barangay Gulod in 2007 (CLUP, 2010-2020).

Housing

Data on housing units in San Mateo is currently not available. With 56,379 households in the municipality, it is estimated that the total number of housing units in the municipality will be around this number. Housing units are distributed among the population centers of the 15 barangays. San Mateo is host to a portion of the Lungsod Silangan Townsite Reservation established through Presidential Proclamation 1283 on 21 June 1974, along with Antipolo City and the Municipality of Rodriguez. The reservation encompasses a total land area of 20,312 hectares by virtue of Presidential Proclamation No. 1637 dated 18 April 1977, a significant increase from the original 5,005 hectares allotted in Proclamation 1283[16]. The reservation aims to accommodate government employees of Metro

[16] Source: http://lcweb5.loc.gov/glin/jurisdictions/Philippines/pdfs/221969-228550.pdf

Manila and Rizal Province. San Mateo Municipal Resolution No. 2013-126 requested DENR to designate 24 hectares within the Lungsod Silangan Townsite Reservation as location of housing project for government employees and relocation site for informal settlers. The 24-hectare property is covered by a Tax Declaration under the name of LGU San Mateo. Municipal Ordinance No. 2017-27 declared 90 hectares of the 3,39 hectares of Lungsod Silangan Townsite Reservation within the jurisdiction of San Mateo as housing project site of the local government. The National Housing Authority allocated Php429M for the development of urban housing facilities for 1,000 informal settler families occupying hazard prone areas. This housing project is known as the "Eco-Tropolis of the East of San Mateo, Rizal" and is envisioned as a sustainable community that will practice green economy and sustainable agriculture, among others

Social Welfare Programs

San Mateo LGU provides mobile social welfare services to various locations in the municipality. Services include seminars on fire safety and crime prevention, medical/dental checkups and mobile pharmacy, local civil registry assistance, free legal consultations, and fogging for dengue prevention. Other social services include financial and medical assistance to needy residents, scholarships and financial assistance, health services, supplemental feeding programs, livelihood skills training and seasonal cash for work programs.

Power Supply and Generation

Power supply in San Mateo is distributed by the Manila Electric Company (MERALCO) to all barangays except Pintong Bukawe which is located at the foothills of the Sierra Madre Mountains. Most of the power distributed in San Mateo is for residential consumers while less than 5% is supplied to commercial and industrial users as well as public lighting or street lights (CLUP, 2010-2020).

Water Supply

Level III water supply in San Mateo is distributed by Manila Water, the water concessionaire for the Metro Manila East Zone which includes municipalities of Rizal Province. The main sources of water supply of Manila Water are the allocation from Angat Dam supplemented by deep wells and pump wells. Areas not served by Manila Water source their water supply from open wells, springs and other groundwater sources.

Transportation

Jeepneys are the most common form of public transportation in San Mateo. Available jeepney transportation routes include Montalban-Cubao, Montalban-San Mateo, and Commonwealth-Philcoa-San Mateo passing through the San Mateo-Batasan Bridge. The only access to Barangay Pintong Bukawe is through Marcos Highway and Cabading and Sapinit Roads in Antipolo City. Jeepney terminals are available in San Mateo Plaza, Barangay Pintong Bukawe, Barangay Banaba (Puregold), Barangay Silangan (AFP Housing and Tierra Monte) and Barangay Sto. Niño (Modesta Village). Other public transportation modes include tricycles and pedicabs, buses, and UV express.

Communication

Communication services in the municipality are provided by PLDT, PT&T and Digitel for landline services and Globe, Smart and Sun Cellular for cellular phone services.

Sports and Recreation

Sports and recreational facilities in San Mateo include 59 basketball courts, 8 swimming pools/resorts, two bowling lanes, 7 public libraries and15 barangay halls/gymnasiums.

Wastewater Treatment

Manila Water operates a septage treatment plant in Barangay Guitnang Bayan II. The plant started operating on May 2007 and is able to treat 585 m3 of septage per day.

Sanitary Landfill

The San Mateo Sanitary Landfill located in Barangay Pintong Bukawe started operating on 16 February 1991. The landfill was operated by the Metro Manila Development Authority and handled wastes from Metro Manila. It had a total land area of 73 hectares with 46.43 hectares utilized for landfill operations. The landfill was closed on 31 December 2000[17]. A 19-hectare sanitary
landfill operated by the San Mateo Landfill and Development Corp. (SMLDC) started operating on May 2011 to handle waste from San Mateo, Cainta and Metro Manila[18]. The Sanitary Landfill is located northwest of the Project site with an approximate distance of 7.36km and will pose no threat in the UWD Project because of its distance.

4.3.3.3 Poverty Profile

A total of 3,665 households in San Mateo are members of the Pantawid Pamilyang Pilipino Program (4Ps) as of March 2020 (**Table EP-20**). This represents 5.1% of the total number of households in the municipality based on projected number of households for 2020[19].

A total of 124 households or about 10.5% of the total number of households in Pintong Bukawe are members of 4Ps. The highest poverty incidence is reported for Barangay Sta. Ana (13.9%), followed by Maly (11.2%), Pintong Bukawe (10.5%), Malanday (9.6%) and Dulongbayan I (8.5%). The lowest poverty incidence is reported in Guitnangbayan I (2.4%).

Table EP-20
Number of 4Ps beneficiaries and estimated poverty incidence in San Mateo as of March 2020[20]

Barangay	No. of Beneficiaries	Projected No. of Households (2020)	Estimated Poverty Incidence
Ampid I	243	8,178	3.0%
Ampid II	89	1,770	5.0%
Banaba	255	7,075	3.6%
Dulongbayan I	168	1,969	8.5%
Dulongbayan II	150	2,489	6.0%
Guinayang	84	2,620	3.2%
Guitnangbayan I	205	8,676	2.4%
Guitnangbayan II	183	4,889	3.7%
Gulod Malaya	122	3,234	3.8%
Malanday	429	4,454	9.6%
Maly	439	3,931	11.2%
Pintong Bukawe	124	1,178	10.5%
Sta. Ana	401	2,881	13.9%
Sto, Niño	183	3,233	5.7%
Silangan	590	15,027	3.9%
Total	**3665**	**71,605**	**5.1%**

[17]Source: http://nswmc.emb.gov.ph/?page_id=922
[18]Source: https://newsinfo.inquirer.net/8880/high-tech-landfill-in-san-mateo-ready-to-process-garbage-from-metro-manila
[19]Source: Projected population and estimated number of households for 2020 were computed based on 2015 population, annual population growth rate and average household size.
[20]Source: Number of 4Ps beneficiaries was provided by the Municipal Social Welfare and Development Office of San Mateo.

4.3.3.4 Income and Expenditures

Annual income of San Mateo comes from locally sourced revenue (i.e. real property tax, business tax, other taxes, regulatory fees, service/user charges, receipts from economic enterprises), internal revenue allotment and shares from national tax collection. The annual income of the municipality for 2020 is estimated at Php585.8M (Office of the Municipal Treasurer).

4.3.3.5 Health Profile

Table EP-21 presents the vital health statistics of San Mateo for 2016 and 2017. Crude birth rate during the two-year period ranged from 16%-17% while crude death rate for both years is at 3%. Maternal mortality rate was less than 1% for both 2016 and 2017. Infant mortality rate was at 4% in 2016 and decreased to 3% in 2017. Neonatal mortality rate is at 5% in 2016 and increased to 7% in 2017.

Table EP-21
Vital health statistics in San Mateo from 2016 to 2017 (MHO, 2018)

Vital Statistics	2016		2017	
	Total	Rate	Total	Rate
Crude birth rate	4,331	17%	4,184	16%
Crude death rate	768	3%	772	3%
Maternal mortality rate	2	0.46%	3	0.71%
Infant mortality rate	17	4%	14	3%
Neonatal mortality rate	23	5%	29	7%

The Municipal Health Office (MHO) of San Mateo provides primary and secondary health care services through health promotion and health education, dengue testing, and screening for early detection of non-communicable or lifestyle diseases such as diabetes and cardiovascular diseases. Diagnostic services offered by the MHO include x-ray and ultrasound, routine laboratory tests (e.g., blood chemistry tests, urinalysis, fecalysis, sputum test, etc.) Primary health care services include:

- Medical consultation and procedures such as suturing, wound care, immunization
- Diabetes consultation and ECG procedures
- Prenatal and infant consultation
- Physical examination for students, teachers and detainees
- Counselling on reproductive health and responsible parenthood as well as family planning
- Pharmacy services for adults and children
- Dental health services such as tooth extraction, temporary filling and fluoride therapy
- Tuberculosis prevention and management
- Animal bite care
- Measles prevention through immunization, and measles case management and reporting
- Dengue prevention through fogging, and dengue case management and reporting

The San Mateo MHO reported a total of 330 dengue cases in 2019. The highest dengue incidence occurred in Barangay Guitnangbayan I (75 cases), followed by Silangan (40 cases), Malanday (46 cases), Ampid I (38 cases) and Dulong Bayan II (23 cases). The lowest number of dengue cases was reported in Pintong Bukawe (2 cases) and Dulong Bayan I (3 cases). Six (6) dengue-related deaths were reported in 2019. There is a possibility that dengue cases in Pintong Bukawe will increase with the introduction of the reservoir of the water supply project. However, the residential area will be far from the reservoir and this will minimize the impact to the community.

Leading causes of morbidity in San Mateo in 2006 are listed n **Table EP-22**. These include upper respiratory tract infection (URTI), acute watery diarrhea, physical injuries, skin disease, asthma, essential hypertension, pulmonary tuberculosis, pneumonia, malaria and mumps. Morbidity data, for 2019 or earlier years, is not available in the data provided by the municipal health office.

Table EP-22
Leading causes of morbidity in San Mateo (MHO, 2006)[21]

Disease	Number
Upper respiratory tract infection	10,348
Acute watery diarrhea	1,981
Physical injuries	1,627
Skin disease	1,582
Asthma	1,150
Essential HPN	849
Pulmonary tuberculosis	837
Pneumonia	784
Malaria	675
Mumps	592

4.4 Existing Conditions of the Host Barangays

4.4.1 Barangay San Rafael, Rodriguez, Rizal

Barangay San Rafael is the site of the project's main structures namely: the dam, the reservoir, the transmission pipe, the road to the water treatment plant, the pump station, and some access roads.

This host barangay has both a mountainous/upland area and a plain/flatland section. Locals refer to these divisions as San Rafael Upper and San Rafael Lower. The barangay's land area of 6,601.45 hectares is equivalent to 17% of Rodriguez. San Rafael is divided into 24 sitios. It has 11 streets and 6 residential subdivisions. Sitio Anipa is a Dumagat area.

4.4.1.1 Population and Livelihood

The population of San Rafael seems to be decreasing. Figures from the 2015 Philippine Statistics Authority say that Barangay San Rafael has a population of 27,956 which makes it the fourth largest in population, among 11 barangays of Rodriguez. Municipal data say that in 2018, the barangay had 27, 910 residents or 6,177 households.

In the 2020 Actual Annual Census of Barangay San Rafael, the total population was recorded at 22,654 or 5,847 families equivalent to 4,818 households. There is no available data on population by sitio or per area. By age, 39% are of the range 0-17 years old (classified as children), 55% are 18-59 years (working age population), and 6% are senior citizens.

The Summary of Annual Census 2020 of San Rafael Upper indicates the following:

- Population is 9,726. Fifty three percent (53%) are males and 47% are females.
- Number of families is 2,457.
- Number of Persons-with-Disabilities is 79, of which 47 are males and 32 are females. of which 47 are males and 32 are females.

Farming and forestry remain a significant source of living in the barangay. In San Rafael Upper, those with livelihood comprise 26%. Sources of livelihood are farming and forestry (20%); unskilled workers (37%); skilled workers (23%); employees/professionals (16%); OFW (2%) and entrepreneurs/business owners (2%)

The Municipal Agriculture Office (MAO) released a document showing two robust farmers' organizations in Barangay San Rafael. One is the Pamana-Matarek Inc. (or Pandayan ng mga Maralitang Nagkakaisang Magulang at Anak ng Montalban para sa Reporma at Kaunlaran Inc.) and the other is the Inigan Upland Farmers' Association.

[21]Source: The health data was obtained from the Sewerage Master Plan and Feasibility Study for the Marikina River Basin Interim Report available at https://openjicareport.jica.go.jp/pdf/11948882_21.pdf

Pamana-Matarek Inc. Has 45 members from 3 sitios, namely: Ligtas, Magloco, Kayrufa. The Inigan Upland Farmers' Association has 82 members from Sitio Inigan and Sitio Casili.

Barangay San Rafael is also one of three (3) barangays (the other two are Macabud and Puray) that are actively covered by the MAO's programs such as: a) agricultural extension services to rice farmers; b) high value crops development; c) organic agriculture; and d) livestock development[22].

Barangay San Rafael also has a Fisheries and Aquatic Resource Management Council. The resource person said that fish from the rivers is mainly for family consumption and not for sale, as fish catch has gradually declined through the years.

In 2015, Barangay San Rafael had 432 registered business establishments including 1 fertilizer dealer, 1 pesticide dealer, 1 seeds dealer, and 1 feeds dealer. It also has 3 markets and 1 agricultural produce center.

4.4.1.2 Protected Area Occupants

Barangay San Rafael was included in the Survey and Registration of Protected Area Occupants (SRPAO) in the Upper Marikina River Basin Protected Landscape (UMRBPL). Results (**Table EP-23**) show the presence of 281 households composed of 692 individuals in 7 sitios within said protected area. Their farm lots and home lots cover a total of 509 hectares. Purok/Sitio Anipa is an Indigenous Peoples Community of Dumagats.

Of the total households, 164 households are qualified tenured migrants. Tenured migrants refer to "protected area occupants who have been actively, continuously and presently occupying a portion of the protected area for five years before the proclamation or law establishing such as a protected area and are solely dependent therein for subsistence."

Table EP-23
Number of Protected Area Occupants and Qualified Tenured Migrants and Area Covered, By Purok/Sitio in Barangay San Rafael, Rodriguez

Name of Barangay	Total No. of Households	Total Household Member (including household head)			Total Area (ha)			Total No. of Qualified Tenured Migrants
San Rafael		Male	Female	Total	Farm Lot (ha)	Home Lot (ha)	Total (ha)	
Purok Inigan	100	236	197	433	207.56	1.834	209.394	72
Purok Kayrupa	104	213	216	429	158.17	2.928	161.098	51
Purok Kayligtas	29	78	59	137	61.25	0.650	61.9	9
Purok Karugo	20	64	44	108	34.00	0.273	36.27657	11
Purok Sabangan	15	57	44	101	22.55	0.241	22.791	11
Purok Anipa	5	10	7	17	4.00	0.065	4.065	3
Purok Casili	8	34	27	61	15.25	0.237	15.487	7
Total	281	692	594	1286	502.78	6.228	509.008	164

Source: Survey of Protected Area Occupants in Upper Marikina River Basin Protected Landscape. DENR Region IV-A. No date.

4.4.1.3 Social Services and Public Utilities[23]

__Health__

In 2015, the barangay health facilities consisted of: 2 barangay health centers, 1 maternity clinic, 1 child clinic and 1 private drugstore. The barangay has 66 health workers and 6 nutrition scholars. In 2014, 30 out of 50 children were identified as moderately malnourished.

[22] Source: Municipal Agriculture Office Annual Report, Montalban, Rizal. 2019.
[23] Source: Socio-Economic Survey of Selected Barangays in Antipolo City, Rodriguez and San Mateo, Rizal Province by APERCU Inc., 2015

Education

Among the barangay's educational facilities are: 7 day care centers, 3 pre-schools, 5 elementary schools and 1 high school.

Housing

The Barangay Census 2020 also says that out of a total of 5636 families: 65.5% of the families own their houses; 14% are renters; 18% share with the owner's house; 1.4% share with a renter's home; and 1% or 45 families are informal settlers. Houses numbering of 4956 comprise 70% of concrete; 15.6% of semi-concrete; 14% of light materials and 0.36% of salvaged materials.

Water and Sanitation

In 2014, 60% of households were served by MWSS. As of 2020, residents of San Rafael Upper have no piped water. They get their water from springs and artesian wells. Half of them buy drinking water from water refilling stations.

This year, for the families in the barangay, 84% have access to piped water while the rest rely on wells and springs. Majority of the families (89%) have water sealed toilets[24].

Power Supply

In 2014, MERALCO was able to serve 60% of the households in the barangay. Now, the number of families with electricity has increased to 72.5%[25]. Currently, in San Rafael Upper, 80% of the households have access to electricity.

Solid Waste Management

The barangay has 1 Materials Recovery Facility.

Disaster Risk Reduction and Management

San Rafael has a written DRR plan, equipment, evacuation center and emergency response team.

Barangay Development Plan

The barangay LGU could not provide a copy of their barangay development plan.

4.4.2 Barangay Calawis, Antipolo City, Rizal[26]

Barangay Calawis is an upland area with rugged mountains which are 1,000-1,200 meters above sea level. Its land size is 9,144.3 hectares equivalent to 18% of Antipolo City. Seventy-five percent (75%) of the barangay land are classified as forest land located in the northeast part of the barangay. It has a population of 5, 932 individuals or 908 families distributed per purok as shown in **Table EP-24**. This barangay is also home to 120 Dumagat families, 70 families of which live in the mountains about 3-4 hours of hiking away from the barangay center.
In 2018, the population increased to 6.542 individuals, of which, 326 are Senior Citizens[27]. Population of working age comprise 54%. Majority of the residents are Tagalogs and some are Aklanons, Bicolanos, Cebuanos and Visayans.

[24] Source: Actual Annual Census of Barangay San Rafael. 2020.
[25] Source: Actual Annual Census of Barangay San Rafael. 2020.
[26] Source: Barangay Profile, Calawis, Antipolo City. First Edition, 2020.
[27] Barangay Development Plan, Calawis. 2020-2021.

Table EP-24
Puroks/Sitios of Barangay Calawis and Number of Families. 2020

Purok/Sitio	Number of Families
Purok 1	81
Purok 2	165
Purok 3	103
Purok 4	129
Purok 5	97
Purok 6	76
Sitio Apia	151
Sitio Balon	13
Sitio Binayoyo	51
Sitio Paglitaw	42
Total	980

The Barangay Development Plan 2020-2021 says that Sitios Kinapuin and Pangolorin were added as sitios, which increases the number of sitios from 4 to 6. In total, Calawis now has 6 Puroks and 6 Sitios.

4.4.2.1 Economic Activities

Even on limited arable land, farming and livestock raising are common forms of livelihood in the barangay with farmers having 2.7 lots each. 80% of working age population are into agriculture. Charcoal making, though considered illegal, is also commonplace. 90% of the barangay population are into this activity. Many are also engaged in buying and selling of agricultural products from the barangay to either Antipolo City or Marikina City.

Proof of active involvement in agriculture and forestry are several farmers' organizations in Calawis such as: the Calawis Agriculture Cooperative, Tulungan sa Kabuhayan sa Calawis, Calawis Upland Farmers Association, Inc. (CUFAI) which do tree planting, agroforestry, forest protection or guarding projects. Other popular jobs are carpentry and driving of public utility vehicles.

In 2015, Calawis had 30 registered business establishments. The barangay's main tourist attractions include: the Bunsuran Falls River, Manadlam Falls, Sitio Kinapuin, and a part of the Payaguan River.

4.4.2.2 Social Services and Public Utilities[28]

Health

Health services are rendered by 19 Barangay Health Workers, 2 Nutrition Scholars and one Nurse. These are augmented by medical missions of the private sector and continuing health programs of the City Government. The Barangay has a health center, a maternity clinic and a child clinic.

Recorded malnutrition rate was 26% or 393 moderately and severely malnourished children out of a total of 1533. Early marriages and teen pregnancies have also been noted.

Education

Calawis has 6 day care centers, 3 elementary schools and 3 high schools located in Sitio Apia, Purok6 and Sitio Binayoyo. The Barangay also supports and promotes the Alternative Learning System to bring out-of-school youth back to school and pursue their studies.

[28] Socio-Economic Survey of Selected Barangays in Antipolo City, Rodriguez and San Mateo, Rizal Province by APERCU Inc., 2015

Solid Waste Management

The barangay has a materials recovery facility. The nearest dump site or sanitary landfill is 10 kilometers away. The LGU has 3 garbage trucks for waste collection. Many still burn or dump their garbage in the creeks.

Disaster Risk Reduction and Management

Calawis has a written DRR plan, equipment, evacuation center and emergency response team.

Water Supply

Water sources in the barangay are deep wells, artesian and shallow wells. Drinking water is bought from water refilling stations. Majority of the households are served by potable water cooperatives, PATUBIG and MAKINAFAI, except for those in Sitios Apia, Balon, Paglitaw which are located higher areas.

Power Supply

MERALCO provides electricity to 60% of households in the barangay.

Barangay Development Plans

Barangay Calawis aims to implement the following programs in the next few years:

- Livelihood and Entrepreneurship development through conduct of trainings in business planning and management, food processing, soap making, dressmaking, cosmetology and reflexology
- De-clogging and Cleaning of Creeks and Canals through “Linis Creek and Bantay Sapa”
- Leadership Trainings for Barangay Officials (e.g. Seminars on the Local Government Code)
- Literacy Improvement through the Alternative Learning System

4.4.3 Barangay Pintong Bukawe, San Mateo, Rizal[29]

Barangay Pintong Bukawe is part of the area which will be inundated when the dam is constructed. It is a bit on the upland side of San Mateo, about 400 meters above sea level.

4.4.3.1 Land Area

This barangay measures 753 hectares in land size, equivalent to 15.6% of the San Mateo’s land area. It is the second largest in area among the 15 barangays of the municipality but with the lowest population density of 6 persons per hectare in 2015, and 7 persons per hectare in 2018.

There are talks about a boundary dispute between Barangay San Rafael (Rodriguez) and Barangay Pintong Bukawe, but nothing in formal documents discusses about this. Accounts say that some residents of Sitio Casili of Barangay San Rafael identify more with Barangay Pintong Bukawe because of easier physical access to said barangay, compared to their mother barangay San Rafael. Both barangays have a Sitio Anipa, although with different numbers of households, and Pintong Bukawe refers to Sitio Casili of Barangay San Rafael, as Purok 7 or Purok Watershed.

4.4.3.2 Population

The barangay population in 2018 was estimated at 5,469 individuals, or 1,311 households, or 1,338 families, distributed among 7 puroks and 1 sitio. (**Table EP-25**)

[29] Source: Barangay Profile, Pintong Bukawe, San Mateo. 2018

Table EP-25
Population and Number of Households by Purok/Sitio in Pintong Bukawe, San Mateo. 2018

Purok/Sitio	Number of Households	Population
Purok 1	320	772
Purok 2	168	909
Purok 3	325	1934
Purok 4	246	917
Purok 5	87	334
Purok 6 or Purok Amianan	79	307
Purok 7 or Purok Watershed	68	224
Sitio Anipa	18	18
Total	**1,311**	**5,469**

Residents of the barangay are said to have come from Aklan, Bicol, Ilocos, Mt. Province, and parts of the Visayas and Tagalog areas. It also has small communities of Dumagats and Aetas.

4.4.3.3 Economic Activities

Majority (60%) of the residents earn their living from farming. Two percent (2%) are into fishing. 20% are salaried employees or workers. 15% are micro-entrepreneurs; and 2% are tricycle or jeepney drivers. The barangay recorded 20 business establishments in 2015.

4.4.3.4 Barangay Income

In 2018, the barangay had a total income of P4.414 million, of which, P3.517 million came from its Internal Revenue Allotment, P0.847 million was from Real Property and Business taxes.

4.4.3.5 Poverty Profile

The Barangay Profile contains a section entitled Pockets of Poverty which says that 546 households are classified as poor (**Table-EP-26**). This means that 42% of the households in the barangay are poor.

Table EP-26
Number of Poor Households, by Purok/Sitio, Barangay Pintong Bukawe. 2019

Purok/Sitio	Number of Poor Households
Purok 1	32
Purok 2	27
Purok 3	317
Purok 4	110
Purok 5	25
Purok 6 or Purok Amianan	7
Purok 7 or Purok Watershed	10
Sitio Anipa	18
Total	**546**

4.4.3.6 Social Services and Public Utilities

Basic services in the barangay are scant and require much room for improvement.

Health

The barangay has only 1 health center.

Education

Educational facilities of the barangay are: 2 day care centers (1 in Purok 3 and 1 in Purok7/Watershed; 1 learning center in Purok2; an elementary school and a high school.

Disaster Risk and Reduction Management

The barangay has an evacuation center. It has no written DRR plan.

Sports, Security and Tourism

The barangay has a barangay plaza, a police station, and an eco-tourism office.

Water Supply

For water supply, Pintong Bukawe residents rely mainly on wells and springs, and water delivery trucks.

Power Supply

MERALCO serves 80% of the households in the barangay.

4.5 Socio-Economic Impact Assessment and Mitigation

4.5.1 Displacement of Settlers and Displacement of Properties

The project proponent, at this point, already has a significant appreciation of the extent of physical displacement of affected families, including a Dumagat community, and the economic disturbance/loss to be caused on indigenous peoples and protected area occupants working on project-affected farmlots and agro-forestry areas. **Figure EP-6** provides a settlements map of the study area.

Updated results of the project's Resettlement Action Plan and Livelihood Restoration (RAPLR) Report (May 2020) (draft report on **Annex K**) point out that 200 families/houses will be affected and require resettlement; that a school, 2 community chapels, a burial site, and 355 hectares of protected area land with 555 claimants will be inundated. (**Figure EP-7**). So far, 21 affected families in the tunnel site have opted for Voluntary Relocation. Talks with them by the proponent are in progress. The breakdown of affected 200 homeowners per sitio is shown in **Table EP-27.**

Table EP-27
Affected Houses/Families, by Sitio and by Facility

Area	Project Facility	Number of Houses/Families
Sitio Inigan, San Rafael	Dam	30
Sitio Maticob, San Rafael	-	10
Sitio Casili, San Rafael	Reservoir	80
Sitio Anipa, San Rafael	Reservoir	40
Purok 7, San Mateo	Reservoir	40
Total		**200**

In the first identification of affected structures/properties by the RAP Team, the total number of affected families was 181 composed of 716 project-affected persons. Those from Barangay San Rafael are 538 individuals and the

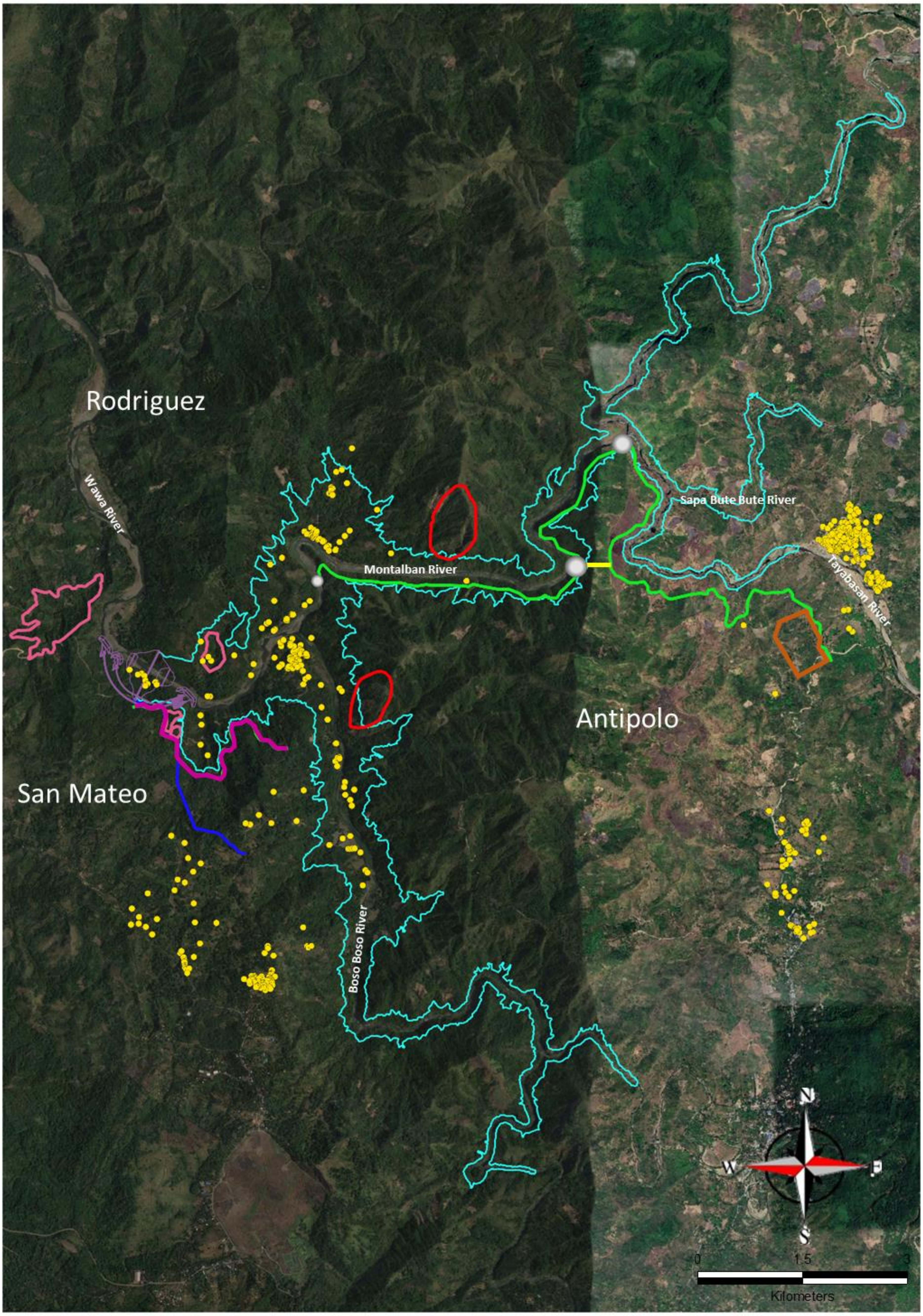

Figure EP-6 Settlements Map	Legend:	DATA INFORMATION/SOURCE:	WawaJVCo INC.
ENVIRONMENTAL IMPACT STATEMENT PEOPLE MODULE Wawa Bulk Water Supply Project – Upper Wawa Dam	Settlements; Pumping Station; UWD Reservoir; UWD Dam and Diversion Tunnels; Transmission / Water Conveyance Pipeline; Transmission / Water Conveyance Pipeline via Tunnel (Optional); Access Road (Original); Access Road (New); Temporary Facilities; Quarry Areas Option 1 & 2; Calawis Water Treatment Plant (not part of the Project)	**Project Components**: WawaJVCo, INC. (2020) **Basemap**: QGIS Imagery, 2020 **Created by**: APERCU CONSULTANTS, INC (2020)	aperçu CONSULTANTS INC.
			SCALE: 1:24,000
			PAGE: 368

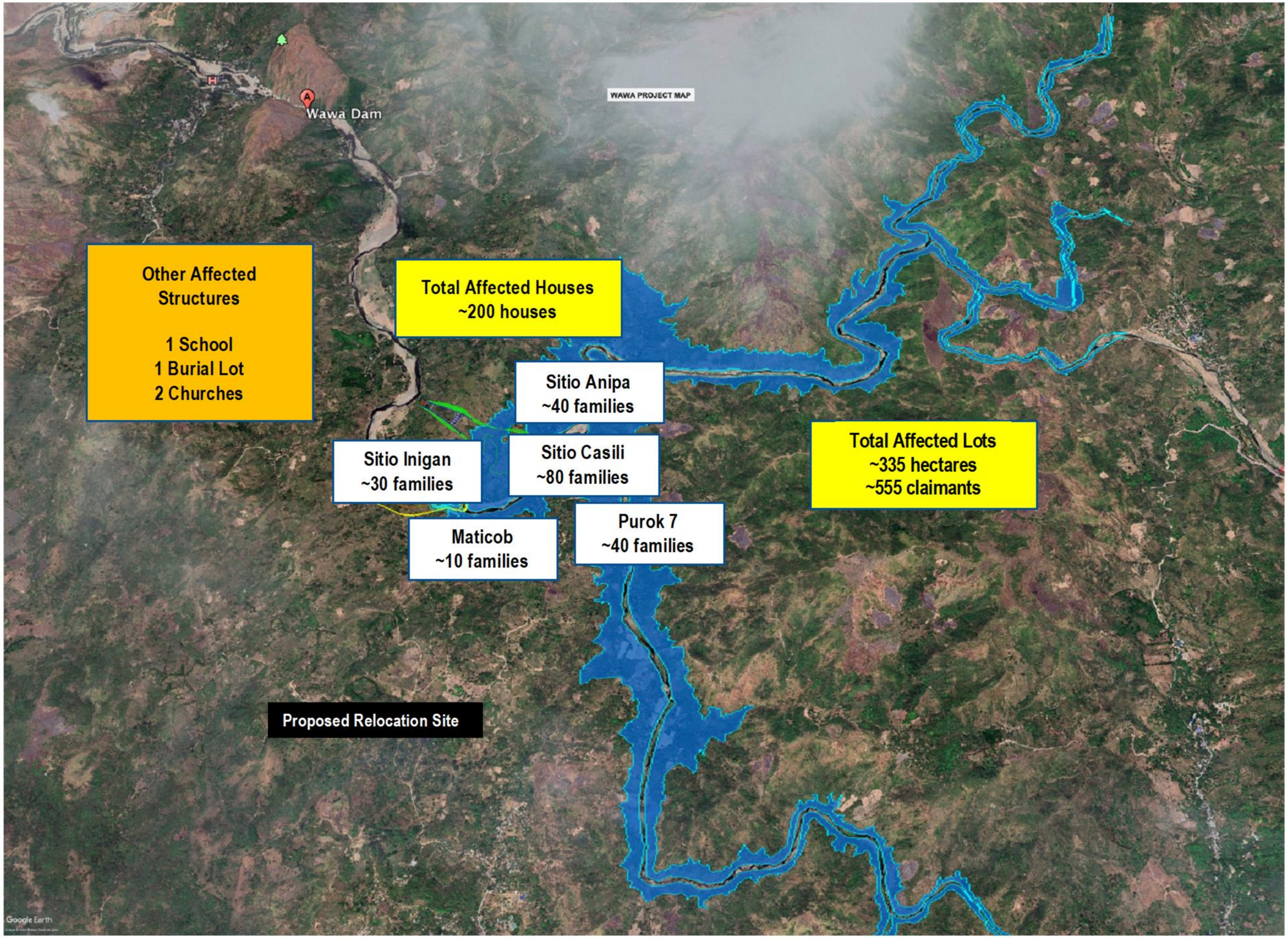

Figure EP-7. Location of Affected Communities	Legend: UWD Reservoir	DATA INFORMATION/SOURCE: Source: Wawa JVCo INC. (2020) Modified by: APERCU CONSULTANTS, INC (2020)	WawaJVCo INC. apercu CONSULTANTS INC.
ENVIRONMENTAL IMPACT STATEMENT PEOPLE MODULE Wawa Bulk Water Supply Project – Upper Wawa Dam			Not to Scale / PAGE: 369

number from Barangay Pintong Bukawe is 178. Two hundred eighty-two (282 lots) are occupied by the affected families, with each PAF claiming 1.45 lots. 53% in Pintong Bukawe claim two or more lots, while 34% in San Rafael say they are occupying two or more lots.

Computing the new number of affected families by the average household size of 4, the total number of project-affected persons would be 800.

Aside from the affected houses, other structures that will submerged and therefore need to be replaced are: 1 elementary school, 2 community churches, and 1 community burial area/cemetery, all in Barangay San Rafael.

The proponent's parcellary survey likewise identified lots along the riverine areas, mostly in Barangay San Rafael, measuring 355 hectares with 555 claimants, and planted with agroforestry species, to also be inundated. Sixty-four percent (64%) or 364 of the claimants are tenured migrants; 8% or 45 are said to have been inherited, and 26% or 145 were claimed to have been transferred to them. Around 8 hectares belong to the Dumagats/Remontados of Rodriguez.

Actions taken by the proponent through its RAPLR Team include:

a) Holding of public Information meeting last Feb 15, 2020 where the following were presented and discussed: exact plan and date of relocation, assistance programs, areas to be inundated, livelihood restoration measures
b) Coming up with Relocation Site Plan
c) Initial inspection and talks with owners of 3 proposed relocation sites recommended by the Barangay Captains of San Rafael and Pintong Bukawe. Two sites were dropped due to lack of legal papers. The third option which is a privately-owned property in Purok 6 or Amianan in Barangay Pintong Bukawe in San Mateo, is being studied.

The proponent is currently preparing for a public consultation to present the findings of the RAPLR Study, the proposed relocation site plan and solicit inputs and comments from the affected families to move the RAPLR program forward.

The proponent will do their best to participatively craft and implement a resettlement and livelihood restoration and disturbance/damage compensation program that is **timely** (prior to project construction phase); **anticipative and responsive to the needs of the affected parties; inclusive,** [involving all stakeholders concerned, especially the project affected-families (both IP and IP) and PA land claimants/holders, the LGU representatives of the two host barangays and municipalities, the receiving LGU and community of the families for resettlement, the PAMB-DENR, and the NCIP]; **sustainable;** and **environment-friendly.**

4.5.2 Limited influx of construction-related workers in host barangays

The construction phase of the project requires about 500 persons for various temporary construction-related jobs. Based on the host barangay and municipal LGUs' demand for preferential employment of locals, it is anticipated that most of the labor requirement of the project will come from local hires from the host barangays. Thus, no large-scale influx of migrant workers is expected.

Also, since the construction jobs are short-term, and workers are usually handled by labor contractors, the tendency for temporary construction workers is to move on with the labor contractor to the next job site. Contracted short-term laborers are also usually provided with temporary living quarters by their employers.

The company will also include in its contractors' contracts the provision of preferential employment for locals and the latter's obligation to provide decent accommodation with basic utilities like electricity, water, health care and sanitation facilities.

There may be a number of outsiders who may wish to avail of micro-business opportunities during the construction phase, but these would not be in droves as the accessibility of the project site is not very easy and transportation cost is also not cheap.

4.5.3 Impacts on Indigenous Peoples and Culture/Lifestyle

As mentioned in previous sections, part of the inundation area is a small Dumagat/Remontado Community in Sitio Anipa which is part of the disputed area between Rodriguez and San Mateo. The proponent is fully aware of the IPRA requirements to apply for a Certification Precondition which involves going through an NCIP-led Free Prior and Informed Consent (FPIC) process with the affected IP community.

The proponent has made representations to the NCIP regarding this. The latter informed the proponent that the CP /FPIC application has to be deferred until the completion of the on-going CP/FPIC process for the Tayabasan Multi-Basin System Project also under Wawa JV Co. Inc. There is a ruling under IPRA that a company can apply for only one CP/FPIC application per project at a time.

4.5.4 Impacts on physical cultural resources

The proposed project will not have any major impacts on physical cultural resources in the target site. The project site does not include any portion of any of the six sites in UNESCO's List of World Heritage Sites in the Philippines, and the 19 sites included in the UNESCO's Tentative List for the Philippines.

The matter on a sacred site of the Dumagats in Sitio Anipa called "Istampang Bato" will be covered in the dialogue/consultation in the required FPIC process for the project. There is a proposal to create a Wawa Ecotourism Site where the Istampang Bato can be transfered which will be decided on during the consultation with Dumagat Community.

4.5.5 Threats to delivery of basic social services and resource competition

At the moment, the host communities have limited electricity and water supply services, not to mention access to adequate health care. If the resettlement of project affected families will be as currently envisioned to be with complete basic social services and utilities, improvement in basic services should happen.

Access roads to the project site will also be built by the company, thus, better access for nature-based tourism sites will be realized.

Forests with adequate, if not full, vegetation are key to a steady water supply for water supply projects. The Rodriguez FLUP named charcoal making as a major threat to the forest and forest land in Rodriguez. If tree cutting for commercial charcoal production is not abated, the project's requirement for environmental services from thickly forested slope and mountains could be threatened.

4.5.6 Threats to public health and safety

Waterborne diseases include malaria, dengue, urinary and intestinal schistosomiasis, cholera, typhoid fever, leptospirosis, diarrhea and dysentery. Dam construction can potentially trigger an increase in the incidence of these diseases since damming of water will increase the habitat required for the survival and/or reproduction of disease vectors, such as Aedes, Anopheles, etc. Changes in water level and downstream sediment deposition can likewise increase the prevalence of waterborne diseases whose vectors thrive in marshland and similar environment. However, studies have shown that spread of waterborne diseases can be controlled through integrated vector control and prevention, water management, etc.

The health profiles of the two host municipalities and one city indicate the following:

- Acute watery diarrhea and malaria are included in the leading causes of morbidity in San Mateo in 2006
- Acute gastroenteritis was the second leading cause of morbidity in Rodriguez in 2000 while dengue and malaria were the 9th and 10th leading causes of morbidity in the municipality. Meanwhile, the 2019 health profile of Rodriguez shows that acute gastroenteritis was the 9th leading cause of adult morbidity and 6th leading cause of child morbidity while dengue and diarrhea were no longer included.
- Acute watery diarrhea was the 6th leading cause of morbidity in Antipolo City in 2016, and the 2nd leading cause of morbidity in 2017 and 2018.

Acute gastroenteritis and acute watery diarrhea are associated with poor sanitation and unsafe drinking water supply. The problem appears to have been partially addressed in Rodriguez but still endemic in Antipolo City as shown by the health morbidity data of these areas. In the absence of recent health morbidity data for San Mateo, it is difficult to assess whether the cases of acute watery diarrhea and malaria have decreased.

The potential problem of increased incidence of waterborne diseases during the construction and operation of the proposed Upper Wawa Dam project can be addressed through the strong partnership between the proponent and host LGUs. The proponent, in coordination with the LGU, will work together to control and prevent the occurrence of disease outbreaks while strengthening the capability of the local health office to respond to water- and vector-borne diseases.

4.5.7 Generation of local benefits from the project

Once the resettlement program is finalized and implemented following a rights-based, inclusive, sustainable and environment-friendly approach and according to the agreed guiding principles, the project-affected families will find themselves in an improved situation prior to the project. They will have better dwellings, better-built public buildings (i.e school, a health center, a covered court, a police outpost, etc), and guaranteed water and power supply, and additional livelihood sources.

There will also be other benefits such as : preferential employment for locals; additional roads from the project-access roads to be built; new micro and small business enterprises from the anticipated tourism development that can arise from the high dam structure and man-made reservoir; a better stocked watershed; and more trade and commerce for the host areas.

Local government units will also increase their revenues from barangay clearances and ID cards for workers, the company and its contractors' business permit payments, real property taxes, increased share from national wealth taxes and earnings from "payment for environmental services" projects by the project proponent.

These all redound to the local residents in the form of necessary infrastructure, government facilities, social services, better compensation for local government employees, capacity building/training projects for workers, farmers, projects for PWDs, women, youth and children, and improvement of governance.

Corporate social responsibility (CSR) projects will certainly augment social services from the government through additional nutrition/feeding programs for children, college scholarships, teen counselling, gender and development, solid waste management trainings and services.

While local residents will be involved in the different phases of the project, this will also mean giving them work experience, new skills and a sense of confidence to become productive citizens.

Surely as all the above are realized, the host barangays are hoped to reduce their pockets of poverty and malnourished children, and see happier, healthier and better educated and equipped members of their communities.

4.5.8 Effects on Riverine Communities and those dependent on their Agroforestry Products

The submerging of 335 hectares of riverine land and agroforestry area is a serious project impact to the 555 affected protected area occupants as it will almost be impossible to replace their farmlots or agroforestry lots within the UMRBPL. This will require long hours of dialogue with the adversely affected parties and consultation with host LGUs and the PAMB-DENT to find acceptable and sustainable solutions.

One course of action is to organize them into agro-forestry associations or cooperatives and involve them in "payment of environmental services" projects where they are given contracts to manage plant nurseries reforest and guard open areas or sections of the protected area or priority areas for reforestation and watershed management in the municipality or cluster of barangays. Funds can come either from the company or the LGU or the PAMB-DENR.

Another possibility is to retool the affected persons to make them eco-tourism workers, forest guards, and priority project or company hires.

4.6 Information, Education and Communication (IEC), Scoping and Consultation Activities

4.6.1 IEC Series and Key Informant Interviews

The Information, Education, Communication (IEC) Series (July 22 to October 10, 2020) for the proposed UWD project conducted for the three host barangays (San Rafael, Calawis, and Pintong Bukawe) and three host municipalities/city (Rodriguez, Antipolo and San Mateo) and the key informant interviews during the reconnaissance visit (September 2 -3, 2010) and data-gathering phase yielded a 100% acceptance for the project.

The IEC Sessions/Project Presentations and Key Informant Interviews elicited a variety of issues and concerns summarized in **Table EP-28**. The lively discussions included a question at the end of the activity whether the participants or key informants were open to the project and whether they wanted the project to proceed. All the consulted host barangays and municipalities/city said Yes. Details of the issues and corresponding responses are expounded in the documentation reports of the IEC Series for the proposed project in **Annex J**.

Table EP-28
Summary of Issues and Concerns Raised in the IEC Series for the Upper Wawa Bulk Water Supply Project

Issue	Pintong Bukawe	Calawis	San Rafael	Rodriguez LGU	San Mateo LGU	Antipolo LGU
Project Description						
Width of affected inundation area	✓					
Project impact on Boso-Boso River	✓	✓				
Provision of water supply for the barangay once project becomes operational		✓				
Meaning of Wawa JVCo			✓			
Resolution of unsolved issues in previous projects of the Violago group			✓			
Project impact on Mapua Bridge and school in Sitio Casili – will the proponent replace these facilities?			✓			
Location of the access road					✓	
Location project seems to the within the disputed area between Rodriguez and San Mateo. If it is clarified that project site is within San Mateo, project will need to secure an endorsement from San Mateo					✓	
Location of transmission line					✓	
Will riprapping be done to stabilize river banks						✓

Issue	Pintong Bukawe	Calawis	San Rafael	Rodriguez LGU	San Mateo LGU	Antipolo LGU
Land						
Rehabilitation of denuded slopes in the project site		✓				
Other reforestation projects in the project site and vicinity such as in Sitio Apia and Ysiro		✓				
Clearing operations for road construction will entail cutting of trees. Aside from DENR permits, proponent needs to secure tree cutting permit from City LGU						✓
Location of nearest fault						✓
Need to secure permit for use of land within protected area						✓
Water						✓
Provision or retention of water flow and surface water supply in areas located downstream of dam			✓			
Need to ensure water supply during the dry season					✓	
Air						
People						
Need for FPIC/ Certification Precondition						✓
Need for a multipartite program to ensure preservation of culture, well being of vulnerable IP communities						✓
Possible physical and economic displacement of communities				✓		✓
Resettlement and compensation of affected persons before start of project construction	✓		✓	✓		
Need for livelihood restoration and education programs of resettled families				✓		
Need for basic social services and utilities for resettlement area				✓		
Need to build replacement structures/facilities such as school building, multi-purpose hall, covered court, health center,barangay hall annex, etc,				✓		
Need to replace/build affected infrastructure and initiate necessary other projects				✓		
Need to determine exact barangay location of project-affected families that will be resettled. If location is within San Mateo, coordination with and endorsement from LGU is needed.					✓	
Capacity of relocation site to accommodate all affected stakeholders from three impact barangays	✓		✓			
Issuance of individual land titles for families who will be relocated	✓					
Inclusion of new settlers of Sitio Casili who were not included in RAP survey in the project's relocation program	✓					
Provision of employment for barangay residents	✓					
Provision of copy of census results to host barangay	✓					
Provision of access for barangay residents to the dam site so the barangay can develop tourism programs		✓				
Inform farmers/owner of farm lots about distance that should be maintained from riverbank		✓				
Flooding of downstream and upstream communities		✓	✓			
Project impact on livelihood of residents including boatmen, upland farmers, etc.			✓			
Project impact during construction of access road and diversion tunnel					✓	

Issue	Pintong Bukawe	Calawis	San Rafael	Rodriguez LGU	San Mateo LGU	Antipolo LGU
Ensure that all affected families, lot/property owners are included in survey			✓			
Maintain or improve existing way of lives of affected residents who will be relocated from the project site			✓			
Preference for affected residents to be relocated within the same barangay			✓			
Difficulty of relocating affected households to nearby sites			✓			
Presence of resource person knowledgeable on relocation concerns in succeeding project presentations			✓			
Will there be incentives for host LGUs, like free water?						✓
Others						
Impact of ongoing infrastructure works in the barangay to road access of barangay residents		✓				
Identification of relocation or evacuation site for residents if a natural disaster occurs		✓				
Availability of a crisis or emergency management plan		✓	✓			
Implementation of project in Mt. Purro (i.e., Wawa Hydropower Project)		✓	✓			
Resolution of issues encountered during the implementation of previous projects of the Violago group in the area			✓			
Clarification on whether team who asked for tree cutting permit is part of the project team of Upper Wawa Dam			✓			
Need for barangay endorsement			✓			
Relation of the current project to the MWSS consultation in Marikina regarding Manila Water project and its impact on water tariff					✓	
Can LGU have a copy of the EIS, so LGU can inform affected communities?					✓	
Does the EIA include a dam breach study and other hazards posed by the project					✓	
What are the project's safety nets in times of disasters?						✓

The Socio-economic Team witnessed an easy acceptance process for the project unlike other dam projects in other areas which are almost always met with strong community opposition. Resource persons said that the social acceptability of the project can be partly attributed to the host LGUs and communities' previous dealings with the project proponent which has on-going projects in the area (such as the Tayabasan Multi-Basin System Project) which went through thorough environmental impact assessment.

The first to give its concurrence to the project was the Rodriguez LGU after the project was presented to the Sangguniang Bayan with the presence of the Municipal Mayor via Zoom meeting on July 22, 2020. Their verbal assent was concretized through Kapasyahan Bilang 156 S. 2020 entitled "*Kapasiyahang Nagpapatibay sa Pagtanggap sa Proyektong Wawa Bulk Water Supply Project ng Wawa JVCo, Inc. sa Sitio Wawa, San Rafael, Rodriguez, Rizal*". The resolution says that the LGU's acceptance of the project is contingent upon the proponent's due consideration and action regarding potential displacement of project-affected families and the provision of appropriate resettlement with social services and utilities, livelihood restoration program, necessary education programs, and replacement of affected infrastructure and buildings (e.g. School building, multi-purpose hall, covered courts, health center, etc.). **Annex N** presents the full text of the resolution.

The Antipolo LGU representatives also expressed approval for the “long overdue project” but intimated concerns about safety features of the dam, making sure that the project has enough safety nets including those that will help preserve and promote IP well-being and culture, and prevent upland and river bank erosion. They also reminded the proponent about compliance of all required permits (including those required by the LGU) prior to project commencement, such as PAMB clearance, SAPA, tree cutting permits and the like.

The San Mateo also said “Yes” to the project while also sharing the observation that project location seems to be within the disputed area between Rodriguez and San Mateo. LGU representatives said that if project site is clarified to fall within San Mateo, especially if San Mateo residents will need to be resettled, the project proponent will need to seek an official endorsement from the LGU and coordinate accordingly regarding resettlement matters.

The three host barangays said that they accept proposed project for its importance of providing water which is a basic need. Besides, the communities realize that they are occupants of government land declared as watershed reservation and protected area. Thus, they cannot refuse government’s development projects.

Concerns raised pertained mostly to: a) the physical and economic displacement of families within the inundation area and where and how they will be properly resettled and compensated and how their livelihood will replaced or restored; b) how can inclusive and sustainable resettlement be done; c) will resettled families be granted individual titles in the resettlement site; d) preferential employment for local residents.

Other issues raised were about a) access of host LGU and residents to the dam site for possible tourism projects; b) effects of the project on existing reforestation projects; c) possible restoration measures of denuded slopes in the project site; d) how to prevent flooding in the upstream and downstream areas; e) how to ensure unhampered access of residents to their barangays during the construction period; f) making sure that host areas and the project have a crisis/disaster management plan and structure, including an evacuation area. Barangay Calawis LGU also asked if their barangay which is not currently served by Manila Water, can expect free water distribution services, or at a discount, being a host area of the proposed project. Needless to say, this request is outside the scope of the proponent as Manila Water, being the concessionaire in the area, has jurisidiction over water supply distribution.

Several offices were visited for their valuable inputs on the proposed project.

The Municipal Agriculture Office in Rodriguez raised the question on whether the farmers who depend on Wawa River for their irrigation requirements will be negatively affected during the dry season due to decreased water flow resulting from the damming of Wawa River. He added that the use of shallow tube wells may be a mitigating measure, but this may not be sufficient for the needs of downstream farmers.

On resettlement, the Rodriquez Housing and People’s Development Office HPDO) shared that the municipality has no more available resettlement areas. Nevertheless, if the proposed project will require resettlement, proper planning and coordination with the Mayor’s office, MPDO, HPDO and the Municipal Engineer’s Office have to be done. The proponent and the concerned barangays which are doing the preparatory requirements will need to coordinate with the mentioned offices.

The Protected Area Superintendent of the Pamitinan Protected Landscape (PPL) said that although the PPL is located downstream of the proposed Upper Wawa Dam, the project will have an impact on this protected area that covers five sitios of Barangay San Rafael. She said that PPL is an ecotourism destination and activities such as swimming and boating within the PA which generate revenues for PA management. She said that the impact of the project on tourism activities in the PPL should be assessed and appropriate mitigating measures should be put in place.

The staff from the Protected Area Superintendent of the UMRBPL shared important points:

- ✓ Relocation site of project-affected IPs can be within the UMRBPL but the relocation site for affected non-IPs residing in the project's impact area should be located outside of the protected area.
- ✓ Community-Based Forestry Management (CBFM) projects in Antipolo are located within Barangays Calawis and San Juan.
- ✓ Certificate of Occupancy (within PAs) is issued by DENR.
- ✓ National Greening Program (NGP) areas are located in Sitio Amianan (Pintong Bukawe) and Sitio Anipa. NGP areas in Sitio Anipa are located on the streambanks and are planted with bamboo. Any impact on NGP areas within the project's impact area should be properly valuated and compensated. Payments are to be given to NGP implementers.
- ✓ The PAMB Clearance for the Upper Wawa Dam Bulk Water Supply Project was issued on February 2020 while the PAMB Resolution was issued on 2019. Application for SAPA is currently ongoing.

4.6.2 Project-Affected Persons and Families

The Socio-Economic and Cultural Survey of 195 respondents from the direct impact barangays (San Rafael in Rodriguez and Pintong Bukawe in San Mateo) conducted in February 11-22, 2020, by the project's Resettlement Action Plan and Livelihood Restoration Program Study Team recorded high percentages in terms of project-affected persons' awareness of the project (94%) and their willingness to be relocated (74%).

4.6.2.1 Awareness about the project

Of the 195 respondents, 94% said that they are aware of the project (**Table EP-29**). They learned about the project from: friends and neighbors (40%); meetings and public consultations (21%); Violago or proponent (19%); project related sources (4%); others (7%) including the Barangay Captain and Punong Tribo); and 9% from unspecified sources (**Table EP-30**)

Table EP-29
Whether or Not Aware of the Wawa Bulk Water Supply Project

Particulars	Total	Barangay San Rafael	Barangay Pintong Bukawe
Base – Total Interviews	195	152	43
	%	%	%
Aware	94%	93%	95%
Not Aware	6%	7%	5%
Total	100%	100%	100%

Table EP-30
Source of Awareness of the Wawa Bulk Water Supply Project

Particulars	Total	Barangay San Rafael	Barangay Pintong Bukawe
Base – Total respondents who are aware of the Bulk Water Supply Project	183	142	41
	%	%	%
Neighbors/Friends	40%	42%	32%
Meeting/Public Consultation	21%	25%	10%
Violago	19%	17%	24%
Project/Surveyor/Engineer	3%	1%	10%
Relative	2%	2%	2%
Radio	2%	2%	2%
NGO's	1%	1%	-

Particulars	Total	Barangay San Rafael	Barangay Pintong Bukawe
Manila Water Employee	1%	1%	-
Purok Chairman/Punong Tribu	1%	1%	-
Drilling Prime	1%	1%	-
Aware (unspecified source)	9%	7%	17%

4.6.2.2 Willingness to be relocated

On willingness to be relocated, 74% expressed they are willing to be relocated. The percentage was higher in San Rafael (77%) compared to 65% in Pintong Bukawe (**Table EP-31**)

Table EP-31
Whether or not Willing to be Relocated

Particulars	Total	Barangay San Rafael	Barangay Pintong Bukawe
Base – Total Interviews	195	152	43
	%	%	%
Willing to be relocated	74%	77%	65%
Not willing	19%	16%	30%
Can't say	7%	7%	5%

4.6.8.3 Preferred area for relocation

Of the 143 respondents who said yes to relocation, 99% wish to be relocated near their current location (**Table EP-32**). One percent (1%) are in favor of balik-probinysa.

Table EP-32
Preferred Area for Relocation

Particulars	Total	Barangay San Rafael	Barangay Pintong Bukawe
Base – Total who are willing to be relocated	143	115	28
	%	%	%
Near current location/near project site	99%	98%	100%
Within San Rafael/near Barangay	48%	59%	-
Within Pintong Bukawe/near Barangay	10%	-	54%
San Mateo	17%	12%	36%
Rodriguez/Montalban	10%	13%	-
Antipolo	1%	1%	-
Kahit saan basta mat tataniman kami	1%	1%	-
Can't say	12%	13%	11%
Balik Probinsya	1%	2%	-

4.6.8.4 Reasons for refusing to be relocated

Among the reasons given for not wanting to be relocated are their livelihood in current location (43%); no source of livelihood in relocation site (14%); difficulty in looking for new source of income (5%), etc. (**Table EP-33**)

Table EP-33
Reasons Why not Willing to be Relocated

Particulars	Total	Barangay San Rafael	Barangay Pintong Bukawe
Base – Total who are not willing to be relocated	37	24	13

Particulars	Total	Barangay San Rafael	Barangay Pintong Bukawe
	%	%	%
Our livelihood is here	43%	42%	46%
No work in the relocation site	14%	13%	15%
Difficult to look for a livelihood	5%	4%	8%
Just pay us for what we have	5%	-	15%
It's here where our plants are	3%	4%	-
Easy to find livelihood here, especially fishing	3%	4%	-
No livelihood for us in the city; here everything is free	3%	4%	-
Not paying for water and power here	3%	4%	-
There's a plan to convert my property into a tourist spot	3%	4%	-
Big income here, enough to send the children to school	3%	4%	-
We have many products; we will lose so much	3%	4%	-
It might be hot in the relocation site, perhaps no water and no fish to catch	3%	4%	-
Here, air is fresh; trees and plants abound	3%	4%	-
Might have difficulty paying the water and power fees in the relocation site	3%	-	8%
No comment	5%	4%	8%

4.6.3 Status of FPIC Process

The Free, Prior and Informed Consent (FPIC) process with NCIP for the project's first component, the Tayabasan Multi-Basin System Project is currently in the advanced stages. Since the Tayabasan Project is also under WawaJVCo. Inc., it can only initiate the FPIC process for the Wawa Bulk Water Supply Project after the FPIC process for the Tayabasan Multi-Basin System Project is completed. This is in compliance with the NCIP ruling under IPRA that a company can apply for only one CP/FPIC application per project at a time.

4.7 Traffic Study

A traffic study was conducted to evaluate the existing transportation and traffic situation in the vicinity of the proposed project site. Sampling dates of the traffic study were scheduled on a weekday (August 14, 2020) and on a weekend (August 15, 2020). Each sampling day lasted for 12 hours from 6:00am until 6:00pm.

4.7.1 Methods & Sampling Stations

Six (6) traffic routes were observed to evaluate the traffic situation and count the vehicles plying on these tracks, namely: (1) vehicles bound for Manila along Marilaque Highway, (2) vehicles bound for Tanay along Marilaque Highway, (3) vehicles entering Sapinit Road, (4) vehicles leaving Sapinit Road, (5) vehicles entering Barangay Pintong Bukawe, and (6) vehicles leaving Barangay Pintong Bukawe **(Figure EP-7)**. **Table EP-34** provides the detailed description of the routes used.

There were two sampling dates purposely scheduled on a weekday (August 14, 2020) and a weekend (August 15, 2020), both covering a 12-hour period of observation from 6:00 am to 6:00 pm. During the study, a Modified Enhanced Community Quarantine or MECQ was temporarily implemented by the government in Rizal Province and other provinces from August 4 to 18 wherein transportations were limited to travel in the area, especially in public vehicles.

The volume of vehicles passing the above-mentioned routes was recorded using data sheets and hand-held counters. Vehicles observed were categorized into two main modes of transportation – private and public. Listed

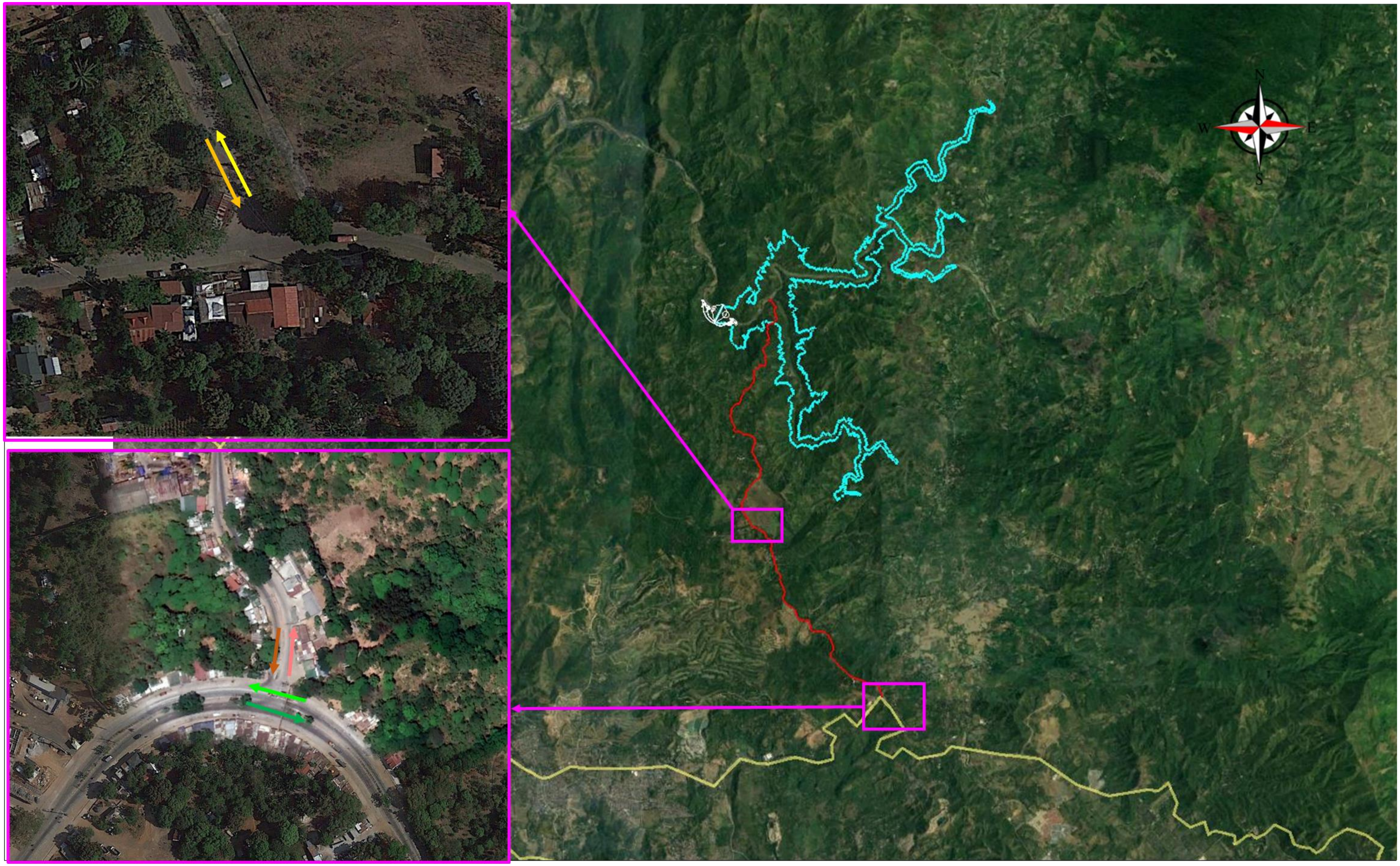

Figure EP-8. Traffic Study Location Map

ENVIRONMENTAL IMPACT STATEMENT
TRAFFIC STUDY
Wawa Bulk Water Supply Project – Upper Wawa Dam

LEGEND:
- Traffic Study Stations
- UWD Reservoir
- Access Road to UWD Location
- Main Highway in Antipolo
- Leaving Sapinit Road
- Entering Sapinit Road
- Bound to Manila
- Bound to Infanta
- Entering Barangay Pintong Bukawe
- Leaving Barangay Pintong Bukawe

DATA INFORMATION/SOURCE:

Project Components: Wawa JVCO, Inc. (2019)
Basemap: ArcGIS Imagery, 2020
Created by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.
aperçu CONSULTANTS INC.

SCALE: 1: 100,000

under private mode of transportation were car/jeep, van/truck, truck, motorcycle, bicycle, and pedicab. Public vehicles included public utility jeepneys or PUJ, bus, minibus, tricycle, and others. Graphical presentations were used to assess the volume of vehicles that were observed on an hourly basis.

Table EP-34
List of All Routes Observed

	Routes	Description
1	Bound to Manila along Marilaque Highway	A section of Marilaque Highway road towards to Manila
2	Bound to Infanta along Marilaque Highway	A section of Marilaque Highway road towards to Tanay
3	Entering Sapinit Road	A road towards to Sitio Sapinit, Barangay San Juan, Antipolo
4	Leaving Sapinit Road	A road leaving the Sitio Sapinit, Barangay San Juan, Antipolo
5	Entering Barangay Pintong Bukawe	This road branches from Sapinit Road leading to the Barangay Pintong Bukawe, Sitio Casili and Sitio Anila
6	Leaving Barangay Pintong Bukawe	This road branches from Sapinit Road leading to the Barangay Pintong Bukawe, Sitio Casili and Sitio Anila

4.7.2 Weekday Traffic Volume

The first sampling date for the traffic study was conducted on August 14, 2020 - a weekday. For the duration of the weekday sampling, a total of 16,674 vehicles were recorded using the six routes.

4.7.2.1 Route 1 – Bound for Manila along Marilaque Highway

The number of vehicles observed plying in the route totaled to 5,739 vehicles with 705 (12%) public and 5,034 (88%) private. The assessment per vehicle type on a weekday showed that the route was mostly used by motorcycles and car/jeeps. (**Figure EP-9**). The volume of vehicles was also assessed on an hourly basis from 6:00am to 6:00pm (**Figure EP-10**). The highest volume of vehicles was tallied during the 5:01pm to 6:00pm period having a total count of 662 vehicles. The lowest volume of vehicles was observed during the 1:01pm to 2:00pm period with a count of 206 vehicles.

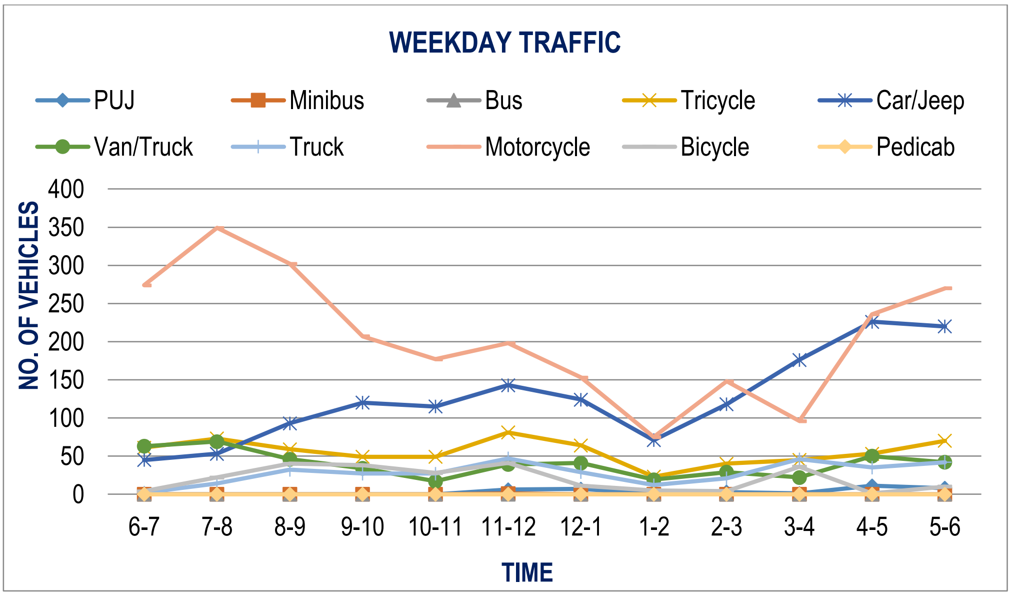

Figure EP-9. Weekday Traffic Volume per Vehicle Type (Route 1 – Bound for Manila)

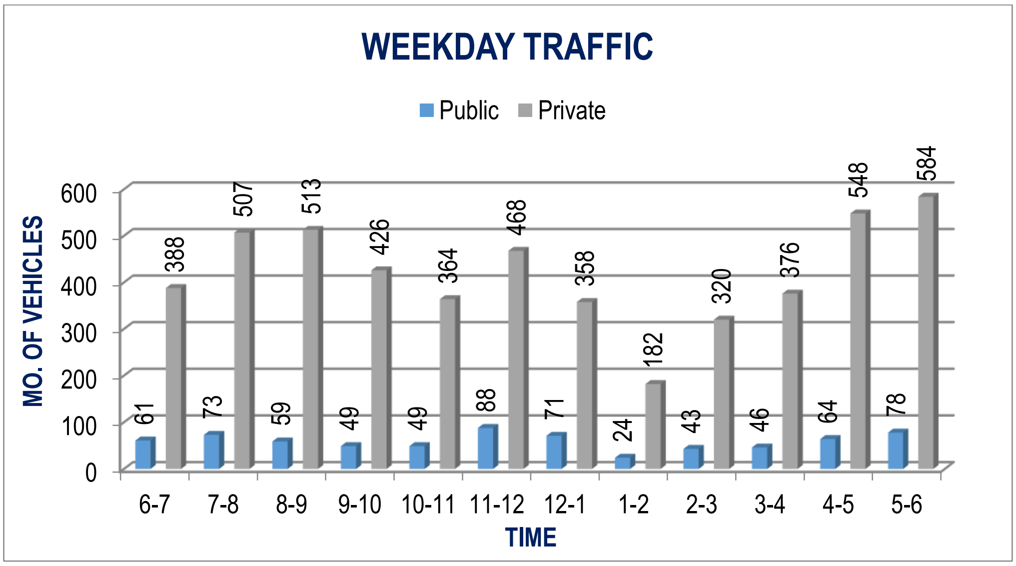

Figure EP-10. Weekday Traffic Volume per Time Period (Route 1 – Bound for Manila)

4.7.2.2 Route 2 – Bound for Tanay along Marilaque Highway

The bound for Tanay during weekday, recorded a total 6,468 vehicles, with 844 (13%) public vehicles and 5,624 (87%) private vehicles. The assessment of volume per vehicles showed on a weekday, the route was mostly used by motorcycle with 2,558 units followed by car/jeep with 1,882 units (**Figure EP-11**). The volume of vehicles was also assessed on an hourly basis from 6:00am to 6:00pm (**Figure EP-12**). During the assessment in time period, the highest volume recorded was during 8:01am to 9:00am period having a count of 725 vehicles and the lowest volume was recorded during 1:01pm to 2:00pm with 370 vehicles.

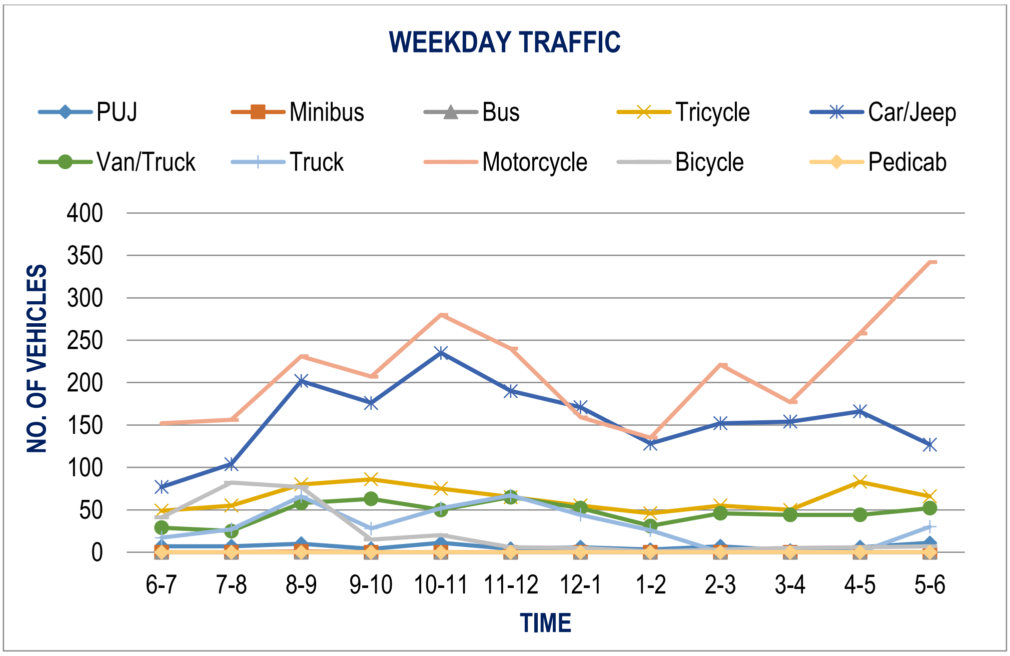

Figure EP-11. Weekday Traffic Volume per Vehicle Type (Route 2 – Bound for Tanay)

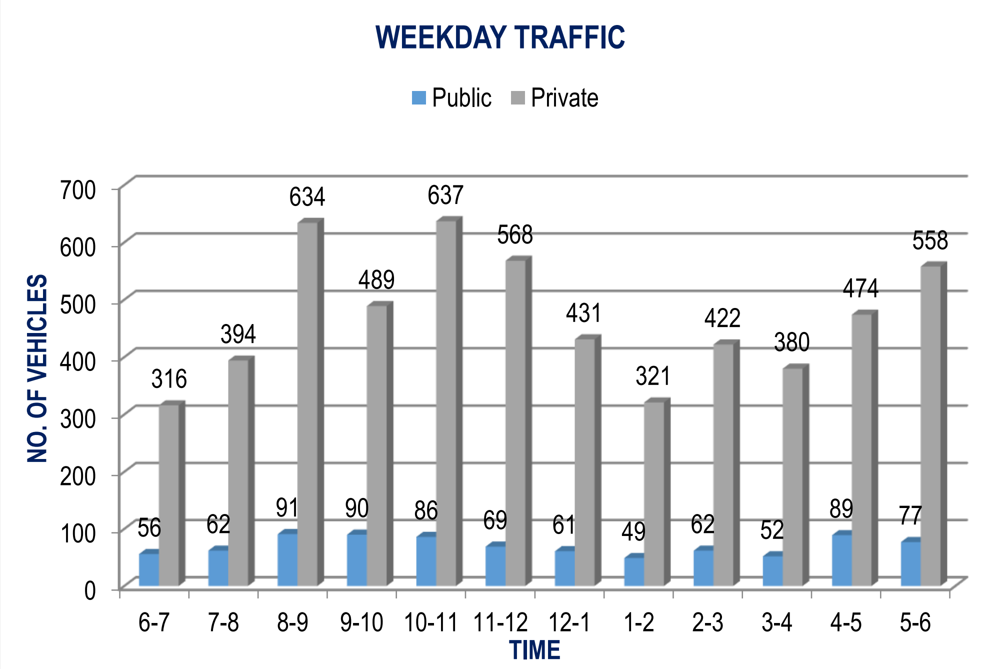

Figure EP-12. Weekday Traffic Volume per Time Period (Route 2 – Bound for Tanay)

4.7.2.3 Route 3 – Entering Sapinit Road

A total of 1,598 vehicles were counted entering the entering the Sapinit Road, with 366 (23%) public vehicles and 1,232 (77%) private vehicles. In terms of volume per vehicle type passing through this route, motorcycle showed the highest number with a total of 611 out of 1,598 vehicles, followed by tricycle with 358 units (**Figure EP-13**). The volume of vehicles was at its peak during the 5:01pm to 6:00pm period while the lowest was recorded during 6:01am to 7:00am period, with the private vehicles outnumbering public vehicles (**Figure EP-14**).

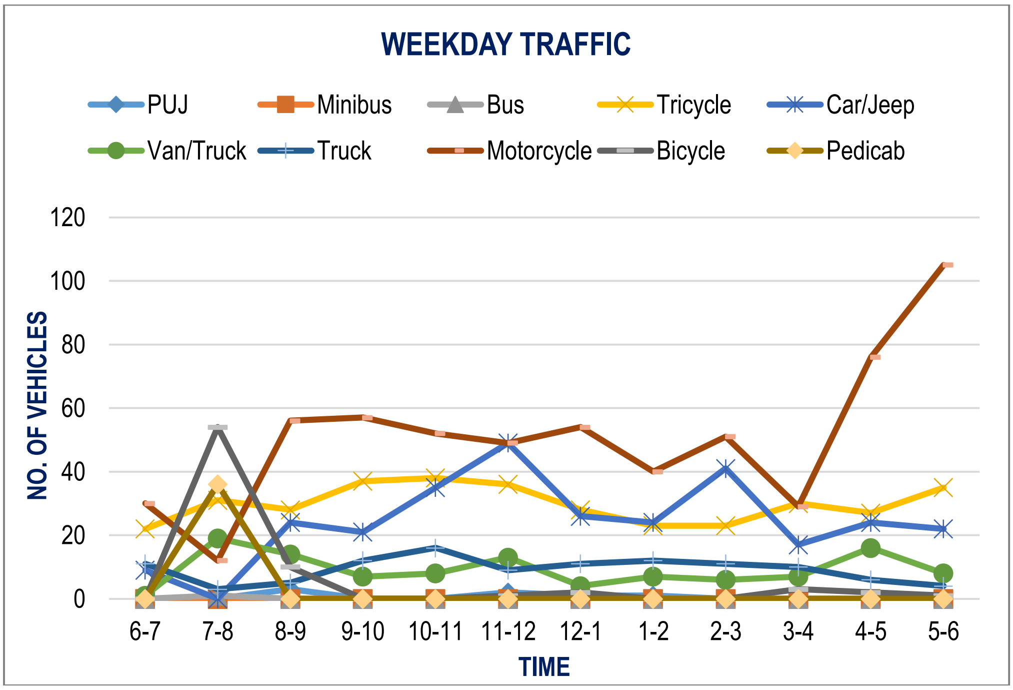

Figure EP-13. Weekday Traffic Volume per Vehicle Type (Route 3 – Entering Sapinit Road)

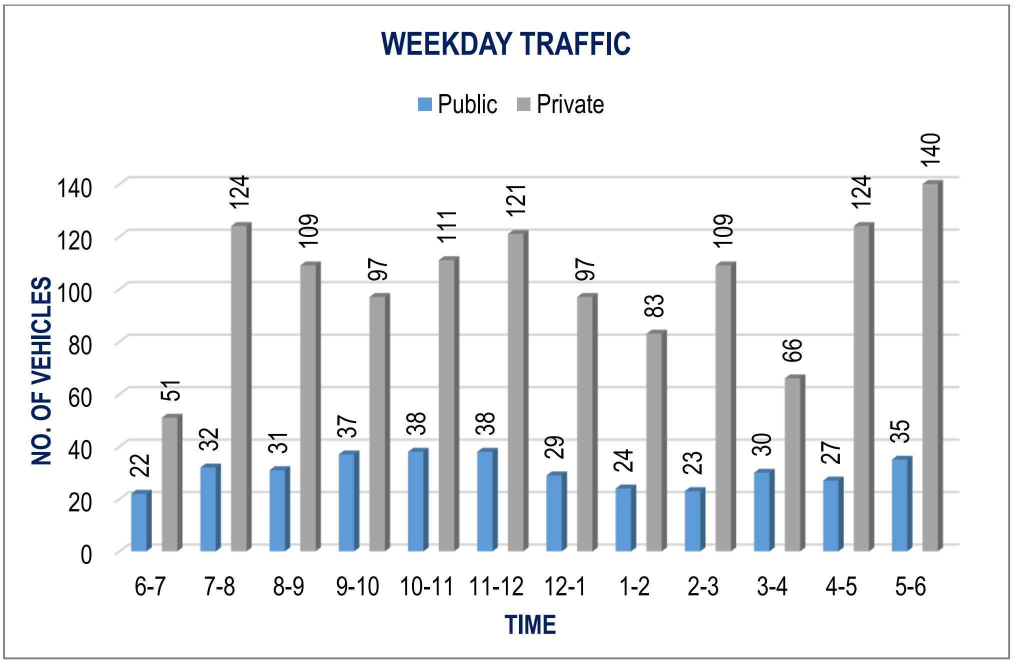

Figure EP-14. Weekday Traffic Volume per Time Period (Route 3 – Entering Sapinit Road)

4.7.2.4 Route 4 – Leaving Sapinit Road

One thousand five hundred eighty-nine (1,589) vehicles were recorded leaving the route of Sapinit Road, with 366 (23%) public units and 1,223 (77%) private units. The highest volume of vehicle leaving the route were recorded on motorcycles with 689 units, followed by tricycle with 359 units (**Figure EP-15).** During the assessment per each time period, the volume of vehicles was at its peak during 7:01am to 8:00am with a volume of 162 vehicles, while the lowest was during 2:01pm to 3:00pm periods. The trend shows that private vehicles outnumbered public vehicles (**Figure EP-16**).

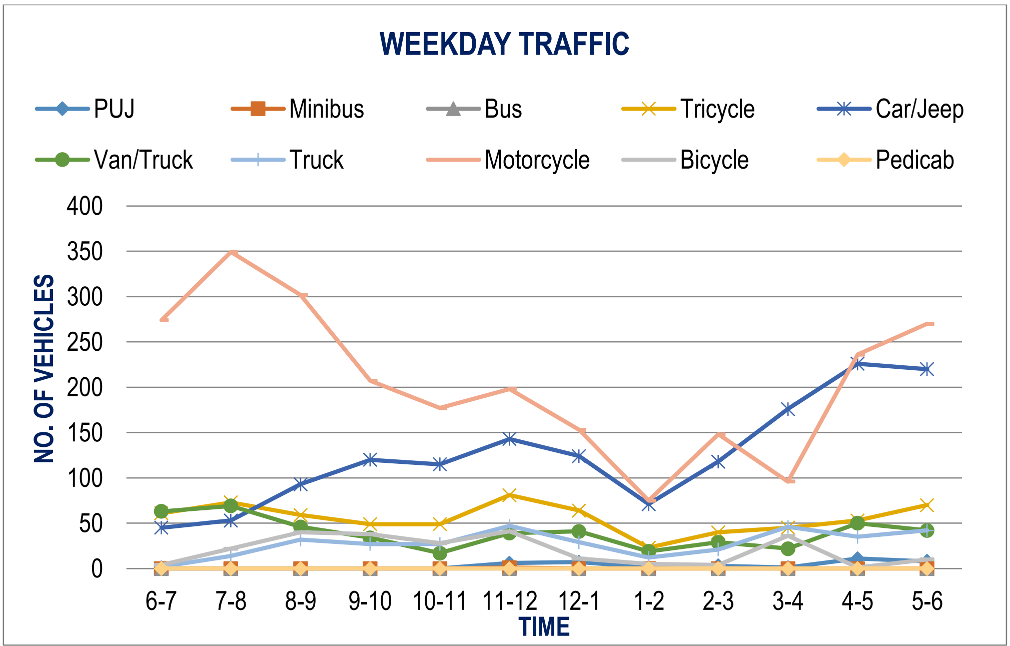

Figure EP-15. Weekday Traffic Volume per Vehicle Type (Route 4 – Leaving Sapinit Road)

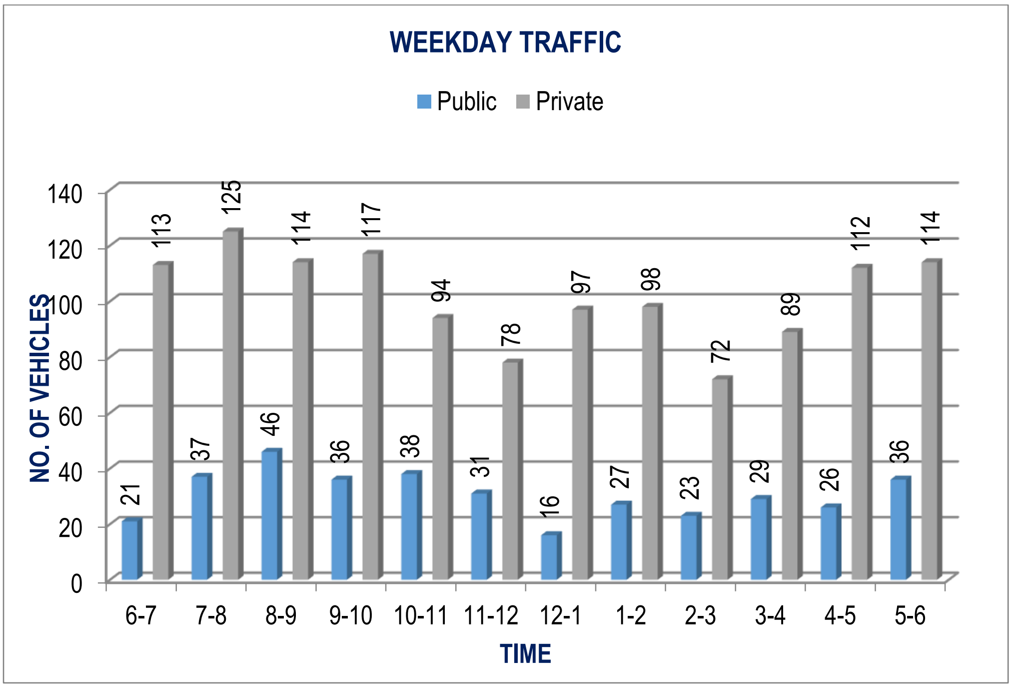

Figure EP-16. Weekday Traffic Volume per Time Period (Route 4 – Leaving Sapinit Road)

4.7.2.5 Route 5 – Entering Barangay Pintong Bukawe

Vehicles entering the route up to Barangay Pintong Bukawe amounted to 664 vehicles composed of 125 (19%) public and 539 (81%) private vehicle. The vehicle type with the highest volume observed during the 12-hour period assessment were motorcycle with 385 units followed by Tricycle with 122 units (**Figure EP-17**). The period 9:01am to 10:00am had the highest volume of vehicles while the 6:01am to 7:00am had the lowest volume of vehicles. Private vehicles were more frequent than public vehicles (**Figure EP-18**).

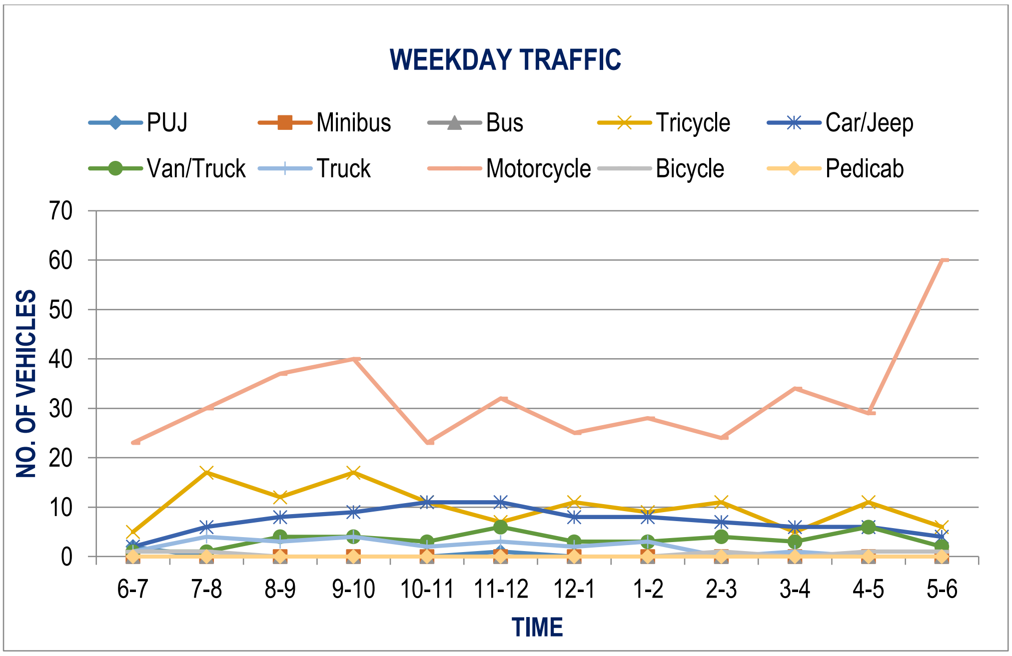

Figure EP-17. Weekday Traffic Volume per Vehicle Type (Route 5 – Entering Barangay Pintong Bukawe)

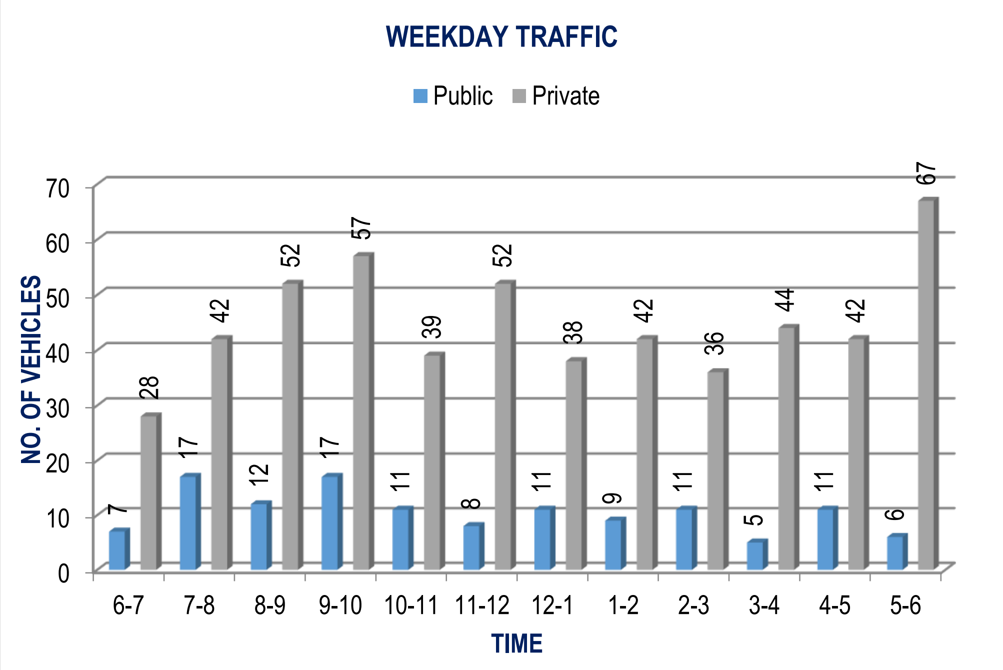

Figure EP-18. Weekday Traffic per Time Period (Route 5 – Entering Barangay Pintong Bukawe)

4.7.2.6 Route 6 – Leaving Barangay Pintong Bukawe

Recorded vehicles leaving entering the route up to Barangay Pintong Bukawe numbered into 616 of which private vehicles tallied a higher a volume with 501 (81%) while public vehicles tallied 115 (19%) units. The most observed vehicle type was the motorcycle with 357 units followed by tricycle with 115 units (**Figure EP-19**). On an hourly basis, the volume of vehicles was at its peak during 7:01am to 8:00am period and the lowest was from 4:01pm to 5:00pm. Private vehicles were more frequent than public vehicles **(Figure EP-20**).

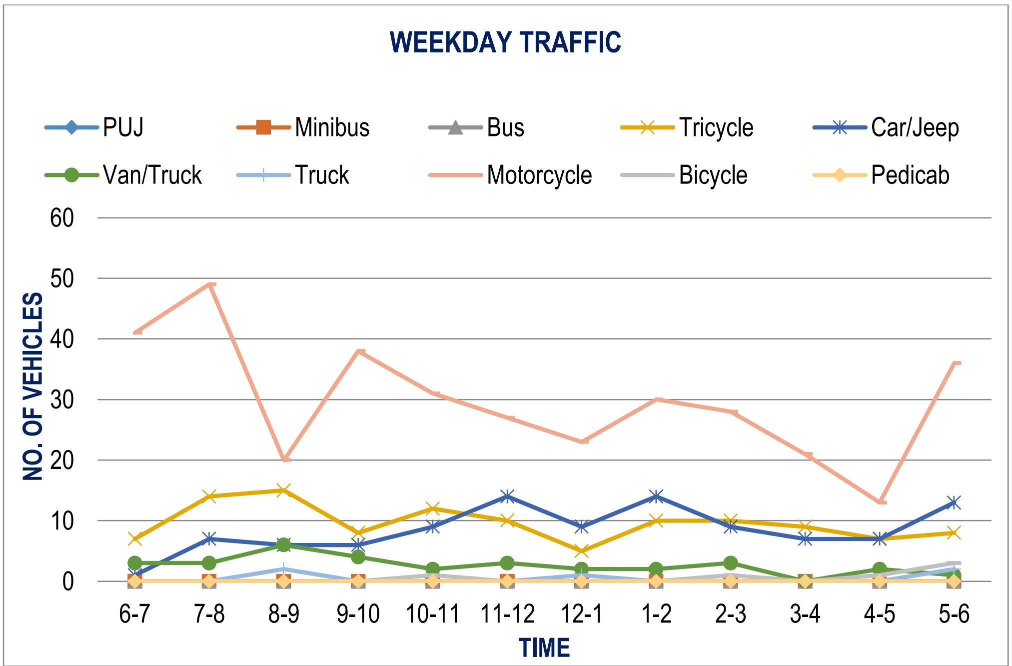

Figure EP-19. Weekday Traffic Volume per Vehicle Type (Route 6 – Leaving Barangay Pintong Bukawe)

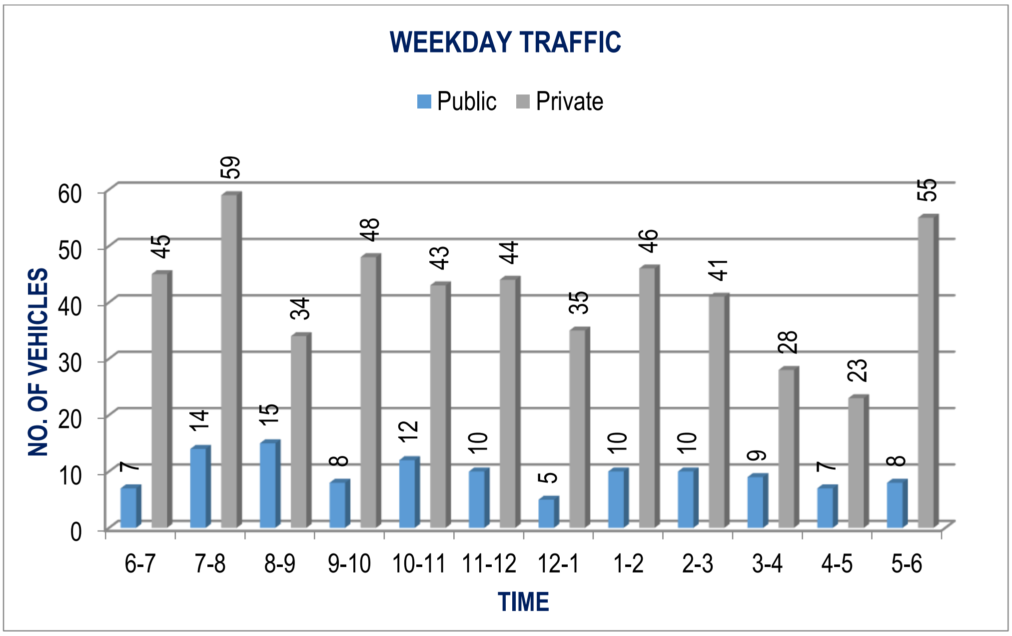

Figure EP-20. Weekday Traffic Volume per Time Period (Route 6 – Leaving Barangay Pintong Bukawe)

4.7.3 Weekend Traffic Volume

The second sampling date for the traffic study was conducted on August 15, 2020 - a weekend. The period of observation was the same as that of the weekday, running from 6:00 in the morning to 6:00 in the evening. Same stations and routes were observed as the weekday sampling. For the duration of the weekend sampling, a total of 20,570 vehicles were recorded from the (6) routes monitored.

4.7.3.1 Route 1 – Bound for Manila along Marilaque Highway

Data for the Bound-for-Manila along Marilaque Highway showed a total volume of 6,781 units with 743 (11%) public and 6,038 (89%) private vehicles. Assessment showed that motorcycles were more frequent in the route with 2,723 units followed by the car/jeep with a total volume of 1,595 units (**Figure EP-21**). In the assessment per time period, the highest volume was recorded during the 8:01am to 9:00am period while the lowest was recorded during the 2:01pm to 3:00pm period. Private vehicles were higher compared to public vehicles (**Figure EP-22**).

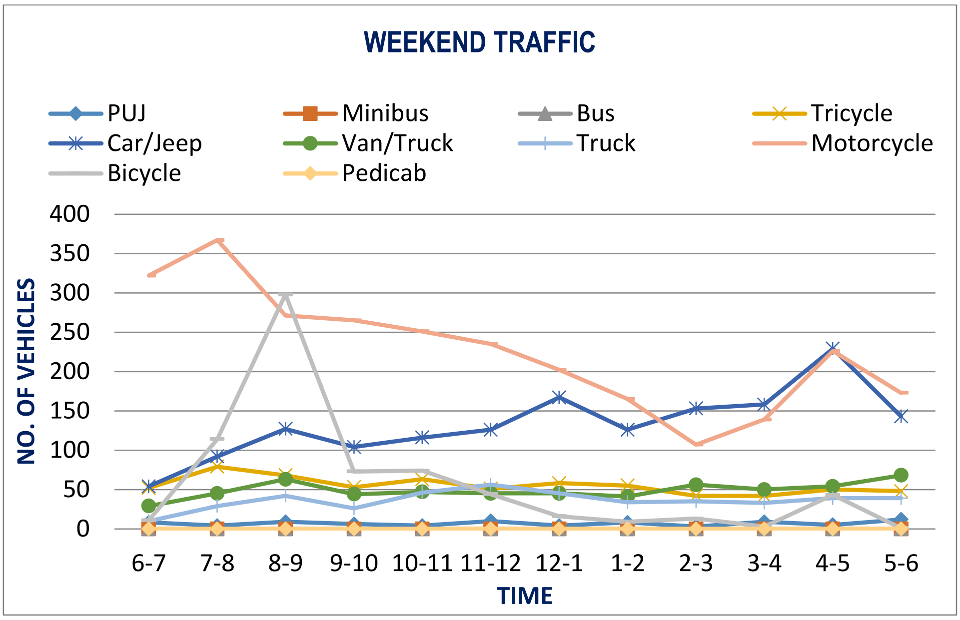

Figure EP-21. Weekend Traffic Volume per Vehicle Type (Route 1 – Bound for Manila)

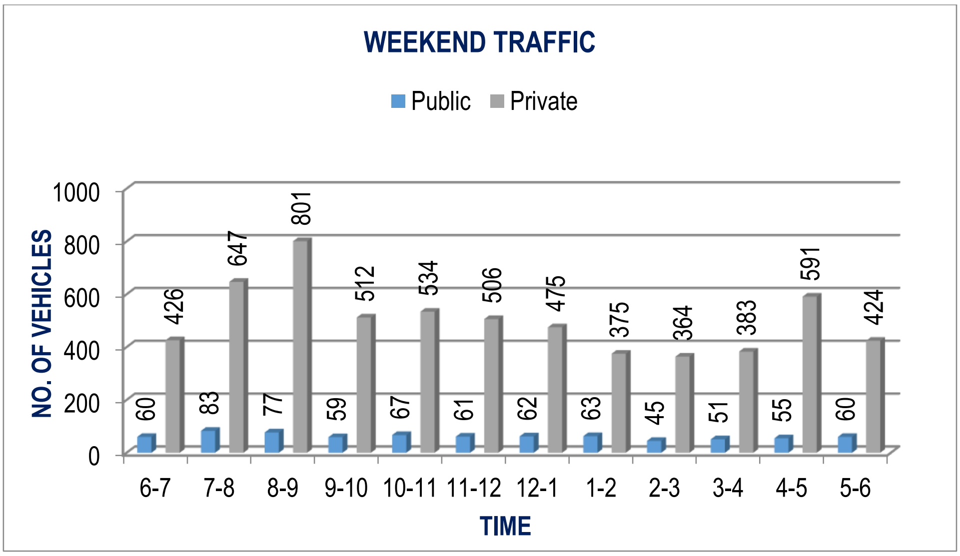

Figure EP-22. Weekend Traffic Volume per Time Period (Route 1 – Bound for Manila)

4.7.3.2 Route 2 – Bound for Tanay along Marilaque Highway

The Bound-for-Tanay along Maralaque Highway recorded a total of 8,929 vehicles with 971 (11%) public vehicles and 7,958 (89%) private vehicles. Most number of vehicles recorded during the study was motorcycles with 3,141 units, followed by car/jeep with 2,790 units (**Figure EP-23**). During the observation per each time period, the volume of vehicles was at its peak at 7:01am to 8:00am with a volume of 1,439 vehicles, while the lowest was during 02:01pm to 3:00pm periods with a volume of 373 vehicles (**Figure EP-24**). The trend in time period indicates that the private vehicles have passed more the highway than the public vehicles.

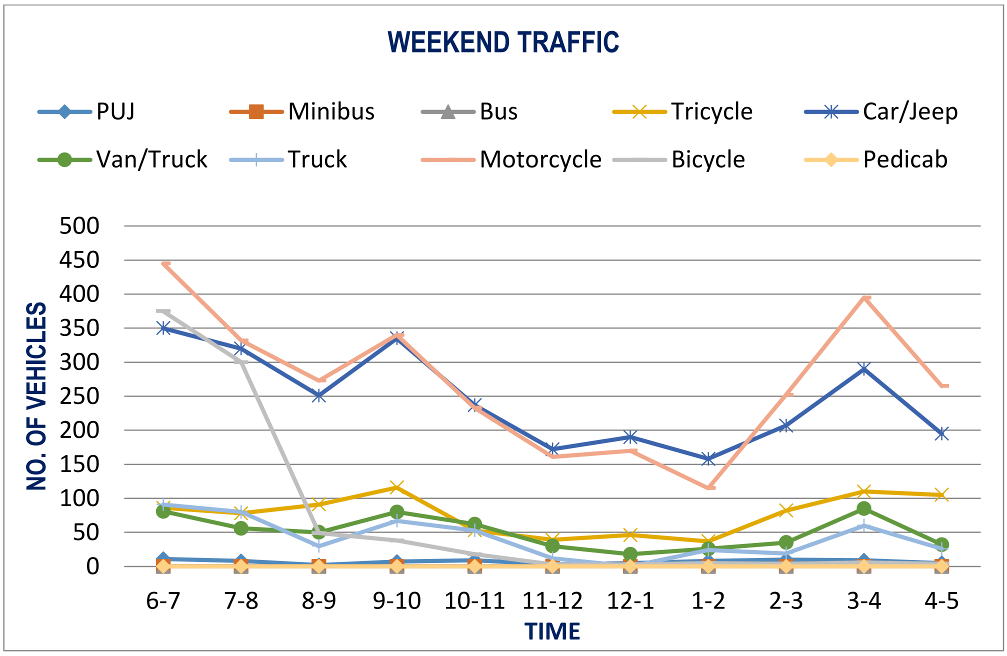

Figure EP-23. Weekend Traffic Volume per Vehicle Type (Route 2 – Bound for Tanay)

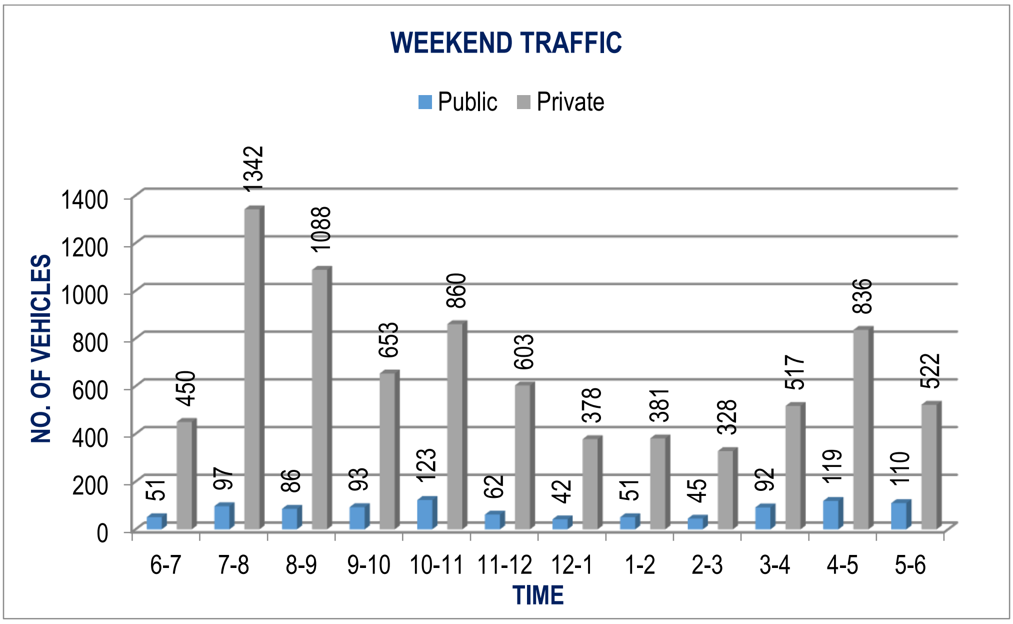

Figure EP-24. Weekend Traffic Volume per Time Period (Route 2 – Bound for Tanay)

4.7.3.3 Route 3 – Entering Sapinit Road

A total of 1,825 vehicles were recorded entering the Sapinit Road, in which 421 (23%) were public and 1,404, were private vehicles. Motorcycles had the highest number units at 725 followed by tricycle with number of 415 units (**Figure EP-25**). The time period 8:01am to 9:00am had the highest number of vehicles observed with a volume of 212 vehicles while the lowest number was observed during 2:01pm to 3:00pm with a volume of 90 vehicles. Throughout the 12-hour sampling period, private vehicles outnumbered public vehicles (**Figure EP-26**).

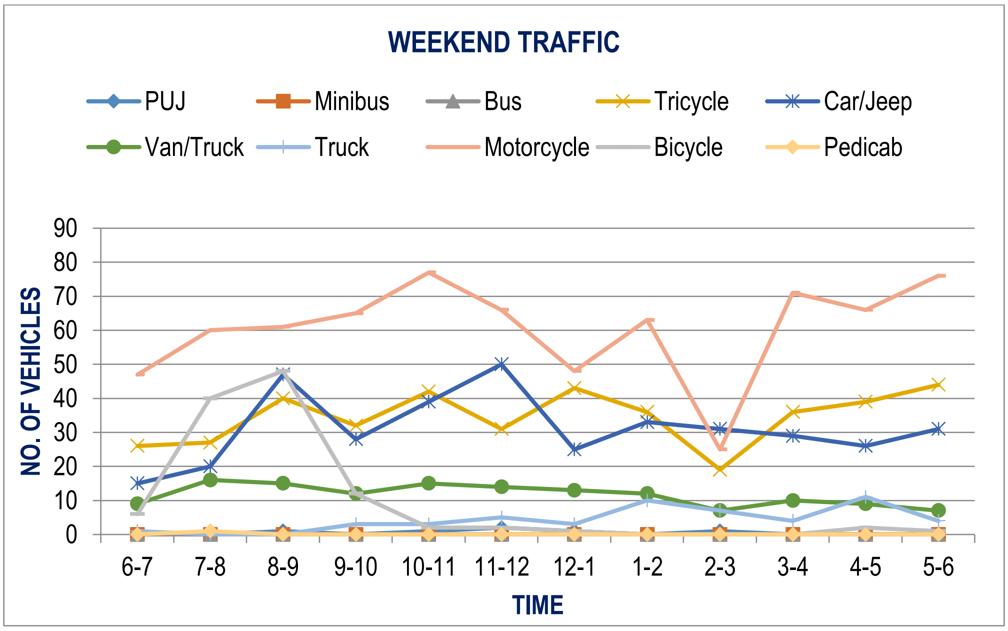

Figure EP-25. Weekend Traffic Volume per Vehicle Type (Route 3 – Entering Sapinit Road)

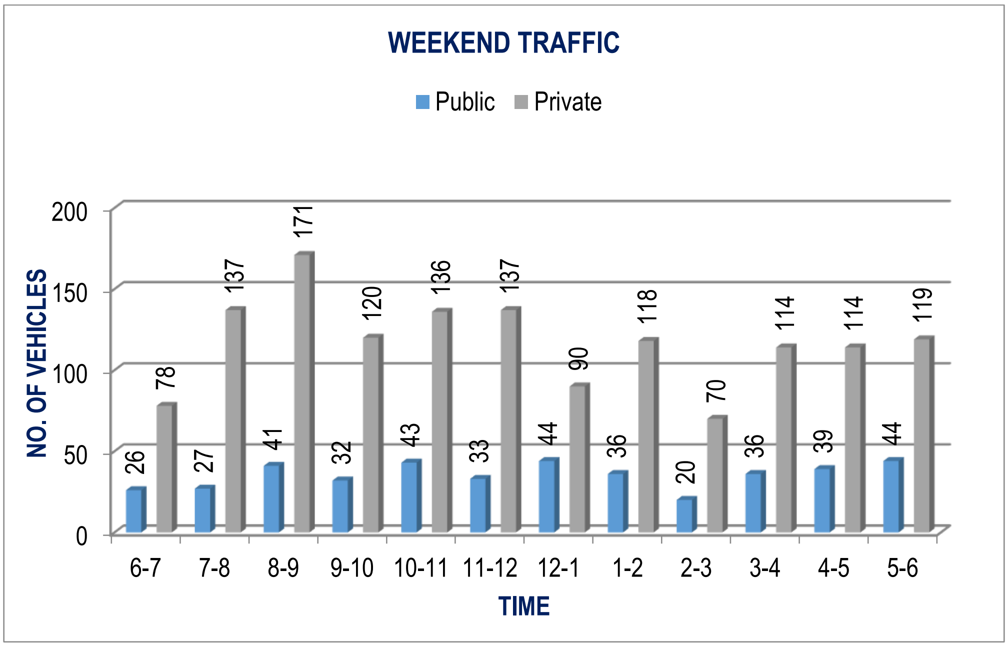

Figure EP-26. Weekend Traffic Volume per Time Period (Route 3 – Entering Sapinit Road)

4.7.3.4 Route 4 – Leaving Sapinit Road

A total of 1,730 vehicles were observed leaving the Sapinit Road over a 12-hour period. The assessment indicates that there were 438 (25%) public and 1,292 (75%) private vehicles observed leaving the route. The vehicle type with the highest volume observed was motorcycle with a total count of 721 units, followed by tricycle with 436 units (**Figure EP-27**). The highest number of vehicles was observed during the 4:01pm to 5:00pm period, while the lowest was from 3:01pm to 4:00pm (**Figure EP-28**).

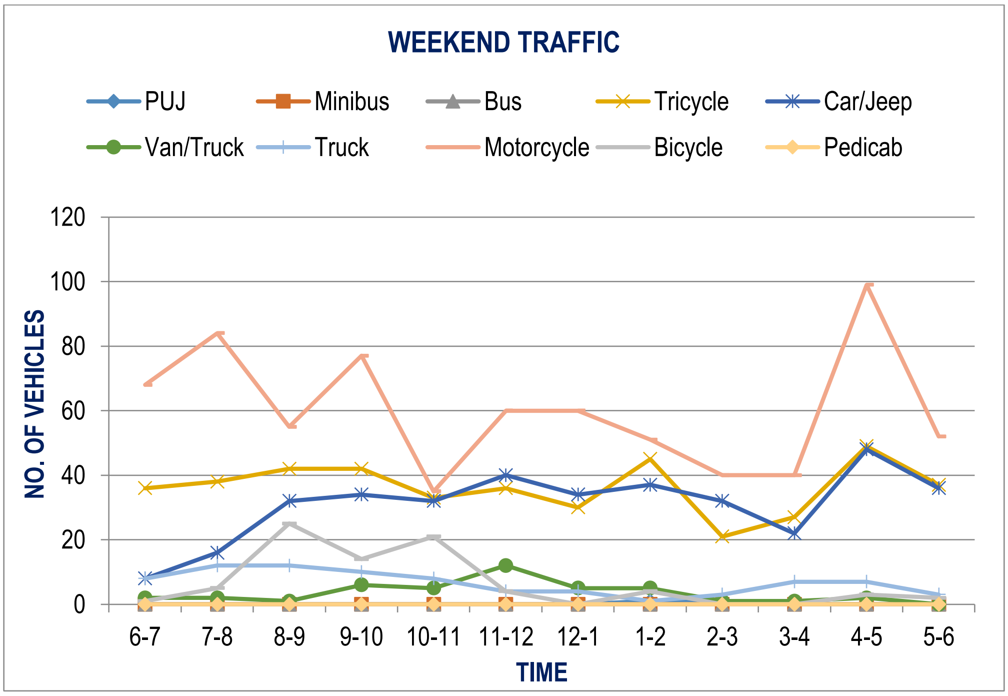

Figure EP-27. Weekend Traffic Volume per Vehicle Type (Route 4 – Leaving Sapinit Road)

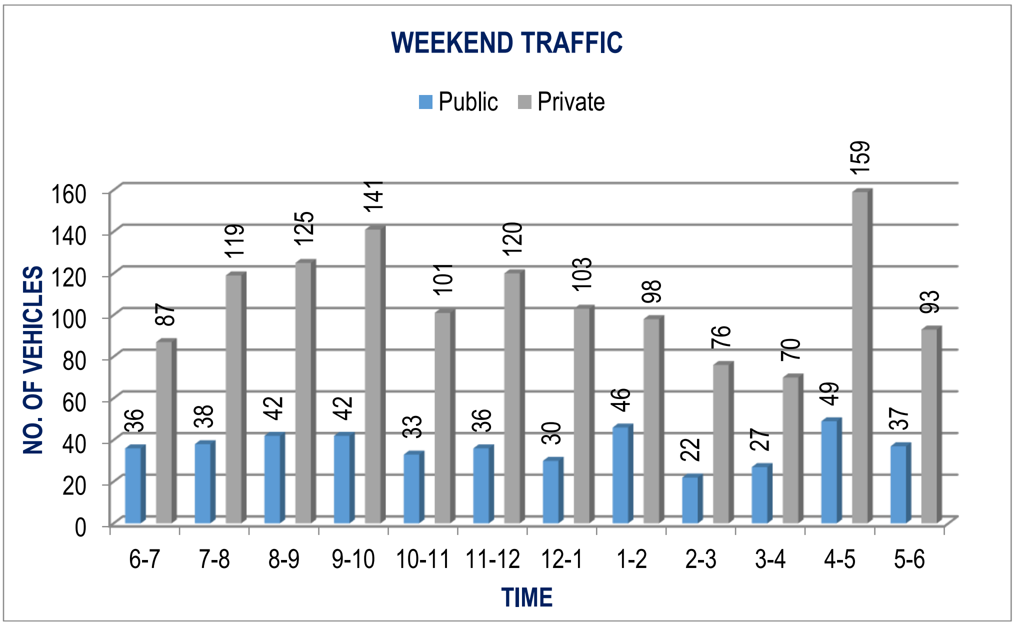

Figure EP-28. Weekend Traffic Volume per Time Period (Route 4 – Leaving Sapinit Road)

4.7.3.5 Route 5 – Entering Barangay Pintong Bukawe

A total of 667 vehicles were recorded entering the route up to Barangay Pintong Bukawe, with 145 (22%) public and 522 (78%) private vehicles. The highest observed vehicle traversing the route was motorcycle with a total count of 393 units, followed by tricycle with a total count of 141 units (**Figure EP-29**). The volume of vehicles was observed to be highest during 4:01pm to 5:00pm period while the lowest was observed during 6:01am to 7:00am. The most common vehicle entering the route was private rather than public (**Figure EP-30**).

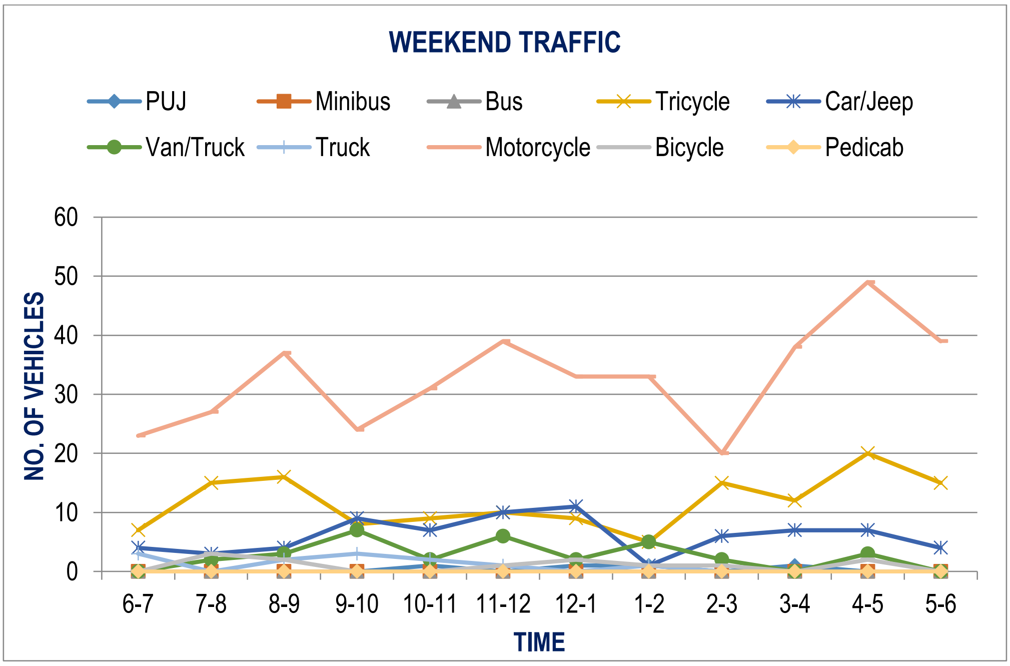

Figure EP-29. Weekend Traffic Volume per Vehicle Type (Route 5 – Entering Barangay Pintong Bukawe)

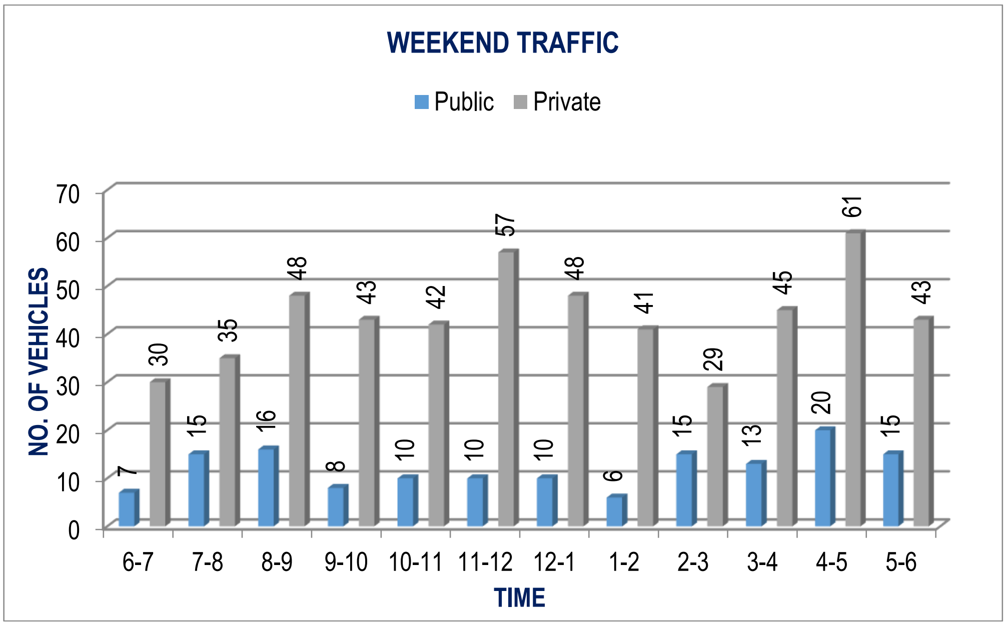

Figure EP-30. Weekend Traffic per Time Period (Route 5 – Entering Barangay Pintong Bukawe)

4.7.3.6 Route 6 – Leaving Barangay Pintong Bukawe

Vehicles leaving the route up to Barangay Pintong Bukawe numbered 638, in which private vehicles was recorded in a higher volume with 507 (79%) units while public vehicles were recorded in 131 (21%) units. The most observed vehicle type was motorcycle with 382 units followed by tricycle with 131 units (**Figure EP-31**). The period of 8:01am to 9:00am had the highest volume of vehicle while the period of 3:01pm to 4:00pm had the lowest volume of vehicles. Private vehicles were more frequent than public vehicles (**Figure EP-32**).

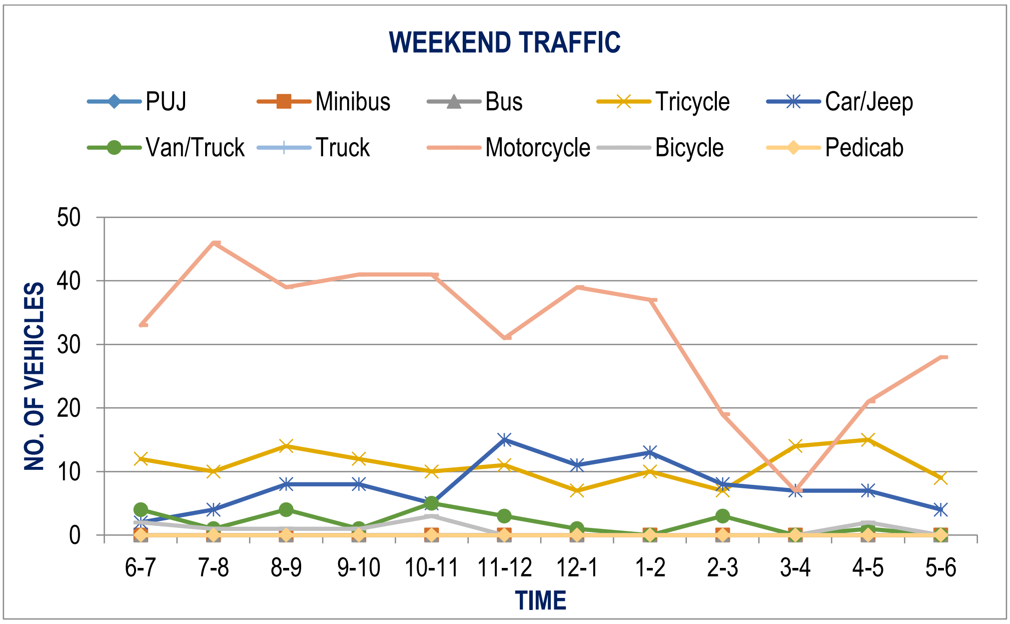

Figure EP-31. Weekend Traffic Volume per Vehicle Type (Route 6 – Leaving Barangay Pintong Bukawe)

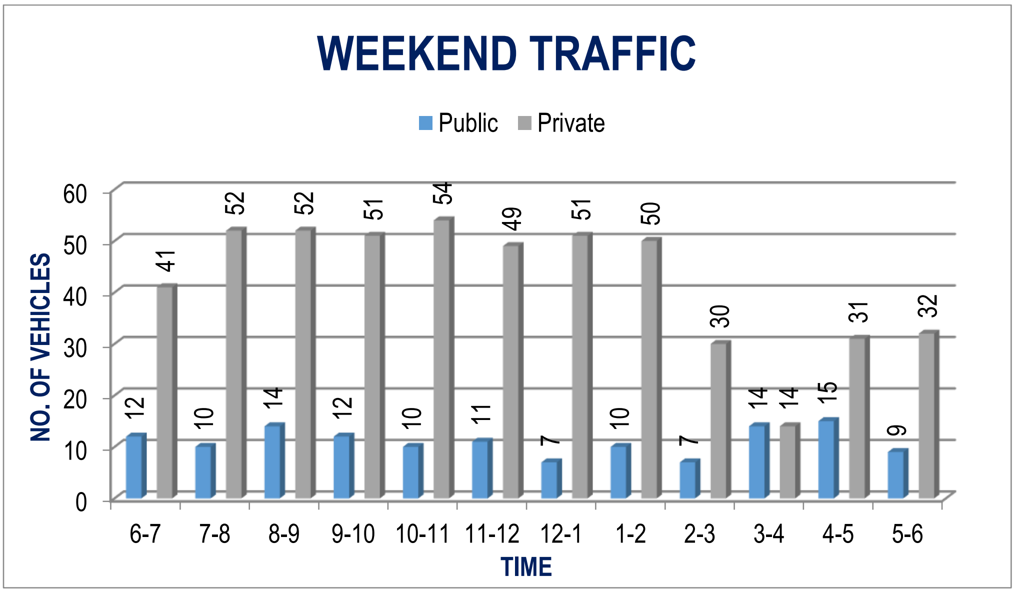

Figure EP-32. Weekend Traffic Volume per Time Period (Route 6 – Leaving Barangay Pintong Bukawe)

4.7.4 Traffic Impact Assessment and Mitigation

Based on the analysis of the recorded data, the weekday and weekend traffic study generated a total vehicle volume of 37,224 units. The weekday sampling tallied a total volume of 16,674 vehicles, which was 19% lower than the weekend sampling with an overall volume of 20,570 vehicles. Majority of the vehicles observed during the study were private units in all the route during weekday and weekend. During the study, a Modified Enhanced Community Quarantine or MECQ was temporarily implemented by the government in Rizal Province and other provinces from August 4 to 18 wherein public transportations were prohibited to travel in the area. On the other hand, private vehicles were allowed to travel during MECQ with strict conditions such as the driver must have a quarantine pass before traveling or the private vehicle has limited number of passengers that is working on a permitted sector. For this reason, private vehicles were more observed during rather than public vehicles.

The vehicle type with highest overall volume was motorcycle with 7,085 units counted over a 12-hour weekday analysis and 8,085 units over a 12-hour weekend day analysis. These counts indicate that motorcycles comprise over 39% of the daily vehicles (42.4% for the weekday and 39.3% for weekend). Car/jeeps were the second highest with 4,151 tallied during the weekday and 5,295 units for weekend. Car/Jeep consisted of 24.9% of the weekday vehicles and 25.7% of the weekend vehicle volume.

In volume per vehicle by route, motorcycles were more frequent in all six (6) routes (Route 1,2,3,4,5 and 6), followed by and car/jeep in Route 1 and 2, which is the main mode of transportation. Because of the pandemic and its guidelines, private vehicles are the most observed type of vehicle observed in the area rather than public vehicles.

A small number of bicycles were observed traveling in all the routes during the weekday and weekend, while minibuses and buses were only seen in the Route 1, 2 and 3 with very few counts during the weekday and were infrequent or absent in all the routes during the weekend. In addition. PUJs were only observed in a small number in Routes 1, 2, 4 and 5 during weekday and Routes 1, 2, 3, 4, and 5 except Route 6 during the weekend.

In general, the numerous amounts of these vehicles in all the six (6) routes increase the levels of carbon monoxide (CO), carbon dioxide (CO2), nitrogen dioxide (NO2), sulfur dioxide (SO2) to the air through emissions, intensifying the air pollution in the area. There are trees observed along the route up to Barangay Pintong Bukawe and Sapinit Road that can help reduce the pollution in the air by filtering it. The overall volume of vehicles observed is a contributor to the degraded air quality in the area. Exhaust emissions of these vehicles contribute significantly to the CO, SO2 and NO2 levels on the air that are very harmful pollutants to human health.

During the construction phase of the Project, movement of construction equipment using large vehicles are expected be seen in the access roads. There will be activities like hauling of materials using these large vehicles that may pose a threat to public safety, especially in areas near the project site.

To address these concerns, various safety and reflectorized traffic signs will be developed from and to the Project site. Signages maybe translated into Filipino and illustrations, drawings or photographs for easy understanding of the community. These will aid both residents and authorized officers and workers of the dam in avoiding potential traffic incidents. It is also important to note that installation of traffic signage along the access road will also prevent vehicular accident risks. Speed limits will be strictly enforced, and water spraying of roads be done more frequently to reduce dust resuspension, especially along the Sapinit Road and Pintong Bukawe Road which will be the access road leading to the dam area.

III. ENVIRONMENTAL RISK ASSESSMENT & EMERGENCY RESPONSE POLICY AND GUIDELINES

1.0 Rationale/Background

The focus of the Environmental Risk Assessment (ERA) in the Philippine EIS System (PD 1586) is on human safety characterized by probabilities, consequences, accidental nature, and acute effects of substances that are explosive, flammable, oxidizing, or toxic. The Revised Procedural Manual (RPM) of DENR Administrative Order (DAO) 2003-30 defined the ERA as "*a process of analyzing and describing the risks associated with a project or activity to ecosystems, human health and welfare*".

Annex 2-7e of the Revised Procedural Manual (RPM) of the DAO 2003-30 provided the guide on the ERA is done during the EIA. An ERA is required if a proposed project will use, handle, transport, store substances that are explosive, flammable, oxidizing, or toxic. Annex 2-7e provides the coverage levels and requirements for determining risk levels. The degree of the ERA is provided by the following levels of coverage:

Risk screening:	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.
Level 1:	Preparation of an Emergency/Contingency Plan.
Level 2:	Conduct a Quantitative Risk Assessment (QRA) and preparation of an Emergency/Contingency Plan based on the QRA results.

Risk Screening is required for the following activities:

a. Facilities for the production or processing of organic or inorganic chemicals using:
   - Alkylation, amination by ammonolysis, carbonylation, condensation, dehydrogenation, esterification
   - Halogenation and manufacture of halogens, hydrogenation, hydrolysis, oxidation, polymerization
   - Sulphonation, desulphurization, manufacture and transformation of sulphur-containing compounds
   - Nitration and manufacture of nitrogen-containing compounds
   - Manufacture of phosphorus-containing compounds
   - Formulation of pesticides and of pharmaceutical products.
   - Distillation, extraction, or solvation

b. Installations for distillation, refining, or processing of petroleum products.
c. Installations for the total or partial disposal of solid or liquid substances by incineration or chemical decomposition.
d. Installations for the production or processing of energy gases, for example, LPG, LNG, SNG.
e. Installations for the dry distillation of coal or lignite.
f. Installations for the production of metals or non-metals by a wet process or by means of electrical energy.
g. Installations for the loading/unloading of hazardous materials as defined by RA 6969 (or DAO 29).

The Levels 1 and 2 coverages in **Table RA-1** depend on the threshold inventory in determining whether or not a proposed project is required to prepare a QRA and/or an emergency/contingency plan. The categories in **Table RA-1** are defined in **Table RA-2**.

Table RA-1
Level 1 and 2 threshold inventory table

Category	Level 1	Level 2
Explosives	10	50
Flammable substances	5,000	50,000
Highly flammable substances	50	200
Extremely flammable substances	10	50
Oxidizing substances	50	200
Toxic substances (low)	50	200
Toxic substances (medium)	10	50
Toxic substances (high)	5	20
Toxic substances (very high)	0.2	1
Toxic substances (extreme)	0.001	0.1
Unclassified (Type A)	100	500
Unclassified (Type B)	50	200

Source: RPM of DAO 2003-30, EMB; values are in tons

Table RA-2
Definition of hazardous substance categories

Category	Description
A. Explosives (Reactivity)	Risk of an explosion by shock, friction, fire, or other sources of ignition.
B. Flammable Substances	Flash point range is 21°C to 55°C and capable of supporting combustion.
Highly flammable	Substances and preparations which may become hot and finally catch fire in contact with air at ambient temperature without any input of energy, or substances which have a flash point lower than 55C and which remain liquid under pressure, where particular processing conditions, such as high pressure or high temperature, may create major accident hazards.
Extremely flammable	Liquid substances and preparations with a flash point <0C and the boiling point (or, in the case of a boiling range, the initial boiling point) of which at normal pressure is <= 35C; gaseous substances and preparations which are flammable when in contact with air at ambient temperature and pressure, whether or not kept in the gaseous or liquid state under pressure; or, liquid substances or preparations maintained at a temperature above their boiling point.
C. Oxidizing substances	Results in highly exothermic reaction when in contact with other substances, particularly flammable substances.
D. Toxic Substances	Low, medium, high, very high and extreme toxicity of substances or preparation.
E. Unclassified Substances	Substances or preparations that react violently with water (Type A), and substances or preparations which release or liberate toxic gas in contact with water (Type B).

Source: Annex 2-7e of the RPM DAO 2003-30

2.0 Information Relating to Blasting Activities

This section describes the indicative blasting activities during the construction phase. The reader is referred to Section 1 (Project Description) of the EIS Report for details of the Operator (WawaJVCo) and other information about the Project.

2.1 Types and Approximate Amounts of Explosives

The preferred explosives to be used during construction are Ammonium Nitrate Fuel Oil (ANFO) and emulsion explosives.

Ammonium Nitrat-Fuel Oil (ANFO) – ANFO is a readily-available, relatively safe, cost effective, and major explosive used in mining and quarrying. The explosive is safe to handle because it requires a blasting cap (booster) to detonate. It is a mixture of Ammonium Nitrate (commercial fertilizer) and Fuel Oil (typically Fuel Oil No. 2). ANFO explosives (emulsion blends, bagged, prills) are used when water or damp conditions are present in the borehole.

When bulk or emulsion blend ANFO is used, the primer is placed on or near the bottom of each borehole with the desired amount of explosive product augured into the hole. This method encases the primer in the blasting agent ensuring good contact. Possible candidate brands include Dyno Nobel Unimax, Unigel, D-Gel 1000, Dynomax Pro. Initiators will include the Dyno Nobel NONEL delay connectors, Dyno Nobel NONEL EZ Det (nonelectric), Special 40-grain Dyno Nobel detonating cord, and the Dyno Nobel NONEL nonelectric shock tube system detonator. These explosives are locally available and supplied by Orica.

Emulsion explosives – Emulsion explosives will be used underground for blasting rock during the construction of the tunnels. This explosive type contains substantial quantities of oxidizer (e.g. ammonium nitrate) dissolved in water droplets, surrounded by an immiscible fuel, or droplets of an immiscible fuel surrounded by water containing substantial amounts of oxidizer (Austin Powder Company, Inc., 2014). Similar to ANFO, emulsion explosives are stable under normal conditions and require a detonator to explode. It may however explode when subjected to fire or shock, especially when confined and in large quantities. Temperatures above 100^{o}C and contamination with other substances (peroxides, chlorates) must be avoided.

2.2 Fuse Types and Detonation Controls

Depending upon size of the pattern, 9, 17, 25, 65, and/or 100 millisecond delays will be used to reduce ground shock and air blast. Detonation controls will be initiated with either shotgun shell primer or electronic shock tube starter. A non-electric initiating line of appropriate length shall be used to connect the initiator to the pattern. Electric initiating equipment may be used occasionally to determine the effectiveness of new or alternative blasting techniques

2.3 Explosives Loading and Handling

All explosives will be delivered to the site on a regular basis and stored in the storage magazine. A storage area for fuel will also be provided. The locations of these are shown in **Figure RA-1**.

2.4 Drill and Blasting Plan

The general description of a drill and blasting plan is described below.

1. Blasting operations will be conducted from Monday to Friday between 9am to 5pm except on local and national holidays. All blasting within 300 feet of roads and road crossings will be between 9am to 5pm.
2. Blasting will not be conducted at times different from those announced in the blasting schedule except in emergency situations such as electrical storms or unscheduled detonations that are required for public safety reasons.
3. Specific warning and all-clear signals audible within 500 meters from the point of the blast will be given. All persons within the permit area will be notified signal meaning through appropriate instructions provided during worker safety orientation. Signs will also be posted. Access will be restricted within 100 meters of the blast that includes stopping or restricting road traffic.
4. Access to blasting area will be restricted to protect the public from the blast effects. Access to the blasting area will be controlled to prevent unauthorized entry before each blast and until the proponent's authorized representative has determined that no unusual circumstances exist after the blast. Access to and travel in or through the area can then safety resume.
5. Areas where charged holes are awaiting firing will be guarded, barricaded, and posted against unauthorized entry.
6. All blasts will be made in the direction of the stress relieved face of the rock being blasted previously marked or blasted.
7. All stemming shall be minimized as specified using clean dry 3/8" crushed stone.

Figure RA-1. Location of the explosive's magazine and fuel tanks	DATA INFORMATION/SOURCE:	WawaJVCo INC. apercu CONSULTANTS INC.
ENVIRONMENTAL IMPACT STATEMENT ERA MODULE Wawa Bulk Water Supply Project – Upper Wawa Dam	**Source Map:** Google Earth Pro, 2020 **Modified by:** APERCU CONSULTANTS, INC (2020)	Not to Scale | PAGE: 398

8. Blasting mats will be used for all blasts to prevent fly rock.
9. All rock drilling operations will be equipped with either wet or dry dust emission controls. Pre-wetting of overburden material prior to blasting as well as the use of blast mats will be used to control dust.
10. Noise and air blast effects (including fly rock and dust migration) will be limited by applying appropriate techniques.

2.5 Procedures for Drilling Patterns

Drill patterns are typically designed to achieve maximum fragmentation from traditional powder factors. Design criteria for the patterns start with the anticipated average depth of material to be blasted. Burden and spacing are derived using traditional powder factors to achieve the desired outcome. In addition, borehole diameter affects the design which relates back to successful long-term powder factors. These patterns are generally located in the field by a designed toe which is transferred to the field. The pattern is then oriented from this predetermined line. These patterns can be drilled vertically or angled depending on the material and desired operational outcome.

In general, the drill holes will be four inches in diameter. The depths drilled for blasts will range from 20 to 30 feet. The number of holes per blast varies widely depending upon the pattern size and location. Typical operations will utilize a 14’ by 14’ drill pattern and 14’ by 16’ pattern when closer to the blast edge.

3.0 Scope and Methods of the ERA

This section defines the scope and methods of the ERA. The general risk assessment is briefly presented followed by the discussion of the methods and the references used.

3.1 General Risk Assessment Process

Environmental impacts described in the EIA are thought of as risks with a high probability of occurrence which needs mitigation (ADB, 1991). While the EIS may identify these impacts qualitatively, risk assessment attempts to quantify the consequence and probabilistic element of these impacts.

Generally, risk assessment identifies and assesses the potential risks to human health and safety. It is also intended to assess the proposed safety management schemes that would minimize if not eliminate such hazards and risks. The general risk assessment process is shown in **Figure RA-2**.

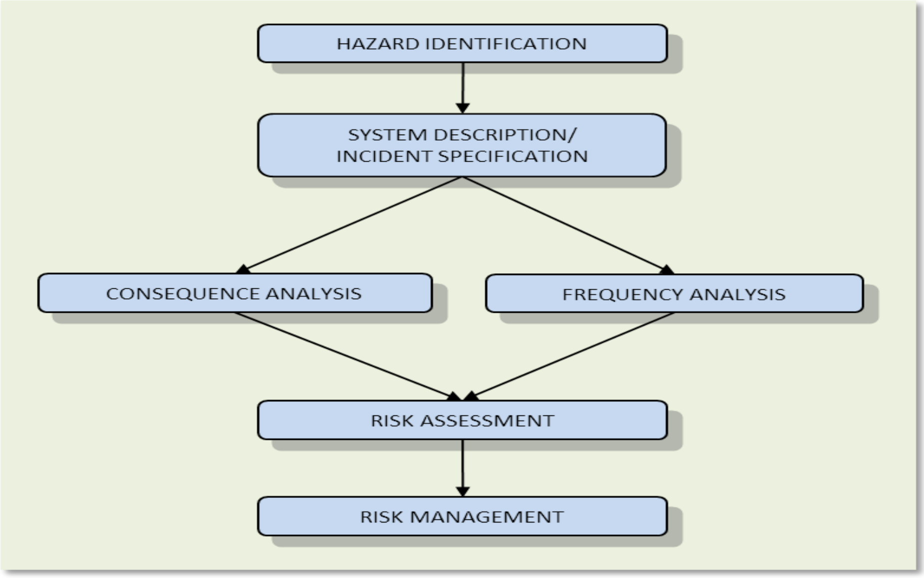

Figure RA-2. Logic diagram of the risk assessment process

Hazard identification is the first step in the risk assessment process. It involves the identification of all possible events or processes that could lead to disastrous or fatal incidents. It also entails defining the inherent and potential hazards of the substances or materials used, as well as process hazards with potential to adversely affect project personnel, the public, and the environment.

Consequence analysis is the second step, involving the estimation and/or assessment of the effects or results of an incident. It uses models beginning with release rates calculations, dispersion and physical effects.

Frequency analysis is the third step and may be defined as the estimation of the likelihood of occurrence of the identified hazard.

Risk is defined as a measure of potential human injury/ death, economic loss, or environmental damage in terms of the probability of the loss, injury/ death or damage occurring and the magnitude of the loss, injury/death or damage if it occurs. It is the product of the calculated consequence of a postulated accident scenario and the probability or frequency of occurrence of such event.

Risk assessment is defined as the examination, analysis, evaluation, and estimation of an adverse or undesirable event occurring in a given project area which could cause unacceptable impacts or results, expressed as fatalities per million per year.

Risk management encompasses the risk assessment process. It is the term applied to a logical and systematic method of identifying, analyzing, assessing, treating, monitoring and communicating risks associated with any activity, function or process in a manner that would enable one to minimize losses and maximize opportunities.

3.2 Methodology for the Proposed Project

Information and data regarding blasting, explosive and fuel storage, and amounts are unavailable at this time. The following were done for the ERA using minimum information from related literature:

1. Identified the hazardous materials based on the RPM Annex 2-7e categorization;
2. Presented the physical and chemical properties of the hazardous materials;
3. Discussed the hazards associated with the transport, handling, storage, and use of the materials;
4. Consequence analysis; and
5. Presented available emergency guides.

3.2.1 Identification of Hazardous Materials

Table RA-2 was used to determine if a material was hazardous or not.

3.2.2 Physical and Chemical Properties of the Hazardous Materials

The physical and chemical properties of the identified hazardous substances and mixtures were taken from the available online MSDS.

3.2.3 Hazards Associated with the Handling and Storage of the Hazardous Materials

The hazards associated with the transport, handling, storage, and use of the identified hazardous materials were taken from available MSDS.

3.2.4 Description of the Consequence Analysis

Due to limited information at this stage, the consequence analysis will determine the potential injury and fatality zones resulting from the accidental detonation of ANFO in storage and transport. The endpoint indicator for the consequence analysis is the blast overpressure, defined as the pressure exceeding ambient pressure due to the shock wave of an explosion. Effects of different blast overpressures on structures and the human body are summarized in **Table RA-3**. The minimum overpressure endpoint for defining hazard zones is 1 psi.

Table RA-3
Effect of various blast overpressures on various structures and the human body

Peak Overpressure	Effect on Structures	Effect on the Human Body
1 psi	Window glass shatters	Light injuries from fragments occur
2 psi	Moderate damage to houses (windows and doors blown out and severe damage to roofs)	People injured by flying glass and debris
3 psi	Residential structures collapse	Serious injuries are common, fatalities may occur
5 psi	Most buildings collapse	Injuries are universal, fatalities are widespread
10 psi	Reinforced concrete buildings are severely damaged or demolished	Most people are killed
20 psi	Heavily built concrete buildings are severely damaged or demolished	Fatalities approach 100%

Source: Zipf, R.K., Jr. & Cashdollar, K.L. in https://www.cdc.gov/niosh

The consequence parameter is the distance to overpressures indicated in **Table RA-3** measured from the center of detonation. The TNT-based equivalency method was used to estimate the blast overpressure radius represented by the formula:

$$R = Z\left(\frac{W_e H_e y}{H_{TNT}}\right)^{\frac{1}{3}}$$

where

R	=	distance to a given overpressure, *m*
Z	=	scaled distances, m/kg$^{1/3}$
y	=	explosion efficiency
W_e	=	explosive detonated, *kg*
H_e	=	heat of explosion of explosive, *MJ/kg*
H_{TNT}	=	heat of explosion of TNT, (*MJ/kg*)

The **explosion efficiency** is defined as the amount of explosives actually detonated. Accidental explosions of storage magazines do not necessarily mean ALL stored explosives are detonated. The initial detonation of a certain amount may or may not detonate nearby stores of the explosive. The initial blast may knock off some of the stored explosives far from the initial explosion site. The scenarios and assumptions for calculating the distances to overpressures indicated in **Table**Error! Reference source not found. **RA-3** are enumerated below while the model inputs are shown in **Table RA-4**.

a) Distances to overpressures were calculated with explosive efficiencies in 10% increments
b) Detonation of the entire cache of explosives during transport (varying amounts)

Table RA-2
Inputs to calculate blast overpressures

Parameter	Unit	Value	Source
Heat of detonation			
TNT	MJ/kg	4.184	National Institute of Standards and Technology, United States Department of Commerce
ANFO	MJ/kg	3.7	Dyno Nobel ANFO
Scaled distance, Z			
1 psi	$m/kg^{1/3}$	10.2	Brasie & Simpson, 1968; Baker et al, 1996
2 psi	$m/kg^{1/3}$	7	Brasie & Simpson, 1968; Baker et al, 1996
3 psi	$m/kg^{1/3}$	5.3	Brasie & Simpson, 1968; Baker et al, 1996
5 psi	$m/kg^{1/3}$	4	Brasie & Simpson, 1968; Baker et al, 1996
10 psi	$m/kg^{1/3}$	2.8	Brasie & Simpson, 1968; Baker et al, 1996
20 psi	$m/kg^{1/3}$	1.9	Brasie & Simpson, 1968; Baker et al, 1996
Explosion efficiency, *y*	dimensionless	10-100%	In 10% increments
Storage (magazine)	kg	50,000	ERA for Wawa PS Hydropower ERA

4.0 Hazardous Substances or Situations

4.1 Identification of the Hazardous Materials

The hazardous materials present during Project implementation are ANFO, emulsion explosives, and industrial diesel. Evaluation of the ERA requirement for the amount to be used is shown in **Table RA-5**. The evaluation is initial due to lack of accurate information about the materials at this time.

Table RA-5
Threshold inventory of materials during Project implementation

Annex 2-7e Classification	Annual weights, MT			Requirement	
	Level 1	Level 2	Wawa	QRA*	E/C Plan**
Explosives	10	50	50[1]		-
Flammable substances(a)	5000	50000	ND[2]	-	
Highly flammable substances(b)	50	200		-	-
Extremely flammable substances(c)	10	50		-	-
Oxidizing (corrosivity/Reactivity) (d)	50	200		-	-
Toxic (medium) (e)	10	50		-	-

Notes: (a) NFPA Fire rating of =<2; (b) NFPA Fire rating of 3l; (c) NFPA Fire rating of 4; (d) NFPA Reactivity rating of >2; (e) NFPA Health rating of >=3; *as post ECC condition; **Emergency/Contingency Plan

4.2 Physical and Chemical Properties of the Hazardous Mixtures

Ammonium nitrate-fuel oil explosives (ANFO), a widely used bulk industrial explosive, are made of an oxidizing agent (94% porous prilled ammonium nitrate) and 6% Fuel Oil #2. ANFO is widely used in coal mining, quarrying, metal mining, and civil construction and applications where low cost and ease of use is required.

Bulk emulsion explosives are usually used in operations requiring large demand for explosives (e.g. open pit mines, quarries). Emulsions are usually safer to manufacture, store, and handle than other commercial explosives (Holmberg, n.d.). Other advantages of emulsion explosives over other commercial explosives are higher velocity of detonation and lower gas emissions (Boshevski, 2013).

[1] Assumed value. Referenced from previous study.
[2] Assumed as Industrial Diesel Fuel

Plate ER-1 and **Plate ER-2** show photographs of typical ANFO and emulsion explosives. **Table RA-6** shows the physical and chemical properties of the hazardous materials during Project implementation. Samples pages of the MSDS used are shown in **Annex L**.

Plate ER-1. Photograph of an ANFO explosive
Source: https://dynobel.com

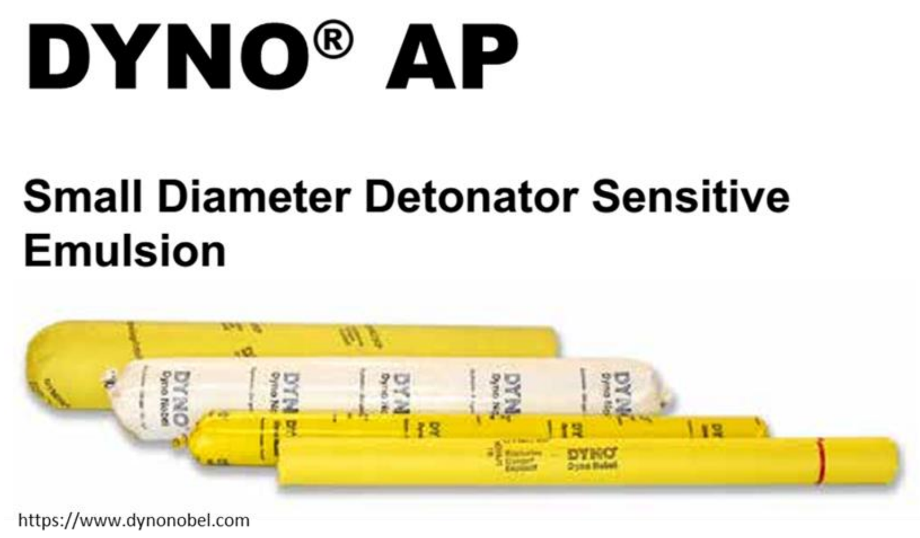

Plate ER-2. Photograph of an emulsion explosive
Source: https://dynobel.com

Table RA-6
Physical and chemical properties of hazardous materials at the proposed Project

No.	Substance	Component	CAS #	Physical state	Odor	Molecular formula	MW	Flash Point	Auto-ignition Temp	Flammable limits (%)		Boiling Point	Melting Point	Specific gravity	Solubility	Vapor Pressure
							g/mol	ºC	ºC	Lower	Upper	ºC	ºC		(in water)	mm Hg
1	Ammonium nitrate-fuel oil (ANFO) (a)	Ammonium nitrate; Fuels, diesel, no.2; Guar gum	6484-52-2; 68476-34-6; 9000-30-0	Solid, Pale, oil-covered prills	Fuel oil	ND	ND	> 49	ND	ND	ND	ND	ND	ND	Ammonium Nitrate component completely soluble	< 5 mm Hg @ 23.9°C
4	Ammonium nitrate/fuel oil, ANFO 94/6 (d)	Ammonium nitrate; Fuels, diesel	6484-52-2; 68334-30-5	Granular Solid, Off-white or Pink	Slight, Kerosene	ND	ND	> 61	ND	ND	ND	ND	ND	0.8 @ 20°C	Partially soluble in water	ND
5	Petron Industrial Diesel Fuel (e)	aliphatic, alicylic and aromatic hydrocarbons	ND	Clear	Characteristic of petroleum products	ND	ND	75	220	ND	ND	ND	ND	837.4 @ 15°C, kg/m^3	Insoluble	ND
6	Chevron (Philippines) Diesel Fuel Oil (f)	Diesel Fuel No.2; Distillates, straight run middle (gas oil, light); Distillates, hydrodesulfurized, middle; Distillates (petroleum), light catalytic cracked; Naphthalene; Total sulfur	68476-34-6; 64741-44-2; 64742-80-9; 64741-59-9; 91-20-3	Liquid, varies depending on specification	Petroleum odor	ND	ND	55	257	0.6	4.7	175.6	NA	0.80-0.88 @ 15.6°C	Soluble in hydrocarbons; insoluble in water	0.04 kPa @ 40 °C
7	ANFO (g)	Ammonium nitrate; Fuels, diesel #2	6484-52-2; 68476-34-6	Solid, pale	Fuel oil	ND	ND	> 61	ND	7	0.5	ND	ND	ND	Soluble	ND

Notes: (a) 2015 ANFO, Dyno Nobel, Inc. SDS; (b) 2015 Dynamite, Dyno Nobel Inc. SDS; (c) 2015 NONEL® Non-electric Delay Detonators, Dyno Nobel Inc. SDS; (d) 2015 Ammonium nitrate/fuel oil, ANFO 94/6, Orica Australia Pty Ltd SDS; (e) 2006 Petron Industrial Diesel Fuel, PETRON CORPORATION, MSDS; (f) 2018 Chevron (Philippines) Diesel Fuel Oil, Chevron Philippines, Inc. SDS; (g) 2016 ANFO, Dyno Nobel Asia Pacific Pty Limited, SDS; ND – no data; NA – not applicable

4.3 Stability and Reactivity Information

The stability and reactivity of the substances and mixtures stored at the tank farm is shown in **Table RA-7**

4.4 Hazards Imposed by the Hazardous Mixtures

The description of the hazards imposed by the substances was presented by its chemical and physical effects.

4.4.1 Emission of Potentially Hazardous Substance (Chemical effects)

Pathway evaluation considers various routes by which a person could be exposed to the hazard identified. Associated with this is the degree to which the hazards can be directly related to human safety. **Figure RA-3** shows the exposure pathway of the Light Fuel Oil and Lubricants to be used during Project implementation.

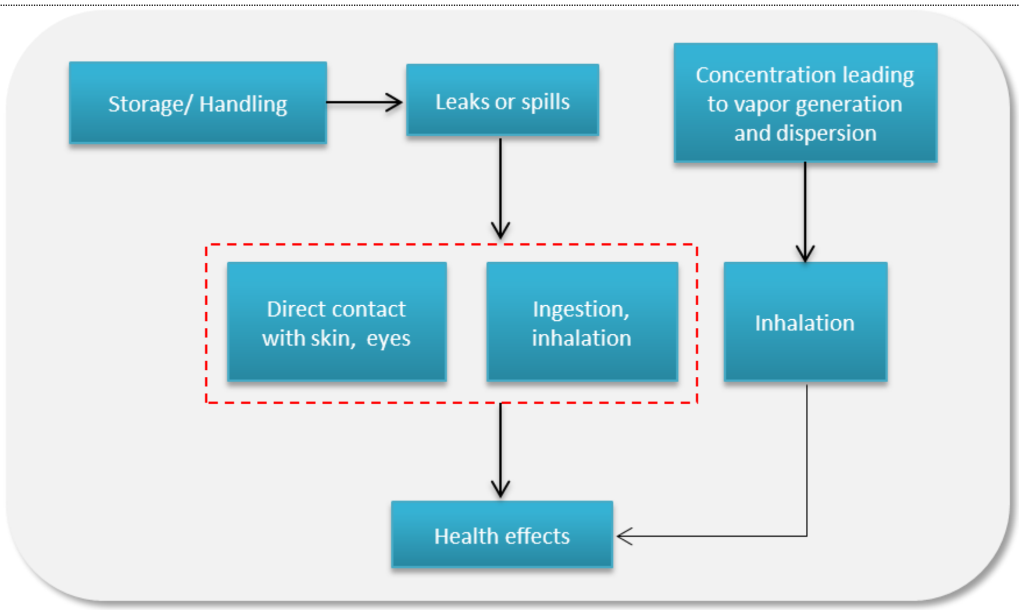

Figure RA-3. Chemical effect pathway

The occupational exposure thresholds from different institutions and the chemical routes and health effects from exposures to the materials are shown in **Table RA-7** to **Table RA-9**, respectively.

Table RA-7
Stability and reactivity properties of materials at the proposed Project

Material	Stability	Conditions to Avoid	Incompatible Materials	Hazardous Decomposition/Reactivity	Hazardous Polymerization
Ammonium nitrate-fuel oil (ANFO)	Stable under recommended handling and storage conditions. May explode when subjected to fire, supersonic shock or high-energy projectile impact, especially when confined or in large quantities.	Direct sunlight. Extremely high or low temperatures. Heat. Sparks. Open flame. Overheating.	Strong acids. Strong bases. Strong oxidizers. Zinc. Copper and its alloys. Organic materials. Combustible materials.	Carbon monoxide. Nitrogen oxides. May cause or intensify fire; May accelerate the burning of other combustible materials. Contact with organic material or combustible material may cause an explosive situation.	ND
Ammonium nitrate/fuel oil, ANFO 94/6	Explosive material. Avoid shock, heat, and mechanical impact, friction between hard surfaces, electrostatic discharge and impingement. Confinement of burning material could result in detonation. Avoid contact with other chemicals including strong acids, alkalis or oxidising agents. Detonation may occur from heavy impact or excessive heating, particularly under confinement.	Avoid exposure to heat, sources of ignition, and open flame. Avoid build-up of Static electricity. Avoid friction. Avoid contact with combustible substances. Avoid contact with other chemicals.	Incompatible with nitrites, chlorates, chlorides and permanganates. Incompatible with strong acids. Incompatible with strong alkalis. Incompatible with combustible materials. Incompatible with moisture. Ammonium nitrate is a powerful oxidizing agent; it is incompatible with tetranitromethane, dichloroisocyanuric acid, trichloroisocyanuric acid, bromates, chlorates, chlorites, hypochlorites, perchlorates, permanganates, chloroisocyanurate, nitrites, and powdered metals.	Oxides of carbon. Oxides of nitrogen. When heated to decomposition (unconfined) ammonium nitrate produces nitrous oxide, white ammonium nitrate fumes and water. When mixed with strong acids, and occasionally during blasting, it produces an irritating toxic brown gas, mostly of nitrogen dioxide. When molten may decompose violently due to shock or pressure. Explosive.	ND
Petron Industrial Diesel Fuel	Material is normally stable at ambient temperature.	ND	Strong oxidizing agents.	In case of combustion or thermal decomposition, carbon monoxide and other toxic and irritant fumes may be formed.	Will not occur.
Chevron (Philippines) Diesel Fuel Oil	This material is considered stable under normal ambient and anticipated storage and handling conditions of temperature and pressure.	ND	Not applicable	None known (None expected); May react with strong acids or strong oxidizing agents, such as chlorates, nitrates, peroxides, etc.	Hazardous polymerization will not occur.

Source: same MSDS in Error! Reference source not found.

Table RA-8
Occupational exposure limits of materials at the proposed Project

Material	Exposure Limit			
	OSHA PEL	NIOSH REL	ACGIH TLV-TWA	Others
Ammonium nitrate-fuel oil (ANFO)	ND	ND	100 mg/m³ (inhalable fraction and vapor); Fuels, diesel 8hr TWA: 5 mg/m³ (stable aerosol); 100 mg/m³, SKIN (total hydrocarbons, inhalable); 200 mg/m³ (vapour)	British Columbia OEL TWA 100 mg/m³ (aerosol, inhalable, and vapour)
Petron Industrial Diesel Fuel	ND	ND	ND	ND
Chevron (Philippines) Diesel Fuel Oil	ND	ND	ND	CVX TWA: Diesel Fuel No.2 100 mg/m³; Philippine TWA: Distillates, hydrodesulfurized, middle 400 mg/m³; Distillates (petroleum), light catalytic cracked 400 mg/m³; Naphthalene 50 mg/m³
ANFO	ND	ND	ND	Safe Work Australia: Dust 10 mg/m³ TWA

Source: same MSDS in Error! Reference source not found.; NOTES: ACGIH - American Conference of Governmental Industrial Hygienists; NIOSH - National Institute of Occupational Safety and Health; OSHA - U.S. Occupational Safety & Health Administration; PEL - Permissible Exposure Limit (OSHA); REL - Recommended Exposure Limit, 10hr TWA (NIOSH); TLV - Threshold Limit Value (ACGIH); TWA - Time Weighted Average (8 hr); STEL - short term exposure limit; IDLH - Immediate Danger to Life and Health

Table RA-3
Routes of exposure and effects of materials at the proposed Project

Material	Eye	Skin	Ingestion	Inhalation
Ammonium nitrate/fuel oil, ANFO 94/6	An eye irritant.	Contact with skin may result in irritation. Will have a degreasing action on the skin. Repeated or prolonged skin contact may lead to irritant contact dermatitis. Can be absorbed through cut, broken, or burnt skin with resultant adverse effects. See effects as noted under 'Inhalation'. Shrapnel from detonation may cause burns and wounds to the skin and eyes.	Swallowing can result in nausea, vomiting, diarrhea, and abdominal pain. Swallowing large amounts may result in headaches, dizziness and a reduction in blood pressure (hypotension).	Material may be an irritant to the mucous membranes of the respiratory tract (airways). Breathing in vapour can result in headaches, dizziness, drowsiness, and possible nausea. Blasting may produce a toxic brown gas of nitrogen dioxide. Inhalation of the gas may result in chest discomfort, shortness of breath and possible pulmonary edema, the onset of which may be delayed. Absorption of ammonium nitrate by inhalation, ingestion or through burnt or broken skin may cause dilation of blood vessels by direct smooth muscle relaxation and may also cause ethaemoglobinaemia.
Petron Industrial Diesel Fuel	May cause eye irritation upon direct contact.	Low order of toxicity under normal use. However, avoid prolonged or repeated contact with the product to prevent defatting and dermatitis. Carcinogenic materials are also present.	Ingestion is an unlikely event. However, accidental ingestion can lead to vomiting and aspiration into the lungs. This can result in chemical pneumonitis, which can be fatal.	Not expected to present an inhalation hazard under normal conditions. Exposure to high vapor concentrations can lead to nausea, headache and dizziness. Prolonged and excessive exposure to mist may cause chronic inflammatory reaction of the lungs and a form of pulmonary fibrosis.
Chevron (Philippines) Diesel Fuel Oil	Not expected to cause prolonged or significant eye irritation.	Contact with the skin causes irritation. Skin contact may cause drying or defatting of the skin. Symptoms may include pain, itching, discoloration, swelling, and blistering. Contact with the skin is not expected to cause an allergic skin response.	Highly toxic; may be fatal if swallowed. Because of its low viscosity, this material can directly enter the lungs, if swallowed, or if subsequently vomited. Once in the lungs it is very difficult to remove and can cause severe injury or death. May be irritating to mouth, throat, and stomach. Symptoms may include pain, nausea, vomiting, and diarrhea.	May be harmful if inhaled. Excessive or prolonged breathing of this material may cause central nervous system effects. Central nervous system effects may include headache, dizziness, nausea, vomiting, and weakness, loss of coordination, blurred vision, drowsiness, confusion, or disorientation. At extreme exposures, central nervous system effects may include respiratory depression, tremors or convulsions, loss of consciousness, coma or death.

Source: same MSDS in Error! Reference source not found.

4.4.2 Occurrence of an Environmental Hazard (physical effects)

Pathway evaluation considers various routes by which persons could be exposed to physical hazards. Associated with this is the degree to which the hazards can be directly related to human safety. The physical pathway diagram for the explosives and Light Fuel Oil to be used during Project implementation is shown in **Figure RA-4**.

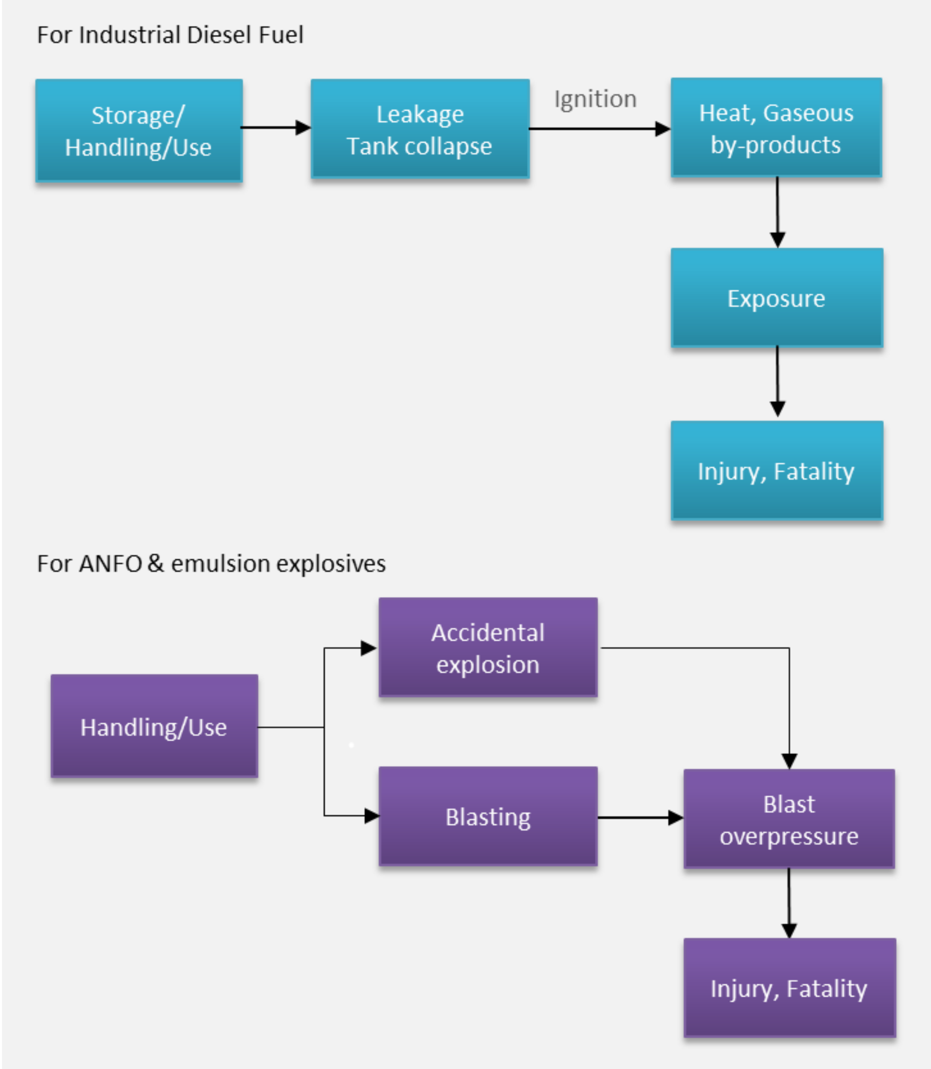

Figure RA-4. Pathway of physical effects

The two physical hazards that may occur during transport, handling, storage, and of these materials that may cause injury and fatality are fires and explosions.

- **Fires** are caused when flammable materials are ignited exposing people and materials to heat. The intensity of heat is known to decrease rapidly proportional to distance from the open flame. Exposure to the resulting thermal radiation may cause injury or fatality.
- **Explosions** occur during blasting, accidental detonation of explosives, and when flammable vapors and gases are ignited and released at high temperatures and elevated pressures. The resulting shock wave (or blast overpressure) may cause injuries, fatalities, or destruction of property.

5.0 Information Relating to the Consequences of Major Accidents, the Probability of its Occurrence and Estimation of the Risk

5.1 Consequence Results

The result of the consequence analysis for the accidental detonation of the explosive magazine at varying yield efficiencies is shown in **Table RA-10**.

Table RA-10
Overpressure distances of accidental detonation of stored ANFO

Overpressure		Effect		Yield Efficiency*									
				0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
kPa	psi	Structures	Human body	Distance, meters									
7	1	(a)	(b)	167	211	241	266	286	304	320	335	348	361
14	2	(c)	(d)	115	145	166	182	196	209	220	230	239	248
21	3	(e)	(f)	87	110	125	138	149	158	166	174	181	187
34	5	(g)	(h)	66	83	95	104	112	119	126	131	137	141
69	10	(i)	(j)	46	58	66	73	79	84	88	92	96	99
138	20	(k)	(l)	31	39	45	50	53	57	60	62	65	67

Notes: *amount of explosive detonated; (a) Window glass shatters; (b) Light injuries from fragments; (c) Windows and doors blown out and severe damage to roofs; (d) People injured by flying glass and debris; (e) Residential structures collapse; (f) Serious injuries are common, fatalities may occur; (g) Most buildings collapse; (h) Injuries are universal, fatalities are widespread; (i) Reinforced concrete buildings are severely damaged or demolished; (j) Most people are killed; (k) Heavily built concrete buildings are severely damaged or demolished; (l) Fatalities approach 100%

At the worst-case, i.e., all stored ANFO are detonated (yield=1), light injuries (1 psi) and a 100% fatality rate (20 psi) were predicted to occur at radii of 361 and 67 meters from the storage magazine. The worst-case hazard zones are shown in **Figure RA-5**.

The lowest explosion yield (10%) that results to light injuries (1 psi) and a 100% fatality rate (20 psi) was predicted to occur at radii of 167 and 31 meters from the storage magazine. Purple cells in **Table RA-10** shows that hazard zones will reach the Temporary Construction Facilities if 20%, 40%, and 80% of the stored ANFO are detonated.

The 1psi overpressure endpoint with varying amounts of transported ANFO to the storage magazine is shown in **Figure RA-6**. The graph can guide the Proponent in establishing exclusion zones or truck signage at the road sections used to transport the ANFO to the site.

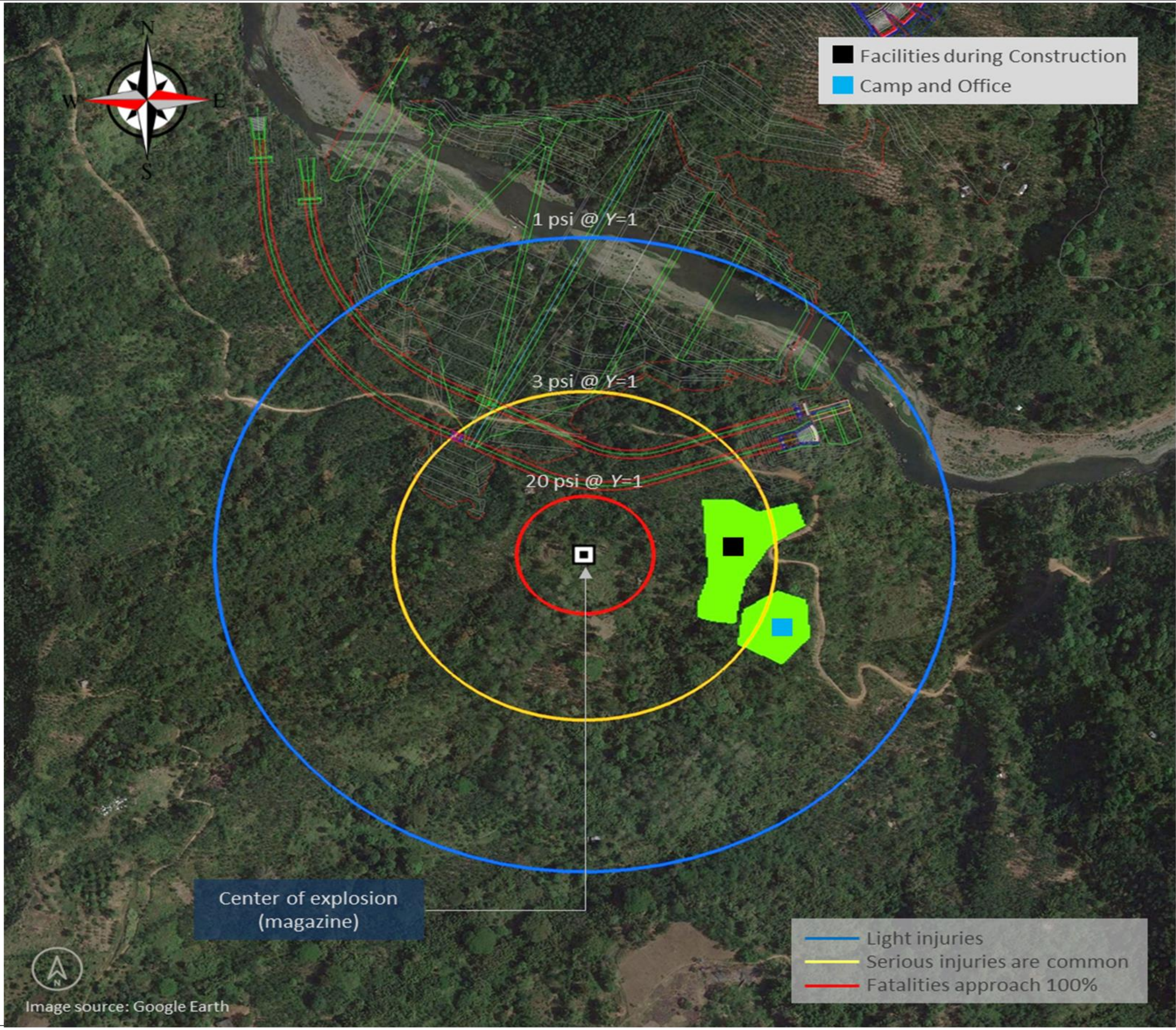

Figure RA-5. Hazard Zones of the accidental detonation of stored ANFO

ENVIRONMENTAL IMPACT STATEMENT
ERA MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

DATA INFORMATION/SOURCE:

Source Map: Google Earth, 2020
Modified by: APERCU CONSULTANTS, INC (2020)

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CONSULTANTS INC.

Not to Scale

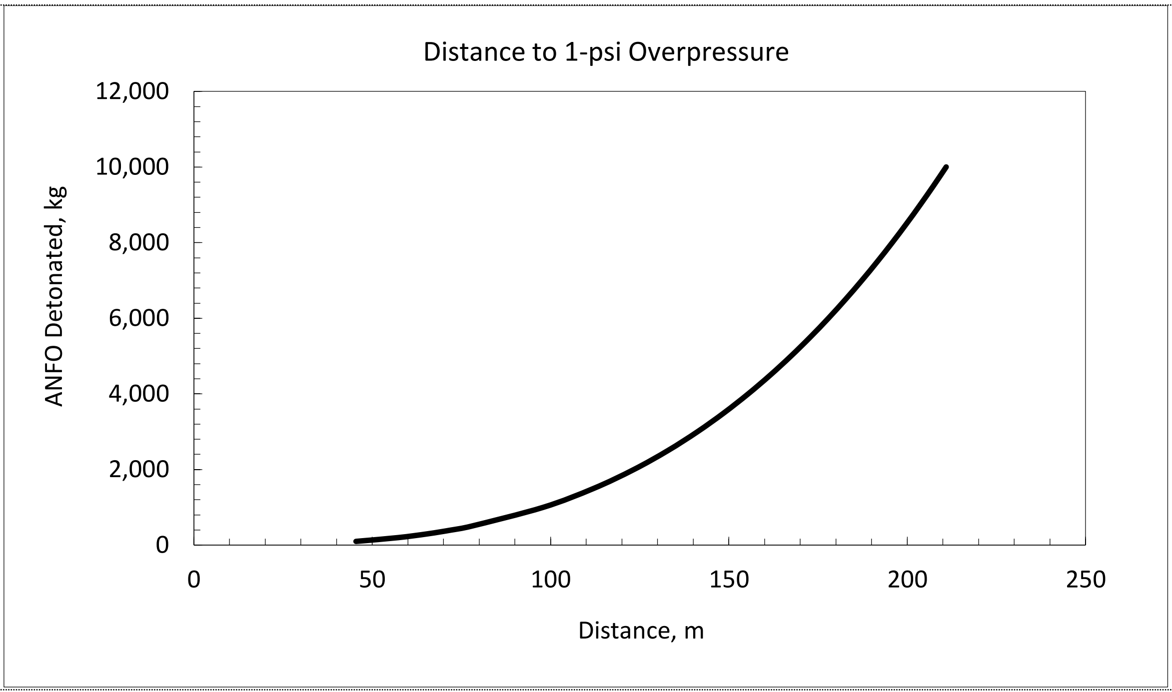


Figure RA-6. Nomograph of ANFO transported and distance to 1 psi

5.2 Conclusions

The consequence analysis showed that the potential exclusion zone from the storage magazine is at least 360 meters. This can be done by either relocating the magazine or the Temporary Construction Facilities and Camp & Office.

6.0 Safety Management System

WawaJVCo is committed to ensure that Project implementation is hazard-free as possible and the factors leading to an accident are minimized if not totally eliminated. To achieve this, the company will formulate and implement the following protocols during the construction and operation phases:

a) Emergency Response
b) Security and Crises Management
c) Road Transport Safety
d) Explosives and Blasting Safety

In addition, the storage, handling, storage, and use of explosives should comply with the following requirements of other government agencies:

a) Rules and Regulations of PD 1866 (Philippine National Police);
b) Implementing Rules and Regulations of the Fire Code of the Philippines (Bureau of Fire Protection);
c) Mine Safety and Health Standard (DENR Administrative Order 2000-98); and
d) Occupational Safety and Health Standards (Department of Labor and Employment).

7.0 Dam Breach Simulation for Upper Wawa Dam

7.1 Introduction

This study was taken from Philkarios (Dam Breach Study for the Upper Wawa Dam Report) to present the dam break analysis of the Upper Wawa Dam Project. The watershed of Marikina River has long been identified as one of the potential raw water sources to augment the water supply requirements for greater Metro Manila and nearby areas. One such project is the Upper Wawa Dam - Wawa Bulk Water Supply Project. The Upper Wawa Dam is to be designed either as a rockfill dam with impervious core or a roller compacted concrete dam to be constructed over the Marikina River in the municipality of Rodriguez, Rizal which when finished aims to add 518 million liters per day (518 MLD) to the existing water supply of Metro Manila, which at present are mainly sourced from Angat Dam in Bulacan.

Dams provide society with essential benefits such as storing water for hydropower production, water supply and irrigation, as a component for flood management, for recreational purposes, among others. One of the inherent hazards of storing water in a reservoir thru a dam or embankment is the potential occurrence of accidental spillages due to overtopping or a breach in the section of a storage dike or containment structure. Breaches in dams generally has a massive, instantly destructive force of a catastrophic nature. They have a very high potential to cause severe environmental, social, and economic harm. Nevertheless, with the advancement in engineering knowledge for dams, and application of international standards for dam engineering design, better construction methodologies and sound engineering management for dam's safety and operation, coupled with the dam operator's knowledge about preventive measures or intervention strategies and appropriate actions in times of emergencies, the probability of dam failure is relatively low and can often be avoided.

According to the Engineering Manual of the US Army Corps of Engineers (USACE, 2018), dam failures can be caused by overtopping a dam due to insufficient spillway capacity during large inflows to the reservoir, by seepage or piping through the dam or along internal conduits, slope embankment slides, earthquake damage and liquefaction of earthen dams from earthquakes, or landslide-generated waves within the reservoir. Hydraulics, hydrodynamics, hydrology, sediment transport mechanics, and geotechnical aspects are all involved in breach formation and eventual dam failure (USACE, 2018).

There are many mechanisms that can be the driving force of a dam failure. The following is a list of mechanisms that can cause dam failures (HEC, 2014):

1) flood event;
2) piping/seepage (internal and underneath the dam);
3) landslide;
4) earthquake;
5) foundation failure;
6) equipment failure/malfunction (gates, etc.);
7) structural failure;
8) upstream dam failure;
9) rapid drawdown of pool;
10) sabotage; and
11) planned removal.

However, regardless of the driving mechanism, almost all failures of the dam begin with a breach formation (USACE, 2018). Basically, breach is defined as an opening or a breakthrough of a dam sometimes caused by rapid erosion of a section of earth embankment by the stored water. Once the dam is breached, large amount of impounded waters behind the dam are released, surging forward as it flows into the downstream area.

Simulation of dam break events and the resulting floods are crucial to characterizing and reducing threats due to potential dam failures. Development of effective emergency action plans requires accurate prediction of inundation levels and the time of flood wave arrival at a given location.

The dam break module within HEC-RAS can be used to simulate the breach of an inline structure such as dam, or a lateral structure such as a levee. HEC-RAS is one of the most popular hydraulic models, is an acronym for the U.S. Army Corps of Engineers' Hydrologic Engineering Center-River Analysis System, and is a software that allows the user to perform either a one or two-dimensional, steady or unsteady flow hydraulic calculations, among others (HEC-RAS Manual, 2016). The objective of this study is therefore to apply HEC-RAS to a dam break analysis based on given geometry data and to predict flood inundation levels downstream of the proposed dam, and to support dam-break flood risk management, which is an important contribution to public safety along the downstream valleys of the project area.

Although the Dam Break simulation presented here is based on the physical configuration of the dam (i.e., length, width, height, diversion tunnel dimensions), changes as to type of the dam structure itself, whether it is to be designed as a rockfill dam with impervious core or a roller compacted concrete dam, will not significantly affect the output results and is therefore can be considered to be valid for both cases.

7.2 Study Area

Upper Wawa Dam (**Figure RA-7**) is to be constructed in one of the tributaries of Marikina River about 3.8 kilometers upstream of the old Wawa Dam and about 13 linear kilometers east of La Mesa Dam. The preliminary design plan indicates that Upper Wawa Dam is about 80 meters in height, with elevation 140 m above sea level (ASL) at its crest, 10 m width at its crest and 450 meters at the bottom, side slopes of 40%, and about 425 meters length at dam's main axis. The spillway is composed of two (2) units of 8.75 m diameter reinforced concrete pipes with corresponding inlet and outlet structures. The maximum flood level is at 135 m ASL, and the minimum operating level is at 87 m ASL.

As previously stated, the dam is one of the components of the Bulk Water Supply Project for the augmentation of water supply requirements of greater Metro Manila area.

Because of the limited availability of river cross-sections downstream of the project area, the digital elevation model (DEM) was used instead for two-dimensional (2D) hydraulic analysis. The DEM was produced by the Shuttle Radar Topographic Mission (SRTM) which is the most complete, high-resolution DEM of the entire Earth. The SRTM-based DEM used for the study area was downloaded from publicly available web site in geotiff image format, in decimal degrees and datum WGS84. The data were then projected to UTM coordinate system zone 51 N, using QGIS software. The DEM was modified to include the finished elevation of the inlet and outlet structures, as well as the portion of the dam. The resulting DEM was then loaded into HEC-RAS and serves as the terrain inputs for 2D unsteady flow modeling.

7.3 Dam Break Simulation and Analysis using HEC-RAS

To visualize the extent of spillage in case such accident occurs in Upper Wawa Dam, dam break analysis was completed using the HEC-RAS hydraulic model.

In a 2D setup, a dam is modelled in HEC-RAS as a storage area or 2D area connection. A 2D connection is represented with a weir profile (that can include outlet structures such as gate and culvert). In this study only weir and embankment profile are entered in the dam schematization since the spillway (i.e., diversion tunnels) is outside of the dam structure. The inset in **Figure RA-8** shows the Upper Wawa Dam and diversion tunnels as 2D connections in HEC-RAS.

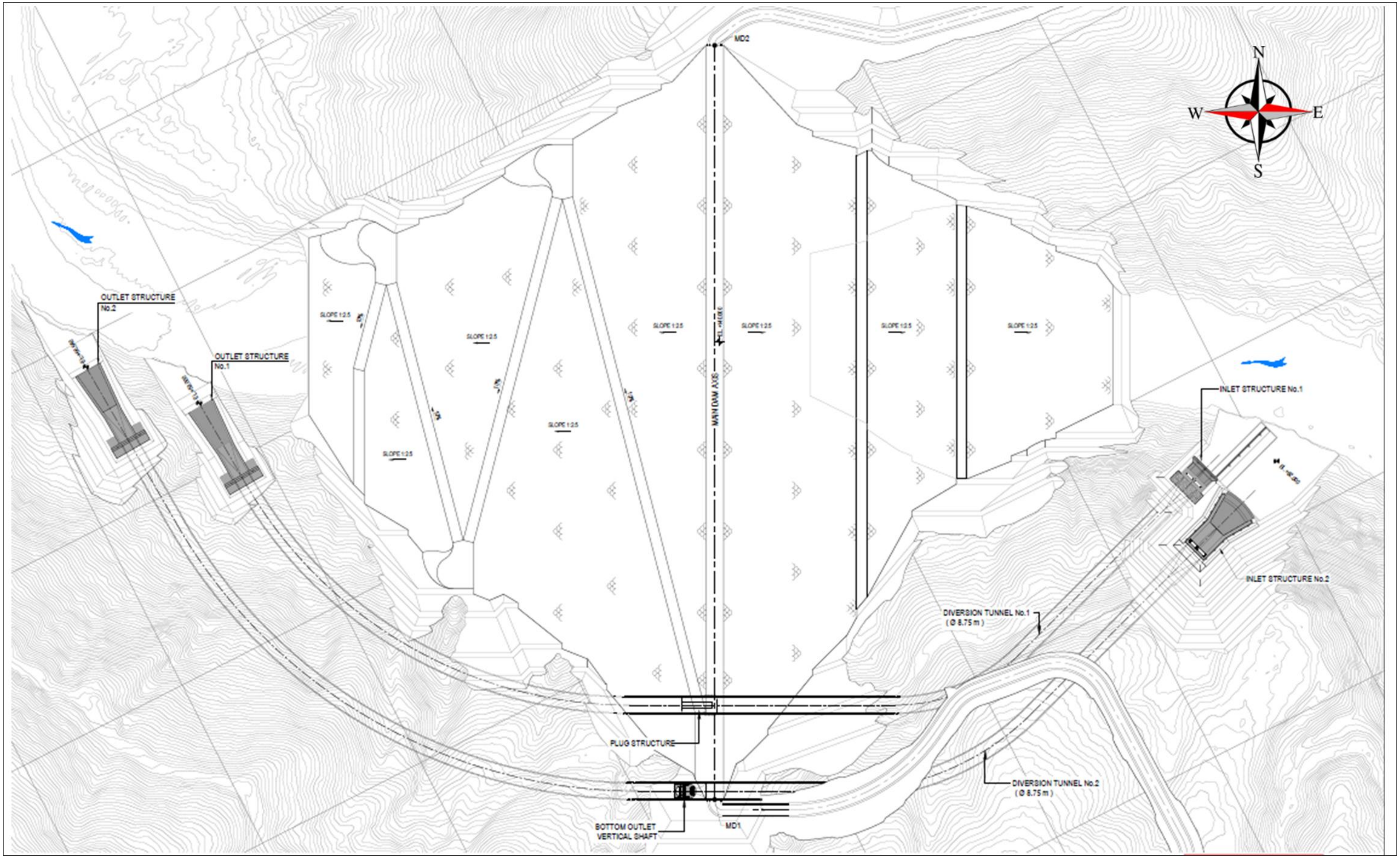


Figure RA-7. Plan view of Upper Wawa Dam and vicinity area.	DATA INFORMATION/SOURCE:	WawaJVCo INC. aperçu CONSULTANTS INC.	
ENVIRONMENTAL IMPACT STATEMENT ERA MODULE Wawa Bulk Water Supply Project – Upper Wawa Dam	**Source Map:** Tractebel, 2020 **Modified by:** APERCU CONSULTANTS, INC (2020)	Not to Scale	PAGE: 415

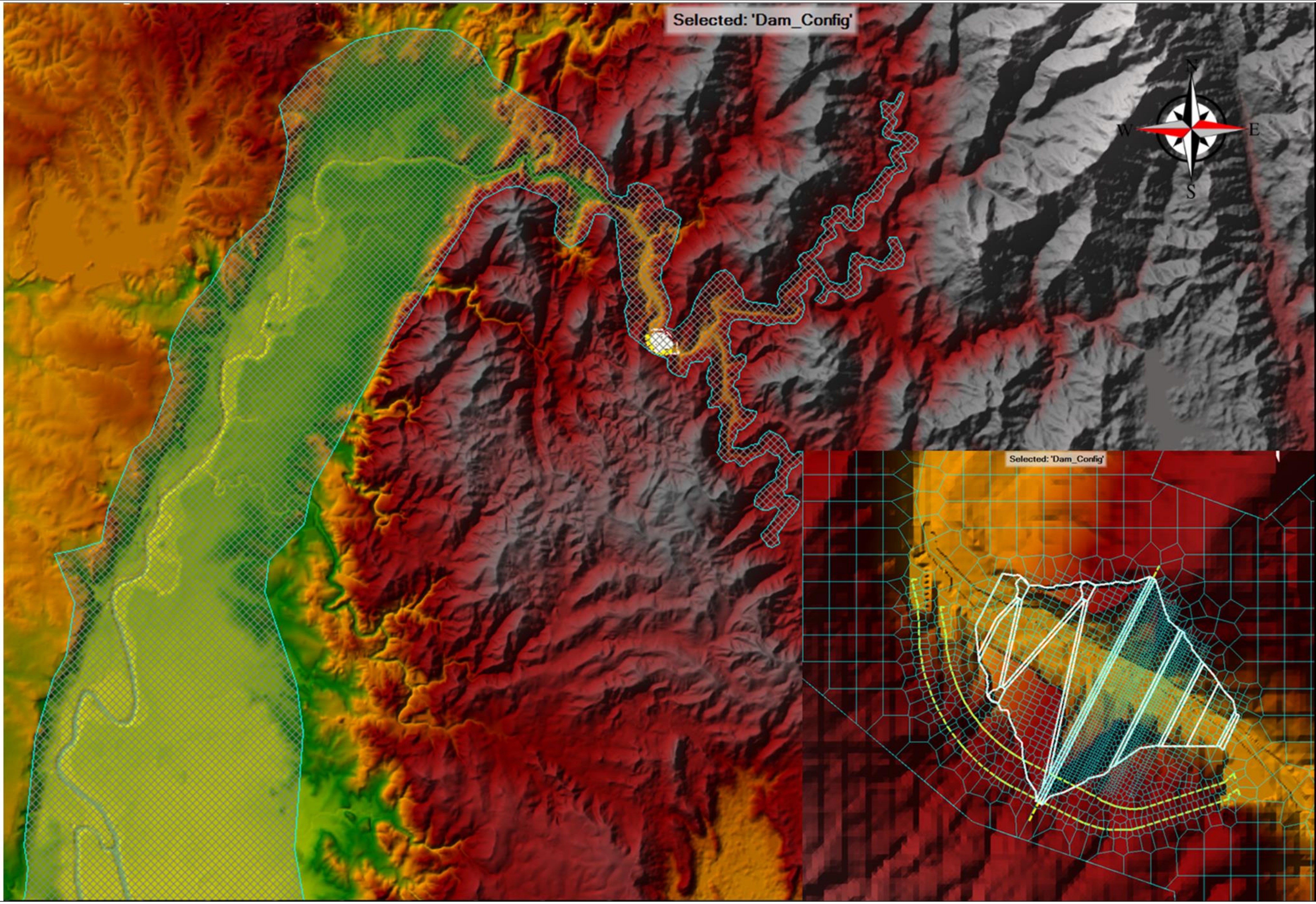


Figure RA-8. Dam and reservoir modelled as a 2D flow area overlaid in the digital elevation model; inset shows the computational mesh of the Upper Wawa Dam.	**DATA INFORMATION/SOURCE:** **Source Map:** Philkairos, 2020 **Modified by:** APERCU CONSULTANTS, INC (2020)	**WawaJVCo INC.** aperçu CONSULTANTS INC.
ENVIRONMENTAL IMPACT STATEMENT **ERA MODULE** **Wawa Bulk Water Supply Project – Upper Wawa Dam**		**Not to Scale** | **PAGE: 416**

The model was set-up to allow breaking of a certain section of the dam once the storage level reaches its normal flood elevation of 131.40 m ASL and letting it flow downstream due to actions of gravity. The geometric characteristics of the dam, as well as the bathymetry of the reservoir and downstream rivers and waterways, with sufficient accuracy are needed for a meaningful study. **Figure RA-9** represents the HEC-RAS geometry data.

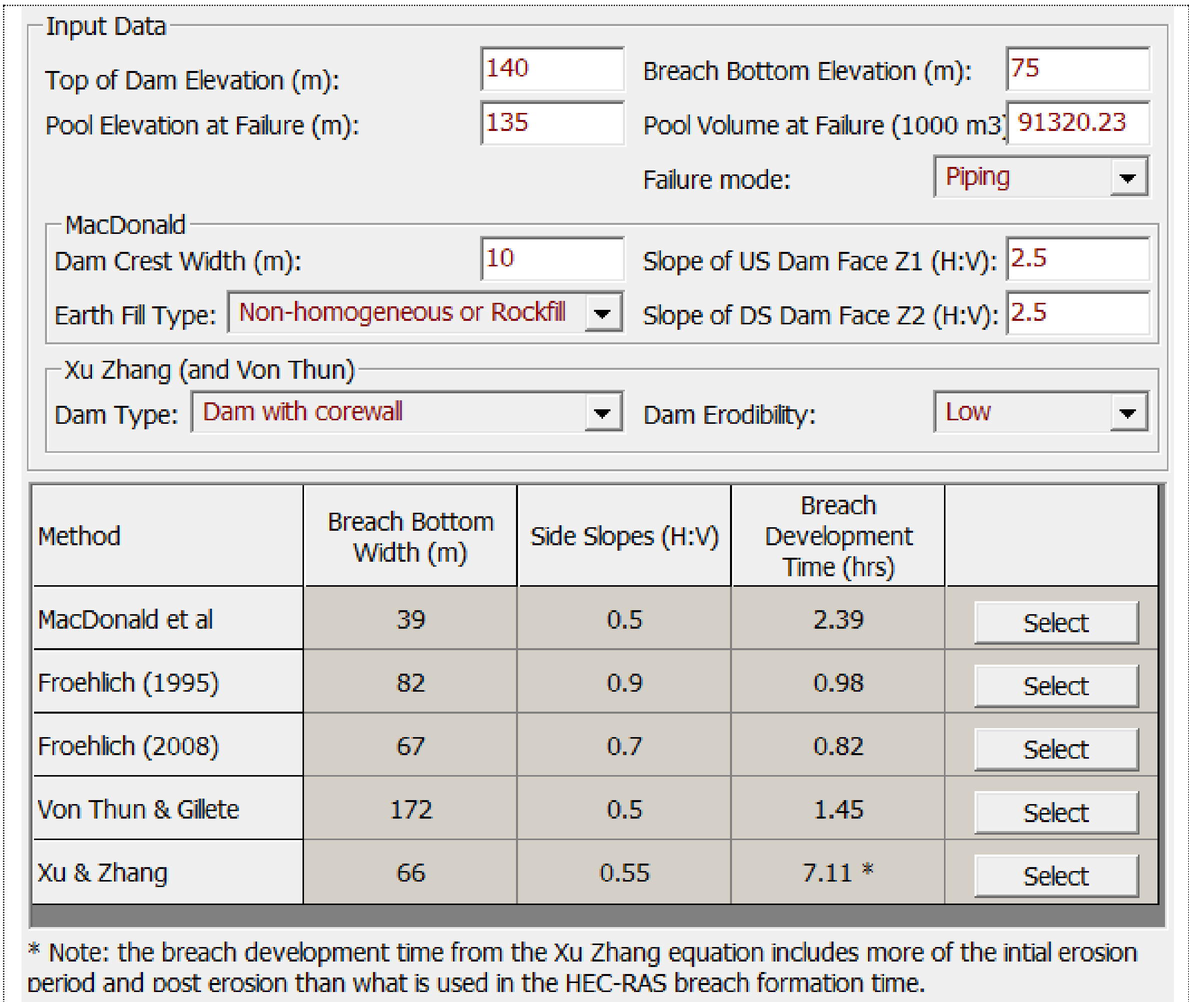
A hypothetical breaching of the dam was conceptualized using the two-dimensional option of the HEC-RAS model. The estimation of the breach location, size, and development time are crucial in order to make an accurate estimate of the outflow hydrographs and downstream inundation. However, these parameters are some of the most uncertain in the entire analysis (HEC, 2014).

In the latest version of HEC-RAS, the user is only allowed to enter a single value of the physical description of the dam breach consisting of the height of the breach, breach bottom width and side slopes. These values represent the maximum breach size. The aforementioned breach parameters, as well as breach development time, were derived using the physical characteristics of the dam structures. Below are the estimated parameters based on the number of regression equations developed by various researchers (see HEC, 2014 for more detailed discussions on these studies.

Except for the breach bottom width which were adjusted to conform with the width of the river, the side slopes and development time of the breach using the Von Thun and Gillette (1990) equation was used as basis for the hypothetical breach data of Upper Wawa Dam. Thus, the formation time of the breach is therefore assumed to be 1.45 hours, with the dam's water elevation of 131.40 meters above sea level triggering the start of the breach.

In addition, only piping break mode was considered because it is assumed that the diversion tunnels of the dam has adequate discharge capacity, as well as the provision of additional 5 meters of freeboard height above the maximum flood elevation, to prevent the dam failure due to overtopping. As explained in (ASDSO, 2020), piping failure of an earth dam takes place when water that seeps through the dam carries soil particles away from the embankment, filters, drains, foundation or abutments of the dam. If the seepage that discharges at the downstream side of the dam carries particles of soil, an elongated cavity or "pipe" may be eroded backward (working upstream) toward the reservoir through the embankment, foundation or abutment. When a backward-eroding pipe reaches the reservoir, a catastrophic breaching of the dam can occur.

In this Dam Break Analysis, the downstream boundary conditions of a constant water levels for Laguna Lake (1.50 m ASL), normal depth for the Pasig River, and upstream inflow hydrographs in river tributaries to fill the dam at a desired maximum flood level to trigger the hypothetical breach. The river inflows from tributaries where then purposely set to minimum after reaching the critical flood elevation to ensure that the resulting propagation of water spillage downstream can be attributed solely to the reservoir of Upper Wawa Dam. The two diversion tunnels were also partially blocked just to maintain minimum flows and prevent dry riverbeds (or zero flow) downstream of the dam.



Method	Breach Bottom Width (m)	Side Slopes (H:V)	Breach Development Time (hrs)	
MacDonald et al	39	0.5	2.39	Select
Froehlich (1995)	82	0.9	0.98	Select
Froehlich (2008)	67	0.7	0.82	Select
Von Thun & Gillete	172	0.5	1.45	Select
Xu & Zhang	66	0.55	7.11 *	Select

* Note: the breach development time from the Xu Zhang equation includes more of the intial erosion period and post erosion than what is used in the HEC-RAS breach formation time.

Figure RA-9. The GUI of HEC-RAS showing the computed breach parameters for various regression methods

7.4 Results and Discussions

Unsteady flow computations in HEC-RAS were utilized for the 24 hours model simulations, wherein the first seven (7) hours of the simulation period is used to ensure that the model reaches its equilibrium state thus preventing the effect of numerical oscillations as a result of the initial conditions of the model run. The next 17 hours were used to compute the hydraulic processes such as the flood depths and flow velocities as the flood moves from the breached dam and into the Marikina River downstream, until the flood recedes to its normal level.

Using the breach parameters as discussed in the previous section, with the initial piping occurred at 7:00 AM and complete breaching of the dam 1.45 hours after, the resulting flood propagation downstream of the breached dam and the extent of areal coverage of the flood are obtained after the unsteady flow simulation.

Flood inundation mapping is the most important dataset derived from dam breach analysis. In this study, the RAS Mapper tool within HEC-RAS were used for the processing of flood maps. The flood map shows the predicted maximum depths of water up to the extent where these flood waters reaches beyond the riverbanks up to the floodplains. Once the flood map is created, it can be overlaid on other relevant maps such as roads, buildings, administrative boundaries or satellite imageries that can be used to identify the existing infrastructures or landscapes within the predicted flood hazard zone.

Figure RA-10 shows the map of the maximum flood depths due to piping failure of Upper Wawa Dam overlaid on a satellite map. The flood map covers 80.98 square kilometers of land with varying depths of submergence. The map shows different water surface depths, differentiating them with color. As seen from the flood map that is overlain on the satellite map of the study area, a number of towns and villages along the Marikina River are affected by the flood caused by piping failure of the proposed Upper Wawa Dam.

Figure RA-11 shows the close-up view of the maximum flood depths at Brgy San Rafael, Rodriguez Rizal, which is one of the first communities to be flooded once the proposed dam breaches. Based on this map, the area of this Barangay nearest the riverbanks of Marikina River is the most vulnerable as the flood depths may reached 10 meters, with arrival time of flood peak predicted to be less than 1 hour after the start of the breach.

Using the simulation results, outflow hydrographs downstream of the breached dam as well as the discharge hydrographs at representative downstream locations are obtained after the unsteady flow simulation. **Figure RA-12** shows different hydrographs from upstream to downstream, starting from the section just downstream of the dam, in the area of Wawa National High School a few hundred meters downstream of the old Wawa Dam, near Eastwood Bridge, near San Jose Bridge, along Batasan-San Mateo Road, in the area of SM City Marikina, near Circulo Verde and finally, in the downstream portion of Manggahan Floodway.

Generally, outflow hydrographs emanating from a flood is characterized by a rising limb, a peak discharge and recession limb. In the case of flow hydrographs shown in the next figure, although the areas under these hydrographs (spilled reservoir volume) are more or less the same, the timing of peak discharge and its magnitude is dependent on the distance of that location to the breach location (or dam). High peak discharge rates and short timing of peak are predicted in areas a few kilometers downstream of the breach, and as the floodwaters cascade towards the generally flat areas downstream, and overflows beyond the riverbanks and into the floodplains, the peak discharge decreases with increased time to peak. The attenuation of the floods are more favorable since more time is available for the evacuations of local communities. It also decreases the hazard potential of the flood.

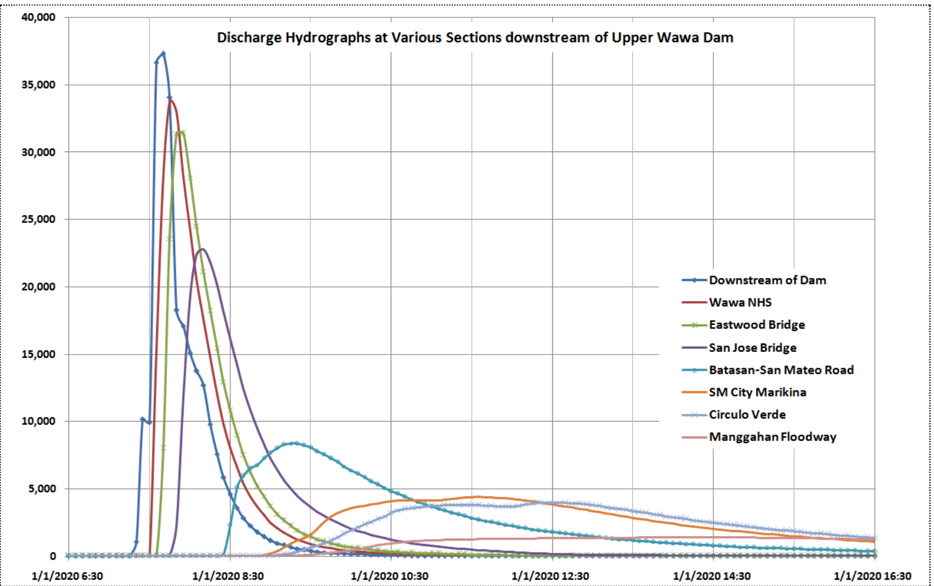


Figure RA-12. Discharge hydrographs for various representative sections downstream of Upper Wawa Dam.

Table RA-11 shows the predicted peak discharges, time of peak and the maximum depths of flood in the channel in the various representative sections downstream of the dam. Based on this table, the peak discharge of flood waters from the dam breach is predicted to reach Brgy. Wawa in 45 minutes, while the town center of Rodriguez, Rizal the flood peak discharge will occur about one (1) hour after the start of the breach. As the flow surges downstream, the flood peaks will reach Brgy. Ampid, San Mateo Rizal in 2 hours, in the vicinity of SM City Marikina in less than 4.5 hours, the area of Circulo Verde in Manggahan Pasig City in about 5.50 hours. Finally, further downstream of Mangahan Floodway towards Laguna Lake, the flood peak will arrive after about 7.33 hours.

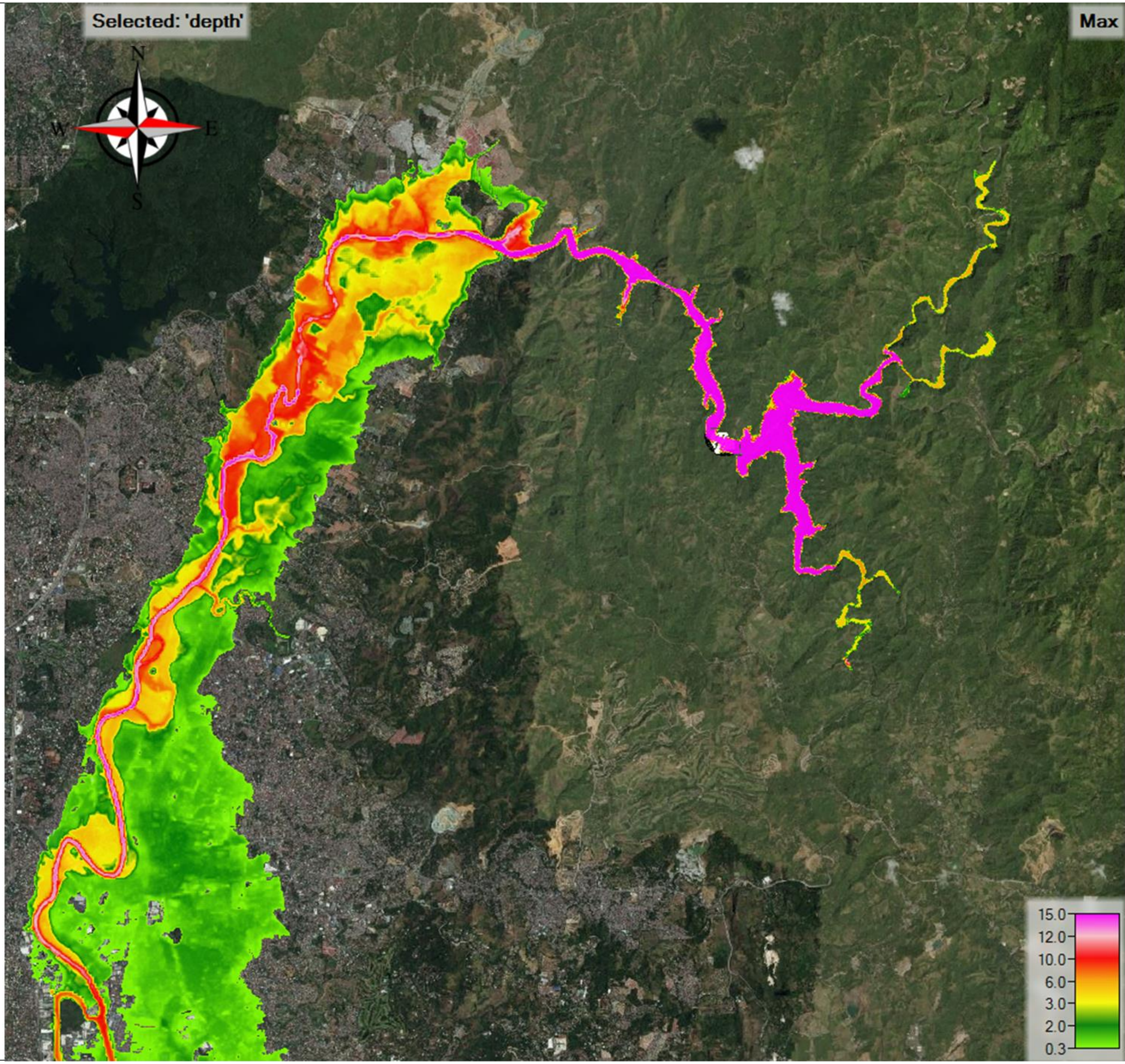


Figure RA-10. Flood inundation map of Upper Wawa Dam and downstream area.

ENVIRONMENTAL IMPACT STATEMENT
ERA MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

DATA INFORMATION/SOURCE:

Source Map: Philkairos, 2020
Modified by: APERCU CONSULTANTS, INC (2020)

WawaJVCo INC.
aperçu CONSULTANTS INC.

Not to Scale

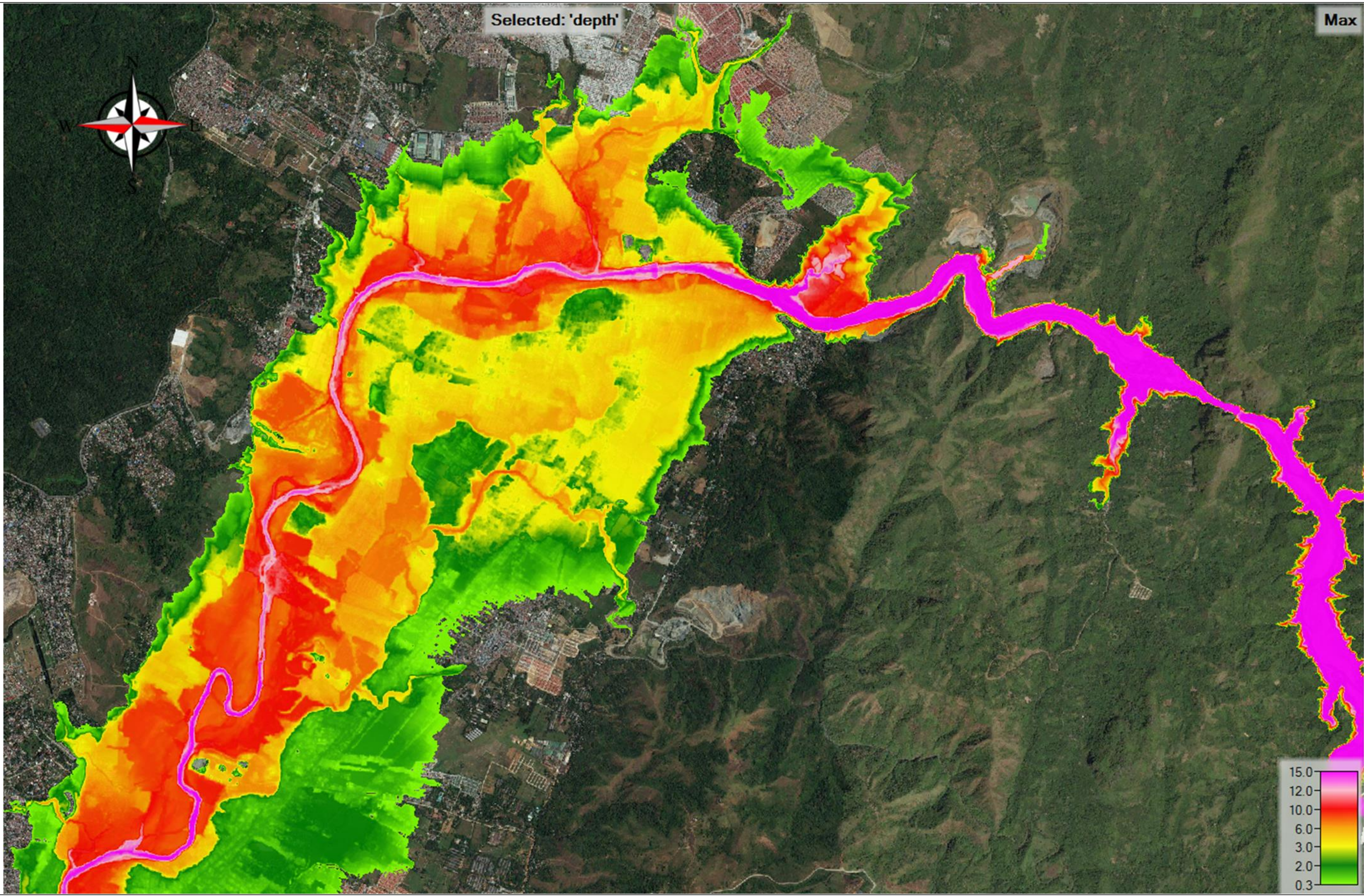


Figure RA-11. Close-up view of the flood inundation map of Upper Wawa Dam and downstream area.

ENVIRONMENTAL IMPACT STATEMENT
ERA MODULE
Wawa Bulk Water Supply Project – Upper Wawa Dam

DATA INFORMATION/SOURCE:

Source Map: Philkairos, 2020
Modified by: APERCU CONSULTANTS, INC (2020)

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Table RA-11
Peak discharge, time of peak and maximum flood depths for various representative sections downstream of Upper Wawa Dam

Location	Peak Discharge, in m^3/s	Time of Peak	Time of Peak Discharge After Start of Breach, in hours	Maximum Flood Depth in the Channel, in meters
Downstream of Dam	37,320.21	7:40 AM	0.67	28.844
Wawa NHS	33,760.85	7:45 AM	0.75	31.609
Eastwood Bridge	31,392.92	7:55 AM	0.92	20.505
San Jose Bridge	22,832.64	8:10 AM	1.17	13.819
Batasan-San Mateo Road	8,407.41	9:15 AM	2.25	14.143
SM City Marikina	4,420.17	11:25 AM	4.42	13.213
Circulo Verde	4,007.50	12:30 AM	5.50	9.805
Manggahan Floodway	1,427.65	2:20 PM	7.33	6.263

To visualize the peak arrival times of the flood in affected areas starting from the initial dam breach due to piping failure, the **Figure RA-13** shows the hourly contours (delineated by white lines) of peak flood arrival time. For example, the maximum flood in the area of Brgy. San Rafael will arrive in less than 1 hour while it will take less than 4.5 hours for the maximum flood to reach the area of SM City in Marikina. The maximum floodwaters is predicted to reach Laguna Lake, thru the Mangahan Floodway, in less than 9 hours.

Aside from flood inundation map, one of the outputs of a hydraulic model like HEC-RAS is the magnitude of flow velocities. With the sudden rush of floodwaters due to dam breach, higher than normal flow velocities are expected which may cause major structural damage or collapse of existing flood protection works along the river, or scouring of riverbeds, among others. High flow velocities may also delay the response for emergencies and evacuation, which may contribute significant losses to life and properties within the most flood-vulnerable communities.

From the velocity map shown in **Figure RA-14**, high flood events occur at the main channels which are potential hotspots for structural damage or property losses, which in some sections reach more than 15 meters per second. Communities located within the towns of Rodriguez and San Mateo, Rizal that are predicted to be the most vulnerable to be inundated by flood waters in less than 2 hours due to dam breach are also vulnerable to high flood flow velocities.

Using the predicted maximum depth and velocity values, the flood severity grid map were then derived by simply multiplying the depth grid times the velocity grid. The flood severity grid map represents the combined effect of depth and velocity, most often communicated in categories of Low, Medium, High, Very High and Extreme Hazard. As a simplified approach, Federal Emergency Management Agency (FEMA) considers the following depth*velocity categories than can be applied when symbolizing the results of the dataset (FEMA, 2018) (**Table RA-12**).

Table RA-12
Simplified Flood Depth and Velocity Severity Grid Symbolization Categories (FEMA, 2018)

Flood Severity Category	Depth * Velocity Range (ft^2/sec)	Depth * Velocity Range (m^2/sec)
Low	< 2.2	< 0.2
Medium	2.2 – 5.4	0.2 – 0.5
High	5.4 – 16.1	0.5 – 1.5
Very High	16.1 – 26.9	1.5 – 2.5
Extreme	> 26.9	> 2.5

To determine the severity of floods at the Barangay level, the GIS shapefiles of the administrative boundaries of identified Barangays affected by the flood is downloaded from publicly available datasets (www.philgis.org). With the predicted maximum depth and velocity values of the areas affected by the dam breach, the area of each cities and municipalities affected by the flood and classified as to the level of risk are summarized in the table below.

Note that the total area of each cities and municipalities reflected in the table below is not the total administrative areas of the LGU but is the total areas of Barangays under their respective jurisdictions that will be traversed by flood. The flood severity levels for each Barangay (**Table RA-13**) were aggregated to come up with city/municipality flood severity categories, as shown in the table below. As an illustration, communities affected by flood in Makati City, Quezon City and Antipolo City are quite minimal, while almost 41% of flood-affected areas within the jurisdiction of Marikina City fall within the high to extreme level of flood severity.

Table RA-13
Summary of Flood Severity Categories for the cities and municipalities affected by the flood

Municipality / City	Total Area of Brgys, has	Severity of Flood (in percent of total area)					
		No Risk (%)	Low (%)	Medium (%)	High (%)	Very High (%)	Extreme (%)
Makati City, MM	127.42	94.5	0.0	0.1	0.1	0.2	5.1
Marikina, MM	2,214.50	40.8	6.5	11.4	21.6	3.2	16.5
Pasig City, MM	2,855.80	35.7	19.4	22.5	14.3	1.1	7.0
Quezon City, MM	4,147.91	94.6	1.3	0.6	1.0	0.4	2.1
Antipolo City, Rizal	9,407.62	94.5	0.9	0.7	0.5	0.3	3.3
Cainta, Rizal	1,738.04	39.1	18.6	19.4	22.0	0.2	0.7
Rodriguez, Rizal	11,058.70	88.7	0.5	0.4	1.0	0.6	8.8
San Mateo, Rizal	4,164.24	74.2	2.2	1.7	7.8	2.5	11.7
Taytay, Rizal	1,728.93	57.4	33.7	2.5	1.2	0.4	4.8

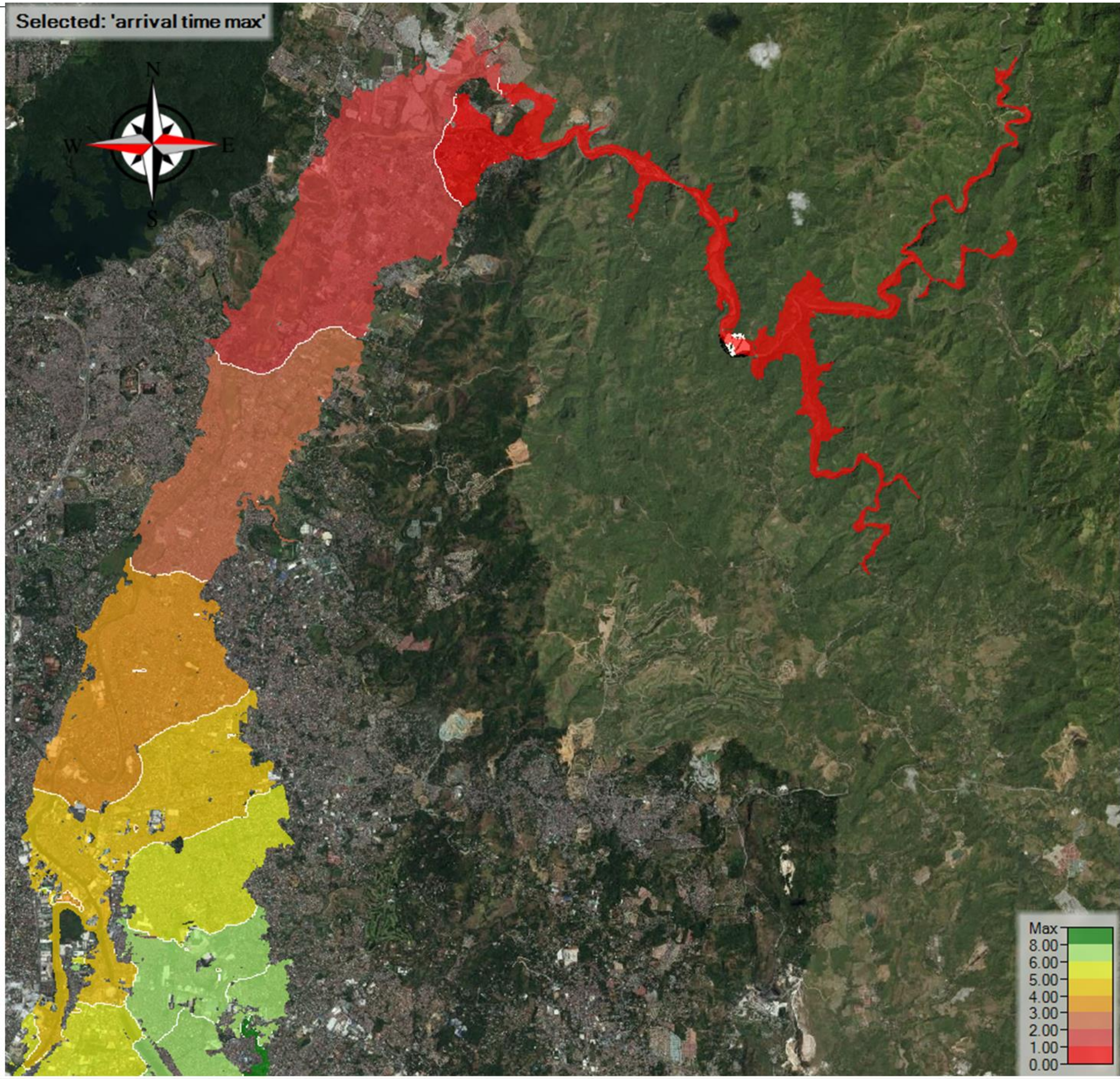

Figure RA-13. Map of estimated arrival times of flood peaks as it flows downstream of Upper Wawa Dam.

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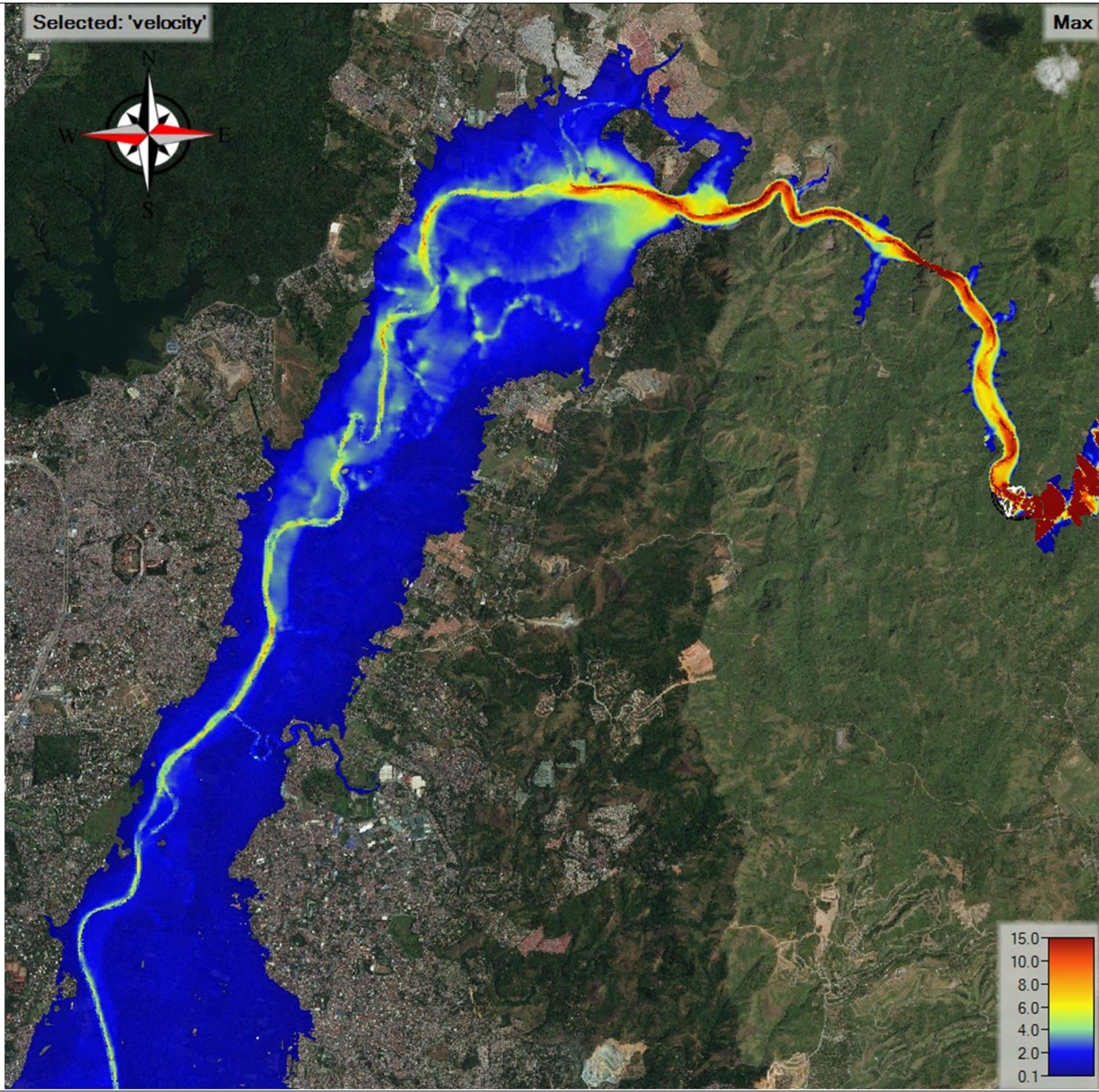

Figure RA-14. The predicted maximum flood velocity map at Upper Wawa Dam and downstream area.

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The flood severity grid map derived from the maximum depth and velocity values predicted by the application of HEC-RAS model for dam breach analysis is shown in the **Figure ER-15**. As previously stated, this severity level classification is based on the simplified categorization by FEMA.

Table RA-14 is the Barangay-level flood severity categories based on the flood severity map shown above, of which together with the generated flood inundation maps can be used for determining priority areas for the necessary flood warning and floodplain infrastructure or development control.

Table RA-14
Barangay-Level Flood Severity Categories

Municipality / City	Barangay Name	Total Area, Hectares	Severity of Flood (percent of land area)					
			No Risk (%)	Low (%)	Medium (%)	High (%)	Very High (%)	Extreme (%)
Makati City, MM	East Rembo	60.61	99.56	0.01	0.03	0.01	0.00	0.40
Makati City, MM	West Rembo	66.81	89.85	0.06	0.11	0.23	0.31	9.43
Marikina, MM	Barangka	86.15	91.18	1.53	3.31	3.96	0.02	0.00
Marikina, MM	Calumpang	79.21	2.31	6.21	25.60	14.81	4.81	46.26
Marikina, MM	Concepcion Dos	198.81	62.18	13.34	17.20	7.28	0.00	0.00
Marikina, MM	Concepcion Uno	376.30	14.89	8.69	13.44	23.89	6.71	32.38
Marikina, MM	Industrial Valley	77.78	80.22	3.10	2.59	3.57	2.94	7.57
Marikina, MM	Jesus de la Peña	91.62	7.41	6.94	8.50	13.56	16.96	46.63
Marikina, MM	Malanday	139.04	15.34	8.45	11.47	35.24	4.42	25.07
Marikina, MM	Marikina Heights	238.51	94.82	3.80	1.33	0.05	0.00	0.00
Marikina, MM	Nangka	141.76	7.51	8.60	14.67	23.78	2.48	42.96
Marikina, MM	Parang	382.87	75.50	4.42	4.42	14.99	0.17	0.51
Marikina, MM	San Roque	106.31	0.43	3.80	20.97	61.00	3.62	10.18
Marikina, MM	Santa Elena	54.54	1.12	4.81	9.23	60.48	1.40	22.97
Marikina, MM	Santo Niño	158.26	0.61	2.79	18.34	60.40	3.96	13.91
Marikina, MM	Tañong	83.32	30.04	10.22	25.36	11.53	3.46	19.39
Pasig City, MM	Bagong Ilog	124.62	98.37	0.03	0.03	0.08	0.05	1.44
Pasig City, MM	Bagong Katipunan	4.74	89.55	0.47	0.98	0.96	0.63	7.40
Pasig City, MM	Bambang	38.53	14.49	72.50	12.86	0.16	0.00	0.00
Pasig City, MM	Buting	20.16	77.77	3.44	0.56	1.62	5.41	11.20
Pasig City, MM	Caniogan	167.86	26.48	28.24	19.95	17.76	0.42	7.16
Pasig City, MM	Dela Paz	200.63	13.03	26.23	31.77	28.63	0.34	0.00
Pasig City, MM	Kalawaan	199.92	62.16	23.04	2.65	1.59	4.89	5.68
Pasig City, MM	Kapasigan	21.02	63.36	3.57	2.65	4.15	2.14	24.13
Pasig City, MM	Malinao	27.99	28.74	45.52	25.75	0.00	0.00	0.00
Pasig City, MM	Manggahan	572.37	22.43	24.62	28.73	16.24	0.85	7.12
Pasig City, MM	Maybunga	176.24	4.34	14.93	25.65	48.50	1.25	5.32
Pasig City, MM	Palatiw	24.34	0.00	30.83	68.61	0.57	0.00	0.00
Pasig City, MM	Pinagbuhatan	147.42	1.74	12.68	71.46	8.54	1.16	4.42
Pasig City, MM	Rosario	161.78	31.56	20.08	13.55	26.01	0.71	8.09
Pasig City, MM	Sagad	11.53	47.60	52.40	0.00	0.00	0.00	0.00
Pasig City, MM	San Joaquin	45.15	70.76	3.55	2.77	2.91	4.96	15.05
Pasig City, MM	San Jose	9.34	68.48	1.24	2.38	4.10	1.70	22.09
Pasig City, MM	San Miguel	72.96	15.78	17.70	48.40	18.10	0.01	0.00
Pasig City, MM	San Nicolas	31.00	12.20	51.28	36.52	0.00	0.00	0.00
Pasig City, MM	Santa Cruz	7.09	1.40	73.24	25.36	0.00	0.00	0.00
Pasig City, MM	Santa Lucia	180.56	13.52	12.92	34.59	22.13	0.89	15.95
Pasig City, MM	Santa Rosa	12.06	36.16	0.79	1.25	3.44	3.83	54.53
Pasig City, MM	Santo Tomas	10.74	2.02	83.87	14.11	0.00	0.00	0.00
Pasig City, MM	Santolan	196.27	10.40	17.86	28.36	14.67	2.07	26.64
Pasig City, MM	Sumilang	17.16	80.23	12.76	0.21	0.24	0.14	6.42
Pasig City, MM	Ugong	374.29	91.92	7.45	0.62	0.01	0.00	0.00

Municipality / City	Barangay Name	Total Area, Hectares	Severity of Flood (percent of land area)					
			No Risk (%)	Low (%)	Medium (%)	High (%)	Very High (%)	Extreme (%)
Quezon City, MM	Bagong Silangan	521.62	85.61	2.30	1.72	2.20	0.71	7.46
Quezon City, MM	Bagumbayan	151.00	66.40	17.49	1.68	3.69	3.64	7.12
Quezon City, MM	Batasan Hills	364.42	84.01	2.69	2.26	5.24	0.99	4.81
Quezon City, MM	Blue Ridge B	12.95	99.94	0.06	0.00	0.00	0.00	0.00
Quezon City, MM	Libis	11.36	99.32	0.68	0.00	0.00	0.00	0.00
Quezon City, MM	Matandang Balara	604.69	96.91	0.73	0.55	0.50	0.39	0.91
Quezon City, MM	Pasong Putik Proper	2,481.88	99.12	0.08	0.06	0.10	0.05	0.59
Antipolo City, Rizal	Bagong Nayon	1,510.92	83.24	1.12	0.79	1.34	0.76	12.76
Antipolo City, Rizal	Inarawan	3,357.77	98.43	0.17	0.09	0.21	0.12	0.99
Antipolo City, Rizal	Mayamot	1,506.15	93.30	3.56	2.78	0.36	0.00	0.00
Antipolo City, Rizal	San Juan	3,032.78	96.35	0.21	0.17	0.32	0.30	2.65
Cainta, Rizal	San Andres	407.93	25.96	21.45	28.34	20.51	0.76	2.99
Cainta, Rizal	San Isidro	908.49	38.79	12.13	18.25	30.73	0.10	0.00
Cainta, Rizal	San Juan	154.53	97.62	2.38	0.00	0.00	0.00	0.00
Cainta, Rizal	San Roque	46.50	55.79	38.56	2.47	3.13	0.05	0.00
Cainta, Rizal	Santa Rosa	29.43	59.98	32.74	2.66	4.61	0.00	0.00
Cainta, Rizal	Santo Domingo	113.53	13.51	30.92	41.60	13.93	0.04	0.00
Cainta, Rizal	Santo Niño	77.64	15.76	75.57	7.91	0.74	0.01	0.00
Rodriguez, Rizal	Balite	308.38	13.05	3.12	2.53	5.91	3.37	72.03
Rodriguez, Rizal	Manggahan	650.67	37.09	1.32	0.95	2.48	2.08	56.08
Rodriguez, Rizal	Rosario	2,717.15	81.18	0.93	0.78	2.02	1.33	13.76
Rodriguez, Rizal	San Jose	622.79	94.08	1.61	0.92	1.79	0.38	1.22
Rodriguez, Rizal	San Rafael	6,759.71	99.69	0.03	0.04	0.09	0.03	0.12
San Mateo, Rizal	Ampid I	127.96	35.23	10.86	4.27	19.90	19.44	10.30
San Mateo, Rizal	Ampid II	39.20	0.44	1.06	1.71	14.48	20.84	61.47
San Mateo, Rizal	Banaba	169.82	25.08	8.80	5.95	16.16	10.25	33.75
San Mateo, Rizal	Dulong Bayan 1	28.37	2.64	0.11	0.28	0.46	0.67	95.84
San Mateo, Rizal	Dulong Bayan 2	141.52	58.06	4.52	3.85	25.94	1.49	6.14
San Mateo, Rizal	Guinayang	224.83	60.70	4.00	3.18	4.58	0.89	26.65
San Mateo, Rizal	Guitnang Bayan I	27.14	0.00	0.00	0.13	31.63	4.57	63.67
San Mateo, Rizal	Guitnang Bayan II	162.38	73.66	3.30	2.75	18.65	1.64	0.00
San Mateo, Rizal	Malanday	271.80	51.97	2.74	4.97	14.56	0.42	25.33
San Mateo, Rizal	Maly	280.89	66.60	5.31	2.66	2.09	0.99	22.35
San Mateo, Rizal	Pintong Bocawe	2,202.47	96.37	0.14	0.09	0.16	0.10	3.15
San Mateo, Rizal	Santa Ana	487.87	43.41	2.96	2.89	26.88	8.10	15.76
Taytay, Rizal	Muzon	441.64	90.92	5.25	1.07	0.57	0.21	1.98
Taytay, Rizal	San Juan	657.95	42.42	48.57	0.90	0.60	0.46	7.05
Taytay, Rizal	Santa Ana	629.34	49.67	38.09	5.04	2.25	0.55	4.40

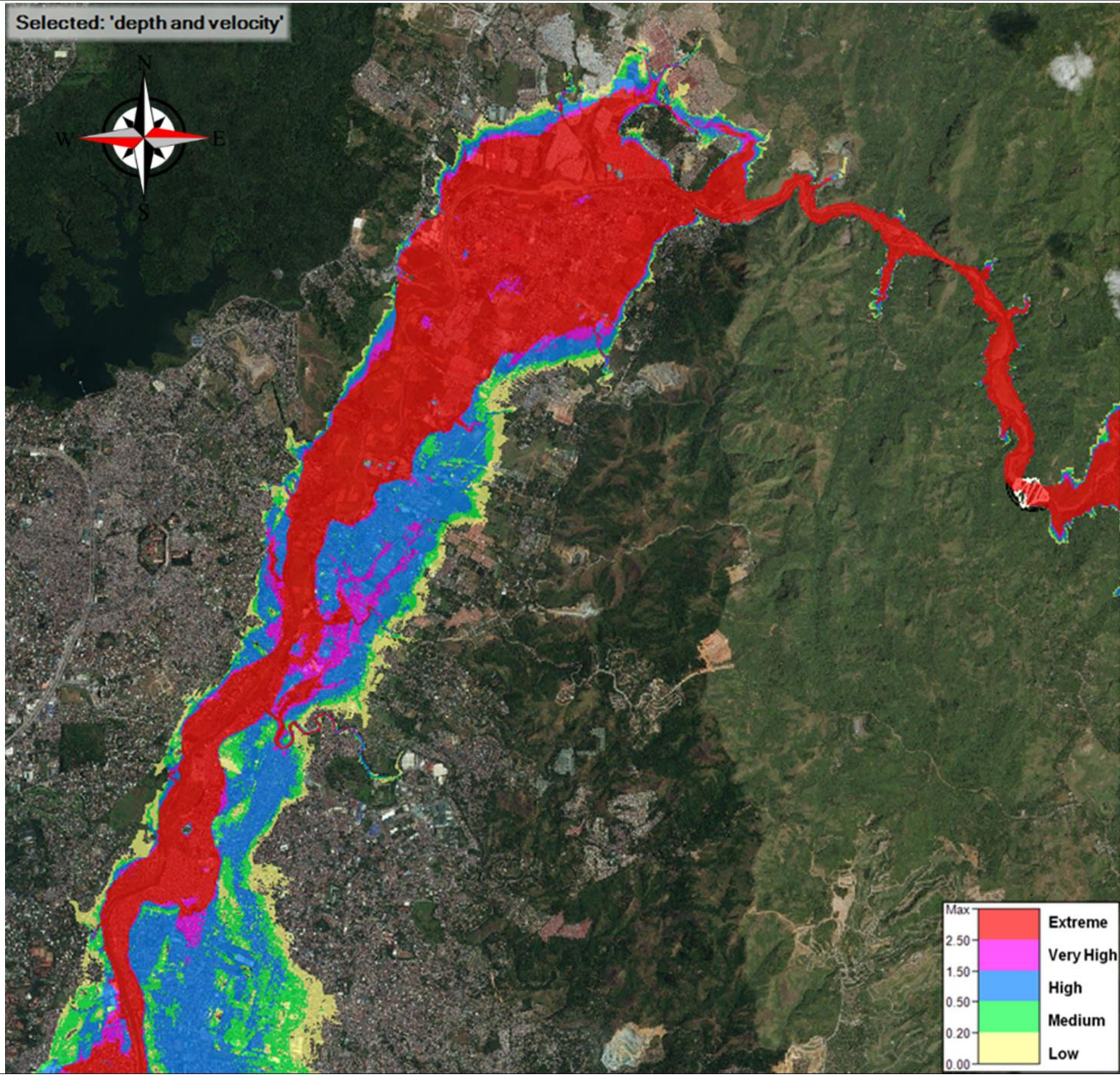

Figure RA-15. Flood severity grid map following FEMA's simplified categories for the study area.

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7.5 Conclusions

The triggering mechanism of a dam break is a rather complex and complicated process and are the subject of continuous researches and studies. The dam breach development parameters are usually based on regression methods developed by various authors. The dam break tool in HEC-RAS provides alternative approach within which those parameters can be estimated based on the physical configuration of the dam.

Using the unsteady flow option of HEC-RAS, the hydraulic computations and simulation of dam breach of Upper Wawa Dam were conducted and analysed based on given geometry data and breach development assumptions. The dam break due to piping failure predicts that the first communities downstream of the dam is the most at risk (extremely high based on FEMA category) as the flood peak arrival time in those areas are less than 1 hour with floodwaters reaching as high as 30 meters. This is not surprising as it is nearer the proposed dam.

Further downstream, based on the comparison of outflow hydrographs at different representative locations the magnitude of peak discharges reduces somewhat but the high water surface level remains to be very high, and along with arrival time for flood peak by a couple of hours, the magnitude and severity of flood risk is predicted to be very high (see severity grid map).

The produced maps and datasets from this study can be used as a guide for determining areas needing flood warnings and infrastructure development such as retrofitting or repair of existing flood control structures, deepening of waterways, and removal of obstructions, among others. Aside from hard infrastructures, there is a need to enhance the existing flood early warning system installed along Marikina River. Part of flood awareness and IEC should include the regular conduct of evacuation and emergency drills to be headed by the local DRRM officers and assisted by the dam operators especially for those communities within the identified high risk areas to better prepare them for any untoward incidences such as the sudden releases of flood waters, or for a worst case scenario like dam breach.

Although this is beyond the scope of the study, the proponent may wish to estimate the cost of economic loss in the event of dam breach which could help in identifying priority intervention or risk mitigation measures based on cost–benefit analyses of such interventions.

Nevertheless, this study provides an overview of how flood severity varies across the downstream areas of the proposed dam development using the dam breach analysis highlighting vulnerable and flood prone areas. Although most of the information is derived from secondary sources, specifically the topography of the terrain used in the modelling study, a more detailed datasets could provide for an improved outputs of flood severity.

Finally, FEMA's Hazard Potential Classification System for Dams is based on the probable loss of human life and the potential for economic losses, environmental damage, and/or disruption to lifelines caused by failure of mis-operation of a dam or its appurtenances. This Hazard Potential Classification System for Dams recognizes that the failure or mis-operation of any dam or water retaining structure, no matter how small, represents a potential danger to downstream life and property (FEMA, 2004). The results of this dam-breach analysis would show that large swath of inundation areas are urban development and resettlement areas and that potential loss of human life, just like what happened during the catastrophic typhoon-induced flooding in the same area (typhoon Ondoy in 2009), is not a remote possibility.

Thus, Upper Wawa Dam can be classified and considered as a High Hazard Potential Dam, based on FEMA's classification standard for any dam whose failure or mis-operation will cause loss of human life and significant property destruction.

IV. IMPACT MANAGEMENT PLAN

Table IMP-1
Impact Management Plan for Upper Wawa Dam Project

PROJECT PHASE/ ENVIRONMENTAL ASPECT	ENVIRONMENTAL COMPONENT LIKELY TO BE AFFECTED	PROJECT ACTIVITIES	POTENTIAL IMPACT	OPTIONS FOR PREVENTION, MITIGATION OR ENHANCEMENT	RATING/PERFORMANCE OF MITIGATING MEASURES	RESPONSIBLE ENTITY	COST	GUARANTEE/ FINANCIAL ARRANGEMENTS
I. PRE-CONSTRUCTION PHASE								
The pre-construction phase includes activities such as planning, conduct of the feasibility study, detailed engineering studies, ocular surveys, and permit procurement. There are limited impacts expected during this phase.								
II. CONSTRUCTION PHASE								
Land Component								
Land Module	Land Use and Classification	Construction and improvement of existing roads, Construction of dam and other project structures (i.e. spillway, pumping station, conveyance pipeline and support facilities such as diversion tunnel and cofferdams) Excavation and earth moving activities	Change of Land Use	• Implement a Watershed Management Framework that will include a comprehensive land use and watershed management plan such as replacement planting and reforestation and as part of the Catchment Area Treatment (CAT) Plan. • Apply for a Special Use Agreement within Protected Areas (SAPA), which shall include a Comprehensive Development Management Plan, and a PAMB Clearance once the ECC is released.	100% compliance to mitigating measures and regular monitoring of the Proponent	Owner	Included in the project development cost	Commitment of Proponent
Land Module	Land Use and Classification	Construction and improvement of existing roads,	Encroachment into Environmentally Critical Areas (ECA)	• Coordinate with PAMB and comply with the Protected Area Management Plan of the Upper Marikina River Basin Protected Landscape (UMRBPL).	100% compliance to mitigating measures and regular monitoring of the Proponent	Owner	Included in the project development cost	Commitment of Proponent

PROJECT PHASE/ ENVIRONMENTAL ASPECT	ENVIRONMENTAL COMPONENT LIKELY TO BE AFFECTED	PROJECT ACTIVITIES	POTENTIAL IMPACT	OPTIONS FOR PREVENTION, MITIGATION OR ENHANCEMENT	RATING/PERFORMANCE OF MITIGATING MEASURES	RESPONSIBLE ENTITY	COST	GUARANTEE/ FINANCIAL ARRANGEMENTS
Land Module	Land Use and Classification	Construction of dam and other project structures (i.e. spillway, pumping station, conveyance pipeline and support facilities such as diversion tunnel and cofferdams) Excavation and earth moving activities activities	Encroachment into Environmentally Critical Areas (ECA)	• Conduct of a Free, Prior and Informed Consent (FPIC) process facilitated by NCIP Region IV-A. • Apply for a Special Use Agreement within Protected Areas (SAPA) and PAMB Clearance once the ECC is released.	100% compliance to mitigating measures and regular monitoring of the Proponent	Owner	Included in the project development cost	Commitment of Proponent
Land Module	Land Use and Classification	Construction and improvement of existing roads, Construction of dam and other project structures (i.e. spillway, pumping station, conveyance pipeline and support facilities such as diversion tunnel and cofferdams)	Land Tenurial Issues	• Verify with NCIP the presence of tenured lands. • Verify with DENR-FMB and PAMB the extent and location of the NGP planting sites in the project site. • Secure agreements with concerned IP groups and social forestry project implementers.	100% compliance to mitigating measures and regular monitoring of the Proponent	Owner	Included in the project development cost	Commitment of Proponent

PROJECT PHASE/ ENVIRONMENTAL ASPECT	ENVIRONMENTAL COMPONENT LIKELY TO BE AFFECTED	PROJECT ACTIVITIES	POTENTIAL IMPACT	OPTIONS FOR PREVENTION, MITIGATION OR ENHANCEMENT	RATING/PERFORMANCE OF MITIGATING MEASURES	RESPONSIBLE ENTITY	COST	GUARANTEE/ FINANCIAL ARRANGEMENTS
		Excavation and earth moving activities						
Land Module	Land Use and Classification	Construction and improvement of existing roads Construction of dam and other project structures (i.e. spillway, pumping station, conveyance pipeline and support facilities such as diversion tunnel and cofferdams) Excavation and earth moving activities	Temporary Impairment of Visual Aesthetics	• Designate specific spoils dump area. • Maximize utilization of spoils/debris and muck. • Dispose rock from both surface and underground excavation works considering the spoils area layout that will maximize the storage volume while minimizing geographical extent; slope height, angle and stability; and spoil area filling sequence and compaction of waste material. • Re-vegetate exposed areas using indigenous species as part of the Watershed Management Framework.	100% compliance to mitigating measures and regular monitoring of the Proponent Absence of large spoils stockpiles in construction areas	Owner	Included in the project development cost	Commitment of Proponent
Land Module	Land Use and Classification	Construction and improvement of existing roads Construction of dam and other project structures (i.e. spillway, pumping station, conveyance pipeline and	Devaluation of Land Value as a Result of Improper Solid Waste Management	• Develop a Solid Waste Management Plan (SWMP) at work areas and worker's camps that includes practices to manage, reduce and reuse waste, and the establishment of a Materials Recovery Facility. • Coordinate with the LGU to determine the capacity to absorb new waste streams. • Implement strict rules on proper solid waste management that are to be	100% compliance to mitigating measures and regular monitoring of the Proponent	Owner and Contractors	Included in the project development cost	Commitment of Proponent and Contractor

PROJECT PHASE/ ENVIRONMENTAL ASPECT	ENVIRONMENTAL COMPONENT LIKELY TO BE AFFECTED	PROJECT ACTIVITIES	POTENTIAL IMPACT	OPTIONS FOR PREVENTION, MITIGATION OR ENHANCEMENT	RATING/PERFORMANCE OF MITIGATING MEASURES	RESPONSIBLE ENTITY	COST	GUARANTEE/ FINANCIAL ARRANGEMENTS
Land Module	Land Use and Classification	support facilities such as diversion tunnel and cofferdams) Excavation and earth moving activities		complied with by all personnel engaged or associated with the project. • Engage third party collectors if the local LGU network cannot accommodate the additional waste. • Appoint a licensed waste contractor for transfer of any hazardous waste from the construction site.	100% compliance to mitigating measures and regular monitoring of the Proponent	Owner and Contractors	Included in the project development cost	Commitment of Proponent and Contractor
Land Module	Geology	Excavation, drilling, filling, controlled blasting, and other earthmoving activities	Change in Surface Landform / Topography / Terrain/ Slope	• Conduct geotechnical studies, engineering design and innovative construction methods to minimize occurrence of destructive geologic processes. • Conduct detailed slope stability assessment for construction at slopes exceeding 22% and hazard assessment for slopes exceeding 60% and extending more than 200m in vertical slope distance. • Use grouting where seepages may occur to minimize water infiltration into natural fractures.	100% compliance to mitigating measures and regular monitoring of the Proponent	Owner and Contractors	Included in the project development and construction costs	Commitment of Proponent and Contractor
Land Module	Geology	Excavation of tunnels and other underground structures	Change in Sub-surface / Underground Geomorphology	• Conduct geotechnical studies to determine areas with potential for having tensional fault or potentially open faults or fractures in the reservoir that could be intruded by pressurized water, and to identify potential instability in the subsurface structures of the rocks. • Use rock bolts, steel support and linings to prevent collapse of any tunnel or chamber.	100% compliance to mitigating measures and regular monitoring of the Proponent	Owner and Contractors	Part of project development and construction costs	Commitment of Proponent and Contractor

PROJECT PHASE/ ENVIRONMENTAL ASPECT	ENVIRONMENTAL COMPONENT LIKELY TO BE AFFECTED	PROJECT ACTIVITIES	POTENTIAL IMPACT	OPTIONS FOR PREVENTION, MITIGATION OR ENHANCEMENT	RATING/PERFORMANCE OF MITIGATING MEASURES	RESPONSIBLE ENTITY	COST	GUARANTEE/ FINANCIAL ARRANGEMENTS
Land Module	Geology	Excavations and construction of dam	Changes in Rate of Erosion and Sedimentation	• Implement reforestation and watershed management activities which will contribute to erosion management. • Provide enclosures to sand and gravel stockpiles to minimize transport of sediments during heavy rains. • Provide siltation ponds or silt traps around the work areas. • Execute major earthworks during dry season; install temporary drainage structures if construction activities will extend into the rainy season.	100% compliance to mitigating measures and regular monitoring of the Proponent	Proponent and Contractors	Part of project development and construction costs	Commitment of Proponent and Contractor
Land Module	Geology	Excavations and construction of dam	Inducement of Subsidence, Liquefaction, Landslides, Mud / Debris Flow	• Place excavated materials in a designated spoils area. • Provide enclosures to sand and gravel stockpiles to minimize transport of sediments during heavy rains. • Provide siltation ponds or silt traps around the work areas. • Execute major earthworks during dry season; install temporary drainage structures if construction activities will extend into the rainy season. • Utilize excavated materials with suitable characteristic as part of the dam embankment or as part of the aggregates for concreting. • Reinforce cement concrete walls, create walls, stream banks and bunds with boulders crates, rock bolting and fencing.	100% compliance to mitigating measures and regular monitoring of the Proponent	Owner and Contractors	Part of project development and construction costs	Commitment of Proponent and Contractor

PROJECT PHASE/ ENVIRONMENTAL ASPECT	ENVIRONMENTAL COMPONENT LIKELY TO BE AFFECTED	PROJECT ACTIVITIES	POTENTIAL IMPACT	OPTIONS FOR PREVENTION, MITIGATION OR ENHANCEMENT	RATING/PERFORMANCE OF MITIGATING MEASURES	RESPONSIBLE ENTITY	COST	GUARANTEE/ FINANCIAL ARRANGEMENTS
				• Re-vegetate exposed areas as part of the Watershed Management Framework.				
Land Module	Geology	Excavations and construction of dam	Changes in Flooding cycle	• Provide robust and constantly updated flood warning and response systems. • Coordinate with EFCOS for system integration.	100% compliance to mitigating measures and regular monitoring of the Proponent	Owner and Contractors	Part of project development and construction costs	Commitment of Proponent and Contractor
Land Module	Pedology	Excavations and construction of dam	Soil Erosion / Loss of Topsoil / Overburden and Bank Stability	• Execute major earthworks during dry season; install temporary drainage structures if construction activities will extend into the rainy season. • Maintain a natural reserve around the reservoir to limit erosion and sediment deposition. • Add sediments downstream and divert sediment-laden flows upstream to reduce erosion and maintain channel morphology. • Install riprap or other bank protection structures and regenerate the buffer zone of riparian woodland. • Develop and implement an Erosion and Sediment Control Plan that is to be incorporated into the Construction Environmental Management Plan for all construction components.	100% compliance to mitigating measures and regular monitoring of the Proponent	Owner and Contractors	Part of project development and construction costs	Commitment of Proponent and Contractor
Land Module	Pedology	Construction of dam and earth moving activities	Change in Soil Quality / Fertility	• Conduct proper and regular maintenance of construction equipment and machinery. • Designate a machine and equipment maintenance area and fuel storage area that is cemented and equipped with	100% compliance to mitigating measures and regular monitoring of the Proponent	Owner and Contractors	Part of construction cost	Commitment of Proponent and Contractor

PROJECT PHASE/ ENVIRONMENTAL ASPECT	ENVIRONMENTAL COMPONENT LIKELY TO BE AFFECTED	PROJECT ACTIVITIES	POTENTIAL IMPACT	OPTIONS FOR PREVENTION, MITIGATION OR ENHANCEMENT	RATING/PERFORMANCE OF MITIGATING MEASURES	RESPONSIBLE ENTITY	COST	GUARANTEE/ FINANCIAL ARRANGEMENTS
				proper drainage canals and oil absorbing material to minimize soil contamination. • Store and dispose used oil and other hazardous wastes in secure area and according to DENR guidelines on handling, management, and disposal of hazardous wastes.				
Land Module	Terrestrial Ecology (Wildlife and vegetation)	Construction and improvement of existing roads Construction of dam and other project structures (i.e. spillway, pumping station, conveyance pipeline and support facilities such as diversion tunnel and cofferdams) Excavation and earth moving activities	Displacement /Disturbance of habitat for flora and fauna	• Conduct complete inventory of vegetation in impact areas. • Establish and implement Watershed Management Framework that will include buffer zone establishment thru assisted natural regeneration (ANR) and enrichment planting; construction of “vengineering” structures to control siltation; earth balling activity on threatened and ecologically important flora; and protection of existing thick vegetation which will serve as sources of seeds and seedlings. • Inform and increase awareness of locals and workers on the importance of the habitats through IECs. • Establish permanent nurseries for the seedlings and wildlings of important species, which will be collected prior to excavation and clearing activities. • Limit development activities within the proposed footprint and active construction areas by delineating the areas to be cleared, to avoid unnecessary clearing.	100% compliant and regularly monitored by the proponent	Owner and Contractors	Included in the construction cost	Include in the Engineering, Procurement and Construction (EPC) Contract
Land Module	Terrestrial Ecology (Wildlife and vegetation)		Displacement /Disturbance of		100% compliant and regularly monitored by the proponent	Owner and Contractors	Included in the	Include in the Engineering, Procurement and

PROJECT PHASE/ ENVIRONMENTAL ASPECT	ENVIRONMENTAL COMPONENT LIKELY TO BE AFFECTED	PROJECT ACTIVITIES	POTENTIAL IMPACT	OPTIONS FOR PREVENTION, MITIGATION OR ENHANCEMENT	RATING/PERFORMANCE OF MITIGATING MEASURES	RESPONSIBLE ENTITY	COST	GUARANTEE/ FINANCIAL ARRANGEMENTS
			habitat for flora and fauna	• Establish and maintain permanent vegetation outside of active construction areas. • Implement "No Hunting" and "No Collecting" policies for fauna and flora, respectively, that will apply to all personnel engaged in the project.			construction cost	Construction (EPC) Contract
Land Module	Terrestrial Ecology (Wildlife and vegetation)	Mobilization and construction of temporary facilities, diversion and earthworks	Threat to existence and/or loss of important local fauna and flora species/habitat fragmentation	• Develop and implement the ANR Plan (as part of Watershed Management Framework) which will retention of vegetated areas through which wildlife may use as areas corridors. • Implement a Wildlife Rescue Plan that includes relocating the rescued wildlife to a suitable habitat.	100% compliant and regularly monitored by the proponent	Owner and Contractors	Included in the construction cost	Include in the Engineering, Procurement and Construction (EPC) Contract
Land Module	Terrestrial Ecology (Wildlife and vegetation)	Mobilization and construction of temporary facilities, diversion and earthworks	Threat to abundance, frequency and distribution of important species	• Establish and implement the Watershed Management Framework that will also consider protecting an equivalent amount of land near the boundary of the watershed to ensure that alternative wildlife refuge is available.	100% compliant and regularly monitored by the proponent	Owner and Contractors	Included in the construction cost	Include in the Engineering, Procurement and Construction (EPC) Contract
Land Module	Terrestrial Ecology (Wildlife and vegetation)	Mobilization and construction of temporary facilities,	Hindrance to wildlife access	• Develop and implement the ANR Plan (as part of Watershed Management Framework) which will retention of	100% compliant and regularly monitored by the proponent	Owner and Contractors	Included in the construction cost	Include in the Engineering, Procurement and Construction (EPC) Contract

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		diversion and earthworks		vegetated areas through which wildlife may use as areas corridors				
Water Component								
Water Module	Hydrology	Construction of dam and cofferdams and earthmoving activities	Change in drainage morphology	• Construct river diversions with sufficient capacity to convey the natural stream flow of the dam. • Provide drainage channels in active excavation and clearing work areas.	100% compliance and regular monitoring and reporting should be done by proponent	Owner and Contractors	Included in the construction cost	Include in the Engineering, Procurement and Construction (EPC) Contract
Water Module	Hydrology	Construction of dam and cofferdams Earth moving activities in the project site	Change in River Water Depth	• Provide sediment/silt traps around the construction sites to prevent sediments reaching the waterways during rainfall. • Build cofferdams upstream and downstream of the diversion to ensure dry working condition while tunneling/excavation is done. • Convey excavated materials to the dam site and use as construction material in building the dam.	100% compliance and regular monitoring and reporting should be done by proponent	Owner and Contractors	Included in the construction cost	Include in the Engineering, Procurement and Construction (EPC) Contract
Water Module	Hydrology	Construction of dam and other infrastructures	Depletion of Water Resources/ Competition in Water Use	• Use other sources of water during construction, i.e. spring water that can be found within the vicinity of the project or a deep well that can be constructed specifically intended for the project but can be donated to the locals upon the completion of the project.	100% compliance and regular monitoring and reporting should be done by proponent	N/A	N/A	N/A
Water Module	Hydrology	Construction of dam and other infrastructures (i.e. spillways, pumping station, conveyance, pipeline, roads,	Reduction in volumetric flow (use of water for concreting, equipment uses, washing, personnel use)	• Source water requirements from springs that are located within close proximity to the construction site.	100% compliance and regular monitoring and reporting should be done by proponent	Owner and Contractors	Included in the construction cost	Include in the Engineering, Procurement and Construction (EPC) Contract

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		temporary and support facilities) Earth moving activities in the project site						
Water Module	Hydrology	Construction of dam, spillways and support facilities (i.e. cofferdams and diversion tunnels) Earth moving activities in the project site	Sediments reaching the waterways due to construction of support facilities, and tunneling/ excavation activities	• Provide sediment/silt traps around the construction site. • Build cofferdams upstream and downstream of the diversion to ensure a dry working condition while tunneling/excavation is done. • All sediments from building cofferdams and from the construction of the main dam and spillways must be conveyed properly and may be used as construction materials.	100% compliance and regular monitoring and reporting should be done by proponent	Owner and Contractors	Included in the construction cost	Include in the Engineering, Procurement and Construction (EPC) Contract
Water Module	Hydrology	Construction of dam, spillways and support facilities (i.e. cofferdams and diversion tunnels) Earth moving activities in the project site	Occurrence or aggravation of flooding in nearby areas due to dam failure during floods	• Construct the river diversion with sufficient capacity for PMF (Probable Maximum Flood) to convey the natural flow downstream during construction.	100% compliance and regular monitoring and reporting should be done by proponent	Owner and Contractors	Included in the construction cost	Include in the Engineering, Procurement and Construction (EPC) Contract
Water Module	Water Quality	Construction of dam and other infrastructures (i.e. spillways, pumping station,	Degradation of water quality through increased sediment from construction	• Conduct best practice in the management of earthworks. • Provide designated settling ponds/basins for run-off within construction areas.	100% compliance and regular monitoring and reporting should be done by proponent	Owner and Contractors	Included in the construction cost	Include in the Engineering, Procurement and Construction (EPC) Contract

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		conveyance, pipeline, roads, temporary and support facilities Earth moving activities in the project site	activities such as earthmoving and excavation	• Designate spoils and excavated material dumping areas that are far or away from the river/springs.				
Water Module	Water Quality	Installation of temporary facilities (i.e. camps and work areas)	Water quality degradation from effluents coming from workers' camps and work areas	• Installation of on-site toilets at working areas and toilet facilities at workers' camps. • Disallow and prevent direct discharge of any wastewater into the rivers and springs.	100% compliance and regular monitoring and reporting should be done by proponent	Owner and Contractors	Included in the construction cost	Include in the Engineering, Procurement and Construction (EPC) Contract
Water Module	Water Quality	Installation of temporary facilities (i.e. camps and work areas)	Water quality degradation from solid waste generated from workers' camps and construction areas	• Establish and Implement the Solid Waste Management Plan (SWMP). • Provide trash bins for various types of wastes in the working areas and in workers' camps. • Provide a Materials Recovery Facility. • Undertake regular segregation, collection and disposal of solid waste.	100% compliance and regular monitoring and reporting should be done by proponent	Owner and Contractors	Included in the construction cost	Include in the Engineering, Procurement and Construction (EPC) Contract
Water Module	Freshwater Ecology	Construction of dam, diversion tunnels and cofferdams, workers' camp and camp offices	Threat to existence and/or loss of important local species and habitat	• Cover collected stockpiles from the construction of dam, especially during heavy rains to prevent erosion of sediment and silt into rivers. • Construct drainage canals to trap and prevent sediment from being washed into nearby river sections. • Implement a proper segregation, re-use, recycle and disposal of wastes.	100% compliance and regular monitoring and reporting should be done by proponent	Owner, Environmental Monitoring Team, DENR	Include in the Construction Cost	Include in the Engineering, Procurement and Construction (EPC) Contract
Water Module	Freshwater Ecology	Construction of dam, diversion tunnels and cofferdams,	Threat to abundance, frequency and distribution of species		100% compliance and regular monitoring and reporting should be done by proponent	Owner, Environmental Monitoring Team, DENR	Include in the Construction Cost	Include in the Engineering, Procurement and Construction (EPC) Contract

PROJECT PHASE/ ENVIRONMENTAL ASPECT	ENVIRONMENTAL COMPONENT LIKELY TO BE AFFECTED	PROJECT ACTIVITIES	POTENTIAL IMPACT	OPTIONS FOR PREVENTION, MITIGATION OR ENHANCEMENT	RATING/PERFORMANCE OF MITIGATING MEASURES	RESPONSIBLE ENTITY	COST	GUARANTEE/ FINANCIAL ARRANGEMENTS
		workers' camp and camp offices		• Conduct regular monitoring of diversity of aquatic fauna and in-situ water quality.				
Water Module	Freshwater Ecology	Construction of dam	Weirs/ dams may block migration of fish.	• Provide fish passage sites to allow migratory fish to pass through.	100% compliance and regular monitoring and reporting should be done by proponent	Owner, Environmental Monitoring Team, DENR	Include in the Operation Cost	Include in the Engineering, Procurement and Construction (EPC) Contract
Air Component								
Air Module	Ambient Air Quality	Site Preparation and construction of project components (dam, spillway, new access roads, pumping station)	Degradation of air quality due to fugitive particulates and emissions	• Divide active construction sites into smaller areas, if possible. • Provide dust suppression measures, e.g., water application and speed restriction, in active construction areas and access roads. • Replace vegetation in non-structure areas and compact exposed soil surfaces to minimize wind erosion of topsoil. • Provide tarpaulin cover on trucks loaded with construction materials. • Haul spoils/excavated earth materials immediately after excavation.	100% compliance and regular monitoring and reporting should be done by proponent	Owner and Contractors	Included in the construction cost	Include in the Engineering, Procurement and Construction (EPC) Contract
Air Module	Ambient Air Quality	Site Preparation and construction of project components (dam, spillway, new access roads, pumping station)	Degradation of air quality due to SO_x and NO_x emissions	• Conduct regular maintenance of heavy equipment and motor vehicles and use low-sulfur fuel to minimize SO_x and NO_x emissions.	100% compliance and regular monitoring and reporting should be done by proponent	Owner and Contractors	Included in the construction cost	Include in the Engineering, Procurement and Construction (EPC) Contract
Air Module	Ambient Noise Quality	Site Preparation and construction of project components	Noise pollution	• Conduct regular maintenance of motor vehicle mufflers.	100% compliance and regular monitoring and reporting should be done by proponent	Owner and Contractors	Included in the construction cost	Include in the Engineering, Procurement and

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		(dam, spillway, new access roads, pumping station)		• Provide barriers and shield if any stationary vibrating equipment. • Schedule noisy activities during daytime as much as possible.				Construction (EPC) Contract
				People Component				
People	Affected Communities	Displacement and relocation of project affected persons/families (PAPs/PAFs) and structures	Physical and economic displacement of PAPs/PAFs	• Prepare and implement a resettlement and livelihood restoration program with disturbance/damage compensation in a timely manner, i.e. prior to project construction. The process should be participatory and should involve the project stakeholders, PA land claimant/holders, host LGU representatives, and LGU/barangay of the receiving community where the relocation site is located.	100% compliance and regular monitoring and reporting should be done by proponent	Owner, Host and receiving LGUs	Part of resettlement and livelihood restoration cost	Commitment of Proponent and host/receiving LGUs
People	Affected Communities	Construction of the dam and related structures	Limited influx of construction-related workers in host barangays	• Include in the contractors' contracts the provision of preferential employment for locals and decent accommodation for outside workers that should be provided with basic utilities such as water, electricity, health care and sanitation facilities.	100% compliance and regular monitoring and reporting should be done by proponent	Owner and Contractors	Included in the construction cost	Commitment of Proponent and contractor
People	Affected Communities	Construction of the dam and related structures	Impact on indigenous peoples and culture/lifestyle	• Comply with NCIP requirements after completion of the CP/FPIC process for the Tayabasan Multi-Basin System project which will also affect the same CADT	100% compliance and regular monitoring and reporting should be done by proponent	Owner	Included in the construction cost	Commitment of Proponent
People	Affected Communities	Construction of the dam and related structures	Impact on physical cultural resources	• Conduct a dialogue/consultation during the required FPIC process for the project. There is a proposal to relocate the "Istampang Bato" to the Wawa Ecotourism Site which will be decided on	100% compliance and regular monitoring and reporting should be done by proponent	Owner	Included in the construction cost	Commitment of Proponent

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				during the consultation with the Dumagat community.				
People	Affected Communities	Construction of access roads	Threats to delivery of basic social services and resource competition	• Construct a resettlement site with complete basic social services and utilities according to approved Philippine standards. • Construct roads that will follow the government standards for the construction of infrastructure projects.	100% compliance and regular monitoring and reporting should be done by proponent	Owner and Contractors	Included in the construction cost	Commitment of Proponent and contractor
People Module	People	Construction of dam, permanent structures (i.e. spillway, pumping station, conveyance pipeline and roads) and support facilities (cofferdam and diversion tunnels) Earthmoving activities	Traffic Congestion	• Set a proper speed limit within the identified busy, congested and prone to traffic areas only e.g. the start of access road construction. • Conduct frequent water spraying of roads to reduce dust resuspension, especially along the Sapinit Road and Pintong Bukawe Road which will be the access road leading to the dam area. • Install a safety and reflectorized traffic signs from and to the Project Site and at the community with languages translated to Tagalog for easy understanding of the people. • Install prominent Speed and Traffic Signs along all access road.	100% compliance and reporting should be done by proponent	Owner	Included in the construction budget	Traffic Management Plan

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III. OPERATION PHASE								
Land Component								
Land Module	Pedology	Operation of Upper Wawa Dam	Soil erosion/ Loss of topsoil/ overburden	• Implement quarterly monitoring of slope stability around the reservoir. • Enhance slope stability with reforestation of areas around the reservoir and of the watershed by the continuous implementation of the Watershed Management Framework.	100% compliance to mitigating measures and regular monitoring of the Proponent	Owner	Included in the operation cost	Commitment of Proponent
Land Module	Pedology	Operation of Upper Wawa Dam	Change in Soil Quality / Fertility	• Implement an environmental management plan that includes a spill control procedure. • Conduct proper and regular maintenance of equipment. • Store and dispose used oil and other hazardous wastes in secure area and according to DENR guidelines on handling, management, and disposal of hazardous wastes.	100% compliance to mitigating measures and regular monitoring of the Proponent	Owner	Included in the operation cost	Commitment of Proponent
Land Module	Geology	Operation of Upper Wawa Dam	Changes in Rate of Erosion and Sedimentation	• Implement reforestation and other watershed management activities to manage and minimize possible erosion in the area.	100% compliance to mitigating measures and regular monitoring of the Proponent	Owner	Included in the operation cost	Commitment of Proponent
Land Module	Geology	Operation of Upper Wawa Dam	Change in Surface Landform/ Topography/ Terrain/ Slope	• Re-vegetate cleared out areas to visually assimilate the old terrain and to maintain slope stability. • Manage water level fluctuations to prevent uncontrolled flow in and outside of designed drainages.	100% compliance to mitigating measures and regular monitoring of the Proponent	Owner	Included in the operation cost	Commitment of Proponent
Land Module	Watershed Management Framework	Impounding water	Loss of terrestrial wildlife and vegetation due to	• Establish and implement Watershed Management Framework	100% compliant and regularly monitored by the proponent	Owner	Included in the operation cost	Include in the EMF/EGF Contract

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			drowning during reservoir filling	• Assist LGUs in protection of nearby forested areas to ensure that alternative wildlife refuge is available. • Implement EMoP section on monitoring of flora, reptile species and other wildlife species.				
Land Module	Watershed Management Framework	Operations and maintenance of dam, pump station, transmission pipe, spillway	Loss of terrestrial wildlife and vegetation due to loss of habitats	• Stop clearing of habitats once the project is operational and restore and/or enhance habitats as part of the Watershed Management Framework. • Protect nearby forested areas to ensure that alternative wildlife refuge is available. • Implement a Wildlife Rescue Plan that includes relocating the rescued wildlife to a suitable habitat. • Implement EMoP section on monitoring of flora, reptile species and other wildlife species.	100% compliant and regularly monitored by the proponent	Owner	Included in the operation cost	Include in the EMF/EGF Contract
Water Component								
Water Module	Hydrology	Operation of Upper Wawa Dam	Change in drainage morphology	• Relocate inhabitants within the inundated areas. • Maintain the required ecological flow by the National Water Resources Board in the river for environmental use of flora and fauna. • Develop the spillways design based on the Probable Maximum Flood to accommodate or convey practically all excess inflows into the reservoir to avoid flooding or avoid dam breach.	100% compliance and regular monitoring and reporting should be done by proponent	Owner	Included in the operation budget	

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Water Module	Hydrology	Operation of Upper Wawa Dam	Reduction in volumetric flow downstream of the lower reservoir	• Maintain the required ecological flow by the National Water Resources Board.	100% compliance and regular monitoring and reporting should be done by proponent	Owner	Included in the operation budget	
Water Module	Hydrology	Operation of Upper Wawa Dam	Change in stream/water depth	• Relocate locals living within the identified inundation areas. • Maintain the ecological flow by the National Water Resources Board to ensure the ecological sustainability at the project site and minimize detrimental effects on water regime.	100% compliance and regular monitoring and reporting should be done by proponent	Owner	Included in the operation budget	
Water Module	Hydrology	Operation of Upper Wawa Dam	Depletion of water resources/ competition in water use	• Consider the ecological sustainability to maintain environmental flows in the rivers,	100% compliance and regular monitoring and reporting should be done by proponent	Owner	Included in the operation budget	
Water Module	Hydrology	Operation of Upper Wawa Dam	Occurrence or aggravation of flooding in nearby areas	• Design the spillways based on the probable maximum flood to accommodate and convey all excess inflows into the reservoir and to prevent flooding upstream or failure by dam breach.	100% compliance and regular monitoring and reporting should be done by proponent	Owner	Included in the operation budget	
Water Module	Hydrology	Operation of Upper Wawa Dam	Sedimentation behind the dam	• Provide adequate protection to the river/reservoir bank in the catchment area. • Extract deposited coarse material from the riverbed, if necessary. • Dredge sediment deposits and use sediment trapping devices, if necessary. • Use gated structures for flushing sediment while maintaining river regime.	100% compliance and regular monitoring and reporting should be done by proponent	Owner	Included in the operation budget	
				•				

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Water Module	Water Quality	Operation of Upper Wawa Dam	Degradation of water quality in the reservoir	• Regular clearing of vegetation will be implemented at the reservoir. • Regular release of water from the reservoir to downstream to prevent algal bloom and maintain water quality.	100% compliance and regular monitoring and reporting should be done by proponent	Owner	Included in the operation budget	
Water Module	Freshwater Ecology	Operation of Upper Wawa Dam	Change in water regime	• Maintain the ecological flow by the National Water Resources Board to ensure the ecological sustainability at the project site and minimize detrimental effects on water regime.	100% compliance and regular monitoring and reporting should be done by proponent	Owner, Environmental Monitoring Team, DENR	Include in the Operation Cost	Include in the Engineering, Procurement and Construction (EPC) Contract
Air Component								
Air Module	Ambient air quality	Operation of Upper Wawa Dam	Air pollution from standby generators and vehicle emissions	• Conduct regular maintenance of mufflers of standby generators and other pertinent equipment. • Use low-sulfur fuel.	100% compliance and regular monitoring and reporting should be done by proponent	Owner	Included in the operation cost	Include in MMT manual of operations Report in SMR
Air Module	Micro-climate	Operation of Upper Wawa Dam	Micro-climate effects due to GHG emissions	• Formulate and implement a greening program to provide carbon sequestration of the project in coordination with the local National Greening Program.	100% compliance and regular monitoring and reporting should be done by proponent	Owner	Included in the operation cost	Include in MMT manual of operations Report in SMR
Air Module	Ambient Noise	Operation of Upper Wawa Dam	Noise pollution from equipment	• Incorporate noise criteria in the specifications and selection of equipment. • Conduct regular maintenance of mufflers of standby generators and other pertinent equipment. • Use effective noise-attenuating materials for the structure and walling. • Plant appropriate vegetation as sound attenuation barriers.	100% compliance and regular monitoring and reporting should be done by proponent	Owner	Included in the operation cost	Include in MMT manual of operations Report in SMR

PROJECT PHASE/ ENVIRONMENTAL ASPECT	ENVIRONMENTAL COMPONENT LIKELY TO BE AFFECTED	PROJECT ACTIVITIES	POTENTIAL IMPACT	OPTIONS FOR PREVENTION, MITIGATION OR ENHANCEMENT	RATING/PERFORMANCE OF MITIGATING MEASURES	RESPONSIBLE ENTITY	COST	GUARANTEE/ FINANCIAL ARRANGEMENTS
People Component								
People Module	Affected Communities	Operation of Upper Wawa Dam	Generation of benefits from the project	• Ensure the relocation site will have upgraded dwellings, better public structures (elementary school, health center, covered court, etc.). • Support development of small and micro business enterprises from the anticipated tourism development will also improve the lives of host communities. Increased revenue from permits, taxes and share from national wealth taxes will help the host LGUs and barangays better serve the local residents through infrastructure development, improved social services, capacity building, etc.	100% compliance and reporting should be done by proponent	Owner	Included in the operation budget	Commitment of Proponent
People Module	Affected Communities	Operation of Upper Wawa Dam	Impact on riverine communities and those dependent on agroforestry products	• Organize the affected PA occupants into agroforestry associations or cooperatives and involve them in the management of fund acquired for the payment of environmental services through management of plant nurseries, guarding of watersheds, and participation and watershed reforestation and management. • Replace the affected farm lots or agroforestry areas with private fam lots.	100% compliance and reporting should be done by proponent	Owner	Included in the operation budget	Commitment of Proponent

PROJECT PHASE/ ENVIRONMENTAL ASPECT	ENVIRONMENTAL COMPONENT LIKELY TO BE AFFECTED	PROJECT ACTIVITIES	POTENTIAL IMPACT	OPTIONS FOR PREVENTION, MITIGATION OR ENHANCEMENT	RATING/PERFORMANCE OF MITIGATING MEASURES	RESPONSIBLE ENTITY	COST	GUARANTEE/ FINANCIAL ARRANGEMENTS
People Module	Affected Communities	Operation of Upper Wawa Dam	Implementation of CSR projects	• Aligned the CSR Project with the development needs of the host LGUs and barangays.	100% compliance and reporting should be done by proponent	Owner	CSR Budget	Commitment of Proponent Proper Coordination with all agencies involved
IV. ABANDONMENT PHASE								
The management measures for the abandonment phase will be formulate two (2) years before the planned closure.								

V. Social Development Plan (SDP) and IEC Framework

1.0 Social Development Plan

1.1 SDP Framework

This Social Development Plan (SDP)[1] for the Upper Wawa Bulk Water Supply Project is based on the consultation activities conducted in the host barangays (**Table SDP-1**).

Table SDP-1
Social Development Plan/Framework

Plans/Programs based on Applicable Various EIA Concerns	Responsible Community Member/ Beneficiary	Linkages with Government Agency/Non-Government Agency and Services	Proponent	Indicative Timeline	Source of Fund
Resettlement/Relocation					
1) Resettlement concerns are currently being addressed through the on-going Resettlement Action Plan and Livelihood Restoration Program Study that has been commissioned to a third party	Potentially project- affected families	RAPLRP Study Team, concerned Barangay and Municipal (LGU) Representatives, PASu	WawaJVCo	Pre-Construction Phase	WawaJVCo
2) Physical and economic displacement of affected riverine and agro-forestry resource holders. This and other concerns such as appropriate damage or disturbance compensation schemes and alternative livelihood and retooling of affected parties are being incorporated in the RAPLRP .	Affected riverine and agro-forestry resource holders and designated LGU representatives	RAPLRP Study Team, concerned Barangay and Municipal (LGU) Representatives, PASu	WawaJVCo	Pre-Construction Phase	WawaJVCo
3) Replacement of affected structures (e.g. school building, chapel, community facilities)	Directly affected communities	RAPLRP Study Team, concerned LGUs, persons-in-charge of affected facilities, concerned LGAs	WawaJVCo	Pre-Construction Phase	WawaJVCo

[1] All the projects will integrate a gender perspective, and health and safety protocols mandated by the Inter Agency Task Force on Emerging Infectious Diseases.

Plans/Programs based on Applicable Various EIA Concerns	Responsible Community Member/ Beneficiary	Linkages with Government Agency/Non-Government Agency and Services	Proponent	Indicative Timeline	Source of Fund
4) Transfer process of burial site	Directly affected communities	RAPLRP Study Team, concerned LGUs, persons-in-charge of affected facilities, concerned LGAs	WawaJVCo	Pre-Construction Phase	WawaJVCo
5) Processing of Voluntary Resettlement of directly affected parties who wish to avail if this program	Directly affected parties	RAPLRP Study Team, concerned LGU representatives and designated company representative	WawaJVCo	Pre and during Construction Phase	WawaJVCo
Sustainable Management of the Forest Ecosystem/Protected Area					
1) Assistance in organizing affected families and riverine/PA resource users, especially the tenured migrants, into upland cooperatives (complete with registration) to be contracted for PES projects.	Affected families and riverine/PA resource users	Concerned barangay officials, POs engaged in contract reforestation, PASu, company representative	WawaJVCo	Pre-Construction Phase	WawaJVCo
2) Formulation and implementation of PES projects.	Organized and registered upland cooperatives of project-affected families and riverine/PA resource users	PASu, host LGUs, company representative	WawaJVCo	Pre-Construction Construction Operation Phases	WawaJVCo
Measures to Ensure Preferential Employment of Local residents					
1) Incorporation of relevant provisions on preferential employment of local; compliance with legal requirements on wages, benefits, health, safety (especially during the national public health emergency) and security; provision of decent workers' accommodation and sanitation facilities	Contractors and subcontractors	Contractors and subcontractors and designated company representatives	WawaJVCo	Pre-Construction Phase	WawaJVCo

Plans/Programs based on Applicable Various EIA Concerns	Responsible Community Member/ Beneficiary	Linkages with Government Agency/Non-Government Agency and Services	Proponent	Indicative Timeline	Source of Fund
2) A pre-project skills training program and orientation sessions for residents of host barangays to prepare them for project-related jobs.	Local residents especially from project-affected families/riverine resource users	Proponent and Host LGU representatives	WawaJVCo	Pre and during Construction Phase	WawaJVCo
CSR Projects and Social Amelioration Measures for Host Communities					
1) Formulation and implementation of CSR project and social amelioration measure according to expressed felt needs of communities and barangay LGUs, especially of the most vulnerable sectors I the community	Most vulnerable sectors of the host communities	Barangay officials and Sectoral Representatives, MSWDO, Company Representative	WawaJVCo	Pre-Construction Phase Construction Operation	WawaJVCo
2) CSR Fund for community-identified direly needed social services and infrastructure	Most needy areas	Barangay LGU, designated company representative in coordination with appropriate Municipal LGU Office	WawaJVCo	Operation phase	WawaJVCo
Provision of Contingency Safety Net Fund					
1) Providing a start-up capital that may be used for emergencies (e.g. extremely dry spells that can cause water shortage for farms, downstream of the dam, natural disasters, etc.) and credit requirements of project-affected residents	ject-affected families and resource users, affected farmers in downstream areas	Project-affected families and resource users, affected farmers in downstream areas	WawaJVCo	Construction Phase	WawaJVCo and chosen contractors
Support Projects for Tourism Development related to the Project					
1) Funding for an appropriate technical working group on Tourism development initiatives related to the project	Tour Operators, Tourism Facility Outfits, Tourism Industries in the Host Areas	Tourism offices of Host LGUs, designated company representatives and	WawaJVCo	Operation Phase	WawaJVCo, Department of Tourism, Host LGUs, Private Sponsors

Plans/Programs based on Applicable Various EIA Concerns	Responsible Community Member/ Beneficiary	Linkages with Government Agency/Non-Government Agency and Services	Proponent	Indicative Timeline	Source of Fund
		possible external consultants			
2) Appropriate SDP Programs and Projects shall be formulated as part of the FPIC process and in conjunction with the IP community's ADSDPP	IP community	Concerned NCIP office, the IP Community, Concerned Host LGUs and designated company representative	WawaJVCo	Pre-Construction Phase	WawaJVCo

The project's Social Development Framework emanates from the following:

a) The need for the company to responsibly undertake sustained measures to effectively mitigate the identified significant negative impacts of the project such as:

- ✓ Physical and economic displacement of households in the inundation area
- ✓ Physical and economic displacement of protected area occupants, who are also tenured migrants, whose land will be lost from the resulting inundation from the project
- ✓ Physical and economic displacement of the affected IP community
- ✓ Loss of certain structures such as chapels, school and other community buildings
- ✓ Loss of sacred sites
- ✓ Loss of planted vegetation from NGP projects
- ✓ Loss of agro-forestry crops/trees from CBFM projects
- ✓ Loss of crops of farmers due to lack of water attributable to the project
- ✓ Adverse effects on tourism activities downstream of the dam

b) The company's call of duty to generously share in the sustainable management of the forest ecosystem from which it derives environmental service of steadily providing for its water requirements while utilizing recommended strategies in the CUMRBPL Management Plan to create livelihood for project-displaced households and tenured migrants.

c) The company's obligation to initiate CSR projects to augment government's efforts social development and well-being of its host communities, and to address the needs of poor families and vulnerable sectors such as malnourished children, youth, women, PWDs, and senior citizens.

d) It is also the responsibility of the company for provide safety nets for its host population in case of adverse circumstances such as decreased water supply for agricultural areas downstream of the dam, calamities such as landslides and flooding, and possible project-related accidents.

e) The need to devise mechanisms to implement the LGU policy for preferential employment of locals and to effectively protect workers' rights to legally mandated wages, benefits, and entitlements such as appropriate accommodations in the project site, proper health and safety equipment.

f) The company can also use the SDP to promote tourism development in the host areas.

g) There is also the need for retooling project affected residents to enable them to do alternative occupations.

Recommended elements of the SDP are:

a) The formulation and implementation of a RAPLR program that is rights-based, inclusive, anticipative and responsive to the needs of the displaced parties, and environment-friendly.

b) An IPDP that is based on the results of the FPIC process with the Dumagat community, and that is anchored on the IP community's Ancestral Domain Sustainable Development and Protection Plan

c) A Menu of social amelioration packages according to type of affected party such as damage or disturbance compensation or damage compensation of for loss of crops affected farmers downstream of the dam, compensation for loss of agroforestry trees of protected area occupants, compensation for or replacement of loss of land of tenured migrants, etc.

d) Formulation and implementation of Payment for Environmental Services projects based on the forest protection strategies of the CUMRBPL Management Plan

e) Company support for Tourism-related projects in the host communities.

2.0 Information, Education and Communication (IEC)

2.1 IEC Framework

The IEC framework below was based on the suggestions during the public consultations conducted, as well as on the continuing activities of the Community Relations Officer of the Proponent.

Table SDP-2
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	Cost Considerations
Potentially project-affected families and affected riverine and agro-forestry resource holders and designated LGU representatives	• Potentially project- affected families and affected riverine and agro-forestry resource holders and designated LGU representatives.	• Official request for meeting/consultation with attachments • Actual meetings/presentation of RAPLR program. • Compensation Schemes and Alternative Livelihood Proposals	• Invitation Letters • Meetings • Focus Group Interviews	• Soonest Possible Time	• Production Cost of IEC Materials • Food for participants
Host Barangay Councils Host City Mayors and key officials (City Engineer, Assessor, Planning, Traffic Management Unit etc.) Host City Councils Provincial Officials	• Project Description and Timeline • Resettlement Action Plan and Livelihood Restoration Program and Compensation Schemes for other Affected Resources • Presentation of salient points of the ECC • Social Development and IEC Plans	• Official letter from Proponent with attachments • Meetings/Project presentations • Periodic Visit to update LGU officials	• Invitation Letters • Meetings • Focus Group Interviews • Open and Constructive Dialogues • PowerPoint presentation	• After the ECC issuance prior to site development and construction • Twice a year or according to project milestones	• Production Cost of IEC Materials • Food for Participants
Potentially-affected families to be relocated, and affected riverine and agro-forestry resource	• Project Description and Timeline • Livelihood Restoration Program and Compensation Schemes for other Affected Resources	• Official letter from Proponent • One day conference	• Invitation Letters • Meetings • Focus Group Interviews • PowerPoint presentation	• After ECC issuance and prior to start of RAP implementation	• Production Cost of IEC Materials • Venue Hall Preparation

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	Cost Considerations
holders, and designated LGU representative	• Presentation of salient points of the ECC • Social Development Plan especially social amelioration measures, livelihood restoration, credit/loan program				• Food for participants • Honoraria for workers/staff to replace income for the day.
Potentially-affected families to be relocated, and affected riverine and agro-forestry resource holders, and barangay LGU representative and PAMB or PASU representative	• Brief orientation on the NIPAS and ENIPAS Acts • Prohibited acts in Protected Areas • Pertinent sections on FLUP and the UMRBPL Management Plant (e.g. threats to forest and forest land and strategies on forest/PA management)	• Official request letter from proponent • One day seminar with Power Point Presentations • Easy to read hand outs	• Invitation Letters • Meetings • Focus Group Interviews • Open and Constructive Dialogues • PowerPoint presentation • Hand-outs	• After ECC Issuance and prior to construction	• Production Cost of IEC Materials • Food for Participants • Posters • Hand outs
Barangay Officials and concerned City Officials	• Available Job Opportunities • Available Pre-job Trainings • Scholarships for Upper Wawa project-related jobs	• Letter from Proponent and SDP Team • Meetings • Posters	• Invitation Letters • Meetings • Focus Group Interviews • Open and Constructive Dialogues • PowerPoint presentation	• After ECC Issuance and prior to construction	• Production Cost of IEC Materials • Food for Participants • Posters • Wawa JV Co website
Sub-contractors for the site development and construction stages Workers	• Salient Points of the Environmental Management Plan and Pertinent points of the ECC. • Brief orientation Preferential Employment of locals, provision of legally mandated wages, benefits, and decent accommodation for workers in the project site, and on the Solid	• This can be integrated in the General HSSE Orientation. • Power point presentations need to be prepared. • Posters on Dos and Don'ts and Reminders on Proper Solid and Liquid Waste Management are needed.	• Invitation Letters • Meetings • Focus Group Interviews • Open and Constructive Dialogues • PowerPoint presentation	• Prior to start of Site Development • Prior to start of construction of segments per host area.	• Food for short seminar • Printing of Posters

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	Cost Considerations
	Waste and Liquid Waste Management Policies of the Host LGUs				
Appropriate IEC Program shall be formulated as part and result of the FPIC process	• Concerned NCIP Office, IP community, Barangay LGU and designated company representative	• IP community	• Invitation Letters • Meetings • Focus Group Interviews • Open and Constructive Dialogues • PowerPoint presentation	• Pre-construction activity onwards	• Proponent

The need for an IEC program is based on the following:

1. The IEC that was done during the EIA was limited, reaching mostly LGU officials and a few leaders in the host areas.

2. The project-affected families who expressed willingness to be relocated in 74%. Many more need to be properly informed to be able to decide whether or not to accept the option of relocation.

3. The holders of the affected riverine and agro-forestry areas still need to be informed that their occupied sites are part of the inundation area, and that consultations with them are needed to finalize matters on disturbance or damage compensation, and ways on how to restore their livelihood.

4. The Socio-Economic Team also observed during the IEC series and data-gathering period that residents in the host areas only knew in general, that part of their barangays or municipalities were covered by a watershed reservation/protected area but their understanding of their responsibilities as occupants of a protected area needs to be raised.

5. LGUs, residents and other stakeholders' need to be regularly updated about the project and its details, especially on the resettlement action plan and livelihood restoration program and compensation packages, so that proper inter and intra-LGU coordination and decisions can be made. For example, discussions on the resettlement site are mostly being discussed by the proponent and the concerned barangay officials. Levelling off among the LGUs involved, about resettlement matters is very crucial. A lot more consultations are needed to flesh out the details and to arrive at a consensus on the resettlement action plan and the compensation packages.

6. Widespread information is also needed so that interested local residents will know about project schedules so that they can submit their timely applications for pre project trainings and actual jobs.

VI. ENVIRONMENTAL COMPLIANCE MONITORING

As specified in the MC 2010-14, the Environmental Compliance Monitoring (ECM) system shall be composed of the following mechanisms to evaluate environmental compliance:

- Self-monitoring Plan (SMP);
- Multi-sectoral Monitoring Framework; and the
- Environmental Guarantee and Monitoring Fund Commitment.

1.0 Self-monitoring Plan

The proposed Self-monitoring Plan (SMP) is presented in **Table ECM-1** that includes the key environmental components (land, water, air and people) categorized per project phase along with its corresponding potential impacts to which DENR Rules and Regulations may be applied. Essentially, the SMP aims to ensure that all emissions and effluents from the project will comply with the DENR Rules and Regulations for instance 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 under **Table ECM-1** were initially assigned the following values:

- Alert (warning): 70% of the limit;
- Action: 80% of the limit; and
- Limit: 90% of DENR standard value.

WawaJVCo will be stringent in monitoring the ‘Alert’ and ‘Action’ values in the EQPL to prevent and avoid reaching the ‘Limit’ values.

Table ECM-1
Environmental Monitoring Plan for the Wawa Bulk Water Supply 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					
			Method	Frequency	Location			EQPL RANGE			MGT MEASURE		
								ALERT	ACTION	LIMIT	ALERT	ACTION	LIMIT
PRE-CONSTRUCTION PHASE													
The Pre-construction phase covers activities like planning, feasibility study, and drawing of plans, 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 (Land Use)	Impairment of visual aesthetics	Presence of solid wastes Stockpiles of construction materials	Visual observation	Weekly	Active construction areas, rivers/ creeks receiving discharge from construction areas project cost	PCO	Part of the project cost	Observed presence of solid wastes	Second offense	Third offense	Determine source of wastes and inform contractor and workers about proper solid waste management	Remind Contractor about SWM measures	Provide written notice to Contractor
Land Component (Geology)	Acceleration of geologic processes	Induced earthquakes and other perceptible earthquakes	Micro-seismic monitoring Use of strong motion accelerographs	During filling up of the reservoir	Reservoir area	Geologist/ Seismologist	Php 1 Million	Visible occurrence of erosion in active construction sites	Increased erosion rates even with measures in place	Occurrence of major slope instability due to project activities	Determine source of erosion and implement mitigating measures	Improve mitigating measures to minimize erosion	Install slope protection measures
		Erosion rates Occurrence of slope instability	Visual monitoring	Monthly during the rainy season	Hillsides with active construction activities	PCO	Part of the project cost	Visible occurrence of erosion in active construction sites	Increased erosion rates even with measures in place	Occurrence of major slope instability due to project activities	Determine source of erosion and implement mitigating measures	Improve mitigating measures to minimize erosion	Install slope protection measures
Land Component (Pedology)	Impact on soil quality	Total PCBs TPH Metals (Pb, As, Zn, Cr, Cu, Hg)	Collection and laboratory analysis of soil samples	Annually	One station near the machine repair shop/ storage area of	PCO	PhP 30,000	One parameter exceeding guideline value	Two parameters exceeding guideline value	Three parameters exceeding guideline value	Determine source of contamination and apply mitigating measure	Determine source of contamination and apply mitigating measure	Determine source of contamination and apply mitigating measure

Key Environmental Aspects per Project Phase	Potential Impacts Per Envt'l Sector	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost	EQPL MANAGEMENT SCHEME					
			Method	Frequency	Location			EQPL RANGE			MGT MEASURE		
								ALERT	ACTION	LIMIT	ALERT	ACTION	LIMIT
					hazardous wastes								
Land Component (Terrestrial Flora)	Loss of vegetation	Species richness, abundance, percent cover, species indices	Quadrant sampling, ocular survey, and interviews	Annually	Sampling sites used for the EIS	Wawa JVCo Inc. EO	Part of the construction cost	30% reduction in the abundance and diversity index based on baseline data	50% reduction in the abundance and diversity index based on baseline data	70% reduction in the abundance and diversity index based on baseline data	Conduct an investigation and identify possible cause. If Wawa JVCo Inc. is not the cause, inform MMT. If Wawa JVCo Inc. is the source, inform the management to improve mitigating measures.	Coordinate with LGUs/MMT. Conduct enrichment planting and monitor quarterly. Conduct IEC activities on the significance of biodiversity to stakeholders. Conduct Assisted Natural Regeneration.	Implement "No Activity Zone" in affected area. Monitor avifaunal species monthly. Conduct IEC activities on "No Activity Zone".
Land Component (Terrestrial Fauna)	Change in Diversity and Distribution of wildlife	Change in Diversity and Distribution of wildlife	Transect walk Mist netting and live trapping	Quarterly	Sampling sites used for the EIS	MMT and wildlife expert	Part of the construction cost	30% reduction in the abundance and diversity index based on baseline data	50% reduction in the abundance and diversity index based on baseline data	70% reduction in the abundance and diversity index based on baseline data	Conduct an investigation and identify possible cause. If Wawa JVCo Inc. is not the cause, inform MMT. If Wawa JVCo Inc. is the source, inform the management to improve mitigating measures.	Conduct enrichment planting. Provide nesting areas for avifaunal species and monitor quarterly. Conduct IEC activities on the significance of biodiversity to stakeholders.	Implement "No Activity Zone" in affected area. Monitor avifaunal species monthly. Conduct IEC activities on "No Activity Zone".
CONSTRUCTION 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 (Water quality)	Impact on Surface Water Quality of Tayabasan, Sapa Bute, Wawa and Boso Boso River	TSS	(S) Grab samples, preserved at 4°C (A) Gravimetric method (dried at 103-105°C)	Quarterly	Sampling sites used for the EIS	Wawa JVCo Inc. EO/ Consultant	Included in annual in-house monitoring budget	Not more than 56 mg/L rise from baseline	Not more than 64 mg/L rise from baseline	Not more than 72 mg/L rise from baseline	Improve mitigating measures or equipment. Re-conduct testing of water quality to verify parameters are within allowable limit. Monitor the conduct of water quality parameters sampling.	Implement appropriate corrective action on the identified pollution source. Conduct re-testing to verify parameters are within allowable limit. Monitor the conduct of water quality parameters sampling. Ongoing rainfall and stream flow measurements for documenting possible climate changes and extreme weather conditions	Temporary stoppage of activity Conduct re-testing to verify parameters are within allowable limit. Monitor the conduct of sampling. Inform MMT/LGUs.
		Oil & Grease	(S) Grab samples, glass bottle washed with solvent, acidification with nitric acid to pH 2, preserved at 4°C (A) Petroleum Ether Extraction					-	-	2			
		DO	In situ using DO meter/ Iodometric					3.5 mg/L	4mg/L	4.5 mg/L			
		Temperature	In situ using DO/ temperature meter					2.5°C max. rise	2.8°C max. rise	3.0°C max. rise			
		pH	In situ using pH meter/ Glass electrode					6.7-8.3	6.2-8.8	6.0-8.5			
		BOD_5	(S) Grab samples, preserved at 4°C (A) Azide Modification dilution technique					4.89mg/L	5.66mg/L	6.3mg/L			
		Fecal Coliform	Multiple tube fermentation technique					140 MPN/100mL	160 MPN/100mL	180 MPN/100mL			

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
		Phosphate	Approved methods of analysis in DAO 2016-08					0.35 mg/L	0.4 mg/L	0.45 mg/L			
		Nitrate	Approved methods of analysis in DAO 2016-08					4.89mg/L	5.66mg/L	6.3mg/L			
		Fluoride	Approved methods of analysis in DAO 2016-08					0.7 mg/L	0.8 mg/L	0.9 mg/L			
		Iron	Approved methods of analysis in DAO 2016-08					1.04mg/L	1.20mg/L	1.35mg/L			
Water Component (Freshwater Ecology)	Erosion of sediments and silt Impacts on diversity of biological communities	In-situ water quality parameters such as pH, dissolved oxygen, temperature, total suspended solids, total dissolved solids	Use of multi-probe water quality meter	Semi-annual	Impact and control stations	Client; Environmental Monitoring Team/ Consultant	Final cost will be determined during implementation of the project (Note: Rough estimate is P500,000 for two monitoring periods/ semi-annual monitoring)	N/A	N/A	Class "A/C" Waters (DENR AO 1990-34) pH – 6.5 to 8.5 DO – 5.0 mg/L TSS- 50mg/l/ not more than 30mg/l	N/A	N/A	Investigate the cause of changes in water quality levels. Increase monitoring of water level parameters to quarterly.
		Biological communities such as phytoplankton, zooplankton, macroinvertebrates and fish	Field survey/ Aquatic Ecology Survey					30% decrease in abundances of aquatic biota which are known indicators of good water	50% decrease in abundances of aquatic biota which are known indicators of good water quality/ habitat conditions	70% decrease in abundances of aquatic biota which are known indicators of good water	Investigate the cause of decrease in abundances of aquatic biota taking into account seasonal and	Increase monitoring of biological communities to quarterly.	Increase monitoring of biological communities to monthly.

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/ habitat conditions		quality/ habitat conditions	temporal variations.		
Water component (Hydrology)	There is no relevant impact on water component because water will be used only for the requirement of the construction personnel on support staff and they will get water from nearby groundwater sources.												
CONSTRUCTION PHASE – AIR and NOISE COMPONENT													
Air component (Ambient air quality	Particulate air pollution	TSP	(S) 1 hr (AM and PM) High Volume- (A) Gravimetric USEPA 40 CFR, Part 50, Appendix B			PCO	Part of operation cost	155	186	207 ug/ncm	ID pollutant source (construction activity, facility, or equipment).	Implement appropriate corrective action at identified pollutant source.	Temporary stoppage of identified construction activity or equipment
Ambient Sound Level	Particulate air pollution	PM10	1-hr (AM and PM) High Volume with 10-micron particle-size inlet (A) Gravimetric USEPA 40 CFR, Part 50, Appendix J	Quarterly (minimum) or as required	Within 200 meters of active construction sites and temporary facilities	PCO	Part of operation cost	101	121	135 ug/ncm	ID pollutant source (construction activity, facility, or equipment).	Implement appropriate corrective action at identified pollutant source.	Temporary stoppage of identified construction activity or equipment
Air component (Ambient sound levels)	Increase in ambient sound levels in receptor areas	Sound levels	1-hr sound measurements using hand-held sound meter (morning, daytime and evening			PCO	Part of operation cost	3 dB less than limit	2 dB less than limit	1 dB less than limit	Identification of possible source of noise.	Corrective action on noise equipment source Re-scheduling of "noisy activities"	Avoid use or replacement of noisy equipment
CONSTRUCTION PHASE – PEOPLE 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
People	Project will lead to the relocation of PAPs/PAFs	Compliance to Resettlement, Relocation and Livelihood Restoration Program	Review of records	Quarterly	Community Relations Office of Project Proponent	PCO	Part of PCO salary	Negative reports from employees and community	Increase in number of informal settlers and complaints regarding the implementation of the WawaJVCo RAP	Multiple complaints filed by the community due to increase in number of informal settlers and complaints regarding the implementation WawaJVCO RAP	WawaJVCo to investigate the cause of negative reports.	Corrective actions to be determined with coordination with LGUs and also corrective actions specified in the RAP	Coordination with LGUs and also corrective actions specified in the RAP
People	Project will increase livelihood opportunitie s for local workers	Number of locals employed by the project	Review of employment records	Quarterly	Contractors' Office	PCO	Part of PCO salary	Negative reports from employees and community	Increase in number of complaints	Multiple complaints filed by the community and employees	WawaJVCo to investigate the cause of negative reports.	Corrective actions to be determined with coordination with LGUs	WawaJVCo to investigate the cause of negative reports.
People	Project will affect a small Dumagat community	Compliance to FPIC process and relevant items in MOA.	Check completion of FPIC process and implementation of relevant items in the MOA	Prior to start of project construction Quarterly	Proponent Records; Sitio Anipa	PCO	Part of PCO salary	Negative reports from community residents	Increase in number of complaints	Multiple complaints filed by the community due to increase in Dumagat community complaints	WawaJVCo to investigate the cause of negative reports.	Corrective actions to be determined with coordination with LGUs	WawaJVCo to investigate the cause of negative reports.
People	Project will affect "Istampang Bato", a sacred site for the Dumagats	Relocation of Istamping Bato	Check compliance to relocation of sacred site	Once prior to start of project construction	Relocation site of Istampang Bato	PCO	People	-	-	-	-	-	-

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
OPERATION PHASE – LAND COMPONENT													
Land Component (Geology)	Erosion can occur in disturbed slopes due to construction of project structures	Erosion of disturbed slopes	Visual monitoring	Monthly during the rainy season	Hillsides near project structures	PCO	Part of the operation cost	Visible occurrence of erosion in disturbed slopes	Increased erosion rates even with measures in place	Occurrence of major slope instability near project facilities	Determine source of erosion and implement mitigating measures.	Improve mitigating measures to minimize erosion.	Install slope protection measures.
Land Component (Pedology)	Erosion of riverbanks and riverbed can result from loss or reduction of sediment load downstream	Erosion of riverbank and riverbed	Visual monitoring	Monthly during the rainy season	Hillsides near project structures	PCO	Part of the operation cost	Observed riverbank erosion downstream of dam	More observed riverbank erosion	More areas downstream exhibit riverbank erosion	Determine cause of riverbank erosion.	Improve mitigating measures to minimize riverbank erosion downstream of dam.	Install riverbank protection structures such as gabion, etc.
Land Component (Terrestrial Flora)	Loss of vegetation	Species richness, abundance, percent cover, species indices	Quadrat sampling, ocular survey, and interviews	Annually	Sampling sites used for the EIS	Client	Part of the Construction Cost	30% reduction in the abundance and diversity index based on baseline data	50% reduction in the abundance and diversity index based on baseline data	70% reduction in the abundance and diversity index based on baseline data	Conduct an investigation and identify possible source. If WawaJVCO is not the source, inform MMT. If WawaJVCO is the source, inform the management to improve mitigating measures.	Improve mitigating measures.	Fortify mitigating measures.
Land Component	Change in Diversity and	Change in Diversity and	Transect walk Mist netting and live trapping	Quarterly	Sampling sites used for the EIS	MMT and wildlife expert	Part of the construction cost	30% reduction in the abundance	50% reduction in the abundance	70% reduction in the abundance	Conduct an investigation	Coordinate with LGUs/MMT.	Implement "No Activity Zone"

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
(Terrestrial Fauna)	Distribution of wildlife	Distribution of wildlife						and diversity index based on baseline data	and diversity index based on baseline data	and diversity index based on baseline data	and identify possible cause. If Wawa JVCo Inc. is not the cause, inform MMT. If Wawa JVCo Inc. is the source, inform the management to improve mitigating measures.	Conduct enrichment planting. Provide nesting areas for avifaunal species and monitor quarterly. Conduct IEC activities on the significance of biodiversity to stakeholders.	in affected area. Monitor avifaunal species monthly. Conduct IEC activities on "No Activity Zone".
OPERATION PHASE – WATER COMPONENT													
Water Component (Water quality)	Impact on Surface Water Quality of Tayabasan, Sapa Bute, Wawa and Boso Boso River	TSS	(S) Grab samples, preserved at 4°C (A) Gravimetric method (dried at 103-105°C)	Quarterly	Sampling sites used for the EIS	Wawa JVCo Inc. EO/ Consultant	Included in annual in-house monitoring budget	Not more than 56 mg/L rise from baseline	Not more than 64 mg/L rise from baseline	Not more than 72 mg/L rise from baseline	Improve mitigating measures or equipment. Re-conduct testing of water quality to verify parameters are within allowable limit. Monitor the conduct of water quality parameters sampling.	Implement appropriate corrective action on the identified pollution source. Conduct re-testing to verify parameters are within allowable limit. Monitor the conduct of water quality parameters sampling. Ongoing rainfall and stream flow measurements for documenting	Temporary stoppage of activity Conduct re-testing to verify parameters are within allowable limit. Monitor the conduct of sampling. Inform MMT/LGUs.
		Oil & Grease	(S) Grab samples, glass bottle washed with solvent, acidification with nitric acid to pH 2, preserved at 4°C (A) Petroleum Ether Extraction					-	-	2			
		DO	In situ using DO meter/ Iodometric					3.5 mg/L	4mg/L	4.5 mg/L			
		Temperature	In situ using DO/ temperature meter					2.5°C max. rise	2.8°C max. rise	3.0°C max. rise			

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
		pH	In situ using pH meter/ Glass electrode					6.7-8.3	6.2-8.8	6.0-8.5		possible climate changes and extreme weather conditions	
		BOD_5	(S) Grab samples, preserved at 4°C (A) Azide Modification dilution technique					4.89mg/L	5.66mg/L	6.3mg/L			
		Fecal Coliform	Multiple tube fermentation technique					140 MPN/100mL	160 MPN/100mL	180 MPN/100mL			
		Phosphate	Approved methods of analysis in DAO 2016-08					0.35 mg/L	0.4 mg/L	0.45 mg/L			
		Nitrate	Approved methods of analysis in DAO 2016-08					4.89mg/L	5.66mg/L	6.3mg/L			
		Fluoride	Approved methods of analysis in DAO 2016-08					0.7 mg/L	0.8 mg/L	0.9 mg/L			
		Iron	Approved methods of analysis in DAO 2016-08					1.04mg/L	1.20mg/L	1.35mg/L			
Water Component (Freshwater Ecology)	Change in water regime	In-situ water quality parameters such as pH, dissolved oxygen, temperature, total suspended	Use of multi-probe water quality meter and flow meter	Semi-annual	Impact and control stations	Client; Environmental Monitoring Team	Final cost will be determined during implementation of the project (Note: Rough estimate is	N/A	N/A	Class "A/C" Waters (DENR AO 1990-34) pH – 6.5 to 8.5 DO – 5.0 mg/L	N/A	N/A	Investigate the cause of changes in water quality levels and ecological flow.

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
		solids and total dissolved solids, and water flow measurement					P500,000 for two monitoring periods/ semi-annual monitoring)			TSS- 50mg/l/ not more than 30mg/l Ecological flow of 0.33m^3/s			Increase monitoring of water level parameters to quarterly. Increase the volume of water released from the dam to increase flow rate.
		Biological communities such as phytoplankton, zooplankton, macroinvertebrates and fish	Field survey/ Aquatic Ecology Survey					30% decrease in abundances of aquatic biota which are known indicators of good water quality/ habitat conditions	50% decrease in abundances of aquatic biota which are known indicators of good water quality/ habitat conditions	70% decrease in abundances of aquatic biota which are known indicators of good water quality/ habitat conditions	Investigate the cause of decrease in abundances of aquatic biota taking into account seasonal and temporal variations.	Increase monitoring of biological communities to quarterly.	Increase monitoring of biological communities to monthly.
Water Component (Hydrology)	Flooding within the area Water discharge	Rain gauge (amount of rain) Water discharge	Install monitoring devices to measure and relay rainfall data and flood monitoring purposes in the catchment area upstream of the dam.	Daily	Project site	Environmental Officer (EO) Pollution Control Officer (PCO) EFCOS	Part of the operation cost	Observed and determined amount of rainfall Observed proper water discharge	Increased water discharge and amount of rainfall Determined or observed any changes in the discharge of the water	Excessive water discharge	Investigate and report the amount of rainfall. Investigate and report the areas with changes in water discharge.	Assess the amount of rainfall or weather condition. Document any changes in weather/amount of rainfall.	Replace damages of drainage control if needed. Report any changes in the conditions of the dam and other structures.

Key Environmental Aspects per Project Phase	Potential Impacts Per Envt'l Sector	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost	EQPL MANAGEMENT SCHEME					
			Method	Frequency	Location			EQPL RANGE			MGT MEASURE		
								ALERT	ACTION	LIMIT	ALERT	ACTION	LIMIT
OPERATION PHASE – PEOPLE COMPONENT													
People	Project will generate revenues for host LGUs and barangays	Payment of local taxes and permits and share from national wealth tax	Inspection of records of tax payments	Annual	Proponent Records	PCO	Part of PCO salary	N/A	N/A	N/A	N/A	N/A	N/A
	Project will augment social services through its CSR projects	Number and types of implemented CSR projects	Checking of records of Community Relations Office	Annual	CSO records	PCO	Part of PCO salary	N/A	N/A	N/A	N/A	N/A	N/A
ABANDONMENT PHASE													
The EQPL scheme for the Abandonment Phase will be formulated 2 years before closure													

2.0 Multi-sectoral Monitoring Framework

Compliance with the various monitoring activities in the project area will be ensured through the creation of a Multi-partite Monitoring Team (MMT). The following shall be represented in the MMT:

	Roles and Responsibilities
DENR-EMB Region IV-A DENR-PENRO DENR-CENRO WawaJVCo representatives UMRBPL representative or PAMB representative Barangay Captain, Calawis Barangays Captain, Pintong Bukawe Barangay Captain, San Rafael IP representative DOE representative/officer WawaJVCo Nominee	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; and

A sample MOA for the creation of the Multi-partite Monitoring Team (MMT). Based on DENR Revised Procedural Manual for DAO 2003-30 (Annex 3-4) is provided in **Annex O**.

3.0 Environmental Guarantee and Monitoring Fund Commitment

3.1 Environmental Guarantee Fund (EGF)

The Environmental Guarantee Fund (EGF) will be set-up to be used 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 the environmental guarantee fund 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 Rizal and NGO/PO representatives. For this project, the indicative amounts for the Trust Fund and Cash Fund that comprise the EGF are **PhP 1,000,000** and **PhP 500,000** respectively 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 WawaJVco shall commit to establish in support of 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 EMF will be approximately **PhP 250,000** so to be finalized at a later date. The actual amount will be agreed upon when the MMT is formed.

VII. EMERGENCY RESPONSE PLAN GUIDELINES

This Emergency Response Plan Guidelines was patterned after the US Federal Guidelines for Dam Safety (FEMA P-64, July 2013).

1.0 Summary of ERP Responsibilities

This summary page is proposed to be the first page of the ERP since it can provide a quick and easy reference to critical activities for implementing the ERP.

It provides the critical responsibilities for responding to an incident and implementing the plan.

2.0 Notification Flowcharts

This section presents the Emergency Action Plan (EAP) for the Upper Wawa Dam Project in case of emergency scenarios. This plan identifies who is to be notified of a dam safety incident, by whom, and in what order. The flowchart is required to have a valid information for the timely notification of those responsible for taking emergency actions. **Figure ER-1** shows a sample flowchart of the EAP that will be followed during an incident. A valid contact information must be included the chart when constructed.

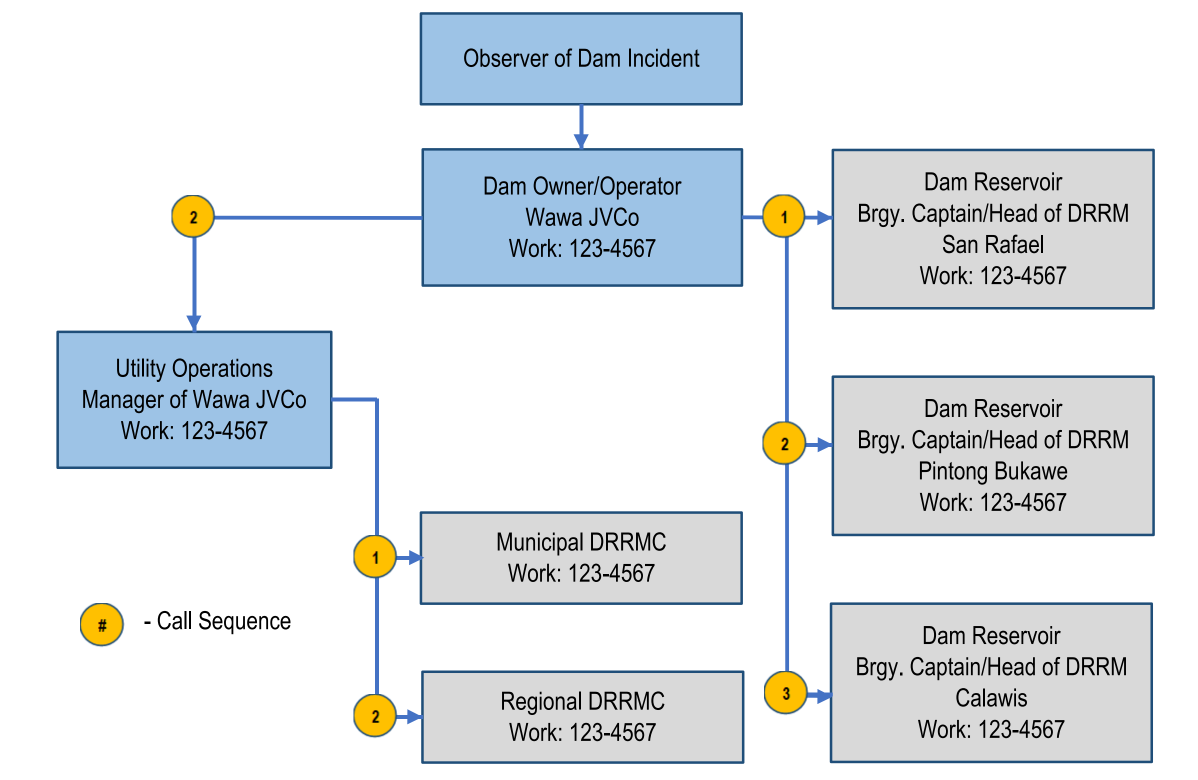

Figure ER-1. Notification Chart

3.0 Statement of Purpose

This Emergency Action Plan defines the responsibilities and provides procedures designed to identify unusual and unlikely conditions that may endanger Wawa Bulk Water Supply Project – Upper Wawa Dam in time to take mitigating action and to notify the appropriate emergency management authorities of possible, impending, or actual failure of the dam.

The ERP intends to safeguard the lives and reduce damage to the property of the citizens of Antipolo, San Mateo and Rodriguez in the event of failure of the dam. It will also be used to provide notification when flood releases can create major flooding or when large runoff may cause major flooding.

4.0 Project Description

A brief project description enhanced by maps/figures showing the start of the dams/ reservoirs in relation to settlements will be provided.

5.0 EAP Response Process

These are the four general steps that should be followed when an unusual or emergency incident is detected at the dam:

Step 1: Incident Detection, Evaluation and Emergency Level Determination - Early detection and evaluation of the conditions or triggering events that initiate or require an emergency response action are crucial. It is important to develop procedures for reliable and timely determination of an emergency level to ensure that the appropriate response actions are taken based on the urgency of the situation.

An example of safety emergency level categories:

1. High Flow
2. Non-failure
3. Potential Failure
4. Imminent Failure

Step 2: Notification and Communication Procedures for early detection are required to allow all entities involved with plan implementation to respond appropriately (**Figure ER-1**).

Step 3: Emergency Actions - Preventive or mitigating actions can be taken to attempt to address conditions at the dam.

Step 4: Termination and Follow-up - Eventually, a determination will need to be made concerning termination of the incident. After the incident is over, follow-up activities may be required.

6.0 General Responsibilities

A determination of responsibility for ERP-related tasks will be made during the development of the ERP. WawaJVCo will be responsible for developing and maintaining the ERP, and in coordination with various DRRM units at various local government levels will be responsible for implementing the ERP. DRRM units are responsible for warning and evacuation within the affected areas.

The ERP will clearly specify the responsibilities of all involved entities to ensure that effective and timely action is taken if an emergency at the dam occurs.

1. Dam Owner Responsibilities

2. Notification and Communication Responsibilities
3. Evacuation Responsibilities
4. Monitoring, Security, Termination and Follow-up
5. Responsibilities
6. ERP Coordinator Responsibilities

7.0 Preparedness

Activities and actions are presented on this section that will be taken before the development of an incident. These activities attempt to facilitate response to an incident as well as prevent, moderate, or alleviate the effects of the incident.

1. Surveillance and Monitoring
2. Evaluation of Detection and Response Timing
3. Access to the Site
4. Response during Periods of Darkness
5. Response during Weekends and Holidays
6. Response during Adverse Weather
7. Alternative Sources of Power
8. Emergency Supplies and Information
9. Stockpiling Materials and Equipment
10. Coordination Information
11. Training and Exercise
12. Alternative Systems of Communication
13. Public Awareness and Communication

8.0 Inundation Maps

Maps will be developed by WawaJVCo based on the final design of the dams. These will show areas that will be flooded and flood peaks at critical locations if a dam failure occurs or there are operational releases during flooding conditions. These will facilitate timely notification and evacuation of areas potentially affected by a dam failure or flood condition.

VIII. ABANDONMENT/DECOMMISSIONING/REHABILITATION POLICIES AND GENERIC GUIDELINES

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 appurtenants 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.

IX. INSTITUTIONAL PLAN FOR IMP 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 socio0economic concerns
MMT	• Conduct compliance monitoring

An Environmental Unit to be headed by an Environmental Manager (EM) shall be established that will be responsible in 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. To facilitate communication and coordination with the members of the MMT and the host community, the EM will work with the Community Relations Officer (CRO) (**Figure IP-1**).

Table IP-2 details the reporting procedures and responsibilities of the personnel included in the organizational chart.

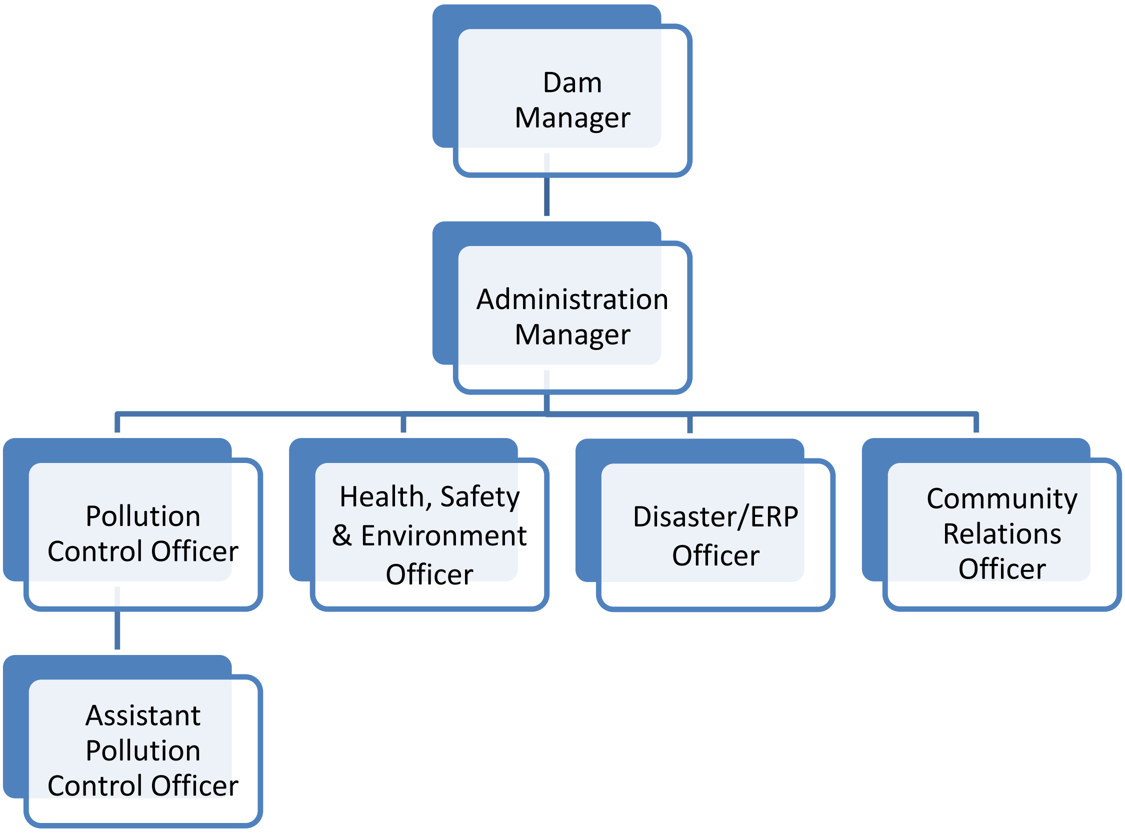

Figure IP-1. Preliminary Organizational Chart of WawaJVCo Environmental Unit

Table IP-2
Reporting Procedures, Responsibilities and their Relationships with other Operating Departments

Operating Departments	Reporting Procedures, Responsibilities and their Relations
Dam Manager	• Coordinate and manage overall project implementation and operation including guiding and supervision of EMP implementation during pre-construction, construction and operation phases • Manage and coordinate environmental monitoring • Coordinate with other departments in relation to environmental management activities • Supervise civil work contractor during construction, including implementation of environmental management activities under EMP • The Dam Project Manager will report the project status to higher organizational level (WawaJVCo)
Administration Manager	• Manage EMP budget and report to WawaJVCo • Integrate EMP specifications in contract documents • Report the budget status or any contract and administrative issues directly to WawaJVCo
Health, Safety and Environment Officer	• Assist Dam Manager in effectively implementing and maintaining Health, Safety and Environment rules and regulations • Assures that required management systems are in place to protect the health and safety of workers and to regularly monitor and report Environment, Health and Safety performance • Assists Dam Manager in monitoring Health and Safety implementation as specified in Standard Operating Procedures, Health and Safety Manual by WawaJVCo, ensure its compliance and give feedback to Dam Manager • Take on the right initiative to ensure problem will be solved in timely, cost efficient and sustainable manner to avoid re-occurrence • Report status regarding health, safety and environmental issues to the Project Dam Manager or directly to WawaJVCo
Disaster/ ERP Officer	• On receipt of early warning or immediately after disaster, the Disaster Risk Officer of the project will convene an emergency meeting with the other officer and with the Dam Manager and activate the disaster response. It will periodically brief the workers and WawaJVCo on the current situation • Facilitate the implementation of disaster preparedness and mitigation activities. It will implement some of the disaster preparedness and mitigation activities such as awareness campaign on do's and don'ts of disaster • Prepare annual report on status of DRM in the district including implementation of the annual DRM programme and submit to the Dam Manager and WawaJVCo.
Community Relations Officer	• Track project communication activities and report on progress each month • Provide information to the community, staff and stakeholders on the progress of programs/activities • Proactively identify potentially contentious community issues, provide advice for effectively managing issues and escalate to manager as appropriate
Assistant/Pollution Control Officer	• Monitor activities pertaining the installation or construction of pollution source and control facilities with the end in view of ensuring their compliance with air, noise and water standard • Supervise the proper operation and maintenance of pollution control facilities of the project • Report with reasonable time to the Dam Manager/WawaJVCo the breakdown of any pollution control facility • Facilitate compliance of the establishment PCO represents with the requirements that may from time to time prescribed by the Manager.

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