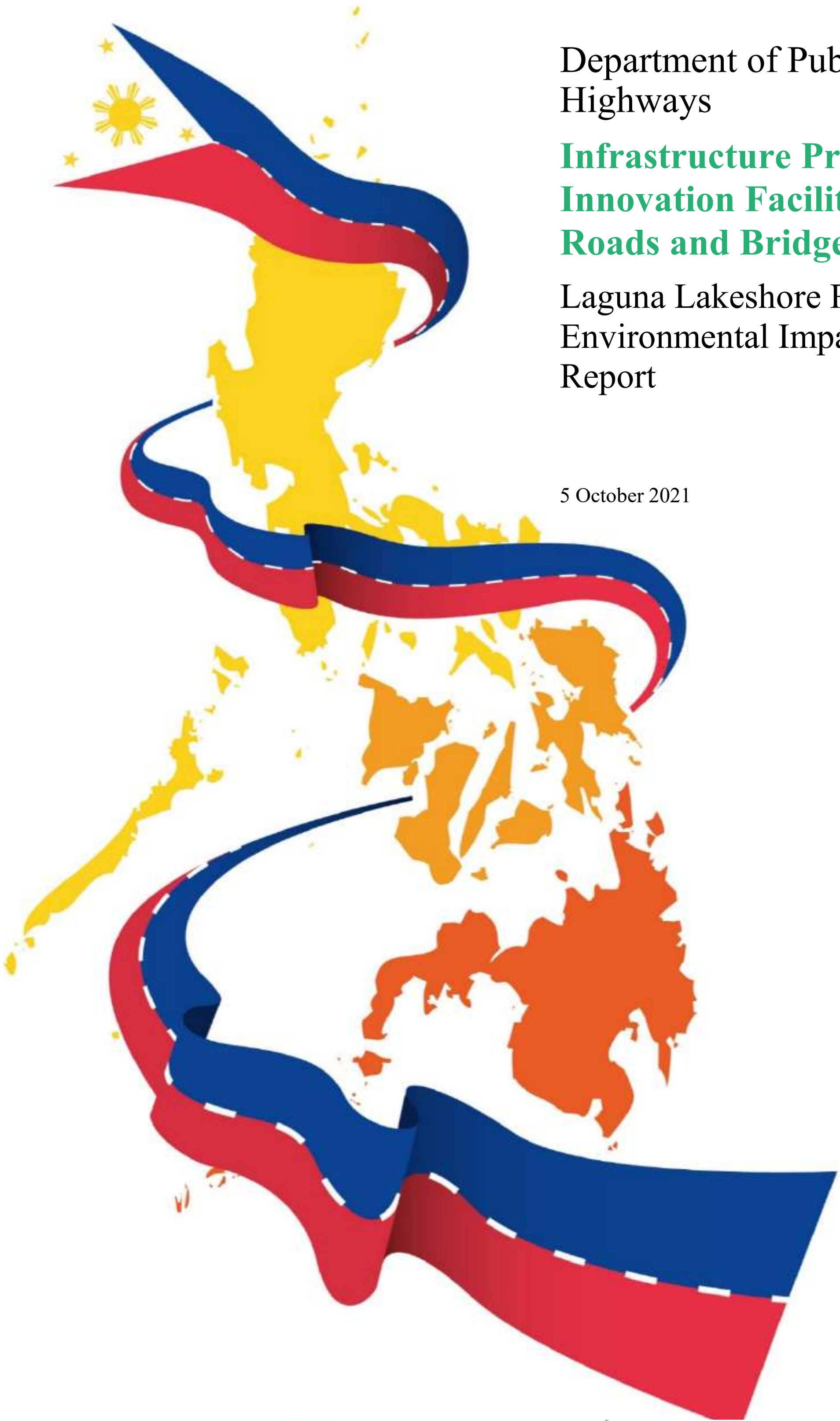

Department of Public Works and Highways

Infrastructure Preparation and Innovation Facility – Output 1 – Roads and Bridges

Laguna Lakeshore Road Network Environmental Impact Statement (EIS) Report

5 October 2021

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List of Abbreviations

ADB	Asian Development Bank
AQI	Air Quality Index
ASR	Air Sensitive Receptors
AWWA	American Water Works Association
BFAR	Bureau of Fisheries and Aquatic Resources
BOD	Biological Oxygen Demand
BSWM	Bureau of Soils and Water Management
CAAP	Civil Aviation Authority of the Philippines
CADT	Certificate of Ancestral Domain Title
CARP	Comprehensive Agrarian Reform Program
CCC	Climate Change Commission
CCO	Chief Compliance Officer
CDD	Consecutive Dry Days
CLIRAM	Climate Information Risk Analysis Matrix
CLUP	Comprehensive Land Use Plan
CMR	Compliance Monitoring Report
CNO	Certificate of Non-Overlap
COD	Chemical Oxygen Demand
CWA	Clean Water Act
DAO	DENR Administrative Order
DED	Detailed Engineering Design
DENR	Department of Environment and Natural Resources
DENR-CENRO	Department of Environment and Natural Resources – Community Environment and Natural Resources Office
DENR-EMB	DENR-EMB – Department of Environment and Natural Resources Environmental Management Bureau
DGAC	Dense-graded asphaltic concrete
DGCS	DPWH Design Guidelines, Criteria, and Standards
DIA	Direct Impact Areas
DO	Dissolved Oxygen
DOE	Department of Energy
DOH	Department of Health
DOLE	Department of Labor and Employment
DPWH	Department of Public Works and Highways
DRAM	DPWH ROW Acquisition Manual
DTR	Daily Temperature Range
ECA	Environmentally Critical Area
ECC	Environmental Compliance Certificate
EGGAR	Engineering Geological and Geohazard Report
EIA	Environmental Impact Assessment
EIARC	Environmental Impact Assessment Review Committee
EIS	Environmental Impact Statement
EMB	Environmental Management Bureau
EMB-MC	Environmental Management Bureau Memorandum Circular
EMP	Environmental Management Plan
EPA	Environmental Protection Agency
EQPL	Environmental Quality Performance Level
ERA	Environmental Risk Assessment
FGD	Focus Group Discussion
FS	Feasibility Study
GAP	Gender Action Plan
GCM	Global Climate Models

GHG	Greenhouse Gas
GIS	Geographic Information System
GRM	Grievance Redress Mechanism
HSE	Health, Safety, and Environment
IEC	Information and Education Campaign
IFC	International Finance Corporation
IIA	Indirect Impact Areas
IPCC	Intergovernmental Panel on Climate Change
IRR	Implementing Rules and Regulations
ITCZ	Intertropical Convergence Zone
JICA	Japan International Cooperation Agency
LBMP	Laguna de Bay Master Plan
LGU	Local Government Unit
LLDA	Laguna Lake Development Authority
LLDA-NIGS	LLDA-National Institute for Geological Sciences
LLED	Laguna Lake Expressway Dike
LLRN	Laguna Lakeshore Road Network
LPDD	Licenses, Patents, and Deeds Division
LRFD	Load and Resistance Factor Design
LTPBM	Long Term Performance Based Maintenance
MCX	Muntinlupa-Cavite Expressway
MFR	Makiling Forest Reservation
MGB	Mines and Geosciences Bureau
MIAA	Manila International Airport Authority
MLD	Minimum Liquid Discharge
MMT	Multi-Partite Monitoring Team
MSL	Mean Sea Level
NAAQGV	National Ambient Air Quality Guideline Values
NAAQGS	National Ambient Air Quality Standards
NAIA	Ninoy Aquino International Airport
NAMRIA	National Mapping and Resource Information Agency
NAS	National Agrometeorological Station
NCCAP	National Climate Change Action Plan
NEDA	National Economic Development Authority
NFSCC	National Framework Strategy on Climate Change
NHCS	Napindan Hydraulic Control System
NHS	National Health Service
NPCC	National Pollution Control Commission
NRS	National Road System
OGAC	Open-graded asphaltic concrete
OSHA	Occupational Safety and Health Association
PAGASA	Philippine Atmospheric Geophysical and Astronomical Services Administration
PAR	Philippine Area of Responsibility
PCCP	Portland Cement Concrete Pavement
PCO	Pollution Control Officer
PEISS	Philippine EIS System
PEM	Philippine Earthquake Model
PENRO	Provincial Environment and Natural Resources Office
PGA	Peak Ground Acceleration
PHIVOLCS	Philippine Institute of Volcanology and Seismology
PNR	Philippine National Railways
PPE	Personal Protective Equipment
PRECIS	Providing Regional Climates for Impact Studies
PSCCA	Philippine Strategy on Climate Change Adaptation
PSHA	Probabilistic Seismic Hazard Analysis
PWD	Persons with Disability
RAP	Resettlement Action Plan
RCMs	Regional Climate Models

RCPs	Representative Concentration Pathways
ROW	Right-of-Way
ROWARAP	Right-of-way Acquisition and Resettlement Action Plan
RSP	Respirable Suspended Particulates
SA	Spectral Acceleration
SACA&D	Southeast Asian Climate Assessment & Dataset
SAFDZ	Strategic Agriculture and Fisheries Development Zone
SDII	Simple Daily Intensity Index
SDMP	Spatial Development Master Plan
SDP	Social Development Program
SLEX	South Luzon Expressway
SMR	Self-Monitoring Reports
SOGI	Sexual Orientation and Gender Identities
SPEI	Standardized Precipitation Evapotranspiration Index
SPS	Safeguard Policy Statement
SRES	Special Report on Emissions Scenarios
TCSS	Traffic Control and Surveillance System
TD	Tropical Depression
TDS	Total Dissolved Solids
TSP	Total Suspended Particles
TSS	Total Suspended Solids
UBIV	Under Bridge Inspection Vehicles
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency
VFS	Valley Fault System
WHO	World Health Organisation
WSDI	Warm Spell Duration Index

Executive Summary

Project Fact Sheet

Name of Project	Laguna Lakeshore Road Network (LLRN) Project
Project Location	National Capital Region: - Taguig City; and - Muntinlupa City Region IV-A / CALABARZON - San Pedro City; - Biñan City; - Santa Rosa City; - Cabuyao City; and - Calamba
Nature of the Project	Road Network
Project Size	Alignment Length: 37.6 km Eight (8) Interchanges with Slip Roads: 7.3 km Width: Dual 2 / Dual 3 Carriageway (Varies)
Summary of Major Components	Viaduct Embankment Interchanges Land Drainage
Project Cost	Approximately Php. 123,776.52 Million (Civil Works) Approximately Php. 177,856.10 Million (Total Project Cost)
Project Duration	2018-2026
Operation Date	2026
Proponent Name	Department of Public Works and Highways
Proponent Authorized Representative	**Emil K. Sadain, CESO I** Undersecretary for UPMO Operations Department of Public Works and Highways
Proponent Address and Contact Details	Address: Bonifacio Drive, Port Area, 652 Zone 068, Manila, 1018 Metro Manila, Philippines Contact Number: +63 2 5304 3805 / +63 2 5304 3681
EIA Preparer (Consultant)	Ove Arup & Partners Hong Kong Ltd and EcosysCorp Inc.

Preparer Contact Person	**David Rollinson** Ove Arup & Partners Hong Kong Ltd – Environmental and Social Team Leader	**Annabelle Herrera** EcosysCorp, Inc. – Project Director
Preparer Address and Contact Details	**Ove Arup & Partners Hong Kong Ltd** 36F The Podium West Tower #12 ADB Avenue corner Julia Vargas Avenue Ortigas Center, Mandaluyong City 1550 Contact No.: +63 2 3485 8200 **EcosysCorp, Inc** Units 712, 716, & 710 JOCFER Bldg. 79 Commonwealth Ave., Q. C. Contact Nos. +63 2 709 1304, +63 2 719 8461	

Proponent's Profile

The Department of Public Works and Highways (DPWH), the main proponent of the project is the lead engineering and construction agency of the Government, tasked in ensuring and designing infrastructure developments such as national highways, bridges, flood control and other related public works.

DPWH has appointed Ove Arup and Partners Hong Kong Ltd (Arup), as the lead consultant for the Environmental and Social Impact Assessment of Laguna Lakeshore Road Network (LLRN) Project. Arup is a multinational firm which provides engineering, design, planning, project management and consulting services for all aspects of the built environment.

EcosysCorp, Inc. was hired by Arup as its sub-consultant to carry out the Environmental Impact Assessment (EIA) including the social aspects such as conduct of public consultation, Information and Education Campaign (IEC), perception surveys, among others for the Project.

Proponent Name	Department of Public Works and Highways (DPWH)
Address	Bonifacio Drive Port Area, 652 Zone 068, Manila, 1018 Metro Manila, Philippines
Authorized signatory/ representative to apply for ECC	**Emil K. Sadain, CESO I** Undersecretary for UPMO Operations Department of Public Works and Highways Room 211, 2nd Floor,

Proponent Name	Department of Public Works and Highways (DPWH)
	DPWH Main Office, Bonifacio Drive, Port Area, Manila, Philippines
Recommending Approvals	**Sharif Madsmo H. Hasim** Director Department of Public Works and Highways Roads Management Cluster II (Multilateral) Unified Project Management Office (UPMO) **Soledad R. Florencio** Project Manager III Department of Public Works and Highways Roads Management Cluster II (Multilateral) Unified Project Management Office (UPMO)
DPWH Contact Person	**Zenaida B. Mauhay** Project Manager II Roads Management Cluster II (Multilateral) Unified Project Management Office Department of Public Works and Highways 2nd Street, Port Area Manila, Philippines zenaida730@yahoo.com +63 2 5304 3727
Arup Contact Person	**David Rollinson** Environmental and Social Team Leader Ove Arup and Partners Hong Kong Ltd (Philippines Branch) david.rollinson@arup.com +63 2 3485 8200
EcosysCorp Contact Person	**Annabelle Herrera** President and Project Director EcosysCorp, Inc. aherrera@ecosyscorp.com +63 2 7759 0012

Process Documentation

- **Project Categorization**

The Laguna Lakeshore Road Network Project (LLRN) – Phase I is an Environmentally Critical Project (ECP) which falls under Category A of the Revised Guidelines for Coverage Screening and Standardized Requirements under the Philippine EIS System as the project will traverse both land and water bodies, specifically the Laguna Lake.

Based on the Revised Procedural Manual of the Department of Environment and Natural Resources (DENR) Administrative Order No. 30 Series of 2003 (DAO 2003-30), major roads and bridges are categorized as Environmental Critical Project (ECP) under Category A and within the scope of the EIS System based on Proclamation No. 2146 (1981) and Proclamation No. 803 (1996).

Environmental Management Bureau (EMB) Memorandum Circular 005 of 2014 (EMB MC 2014-005) or the Revised Guidelines for Coverage Screening and Standardized Requirements under the Philippine EIS System states that infrastructure, more specifically roads and bridges, must secure an Environmental Compliance Certificate (ECC) through conduct of full-blown Environmental Impact Assessment (EIA) as the project poses significant environmental impacts.

With this, an Environmental Impact Statement (EIS) Report has been prepared for the ECC application of the project. This report will outline the current conditions of the project area and will present all potential impacts that may be found significant.

- **Definition of EIA**

DENR Administrative Order (DAO) 2003-30 defines EIA as a systematic process that involves the prediction and evaluation of significant impacts of a project, including cumulative impacts on the environment all throughout its life cycle (construction, operations, and abandonment phase). It involves designing appropriate preventive, mitigating and enhancement measures addressing the consequences in attaining socio-economic and environmental balance.

- **Scope of the EIA Study**

This EIS Report covers the environmental and social impact assessment and activities associated with the feasibility studies of the project. The contents of this report include the following major and critical components based on the requirements stipulated in the Annex A of the DENR Administrative Order No. 2019-16 "Streamlining the Environmental Impact Assessment (EIA) process and requirements for projects under the Build Build Build Program":

1. Project Description
2. Environmental Impact Assessment (EIA) Summary
3. Assessment of Environmental Impacts
4. Environmental Management Plan (EMP)
5. Environmental Risk Assessment (ERA) and Emergency Response Policy and Guidelines

6. Social Development Program (SDP)
7. Information and Education Campaign (IEC)
8. Self-Monitoring Plan, Multi-Sectoral Monitoring Framework and Environmental Guarantee and Monitoring Fund Commitments
9. Decommissioning/ Abandonment/ Rehabilitation Policy, and
10. Institutional Plan for Environmental Management Plan (EMP) Implementation

All regulations and cited information are aligned with the rules and regulations of the Philippines in relation to its compliance with the requirements of the Department of Environment and Natural Resources (DENR) and Asian Development Bank (ADB), primarily the Guidelines on Environmental Assessment and Safeguard Policy Statement (SPS) 2009.

As part of the ECC application process, a series of activities such as LGU consultations, socioeconomic and perception surveys, and public consultations were carried out for completion of the EIA. Information and Education Campaigns (IEC) and coordination meetings with LGUs and other stakeholder engagement activities were carried out in conformance with the revised LLRN scheme consistent with the guidelines prescribed by DENR-EMB and ADB Safeguards Policy.

Baseline environmental sampling for air, surface water, ground water, and sediment were conducted. Terrestrial and aquatic ecological surveys were accomplished by experts. The Right-of-Way Acquisition and Resettlement Action Plan (ROWARAP) has been prepared for the project which includes surveys for land and structures that may be affected by the proposed alignment.

- **EIA Team**

The EIA Team for the preparation of the environmental impact assessment of the LLRN Project consists of the following experts and members:

Name	Role in the EIA Study	Qualifications
Ove Arup and Partners Hong Kong Ltd.		
David Rollinson	Environmental and Social Team Leader	BSc (Hons) Environmental Biology MSc Environmental Management
Angel Salcedo	Environmental and Social Specialist	EIA Registration No. IPCO 334 MSc Environmental Engineering B.S. Chemical Engineering
Maria Catherine Rontos	Environmental and Social Specialist	EIA Registration No. IPCO 037 Diploma in Urban and Regional Planning B.S. Environmental Planning and

Name	Role in the EIA Study	Qualifications
		Management
Geanella Allyson Belino	Environmental and Social Specialist	M.A. Urban and Regional Planning B.S. Environmental Planning and Management
Gabriel Luis Mabanta	Environmental and Social Specialist	B.S. Environmental Science
EcosysCorp Inc.		
Frederick Esternon	Head - EIA Preparer Environmental and Social Specialist	EIA Registration No. IPCO 311 Environmental Management Specialist B.S. Forestry and Natural Resources
Victor Valderama Jr.	Terrestrial Ecology Specialist (Flora and Fauna)	B. S. Forestry and Natural Resources PhD Environmental Engineering
Ruben Estudillo	Aquatic and Marine Ecology Specialist	PhD Marine Science (Units Earned) MSc Marine Science Ecology B.S. Marine Science
Elenor De Leon	Environmental and Social Specialist	EIA Registration No. IPCO 425 Master in Development Management Master of Environment and Natural Resources Management (Units earned)

EIA Study Schedule

EIA wait	2019		2020												2021											
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
DPWH Endorsement for IEC Coordination (27/11/19)																										
IEC Meeting with City/Municipal LGUs																										
Health & Safety Protocols Prep Activities																										
Barangay-level IEC																										
Conduct of SES and FGDs																										
Preparation for the public scoping																										
Public scoping proper																										
Technical Scoping with EMB																										
Field Surveys (freshwater and terrestrial ecology																										

EIA wait	2019		2020												2021											
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
sampling including riparian)																										
Climate Risk and Vulnerability Analysis																										
Impact Assessment and Mitigation																										
Environmental Management Plan																										
Draft EIS Report preparation and submittal																										
Official acceptance of the EIS																										
1st EIA Review meeting																										
AI submission																										
Public Hearing																										
Site inspection																										
Revised EIS submitted																										
Public Hearing																										

EIA wait	**2019**		**2020**												**2021**											
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
proceedings submitted																										
2nd EIA Review Meeting																										
Posting at EMB website																										
EIARC report submission by EIARC Chair																										
EIARC recommendations decision by EMB Director / Endorsement from OD to the Office of the Secretary for clearance																										
ECC Approval/Disapproval by EMB Director																										

EIA Study Area

The road network caters the area in the vicinity of Laguna de Bay. Phase I runs along the western coastline of the Lake while Phase II stretches in the Northern to Southern coastline via an eastern route.

The proposed alignment is a combination of viaduct and embankment. The alignment will start in Brgy. Lower Bicutan in Taguig City and end in Brgy. Bucal in Calamba. It has eight (8) interchanges distributed along the course of the alignment and will provide access to seven (7) cities/ municipalities in the western side of the lake.

The table below summarizes the coverage of the EIA study in Metro Manila and the province of Laguna:

Table 1A EIA Study Coverage

City/Municipality			Number of Barangays Covered
Metro Manila	1	Taguig	3
	2	Muntinlupa	8
Laguna	3	San Pedro	3
	4	Biñan	4
	5	Sta. Rosa	3
	6	Cabuyao	5
	7	Calamba	8
Total	**7 Cities/Municipalities**		**34 Barangays**

EIA Methodologies

The methods of the EIA include collection of primary and secondary data, the alignment option selection, the ADB Categorization, and the assessment of potential environmental and social impacts and the proposed mitigation measures. These are described in detail as follows:

Compliance: This report has been prepared in accordance with ADB SPS (2009), ADB's Environmental Assessment Guidelines (2003), and the guidelines and requirements of the Philippine's DENR Administrative Order 2003-30 (DAO 2003-30) – Implementing Rules and Regulations of Presidential Decree 1586 (Establishing Environmental Impact Statement System, including Environmental Management Bureau Memorandum Circular 2014-005 (EMB-MC 2014-005) – Revised Guidelines for Coverage Screening and Standardised Requirements under the Philippines EIS System (PEISS) under DENR Administrative Order No. 2019-16.

Categorization: EMB-MC 2014-005 states that infrastructure, more specifically roads and bridges, must secure an Environmental Compliance Certificate (ECC), through conduct of full-blown Environmental Impact Assessment (EIA) as the project poses significant environmental impacts. The project falls under Category A of the ADB SPS guidelines (2009) as the project is perceived to have adverse environmental and social impacts. For Projects under Category A, an EIA Report shall be submitted and be approved by ADB's Chief Compliance Officer (CCO). Other existing regulatory and institutional framework required for the Project from pre-construction, construction, and operation phases are presented in this report.

Review of Secondary Data: Readily available secondary data regarding the Project are used as baseline information. These are published materials made available by the local government and non-government bodies and were reviewed to verify usefulness before adopting to be used in the report.

Site Reconnaissance and Investigation: During the EIA study after project categorization, site visits and investigation would be required through the study that will form part of the preparation of public consultation and feed into the overall assessment.

Alignment Option: The team continuously studied the optimum alignment option for the Project. The studies conducted consist of options selection workshop, initial site visits as well as investigations and desktop reviews to help the team in the selection process. This report will give a brief background on the scoring procedures and lists the criteria used to come up with preferred alignment.

Identification of Impacts: Identification of impacts was done for each option through desktop review, after which, the findings were then verified by site investigations. Constraints were further identified and discussed. A study for mitigation measures will then be considered in relation to the laws and regulations for each respective module ranging from the use of machineries, proper use and storage of materials, trainings of personnel, safety rules of contractors, staff and employees, and traffic management.

Table 1B Summary of EIA Methodologies

EIA Key Components	Methods
Land	
Land Use and Classification	Review of secondary data from comprehensive land use plans
Geology/Geomorphology	Interpretation of existing mappings, including topographic, geologic, flood maps, landslide susceptibility maps, and existing ground investigation information. Technical reports regarding the geologic conditions of the project area, other geology-related resources; and results of field inspection
Geohazard Assessment	
Pedology	
Terrestrial Ecology: Flora Assessment	• Transect survey • Use of quadrat sampling plots • Documentation of tracts and coordinates of sampling stations using GPS
Terrestrial Ecology: Fauna Assessment	• Transect survey • Netting • Trapping • Night sampling
Water	
Hydrology/ Hydrogeology	Review of secondary data: • Comprehensive land use plans, • Integrated Water Resource Management Master Plan by the Provincial Government of Laguna, • Related hydrologic studies, and • Historic flood levels
Water Quality	Sediments, and surface and groundwater sampling
Freshwater (Lake) Ecology	• Review of secondary data from comprehensive land use plans • Phytoplankton & Zooplankton - Plankton net vertical haul (water column sampling)from near the bottom to the surface and laboratory microscopic analysis • Primary Productivity (Chlorophyll-*a*)

EIA Key Components	Methods
	- Surface water sampling and laboratory analysis • Ichthtyoplankton (Fish Eggs & Fish Larvae) - Bongo net surface tow for 10 minutes and laboratory analysis • Soft Bottom Infaunal Benthos - Ekman bottom grab sampling and laboratory microscopic analysis - Fish and Aquatic Invertebrates - Actual observations of fishing activities - Informal interviews - Visit to fish landing and fish market - Secondary data gathering from internet search, survey reports, scientific publications, and published and unpublished literature • Aquatic Macrophytes/Plants - Field observations and interviews - Secondary data gathering from internet search, reports, scientific publications, and published and unpublished literature • Fisheries (Fish Capture and Aquaculture) - Field observations and informal interviews - Secondary data gathering from internet search, scientific publications, field survey reports, and published and unpublished literature
Air	
Ambient Air sampling	• Ambient air sampling • Air dispersion modelling
Noise sampling	• Noise sampling • Noise modelling
People	
Public Participation and Scoping	• Preliminary desk research • Site visits • Initial consultations • Stakeholder mapping • Key informant interviews • Consultations • Household survey
Environmental Risk Assessment	
Environmental Risk Assessment	• Gathering and review of Secondary Data - Local weather stations - PAGASA Climate Extreme Projection • Desktop review • GHG calculations based on 2006 IPCC Guidelines for National Greenhouse Gas Inventories
Traffic Impact Assessment	
Traffic Impact Assessment	• Vehicle – classified count surveys • Secondary data review • Travel time savings analysis

Public Participation Activities

DENR Administrative Order (DAO) No. 2017-15 provides the guidelines on public participation under the Philippine EIS system. In line with this guidelines, initial stakeholder identification and IEC meetings were done.

Scoping is that stage in the EIA process where project information and impact assessment requirements are established to provide the proponent and stakeholders the scope of work and terms of reference for the EIS. And in adherence to the principle of public participation upheld by DENR Administrative Order 2017-15 (Guidelines on Public Participation under the Philippine Environmental Impact Statement (PEIS) System), the conduct of public scoping involves identified project stakeholders.

The public scoping activities for the Laguna Lakeshore Road Network (LLRN) Project were conducted in November 10, 11, 26, 2020 and January 13, 2021. The public scoping set up was a combination of online and onsite activities. This is in compliance with the minimum Public Health Standards for COVID-19 Mitigation Risk set by the Department of Health thru DOH Administrative Orders 2020-15 and 2020-16, and in consonance with EMB Memorandum Circular No. 2020-30, the alternative method for ensuring public participation selected is via the blended video conferencing and small group meetings, as well as focus group discussions with important stakeholders.

In compliance to the recommendation of EMB Director William Cunado, a second set of scoping meeting was led and initiated by DENR-EMB Central Office in June 17, 2021, this time through Zoom with morning and afternoon sessions.

Table 1C Summary of Pre-Scoping IEC Activities and Issues

LGUs Covered by IEC	Actual IEC Schedule / Dates	Issues Raised / Suggestions Provided
Taguig City Barangays Lower Bicutan, Upper Bicutan, Bagumbayan	January 26, 2021	▪ Access of fisherfolk to the lake ▪ Clearing of water hyacinth on the lake ▪ Identification of PAPs ▪ Coordination between the DPWH and LLDA ▪ Alternative livelihoods for those who will be displaced
Muntinlupa City Barangays Buli, Cupang, Poblacion, Alabang, Bayanan, Putatan, Tunasan, and Sucat	▪ Sept. 16, 2020 ▪ Oct. 16, 2020 ▪ Oct. 21, 2020 ▪ Nov. 10, 2020	▪ Target date for construction ▪ Manner of identifying PAPs ▪ Area for the relocation site ▪ Extent of land to be acquired from private properties Height of the viaduct ▪ Distance of the LLRN from the shoreline ▪ Inland areas in the City where structures will be built ▪ Access of fisherfolk, especially during construction ▪ Ensuring access of fisherfolk by putting it in writing ▪ Project impact to fish cages ▪ Impact of noise and vibration to fish catch ▪ Project impact to kangkong (water hyacinth) farmers ▪ Manner of identifying project-affected fisherfolk ▪ Construction of posts on water that might affect fish catch ▪ Compensation for PAPs

LGUs Covered by IEC	Actual IEC Schedule / Dates	Issues Raised / Suggestions Provided
		▪ Accumulation of water lilies ▪ Site for relocation ▪ Design of the interchanges ▪ Identification of PAPs for compensation ▪ Coordination between LIACs for LLRN and NSCRP ▪ Relocation for PAPs in Sucat ▪ Reclamation sites to be turned into relocation site for displaced residents of Sucat ▪ Compensation options for PAPs ▪ Dissemination of information about the project, especially relocation. ▪ Dissemination of information about the project, ▪ Rights of and compensation of PAPs, especially renters.
Biñan City Barangays Dela Paz, Malaban, Casile, and San Antonio	▪ Sept. 1, 2020 ▪ Nov. 11, 2020	▪ Possible re-alignment to avoid some properties ▪ Access roads will be affected by the project ▪ Compensation for PAPs ▪ Dissemination of information about the Project
Cabuyao City Barangays Bigaa, Gulod, Marinig, Baclaran, Mamatid, and Butong	▪ Sept. 3, 2020 ▪ Sept. 8, 2020 ▪ Nov. 26, 2020	▪ Compensation for renters ▪ Compensation for multiple occupants of structures/properties ▪ Treatment for PAPs with tax declaration only or with land titles that are not named after them ▪ Dissemination of information about project activities ▪ Extent of project impact ▪ Manner and execution of compensation and relocation for PAPs ▪ Amenities/facilities on the relocation site ▪ Measurement of the alternative road project of the government ▪ Relocation site ▪ PAPs with land titles that are named after their deceased parent ▪ Project impact on livelihoods ▪ Local hiring ▪ Lake water will become murky during the construction phase ▪ Areas to be traversed by the alignment ▪ Flood prevention
Sta. Rosa City Barangays Sinalhan and Aplaya	▪ Sept. 16, 2020 ▪ Sept. 19, 2020 ▪ Nov. 26, 2020	▪ Site for relocation ▪ Identification of PAPs and structures that will be affected ▪ Compensation for PAPs ▪ Properties that will be traversed by the alignment ▪ Identification of PAPs ▪ Project's environmental impacts to livelihood ▪ Livelihood assistance to fisherfolk ▪ LLRN distance from the shoreline
Calamba City	▪ Sept. 24, 2020	▪ Barangays to be traversed by the project ▪ Presence of fish sanctuary in Lecheria,

LGUs Covered by IEC	Actual IEC Schedule / Dates	Issues Raised / Suggestions Provided
Barangays Lecheria, Halang, and Bucal	▪ Nov. 26, 2020	Bucal, and Pansol ▪ Assurance of compensation for affected fisherfolk ▪ River of Bucal that will be affected ▪ Fisherfolk access to the Lake ▪ Project impact on nearby farm lots ▪ Compensation for PAPs
San Pedro City Barangays San Roque and Cuyab	▪ Oct. 1, 2020 ▪ Nov. 11, 2020	▪ Distance of LLRN alignment from the shoreline ▪ Areas to be traversed by LLRN ▪ Residential structures to be affected ▪ Project might worsen flooding in San Roque and Cuyab ▪ Explanation on the catchment drain and how it will affect flooding in the barangay ▪ Compensation for PAPs, including affected livelihoods ▪ Rehabilitation of access roads to be affected ▪ Location of interchange exits ▪ Design of the LLRN (i.e., if road-dike structure will be adopted) ▪ Project consideration for the fish sanctuary in San Pedro City

EIA Summary

Integrated Summary of Impacts and Residual Effects after Mitigation

Table 1D Integrated Summary of Impacts and Residual Effects after Mitigation

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
Pre-Construction				
Preparation of the project site for construction	Terrestrial Ecology	Cutting down of trees along the road right – of – way Displacement of animals, insects and avifauna	• Delineation of areas to be cleared based on the actual corridor of the alignment should be implemented on the ground to avoid and minimize unnecessary clearing, • Identification of site for replacement tree planting • Compliance with conditions of DENR/LGU, Tree Cutting Permit, ROW • Provide temporary fencing to vegetation that will be retained.	The proponent will ensure 80 to 100 % efficiency on areas for land clearing, compliance with the tree cutting permitting mandate, and tree replacement.
	People	Temporary disruption and relocation of utility services *(telephone lines,*	• Preparation of utilities relocation plan and inventory of the affected utilities will be done during the DED stage of the project to consider the final LLRN	Ensure 100% implementation of the approved and final utilities relocation plan of the project, and agreement with the affected LGUs and concerned utility companies and service providers.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
		electric poles and wires, and water lines) existing within LLRN ROW	ROW; • Close coordination with the affected LGUs and concerned utility companies and service providers with regards to project timeline, project plans and utility relocation schedule / activities.	xxi
	Water Quality	Inconsistency on DENR, LLDA and LGU's current mandate to rehabilitate and improve the water quality of Laguna Lake	• Regular water quality monitoring, • Regular coordination with LGU's, DENR and LLDA.	The proponent will ensure that impacts of the project on water contamination will be 80 to 100% mitigated.
Procurement and planning	Economy	Increase business opportunity due to purchase of construction materials	• Purchase from local suppliers whenever possible • Secure services of residents whenever possible	Around 80% prioritization of purchase of materials from local suppliers, sourcing of materials from nearby provinces, and acquiring services of locals, depending on availability of resources.
A.3. Land acquisition and resettlement	People	Displacement of settlers, Disturbance of properties and Loss of livelihood of project affected persons	• Preparation of FS and DED Resettlement Action Plan. The RP will be based on the final detailed design of the project to avoid involuntary resettlement; • Implementation of the approved Resettlement Action	Implementation of the ROW acquisition and resettlement will be 100% in accordance with the final agreement between DPWH and the Project Affected Persons (PAPs)

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
			Plan (RAP) of the Project in accordance with the applicable government process and directives; • Provide relocation / compensation to affected landowners, households, and owners of other establishments based on the Entitlement Matrix (EM) prepared for the project • An agreement should be settled between DPWH and the landowner. • Ensure that all losses and entitlements of the project affected persons will be compensated accordingly and in a timely manner; • Continuous consultations with the project affected persons to inform them about the status and resettlement plan schedule of LLRN; • Coordination with DHSUD and the LGUs for the proper preparation and implementation of Right-of-	

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
			Way Acquisition and Resettlement Action Plan (ROWARAP) • Regularly monitor of presence/absence of complaints from PAPs. • Immediate action on the stakeholder complaints through the implementation of Grievance Redress Mechanism (GRM)	
		Public resistance on the proposed development project	• Undertake consultation meetings with stakeholders including IEC, FGD and other consultation meetings • Conduct FGD and consultation meetings with LGU, directly affected people, and key stakeholders	100% inclusion and participation of representatives from all affected LGUs - Taguig, Muntinlupa, San Pedro, Biñan, Sta. Rosa, Cabuyao, and Calamba in meaningful consultation meetings
Construction				
Soil excavation activities	Land	Increased suspended and dissolved solids, color, and turbidity in streams and Laguna Lake	• Proper management of stockpiles and the drainage system should be undertaken. To avoid contamination by rain washing, stockpiles should be distant from the waterways and covered.	Impacts on existing water quality will be 80% to 100% mitigated to prevent increase in suspended and dissolved solids, color and turbidity. Proponent will ensure 100% compliance to DENR water quality standards.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
			• Apply proper siltation control measures • Excavated materials, such as soil debris, will be hauled out from the site • Regular monitoring of the adjacent water bodies	
General Construction Activities	Land and Water	Excessive oil and grease, and other particulate material due to run off or spillages on site may degrade water quality	• Project will have oil-water separators to remove oil from effluents prior to discharge • Organized waste storage with an impermeable area will be implemented for bulk waste oils and lubricants • Implement a proper waste management in accordance with RA 9003 • Waste oils and other hazardous wastes will be collected by a DENR-EMB accredited third-party hauler and treater • Emergency and contingency plan will be made in case of spills • Maintenance and proper use of construction materials and	Proper waste management practices will be 90% to 100% implemented to prevent spillages that may degrade water quality. This will also depend on DENR accredited hauler collection.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
			heavy machinery	
		Domestic waste generated by the workforce may be carried to nearby water bodies due to poor waste management.	• Require contractors to implement proper solid waste management throughout the development stages of the project to ensure pollution control management • Conduct trainings and seminars to disclose plans and improve awareness on proper solid waste management practices • Stockpiles will be placed away from water sources and protected against natural elements • Sewage waste discharges will be directed to a local septic tank • Temporary sanitary facilities should be employed on-site • Construction materials, substances, chemicals, etc. shall be properly stored and managed in a secured designated storage area with provision of secondary	Proper waste management practices will be 90% to 100% implemented in accordance with the Solid Waste Management Plan and aligned with the requirements of RA 9003 to prevent impacts to the lake and other nearby water bodies. The DENR-EMB accredited hauler will also contribute to the efficacy of the proposed measures.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
			containment	
		• Soil compaction from construction on land may increase risk of surface runoff, • Debris, contaminants and sediments from construction may runoff to water streams including liquids such as gasoline and oil	• Low level culverts are to be provided for river stream connecting to the lake; intercepting channels and box culvert are also proposed along the western side of shoreline embankments to provide drainage capacity to the lake and shoreline area • Implement an organized waste storage with bulk waste oils and lubricants placed in impermeable area with appropriate secondary containment • Implement proper waste management and housekeeping measures • Waste oils and other hazardous wastes will be collected by an accredited third-party hauler and treater • A health and safety management plan will be prepared and implemented to establish protocols and procedures in addressing	Proper equipment maintenance, disposal of hazardous wastes and non-recyclable wastes, and expert handling of waste oil and oil spills will translate to 80% to 100% efficiency in pollution control. Compliance to plans and standards (i.e. RA 6969) will be ensured for proper disposal practices.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
			potential health and safety emergencies (i.e., oil spills)	
	Water Quality	Increase organic contaminants (BOD, ammonia, phosphorus) if domestic wastewater is not properly managed.	• LLRN road network is designed with intercepting channels and box culverts to be provided in regular intervals to allow the catchment area along the shoreline embankment be drained to prevent runoff of waste materials into the lake • Strict implementation of waste management rules and regulation shall be made.	Potential impacts that may be due to mismanaged domestic wastewater caused by the project will be at least 80% mitigated, but the proponent will ensure 100% compliance with RA 9275.
Operation / Maintenance				
Project Operation	Air and Noise Quality	Increased fossil fuel emissions from the vehicles that utilize the highway	• Plant trees in between project site and local communities to reduce their exposure to these emissions as the vegetation act as a buffer. • Proper and efficient use of fuel-powered equipment for air pollution reduction. • Safety briefings, giving importance to personal and environmental implications. Ensure the proper use of	Due to the permanent effect of the project, the proponent will ensure that design will utilize only to the planned alignment. Proponent will ensure that 80% to 100% of the mitigation plans be complied wit

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
			personal protective equipment (PPE) based on Occupational Safety and Health Association (OSHA) guidelines. • Turn off the engine of idling vehicles to prevent wasting fuel.	
		Increase in noise level – Frequent passage of transportation vehicles in the project	• Installation of 3m high noise barrier and low noise road surfacing are recommended for the noise-sensitive receivers • Install larger numbers and more noticeable "No blowing of horn" signs • Provide buffer area that will enforce noise mitigating procedures • Conduct regular noise monitoring at sensitive receptor areas to prevent effects on human health	Permanent impact of the project. Proponent will ensure continuous noise monitoring during operations phase.
	People	Increased probability of road accidents due to increased	• Post appropriate signage along the alignment to warn both residents and motorists • Widely disseminate	Road traffic accident increase will be a permanent impact of the project. It will be mitigated 70% to 80% by the proposed mitigating measures. Effectiveness will

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
		traffic and higher speed limit on the bridge/viaduct	information on allowed vehicles on the bridge and speed limit • Provide a crew to monitor traffic on the bridge/viaduct Continuous coordination with the LGUs and affected barangays	depend on the road users' compliance to traffic rules and regulations.
	Economy	Improved mobility is foreseen and contribution to the access of economic opportunities for the growing population in the region.	Positive Impact	Permanent impact of the project.
Decommissioning/Abandonment				
Disintegration of the demobilized structure	Water Quality	Impacts on existing water quality of laguna lake - Turbidity - Solid Waste	Implementation of approved decommissioning plan by the EMB	Impacts on existing water quality of Laguna Lake caused by the project will be 80% to 90% mitigated based on the approved decommissioning plan of EMB, depending on the contractor, but DPWH will ensure 100% compliance with the approved plan of EMB.

Risks and Uncertainties Relating to the Findings and Implications for Decision Making

Risks and uncertainties anticipated regarding the construction and operation of the road network are shown in **Table 1E**.

Table 1E Risk and Uncertainties of the Project

EIA Module	Risks and Uncertainties	Control Measures
Project Design	Structural failure due to possible occurrence of unprecedented natural calamities such as earthquakes, ground rupture, storm surge, etc.	• Use of good and competent designer and contractor for the project; supervision is needed to ensure high quality finish of the road network; • Use of high-quality materials and scaffoldings during construction; Regular maintenance and monitoring of the structure particularly during operations phase;
	Damage or collapse due to wave impacts and the risk of overtopping in relation to a storm-surge scenario	LLRN is elevated to minimize overtopping within allowable thresholds, and the embankment slope angle and rock armour protection system are designed to mitigate any adverse impacts from tsunamis or seiches; Detailed numerical modelling and hazard assessment should be undertaken during Detailed Engineering Design – considering a combination of actual anticipated ground movement, water levels, slope instability, etc
	Damage or collapse due to seiches and storm surge	
Water Quality	Increase in susceptibility to flooding	• Design of structures to have a clearance above established flood levels; • Consider wave impacts and the risk of overtopping in relation to a storm-surge scenario during a time of elevated water levels due to flooding; • Ensure that there is efficient flow and removal of surface water by establishing appropriate drainage canals; elevation of the area and the proximity to the sea shall be considered in detailed design and planning; • Full hydraulic modelling and a coastal flooding study should be carried out at the detailed design stage to reassess the wind-wave and overtopping conditions at the embankment once the alignment and structural form is finalized.

EIA Module	Risks and Uncertainties	Control Measures
	Degradation of water quality	• Design and implementation of appropriate erosion control measures (additional pavements, concrete seawalls, sediment traps, and barriers during heavy rain periods); place away stockpiles from water sources; • Haul out excavated materials, waste soils, and other debris will be hauled out from the site at the designated area such as landfill site; • Regular monitoring of adjacent water bodies; • Installation of oil-water separators to remove oil from effluents prior to discharge.
Ambient Air and Noise	Alteration of air quality from vehicles, fugitive dust and from equipment use	• Periodic monitoring of the concentrations of PM2.5, PM10, TSP, SO2 and NO2 shall be done to ensure that the levels of these pollutants will still be within the DAO 2000-81; • Regular and adequate water spraying especially during transportation of materials to minimize dust particles
	Increase in noise levels from construction activities and operations	• Installation of noise barrier and low noise road surfacing; • Scheduling and limiting loud activities at nearby settlements; • Periodic monitoring and evaluation of noise levels, among other parameters included in the ECC for future references
Terrestrial Flora	Unanticipated additional cutting of trees or other vegetation during DED stage that may cause delay on the tree inventory and application of the tree cutting permit.	The project has to wait for the detailed engineering survey and secure design confirmation regarding the possible minor adjustment prior to the acquisition of ROW and necessary permits.
Terrestrial Fauna	None	The study area taken for the terrestrial fauna study and impact assessment covers the primary impact area (the main alignment) and the secondary impact area (adjacent areas). The possible changes for some portions of the project design during the DED will not affect the established sampling points, impact management plan, and EMoP formulated for the proposed project. The results still cater such anticipated changes.

EIA Module	Risks and Uncertainties	Control Measures
People	As the project plans and alignment may still change due to the result of detailed engineering design, this may impact the plans for ROW acquisition and that number of structures, PAPs may still change	Wait for the detailed engineering survey and secure design confirmation regarding the minor adjustment to the alignment perior to the acquisition of ROW

1 Project Description

The Laguna Lakeshore Road Network (LLRN) Project is one of the seven projects under the Infrastructure Preparation and Innovation Facility (IPIF) which aims to support the Department of Public Works and Highways (DPWH) to deliver more effective, efficient and innovative infrastructure projects all over the country. LLRN caters the area in the vicinity of Laguna de Bay, with a road network scheme that is divided into two phases:

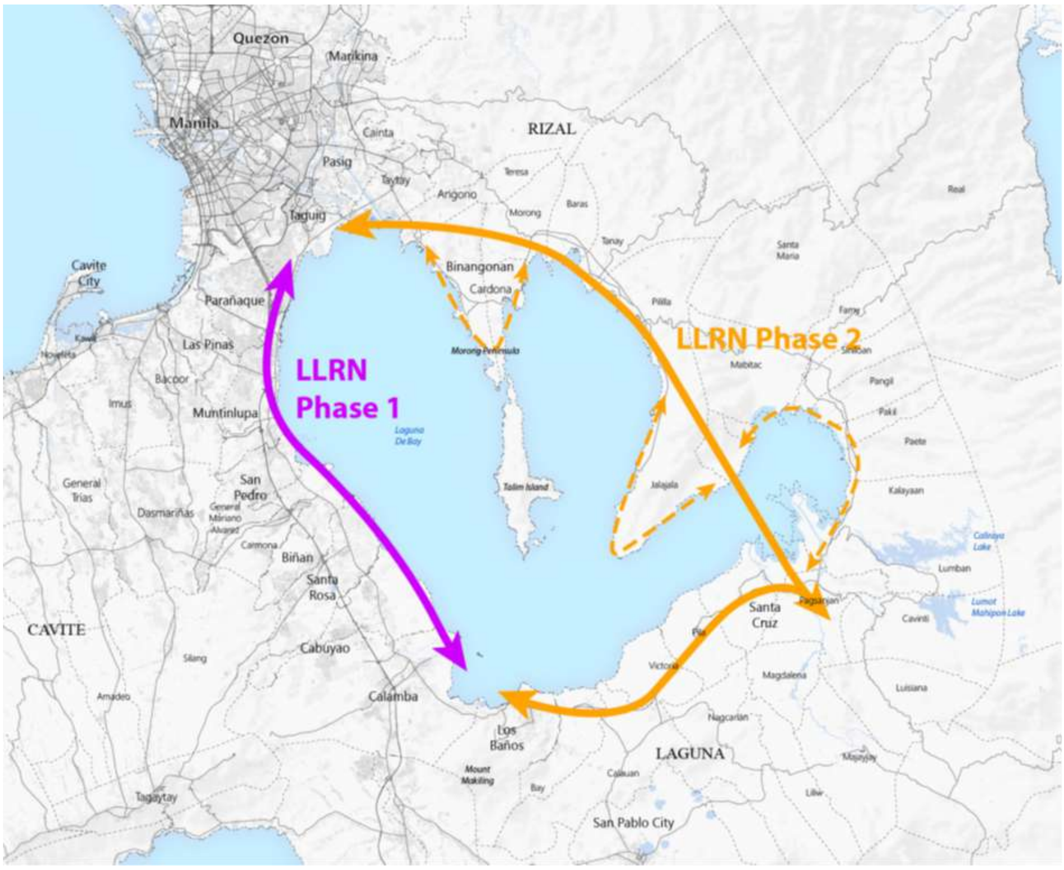


Figure 1- 1 The Outline Master Plan Phase I and Phase II of LLRN

Phase I runs along the western coastline of the Lake while Phase II stretches in the Northern to Southern coastline via an eastern route. The current study is for Phase I of the project.

1.1 Project Location and Area

1.1.1 Description of Project Area

The proposed LLRN will provide a road corridor to facilitate traffic flow from Metro Manila to the province of Laguna in Region IV. The preparation of the Feasibility Study (FS) will be used to develop the preferred road connector scheme including preliminary engineering, economic, and environmental and social impacts.

The final alignment, which has a total of approximate length of 37.6 kilometres with a total of 7.3 kilometers of slip roads, is to be built along the west shoreline of Laguna Lake. Majority of the proposed road is along Laguna Lake shoreline with a combination of viaduct and shoreline embankment. The alignment will start in Barangay Lower Bicutan in Taguig City and end in Calamba City. There will be eight (8) interchanges at the mainline – one interchange in Taguig at Barangay Lower Bicutan; three interchanges in Muntinlupa at Barangays Sucat, Alabang, and Tunasan; four interchanges in Laguna at the City of San Pedro/Biñan, Santa Rosa, Cabuyao and Calamba. Interchanges are distributed along the course of the alignment and will provide access to seven cities in the western side of Laguna Lake. These interchanges are proposed to connect to municipal boundaries at the nearest public road.

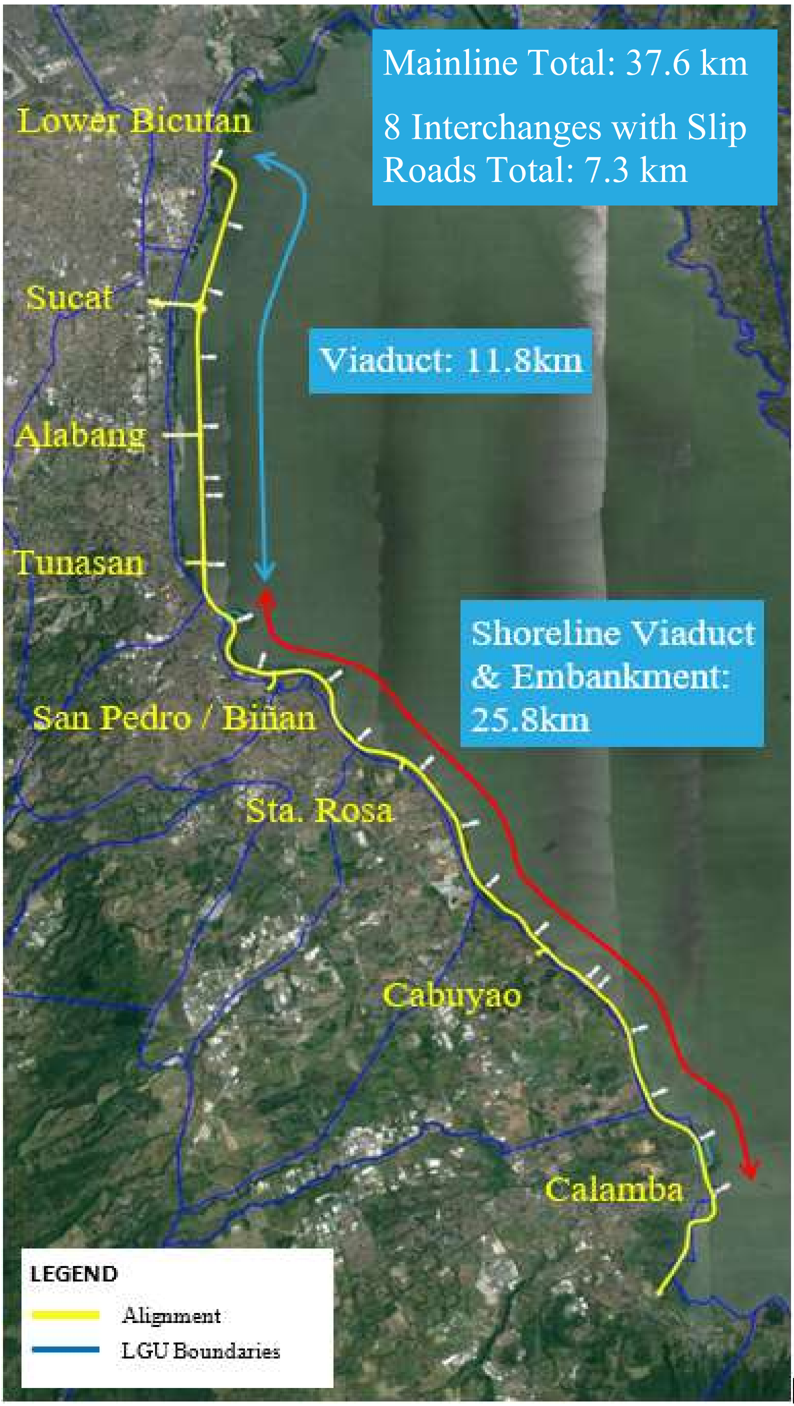


Figure 1- 2 LLRN Phase I Final Confirmed Alignment along the Western Coast of Laguna Lake

From the starting point of LLRN at Lower Bicutan interchange, approximately 11.8km of viaducts is proposed to Tunasan interchange. The viaduct is approximately 400-500m away from the shoreline which traverses several fish pens and fish cages in Taguig and Muntinlupa.

From Tunasan Interchange to the end of LLRN Phase 1 at Calamba Interchange, approximately 25.8km of mixed shoreline viaduct and embankment is proposed. Along this corridor and coastline, there are many existing housing structures and some fishing boats but mostly are vacant areas and vegetations. River bridges are proposed to span over major creeks or rivers that crosses the proposed alignments, such as San Cristobal River and San Juan River near the headland of Cabuyao. Low level culverts are to be provided for river stream connecting to the lake.

In Taguig City, the roundabout interchange is in Barangay Lower Bicutan connecting to C6 near the Lakeshore Hall and Lower Bicutan Barangay Hall which are all near the shoreline of the lake. There are three arms at the roundabout which connects to the northbound and southbound of C6 and the mainline into the lake.

In Barangay Sucat, the proposed Channelized T-Intersection will be located directly at the intersection of Meralco Road and East Service Road of South Luzon Expressway (SLEX). Connecting this intersection to the mainline is a 1,685-meter slip road that will traverse and climb over a large area of private land with cogon grasses and different kinds of weeds including a Jeepney Terminal, and it crosses the PNR railway track near the Sucat Station, two (2) roads namely Manuel L. Quezon and T. Posadas Ave. and inhabited areas near the shore of the lake.

In Barangay Alabang, the mainline will be connected by an 860-meter slip road to the intersection of Montillano Street, Manuel Quezon at the north and Ilaya Road at the south. At this junction, there are several residential and commercial structures including the Alabang Medical Clinic and Iglesia Ni Cristo.

In Barangay Tunasan, a provision of interchange as requested by the LGU of Muntinlupa has been considered. A vacant area which is 100 meters away from the shoreline is the landing point of the 460-meter slip road from the mainline. This is situated close to Umali St. and Buendia St. wherein the Muntinlupa Science High School and Muntinlupa Sports Complex are close by.

Near the border of Barangays Landayan and De La Paz in the cities of San Pedro and Biñan, respectively, in Laguna is another landing point located at the end of Hernandez St., which connects to the mainline with a 435-meter slip road that mostly traverses vacant lands, an unnamed road and a few residential structures. The entire 1.4 km stretch of Hernandez St. up to Manila South Road is occupied by commercial establishments and clusters of residential houses. Nearby are the Landayan Elementary School, Landayan Barangay Hall, South Fairway Homes Subdivision and South Springs Residential Estate.

In Barangay Sinalhan in Sta. Rosa, the proposed grade-separated interchange from the mainline at the shoreline will connect to Brgy. Sinalhan Road via a 210-meter slip road which will traverse several residential structures, vacant areas and clusters of various trees. Near the landing point is Sinalhan Integrated High School and along Brgy. Sinalhan Road are a mixture of low rise commercial and residential structures.

In Barangay Marinig in Cabuyao, from the at-grade roundabout of the mainline at the shoreline, a 205-meter slip road is to connect to Marinig Road by traversing a heavily vegetated area and low-rise residential structures. Both sides of this road are occupied by residential houses and compounds. 300 meters north of this landing point is the University Of Perpetual Help System Maritime Training Center and Cabuyao River while 300 meters south is the intersection of Marinig Road and Southvile Road where the Cabuayo Fish Port and North Marinig Elementary School are located nearby.

In Barangay Palingon in Calamba, the at-grade roundabout of the mainline is located along the shoreline and 420 meters away from Calamba Bayside Integrated School. 600 meters west of this interchange is the Lingga Barangay Hall and 500 meters south is the Calamba Baywalk. From the roundabout, a 3,450-meter slip road connects to the adjacent interface project, Calamba-Los Baños-Bay Bypass via another at-grade roundabout connection.

Public utility vehicles, tricycles, and private vehicles are the main means of transportation in the area. The fastest existing road connection between Laguna and Metro Manila is mainly via SLEX and the Manila South Road which takes approximately 2 - 3 hours during peak hour of a normal weekday to complete the journey.

Table 1.1 Location of LLRN Interchanges

Region	Province	City	Location of interchange
National Capital Region		Taguig	Lower Bicutan
		Muntinlupa	Sucat
			Tunasan
			Alabang
Region IVA	Laguna	San Pedro City	Municipal boundary of San Pedro and Biñan
		Biñan City	
		Santa Rosa City	Sinalhan
		Cabuyao City	Marinig
		Calamba City	Bucal

1.1.2 Impact Areas

Table 1.2 Direct and Indirect Impact Areas

Impact Areas	Direct Impact Areas (DIA)	Indirect Impact Areas (IIA)
Taguig	Main and direct alignment of LLRN within portion of Barangay Lower Bicutan	Side of LLRN alignment within portions of Barangays Lower Bicutan, Upper Bicutan and Bagumbayan

Impact Areas	Direct Impact Areas (DIA)	Indirect Impact Areas (IIA)
Muntinlupa	Main and direct alignment of LLRN within portions of Barangays Sucat, Alabang and Tunasan	Side of LLRN alignment within portions of Barangays Sucat, Buli, Cupang, Alabang, Bayanan, Putatan, Poblacion and Tunasan
San Pedro City	Main and direct alignment of LLRN within a portion of Barangay Landayan	Side of LLRN alignment within portions of Barangays Cuyab, San Roque, and Landayan, consistent to the design and alignment
Biñan City	Main and direct alignment of LLRN within a portion of Barangay Dela Paz	Side of LLRN alignment within portions of Barangays Dela Paz, Malaban, Casile, and San Antonio, consistent to the design and alignment
Santa Rosa City	Main and direct alignment of LLRN within portions of Barangays Aplaya and Sinalhan	Side of LLRN alignment within portions of Barangays Aplaya, Caingin and Sinalhan, consistent to the design and alignment
Cabuyao City	Main and direct alignment of LLRN within a portion of Barangay Marinig	Side of LLRN alignment within portions of Barangays Baclaran, Bigaa, Butong, Marinig, and Gulod, consistent to the design and alignment
Calamba City	Main and direct alignment of LLRN within portions of Barangays Palingon and Bucal	Side of LLRN alignment within portions of Barangays Uwisan, Looc, Sampiruhan, Palingon, Lingga, Lecheria, Halang and Bucal, consistent to the design and alignment

Figure 1- 3 Vicinity Map

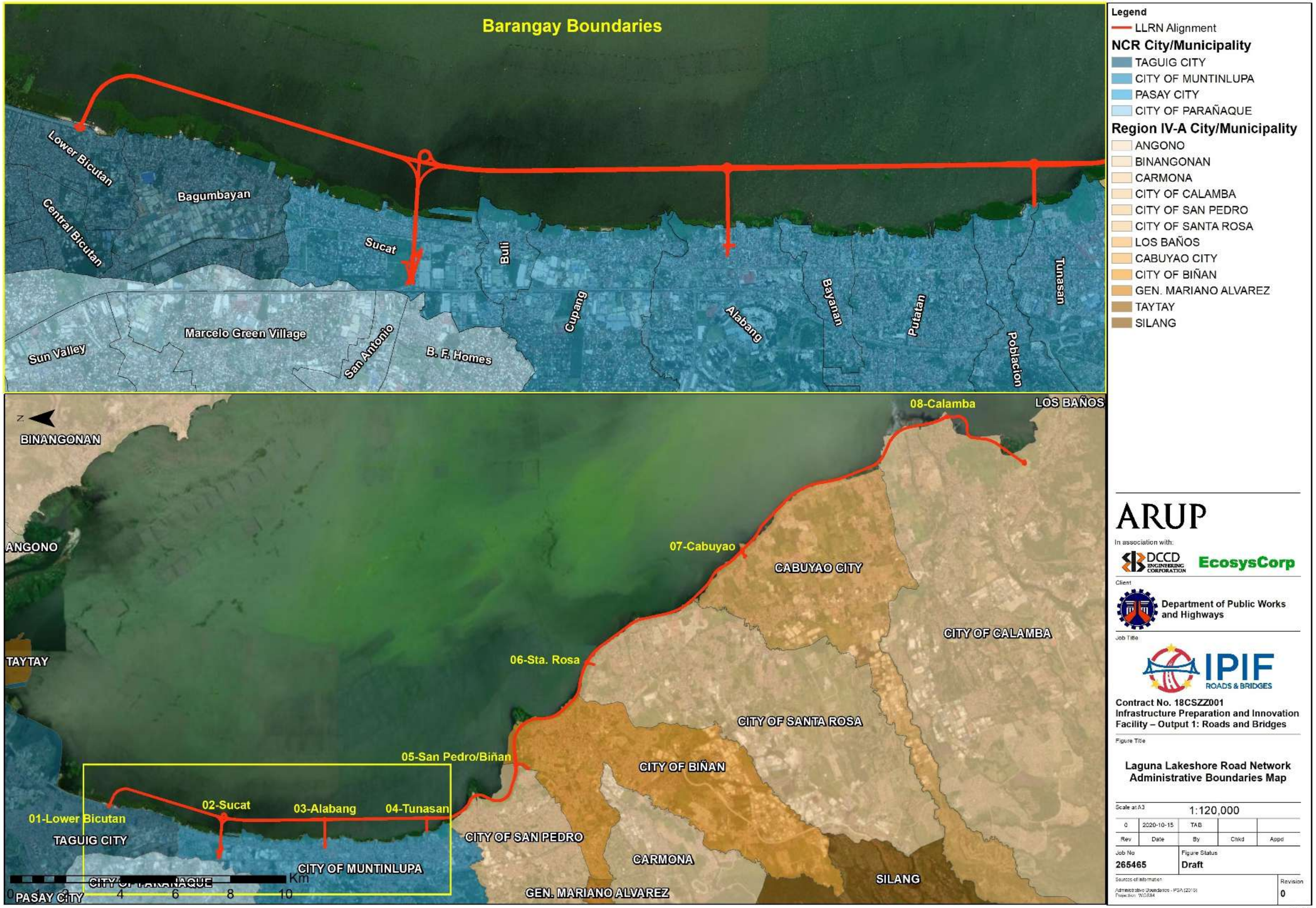


Figure 1- 4 Municipal Boundary Map of Muntinlupa

Figure 1- 5 Municipal Boundaries of San Pedro, Biñan and Sta. Rosa

Figure 1- 6 Municipal Boundaries of Cabuyao and Calamba

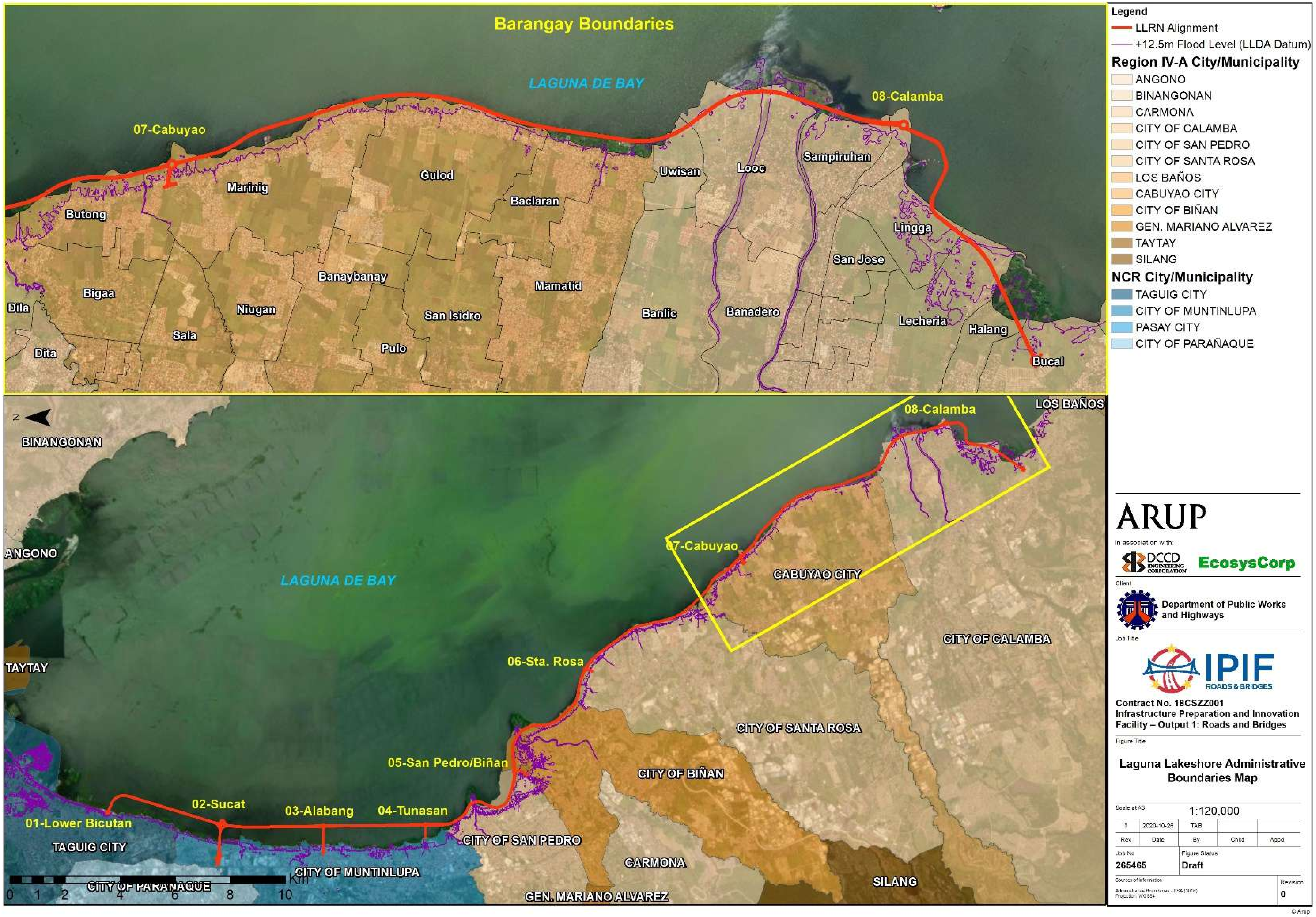


Figure 1- 7 NAMRIA Map Showing the Impact Barangays and its Boundaries

1.2 Project Rationale

During the World Economic Forum (WEF) on the Association of Southeast Asian Nations (ASEAN) held in Cambodia, Philippine President Rodrigo Roa Duterte presented the administration's 0 to 10-point socio-economic agenda. The 4th agenda aims to accelerate annual infrastructure spending to account for 5% of the gross domestic product. In line with this, the administration intends to spend 8-9 trillion pesos from 2017-2022 solely for infrastructure. These infrastructure projects will allow the recipient communities to have an easy access going to work, businesses, markets, education, and other services. According to the project administration manual of the Asian Development Bank, for the infrastructure preparation and innovation facility, the impact of underdeveloped public infrastructure in the Republic of the Philippines will impede the potential of businesses and economic opportunities in the country.

The overarching intent of the project is to provide a safer and faster alternative to the motorists traveling south / north to vitalize the economies for the surrounding areas including Laguna, Rizal, Quezon, and Batangas.

The project will contribute to the access of economic opportunities for the growing population in the region.

The project will provide:

- A resilient, reliable transportation link for residents and commuters
- Faster journey travel times
- Ease of access to tourism activities
- Enhanced internal circulation, mobility, and external linkages to support the growth potential of the region

The project will provide **economic development opportunities** for:

- Enhanced productivity due to better accessibility and savings in travel time
- Improved land mix resulting from reclamation activities

The **economic outcomes** that this project will support are:

- Cost: Reducing the economic cost of transportation
- Economic development and diversification: Supporting economic development and diversification of the region
- Wider economic development: Supporting integrated, equitable economic development of the region within the country

The project will also impact upon **social outcomes**, the net result being positive:

- Accessibility: Enhancing community access to employment, education and other social services. Social benefits will primarily accrue to the residents in terms of enhanced access to the key health, education and other amenities provided within the National Capital Region.

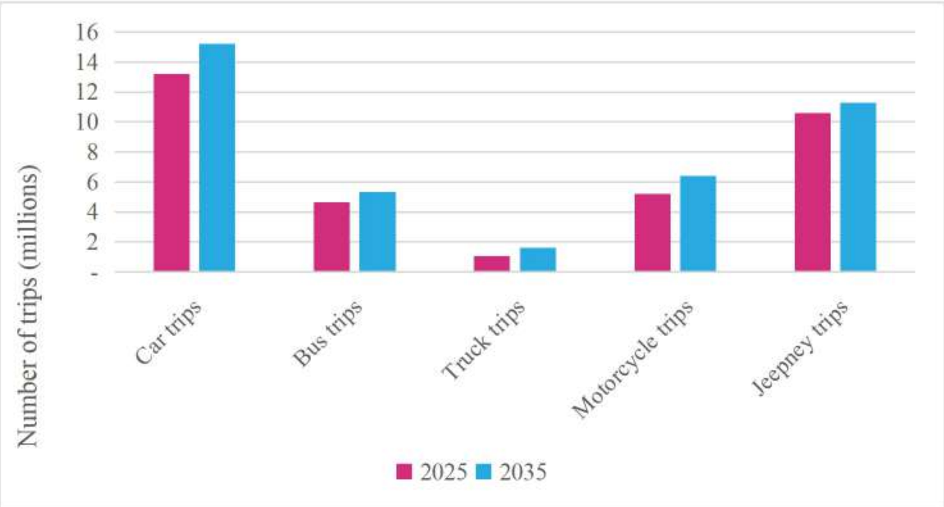
However, there are likely to be some adverse social impacts during construction as a result of property resumptions and short-term income impacts for fisherfolks and associated businesses at the lakeshore. These impacts and proposed mitigations will be detailed in the report.

1.2.1 Regional Context

In the National Capital Region (NCR), rapid economic and population growth in the last decade has outpaced investment in infrastructure. This has resulted in a congested traffic network with long journey times and travel time reliability issues which adversely affects productivity and economic growth.

Over the period from 2010 to 2045, it is estimated that the Philippines population will grow by 50 million people. Over 2.6 million of this increase will occur in NCR and 7.4 million in Calabarzon[1]. The population growth of the cities that would be connected by LLRN between 2000 and 2015 ranged between 24% in Los Baños and 190% in Cabuyao[2].

Significant levels of congestion exist within Metro Manila and along the national highway from Metro Manila to Los Baños in Laguna. Metro Manila's roads directly support 35 million trips made every weekday (based on 2025 projected travel on the existing transport network). Given significant population growth, the number of trips is expected to increase substantially as shown in **Figure 1-8**. Furthermore, as the Philippines becomes a more advanced economy, usage of cars and heavy vehicles for goods movement will increase. By 2025, it is estimated that this increase in vehicles will further slowdown traffic leading to average travel speeds for cars of only 16 km/h and 9 km/h in Metro Manila and Laguna, respectively.



[1] Philippines Statistics Authority, population projection Statistics accessed on 31 February at URL: https://psa.gov.ph/statistics/census/projected-population

[2] Philippines Statistics Authority, 2000 and 2010 censuses

Figure 1-8 Expected trip change between 2025 and 2035 based on transport modelling

Throughout this period, there will be significant growth in both employment and the workforce across NCR as well as land use change in order to accommodate said growth. It will be critical for Metro Manila's success to ensure employment, economic activity, and industrial land is distributed efficiently across the region and that land uses are well supported by transport.

While population and economic activity is concentrated in Metro Manila, there is also a growing population and economic activity towards the Laguna province with several economic zones in the area. High quality transport connections between these areas are critical to the successful development and growth. It will be essential to enable better and faster access to employment opportunities in Metro Manila. The LLRN scheme seeks to address these issues.

1.2.2 Transport benefits

Due to the significant levels of congestion, this is leading to long journey times which impacts on workers, residents and tourists traveling between the two areas, businesses in Metro Manila and the provinces around Laguna Lake, and tourism destinations in Laguna, Rizal, Quezon and Batangas.

The volume to capacity ratios on key links in the network illustrated in **Figure 1-9**, exceed 1.50 which is beyond what is considered reasonable to support an efficient road network.[3] In practise, this means that roads are carrying 50% more vehicles than they were designed for. A volume to capacity ratio less than 0.85 generally indicates that adequate capacity is available, and vehicles are not expected to experience significant queues and delays. As the v/c ratio approaches 1.0, traffic flow may become unstable, and delay and queuing conditions may occur. The figure shows the level of service throughout much of the corridor is graded at 'F'; the lowest score possible.

[3] National Economic Development Authority, Roadmap for Transport Infrastructure Development for Metro Manila and its Surrounding Area, pg. 3-7, http://www.neda.gov.ph/wp-content/uploads/2015/03/FR-SUMMARY.-12149597.pdf

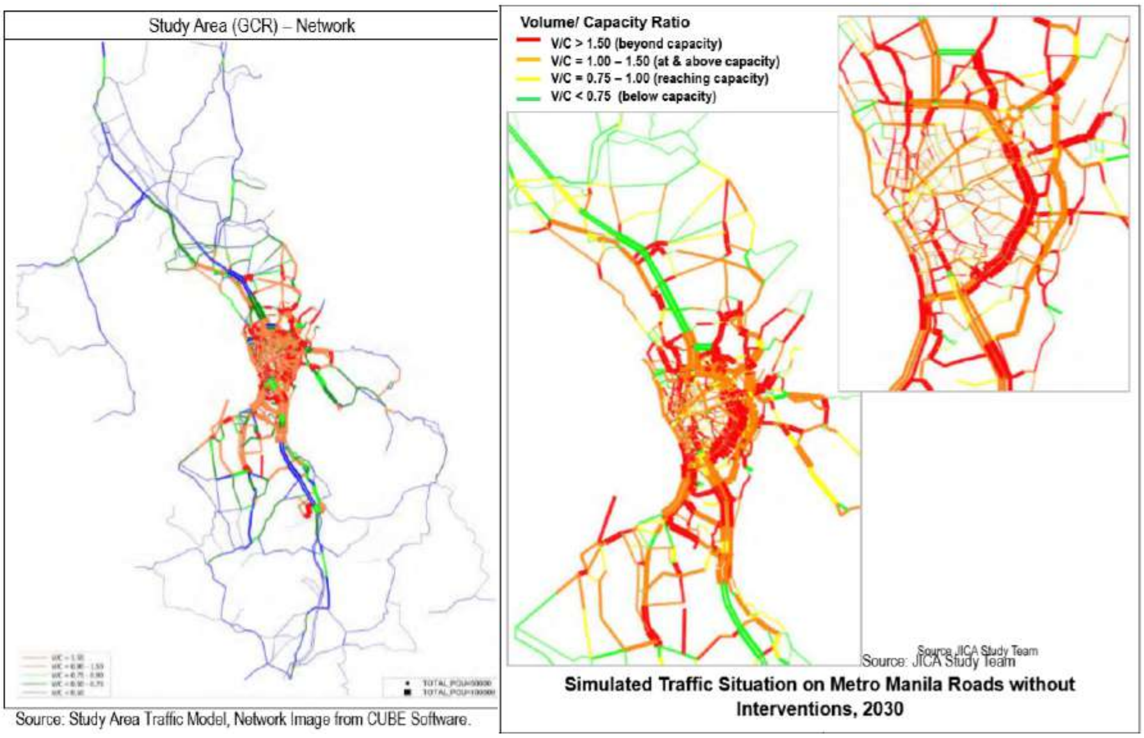


Figure 1- 9 Traffic Model- Highway Network Traffic Volume and V/C Ratio[4].[5]

These capacity constraints pose a limitation on the future development potential of the economy. The road network in NCR serves a function not only for transporting workers, tourists and residents within this region, but also in supporting the transit of goods and services domestically and internationally. As shown in **Table 1.3**, approximately 46% of all of the Philippines' cargo throughput in 2016 occurred in the Metro Manila and Batangas provinces.

Table 1.3 Local Ports by Share of Total Philippines Cargo and Passengers, 2016[6]

Port	Cargo freight		Passengers	
	Tonnes (millions)	% of total	Passengers (millions)	% of total
Port of Batangas	23.4	9.6%	7.9	11.5%
Metro Manila	89.4	36.7%	1.3	1.9%
Philippines (Total)	243.7	100%	68.9	100%

[4] Roadmap for Transport Infrastructure Development for Metro Manila and its Surrounding Area, NEDA Technical Report No.2, Figure 4.3.1 <http://www.neda.gov.ph/roadmap-transport-infrastructure-development-metro-manila-surrounding-areas-region-iii-region-iv/>

[5] National Economic Development Authority, Roadmap for Transport Infrastructure Development for Metro Manila and its Surrounding Area, pg. 3-7, http://www.neda.gov.ph/wp-content/uploads/2015/03/FR-SUMMARY.-12149597.pdf

[6] Philippine Ports Authority (2016) Annual Report

The construction of LLRN would ease the pressure on the network, creating a direct route between Laguna and Metro Manila. It would lead to a reduction in congestion and improve the network performance.

Travel times will also improve significantly following the implementation of the proposed scheme. As extracted from LLRN B2: Alignment and Traffic Study report, the provision of LLRN will reduce the travel time along the corridor of the project. **Table 1.4** presents the comparison of travel time in 2035 AM between the "with project" case and "without project" case.

Table 1.4 Travel Time Saving for 2026 and 2035 AM (with project - without project) (minutes)

	(Minutes)	
Locations	**2026**	**2035**
Between Metro Manila sector and Laguna sector	-2	-13
between Alabang and Bicutan	-10	-10
between Biñan and Bicutan	-50	-60
between Santa Rosa and Bicutan	-20	-30
between Calamba and Bicutan	-10	-50

With the introduction of LLRN in the network, the average time saving between Biñan, Santa Rosa, Calamba and Bicutan sectors during AM peak hour will be about 20-50 minutes in 2026 and about 30-60 minutes in 2035.

By improving the overall inner-city urban road network by diverting traffic and reducing pressure on the existing Metro Manila transport network LLRN will also lead to a reduction in Vehicle Operating Costs (VOCs). This traffic diversion also reduces costs for existing users on other routes from where the diversion originated.

See **Sec. 2.5.5 Traffic** and **Appendix O . B2 Traffic Study, and Highway Alignment and Design** Report for further discussions.

1.2.3 Meeting population growth challenges and providing access to employment

LLRN will serve population growth by increasing Metro Manila's network capacity, making it easier for people to move around the city. One of the key drivers of future economic growth in both regions will be infrastructure investment. Metro Manila's strong population growth is resulting in more development being pushed out into the urban fringe. As distances between business, housing and the city become larger due to urban sprawl the role of transport infrastructure becomes ever more important.

As mentioned above much of the significant population increases forecast for the Philippines will be concentrated in NCR and Calabarzon region, in which the LLRN project would be located. By 2045, this combined population is expected to reach 34.6 million.[7]

The proposed road network connects some of the fastest growing cities in the regions; a few of them have doubled or tripled their population over the period 2000-2015.

[7] Philippines Statistics Authority, 2010, Census-based population projection in collaboration with the inter-agency working group on population projection.

Table 1.5 Population in cities connected by LLRN, 2000-2015[8,9]

City	Population census 2000	Population census 2010	Population census 2015	Percentage Change
Cabuyao	107,000	248,000	309,000[10]	190%
Calamba	281,000	389,000	454,000[11]	61.7%
Los Baños	82,000	102,000	112,000	24.2%
Manila	1,581,000	1,652,000	1,780,000	12.6%
Muntinlupa	379,000	460,000	505,000	33.0%
Taguig	467,000	644,000	805,000	72.2%

A key challenge will be ensuring access to employment for this rapidly growing population; increased transport capacity to support this growth will be critical to supporting economic development and social wellbeing.

The City of Taguig connects Metro Manila to Laguna de Bay and is one of the top contributors to Gross Value Added (GVA[12]). Transport access is a key need for industry in the area, particularly for the stronger performing sectors including wholesale, transport and storage, and manufacturing. However, the existing transport corridor in the area (consisting mainly of the South Luzon Expressway and the Manila South Road), is already heavily congested. As a connector to such a productive business centre, the economic costs of this congestion are amplified, detracting from worker productivity and access to markets.

1.2.4 Employment in agriculture and fishing

Agriculture and fishing are key industries for the local economy and preserving them are critical. Towns in the eastern and southern area of Laguna Lake in the provinces of Rizal and Laguna rely on agriculture, fishing, and small businesses.

Laguna Lake is one of the primary sources of freshwater fish in the country and considered as one of the main sources of livelihood of the fisherfolks producing 37k to 47k metric tons of fish from 1997 to 2000. The west-side of the lake has more suitable conditions for fishing industries. Most fish-pen and fish-cage structures are in this area. Aquaculture is more dominant compared to artisanal fishing. Uncontrolled development around the lakeshore could compromise land and water quality. Consequently, there is a need to preserve lakeside areas, securing future viability of the local fishing industries.

[8] Source: Philippines Statistics Authority, 2000-2015 censuses
[9] Rounded to the nearest 1000
[10] http://rsso04a.psa.gov.ph/article/special-release-result-2015-census-population-cabuyao-laguna
[11] http://rsso04a.psa.gov.ph/article/special-release-result-2015-census-population-calamba-city-laguna
[12] OECD 2017, Employment and Skills Strategies in The Philippines

The lake was classified as Class C water under the Water Quality Criteria of the DENR Administrative Order No. 34. This means that the lake is intended for fisheries propagation, secondary recreation activities (e.g., boating) and industrial water supply. However, recent studies show that the lake has been classified to 'non-contact recreation' due to its general pollution levels. The LLDA is the principal body working towards the sound ecological governance and sustainable development of the lake. In 2014, it has been observed that the depth of the lake has diminished over the last 17 years which is a clear indication that it is silting up. At present, challenges being faced by the community include issues in decreasing quantity of harvests, over-crowding of fish-cage and fish-pen structures, pollution, declining food sources, and illegal fishing activities. Despite these circumstances, the lake still has semi-natural and undisturbed shoreline. At the vicinity of the project in the province of Laguna, agriculture land is abundantly located. The lake also functions as a source of irrigation for various agricultural farmlands in the lakeshore towns of Laguna and Rizal. Some lakeshore areas are being utilized for cultivating water spinach (kangkong) particularly during low water level periods.

The environmental and social impact assessment identified that there will be adverse effects on informal communities along the lake sure and resettlement during the construction stage of LLRN including economic displacement of fishing activities will occur as a result of the scheme. However, during the operation of the scheme, it is proposed that there may be benefits in the longer term. The proposed Development Outline Master Plan of which LLRN forms a part of, will attract new growth into strategic transit-oriented nodes to curtail loss of natural lands along the rapidly-expanding western lakefront. The new corridor would create opportunities for compact, mixed-use development, while also preserving agriculture and associated cottage industries that provide food and goods to local urban areas. Improved access to agricultural lands and protecting the lake will support secure employment for farm workers and fisherfolks.

There are a number of existing protections in place to support employment and livelihoods in the Laguna De Bay area in which the LLRN would need to comply with and support. The Laguna De Bay Fishery Zoning and Management Guidelines (2018) seeks to:

- Promote the socio-economic well-being of people in the region by setting up zoning and management guidelines that is legally compliant in keeping with ecologically sustainable and equitable environmental principles
- Encourage marginal fisherfolk to organize themselves into groups or associations to enhance their capabilities for self enhancement

1.2.5 Providing development-enabling infrastructure

An effective and efficient transportation network prevents rising economic and social costs caused by congestion and provides businesses with significant opportunity to expand. The reduced travel time and costs will enable businesses to access markets in areas that have been costly or inconvenient to access. Businesses will also have access to wider talent pools, as workers in other areas are more readily able to travel efficiently.

With increased accessibility to a number of destinations, the LLRN is anticipated to catalyse the development potential along its route.

1.2.5.1 Tourism development

Tourism is an example of the development potentials that LLRN will facilitate. The improved connectivity and reduced journey times enabled by the LLRN scheme would support tourism initiatives such as ecotourism in the Laguna de Bay. It is also expected that through improved connectivity, the areas surrounding the Laguna Lake could become master-planned waterfront urban developments and protected areas can serve as an ecotourism and leisure zone to maximize its tourism potentials and stimulate the development of scenic lakeside communities. Growing community-based ecotourism which shows and conserve the natural and cultural resources of the region, while providing employment, will be a central element to the sustainable development of the corridor.

The Calabarzon Regional Development Plan 2017-2022[13] sets out the need for improved infrastructure and transport connections between Metro Manila and Laguna Lake to enable a thriving tourism industry on the waterfront of Laguna Lake such as San Pedro. San Pedro is a key pilgrimage destination, especially during holy weeks and other religious festivities attracting more than a million pilgrims every year. Aside from its religious and spiritual significance, this tourism magnet brings significant economic development to the region.

The proposed LLRN will play a key role in enabling this development of the tourism industry around Laguna Lake. It will be critical to overcome some of the barriers identified in the regional development plan such as traffic congestion to tourist destinations. The proposed LLRN will better connect local tourists from NCR to the lake as well as providing a reliable, fast and direct transport link for international tourists arriving at Ninoy Aquino International Airport travelling to ideal starting points for exploring the lake such as San Pedro or Biñan. Additionally, LLRN will also improve the local infrastructure including bike paths and lakeside promenades making the corridor a more attractive destination.

1.2.5.2 Facilitating trade

The LLRN will improve part of the road network between the biggest seaports in the country, Port of Manila with a gross registered tonnage of 114 million in 2017 and the second biggest Batangas Port, located about 110 km south of Metro Manila and gross registered tonnage just below 80 million.[14] The LLRN will support faster and more reliable journeys to a section of the network between these ports helping to facilitate improvements in productivity and Gross Domestic Product (GDP).

Over the period 2010-2017, both ports have been growing their operating capacity. Currently, there is no freight rail infrastructure in the Philippines, and increases in shipped goods puts additional operational and environmental pressure on the existing road network in Metro Manila and Laguna regions.

In acknowledgement of this, plans have been announced to revive the operation of a container cargo rail from Port Area in Manila to Laguna province under the *Build, Build, Build* program to decongest the Delpan-Roxas Boulevard-Osmeña highway corridor in

[13] Development Plan 2017-2022 http://www.neda.gov.ph/wp-content/uploads/2018/02/4A-CALABARZON-RDP-2017-2022-15Septver.pdf
[14] Gross registered tonnage, Port of Manila and Batangas, 2010-2017. Source: Philippine Port Authority

Manila.[15] However, the increase in the Manila and Batangas ports' operations will have a broader impact on the road infrastructure, therefore increasing the case for upgrades of the network.

1.2.6 Enhancing transport network resilience from flooding

The Philippines' National Capital Region is exposed to multiple natural hazards, with flooding often recurrent on an annual basis in many of its low-lying areas. It's challenging topography, waterway paths and seismology contribute to make the area vulnerable to hazards[16].

As the impacts of climate change increase in magnitude, low-lying regions such as these will be at the greatest risk of flooding, extreme temperatures and other natural disasters.

Ensuring that infrastructure is sufficiently resilient to withstand these effects will only increase in importance over time. That which is insufficient will generate significant reconstruction costs, as well as stunting economic growth and threatening the wellbeing and living standards of the population.

The LLRN scheme will be built to withstand increasingly severe weather events, thereby contributing to the resilience of the national asset base, and therefore its economic development. The scheme is likely to lead to reductions in the cost of flood protection in the future.

1.2.7 Accessibility to services

A lack of accessibility can result in poor health outcomes and the economic marginalisation of vulnerable demographic groups, such as those with low incomes. Relieving congestion and improving travel times will aid an improvement in accessibility for residents to local facilities.

Ensuring social infrastructure and employment lands are well serviced by the LLRN will help to support economic growth in the corridor. **Figure 1-10** shows location of key social and economic infrastructure within a 10km buffer of the LLRN. Overall, the LLRN will improve access to over 600 education institutions (elementary schools, secondary and tertiary schools, universities/ colleges), over 700 social infrastructure facilities (inclusive of hospitals) and 120 manufacturing areas.

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[15] Manila Standard October 2018, http://manilastandard.net/business/transport-tourism/277153/dotr-to-revive-manila-laguna-cargo-rail-project.html

[16] National Economic Development Authority, Roadmap for Transport Infrastructure Development for Metro Manila and its Surrounding Area, pg. 3-7, http://www.neda.gov.ph/wp-content/uploads/2015/03/FR-SUMMARY.-12149597.pdf

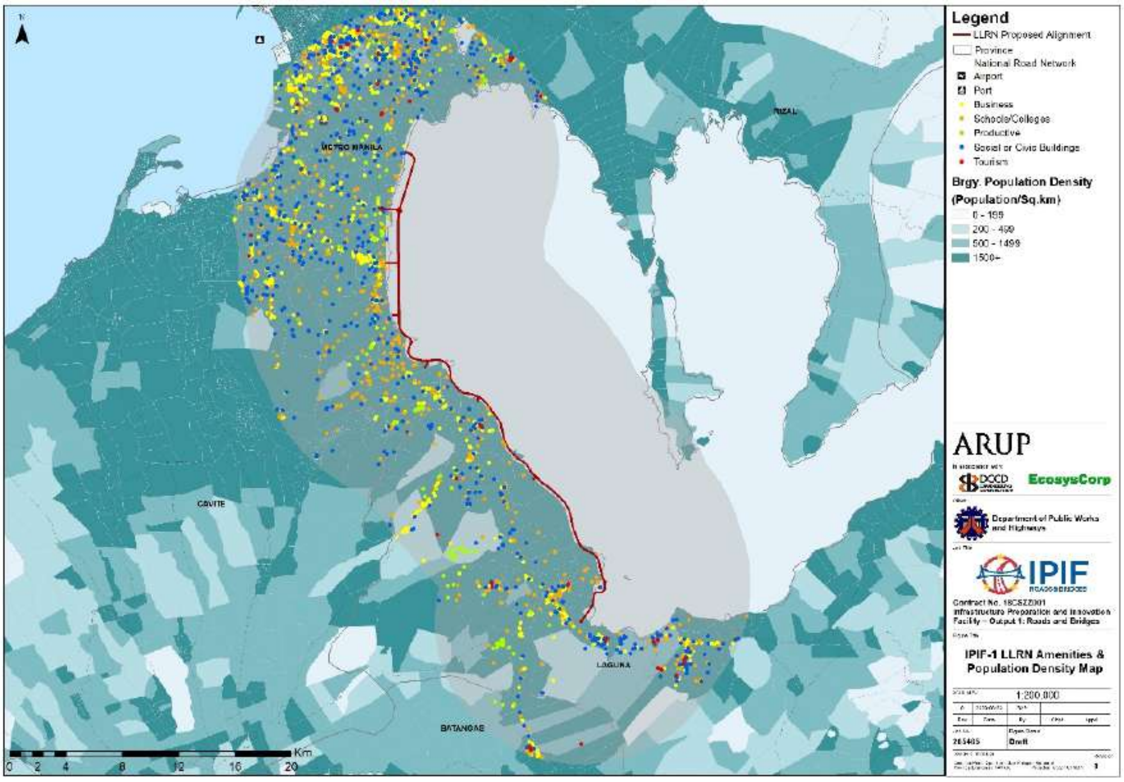


Figure 1- 10 Social infrastructure in a 10km buffer from the LLRN

1.2.8 Summary

In summary the LLRN scheme will provide congestion relief for the national highway from Metro Manila to Laguna. In doing so average journey times will be reduced for the workers, tourists and residents traveling in these provinces as well as for goods and services being transited domestically and internationally. This will have a beneficial effect on local industries including tourism, industries operating around the port and agriculture. The scheme will also help to protect the Laguna Lake shoreline from erosion, enhance transport network resilience from flooding and improve access for residents to local services. The project objectives, outputs, outcomes and impacts of the scheme are summarised in the following flow chart.

1.3 Project Alternatives

1.3.1 Options Considered in Stage I

1.3.1.1 Initial Development of Options

During Stage I of the Feasibility Study, the study area of the LLRN Phase 1 mainline covered the western shoreline of Laguna Lake from Taguig City to Los Baños, Laguna (**Figure 1- 11**). Five options including embankment, bridges and embankment were developed up to concept design (**Figure 1- 12**).

Figure 1- 11 Stage I Site Plan of the Study Area

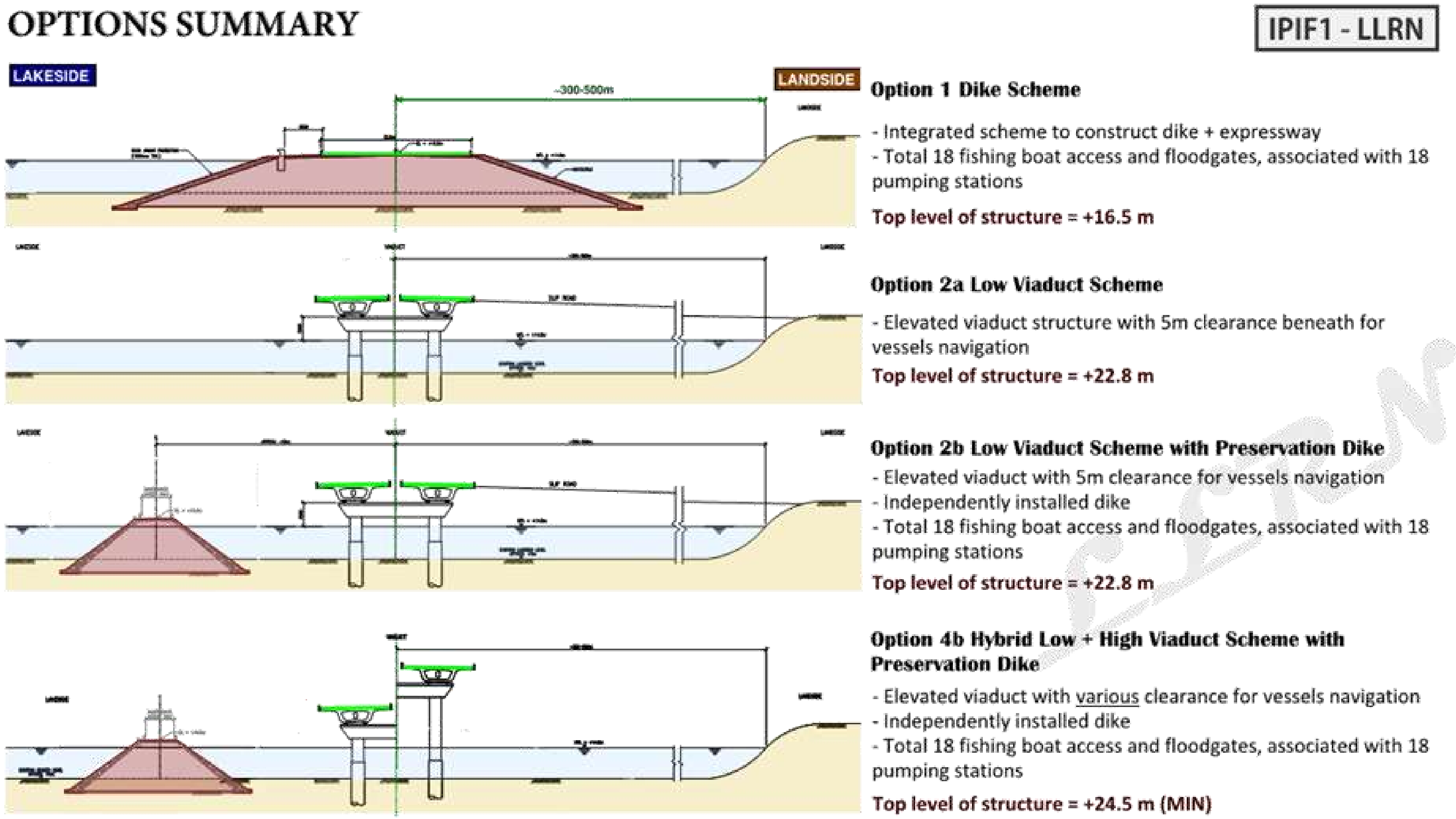


Figure 1- 12 Summary of Options for Comparison and Scoring

Option 1- Embankment Option: it is an integrated scheme, as shown in **Figure 1- 12**, to construct a dike + expressway along west lakeshore line with sufficient number of controlled flood gates along the dike.

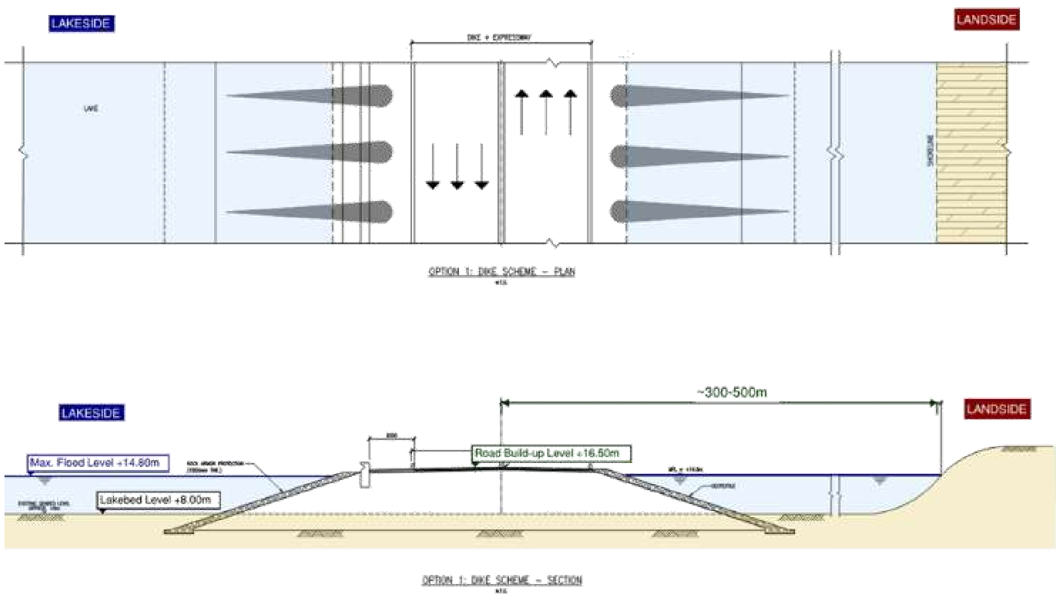


Figure 1- 13 General Layout of Option 1

Option 2A, 2B and 4B were viaduct scheme with different elevation to make balance on the provision of future development along the shoreline and visual impact to the lake. Viaduct option (**Figure 1- 14)** have minimal impact to the existing fisherfolk and vessel transportation.

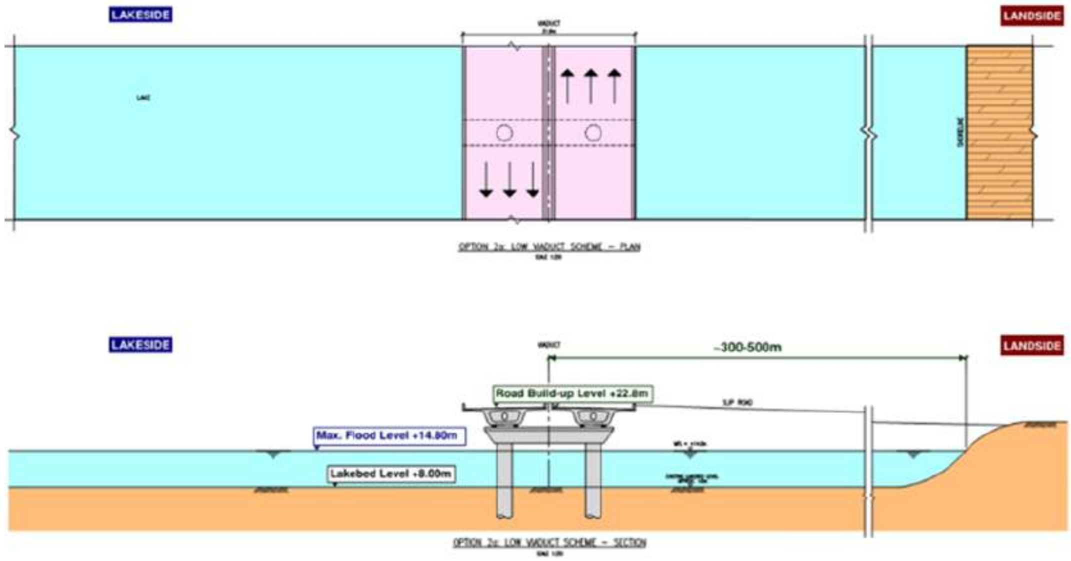


Figure 1- 14 General Layout of Option 2A

Option 5 - Combination Viaduct + Dike Scheme was developed in the Option Selection Workshop which was held on 20th February 2019. In this option, providing a 51km long high-standard expressway comprising of the combination of dike and viaduct along west shore of the Laguna Lake with interchanges from Bicutan/Taguig in Metro Manila through Calamba to Los Baños in Laguna in Phase 1. There were 8 number of interchanges identified at Stage I Hagonoy, Sucat, Muntinlupa, San Pedro, Biñan-Sta Rosa, Cabuyao, Calamba and Los Baños, each location is subject to further review in Stage II with a safer, reduce travel time and increase economic development along Lower Bicutan to Los Baños.

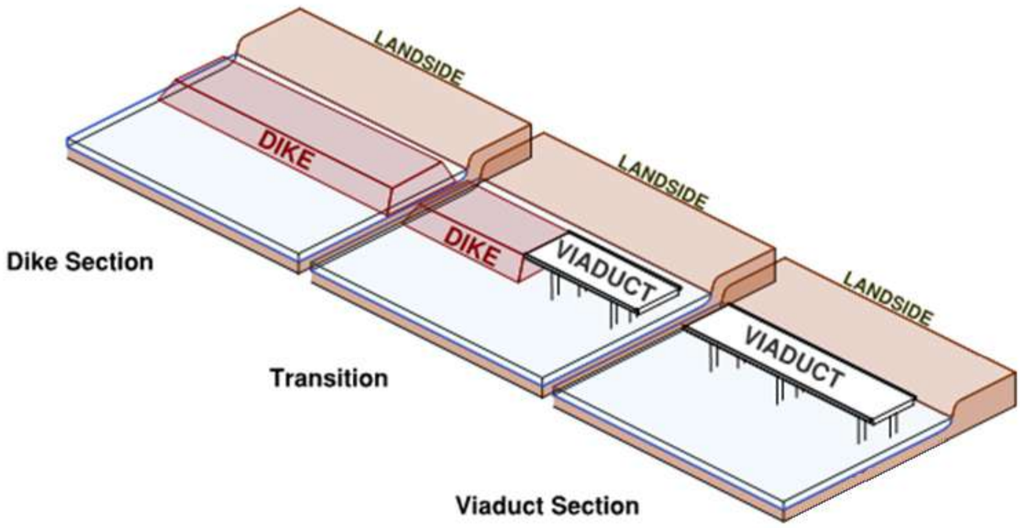


Figure 1- 15 General Layout of Option 5

1.3.1.2 Summary of Alignment Options Recommended

As re-capped in the previous sections, the horizontal alignment for all options is fundamentally the same. The landing points, interchanges, toll plazas and service stations arrangement are therefore the same. Distinctive features of each options are summarized in **Table 1.6**.

Table 1.6 Summary of Key Engineering Parameters of Options

	Option 1: Dike Scheme	Option 2a: Low Viaduct Scheme	Option 2b: Low Viaduct Scheme with Preservation Dike	Option 4b: Hybrid Low + High Viaduct with Preservation Dike	Option 5: Combination of Viaduct + Dike
Mainline Vertical Alignment	Top level of highway road surface is +6.022mSL.	Top level of highway road surface is +12.322mSL.	Top level of highway road surface is +12.322mSL. Top level of preservation dike is +6.022mSL.	Top level of highway road surface varies from +12.322mSL to +14.022m. Top level of preservation dike is +6.022mSL.	Top level of highway road surface varies from +12.322mSL to +14.022m.
Dike Structure	Top width of the dike is 40.9m.	NA	Top width of the dike is 8m.	Top width of the dike is 8m.	Top level of preservation dike is +6.022mSL.

	Option 1: Dike Scheme	Option 2a: Low Viaduct Scheme	Option 2b: Low Viaduct Scheme with Preservation Dike	Option 4b: Hybrid Low + High Viaduct with Preservation Dike	Option 5: Combination of Viaduct + Dike
Pump Design	Total 18no. pumping stations, each with 6-12 nos. of vertical axial pumps. Minimum capacity of pump is 40m3/s @ 3.8m	NA	Total 18no. pumping stations, each with 6-12 nos. of vertical axial pumps. Minimum capacity of pump is 40m3/s @ 3.8m	Total 18no. pumping station, each with 6-12 nos. of vertical axial pumps. Minimum capacity of pump is 40m3/s @ 3.8m	NA
Flood Gate Design	Total 18 no. flood gate along LLRN. Each pumping station consisting 16 nos. of sluice gates span across 300m dike opening. The proposed dimension is 18m x 8m (W x H).	NA	Total 18 no. flood gate along LLRN. Each pumping station consisting 16 nos. of sluice gates span across 300m dike opening. The proposed dimension is 18m x 8m (W x H).	Total 18 no. flood gate along LLRN. Each pumping station consisting 16 nos. of sluice gates span across 300m dike opening. The proposed dimension is 18m x 8m (W x H).	NA
Superstructure Design	NA	Continuous bridge with beam and slab or box girder, typical span of 50m.	Continuous bridge with beam and slab or box girder, typical span of 50m	Continuous bridge with beam and slab or box girder, typical span of 50m	Continuous bridge with beam and slab or box girder, typical span of 50m
Substructure Design	NA	Monopile or multiple piles with pile cap	Monopile or multiple piles with pile cap	Monopile or multiple piles with pile cap	Monopile or multiple piles with pile cap

The review on environmental and social key aspects was carried out in Stage I, outlining the existing conditions and possible constraints in the landing, and connecting areas and initially identify affected areas.

In addition, the environmental considerations include studies on the effects to the adjacent land and the environment, community impacts and ecologically sensitive areas. The following sections discuss about the laws and regulations for DENR and ADB requirements and the preliminary conditions in environmental and social studies:

- Adverse impacts upon the livelihoods of fishery along the Laguna lake shoreline operators and land transport operators
- Displacement of some community members and organizations as a result of land resumptions
- Residential communities and businesses are likely to require resettlement, subject to the final road alignment. A Resettlement Action Plan (RAP) has been prepared and stakeholder engagement process were undertaken.

These impacts should be managed appropriately through the provision of appropriate assistance to affected groups, to ensure that the net benefits of the LLRN are distributed equitably.

The LLRN project will have significant social and economic benefits for the greater community over time. The distinguishing characteristics of each option in terms of issues and benefits are presented in **Table 1.7**.

Table 1.7 Key Issues and Benefits

Option	Key Environmental /Social /Economics Issues	Key Environmental /Social /Economics Benefits
Option 1: Dike Scheme	Reduced connectivity between the inland channel and lake may reduce lake habitat Significant dredging which may leading to soil contamination and water quality degradation Intensive construction leading to noise and air pollution impacts to nearby sensitive receivers, congested traffic area during the construction phase. Greater impact on fishing activities and other economic activities on the lake	Flood alleviation
Option 2a: Low Viaduct Scheme	Minimal contribution to lake preservation	Allowing access to the lake for fisherfolk and other users. Minimal footprint within the lake Lower environmental impact during construction due to less intensive construction methodology and less dredging requirement
Option 2b: Low Viaduct Scheme with Preservation Dike	Significant dredging which may leading to soil contamination and water quality degradation Reduced connectivity between the inland channel and lake may reduce lake habitat	Lower environmental impact during construction due to less intensive construction methodology

Option	Key Environmental /Social /Economics Issues	Key Environmental /Social /Economics Benefits
Option 4b: Hybrid Low + High Viaduct with Preservation Dike	Significant dredging which may leading to soil contamination and water quality degradation Reduced connectivity between the inland channel and lake may reduce lake habitat	Lower impact to existing urbanization patterns and ecosystems, provided that the increased height remains a passage for ecology and marine traffic. Limited visual impact
Option 5: Combination of Viaduct + Dike	Reduced connectivity between the inland channel and lake may reduce lake habitat	Flood alleviation

1.3.1.3 Option Selection Methodology

The assessment comprises the determination of a ranking or weighting system based upon established metrics. The metrics include both measurable (for example, cost) and other more subjective non-quantifiable items such as some of the potential environmental impacts. They are grouped under six categories, namely technical, financial, economic, environmental, social and preservation of the Laguna Lake. Metrics under the first two categories represent the engineering solution and the upfront costs for implementation, while others address long-term-oriented strategic drivers and project outcomes.

1.3.1.4 Methodology Summary

The evaluation procedure involves the comparison of each option against baseline metrics. The broad methodology is as follows:

- Develop a set of main criteria and metrics for the three alignment options to be relatively compared, i.e., the dike, viaduct, and combination options
- Score each option against the metrics using a grading scale
- Assign weightings to the metrics to form baseline models
- Weight individual scores on each criterion and calculate the sum to produce a weighted average score for that option, as follows:
    - Weighting Average Score of Option i = Σ (Wj x Score ij) / Σ (Wj), where Wj is the weighting of a particular criterion.
    - Compare the weighted average for each option and rank accordingly; and
    - Test the sensitivity of the rankings of the options to determine which option is most robust.

1.3.1.5 Comparison Metrics and Scoring

The metrics for the evaluation were grouped under the following criteria categories:

- Technical
- Financial

- Economic
- Environmental
- Social
- Preservation of the Laguna Lake

Each category was divided into several definable criteria (metrics), which each alignment option was scored against. For each of the metrics the order of preference was identified along with a scaling of base score, which can be a maximum of 10.

For base score of scale of 10, score of 8 to 10 – Excellent; score 6 to 8 – Good; score 4 to 6 – Fair; score 2 to 4 – Poor and 1 to 2 – very poor. Or in general a score of 5 and above is considered to be relatively satisfactory and a score below 5 is less than satisfactory. A score of 1 can be considered to be highly undesirable and approaching an insurmountable problem.

When 0 is scored for a particular discipline, the entire option is insurmountable and is considered as a nonstarter. This score is required as in some cases, an option cannot be found infeasible for a particular discipline until a very late stage.

1.3.1.6 Weighting Criteria

For the comparison process, a series of weighting sets have been developed to focus on the most appropriate option, with each of the alignments being scored against the criteria and the overall weightings applied. The weighting set is shown in the table below. It should be noted that at the time of preparation, all the metrics were initially proposed and can be increased or omitted subject to the comments from stakeholders. It must be emphasized that the total percentage of the weightings must be 100% in any circumstances.

Table 1.8 Weighting Criteria Categories

Criteria Categories	Weightings
Technical	25%
Financial	15%
Economic	20%
Environmental	10%
Social	15%
Preservation of the Laguna Lake	15%
Total	100%

It is recognized that the degree of importance applied to each element is fundamental to the selection process and therefore an additional number of weighting sets have been included in the evaluation as sensitivity tests to help focus in on the most appropriate options.

Criteria

The criteria identified for assessment under each category are described from **Table 1.9** to **Table 1.11**. Each criteria category has been assigned a "weighting proportion" which denotes the relative percentages of the items as a fraction of the weighting value.

Table 1.9 Technical Criteria

Technical Matters Criteria	Scoring Principle The option(s) would score higher if -	Weighting Proportion	Overall Weighting
Availability of construction materials	the construction materials (e.g., filling materials, concrete mix, precast element) are more readily available	20.0%	5.0%
Flood protection consideration	it has greater contribution to flood protection to inland areas	15.0%	3.75%
Implementation programme	the implementation (design and construction) programme is shorter	20.0%	5.0%
Constraints and risks to implementation	there is less constraints and risks to the project implementation	15.0%	3.75%
Operation and maintenance considerations	the long-term operation and maintenance operations are less onerous and require less special arrangement	15.0%	3.75%
Pedestrian permeability	it offers better walkability between development and to access the waterfront	15.0%	3.75%
Total		100%	25.0%

Table 1.10 Financial Criteria

Financial Criteria	Scoring Principle *The option(s) would score higher if -*	Weighting Proportion	Overall Weighting
Construction cost	the construction cost is less	60.0%	9.00%
Clearance, compensation and resettlement	the option involves less clearance/compensation/resettlement cost	10.0%	1.50%
Risk and uncertainty	less risk and uncertainty to cost	10.0%	1.50%
Operation and maintenance	the recurrent cost is less	20.0%	3.00%
Total		**100%**	**15.0%**

Table 1.11 Economic Criteria

Economics Criteria	**Scoring Principle** ***The option(s) would score higher if -***	**Weighting Proportion**	**Overall Weighting**
Ability to improve existing transport networks	economic benefits (travel time saving, fuel saving, accident rate reduction) from the improvement of traffic conditions	30.0%	6.0%
Growth opportunities of the surrounding area and its supply chains Accessibility impacts on labour market, employment, and productivity	more people can have better access to labour market, employment, and productivity.	30.0%	6.0%
Accessibility impacts on labour market, employment, and productivity	more people can have better access to labour market, employment, and productivity.	10.0%	2.0%
Impact on fishing industry	it imposes less impact on the local fishing industry	20.0%	4.0%
Impact on land use capacity and development	there are more economic benefits to the local land use and industrial mix	10.0%	2.0%
Total		100%	20.0%

Table 1.12 Environmental Criteria

Environmental Criteria	**Scoring Principle** *The option(s) would score higher if -*	**Weighting Proportion**	**Overall Weighting**
Encroachment in Environmental Critical Areas (ECAs)	it does not encroach or is considered unlikely to impact upon ECAs	10.0%	1.0%
Areas of Cultural Heritage	it does not encroach or is considered unlikely to impact upon areas of cultural heritage	10.0%	1.0%
Vegetation removal (including trees)	it impacts a smaller scale and value of vegetation	10.0%	1.0%
Loss of habitat, threat to species, and hindrance to	it has less impacts on important or valuable	15.0%	1.5%

biological access	ecological habitats and hindrance to biological (freshwater/marine/wildlife) access		
Impact on marine and freshwater	it has less impact on marine and freshwater	20.0%	2.0%
Air pollution and increase in noise level	it produces lower air quality and noise impacts	10.0%	1.0%
Existing soil contamination	it is anticipated to affect or cause none or smaller amount of land with soil contamination	5.0%	0.5%
Waste generation	it is anticipated to generate less waste, e.g., less dredging of the lakebed expected	10.0%	1.0%
Quality of visual experience	it is visually attractive (impactful) and could incorporate local arts and culture in the design	10.0%	1.0%
Total		100%	10%

Table 1.13 Social Criteria

Social Criteria	Scoring Principle *The option(s) would score higher if -*	Weighting Proportion	Overall Weighting
Displacement of informal settlers	it encroaches smaller amount of area with informal settlers	15.0%	2.3%
Indigenous people	it encroaches smaller amount of area with or near to indigenous people	5.0%	0.8%
Right of Way conflict	it requires land where the current land use would not result in difficult issues to be resolved.	10.0%	1.5%
Traffic congestion during construction	during the construction it is likely to cause less impact to the local road traffic	10.0%	1.5%
Resettlement impact	it is expected to cause smaller scale of resettlement	20.0%	3.0%
Economic displacement	it is expected to cause smaller scale of economic displacement, including the	20.0%	3.0%

Social Criteria	Scoring Principle *The option(s) would score higher if -*	Weighting Proportion	Overall Weighting
	fishing industry		
Local context sensitivity	it demonstrates greater empathy towards the local culture	20.0%	3.0%
Total		100%	15%

Table 1.14 Preservation of the Laguna Lake

Social Criteria	Scoring Principle *The option(s) would score higher if -*	Weighting Proportion	Overall Weighting
Preservation of the Laguna Lake	it demonstrates greater ability to maintain and safeguard the lake to meet the long-term objectives for the lake which is a critical natural resource for Metro Manila and the CALABARZON Region.	100.0%	15.00%
Total		**100%**	**15%**

1.3.1.7 Option Selection Workshop

An option selection workshop was held on 20 February 2019 to compare the advantages and disadvantages of all options considered in order to select which option to take forward to Stage II of the Feasibility Study. In the workshop, the following process was followed to gain agreement by all the stakeholders.

Firstly, the alignment options and concept design as discussed were presented. The associated implementation durations and approximate cost estimates were also presented.

Secondly, following the presentations of the options:

1) The option selection methodology was presented detailing the criteria and scoring system to be adopted to evaluate and compare the options.
2) Suggested scores for each scoring criteria were presented by the consultant. The weighted scores were then calculated. The summary of results was then shown to audience.
3) The stakeholders in the workshop were then given the opportunity to comment and discuss the scores and any other pertinent issues. The scores of all the criteria and the preferred alignment option were then agreed and concluded in the workshop.

Figure 1- 16 WS1 Option Selection Workshop, 20 February 2019

Through the options assessment process, each option was given a score in various criteria that had been identified as key to the success of the project in the categories, Technical, Financial, Economic, Environmental, Social and Preservation of the Laguna Lake, and an overall preferred option was chosen.

1.3.1.8 Assessment of Alternative Options

Based on the scores on each sub-criterion and the option selection method stipulated, a summary for overall scoring results is shown in **Table** and six sets of sensitivity test have been carried out. For all six sets of sensitivity test, Option 5 – Combination Viaduct + Dike Scheme all ranks 1st among 5 options.

The findings and assessment for each criterion per alternative option are discussed in detail in the table below.

Table 1.15 Summary of Assessment of Alternative Options for LLRN

Criteria	Option 1 Dike Scheme	Option 2a Low Viaduct Scheme	Option 2b Low Viaduct Scheme with Preservation Dike	Option 4b Hybrid Low + High Viaduct Scheme with Preservation Dike	Option 5 Combination Viaduct + Dike Scheme
TECHNICAL					
Availability of Construction Materials	• Requires the largest volume of filling materials among all schemes. • Requires the smallest amount of reinforcement among all schemes	• No dike involved in the scheme and therefore the filling materials needed are minimal. • Requires a smaller amount of reinforcement compared with the higher viaduct schemes	• Requires a moderate amount of filling materials. • Requires a smaller amount of reinforcement compared with the higher viaduct schemes	• Requires a moderate amount of filling materials. • Requires a larger amount of reinforcement compared with the lower viaduct schemes	• Requires a moderate amount of filling materials. • Requires a smaller amount of reinforcement compared with the lower viaduct schemes
Flood Protection	• The proposed dike enhances the flood protection.	• The proposed viaduct does not provide flood protection.	• The proposed preservation dike enhances the flood protection.	• The proposed preservation dike enhances the flood protection.	• The proposed dike in some region enhances the flood protection locally.
Implementation Programme	• The implementation programme is expected to be the	• The implementation programme is expected to be the	• The implementation programme is expected to be the	• The implementation programme is expected to be the	• The implementation programme is expected to be the

Criteria	Option 1 Dike Scheme	Option 2a Low Viaduct Scheme	Option 2b Low Viaduct Scheme with Preservation Dike	Option 4b Hybrid Low + High Viaduct Scheme with Preservation Dike	Option 5 Combination Viaduct + Dike Scheme
	3rd shortest among all options.	shortest among all options.	4th shortest among all options.	longest among all options.	Second among all options.
Constraints and Risks to Implementation	• During construction, attention shall be paid for controlling the compaction ratio. Large scale casting yard not required.	• Local capability for viaduct construction available but shallow lake depth may be questionable for large machine. Large scale casting yard not required.	• Considered most risky among all options by combination of two main structure (Dike + Viaduct) (together with Option 4b). Large scale casting yard not required.	• Considered most risky among all options by combination of two main structure (Dike + Viaduct) (together with Option 2b). Large scale casting yard not required.	• During construction, attention shall be paid for controlling the compaction ratio. Local capability for viaduct construction available but shallow lake depth may be questionable for large machine. Large scale casting yard required.
Operation and Maintenance Considerations	• The pumping station and west-side waterway requires greater maintenance	• The viaduct is relatively easy to maintain.	• The pumping station and west-side waterway requires greater maintenance	• The pumping station and west-side waterway requires greater maintenance	• The lesser pumping stations and west-side waterway requires moderate

Criteria	Option 1 Dike Scheme	Option 2a Low Viaduct Scheme	Option 2b Low Viaduct Scheme with Preservation Dike	Option 4b Hybrid Low + High Viaduct Scheme with Preservation Dike	Option 5 Combination Viaduct + Dike Scheme
	efforts. Inland channel regular dredging		efforts. Inland channel regular dredging	efforts. Inland channel regular dredging.	maintenance efforts. Inland channel regular dredging
Pedestrian Permeability	• Undesirable as the pedestrian access to the western waterfront of the reclamation area is blocked by the highway on the dike. Required overpasses severely limit the accessibility of the waterfront.	• Allows pedestrian full access to the eastern waterfront.	• Allows pedestrian full access to the eastern waterfront.	• At Higher Viaduct portion allows pedestrian full access to the western waterfront but underneath the viaduct compare to Option 2a and 2b.	• Viaduct Portion: Allows pedestrian full access to the eastern waterfront. Dike Portion: undesirable as the pedestrian access to the western waterfront of the reclamation area is blocked by the highway on the dike. Required overpasses severely limit the accessibility of the waterfront.

Criteria	Option 1 Dike Scheme	Option 2a Low Viaduct Scheme	Option 2b Low Viaduct Scheme with Preservation Dike	Option 4b Hybrid Low + High Viaduct Scheme with Preservation Dike	Option 5 Combination Viaduct + Dike Scheme
FINANCIAL					
Construction Cost	• Construction Cost = PHP 187bn	• Construction Cost = PHP 281bn	• Construction Cost = PHP 337bn	• Construction Cost = PHP 344bn	• Construction Cost = PHP 270bn
Compensation and Resettlement Cost	• The embankment occupies more lake area than other scheme, fishery compensation may require more	• Less footprint within the lake area	• Preservation dike footprint is less than Option 1	• Preservation dike footprint is less than Option 1	• Preservation dike footprint is less than Option 1
Risk and Uncertainty to Cost	• In general, lesser cost and reduce risk and uncertainty. While uncertainty cost on contaminate soil.	• No dredging is required, while the construction cost is high due to import or reinforcement/ steel for viaduct and higher cost than option 1	• Smaller amount of dredging required less uncertainty on contaminated soil	• Smaller amount of dredging required less uncertainty on contaminated soil	• Hybrid of dike and low viaduct, the risk and uncertainty are between Option 1 and Option 2a
Operation and Maintenance Costs	• Maintenance cost per year = ~9bn PHP	• Maintenance cost per year = ~2.8bn PHP	• Maintenance cost per year = ~6.4bn PHP	• Maintenance cost per year = ~6.5bn PHP	• Maintenance cost per year = ~8.2bn PHP
ECONOMIC					

Criteria	Option 1 Dike Scheme	Option 2a Low Viaduct Scheme	Option 2b Low Viaduct Scheme with Preservation Dike	Option 4b Hybrid Low + High Viaduct Scheme with Preservation Dike	Option 5 Combination Viaduct + Dike Scheme
Ability to Improve Existing Transport Networks	• Travel time and distance would be similar for option 1, 2a and 2b with nil significant difference.	• Travel time and distance would be similar for option 1, 2a and 2b with nil significant difference.	• Travel time and distance would be similar for option 1, 2a and 2b with nil significant difference.	• a longer ramp with more land / spiral ramp to be constructed which would increase travel distance and increased difficulty for drivers.	• Travel time and distance would be similar for option 1, 2a, 2b and 5 with nil significant difference.
Growth Opportunities of The Surrounding Area and Its Supply Chains	• For dike, at grade level development limited.	• Further development outside the viaduct footprint.	• Further development outside the viaduct footprint.	• Higher viaduct presents greater opportunity for land use within vicinity of the road.	• Dike and Viaduct coverage to merge with the existing condition and provision of future development
Accessibility Impacts on Labour Market, Employment and Productivity	• The road alignment will connect to and support current/future developments	• The road alignment will connect to and support current/future developments	• The road alignment will connect to and support current/future developments	• The road alignment will connect to and support current/future developments to a greater extent	• The road alignment will connect to and support current/future developments
Impact on Fishing	• Vessel would	• The road	• Vessel would	• Vessel would	• Vessel would

Criteria	Option 1 Dike Scheme	Option 2a Low Viaduct Scheme	Option 2b Low Viaduct Scheme with Preservation Dike	Option 4b Hybrid Low + High Viaduct Scheme with Preservation Dike	Option 5 Combination Viaduct + Dike Scheme
Industry	need to access across the dike from spillway/ lock gate.	alignment will not impede fishing industry.	need to access across the dike from spillway/ lock gate.	need to access across the dike from spillway/ lock gate.	need to access across the dike from spillway/ lock gate in Dike section or underneath the viaduct section.
Impact on Land Use Capacity and Development	• It's limited the future development	• Good ability to connect regions to broader manila metro providing land use uplift opportunity.	• Good ability to connect regions to broader manila metro providing land use uplift opportunity.	• Strong ability to connect regions to broader manila metro providing land use uplift opportunity and use the area underneath the viaduct.	• Future development is limited at dike portion. At viaduct portion, Good ability to connect regions to broader manila metro providing land use uplift opportunity
ENVIRONMENT					
Encroachment in Environmental Critical Areas (ECAs)	All options are considered to encroach upon an ECA given that the project triggers the following three categories: 1) Along the coast of a water body; 2) In a flood prone area that is frequented by typhoons; and 3) In an area of seismic activities, i.e., the west valley fault. The dike schemes are scored slightly higher as they are aimed at alleviating flooding.				
Areas of Cultural	At the time of option selection studies, there are no known cultural heritage resources that would be directly impacted by				

Criteria	Option 1 Dike Scheme	Option 2a Low Viaduct Scheme	Option 2b Low Viaduct Scheme with Preservation Dike	Option 4b Hybrid Low + High Viaduct Scheme with Preservation Dike	Option 5 Combination Viaduct + Dike Scheme
Heritage	the alignment. However, it is known that there are a number of important churches and old buildings in the vicinity and any impact would be properly explored in the EIA phase.				
Vegetation Removal (Including Trees)	It is considered that the extent of vegetation removal will be similar for all of the options. Given the densely populated urban coastline of Laguna Lake it is not considered that there will be much in the way of vegetation clearance other than aquatic plants such as water cabbage.				
Loss of Habitat, Threat to Species, And Hindrance to Biological Access	The Laguna Lake is considered to have a relatively low plant diversity but is habitat to a number of aquatic species. Both alignment options would not occupy a large footprint within the lake as a whole and any construction impacts are considered temporary. The dike schemes are scored lower as they would reduce the connectivity between the inland channel and lake thus potentially reducing habitat.				
Impact on Marine and Freshwater	• The dike scheme will involve more intensive construction than the other schemes, leading to significant dredging which may leading to greater impacts on the water quality.	• The low viaduct scheme is considered easier to mitigate any impacts as the scale of construction is smaller than that of a dike and mitigation measures such as silt curtains at each viaduct can prove more effective.	• This scheme is considered to be less intensive than the Dike Scheme but more intensive than the viaduct schemes.	• This scheme is considered to be less intensive than the Dike Scheme but more intensive than the viaduct schemes.	• The impact on marine and fresh water of this scheme is between Option 1 and Option 2A

Criteria	Option 1 Dike Scheme	Option 2a Low Viaduct Scheme	Option 2b Low Viaduct Scheme with Preservation Dike	Option 4b Hybrid Low + High Viaduct Scheme with Preservation Dike	Option 5 Combination Viaduct + Dike Scheme
Air Pollution and Increase in Noise Level	• The dike scheme will involve more intensive construction than the other schemes, leading noise and air pollution impacts to nearby sensitive receivers.	• The low viaduct scheme is considered to produce less air and noise impacts due to the less intensive construction methodology.	• This scheme is considered to be less intensive than the Dike Scheme but more intensive than the viaduct schemes.	• This scheme is considered to be less intensive than the Dike Scheme but more intensive than the viaduct schemes.	• The noise and air quality impact of this scheme is between Option 1 and Option 2A
Existing Soil Contamination	• The dike scheme will involve considerably more dredging than the other schemes, which may potentially lead to significant accumulation of contaminated sediment. However, this presents an opportunity to remove a	• This scheme will lead to lower amounts of dredged sediment being generated, leading to lower remediation efforts.	• The scheme will have a slightly higher generation of sediment in comparison to the viaduct schemes but will also remove a pollutant from the lake.	• The scheme will have a slightly higher generation of sediment in comparison to the viaduct schemes but will also remove a pollutant from the lake.	• The scheme will have a slightly higher generation of sediment in comparison to the viaduct schemes but will also remove a pollutant from the lake.

Criteria	Option 1 Dike Scheme	Option 2a Low Viaduct Scheme	Option 2b Low Viaduct Scheme with Preservation Dike	Option 4b Hybrid Low + High Viaduct Scheme with Preservation Dike	Option 5 Combination Viaduct + Dike Scheme
	pollutant from the lake and ensure that it is disposed of properly.				
Waste Generation	• The dike scheme will involve the dredging of a considerable amount of sediment that will need to be dealt with. However, if of good enough quality the sediment can be reused in construction (i.e. backfill).	• The viaduct scheme will lead to a lesser quantity of waste being generated from construction.	• The scheme will have a slightly higher generation of waste in comparison to the viaduct schemes but will also provide an opportunity for the reuse of a material in construction (i.e. backfill).	• The viaduct scheme will lead to a lesser quantity of waste being generated from construction.	• The scheme will have a slightly higher generation of waste in comparison to the viaduct schemes but will also provide an opportunity for the reuse of a material in construction (i.e. backfill).
Quality of Visual Experience	• The dike scheme is expected to be less obtrusive that a viaduct scheme but will be low lying and block the view of the	• Similar to the dike scheme, the viaduct would be low lying.	• Similar to the dike scheme, this scheme would be low lying.	• Similar to the dike scheme, this scheme would be low lying in places.	• Similar to the dike scheme and low viaduct scheme, this scheme would be low lying in places.

Criteria	Option 1 Dike Scheme	Option 2a Low Viaduct Scheme	Option 2b Low Viaduct Scheme with Preservation Dike	Option 4b Hybrid Low + High Viaduct Scheme with Preservation Dike	Option 5 Combination Viaduct + Dike Scheme
	entire lake for nearby visual sensitive receivers.				
SOCIAL					
Displacement of Informal Settlers	It is considered that given the density of the urban areas along the Laguna Lake coastline, all of the alignments and interchanges would encounter significant impacts in terms of informal settlers, with regards to building connections to the alignment from the coast.				
Indigenous People	It is considered that none of the alignments would encroach upon or impact Indigenous people.				
Right of Way Conflict	It is considered that given the density of the urban areas along the Laguna Lake coastline, all of the alignments and interchanges would encounter significant impacts in terms of securing right-of-way, with regards to building connections to the alignment from the coast.				
Traffic Congestion During Construction	It is considered that all the alignment options will exacerbate an already congested traffic area in the construction phase. However, the dike schemes score lower, as the duration and intensity of construction is expected to be higher (i.e. more equipment and vehicles travelling to work sites over a longer period of time).				
Resettlement Impact	It is considered that given the density of the urban areas along the Laguna Lake coastline, all of the alignments and interchanges would encounter significant impacts in terms of informal settlers, with regards to building connections to the alignment from the coast.				
Economic Displacement	• Occupy a larger footprint than other schemes, potentially	• The low viaduct scheme will occupy less of a footprint than the	• Will occupy a larger footprint than the viaduct scheme but allow	• Will occupy a larger footprint than the viaduct scheme but allow	• Occupy a smaller footprint than option 1, potentially

Criteria	Option 1 Dike Scheme	Option 2a Low Viaduct Scheme	Option 2b Low Viaduct Scheme with Preservation Dike	Option 4b Hybrid Low + High Viaduct Scheme with Preservation Dike	Option 5 Combination Viaduct + Dike Scheme
	displacing fishing activities and other economic activities on the lake. The dyke would also potentially block direct access to the lake.	dike scheme and allow access to the lake for fisherfolk.	access to the lake in places.	access to the lake in places.	displacing fishing activities and other economic activities on the lake. The dike would also potentially block direct access to the lake.
Local Context Sensitivity	• The surface highway severs connectivity perpendicular to the dike alignment, disconnecting the waterbodies and potentially disrupting ecological and urbanization patterns	• The low viaduct has reduced impact to existing ecological and urbanization patterns, provided that the passage underneath remains a passage for ecology	• Although the low viaduct provides a reduced impact, the adjacent dike disrupts ecosystems and urbanization patterns	• The hybrid viaduct scheme has lower impact to existing urbanization patterns and ecosystems, provided that the increased height remains a passage for ecology and marine traffic. The visual impact of this option is reduced at certain locations, improving the	• The surface highway severs connectivity perpendicular to the dike alignment, disconnecting the waterbodies and potentially disrupting ecological and urbanization patterns

Criteria	Option 1 Dike Scheme	Option 2a Low Viaduct Scheme	Option 2b Low Viaduct Scheme with Preservation Dike	Option 4b Hybrid Low + High Viaduct Scheme with Preservation Dike	Option 5 Combination Viaduct + Dike Scheme
				rating for this option	
Preservation of the14aguna Lake	• The dike scheme will result in sediment being removed from the lake and water levels potentially increasing thus increasing the carrying capacity of the lake as a natural resource. Further, the dyke will protect nearby areas from flooding. However, the scheme may prevent fisherfolk from accessing the natural resource.	• The viaduct scheme will improve the connectivity around the Laguna lake, but would not play a part in preserving the lake in the long term. It will, however, ensure continued access to the lake for fisherfolk and other users.	• This scheme will help to prevent flooding and will remove silt from the lake as well as potentially increasing water levels. However, it will not be as effective as the dike scheme. On the other hand, the viaduct sections will allow access to the lake.	• This scheme will help to prevent flooding and will remove silt from the lake as well as potentially increasing water levels. However, it will not be as effective as the dike scheme. On the other hand, the viaduct sections will allow access to the lake.	• The protection is provided after assessment on the land use, flood hazard, etc.

As a result of the options selection workshop and the findings of the Stage I Options Study, Option 5 - Combination Viaduct + Dike Scheme was chosen to take forward to Stage II of the Feasibility Study. This option is the most suitable with the best overall balance of positive outcomes, cost, ease of implementation, and minimum negative impact.

Table 1.16 Overall Scoring results under Base Case

Criteria	Technical	Financial	Economic	Environmental	Social	Lake Preservation	Total out of 10	Total out of 100	Rank
Weighting	25%	15%	20%	10%	15%	15%			
1	1.63	1.14	1.08	0.51	0.54	1.20	6.10	61.0	4
2a	1.86	1.10	1.38	0.70	0.72	0.60	6.36	63.6	2
2b	1.75	0.83	1.16	0.62	0.62	1.05	6.02	60.2	5
4b	1.68	0.74	1.38	0.62	0.71	1.05	6.17	61.7	3
5	1.98	0.95	1.48	0.63	0.68	1.05	6.76	67.6	1

1.3.1.9 LLRN Technical Frameworks Forum

On 14th March 2019, the LLRN Technical Frameworks Forum held in Asian Development Bank HQ Ortigas, the preferred Option was further presented to major stakeholders including ADB, DPWH, LLDA, Province of Rizal, Province of Laguna, and Local Government Unit of Muntinlupa City. As an integral part of the detailed Feasibility Study, a Road Network Master Plan shall be developed to map out various projects around the lake that are being envisioned, proposed and implemented.

Figure 1- 17 LLRN Technical Framework Forum, 14 March 2019

After confirmation from the Proponent, the preferred option was taken forward to be further studied in Feasibility Study Stage II and Preliminary Design. The primary objective of Stage II is to evaluate whether the project is viable or not.

With ongoing review and discussion during Stage II, it was agreed with the DPWH that the alignment should be further refined. The final alignment as agreed to be detailed during Stage II is presented in the next section.

1.3.2 The Final Confirmed Alignment

The LLRN is proposed with majority of road along the shoreline of Laguna Lake. The Phase I of this Project will be mainly along the Western coast. Phase II will run around the Northern and Southern coastline of the Lake via Eastern the coast. The total length of Phases I and II could exceed 100km.

The final confirmed alignment of Phase I will start at a roundabout interchange connecting to C6 at Lower Bicutan, north of the existing Lakeshore Hall. The alignment begins eastward into Laguna Lake before turning southward and traverse off-shore along the coastal communities of Muntinlupa City at Sucat, Alabang, then on-shore from Laguna Province at San Pedro, Biñan, Santa Rosa, Cabuyao and end at the coastline of Calamba. There will be a stub end for the connection to Phase II as well as link road to the Calamba central area.

The total length of the final refined mainline from Lower Bicutan to Calamba is 37.6 km. There will be 8 interchanges at the mainline with a total of about 7.3 kilometers of slip roads. The interchanges are proposed at Lower Bicutan, Sucat, Alabang, Tunasan, San Pedro/Biñan, Santa Rosa, Cabuyao and Calamba. They are proposed to connect to Municipal Boundaries at the nearest public road. LLRN FS aims to provide the concept for the connection to the centre of communities which is preferred to be at Manila South Road, but details as well as the ROW and negotiation are proposed to be carried out by the LGUs. These local connections to Manila South Road from the interchanges of San Pedro/Biñan, Sta. Rosa and Cabuyao, which will be studied further and finalized in the Detailed Engineering Design (DED) Stage, are approximated to have a total of 6.3 km. In 2026 when LLRN starts operation, it is expected that the connection works of all these interchanges would have been implemented except for those at the Tunasan Interchange. Our traffic forecast and economic appraisal have adopted this implementation assumption.

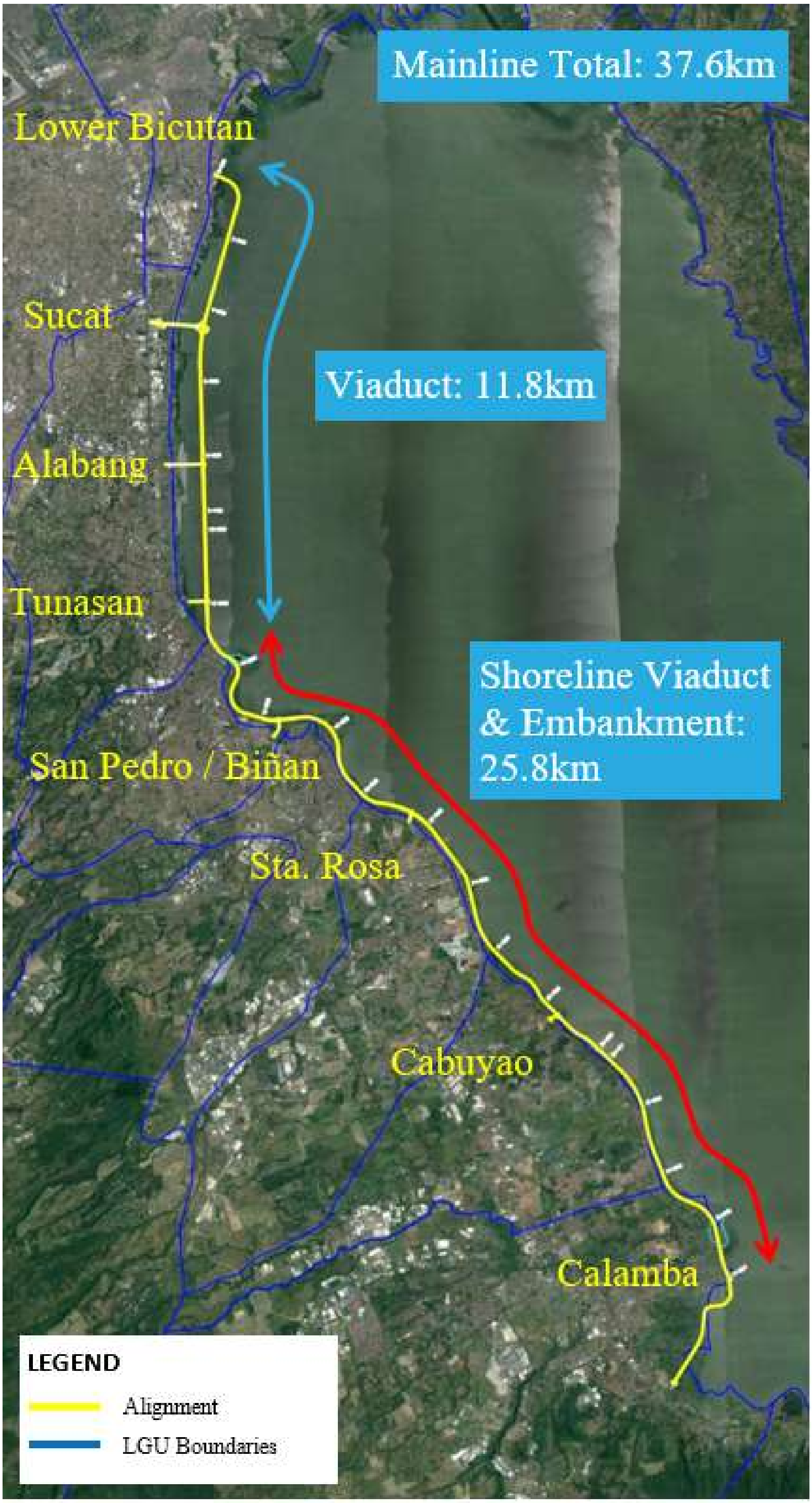


Figure 1- 18 LLRN Phase I Final Confirmed Alignment along the Western Coast of Laguna Lake

1.3.3 Technology Option

No alternative technologies, operation processes and measures to minimize wastes have been identified at this stage. The process technology that will be used in preventing adverse impacts to the environment is discussed in **Section 1.5**. The design selection for storage is not applicable for the infrastructure project.

1.3.4 Resources

The majority of the materials that will be required for the construction of the project will be sourced locally to minimize the number of imported materials and machinery required. Embankment filled materials will be sourced locally in Laguna Lake and surrounding area. For viaducts on land, most of the bridge structures in the Philippines are concrete bridges and therefore it is recommended that concrete bridges should be considered, wherever possible. As for the electricity needed for the bridge, there should be an independent back-up power supply source either from an independent power plant and network or from diesel generator sets, in case of failure of the primary supply. A UPS system will cover the power demand of the vital functions during the period it takes before switch over to the back-up source.

1.3.5 Comparison of Environmental Impacts of Each Alternative

Under the Environmental Criteria, there are nine sub-criteria considered:

Table 1.17 Sub-criteria for Environmental

Criteria Title	The option(s) would score higher if -	Weighting	Overall Weighting
Encroachment in Environmental Critical Areas (ECAs)	it does not encroach or is considered unlikely to impact upon ECAs	10.0%	1.0%
Areas of Cultural Heritage	it does not encroach or is considered unlikely to impact upon areas of cultural heritage	10.0%	1.0%
Vegetation removal (including trees)	it impacts a smaller scale and value of vegetation	10.0%	1.0%
Loss of habitat, threat to species, and hindrance to biological access	it has less impacts on important or valuable ecological habitats and hindrance to biological (freshwater/marine/wildlife) access	15.0%	1.5%
Impact on marine and freshwater	it has less impact on marine and freshwater	20.0%	2.0%

Criteria Title	The option(s) would score higher if -	Weighting	Overall Weighting
Air pollution and increase in noise level	it produces lower air quality and noise impacts	10.0%	1.0%
Existing soil contamination	it is anticipated to affect or cause none or smaller amount of land with soil contamination	5.0%	0.5%
Waste generation	it is anticipated to generate less waste, e.g. less dredging of the lakebed expected	10.0%	1.0%
Quality of visual experience	it is visually attractive (impactful) and could incorporate local arts and culture in the design	10.0%	1.0%
	Total	100%	10%

Under the Social Criteria, there are six sub-criteria considered:

Table 1.18 Sub-criteria for Social

Criteria Title	The option(s) would score higher if -	Weighting	Overall Weighting
Displacement of informal settlers	it encroaches smaller amount of area with informal settlers	15.0%	2.3%
Indigenous people	it encroaches smaller amount of area with or near to indigenous people	5.0%	0.8%
Right of Way conflict	it requires land where the current land use would not result in difficult issues to be resolved.	10.0%	1.5%
Traffic congestion during construction	during the construction it is likely to cause less impact to the local road traffic	10.0%	1.5%
Resettlement impact	it is expected to cause smaller scale of resettlement	20.0%	3.0%
Economic displacement	it is expected to cause smaller scale of economic displacement, including the fishing industry	20.0%	3.0%
Local context sensitivity	it demonstrates greater empathy towards the local culture	20.0%	3.0%
	Total	100%	15%

Table 1.19 shows the summarized environmental and social constraints along the alignment options.

Table 1.19 Summarized Environmental and Social Constraints along the Alignment

Environmental/	Constraints

Social Aspect	
Land	Most of the connecting areas are situated in built-up areas, with few trees/vegetation in some areas such as Binan-Sta. Rosa interchanges.
Water	May potentially affect current lake uses e.g., potable water supply, fisheries and aquaculture, flood control projects, etc.
Air	Air and noise pollution are expected to increase during construction phase.
People	Traffic congestion is a concern since the project is situated in built-up areas. Utilities i.e., high-tension wires are also considered as constraints. Land acquisition will also be critical due to presence of informal settlers. Displacement and resettlement of some residential communities (subject to the final road alignment) Adverse impacts upon the livelihoods of fishery along the Laguna lake shoreline operators and land transport operators

1.3.6 No Project Option

As the intent of the project is to provide a safer and faster alternative to the motorists traveling South/North to vitalize the economies for the surrounding areas including Laguna, Rizal, Quezon and Batangas, listed are the following potential effects if there will be no LLRN Project:

- There will be reduced or limited connectivity and access to economic opportunity that will support the growth potential of the cities and the region.
- Reduced community access to employment, education and other basic social services such as health facilities and other key amenities provided within the National Capital Region
- Little to no improvement on travel times of residents and commuters to and from the project host cities.
- Costs incurred through long travel times and vehicle operating costs
- Development pressure on sensitive lands will not be relieved as the project is anticipated to create opportunities for compact and improved-mixed use development areas.
- Missed opportunity to support tourism activities as LLRN will provide ease of access to tourist areas in Metro Manila and Laguna, and adjacent cities and municipalities.
- There will be greater externalities resulting from congestion, including noise, emissions, and air quality impacts
- There will be limited opportunities to enhance the natural landscapes, create balanced development, and expand eco-tourism

1.4 Project Components

1.4.1 Main Components – Form of Road

The Phase 1 of LLRN will generally be a dual 2-lane (2x2) carriageway roadway with the exception between Sucat Interchange and Santa Rosa Interchange, where dual 3-lane (2x3) carriageway is proposed for the mainline for approximately 12km long.

Dual 2-lane carriageway slip road corridor are designed to connect LLRN to existing road network. Slip roads in between the proposed trumpet interchanges will be single lane per direction.

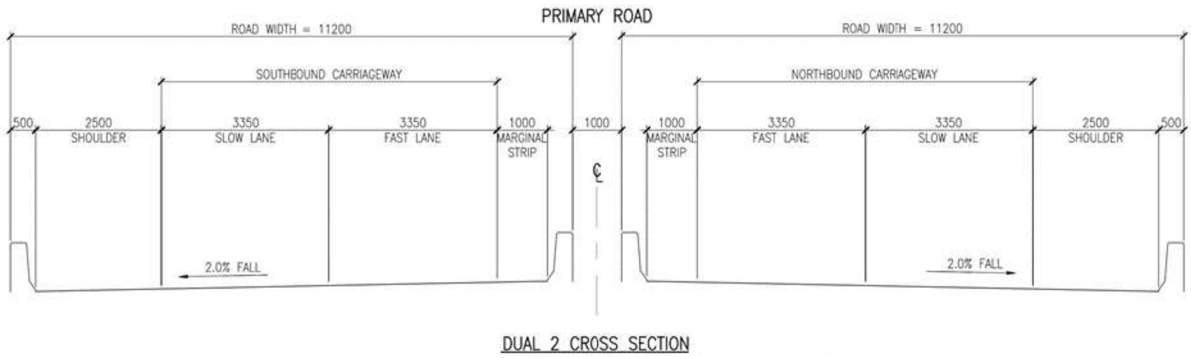


Figure 1- 19 Functional Cross Section for Mainline

The LLRN will be an open highway, i.e., toll-free. Certain sections can include enhanced amenities for pedestrians such as a roadside promenade that includes a 3.5 m wide cycle track and sidewalk on the lakeside.

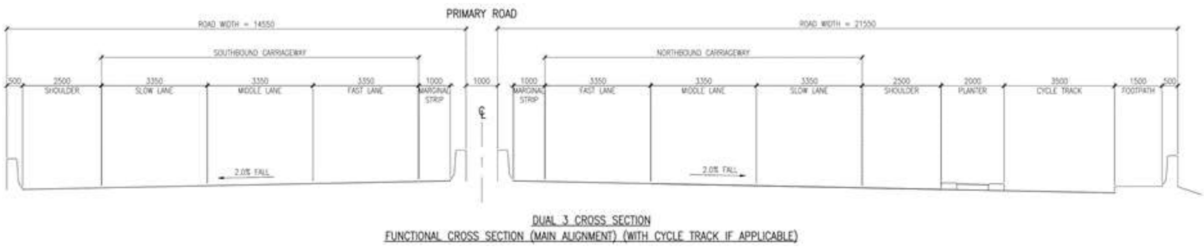


Figure 1- 20 Functional Dual 3 Cross Section with Cycle Track (if applicable)

LLRN Phase I will be formed by two proposed sections for the recommended option:

1.4.2 Section 1 – Viaduct

From the starting point of LLRN at Lower Bicutan interchange, approximately 11.8km of viaducts is proposed to Tunasan interchange (**Figure 1- 21**). The viaduct is approximately 400-500m away from the shoreline. Adequate headroom or clearance underneath the viaduct will be provided for navigation of boats from/to the lake.

Grade-separated interchanges are proposed at Sucat and Alabang, while an at-grade interchange is proposed at Lower Bicutan. The Sucat interchange will utilize a trumpet interchange layout while Lower Bicutan and Alabang will be a grade-separated roundabout.

The interchanges are proposed to connect to the nearest existing shoreline roadway and further connection to Manila South Road will be carried out by local LGUs.

Figure 1- 21 Viaduct Section of Mainline Alignment

1.4.3 Section 2 – Shoreline Viaduct & Embankment

From Tunasan Interchange to the end of LLRN Phase 1 at Calamba Interchange, approximately 25.8km of mixed shoreline viaduct and embankment is proposed (**Figure 1- 22**). The LLRN roadway will be constructed by segments of viaducts and earth bund along the shoreline suitable to adjacent terrain and nearby drainage scheme. River bridges are proposed to span over major creeks or rivers that crosses the proposed alignments, such as San Cristobal River and San Juan River near the headland of Cabuyao. Low level culverts are to be provided for river stream connecting to the lake. An intercepting channels and box culvert are also proposed along the western side of shoreline embankments to provide drainage capacity to the lake and shoreline area.

Grade-separated roundabout interchanges are proposed for Tunasan, San Pedro/Binan, and Santa Rosa, while at-grade roundabout interchanges are proposed for Cabuyao and Calamba. The interchanges are proposed to connect to the nearest existing shoreline roadway by embankments and further connection to local major roads will be undertaken by local LGUs. Apart from Tunasan, which was agreed to terminate at the shoreline, the local authority will address the connection from the main road to the Tunasan interchange. These local connections will be studied further and finalized in the DED Stage.

In **Appendix O . B2 Traffic Study, and Highway Alignment and Design** Report, more detailed maps of the alignment and interchanges are shown in **Appendix A Highway Alignment Drawings**.

Figure 1-22 Shoreline Viaduct + Embankment Section of Mainline Alignment

Along the shoreline, there are many fisherfolks and boats seen from satellite images, in particular at San Pedro, Binan, Santa Rose and the northern part of Cabuyao. For easy understanding the fishing boat distribution, a density map has been prepared by using satellite image on one particular date.

Figure 1-23 Fishing Boat Density Map – April 2017

To reduce the impact to the fishery, fishery basins is a feasible facility to be incorporated along the LLRN mainline. Each fishery basin would be sized to fit the local fish boat demand and have adequate navigation clearance connect between the basin and Laguna lake. It is proposed all barangays along the shoreline to have minimum 1 fishery basin and more depending on demand. It will be useable all year around to avoid excessive relocation to existing fisherfolks. However, it is unavoidable that there might still be some fisherfolks and fish pans that need to be relocated.

1.4.4 Viaduct

1.4.4.1 Overview

Preliminary design of viaduct consists of 3 parts, lake viaduct, embankment viaduct and land viaduct. Lake viaduct is proposed to be located at northern part of LLRN, coupled with interchanges and slip roads connected to the shoreline so as to have more extensive transport network. Embankment viaduct is short bridges proposed to connect the embankment openings near the river mouth to the lake. The Land Viaduct will connect the offshore viaduct to the existing national highway road system.

1.4.4.2 Lake Viaduct

At the northern portion of around 10km, a preliminary assessment of the ground conditions indicates the soil parament is weak. Expensive ground treatment will be required for any embankment or reclamation. And locally there are a lot of channels and piers along the shoreline, navigation from/to the lake are frequent. There are also some intake and outlet pipes from some existing and planning water treatment works or wastewater treatment works. Considering ground condition and local social impact, viaduct is a better option than embankment.

1.4.4.2.1 Superstructure Arrangement

Considering the navigation of vessels within the lake, 4m vertical clearance from the design water level (+2.022mSL) to the soffit level. As discussed previously, LLRN mainline is various from 2 lanes to 3 lanes in each direction due to the higher traffic demand in some location. The structural form of the viaduct considered in Stage I as precast AASHTO / NU girders or box girders. Typical beam and slab cross sections are shown in **Figure 1-24** and **Figure 1-26**.

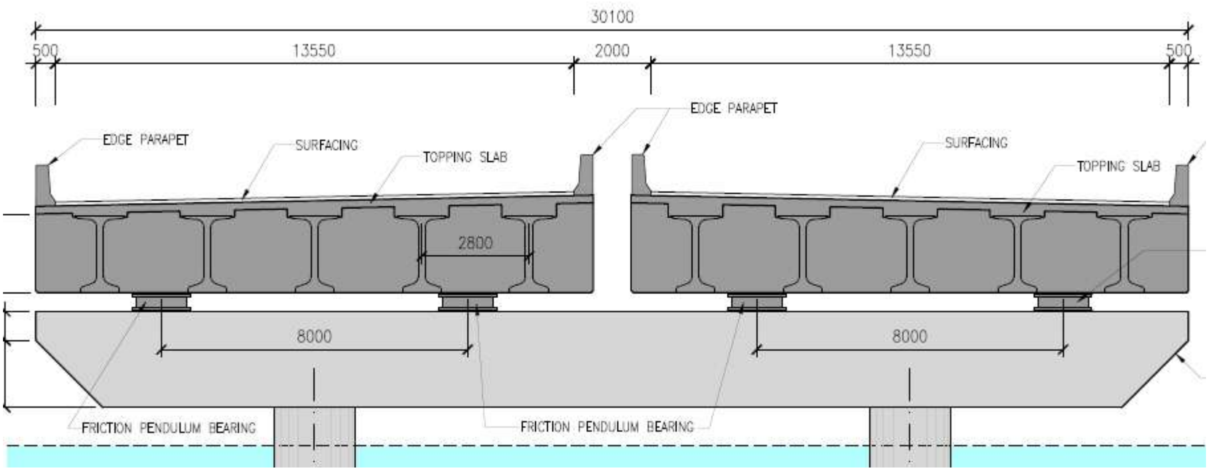


Figure 1-24 Typical Section of Lake Viaduct with AASHTO/NU Girder

An example of such a structural form is the 'Skyway' officially known as Metro Manila Skyway System that was built in the Philippines. **Figure 1-25** shows a portion of the elevated expressway's deck.

Figure 1-25 Metro Manila Skyway System

Box girders are another possible superstructure option and could either be in prestressed or RC depending on proposed span. RC bridge could provide good performance with smaller span length. But with increase of span length, the prestressed box becomes more economical. **Figure 1-26** show the typical cross-section of box girder. The internal void can also serve as a space to house utilities while providing safe maintenance access at the same time. **Figure 1-27** shows Calumpang Bridge which consists of box girder.

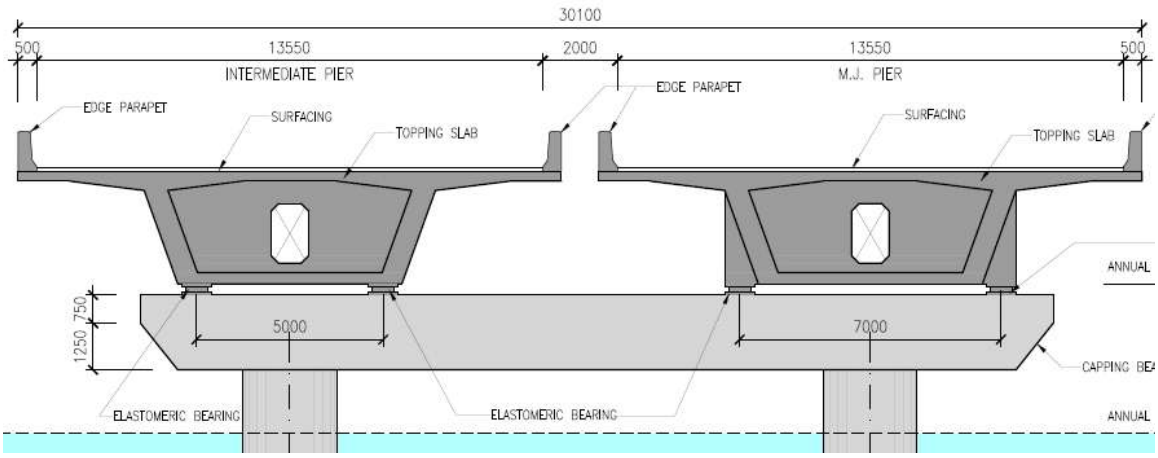
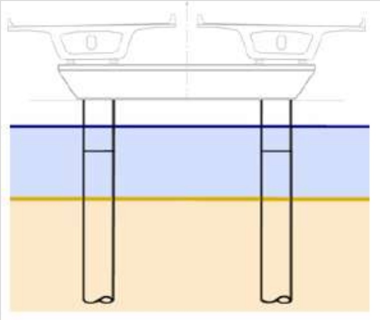


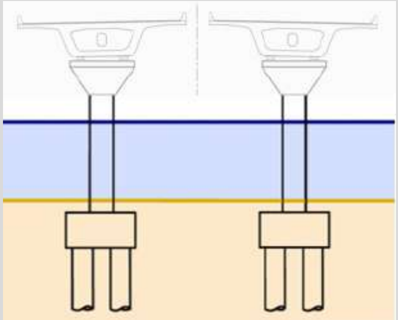
Figure 1-26 Typical Section of Lake Viaduct with Box Girder

Figure 1-27 Calumpang Bridge

1.4.4.2.2 Substructure Arrangement

The substructure of the viaduct could be monopiles, multiple piles with buried pile cap, or multiple pile with exposed pile cap (as shown in **Figure 1-28**, **Figure 1-29** and **Figure 1-30**). To minimise the impact to the lakebed and useable surface in the lake, monopiles are adopted (**Figure 1-28**), i.e., no pile cap will be required. In addition, the construction time and cost, as well as environmental impact associated with the pile caps can be minimised. However, the monopile substructure is only suitable for certain height as the pile/pier becomes too slender when the road level is too high. At the same time, there is practical limit to the pile size and hence this limits the span length of the superstructure.





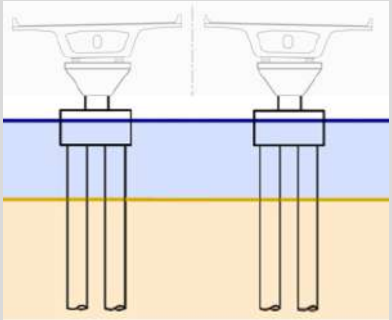


Figure 1-28 Monopile without Pile Cap

Figure 1-29 Multiple Pile with Buried Pile Cap

Figure 1-30 Multiple Pile with Exposed Pile Cap

In monopile scheme, a crosshead beam is adopted to support the superstructure, transfer vertical load from superstructure to monopile and to form a portal frame to enhance the structural stability in transverse direction of the viaduct. Dimension of the crosshead beam varies due to different superstructure type, articulations, and foundation layout, etc. The typical arrangement is shown in **Figure 1-31**.

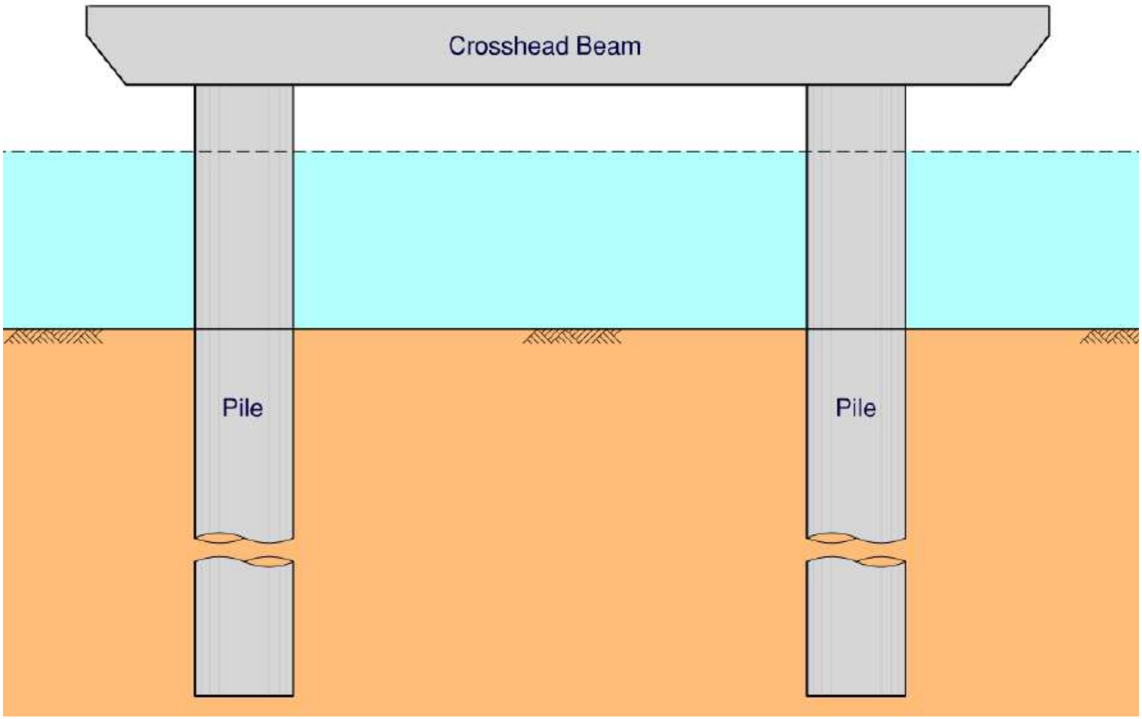


Figure 1-31 Typical Arrangement of Crosshead Beam

1.4.4.2.3 Foundation Arrangement

Both bored pile and driven steel pipe pile have been analysed in current study. The adoption of driven steel pipe pile could provide easier construction and less construction time as compared to bored pile. But considering the ground condition of LLRN, the driven pile is relatively difficult to be constructed. And the construction cost for driven steel pipe pile which need import material from oversea is higher than the bored pile. Hence, bored pile is recommended at this stage. Subject to more geotechnical information from Ground Investigation, the option for driven pile could be further study in detail design stage.

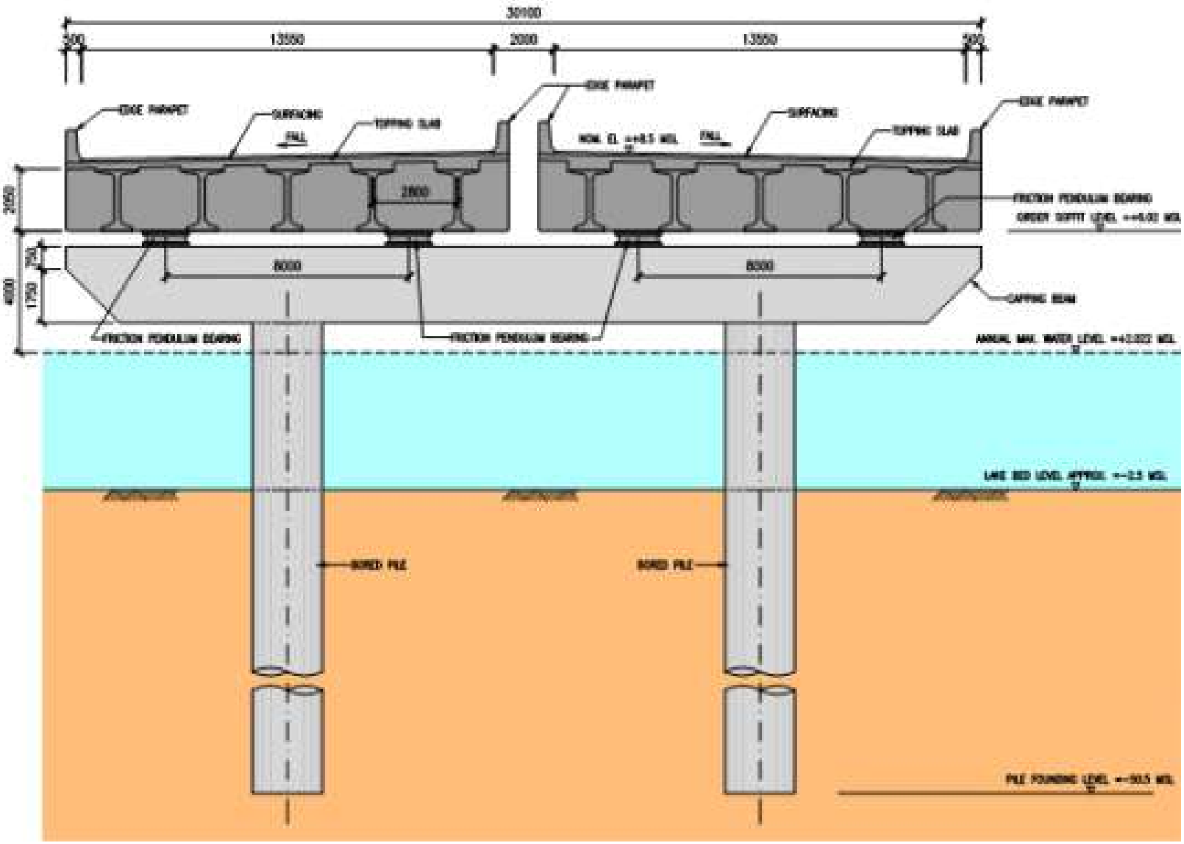


Figure 1- 32 In-lake viaduct cross section and arrangement

1.4.4.3 Embankment Viaduct

As discussed previously, bridges need to be provided along the embankment at various location to allow boats navigation form/to the lake from the fishery basin and outlet opening for the rivers and streams. The structural form and general arrangement us similar with lake viaduct. The typical span arrangement for embankment viaduct is 4 x 30m, which the total length is 120m for each bridge.

Figure 1- 33 Embankment Viaduct at River outlet and fishery basin

1.4.4.3.1 General Arrangement

Similar to the lake viaduct, the embankment viaduct consists of dual 2-lane carriageway. Considering the navigation of vessels from/to the lake, 4m vertical clearance from the design water level (+2.022mSL) to the soffit level of superstructure. For 30 metre short span, precast NU girder is more appropriate as precast prestressed girders are commonly used in Philippines and local contractors are well experienced in constructing this type of viaduct with precast girders. 4 Nos. of 1.6m deep NU girder is proposed in each direction as shown in **Figure 1- 34**.

Monopile foundation is proposed, no pile cap will be required. In addition, the construction time and cost, as well as environmental impact associated with the pile caps can be minimised. A crosshead beam is required to support the superstructure, transfer vertical load from superstructure to monopile and to form a portal frame to enhance the structural stability in transverse direction of the viaduct.

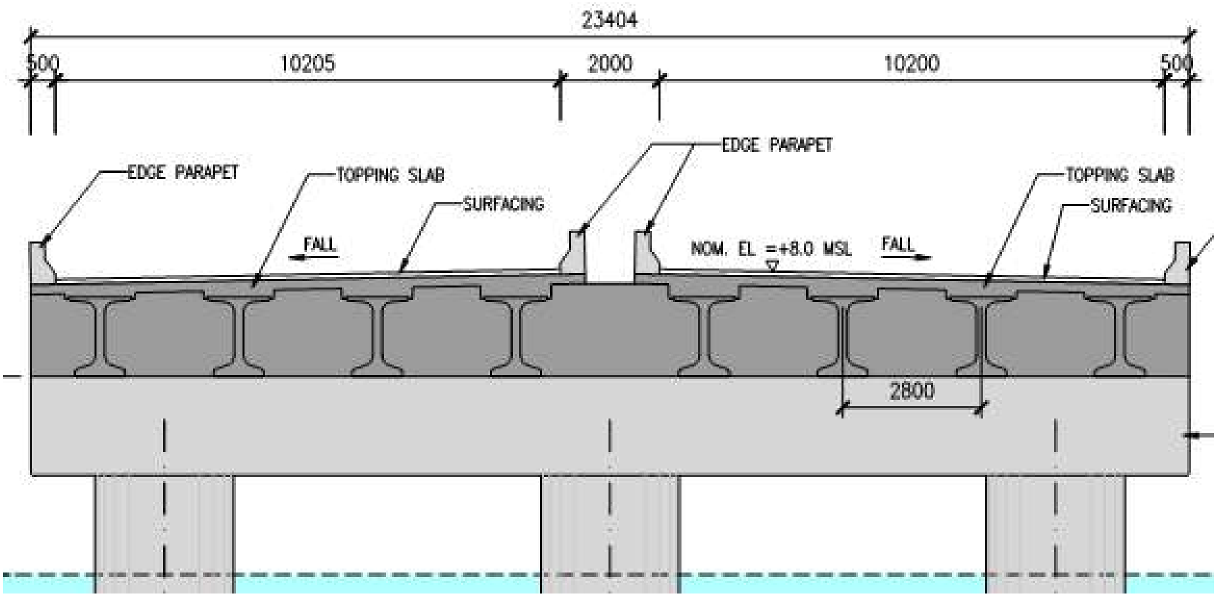


Figure 1-34 Typical Section of Embankment Viaduct with NU Girder

1.4.4.3.2 Articulation

For embankment viaduct, superstructure is proposed to be monolithically connected to the substructure at internal pier to form a strong frame enhancing the global stability of the bridge. Movement joints (M.J) are required at each abutment, and bearings are required at abutment (see **Figure 1-35**).

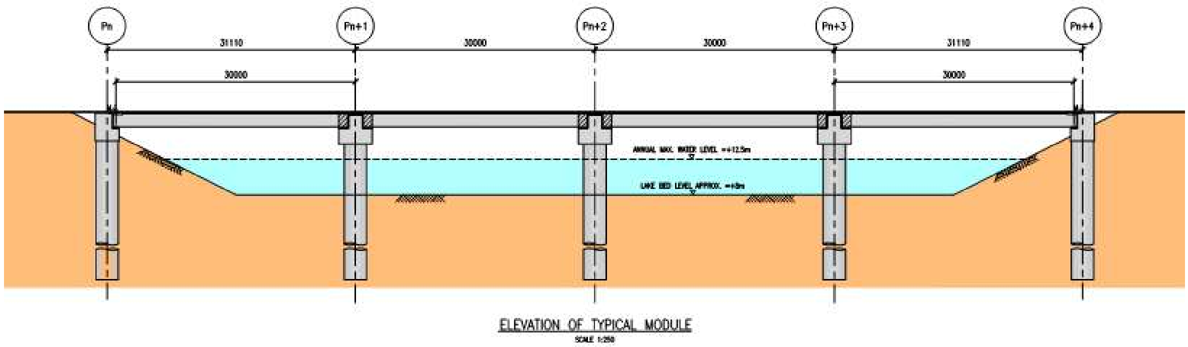


Figure 1-35 Typical Arrangement of Embankment Viaduct

1.4.5 Embankment

1.4.5.1 General

The proposed embankment scheme is an integrated scheme, as shown in **Figure 1-36**, to construct an earth filled embankment along the mainline. The embankment structure to serve as a wave breaker to protect the inland area. Along the shoreline embankment, there will be sufficient number of access opening for fishing boat access to the lake, rivers/ streams outlet. Intercepting channels and box culverts to be provide in regular interval to allow the catchment area along the shoreline embankment be drained. More discussion on each topic as follow.

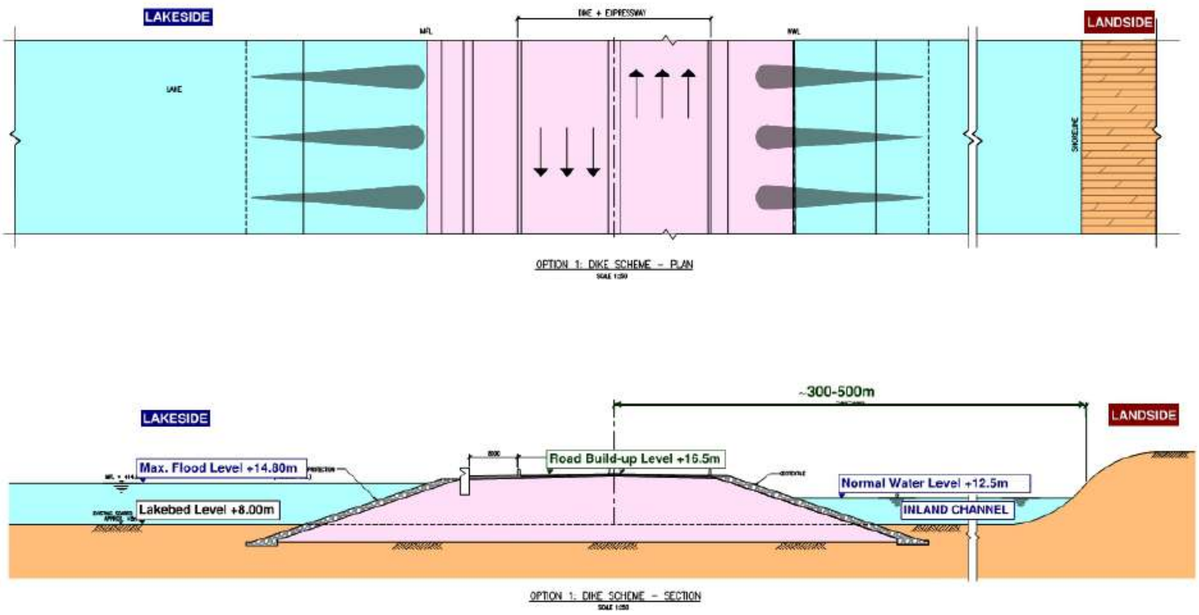


Figure 1- 36 General Layout of Embankment

Figure 1- 37 Rendered View for Embankment with opening

The embankment slope angles at both sides of embankment have been determined considering the following parameters:

- Seismic load
- Maximum wave height during the design event
- Shear strength parameters of available embankment material

The crest of the embankment is based on hydraulic and lake/ maritime assessment which determines the maximum water level, wave height and storm surge, etc to provide a safe level with sufficient freeboard for the users and its width is established to be compliant with the criteria for a high standard highway. The provision for permanent settlement of the foundation base, settlement of the dike body and the settlement during the construction must be taken into consideration in the design of dike crest level.

For the LLRN FS study, there are few types of embankment and the design criteria and consideration on each type to be discussed in following sections.

1.4.5.2 Shoreline Embankment Design Criteria

Majority of the embankment is located from Tunasan to Calamba. It is approximately 25.8km long embankment with many embankment viaducts to allow river outlet, existing fisher folk crossing. The embankment viaduct design is covered in Section 1.4.4.3.

1.4.5.2.1 Proposed Works

Based on the limited site investigation data, the subsurface soil is generally loose and silty at the top 2m from the seabed, hence 2m thick topsoil is proposed to be removed and replaced with a 0.5m stone blanket and a further 1.5m replacement sand underneath the stone blanket. It is proposed that the embankment to have a 1:3 slope.

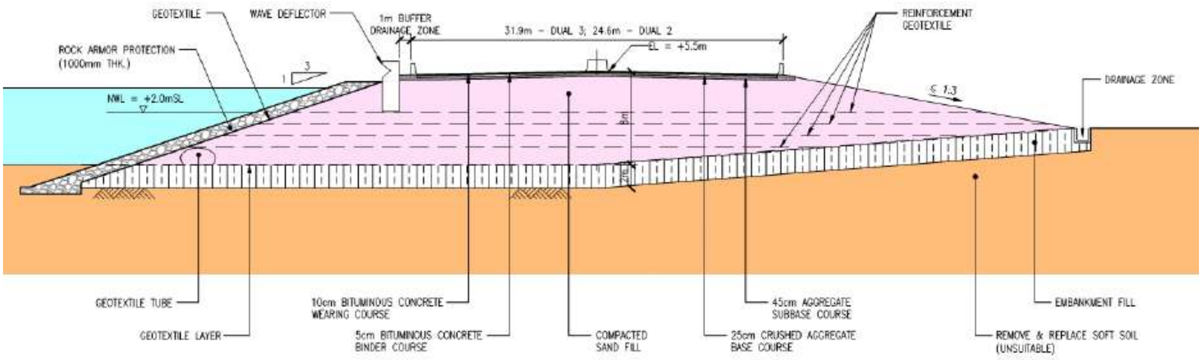


Figure 1- 38 Typical Onshore Embankment with Stone Blanket at the bottom

In order not to adverse the river flow toward the Laguna lake, a wide opening on each river and stream outlets are proposed, illustrate in **Figure 1- 39**. More discussion on drainage design refer to Section 1.4.6.9.1 in this report.

Figure 1-39 Typical Bridge over Streams/ Rivers

1.4.5.3 Embankment with Ground Treatment

1.4.5.3.1 Proposed Ground Treatment Works

As per the road alignment design, at Sucat and Alabang interchanges, there will be approximate 1km embankment, as shown in **Figure 1-40** to allow the slip road connection flyover above the mainline. Based on the limited site investigation data, the subsurface soil is reported generally loose and silty at the top 3m from the lakebed, hence 2m thick topsoil is proposed to be removed and replaced with a 0.5m stone blanket and a further 1.5m replacement sand underneath the stone blanket. Geotextile shall be laid on top of the stone blanket.

At the potential liquefaction area identified in **Figure 1-42**, proposed ground treatment consists of stone columns of 1.0m dia. at 2.0m triangular grid spacing with 20m length to be installed underneath the embankment within the liquefaction zone. Outside of potential liquefaction area, 1:3 slope embankment sitting on a stone blanket is proposed instead, further detail of the design can be referred to Section 1.4.5.2.

Figure 1- 40 Sucat, Alabang Embankment

Figure 1- 41 Sucat Interchange

The embankment with stone column ground treatment is required length in approximated 1km in length of LLRN mainline based Ground Condition Assessment. In the northern portion of the alignment the ground condition assessment indicated that the area is prone to liquefaction hazard and the thickness of the liquefiable zone is up to 20m thick below the lakebed. The southern part of the alignment, based on one borehole, showed a liquefiable layer of 2m near the surface which could be removed by dredging and replacing with stone blanket. The dredged soil can be used as fill materials

From the most recent feasibility study conducted by the United States Agency for International Development (USAID) around the Laguna Lakeshore project site 2013, only 11 numbers of borehole logs have been retrieved and found useful. Most of the boreholes were concentrated in the northern portion of the alignment and indicated that area to be prone to liquefaction hazard and the thickness liquefiable zone is up to 20m thick below the lakebed. The southern part of the alignment is only represented by one borehole. It indicated that the liquefiable layer was only as thick as 2m at the top. It can be removed by dredging and replacing with stone blanket. The dredge soil can be used as fill materials and it is further discussed in Section 1.5.1.2.1 below. The available borehole locations from this report as indicated in the map **Figure 1- 42** below.

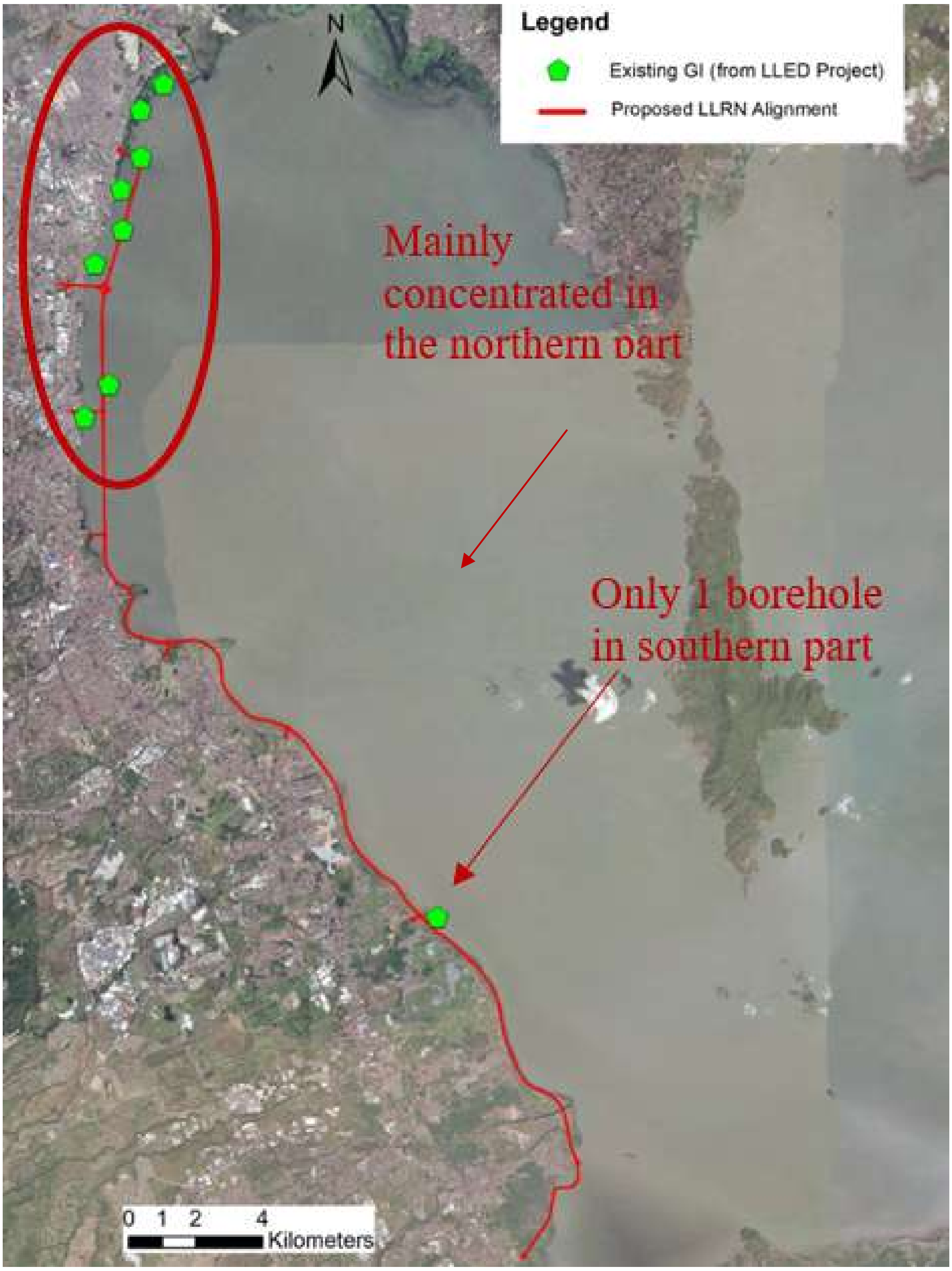


Figure 1- 42 Existing Borehole Data Locations Along the Alignment

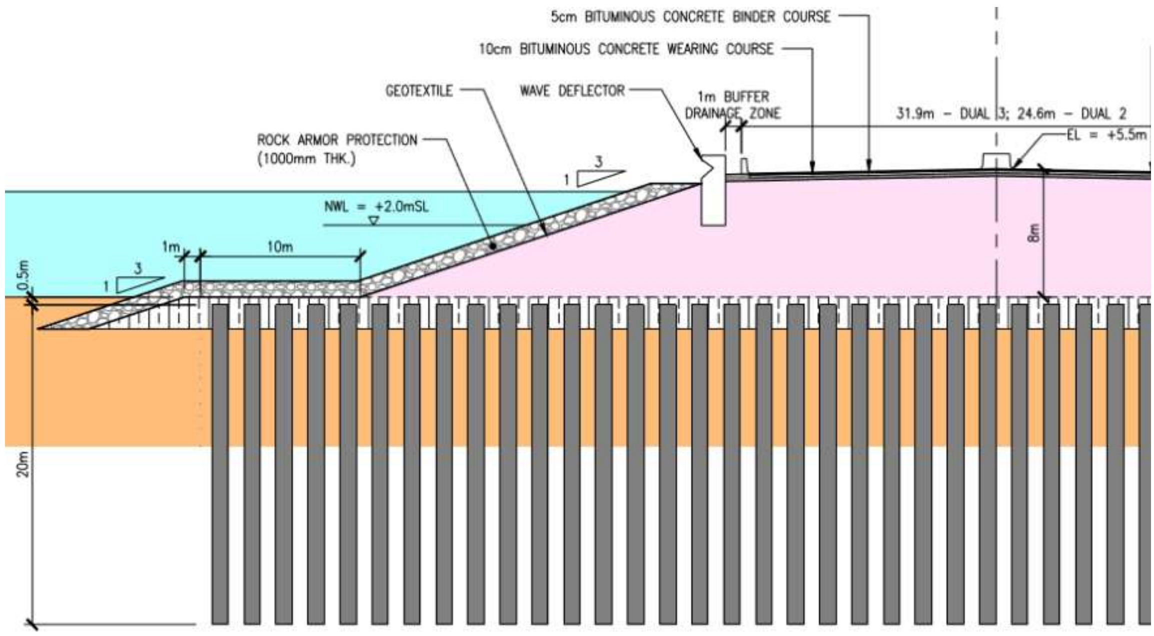


Figure 1- 43 Typical Embankment Foundation Detail with Stone Column ground treatment

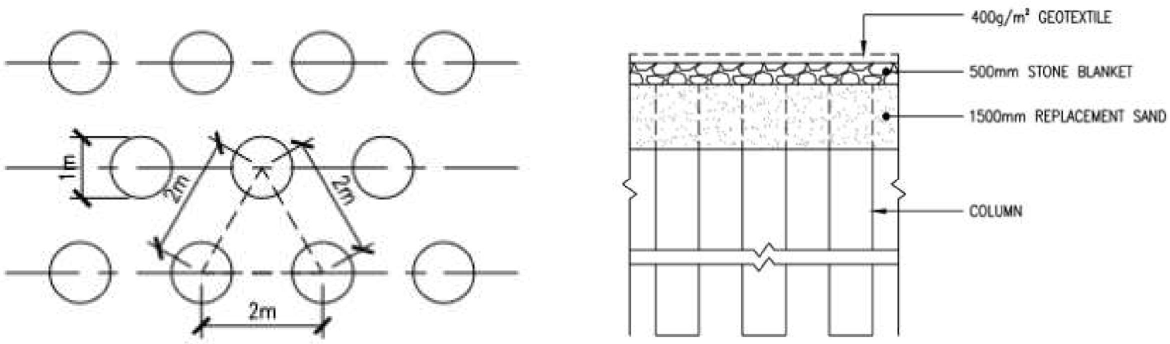


Figure 1- 44 Typical Stone Column Layout Plan and Details

1.4.5.4 Slope Protection System

The slope surfaces should be covered with geotextile at landside and armour rock protection system at lakeside. The typical embankment arrangement is shown in Drawing No. IPIF1/LLRN/FS-PD/4001 to 4002.

Shallow revetment toes are applicable at the areas where the erosion rate is low, the revetment toes only resist the wave-induced currents at the embankment toe. Common types of shallow revetment toes are shown in the following Figure:

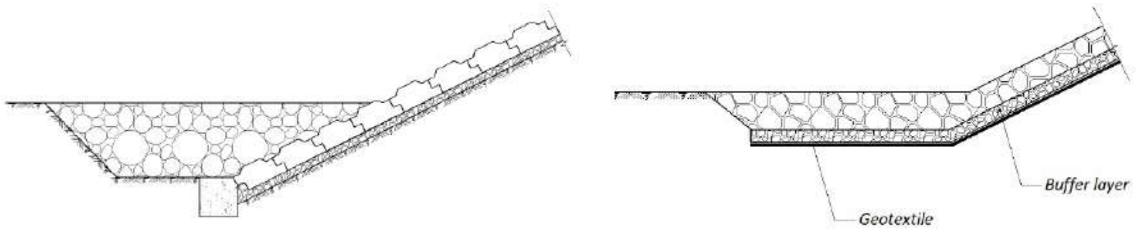


Figure 1- 45 Extracted from Technical Standards in Sea Embankment Design

1.4.5.4.1 Armour Size

Based on the Hudson and van der Meer formulae for deep and shallow water conditions, the armour size assessment for the embankment determined that 2-ton armourstone would be adequate. The standard of damage in the design allows for minor movement and replacement of armour units in the aftermath of extreme events. Geofilters or underlayer rock may be constructed to prevent erosion of the finer embankment core materials through the larger rock armourstone.

1.4.5.4.2 Slope Arrangement

The embankment shall have a slope of 1V:3H with a crest level topping out at +16 m relative to project datum to achieve the allowable overtopping rate. The below arrangement may be considered depending on the construction method. The concrete crest wall may be used in place of naturally sloped armourstone on the landward side.

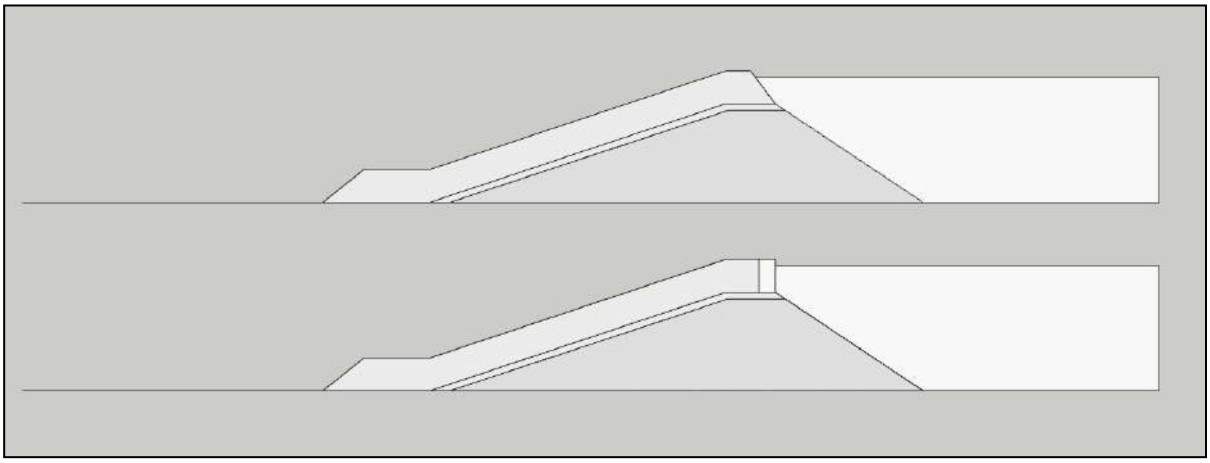


Figure 1- 46 Embankment Arrangement for LLRN; a concrete crest wall may be raised to further limit over-topping discharge across the cope-line

It is recommended that full hydraulic modelling and a coastal flooding study should be carried out at the detailed design stage to reassess the wind-wave and over-topping conditions at the embankment once the alignment and structural form is finalized

1.4.5.5 Embankment Foundation and Settlement Control

Embankment foundation must ensure the stability in terms of stresses under the impacts of active loads and seismic load. In case the embankment foundation does not meet the design requirements and standards, additional ground improvement will be required.

Where the thin, soft soil layer is encountered underneath the proposed embankment body, geotextile fabric can be placed between the embankment body and foundation for the purpose of filtration, drainage, isolation, reinforcement, uniform distribution of stresses, reduction of irregular settlement, reduction of lateral deformation and strengthening the stability of foundation soil. Based on the technical requirements and available conditions, one or more layers of geotextiles can be placed on the abutting surface and in the embankment body.

In case the embankment foundation is on soft soil, the construction time could be extensive, hence the effective method is to build up the embankment body gradually in layers, so that the soft soil can have sufficient time to consolidate, and thereby increasing its bearing capacity. To speed up consolidation of the reclamation area, provision of sand drain or vertical drain can be considered at sufficient spacing and depth along the reclamation area.

1.4.6 Interchanges

1.4.6.1 Land Viaduct Concept Design

The Land Viaduct will connect the offshore viaduct to the existing national highway road system. Strong Selection Criteria for Land Bridges Structural Form during this FS is in line with most common local practice and guidelines as specified in the Design Basis Report.

1.4.6.2 General Arrangement

During the preliminary stage and for the purpose of analysis, **Figure 1-47** showing the typical arrangement of land viaduct having 4 spans in between movement joints were considered.

Piers in between the movement joints are assumed to have pin connection with the superstructure in both transverse and longitudinal directions. Columns act as cantilever in the longitudinal direction but not in the transverse direction. The superstructure, composed of I – girders with the deck slab, acts as a continuous composite section over the piers.

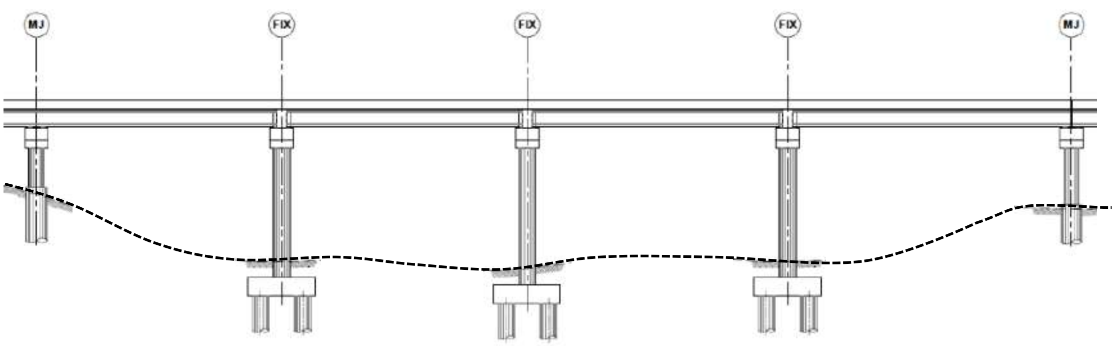


Figure 1- 47 Typical Arrangement of Land Viaduct

1.4.6.3 Seismic Design

The seismic design of land viaducts is based on the generated response spectrum for 1000 – year return period earthquake. For the substructure, AASHTO plastic hinging method is proposed for the design of pier column – foundation. Corresponding response modification factors (R-factors) were used based on the submitted Basis of Design document.

1.4.6.4 Superstructure

Preliminary Structural elements are most likely similar with common local practice and guidelines to ensure that local parametric costs with minimal variations are within the threshold of acceptability until such time that the project has reached the succeeding final design stages of implementation.

Superstructure precast configuration will likely improve during the succeeding stages of design, viz. DED can introduce more cost-efficient innovation in response to latest materials/products evolving as widely accepted linkages of Superstructure and Substructure.

Bridge spanning and precast prestressed girder arrangement may likely be adjusted but anticipated with workable cost variance when final adjustment on all project elements is commonly balanced along with:

- Economy
- Bridge Inspection – accessibility
- Maintenance
- Aesthetics
- Effect on existing roads
- Presence of utilities
- Constructability
- Political and environmental issues

1.4.6.5 Typical Cross Section

Two options were considered for land viaduct. Option 1 is composed AASHTO Type VI Girders at 40-m span (**Figure 1- 48**) while Option 2 has NU 2000 Girders at 45-m span (**Figure 1- 49**). AASHTO girders are commonly used in the Philippines while NU girders are just being introduced in the ongoing Cebu-Cordova Link Expressway Project.

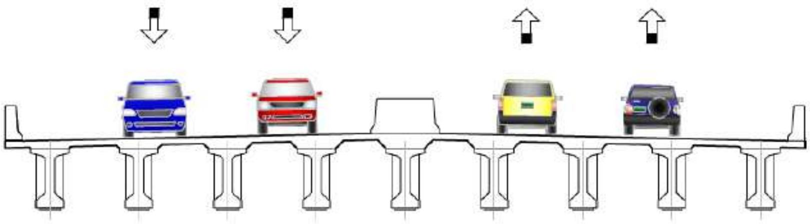


Figure 1- 48 AASHTO Type VI

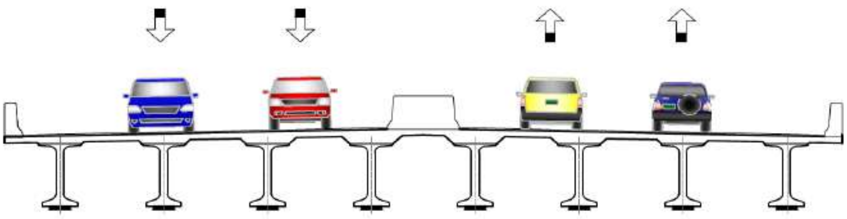


Figure 1- 49 NU 2000 Girder

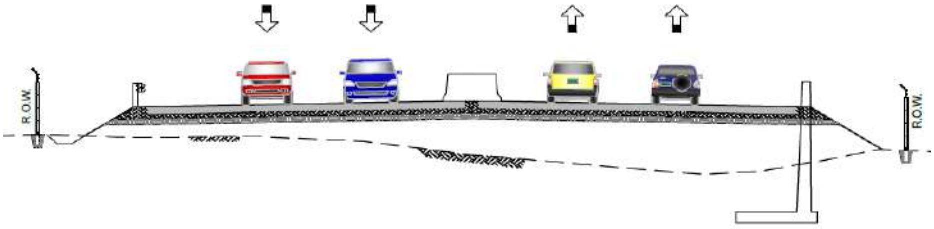


Figure 1- 50 Typical Cross Section for Embankment Section

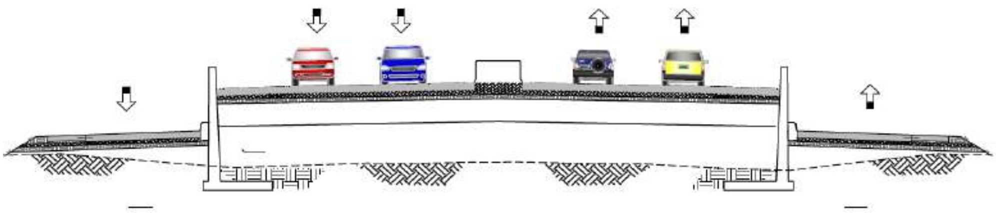


Figure 1- 51 Typical Cross Section for Embankment w/ Side Road/Service Road

1.4.6.6 Substructure

For simplicity of the design and presentation on the results of preliminary analysis, columns were identified to rest on pile cap supported by bored piles foundation. Further analysis and validation of the proposed substructure configurations and foundation shall be done when Geotechnical data are already available.

Figure 1- 52 shows typical substructure configuration for viaduct piers.

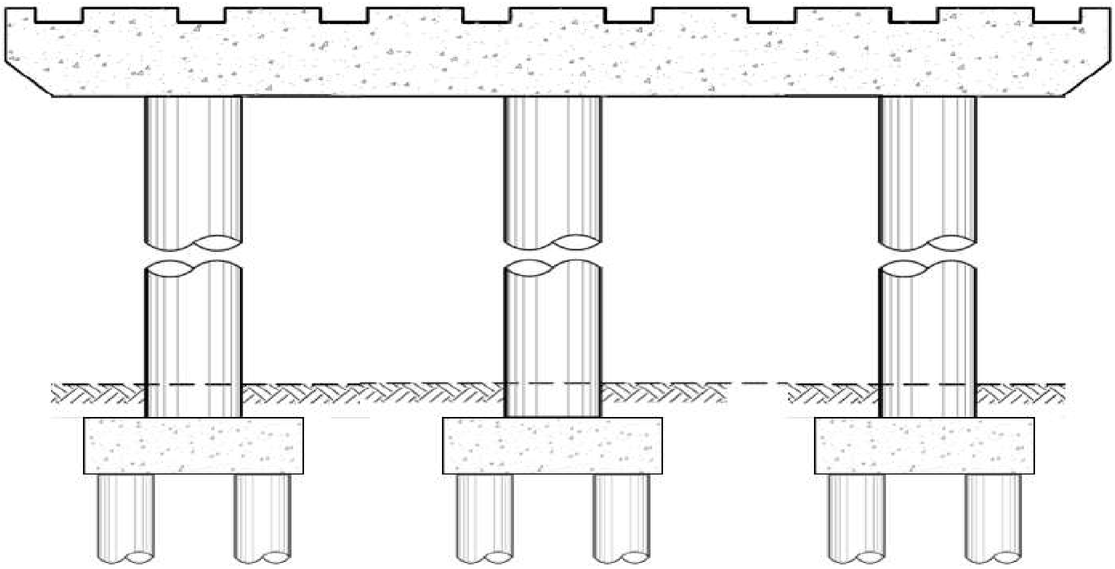


Figure 1- 52 Typical Substructure Configuration

1.4.6.7 Foundation

Concrete and Steel piles were considered and studied as the solution to the foundation at land viaduct. A comparison was made as shown in **Table 1.20** and it showed that concrete bored piles have a great advantage than steel piles. Hence, concrete bored piles are proposed.

Table 1.20 Concrete Bored Piles vs Steel Piles

Criteria	Concrete Bored Piles Steel Piles *min. max.*	Remarks
Capacity		• Concrete bored piles have a larger skin friction compared to Steel piles. • Concrete bored piles can be socketed as opposed to Steel piles.
Constructability		• Based on the assumption that LLRN shoreline with various thickness of Alluvium up to 25m and bed rock data is limited, concrete bored piles are also proposed for ease of construction.
Cost		• The use of steel piles for rock-solid stratum is not practical to use.

1.4.6.8 Types of Interchanges

The LLRN Phase I will be connectable to SLEX at 3 interchanges at the Northern part via their slip roads where SLEX is close, namely, Lower Bicutan, Sucat and Alabang. These 3 interchanges and their slip roads will be preliminary designed and ROW acquisition carried out in this Study. It is noted that although the majority of the mainline will be viaduct, for more cost effectiveness forming the interchange structure by embankment locally might be necessary.

For the middle portion near Muntinlupa, there are 4 interchanges, namely Tunasan, San Pedro/ Biñan, Santa Rosa and Cabuyao, which are quite far away from SLEX. The aim for slip roads is to provide the connection to the local main road, Manila South Road, but the required connection road from LLRN is quite long and involve extensive ROW acquisition. Therefore, it is proposed to terminate the slip road connection at the nearest existing road near the Municipal Boundary at the shoreline.

In the long run, the slip road connection to Manila South Road is necessary but the design of the alignment and ROW acquisition shall be dealt with by the local LGUs. It is also understood that there is a Cavite – Laguna Expressway under construction ending/starting at Biñan/Santa Rosa that can provide an additional connection, however it is located even further than SLEX, i.e. too far away and complex for direct connection from LLRN.

The Calamba Interchange is the end point of the Stage 1 LLRN at Palingon. It will be connected to the Calamba city centre by a dual 2-lane road of 3km to the proposed Calamba-Los Baños-Bay Bypass.

Entries and exits to the Highway Mainline will require an interchange for ramps and junctions to connect in a continuous one-way free-flow manner. Different movements and locations of these ramps leads to different types of interchange. Three types of potential interchange and junctions have been proposed in the mainline. These are shown and described in detail in **Figure 1- 53**.

Trumpet interchange is a 3-leg interchange which takes the shape of trumpet. Trumpet interchanges have been used where one connection terminates at the highway mainline. This layout involves loop ramps connecting traffic entering or leaving the mainline with the far side of continuous highway. This type of interchange allows for free flow of traffic in all direction.

B. Grade-Separated Roundabout

Grade-separated roundabout is type of interchange connecting between a highway and minor roads. The slip roads to and from the highway converge at a single roundabout, which is grade-separated from the mainline with bridges. The roundabout allows for multiple direction of connections with minor roads in a one direction of flow around a central island. This type of interchange allows for free flow of traffic to be maintained along the highway mainline.

C. At-Grade Roundabout

At-grade roundabout is a circular intersection or junction for multiple directions of connection where traffic flow in one-direction around a central island. The advantage of roundabout will move traffic through an intersection more quickly, and with less congestion on approaching roads. It promotes a continuous flow of traffic unlike the road intersections with traffic signals wherein the drivers should wait for a green light to get through the intersection. Traffic is not required to stop – only yield – so the intersection can handle more traffic in the same amount of time. It is generally safer than the traditional intersection because it has fewer conflict points and allow for higher traffic junction capacity

Figure 1- 53 Visualizations of different interchange types

1.4.6.9 Proposed Interchanges in LLRN

The interchange types were chosen based on criteria and constraints such as traffic volume and topographic/terrain constraints, but as well as capacity for new planned or future developments. The types of interchanges applied are presented in **Table 1.21**.

Table 1.21 Proposed Interchange Type

Interchanges	Year 2026 Daily Traffic Flow		Proposed Interchange Type	Slip Road Length (Meter)
	To LLRN	From LLRN		
Lower Bicutan	10,200	11,500	At-Grade Roundabout	N/A
Sucat	10,500	10,300	Trumpet Interchange	1,685
Alabang	8,600	6,500	Grade-Separated Roundabout	850
Tunasan	N/A	N/A	Grade-Separated Roundabout	460
San Pedro/ Biñan	11,000	11,800	Grade-Separated Roundabout	435
Sta. Rosa	1,900	1,800	Grade-Separated Roundabout	210
Cabuyao	2,200	3,300	At-Grade Roundabout	205
Calamba	5,800	5,000	At-Grade Roundabout	3,450
			Total	**7,300**

At Tunasan interchange, it was designed as a stop end in the shoreline under LLRN project, i.e. No Traffic flow estimated in LLRN traffic model.

1.4.6.9.1 Lower Bicutan Interchange

The Lower Bicutan Interchange is a roundabout located at C6 road. It is located at CH0+000 in LLRN. There are 3 arms at the roundabout, connecting north and southbound of C6 and proposed LLRN. The designed roundabout will connect into C6's dual 2-lane carriageway (2 x 3.35m lane width each direction) and paved with Portland Cement Concrete Pavement (PCCP).

The LLRN will be at-grade but rise up gently in the form of an abutment then in the form of viaduct to run eastward. The Lower Bicutan Barangay Hall is also very close to the west of C6. No residential structures will be affected.

Figure 1- 54 Proposed Roundabout Connection, Lower Bicutan Interchange

1.4.6.9.2 Sucat Interchange

Sucat is the most important interchange in LLRN, as it provides the shortest connection to SLEX. It is located at CH4+500 in LLRN. The entry/exit to SLEX will be via Meralco Road. There are over 30% of traffic flow through this junction. But Sucat is also the most difficult junction to be constructed as there are many constraints and interfaces. An important constraint is PNR's upgrade of Sucat Station to accommodate a 2 levels railway.

The proposed trumpet interchange connection to existing road network will be located at the intersection of Meralco Road and East Service Road of SLEX, 790 meters from LLRN main alignment. It traverses a large area of private land with cogon grasses and different kinds of weeds including a Jeepney Terminal, and it crosses the PNR railway track, two (2) roads namely Manuel L. Quezon and T. Posadas Ave. and inhabited areas near the shore of Laguna Bay.

The LLRN 1,685 - meter slip road has to climb over it as the 3rd layer road to merge with Meralco Road. The advantage in directly connecting to Meralco Road will provide more safety and efficiency. It reduces the number of possible conflicts as the traffic goes continuously. Also, by channelizing the Entry/Exit traffic at East Service Road will provide the driver a lesser tendency to reduce the speed while entering or exiting the intersection from the carriageway.

Figure 1- 55 Proposed Junction, Sucat Interchange

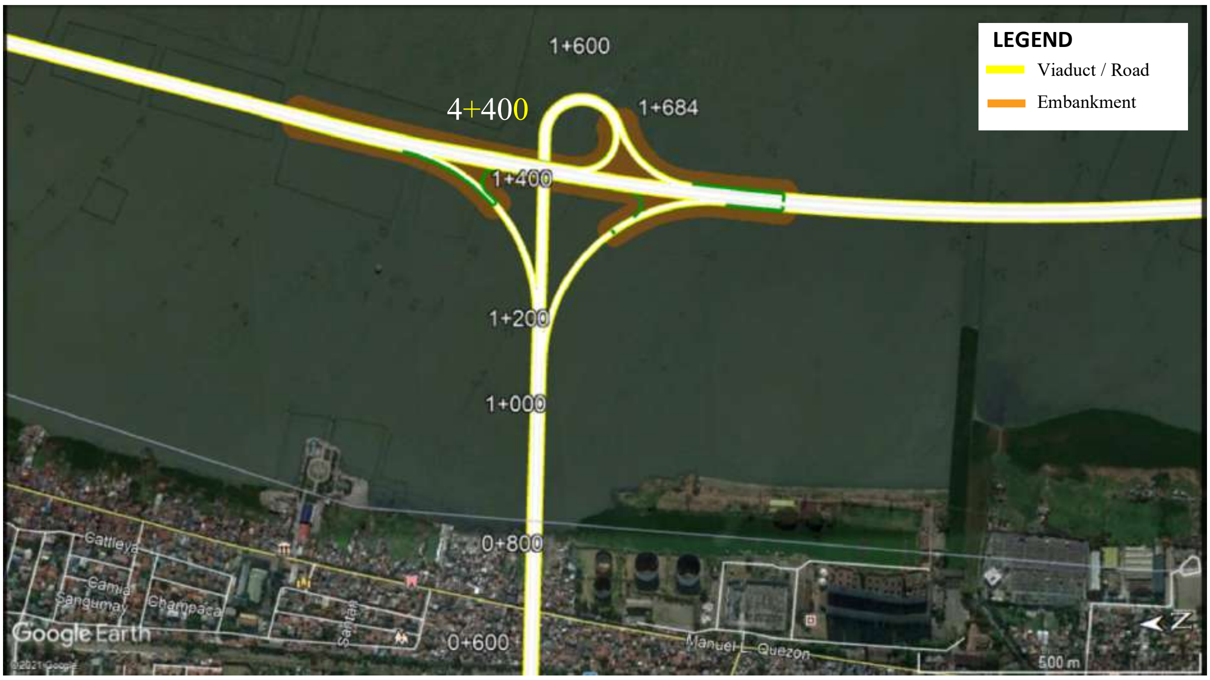


Figure 1- 56 Proposed Trumpet Interchange, Sucat Interchange

There will also be an Intermodal Terminal for public vehicles near the new Station, thus it might be underneath the LLRN slip road bridge. Since this requires the slip road viaduct to be very high, the interchange at mainline will better be in the form of a trumpet interchange such that the slip road will fly over the mainline in a form of viaduct.

In traffic point of view, a trumpet interchange in fact performs better than at-grade priority junctions such as a roundabout. It might consider to employing an in-lake embankment (despite ground treatment my required based on the existing geologist study) for around 300m to 400m long to reduce the level of the mainline such that the slip road viaduct can be lowered as much as possible when crossing the mainline. At the western side of the railway, the land is high, the flyover may have to connect Meralco Road at a high elevation, but desirable gradient will be adopted.

1.4.6.9.3 Alabang Interchange

The proposed grade separated roundabout interchange for Alabang is located at CH8+200 in LLRN. It will be connected to the local junction of Montillano Street, Manuel Quezon at North and Ilaya Road at South. The designed 850-meter slip road connection will be a dual 2-lane carriageway slip road corridor (2 x 3.35 m lane width each direction) and paved with Portland Cement Concrete Pavement (PCCP).

The interchange is also situated very close to SLEX, but the arrangement at the SLEX side is more convenient to connect the Northbound rather than Southbound of SLEX. Due to the constraints of the double railway line and the SLEX viaduct, the slip road is so short that there is not adequate length to provide a desirable gradient to connect Montillano Street.

The Montillano Street is itself a narrow road, at-grade with the existing railway and a junction at Ilaya. A roundabout option is proposed underneath the mainline and the western leg will connect to this Montillano Street/Ilaya junction. Improvement at the western end of Montillano Street is expected for the connection to SLEX Southbound as well as to Skyway.

Figure 1- 57 Proposed Grade-Separated Roundabout Interchange, Alabang Interchange

1.4.6.9.4 Tunasan Interchange

A provision of interchange as requested by the LGU of Muntinlupa has been considered with slip road 100m away from the shoreline and expected to connect at MCX with a 460-meter slip road. Major ROW acquisition is necessary but subject to the preference of LGU. The designed connection will be a dual 2-lane carriageway corridor (2 x 3.35m lane width per direction) and paved with Portland Cement Concrete Pavement (PCCP). This road connection will be studied further and finalized in DED Phase.

Figure 1- 58 Proposed Grade-Separated Roundabout Interchange, Tunasan Interchange

1.4.6.9.5 San Pedro/ Binan Interchange

The proposed grade-separated roundabout connection is located at the Municipal Boundary of San Pedro/Binan along Laguna Lake shoreline. The 435-meter slip road from the roundabout will connect to the inland by an at-grade levelled slip road. The slip road is expected to further run South-West to connect Manila South Road in the future, wherever possible subject to the LGU's ROW acquisition. Hence, the slip road is planned to connect to some roads within the new development or Hernandez Street at the existing shoreline in the current stage. The designed slip road connection will be a dual 2-lane carriageway corridor (2 x 3.35 m lane width each direction) and paved with Portland Cement Concrete Pavement (PCCP).

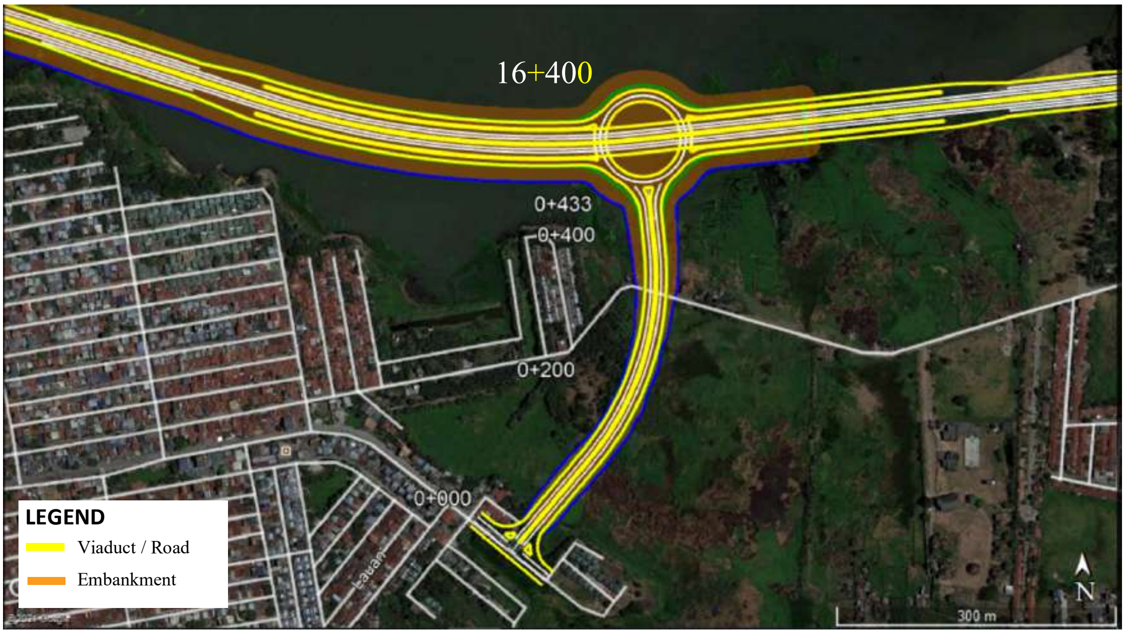


Figure 1- 59 Proposed Grade-Separated Roundabout Interchange, San Pedro / Binan Interchange

1.4.6.9.6 Sta. Rosa Interchange

The proposed grade-separated interchange will be located at the Laguna Lake shoreline near Sta. Rosa. For the current stage, the 210-meter slip road is proposed to connect from the at-grade roundabout to existing at-grade Brgy Sinalhan Road. The future road extension shall connect south west to the junction at Manila South Road/JP Rizal Street subject to the preference of the LGU. The designed slip road will be a dual 2-lane carriageway corridor (2 x 3.35 m lane width each direction) paved with Portland Cement Concrete Pavement (PCCP).

Figure 1- 60 Proposed Grade-Separated Roundabout Interchange, Sta. Rosa Interchange

1.4.6.9.7 Cabuyao Interchange

The proposed junction layout will be an at-grade roundabout. For the current stage, the 205-meter slip road is proposed to connect from the roundabout to the existing at-grade Marinig Road, but ultimately, the slip road shall extend westward to connect Manila South Road/ JP Rizal Street. However, it may have to span over the planned PNR double level railway, which will be an important constraint for design consideration, but the final routing is subject to the preference of the LGUs. The designed slip road will be a dual 2-lane carriageway corridor (2 x 3.35 m lane width each direction) paved with Portland Cement Concrete Pavement (PCCP).

Figure 1- 61 Proposed Roundabout Interchange Option, Cabuyao Interchange

1.4.6.9.8 Calamba Interchange

The Calamba Interchange is an at-grade roundabout with a 3,450-meter slip road connecting to the adjacent interface project, Calamba-Los Banos-Bay Bypass via another at-grade roundabout connection. Openings with sufficient vertical clearance for boats and ferries would be required to maintain access to the lake.

The intention of this interchange is designed for a grade-separated interchange for the future extension of LLRN mainline toward Los Banos across Laguna Lake. The mainline will continue as a dual 2-lane carriageway corridor in the form or viaduct or embankment across the Laguna Lake bay. Openings with sufficient vertical clearance for boats and ferries would be required to maintain access to the lake.

The designed slip road will be a dual 2-lane carriageway corridor (2 x 3.35m lane width each direction) paved with Portland Cement Concrete Pavement (PCCP). A short segment of slip road will be in-lake to pass around the existing port. This segment will have viaduct segment to provide vertical clearance for boat access to port.

Figure 1- 62 Current Proposed At-Grade Roundabout Interchange, Calamba Interchange

Figure 1- 63 Proposed Roundabout Interchange with Interface Project, Calamba-Los Baños-Bay Bypass

1.4.7 Drainage Considerations

The purpose of an effective drainage system is to ensure that rainwater runoff is discharged directly from the road surface. Two types of drainage provision are necessary for the project.

i. The drainage system collecting surface runoff on the road; and

ii. The drainage system which maintains the original waterway from land to the lake, as the proposed embankment may intercept the original drainage pathway.

The design of the drainage system will be in accordance with the DPWH Design Guidelines, Criteria and Standards (DGCS), Volume 4 Highway Design, 2015. The design of storm drainage requires the prediction of the magnitude of peak rates of surface run-off (hydrology analysis) followed by the design of the drainage structures and facilities to accommodate the surface run-off (hydraulic analysis). The resultant drainage system should be capable of collecting and handling the design flow and routing to the main outlet drain of the designated outfall. Each structure along the expressway project that crosses rivers, creeks, ditches, and waterways should also be adequately sized to allow the unimpeded flow of water.

Table 1.22 Design Return Period

Type of Structure	Design Discharge Recurrence Interval
Bridges	50 years
Reinforced Concrete Box Culverts	25 years
Reinforced Pipe Culverts	15 years
Surface Drainage	10 years
Side Ditches	10 years

Table 1.23 Design Water Level

Scenario	Level (m) *, LLDA Datum
Mean Lower Water Level	+10.69
Maximum Lower Water Level	+11.19
Mean Water Level	+11.33
Mean Higher Water Level	+12.07
Maximum Higher Water Level	+14.03
Maximum Water Level (100-year event)	+14.3

* Referenced from the interfacing Parañaque Spillway Project

Effective drainage is a critical element in the design of highways, but should also be designed, built, and maintained with consideration of the consequences on the environment. Further review for the overall drainage system and provision on flap gates shall be conducted in the DED Stage.

1.4.7.1 Choice of Drainage System

Pipe and box culverts are typical structures in all road projects. These structures will be proposed at strategic locations where waterways cross the project road alignment other than major creeks and rivers where bridges/box culverts are proposed to be constructed.

Natural canals and small waterways will also be provided with crossing conduits. The appropriate size for pipe or box culverts will be designed. Based on the orientation of the waters, the proposed structures will either be at normal angles or skewed relative to the project road alignment.

The following design requirement from DGCS Volume 5 summarized in Table **1.24** would be adopted for road drainage design of viaduct and embankment:

Table 1.24 Design Standard for Bridge Deck Drainage

Bridge Drain Spacing	≤ 5m (Figure 4.6-1)
Diameter	≥150mm
Velocity	≥ 0.8 m/s
Return Period	10 years
Time of concentration	5 minutes

1.4.7.2 Drainage from Bridges and Viaducts over Water/Land

The bridge deck drainage systems shall be designed to effectively remove runoff from the bridge deck and divert it to the bridge abutments and discharge it to existing stormwater drainage systems, outlets or directly into lake where stormwater drainage system does not exist.

Other design considerations are listed as following –

a. The discharge points from the pipe shall be at least 0.2m below the lower level of the adjacent bridge superstructure, and at least 2.0 m clear of bridge abutments and piers.
b. Runoff collection pipework attached to the underside of the bridge deck shall not pass through any girder, box girder or diaphragm.
c. Pipe outlets shall be located such that a 45° cone of splash will not touch structural components
d. Use of free drops or slots in parapets wherever practical and permissible.
e. Use of bends not greater than 45°.
f. Use of cleanouts.
g. Downspout to transfer the runoff from superstructure level to ground/water level. The downspout may be either built into concrete columns or attached to the columns (**Figure 1-68**).
h. Outlet structures to discharge the runoff into the existing stormwater drainage system or into the receiving waterbody.

i. The size and number of deck drains should be such that the spread of the deck drainage does not encroach on more than one half the width of any designated traffic lane.
j. The flooding adjacent to drain inlets should not encroach on any portion of the designated traffic lanes.
k. Gutter flow should be intercepted at cross slope transitions to prevent flow across the bridge deck.

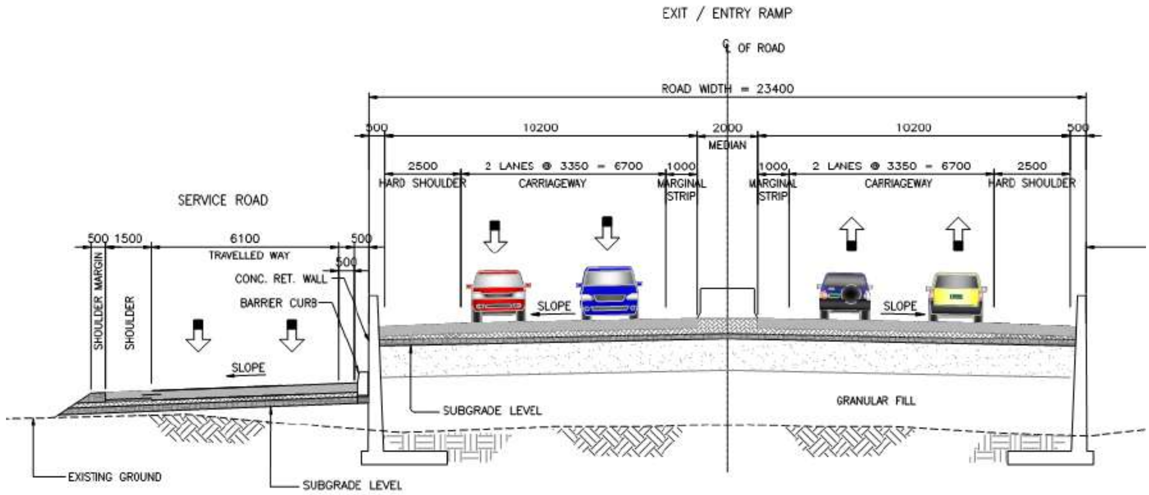


Figure 1- 64 Land fill drainage section

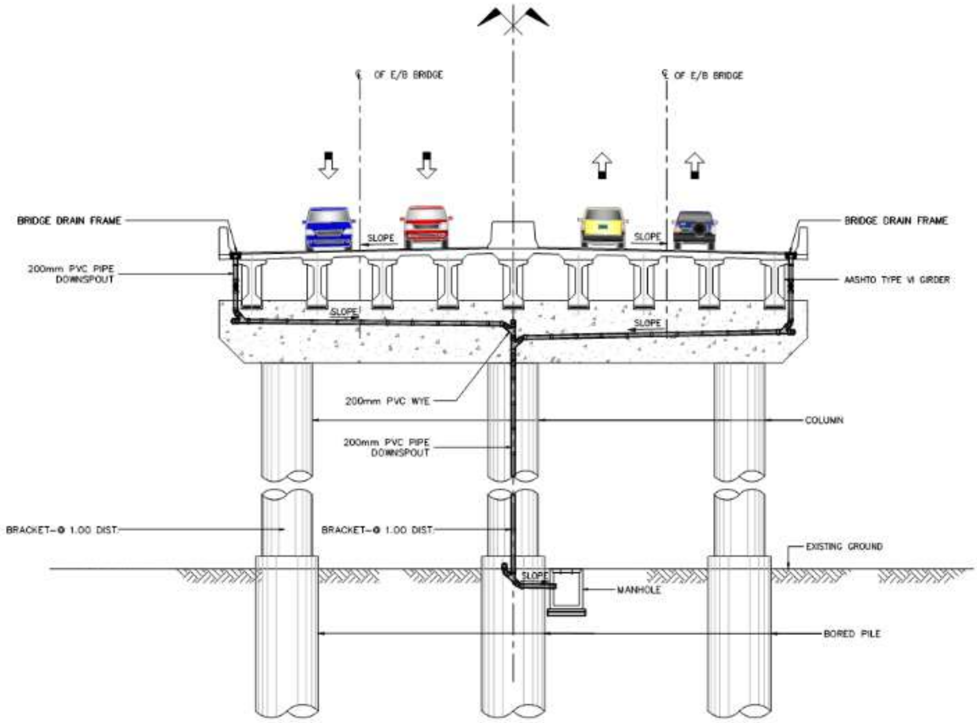


Figure 1- 65 Land Viaduct drainage section

1.4.7.3 Drainage from Embankment

Similarly, the road drainage at embankment sections shall be designed to effectively collect and convey surface runoff via road gullies and gully pipes in the form of closed conduits in accordance with the relevant requirements of DGCS Volume 4. The surface runoff collected at the inland portion of the carriageway would be discharged to the proposed channel along toe of the embankment slope for subsequent discharge to the lake. On the other hand, runoff collected along the lakeshore would be discharged directly to the lake via gully outlet pipes down the embankment slope. Detailed drainage arrangement shall be further developed in future stages.

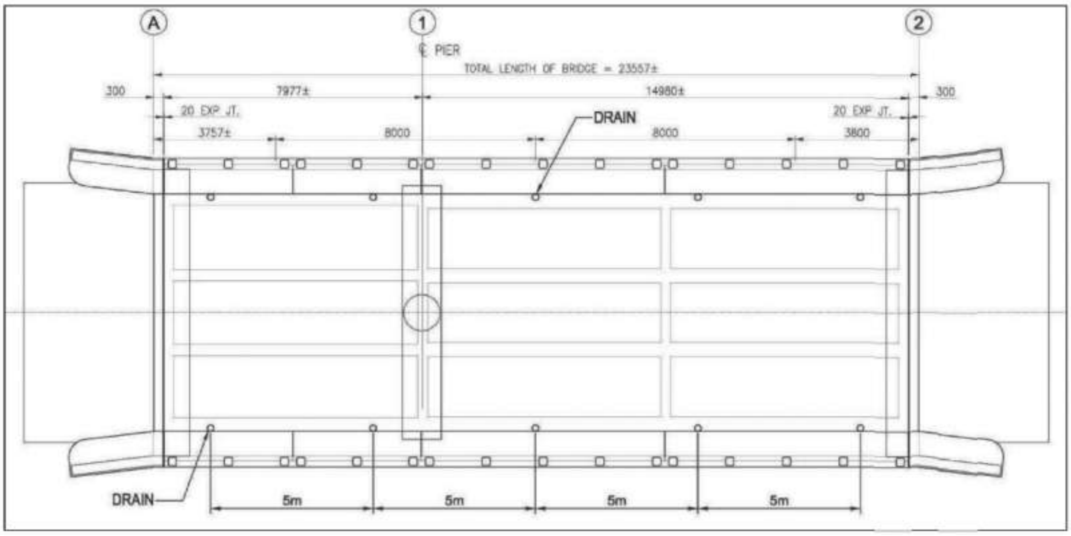


Figure 1- 66 Spacing of Bridge Drains

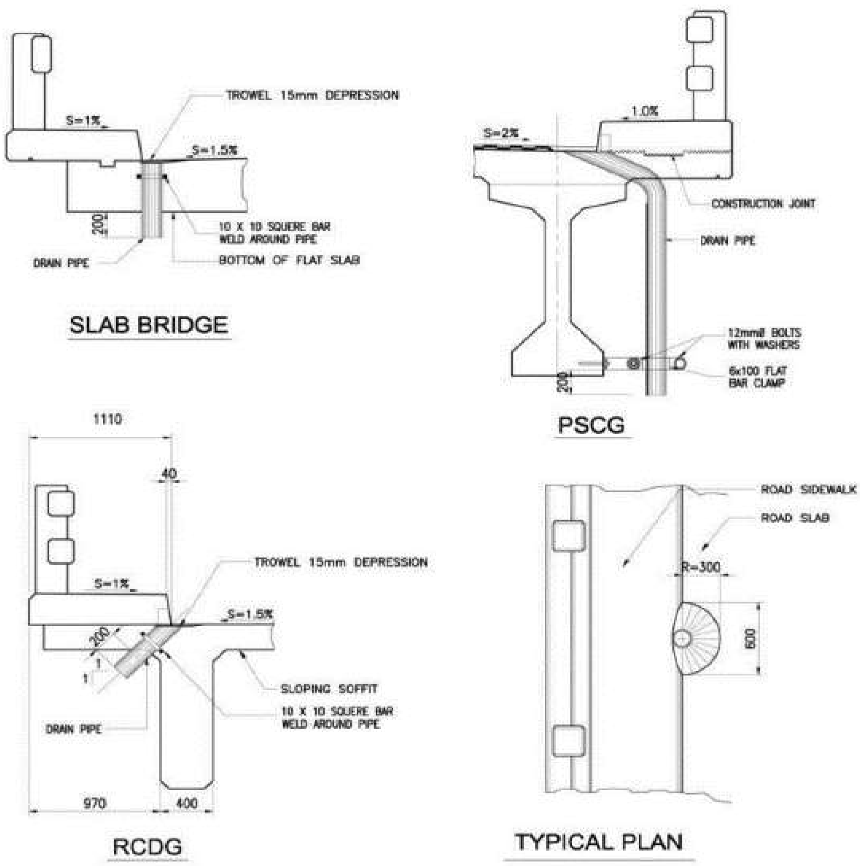


Figure 1- 67 Typical Free Drop Drainage Details

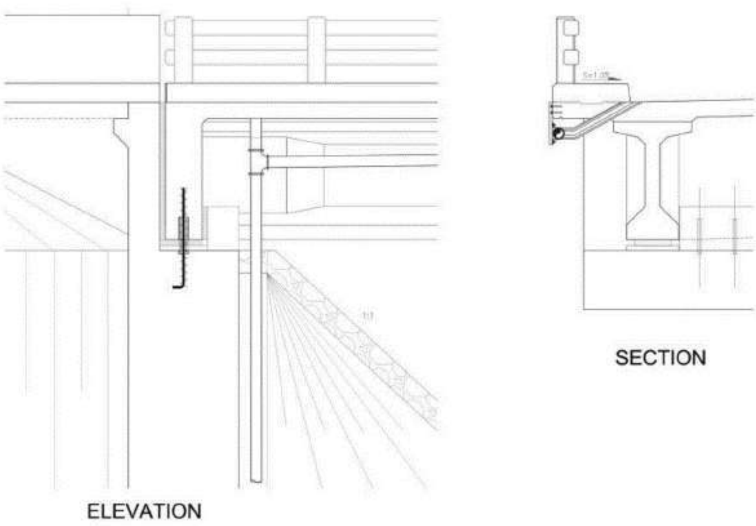


Figure 1- 68 Lateral Pipe Ending to a Downspout

1.4.7.4 Drainage Design of Shoreline Embankment

While the viaduct itself would serve as openings allowing conveyance of overland flow to the lake, the proposed drainage strategy at the shoreline embankment section involves provision of surface channels at toe of embankment slope to collect overland flow and discharge box culverts across the embankment to effectively discharge to the lake. The surface channels are proposed to be equipped with permeable bottom in order to mitigate accumulation of stagnant water. Preliminary hydraulic calculations on the sizing of surface channels and box culverts have indicated that rectangular surface channels of 3000(W) x 1000(H) and a single cell 2500(W) x 1500(H) discharge box culverts at equal spacings ranging from approximately 120m to 200m would adequately serve its catchment. A catchment plan highlighting the portion of overland flow conveyed to the intercepting channels and culverts is shown in **Figure 1- 69**.

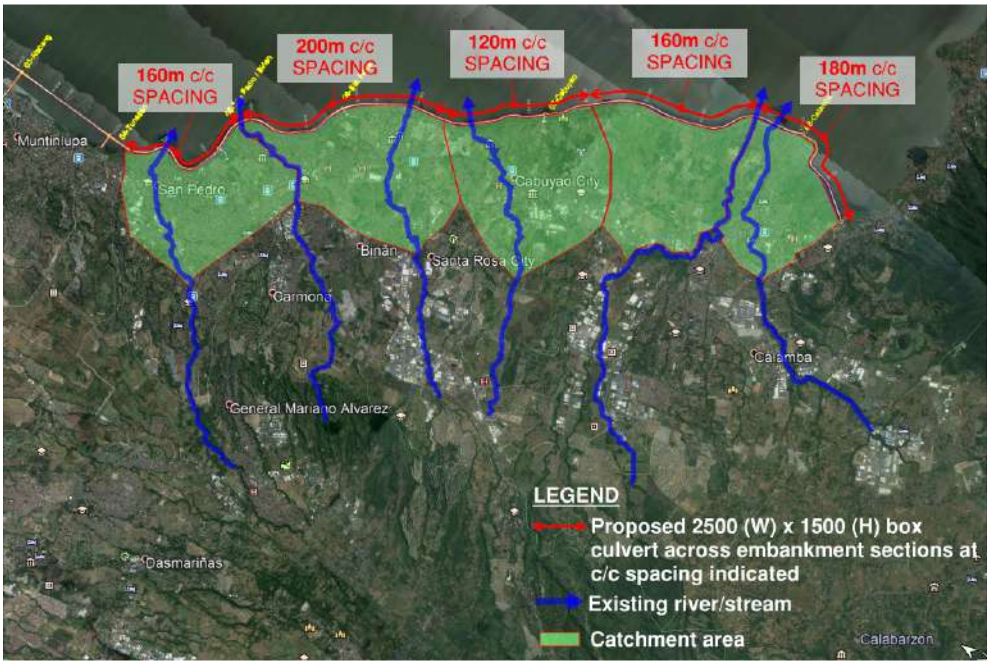


Figure 1- 69 Catchment Area Plan of the Overland Flow

The overall land drainage discharge strategies as depicted in the following figures:

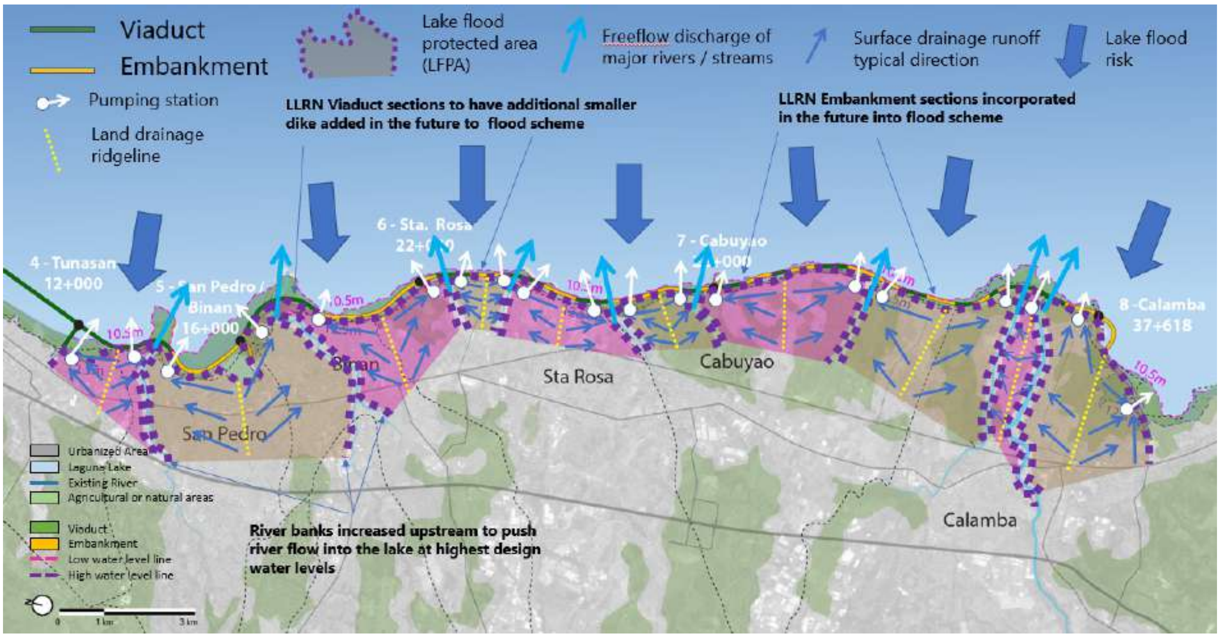


Figure 1- 70 Overall Land Drainage Strategies from Tunasan to Calamba

The proposed drainage strategy at shoreline embankment and its typical cross-section are shown in **Figure 1- 70** to **Figure 1- 72** respectively.

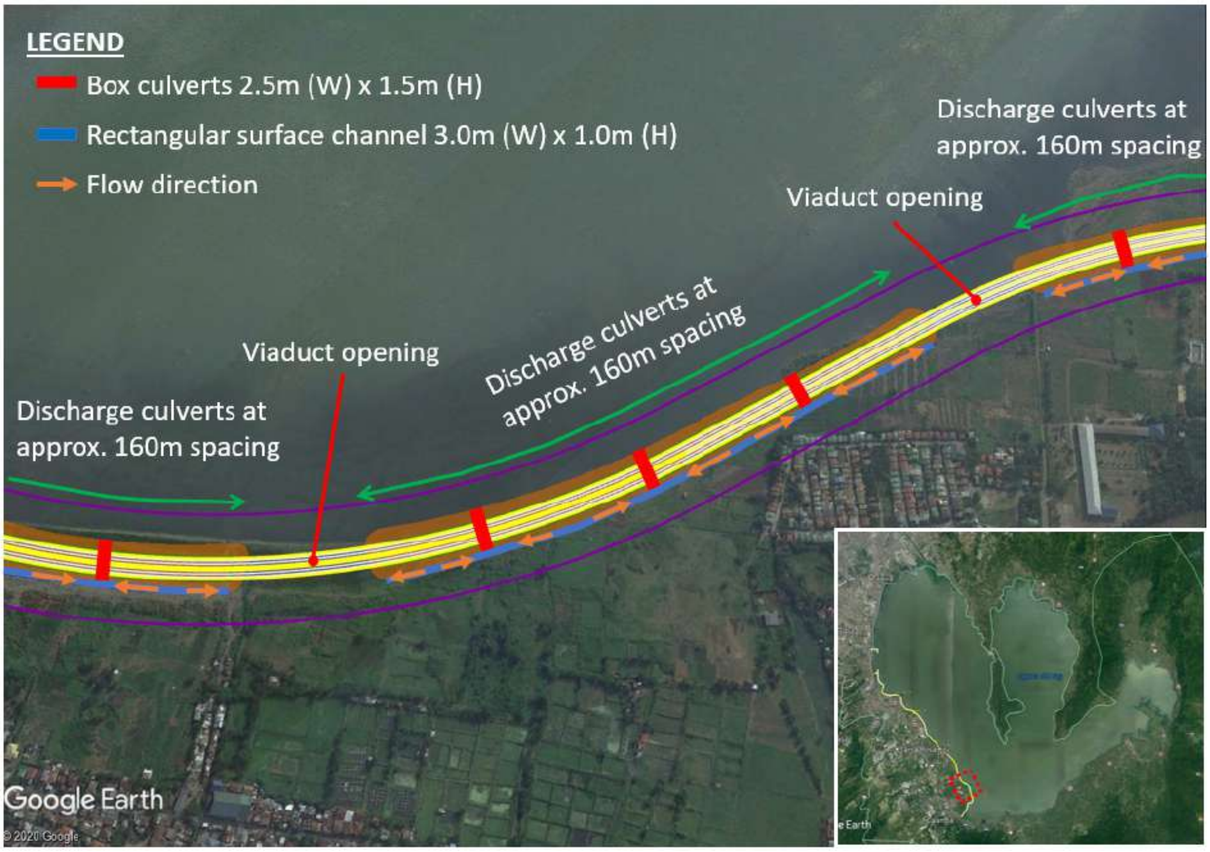


Figure 1- 71 Preliminary Drainage Scheme at Shoreline Embankment

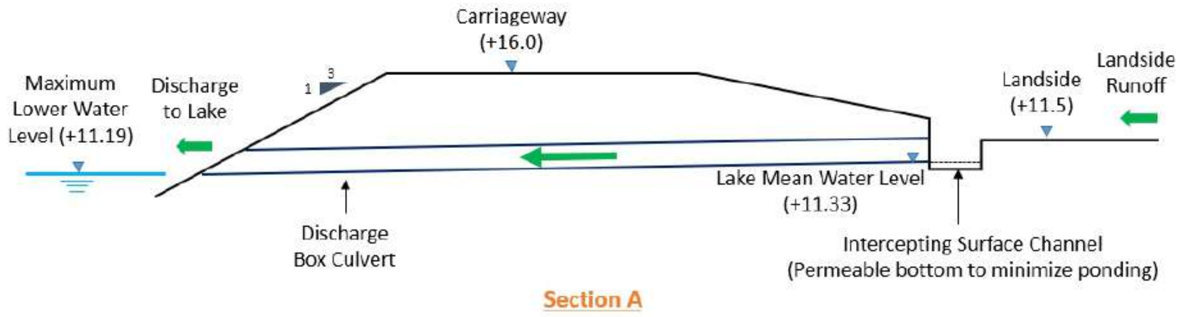


Figure 1- 72 Typical Cross-Section of Drainage System at Shoreline Embankment

1.4.8 Associated Infrastructure Facilities and Buildings

Apart from the mainline above, the project will also need to include the associated infrastructure facilities/buildings for operation and maintenance purpose.

1.4.8.1 Administration Building

An administration building might be required which will include facilities for inspection and maintenance staff, storage of records of maintenance activities and control room for the traffic control and surveillance system (TCSS) equipment if required.

1.4.8.2 Public Assistance Amenities

Since this will be a long drive from the North to the South, especially during peak seasons, public amenities might be necessary such as toilets, information/assistance desks, parking areas, waiting areas, security outposts, gasoline stations, etc.

1.4.8.3 Maintenance Depot

These design standards contain principles and requirements for safety, serviceability, and durability. It assumes that maintenance activities are performed during the working life of the bridge structures to enable them to fulfil the requirements for reliability. To preserve the intended reliability of the structures, there is an absolute requirement for ongoing inspection and maintenance. Replacement or repair of certain components shall be carried out as necessary to ensure that the reliability of the structures is not reduced during the intended service life.

The LLRN is primarily composed of viaducts, embankments, bridges, and interchanges. Maintenance of these components is important, and it may be necessary to procure appropriate machines such as Under Bridge Inspection Vehicles (UBIV) for viaducts, bridges, and interchanges. See **Figure 1- 73**. This is likely to require a centralised depot where there will be parking spaces for maintenance vehicles, space for storage of spare parts, workshops as well as staff amenities and facilities.

Figure 1- 73 Under Bridge Inspection Vehicles (UBIV)

Offshore viaducts and bridges may also be inspected, especially those portions of the structures above water, using inspection boats. Also, this may require a slipway or shelter.

Figure 1- 74 Inspection Boats

1.4.8.4 Casting Yard and Works Stations

It is foreseen that there will be large amount of construction activities during the implementation/ construction phase. To minimize the impact to existing road network, whose capacity is about to be exceeded in some location, casting yards along the main line are proposed. Ideally the casting yards could be located at headlands with widening of existing roads. Also, the casting yards could be located at position of future service stations along the proposed highway to avoid waste of reclamation and reduce unnecessary acquisition of land. The selection of casting yard locations should minimize the impact to local residents and environment. The project could be split into a number of packages with covered construction yards for precast element construction. Two possible casting yard/ works area locations have been identified (see) Further study would be required at detailed design phase and contractor to further investigate the proposed location.

The size and choice of location of casting yard are specific for each project. The relevant parameters that need to be considered include (but not limited to) the following:

- Availability of suitable land and accessibility
- Speed of construction / production rate
- Logistics of raw material and finished products
- Logistics of construction workers
- The range of activities to be carried out
- The depth of water for barges

The details of possible casting yards are listed in **Error! Reference source not found.Error! Reference source not found.**. The size of casting yards is for reference only, the final size and locations will be studied to suit the construction method and number of contracts. Layout plan for possible casting yards are shown in **Error! Reference source not found.** and **Error! Reference source not found..**

Table 1.25 Possible Casting Yard and Works Stations Details

	Total Area (km^2)	Reclamation (km^2)	Un-used Green Land (km^2)	Farm Land (km^2)
Casting Yard 1 At headland near Santo Nino, San Pedro	0.2	0	0.2	0
Casting Yard 2 Between river mouth of San Cristobal River and San Juna River, Calamba	0.28	0	0	0.28

Figure 1- 75 Possible Locations of Casting Yards and Works Stations

Figure 1- 76 Possible Location of Casting Yard 1

Figure 1- 77 Possible Location of Casting Yard 2

In general, the casting yard and works area to be adjacent to the work fronts, the closer it is the better. The length of time needed to transport precast segments from the yard to the work front needs to be considered. If the barging/transportation time exceeds a work shift, then it may be beneficial to have a storage facility closer to the site (if available). Very long barging times introduce weather dependency and uncertainty.

These casting yards could be transformed to service station in the operation phase to provide resting area, gas station along the LLRN mainline. The layout plan and transformation to be design in DED phase.

1.4.8.5 Dumping Area

There will be many excavation activities such as bored piling and/or pile cap construction for both land and marine viaducts and embankment base layer. It is necessary to identify dumping/storage areas for material which is either suitable or unsuitable for re-use. If the dredged material from the bored piles it is likely to be unsuitable material and cannot be used for site formation works, these excavated materials might need to be dumped at identified area such as landfill site. This has to be controlled in a suitable manner with minimum impact to the environment. The dumping site would ideally be as close to the project location as possible to reduce the cost of transportation, it needs to be further study in DED phase.

1.4.8.6 Haul Road

Haul road(s) to and from the construction sites and in particular the works area(s), barging point(s) and/or casting yards will be required. The capacity of existing roads will need to be checked and upgraded if necessary, to suit the construction activities. This may need to be carried out as advanced works.

1.4.8.7 Fishing Ports

The affected municipalities have fisher folks. It is very important to provide the fisher folks a port in each municipality. It must be deep enough for the fisher folks to moor anytime of the day. This should include the approach canal, wave protection, light house, warning and marking buoys, navigational aids, pontoons, walkways, waiting shades, marketplace, parking areas, gasoline stations, etc. For a similar port, please see **Figure 1- 78**.

Figure 1- 78 Typical Fishing Port

1.4.8.8 Future Road Extension

The current scope of LLRN aims to connect the nearest existing shoreline roadway for proposed interchanges. However, as part of a bigger improvement scheme to traffic around Laguna Lake, it is essential to provide connection from existing major roads, such as Manila South Road, to connect to LLRN.

The road classification proposed for slip road is Primary Road, primarily to match the road cross section and standard applied to LLRN mainline. The slip roads extension should be designed similar to currently proposed slip road corridor (minimum 2 lane per direction), in order to provide sufficient traffic capacity and avoid congestion ingress/egress to LLRN interchange. The routing of the slip road should minimize local impact and land resumption while maintaining a more direct connection to LLRN.

Based on design standard of DGCS Volume 4, the lane should be 3.35m wide, with 2.5m far side shoulder, 1.0m near side marginal strip and a 2.0m wide median including the parapet barrier. The design speed of 80km/h and maximum gradient of 4.0% are considered in flat topography but can be adjusted to 60km/h and maximum gradient of 5% if in rolling topography. For horizontal alignment of mainline, higher radius of curvature should be used to maintain the highspeed and comfortability of the highway, hence minimum radius of 120m must be maintained for rolling topography.

Multiple extension schemes for different interchanges were proposed to local LGU at this stage as illustrate in figures below. From Manila South Road, these road extensions, which will be studied further and finalized in the DED Stage, will connect to the interchanges of San Pedro / Biñan, Sta. Rosa and Cabuyao with approximated lengths of 1.5 km, 1.8 km and 3 km, respectively, for a total of 6.3 km. The implementation of the final road extensions will be undertaken by the local LGUs or DPWH Region IV-A.

Figure 1- 79 Proposed Schemes to Connect Manila South Rd for San Pedro/Biñan Interchange

Figure 1- 80 Proposed Extension to Connect Manila South Rd for Santa Rosa Interchange

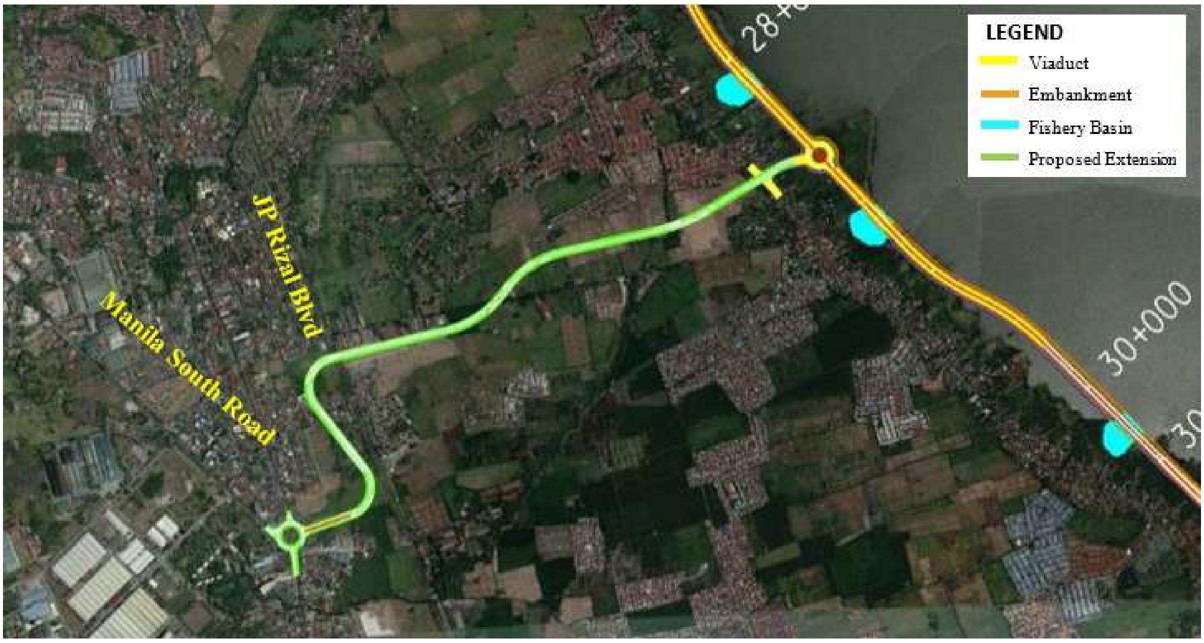


Figure 1- 81 Proposed Extension to Manila South Road for Cabuyao Interchange

1.4.9 Pollution Control Devices and Waste Management System

Pollution control devices and waste management system will serve as significant components of the project in the various development phases of the project. Presented in the next subsections are the proposed pollution control devices and waste management system:

1.4.9.1 Air Pollution Control

It is expected that air contaminants/pollutants will be generated especially during the construction phase of the project. Emissions may be caused by earthworks on the project site, use of heavy equipment and machineries, and other construction activities that may contribute to air pollution. The project will apply proposed measures to minimize and if possible, avoid air pollution brought by the construction activities on site. The following correction methods are proposed to reduce the emissions to a manageable range:

- To determine the condition of the ambient air in the project site, air quality sampling and monitoring shall be conducted during the construction phase. Air pollutant concentrations will be monitored via regular sampling to ensure conformity with the National Ambient Air Quality Guideline Values (NAAQGV).
- Machineries, equipment, and vehicles will be maintained properly. Emission testing is suggested to be performed, and results will be presented through the Self-Monitoring Reports (SMR) to the DENR.
- As much as possible, use of low sulfur fuel and fuel efficiency of equipment and vehicles will be ensured

1.4.9.2 Noise Pollution Control

During construction phase, construction works, and usage of equipment will increase generation of noise. The proposed noise pollution control and management include the following:

- Noise levels must be closely monitored to minimise high exceedances in permissible levels. As needed, use of movable noise barriers is recommended in areas where noise levels are expected to be generated by use of machineries or equipment for the construction works
- Installation of a 3m high noise barrier (length of noise barrier ranges from 350m to 1360m) along the traffic road

1.4.9.3 Water Pollution and Wastewater Management

As LLRN runs across Laguna Lake and the shoreline of its surrounding communities, management of water pollution and wastewater is crucial for the project. One of the main strategies is a preventative source control wherein stronger control at the source of pollutants must be in place. This includes the following:

- Efforts to prevent trash and debris from entering the drainage system shall be in place which can be achieved by providing trash receptacles at key locations, and trash racks in storm water management features
- To prevent water pollution, the drainage area will contain a filter to separate water contaminants such as oil and grease, which will be drained and collected in sump
- For heavy construction work such as dredging for barge access, there will be an installation of well-designed silt curtain control scheme
- Include site design features that will prevent and contain contaminated spills such as knee walls, berms, secondary containment areas, oil/water separators
- For wastewater generated from the construction activities, treatment and collection must be done by a third-party contractor accredited by the Department of Environment and Natural Resources Environmental Management Bureau (DENR-EMB).

1.4.9.4 Waste Management System

Waste materials that will be generated from the project during construction of the road will include construction spoils, excavated materials, domestic wastes (both solid and liquid) from worker camps, hazardous waste such as used oil, empty paint containers, toxic waste, and other types of waste.

The project proponent shall require the contractor to submit a detailed Solid Waste Management Plan as part of the construction plan, including necessary permits for disposal of waste at a Government-approved disposal site.

The Waste Management Plan for work sites and construction camp shall provide procedures for management of domestic wastes, hazardous wastes, and sewage. There should be an evaluation of the type and quantities of waste to provide detailed arrangements for storage and transportation of waste from source to disposal point.

Waste generated during this phase will be managed in accordance with the waste management plan and in coordination with the solid waste management office of local government units. This is important because the LGUs have their specific contractors and accredited waste hauler that manages collection and disposal of construction waste and other types of waste.

Collection points will be assigned, and garbage bins shall be placed in strategic locations and regular maintenance of the area shall be done. The assigned pollution control officer (PCO) for the project shall monitor the activities upholding the social safeguard and environmental policies concerning the project.

For hazardous waste, the project shall also register with the DENR as Hazardous Waste Generator, in compliance with the requirements of Republic Act 6969. Treatment and disposal of toxic and hazardous waste shall be done by a DENR-EMB accredited contractor.

1.5 Process / Technology

1.5.1 Construction Method

The construction methods that the project may employ for the proposed viaduct and embankment are described below.

1.5.1.1 Viaduct

1.5.1.1.1 Dredging for Barge Access

Dependent on the methodology of embankment, there might be a necessity for navigation of barges for delivery/disposal of material within the lake. Land filling for embankment is a major activity, dredging might be necessary before it, either to expose the silt for taking out the sand or dredging of navigation channel for deeper barges. For the piling activity. There might be barging points or wave breakers for protection of barges. Typical dredging machines are shown in **Figure 1- 82**, could be used to clear the bed of lake to increase water depth. With larger water depth, piling barges, floating cranes, flattop delivery barges could access the working area.

Figure 1- 82 Dredging Machines

The main advantages of this method are:

- Less temporary works are required for the construction of piles, substructures, delivery, and erection of superstructure;
- Construction sequence arrangement is more flexible for better control of programme;
- Minimum interruption to the navigations on the lake could be achieved as no obstacles would be formed at location of proposed viaduct.

The main disadvantages of this method are:

- There will be large environment impact to the lake due to dredging works and silt curtain would be required to minimize the impact

1.5.1.1.2 Temporary Steel Deck and Piling Platform

General access for construction could be provided by constructing temporary access deck and working platform for piling and delivery of construction materials. Temporary deck could consist of temporary steel piles and prefabricated light steel deck. An example of this method is the temporary trestle bridge for Shenzhen Western Corridor Bridge in Hong Kong (see **Figure 1- 83**).

Figure 1- 83 Temporary Steel Deck Access and Working Platform for Piling Machines

Some advantages of this method are:

- Lower environmental impact to the lake;
- Convenient transportations of construction plants and materials;

The main disadvantage of this method is that large number of temporary structures will be required during the construction followed by their removal.

1.5.1.1.3 Temporary Dry Working Platform

In this method, temporary dry working platform would be constructed using high-strength fabric tube with sand fill as a reclamation dyke. The dry working platform will be above water level. After completion of temporary dry working platform, land construction plants could be used, and the construction method for piling would be similar to land-based methods, as shown in Figure 1- 84. The temporary dry working platform could be removed after the completion of the viaduct. This method would be particularly advantageous with development reclamations as the dry working platform could be integrated with the development reclamation.

Figure 1- 84 Temporary Dry Working Platform

The main advantages of this method are:

- Creation of temporary construction platform above water level will allow the adoption of land-based machinery;
- The construction would not be influenced by waves and construction operations would be smoother;
- The use of land-based construction plant and method has less cost and shorter construction period compared to the use of marine based machinery like barges, boats, etc.

The main disadvantages of this method are:

- There will be environment impact during the construction period
- Cost of construction of temporary dry platform might be high due to various site conditions and requirements. However, cost be mitigated if the dry working platform is incorporated into the development reclamation.

1.5.1.1.4 Pile Foundations

The use of reinforced concrete bored pile shall be adopted in the preliminary design for the foundation. Driven piles may also be an economical solution and shall also be considered. Driven piles are easier to construct than bored piles, but each pile capacity is less hence more piles are needed for each support. The pile type, size, number, and arrangement shall all be finalized in the detailed design phase.

1.5.1.1.5 Pile Bent and Super Structure

For the substructure of the majority of the mainline viaduct, pile bents with bored piles is the proposed option, as shown in **Figure 1- 85**. These types of piles are constructed and extended above water up to the base of crosshead which supports the superstructure. There is no pile cap required for this substructure which eliminates the construction time, cost and environmental impact associated with pile cap construction. This substructure is only suitable up to a certain height as the bored pile/column will become too slender when the road level is high.

Figure 1- 85 Pile Bent Support of Incheon Bridge Viaduct, Korea

1.5.1.1.6 Superstructure Construction

For beam and slab scheme, the proposed construction method of precast beams are erected by back feed launching gantry. In this method, the precast beams would be erected first on temporary bearings on the pier crossheads or portal beams (**Figure 1- 86**). Then permanent formwork would be installed on the beam for the deck slab, which would then be cast in-situ. To make the individual spans continuous, concrete diaphragm can be cast between the end of two spans.

For deck supported on bearings, the load will be transferred to permanent bearing after in-situ diaphragm and slab gained enough strength, hence the viaduct could reach desired articulation. For viaduct with monolithic connection between deck and substructure, the in-situ diaphragm would be casted monolithically with the crosshead beam to form the joint. For lake viaduct and embankment viaduct, the main steps of superstructure construction method are shown in **Figure 1- 87** and **Figure 1- 88**.

Figure 1- 86 Precast Beams Erected by Back Feed Launching Gantry

The main advantages of this method are:

- Precast AASHTO/NU Girder are commonly adopted in Philippine.
- Widening of road to enhance capacity is relatively easy with this option and can be done by adding an extra beam and stitching the top slab to the existing slab.
- Stressing of prestress tendon is completed in casting yard other than on site, therefore, quality is more controllable and less in-situ works are required. The casting can be parallel with the construction of substructure and foundation, the construction is more flexible.

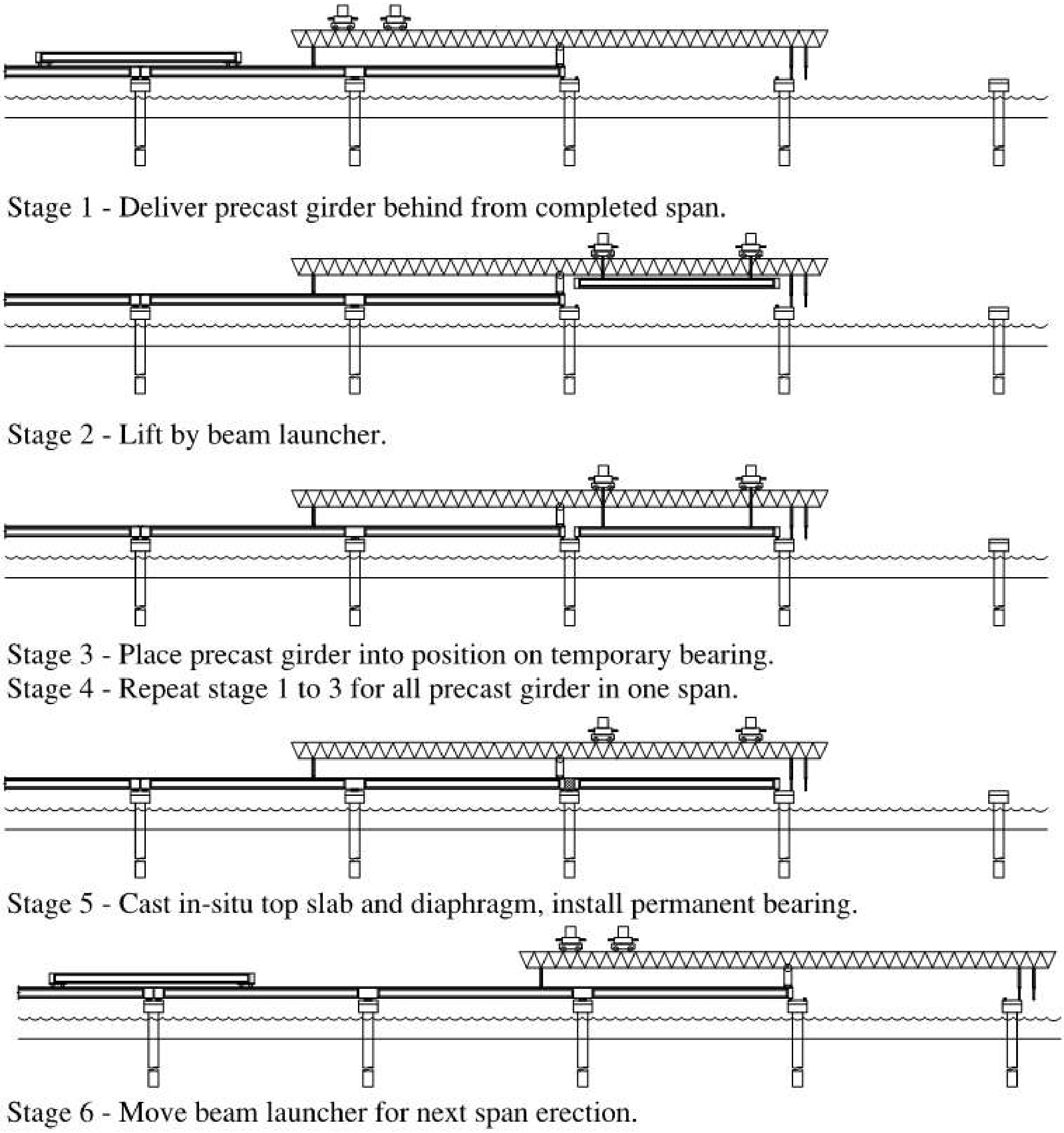


Figure 1- 87 Construction Method of Lake Viaduct

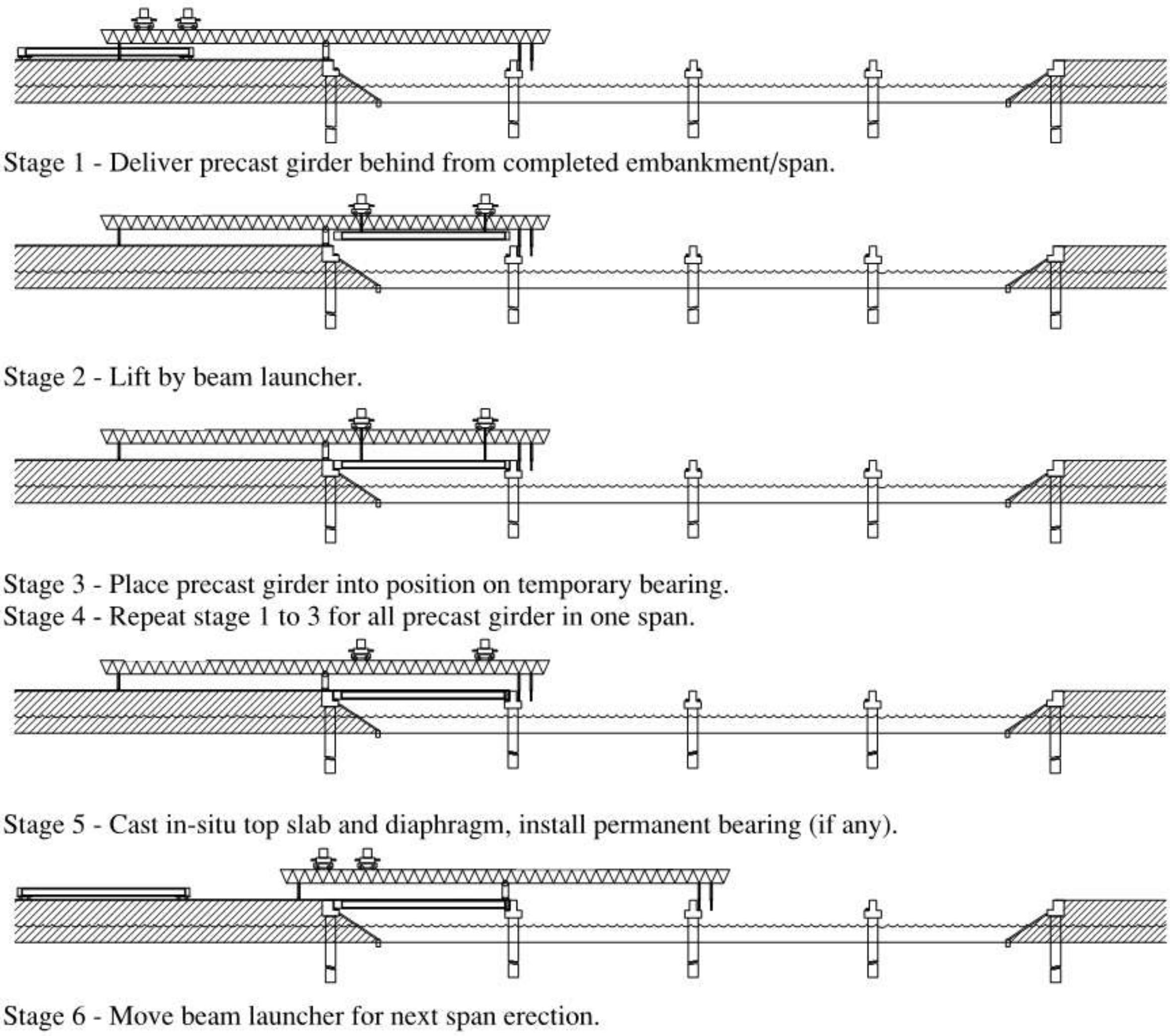


Figure 1- 88 Construction Method of Embankment Viaduct

1.5.1.2 Embankment

The construction methods presented in the following paragraphs are commonly adopted worldwide. Whilst the local contractors can refer to them, these methods are subject to changes in accordance with the availability of construction vessels and plants and the construction practice of the local industry.

1.5.1.2.1 Source of Construction Material

Based on the previous material source exploration in PEA 1991 Feasibility Study of the Laguna De Bay Reclamation Project, it was estimated that around 220 million cubic metres of sand and fill materials exist along the identified area, refer to Figure 1- 89 The required total earth fill material for LLRN embankment is around 16 million cubic metres based on current estimation.

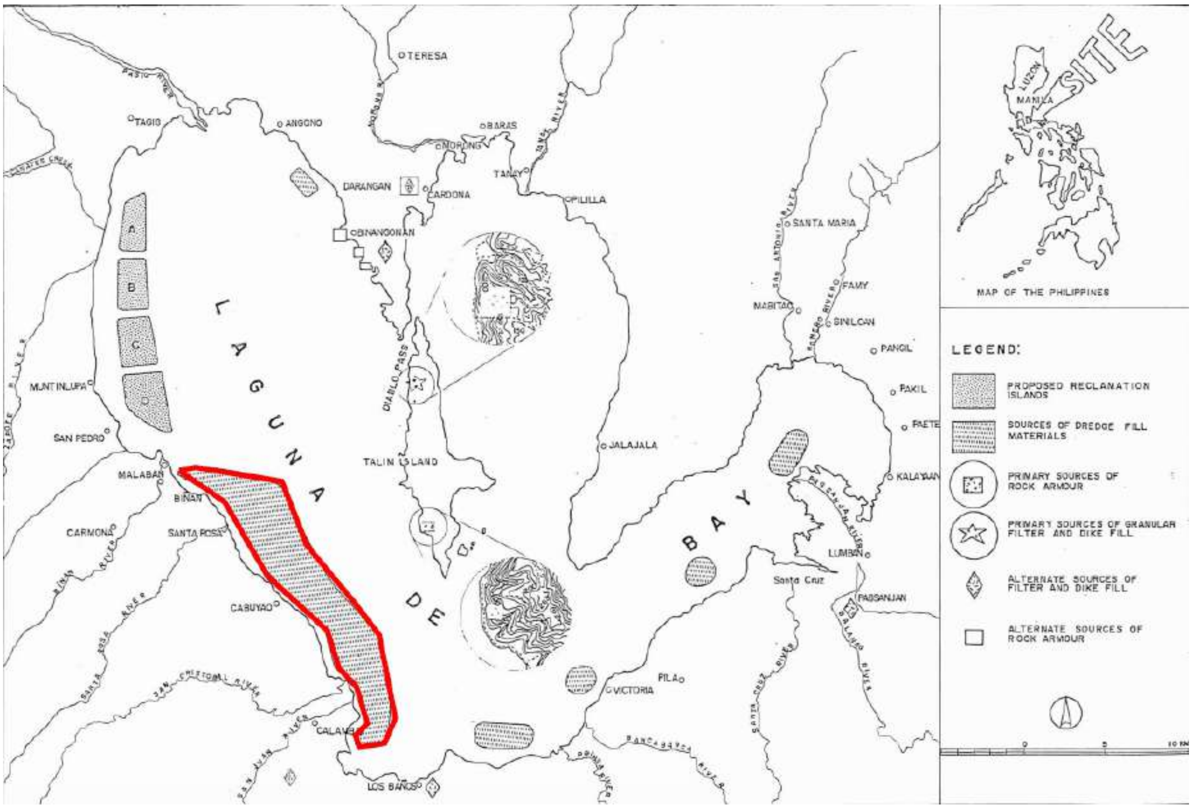


Figure 1- 89 Sources of Dredge Fill and Rockfill Materials (PEA Feasibility Study 1991)

Apart from the fill material from the lake, there are other sources from nearby provinces for materials explored in this study, however the impact on land environment and traffic impact during construction have to be considered. At this stage, using material from the lake is recommended.

1. Pampanga is an alternative source for sand that can be used for backfilling the embankment. It is about 113 km via the NLEX.
2. Tuy and Calatagan, Batangas for aggregates (Fine and Coarse) and boulders produced from basalt quarry and crushing plant. It is about 114 km via Santa Rosa-Tagaytay Road.
3. Ternate, Cavite for aggregates (Fine and Coarse) and boulders produced from basalt quarry and crushing plant. It is about 60 km via Dasmarinas-Carmona Road.
4. Antipolo and Teresa Rizal for aggregates (Fine and Coarse) and boulders produced from basalt quarry and crushing plant. It is about 45 km via the C6 Road.
5. Rodriguez, Rizal for aggregates (Fine and Coarse) and boulders produced from basalt quarry and crushing plant. It is about 50 km via C6 Road.
6. Sariaya, Quezon for aggregates, boulders and armour rocks. It is about 100 km via SLEX.

For base course, sub-base materials, and backfilling materials, the above sources can provide the materials. According to the "CY 2019 UPDATED MATERIALS MAP" published by Department of Public Works and Highways LAGUNA I District Engineering Office on 8th May 2019, three different materials sources within the fourth district of Laguna are identified, and all three available sources are Boulders, Gravel, Sand and Ready-Mix Concrete. The sources' location and site view are shown as following **Figure 1- 90** to **Figure 1- 93.**

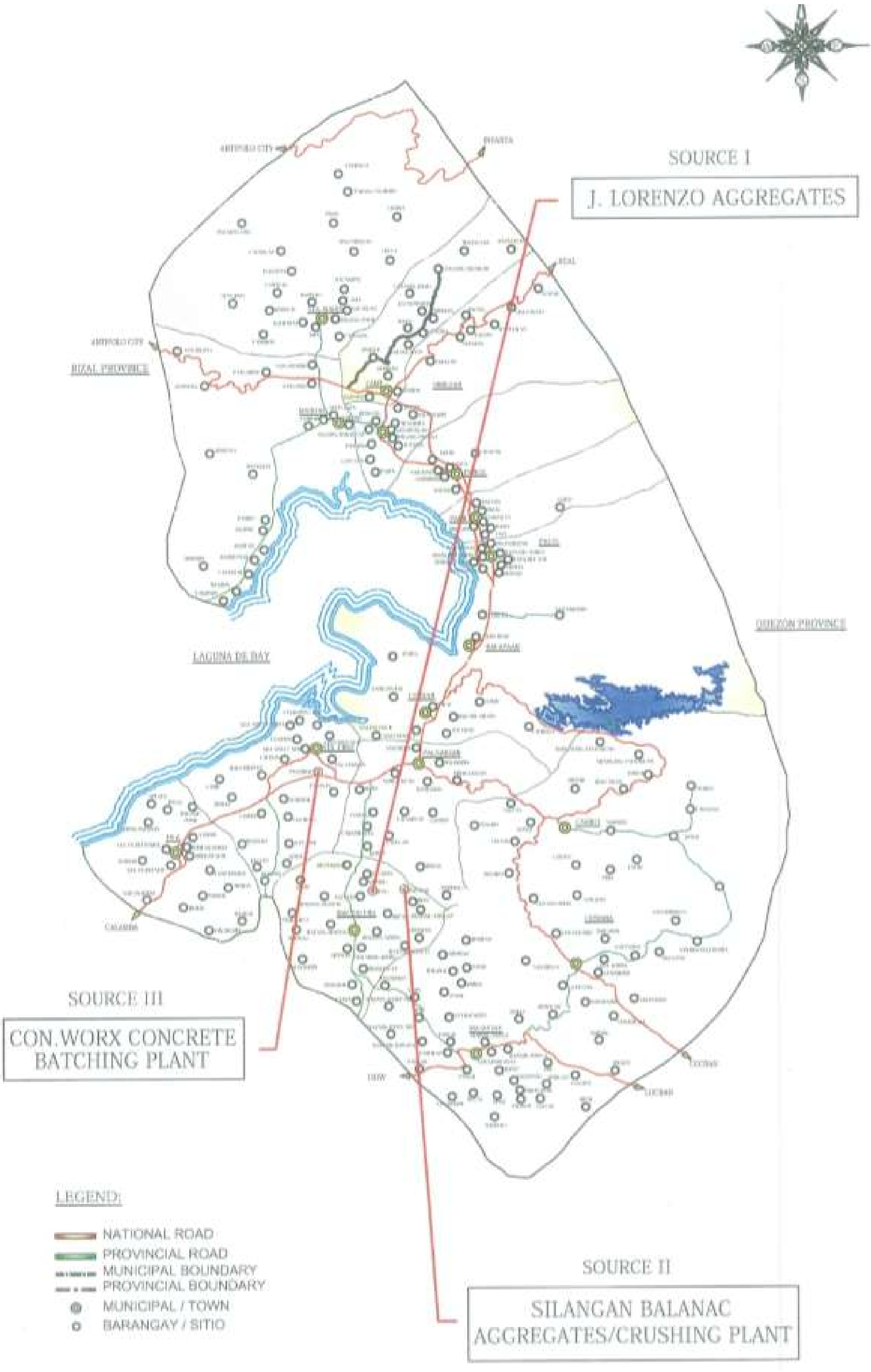


Figure 1- 90 Materials Source Location Map

NAME: J. LORENZO AGGREGATES
Location: Km 89+283 National Road, 4.2Km. Leading to Provincial Road, Right & 2.3 km access road. Brgy. Ilog, Magdalena, Laguna.
Kind of Materials Available: Boulders, Gravel & Sand.
Available: G-1, 20-30 cu.m. /day
3/4, 20-30 cu.m. /day
S-1, 40-50 cu.m. /day
Uses: Borrow Fill, Item 200, 201, 300, 311, 505 & 506

Figure 1- 91 Sources I Site View

NAME: SILANGAN BALANAC AGGREGATES/CRUSHING PLANT
Location: : Km 90+300 National Road, 4.9 Km. leading to Provincial Road, Right & 350m access road. Brgy. Balanac, Magdalena, Laguna.
Kind of Materials Available: Boulders, Gravel & Sand.
Available: G-1, 50-60 cu.m. /day
3/4, 50-60 cu.m. /day
S-1, 40-50 cu.m. /day
Uses: Borrow Fill, Item 200, 201, 300, 311, 505 & 506

Figure 1- 92 Sources II Site View

NAME: CON.WORX CONCRETE BATCHING PLANT
Location: Km 86, National Highway, Brgy. Patimbao, Sta. Cruz, Laguna.
Kind of Materials Available: Ready Mix Concrete
Production Output: 75 cu.m. /day
Source of Raw Materials: Holcim Aggregates
Accreditation: DPWH-BRS Accredited

Figure 1-93 Sources III Site View

Based on the identified available sources, the embankment fill materials would comply with the embankment design and construction requirement.

1.5.1.2.2 Stone Column Construction

Stone column is proposed to be installed in potential liquefaction zone to mitigate soil liquefaction issue during earthquake events. Stone column can also help increase the bearing capacity and reduce the ground settlement.

The 2m thick loose sandy silt at the top portion of the seabed should be dredged and replaced with qualified rock fill (gravel) blanket prior to install the stone column. The offshore bottom-feed method could be adopted for the stone column installation. A barge or a pontoon is used to serve as a working platform on which a crawler crane of sufficient capacity is mounted to support the custom built vibro string assembly. Positioning of the stone column is often done with the assistance of a global positioning system. Penetration to the required depth below seabed level is assisted by the combined action of vibrations and compressed air. Stone is fed to the vibrator either using a long arm excavator or other stone transport systems. A schematic diagram of a typical set-up for the offshore stone column installation and some typical barges are shown in **Figure 1-94.**

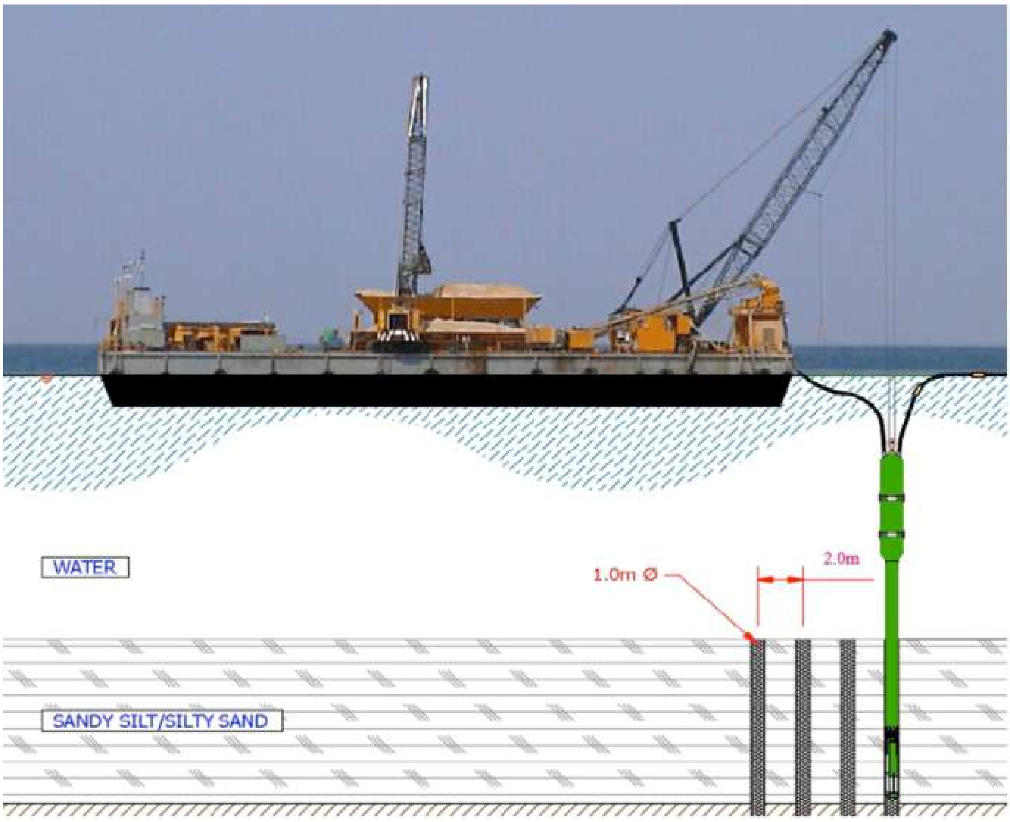


Figure 1- 94 Stone Column Construction

Figure 1- 95 Stone Column Installation

1.5.1.2.3 Construction of Embankment

On top of the fill blanket, geotextile should be laid prior to building up the embankment. Staged construction should be adopted to raise the embankment. The conventionally compacted thickness for each filling layer is various. The layer thicknesses are dependent on the maximum particle size of the embankment material and the efficiency of the compaction equipment. The next layer should not commence unless the required compaction of existing layer of fill is achieved. In case of raising the embankment on a soft soil, the rate of filling is governed by the stability and degree of consolidation which are usually related to observations of excess pore water pressures in the ground.

In general, fill material should be placed systematically and in uniform layers to the correct width and side-slopes. Care is required to ensure that the material is placed correctly to avoid loose, uncompacted edges, clue either to blading off surplus material, or to the addition of material due to insufficient width.

Geotextile tubes should be used to facilitate the construction of the embankment. By placing them at the toe of the embankment, they can serve as a protection against erosion. The rock armour protection facing shall be built up in layers ahead of each layer of filling.

Figure 1- 96 Placement of Geotextile Tube

1.5.1.2.4 Vessel Navigation

Water access is essential for the proposed construction methods and the site location presents several logistical constraints for consideration to make marine-based construction viable. Typical work vessel types for reclamation or embankment construction include:

- Flat-top barge
- Crane barge
- Hopper barge
- Tugs (for unpowered barges)
- Motorboat / Launch
- Specialised Dredger

Upon tender award, work vessels must be mobilised from supplier storage/berths, likely sourced elsewhere in the Philippines or internationally. External water routes to the site are therefore limited to Pasig River, which runs from Manila Bay to the north-western tip of Laguna Lake. Any marine navigation, self-propelled or towed, through Pasig River presents the first constraint: all transiting vessels must fit through inland waterways and structures and comply with local navigation practices. The vessels' water draft, air draft and beam should have sufficient clearance from the riverbed, bridge deck and piers, respectively.

Within the project site, work vessels should be able to deploy and operate across the many work-fronts. During this stage, vessels may be heavily laden with dredged soils or construction fill materials for transport across the site. Further dredging works may be needed to maintain a navigation channel for these vessels with sufficient depth clearance. Alternatively, the laden draft of vessels may be tightly controlled to avoid the additional dredging.

In view of the constraints for mobilising and operating in Laguna Lake, it is recommended that non-specialised, shallow-drafted, or draft-controlled work vessels should be procured to carry out construction of the LLRN. It is possible that specialised plant may be brought via overland routes and then loaded onto general work barges; supporting infrastructure may need to be constructed, such as a temporary causeway. Loaded vessels may also need to limit quantities of cargo in their holds to successfully navigate through un-dredged shallow water areas and maintain stability during construction, particularly with lifting works.

1.5.2 Pollution Control and Waste Management

The project will require contractors to implement proper solid waste management throughout the development stages of the project to ensure pollution control management of varying types of waste that will be generated especially during the construction phase.

To properly manage domestic waste from workers camp, the contractor should install portable toilets where appropriate and should be regularly cleaned to maintain sanitation at the site. Regular domestic waste generated on site should be collected daily by an accredited waste hauler to ensure cleanliness in the work areas and prevent possible water quality impacts to drainages and the lake.

During construction phase, potential spill and leakage of fuel, petroleum products, lubricants, solvents, and other pollutants related to vehicle and equipment fueling, maintenance, and cleaning may cause water pollution. All construction materials, substances, chemicals, etc. will be properly stored and managed in a secured designated storage area with provision of secondary containment.

Properly designed silt traps will be installed for all nearby water bodies, especially the lake. The waste soil and other debris will be properly handled and disposed on a regular basis. Trainings will be provided to site workers to improve their awareness on proper solid waste management practices.

At the construction stage, all these proposed methodologies shall be monitored. A Pollution Control Officer (PCO) during the construction phase shall be appointed by the Contractor. The Contractor shall then be required to prepare a Compliance Monitoring Report (CMR) indicating the status of implementation of the Environmental Management Plan (EMP) and the compliance of the project with the Environmental Compliance Certificate (ECC) (if issued). The CMR shall be prepared and submitted on the required timeframe to DENR-EMB.

1.5.3 Operation and Maintenance

The design of the structures will be in accordance with the Design Standard guidelines of DPWH and other specifications of the project, where necessary. These design standards contain principles and requirements for safety, serviceability, and durability. It assumes that maintenance activities are performed during the working life of the structures in order to enable them to fulfil the requirements for reliability.

In order to preserve the intended reliability of the structures there is an absolute requirement for ongoing inspection and maintenance. Replacement or repair of certain components shall be carried out as necessary to ensure that the reliability of the structures is not reduced during the intended service life.

Depending on the frequency of the scheduled maintenance activities, they may be classified as routine, periodic or annual maintenance activities. Examples of these activities include -

1. Routine Maintenance Activities
   - Pothole patching, sealing of cracks on pavement
   - Grading and patching of shoulders
   - Drainage cleaning and clearing
   - Roadside and future maintenance; vegetation control, road signs and guardrail cleaning and repainting; and maintenance of other street furniture
   - Road marking maintenance
   - Viaduct maintenance, structure inspection
2. Periodic Maintenance Activities
   - Resealing of pavement
   - Re-gravelling of shoulders
   - Viaduct parapet repairs
3. Annual Preventive Maintenance Activities
   - Annual asphalt concrete overlays
   - Sectional replacement of Portland Cement Concrete pavement and road markings.

While the final selection of the maintenance party is subject to the overall resources planning of DPWH at the time of project completion, when applying for funds through the General Appropriation Act for the maintenance activities, two categories of funds may be considered.

a. **Preventive Maintenance** – this involves implementation of annual preventive maintenance program for the National Road System (NRS) to ensure that the roads under the NRS would remain in good condition. With the funding, the DPWH may undertake the maintenance works by the Central Office or Regional Offices.

b. **Long Term Performance Based Maintenance (LTPBM)** – this subcomponent aims to test the performance of multi-year contracts including routine, periodic and preventive maintenance activities. Payment under the LTPBM contracts will be based on outcomes such that whatever the contractor is expected to perform must meet the established standard (minimum service level). In this case, a private company will be engaged through contracts to perform the services.

Even though the private sector may demand a larger profit margin as they perform the tasks, it is expected that this increase in costs will be offset by the higher efficiency of the works. The cost implication of the choice of maintenance party is expected to be minimal and our projection therefore do not distinguish the different scenarios. The final arrangement is subject to further coordination and discussion during the DED stage.

1.6 Project Size

The project is a road network with two lanes on each direction along the mainline except for the section between Sucat and Sta. Rosa with three-lanes on each direction. Each lane is 3.35m wide with 2.5m far side shoulder with 3.5m-wide cycle track and sidewalk on the lakeside for certain sections. The total mainline length is 37.6km which is divided into two sections - Section 1 with a Viaduct of about 11.8km and Section 2 with shoreline viaduct and embankment of about 25.8km. It has a total of eight (8) interchanges with slip roads of about 7.3 kilometers - (1) Lower Bicutan, (2) Sucat, (3) Alabang, (4) Tunasan, (5) San Pedro/ Biñan, (6) Santa Rosa, (7) Cabuyao, and (8) Calamba. The road network will require a total land area of 210,994.38 m^2 and affect a total fish cage area of 837,400.00 m^2.

1.7 Development Plan, Description of Project Phases and Corresponding Timeframes

The project components will be implemented according to the Department of Public Works and Highways (DPWH) Standard Specifications, Volume II: Highways, Bridges and Airport (the Blue Book) 2004 edition. This will be supplemented with additional project-specific specifications, where necessary.

1.7.1 Project Phases

Major activities that will be carried out in the pre-construction and operation phase are summarized in **Table 1.26**. A brief description of specific activities and the potential environmental impacts associated with the works are also in the table below.

Table 1.26 Summary of Major Project Activities

Major Activities	Description	Potential Environmental Impact
Pre-construction		
Site Preparation	This includes site preparatory activities such as land clearing and/ or tree cutting activities.	Generation of waste and hazardous materials may lead to spillages. Loss of vegetation, disturbance to biodiversity, may trigger soil erosion, and induce landslides
Ground Preparation and Earthworks	Activities may include excavation for foundations; cut and fill; levelling and	Generation of noise and air pollutants, ground shaking

Major Activities	Description	Potential Environmental Impact
	compaction, and other engineering works	
Major Activities	Description	Potential Environmental Impact
Land and ROW Acquisition for Project-Affected-Persons (PAPs)	Land acquisition activities include stakeholder engagements and corresponding social activities to acquire necessary permits/ documents pertaining to land ownership.	Displacement of people and loss of livelihood
Construction		
Transport of Materials	This involves mobilization of construction vehicles (i.e. trucks and vessels) and heavy equipment for hauling and transport of materials.	Noise and air pollutant generation, traffic congestion Lake pollutant generation
Construction of Temporary Facilities	These are facilities in the construction site that are built temporarily such as housing for workers, construction offices, storage facilities, etc.	Noise and air pollutant generation, ground shaking, domestic solid wastes and wastewater accumulation, disturbance to sensitive receptors
Dredging and Excavation	Dredging and excavation involve removal of silt, sediments, and other materials. Soil will be removed to a required depth in which the foundation of the structure will be placed	Noise and air pollutant generation, change in channel beds, disturbance to marine and terrestrial habitats
Operation of Heavy Machineries	Operation of these heavy machineries are for civil works such as the construction of casting yard, foundations, bridge and interchanges, and bridge structure	Noise and air pollutant generation, ground shaking, disturbance to marine and terrestrial habitats, domestic solid wastes and wastewater accumulation, disturbance to sensitive receptors

1.7.1.1 Pre-construction/Pre-operational Phase

The pre-construction phase involves planning and conduct of the detailed engineering design for the project components, obtaining ROW and necessary clearances and local permits, pre-qualification of contractors and awarding of contracts, and mobilization for construction.

During the pre-constructional phase, the contractor(s) will mobilize equipment and supplies to the project site, erect temporary facilities for workers and field office, storage sheds and workshops required for the management and supervision of the project. Construction management staff and workers, including local labour, which will include women. Casting yard, which will also serve as a dry dock, will be set up where precast concrete elements such as girders and beams will be casted.

The Road Right-of-Way (RROW) and compensation process will be completed before the start of construction. Affected land and property must be cleared before the start of construction, including properties that should be demolished for the construction of land viaduct, ramps and roundabout junctions. Trees and vegetation areas on the site will be removed at site clearing phase.

Detailed geotechnical and subsurface investigations will be conducted. Ground preparation and earthworks will commence at the pre-construction phase. As the layout of the structure should be already set accurately at this stage, excavation work will begin, where the soil will be removed to a required depth in which the foundation of the structure will be placed. Heavy machineries like boulders, backhoe, shovels, and scooper will be used for earthworks i.e., removing of excessive soil and other material from construction site.

A health and safety management plan will be prepared and implemented to establish protocols and procedures in addressing potential health and safety emergencies (e.g., oil spills).

Construction of temporary facilities will also be built during this stage depending on the number of workers that will be hired and the actual civil works. The acquired land will be utilized for construction of these.

There may be minimal disruption to road users in the vicinity of the project site during the construction phase. Access roads may need to be opened prior to the commencement of construction-related activities. Any required road closures or detours will be clearly marked to ensure that there are no safety risks for road users, and any possible distribution will be minimized.

Following are the clearances, permits and documentations needed:

Table 1.27 Clearances, Permits, and Documentation Requirements

Permits / Clearances	Authorities Involved
Pre-Construction	
Barangay Endorsement to the Project (Certificate of No Objection/ Barangay Resolution)	All concerned barangays
City Endorsement for the Project (Certificate of No Objection/ Board Resolution)	City/ Municipal LGU
Land Use Conversion or Land Use Reclassification (as needed)	City Planning and Development Office/Zoning Board
Area Status and Clearance	Department of Environment and Natural

Permits / Clearances	Authorities Involved
	Resources – Community Environment and Natural Resources Office (DENR-CENRO)
Zoning Certificate (Certificate of Zoning Compliance)	Zoning Division, City LGU
Environmental Compliance Certificate	Department of Environment and Natural Resources – Environmental Management Bureau (DENR-EMB)
Tree Cutting Permit (as needed)	DENR – Provincial and Community Environmental and Natural Resources Office (PENRO and CENRO)1
Authority Over the Land/Waiver of Rights	Lot owner (s)
Proof of Ownership of Land	Registry of Deeds, or depends
Construction Permits (Building & Ancillary Permits (Mechanical, Electrical, Sanitary/ Plumbing, and Electronics)	City/ Municipal Office of the Building Official
Road-right-of way	Department of Public Works and Highways (DPWH)/ Private lot owner
Locational Clearance	City/ Municipal Planning Division Office
Excavation Permit	City/ Municipal LGU
Fire Safety Evaluation Clearance	Bureau of Fire Protection, City/ Municipal LGU
Dumping Permit	City/ Municipal LGU
Occupancy Permit	LGU/ City/ Municipal Office of the Building Official
Fire Safety Inspection Clearance	Bureau of Fire Protection, City/ Municipal LGU
Electrical Connection Agreement	City/ Municipal LGU
Water Permit*	National Water Resources Board (NWRB)
Navigational Clearance*	Philippine Coast Guard
Coastguard Clearance*	Philippine Coast Guard
Certificate of Non-Overlap	NCIP
Certificate of No Objection	LGUs/ Barangays
Construction/ Building Permit	LGUs
CAAP Clearance (as required)	Civil Aviation Authority of the Philippines
BFAR Clearance*	Bureau of Fisheries and Aquatic Resources
Construction	
Registration of Safety Officer	Department of Labor and Employment (DOLE)

Permits / Clearances	Authorities Involved
Environmental registration for managing heads	Department of Environment and Natural Resources – Environmental Management Bureau (DENR-EMB)
Registration for Pollution Control Officer	Department of Environment and Natural Resources – Environmental Management Bureau (DENR-EMB)
Hazardous waste generator ID	Department of Environment and Natural Resources – Environmental Management Bureau (DENR-EMB)
Permit to Transport	Department of Environment and Natural Resources (DENR)
Wastewater discharge permit	Department of Environment and Natural Resources – Environmental Management Bureau (DENR-EMB)
Permit to Operate Generator Sets	Department of Environment and Natural Resources – Environmental Management Bureau (DENR-EMB)

Note: [1]Tree cutting permit should emanate from DPWH to be submitted to the DENR-CENRO. Tree marking of the affected trees should be in coordination with the concerned DENR-CENRO. To expedite this, it is suggested that personnel from the DENR Regional Office Licenses, Patents and Deeds Division (LPDD) should also be present. Replacement seedlings should also be prepared in advance once the affected trees are marked, as may be concurred by the DENR
**With coordination between the Proponent and LLDA*

1.7.1.2 Construction/Development Phase

Provided below are brief discussion of construction methods that the project may employ. The construction methods presented in **Section 1.5.1** are commonly adopted worldwide. Whilst the local contractors can refer to them, these methods are subject to changes in accordance with the availability of construction vessels and plants and the construction practice of the local industry.

The construction or development phase of the LLRN will involve the following activities:

- Dredging for barge access
- Construction of temporary steel deck and piling platform
- Construction of temporary dry working platform
- Installation of pile foundation
- Casting yard preparation
- Excavation activities
- Superstructure construction

1.7.1.2.1 Contract Packaging

It is recommended that the civil works for LLRN divided into four construction packages in order to increase the pool of bidding contractors and hence enhance competition. If the whole link were to be procured as a single construction contract, only joint venture consortia involving very large contractors would be expected to bid. This could result in limited competition and the risk that only one or two large consortia express interests in the project.

As illustrated in **Figure 1-97** , the 37.6 km mainline with eight (8) interchanges that has a total of 7.3 kilometers of slip roads is envisaged to be divided into 4 packages. It is intended that each section will be 1 contract as the construction activities are more or less the same, thus it will be logical to have 4 contracts for the entire project. The final packaging could be further split to control each package cost and size if required, further study could be carried out in Detailed Engineering Design (DED) phase.

- **Package 1** Main Viaduct Contract from Lower Bicutan to Alabang interchange
- **Package 2** Shoreline embankment + Viaduct Contract from Alabang to San Pedro/ Biñan interchange
- **Package 3** Shoreline embankment + Viaduct Contract from San Pedro/ Biñan to Cabuyao interchange
- **Package 4** Shoreline embankment+ Viaduct Contract from Cabuyao to Calamba

Under this arrangement, it is necessary to explore vacant land or form the land for the use of Works Area, fabrication yard and stacking yards for precast segments. They size of the areas will range from 3 to 10 ha each to suit the function. It will be ideal to form the land by reclamation for this purpose in advance contracts.

Part of the recommended strategy for dividing the link into packages is to allow contractors to bid for more than one package, to give the opportunity for contractors to offer discounts due to economies of scale. However, employing different contractors may provide better risk management. Also enabling works and sub-structure contracts could be issue in advance to the superstructure for the tight programme.

The proposed packages and estimated cost as shown below:

Contract Package	Segment	Approx. Mainline Length (km)	Approx. Viaduct Length (km)	Approx. Embankment/At-grade Length (km)
Package 1	Lower Bicutan to Alabang	8.1	6.7	1.4
Contract Package	Segment	Approx. Mainline Length (km)	Approx. Viaduct Length (km)	Approx. Embankment/At-grade Length (km)
Package 2	Alabang to San Pedro	8.5	5.6	2.9
Package 3	San Pedro to Cabuyao	11.8	5.2	6.7
Package 4	Cabuyao to Calamba	9.4	3.6	5.8

Figure 1- 97 Proposed Contract Packages for LLRN

1.7.1.3 Operational Phase

While the final selection of the maintenance party is subject to the overall resources planning of DPWH at the time of project completion, when applying for funds through the General Appropriation Act for the maintenance activities, two categories of funds may be considered.

- **Preventive Maintenance** – this involves implementation of annual preventive maintenance program for the National Road System (NRS) to ensure that the roads under the NRS would remain in good condition. With the funding, the DPWH may undertake the maintenance works by the Central Office or Regional Offices.

- **Long Term Performance Based Maintenance (LTPBM)** – this subcomponent aims to test the performance of multi-year contracts including routine, periodic and preventive maintenance activities. Payment under the LTPBM contracts will be based on outcomes such that whatever the contractor is expected to perform must meet the established standard (minimum service level). In this case, a private company will be engaged through contracts to perform the services.

Even though the private sector may demand a larger profit margin as they perform the tasks, it is expected that this increase in costs will be offset by the higher efficiency of the works. The cost implication of the choice of maintenance party is expected to be minimal and our projection therefore do not distinguish the different scenarios. The final arrangement is subject to further coordination and discussion during the DED stage.

1.7.1.4 Decommissioning Phase

Decommissioning phase will be after the project has ended its operational phase. This will include demobilization of temporary facilities and structures such as accommodation for works, and removal of all equipment. Construction areas will be cleared and cleaned of any construction waste or debris. Demobilization and restoration work will comply with the accepted procedures and standards prescribed in the approved civil works contract, per DPWH standards. DPWH should hire a consultant to prepare a separate comprehensive decommissioning plan and/or rehabilitation management plan (RMP) to address specific issues with regards to the abandonment of the project. This shall be prepared and submitted to DENR for review and approval prior to actual project decommissioning.

1.7.1.5 Project Schedule

The project schedule is shown in **Figure 1-98** below. Project preparation and identification started last 2018, while the Detailed Engineering Design Phase I will commence in 2021. The construction is expected to start by 2022 and end by the year 2026 as of December 2020 updates.

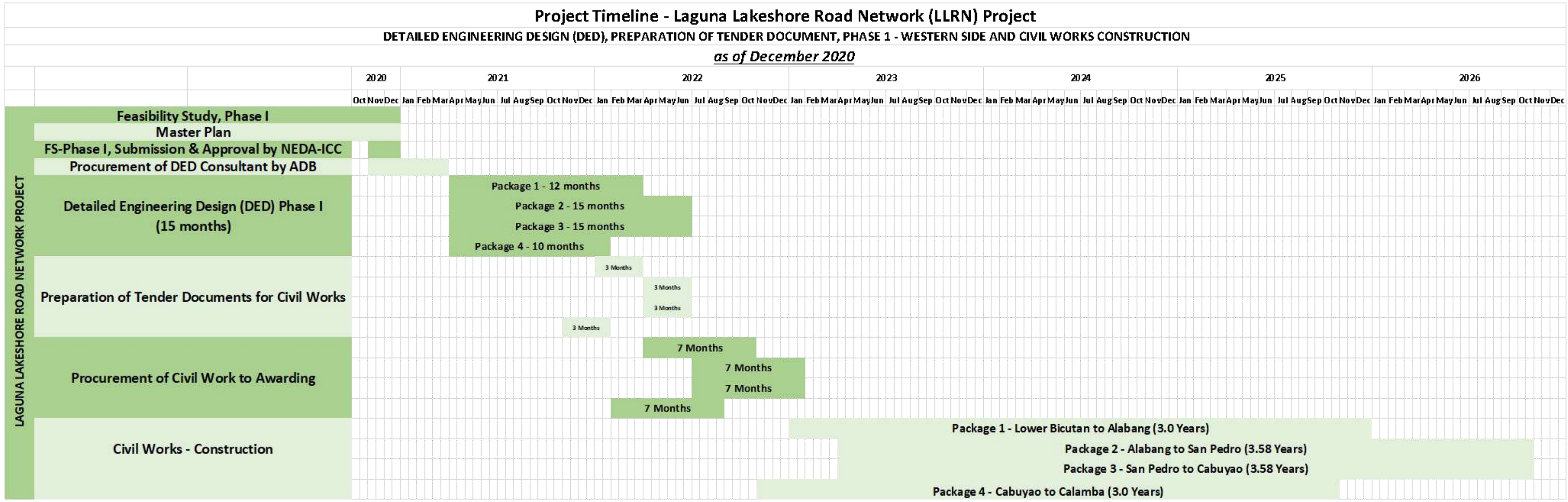


Figure 1-98 LLRN Project Schedule

1.8 Manpower

1.8.1 Preconstruction Phase

The manpower necessary during pre-construction phase are the project proponents, consultants, and sub-consultants of the project. The total estimated manpower for this phase is listed in **Table 1.28**.

1.8.2 Construction Phase

During construction, the work force will consist skilled and unskilled workers for the construction, where hiring of qualified locals is recommended.

A percentage of the construction manpower will be provided by the contractor; hence DPWH will require the contractor to adopt strict policy requiring sourcing workforce from qualified locals and to develop scheme of prioritization in local hiring.

Furthermore, DPWH will strictly enforce RA 6685 in the project. This act requires private contractors to whom the project have been undertaken to hire at least 50% of the qualified unskilled and at least 30% of the qualified skilled workers from the host city or municipality of the project.

Moreover, the contractor is required to apply labour standards and equal pay for work of equal value for both men and women. Equal opportunities will be provided for men and women. A target percentage of female workers will be set on the DED stage of the project.

Lastly, it will be part of the policy of DPWH to hire qualified applicants including persons with disability (PWD), members of indigenous communities, senior citizens, and those any sexual orientation and gender identities (SOGI). These all will be part of the Terms of References (TOR) of the contractor during construction and operations phase.

1.8.3 Operation Phase

For the operations, there will be lesser people hired as compared to the construction phase of the project. The operation phase will need people who will handle the security and passage of vehicles, as well as the maintenance and repair work of the road. DPWH commits to the implementation of an employment protocol, prioritizing locals as a hiring policy.

Table 1.28 Summary of Manpower Requirements for the Project

Project Phase	Estimated Manpower Requirements	Tasks to Perform	Skill Requirement/s
Pre-Construction	< 5% of total workers in construction	Pre-drilling Surveying Ground investigation	General site workers, surveyors, crane/heavy machinery operator etc.
Construction	Approx. 4,000 to 5,000 workers at the peak of a 4-year construction	Site office and precast yard set up Foundation construction – Lake Foundation construction – Land Viaduct construction Embankment construction At grade road construction	Earth filling and compaction for embankment, Concreting, formwork/falsework erection, reinforcement fixer, crane/heavy machinery operator, welders, truck/lorry drivers, general site workers, surveyors, precast factory workers etc.
Operations Phase	40-60 worker/officer	Security Operation Maintenance and repair Inspection	Inspectors, security officer, technicians for repair and maintenance,

Note: Subject to further refinement during DED stage.

1.9 Indicative Project Investment Cost

The civil works of the project will cost approximately **PhP 123,776.52 Million**, while the estimated total cost of the proposed LLRN project including DED and GI is **PhP 177,856.10 Million**.

2 Assessment of Environmental Impacts

This Chapter presents the initial assessment findings of potential environmental and social impacts of project activities to land, air, water, and people of the proposed Laguna Lakeshore Road Network Project (LLRN). Methodologies employed for each component are discussed in each subsection. Key findings on the baseline environmental conditions will be presented, followed by the perceived significant impacts identified for each component with corresponding proposed mitigation measures. The coverage of the study includes the environmental and social constraints for the whole stretch of the current alignment scheme of the project. This chapter will be updated as the impact assessment studies are still ongoing for each environmental component.

2.1 The Land

The area of study is bounded between two regions: The National Capital Region (NCR) and Region IV-A (R4A) or the CALABARZON (Cavite, Laguna, Batangas, Rizal and Quezon) Region. This covers the cities of Taguig and Muntinlupa for NCR and San Pedro, Biñan, Sta Rosa, Cabuyao and Calamba in the Province of Laguna, Region IVA.

Figure 2- 1 LLRN Alignment

The LLRN alignment has a 37.6 km length with eight (8) interchanges that has a total of about 7.3 km of slip roads and has been designed considering various challenges, and discussions were carried out with various stakeholders such as the LGUs, LLDA, DENR, NHA, DHSUD, DPWH, the private sector, etc.

2.1.1 Land Use and Classification

2.1.1.1 Methodology

Land use and classification included reviews of the available and recent Comprehensive Land Use Plans of the Cities of Taguig, Muntinlupa, San Pedro, Biñan, Santa Rosa, Cabuyao, and Calamba. Since the project's major components will be built along the shoreline of Laguna Lake, the study also included a review of the Laguna de Bay Basin Master Plan. The impacts assessed are on compatibility of the proposed project vis-à-vis the existing, proposed land use and classification.

2.1.1.2 Baseline Environmental Conditions

The proposed LLRN Right-of-Way (ROW) will directly traverse portions of 2 cities in the National Capital Region: Taguig and Muntinlupa; and 5 cities in the Province of Laguna (Region IVA): San Pedro, Biñan, Santa Rosa, Cabuyao, and Calamba. A total of 11 Barangays will be directly affected by the alignment. The proponent is working together under a Memorandum of Agreement with the Laguna Lake Development Authority (LLDA) as the responsible government body that is mandated to manage the lake.

Laguna de Bay or Laguna Lake is reported to be the largest inland body of water in the country while it is the 3rd largest freshwater lake in Southeast Asia. The lake has an aggregate surface area of approximately 900 km^2 with highest elevation of 12.50 meters and around 76,000 hectares when it is at its average lowest elevation of 10.50 meters.[17] It has become the catch basin to NCR's population and urbanization which resulted to the lake's increase in levels of agricultural, industrial, and domestic wastewater pollution.

Majority of land on the west shore in proximity to the proposed alignment is urbanized. The covered area of the alignment is mostly composed of mixed land use, comprising of residential (e.g., subdivisions and condominiums), commercial (e.g., restaurants), industrial (e.g., water treatment plants and pumping stations), institutional (e.g., schools and churches) and open spaces (e.g., parks and cemeteries). These developed urban areas have a major influence on the interchanges that will connect the proposed road to the local road network, as the proposed junction with the existing road networks needs to consider the road level differences, utilities, and other critical infrastructure in these urban areas.

Based on the available 2003 existing general land use data in Laguna de Bay basin, land uses vary and can be grouped into the following categories:

Table 2.1 Laguna de Bay Basin Existing Land Use, 2003

Land Use, 2003	Percentage Cover %
Agriculture	20%
Built-up / Urban	23%
Open Space Grassland / Brushland	47%
Forest	10%
Total	**100%**

The Laguna de Bay Basin Master Plan: 2016 and Beyond

For strategies, programs for protection, rehabilitation and enhancement of the environment the lake's natural resources, the Laguna de Bay Master Plan (LBMP) was formulated in 1995. This plan has been revisited by the Laguna Lake Development Authority (LLDA) in 2011

[17] Laguna Lake Development Authority, LLDA website: https://llda.gov.ph/ [Accessed 05 March 2021]

which resulted to the development of the '**Framework for the New Laguna de Bay Master Plan: Laguna de Bay Basin 2020**'. This new plan intends to focus on the following:

- Paradigm enhancement or the strengthening of LLDA's regulatory mandate and intensifying implementation of big-ticket programs and projects to push economic growth and sustainable development;
- Financing new programs/projects following PPP approach to attract private sector participants to join hands with LLDA in developing and implementing PPP programs/projects
- Climate proofing the lake basin against the impacts of climate change. It contains initial strategies to harness the economic potentials of the Basin to ensure sustainable use of the Lake and its resources. It outlines priority environmental and water-related infrastructure projects that can be financed through private-public participation.

Moving forward, with the help of the academe, LLDA prepared the **Spatial Development Master Plan** (SDMP) for the Laguna de Bay Region. It is a development framework consisting of spatial and non-spatial broad-based strategic policy and program directions, anchored on the 1995 LBMP. The SDMP was approved and pursues the following:

- Identify policies that will strengthen the Authority's regulatory mechanism;
- Develop strategies that will implement big-ticket programs and projects identified in the Master Plan for the Laguna de Bay Basin: Land and Lake Water Use and Physical Development Plan;
- Develop policies that will address existing and emerging natural resource challenges and other issues such as climate change, disaster reduction, among others.

With the aim for a more cohesive approach and to harmonize all the past and recent outputs of the plans, LLDA developed the **Laguna de Bay Basin Master Plan: 2016 and Beyond** which aims to integrate basin-scale strategic policies, program/project concepts towards the development of a set of more detailed sub-basin or thematic plans in the coming years. The master plan was developed due to the following main concerns:

- Environment and health risks that are posed to the citizens living in the basin particularly that segment of the population that are highly vulnerable to poor environmental quality;
- Institutional capacity challenges in balancing the wide range of demanding interests from stakeholders; and
- Lack of mechanisms and technology for the development of environmental and water-related environmental programs that are imperative in order for sustainable development to take place.

Moreover, the following issues are the most crucial issues that needs urgency to be addressed:

- Pollution and waste primarily from domestic and agricultural sources
- Multiple and often conflicting water uses
- Vulnerability of lakeshore settlements and developments to flood hazards and related health and economic risks, and indecision over resettlement
- Poorly regulated developments on the shoreland, and critical watersheds inclusive of tenurial constraints, database management and monitoring

- Fragmented utility infrastructure developments, including siting and development regulations of these investments
- Absence of critical collaboration among ENR authorities on highly stressed ecosystems within the lake basin
- Limited financing of conservation and regulatory programs/projects
- Need for lake-sensitive economic opportunities to expand livelihood opportunities

Proposed Medium-Term Development Directions

Listed below are the directions for the Laguna de Bay Development:

- Intensify waste and pollution control towards through adaptive waste management systems primarily for domestic and agricultural sources;
- Rationalize water use zoning to harmonize all uses within the lake including navigation and water-related waste management infrastructure;
- Promote security of lakeshore communities from flooding, health risks and minimize
- Economic displacement through effective flood control programs and appropriate resettlement plans;
- Rationalize watershed and shoreland specific management policies based on validated threshold and vulnerability to sustain their ecological functions focused on incentive-based regulations and adaptive co-management systems;
- Rationalize service and infrastructure-based network support for environmental management and sustainable economic uses of lake basin resources;
- Rationalize ecotourism potential as development driver and promote lake-sensitive eco-tourism developments; and
- Adopt of innovative financing schemes beyond regulatory fee collection maximizing
- Market-based instruments and PPP schemes.

Recommended Long-Term Development Directions

- Improve ecosystem-based performance monitoring and data management;
- Intensify community-based and incentive-focused waste management systems for lakeshore settlements;
- Upgrade quality control for lake water suited as source of freshwater of the region and parts of Metro Manila;
- Promote adaptive co-management systems on critical areas in the shoreland consistent with rationalized water use zoning;
- Create opportunities for sustainable livelihoods through PPP schemes suited for lakeshore and upland communities;
- Intensify development and use regulations for highly extractive economic activities with primary focus on restoration costs;
- Pursue measures that will create buy-in culture for critical environmental protection
- and regulation policies;
- Adopt measures that will create buy-in culture for critical environmental protection and regulation policies;
- Comprehensive and continuing retooling of LLDA personnel; and
- Promote PPP as a means of financing major investment programs and projects.

National Capital Region

Taguig City

Taguig has a total land area of 4,548 ha and is predominantly a residential area with a total of 155.69 ha of residential land areas, while 30.30 ha are used as industrial land, 22.56 ha are used for commercial areas, while there is a remaining 0.20 ha of land used for Agriculture, see **Table 2.2**. The City of Taguig does not have an approved Comprehensive Land Use Plan (CLUP) as of writing, so the existing land use data presented is an extract from the existing CLUP (2005) of the LGU acquired from their City Planning and Development Office in 2020.

Taguig Interchange of the alignment will be built in a portion of Barangay Lower Bicutan. The proposed roundabout connection will be situated at C6 road. The existing Circumferential Road 6 (C6) section at Lower Bicutan was built as a road dike protecting these areas from floods brought about by the increasing water level of Laguna de Bay during the wet season.

Table 2.2 Existing Land Use Intensities per Barangay, Taguig City

Barangay	Area (ha)	Residential	Agricultural	Commercial	Industrial	Total
Bagong Tanyag	217	8.10	-	0.40	0.82	9.32
Bagumbayan	362	13.03	0.06	0.77	18.98	32.83
Bambang	92	1.72	0.03	0.04	0.09	1.88
Calzada Tipas	177	2.37	-	0.12	-	2.49
Hagonoy	162	5.36	0.04	0.59	0.01	6.00
Ibayo-Tipas	156	6.49	0.03	0.36	2.45	9.32
Ligid-Tipas	68	1.87	-	0.22	0.05	2.14
Lower Bicutan	235	18.64	-	2.78	0.12	21.54
Maharlika Village	51	0.59	-	0.01	-	0.60
Napindan	270	2.36	-	0.06	-	2.42
Palingon Tipas	117	2.54	0.02	0.03	-	2.60
Sta. Ana	22	2.59	-	0.06	-	2.65
Signal Village	110	28.91	-	0.91	0.00	29.82
Tuktukan	31	3.44	-	1.45	0.07	4.97

Barangay	Area (ha)	Residential	Agricultural	Commercial	Industrial	Total
Upper Bicutan	144	22.59	-	0.91	0.07	23.57
Ususan	145	7.32	-	0.49	0.48	8.29
Wawa	198	3.92	0.03	0.09	0.06	4.10
Western Bicutan	365	7.99	-	2.07	6.40	16.46
Fort Bonifacio	1,626	15.85	-	0.21	0.70	16.76
Total	**4,548**	**155.69**	**0.20**	**11.56**	**30.30**	**197.75**

Muntinlupa City

Based on the 2014 existing land use distribution of Muntinlupa, residential areas cover the biggest percentage of land with 1,853 ha. Roads and idle lands during this time cover 414 ha and 420 ha, respectively. Idle lands are mostly found in the New Bilibid Prison in Barangay Poblacion and some unoccupied areas in Tunasan. Commercial areas which comprises about 289 ha area are mostly found in Barangays Alabang, Ayala Alabang, Tunasan, and Cupang.

It is expected that since the last updated existing land use of the City, there are already land use shifts and changes with these values. Based on the observed land use trend and pattern in the City, Muntinlupa has been undergoing a significant transition from a bedroom community to a commercial district. The table below presents the existing land use of Muntinlupa City as presented in their 2016-2026 CLUP and shown in the map in **Figure 2-2**. The proposed land use plan for Muntinlupa is shown in **Figure 2-3** and the proposed land use map for each Barangay is also depicted in the following pages.

The interchanges in Muntinlupa City are located in Sucat, Tunasan, and Alabang. The potential impacts of the alignment in these barangays are discussed in the succeeding section.

Table 2.3 Existing Land Use, Muntinlupa City, 2014

Existing Land Use, 2014	Total (Ha)	Percentage %
Residential	1853	46.62%
Idle Lands	420	10.57%
Roads	414	10.44%
Institutional	298	7.48%
Commercial	289	7.27%
Rivers and Creeks	225	5.66%
Industrial	135	3.40%
Informal Settlements	94	2.37%
Parks and Open Spaces	78	1.96%

Socialized Housing	65	1.62%
Cemetery	58	1.45%
Utilities	34	0.85%
Tourism Sites	12	0.31%
Total	**3,795**	**100%**

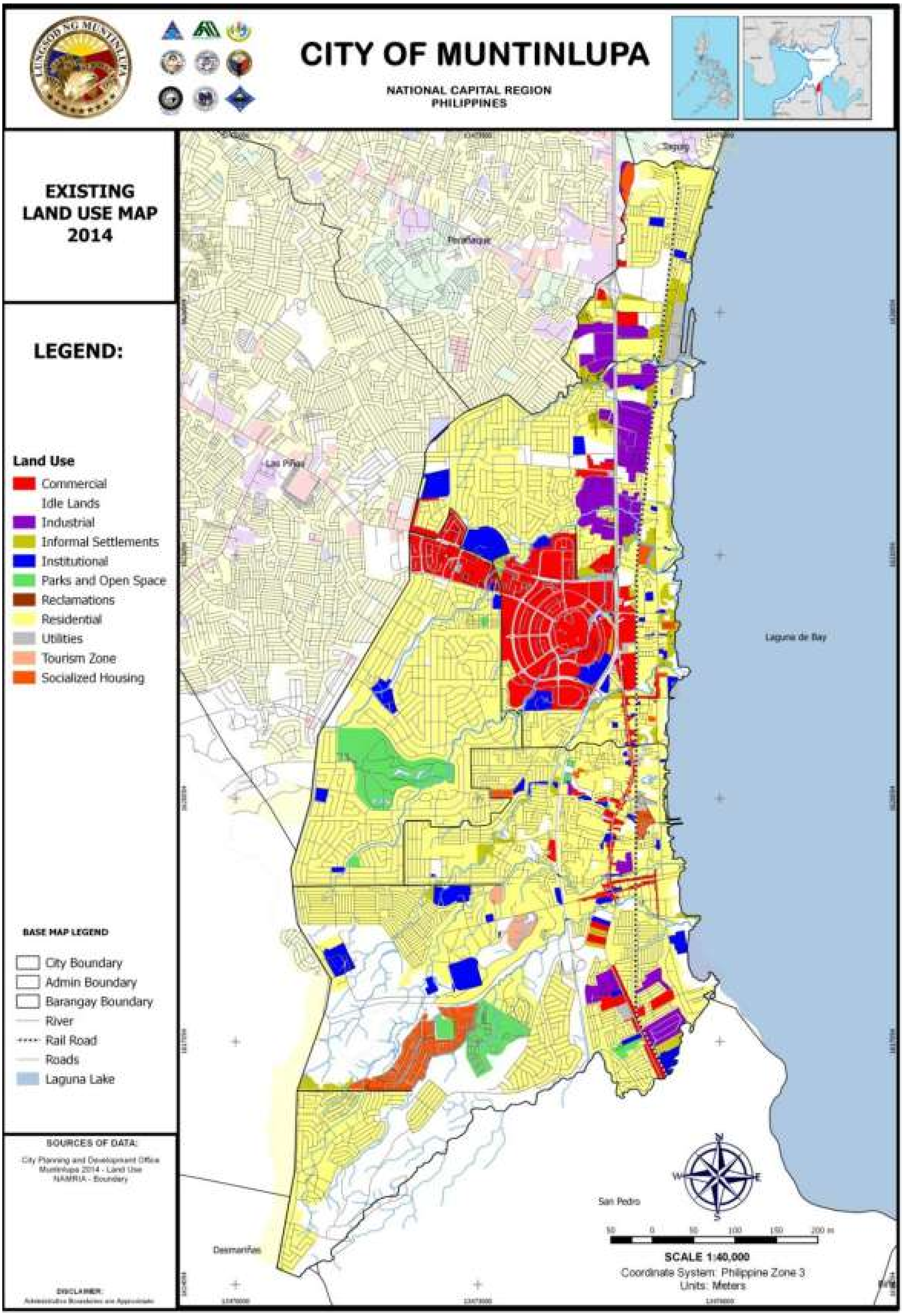


Figure 2- 2 Existing Land Use Map, Muntinlupa City, 2014

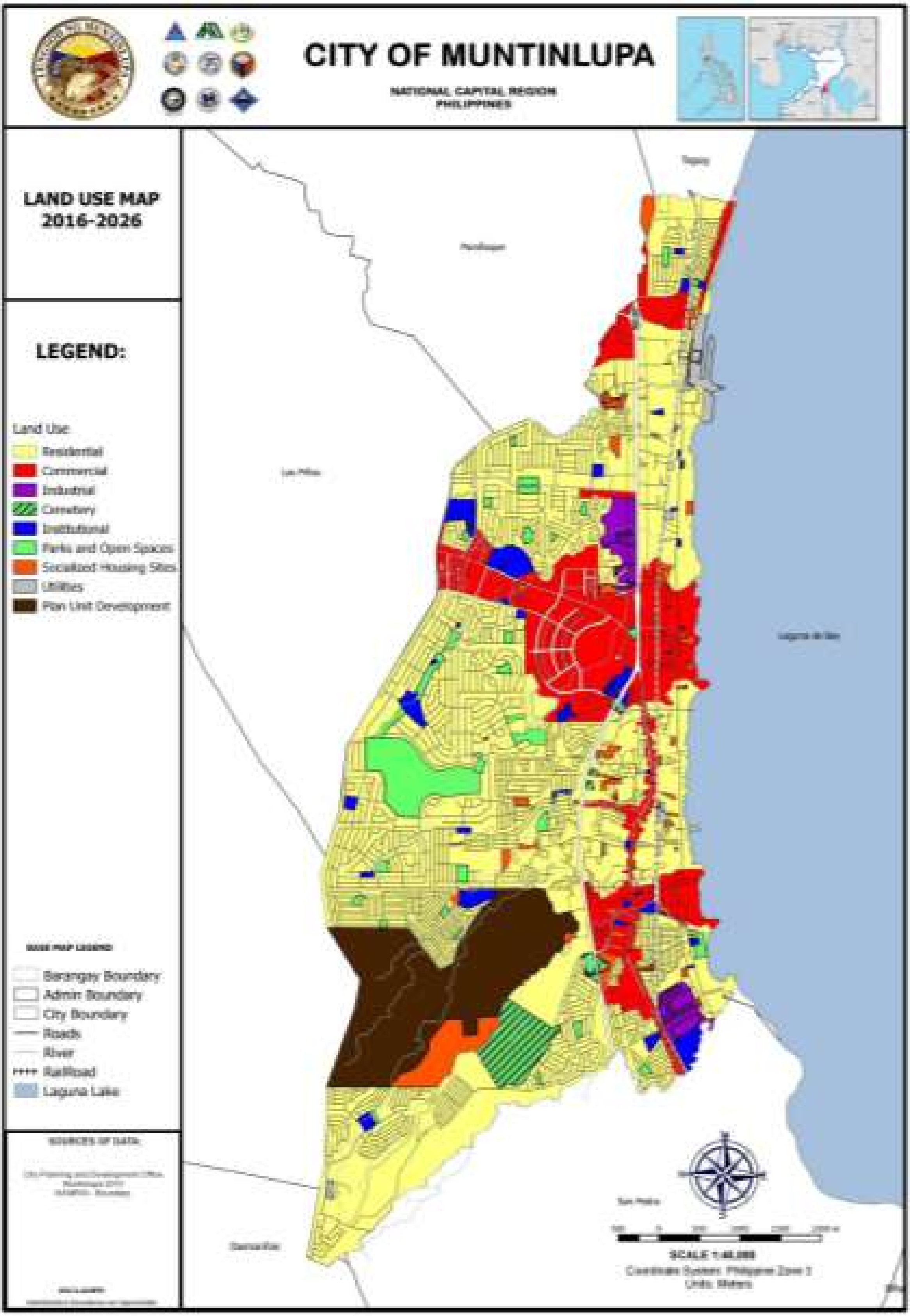


Figure 2- 3 Proposed Land Use, Muntinlupa City, 2016-2026

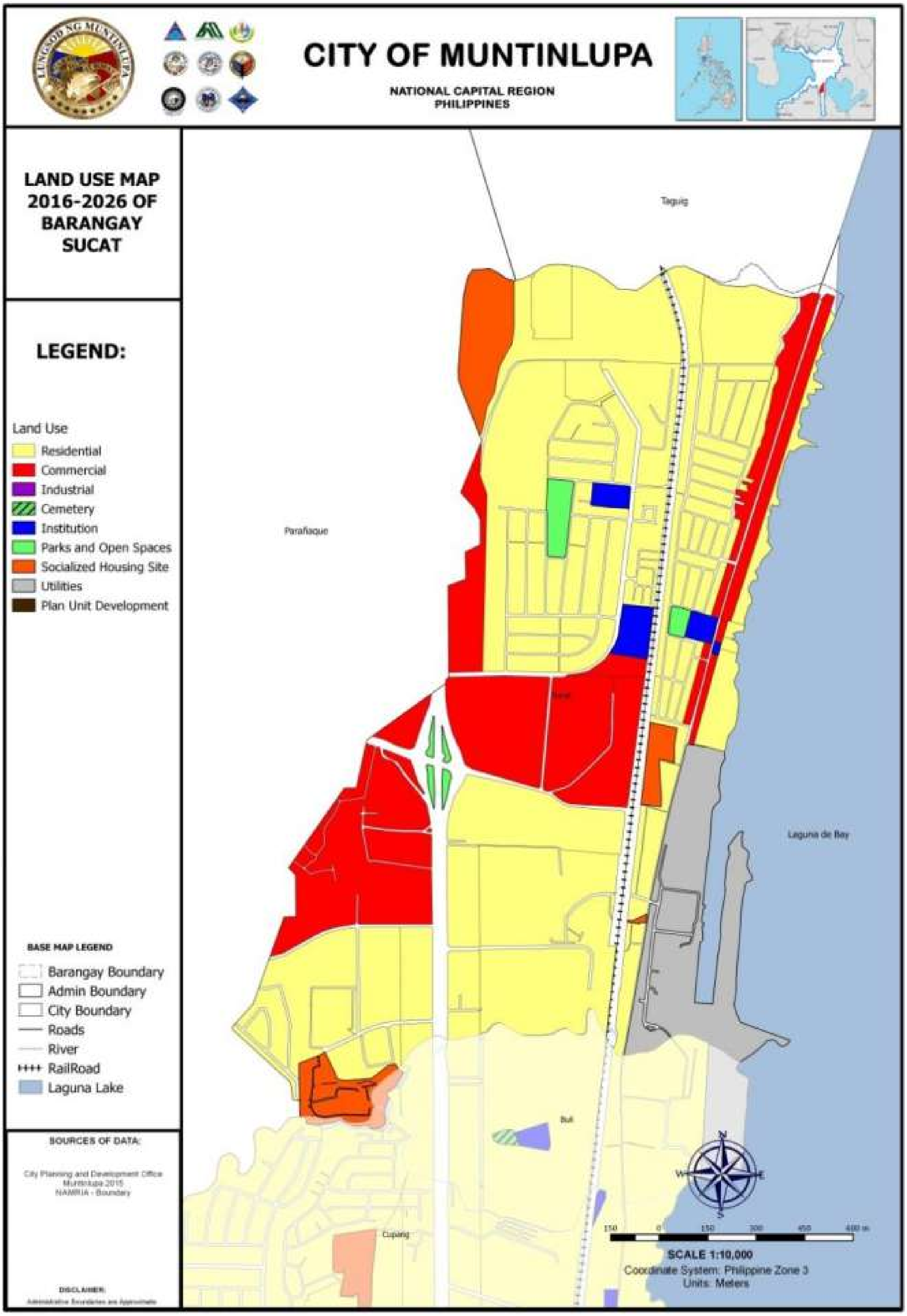


Figure 2- 4 Land Use Plan, Barangay Sucat Muntinlupa City, 2016-2026

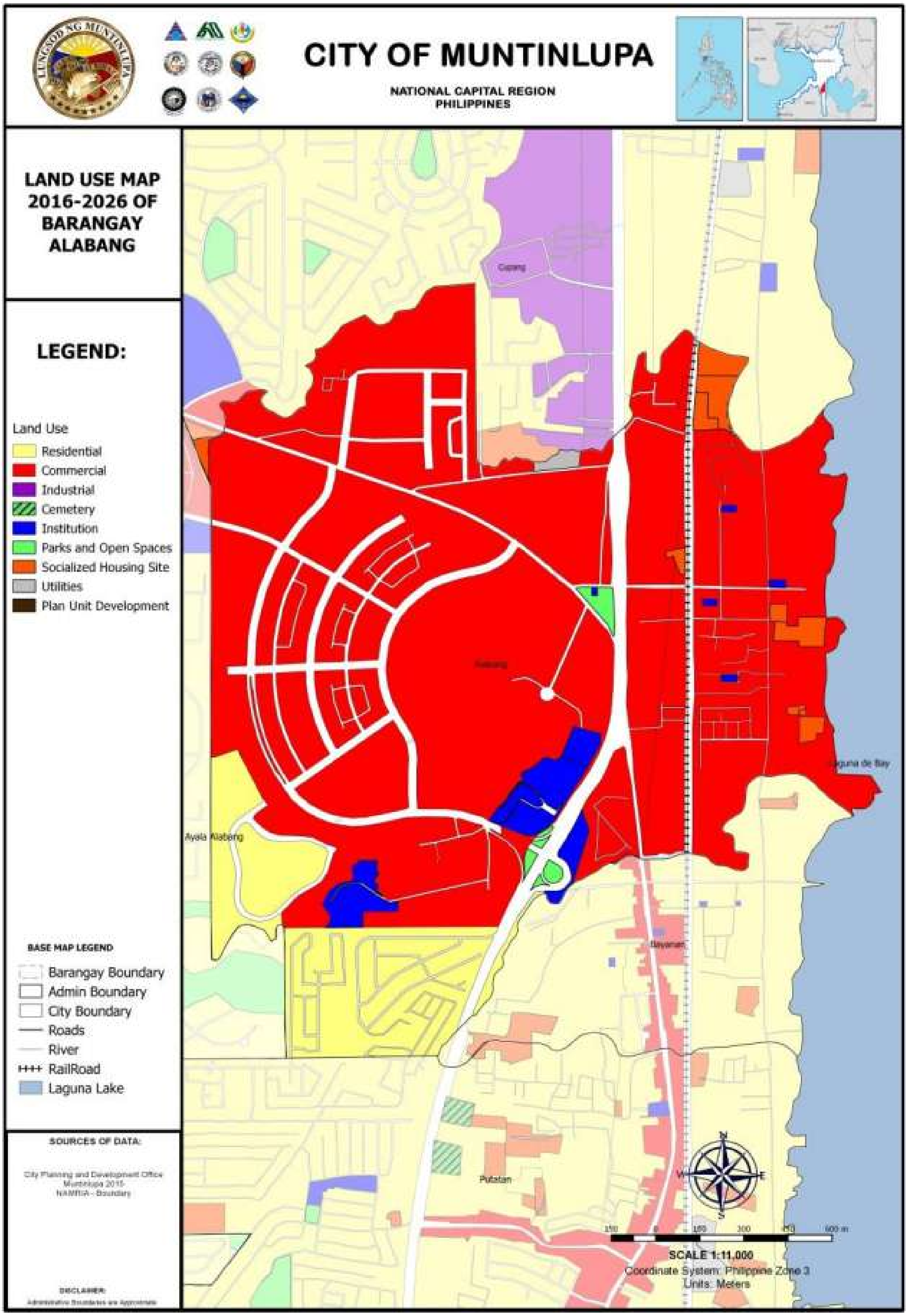


Figure 2- 5 Land Use Plan, Barangay Alabang Muntinlupa City, 2016-2026

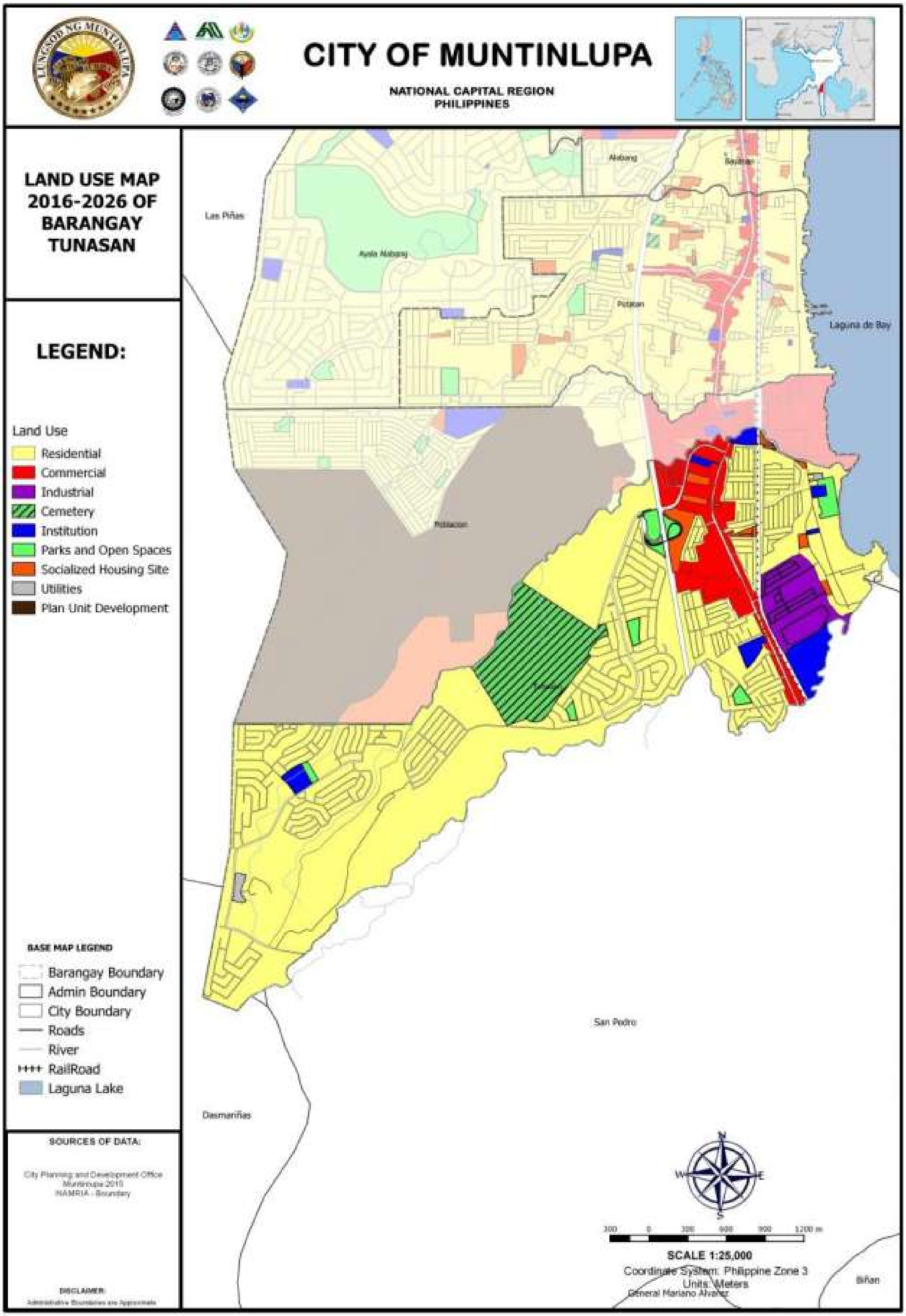


Figure 2- 6 Land Use Plan, Barangay Tunasan Muntinlupa City, 2016-2026

Region IVA – Laguna

San Pedro City

The main and direct alignment of LLRN will pass through a portion of Barangay Landayan in San Pedro City. San Pedro City is located in the Province of Laguna with a total land area of 2,335.69 hectares. The City is known as a dwelling place or dormitory town and most of the economic opportunities are found outside the city. Based on the 2014-2023 CLUP of San Pedro, Residential area covers the largest portion of the land use of the City which totals to 1,276.92 ha.

Commercial areas comprise 113.27 ha of land which are mostly concentrated near the Old National Highway and major roads. This development pattern attracts vehicular traffic along major roads that contributes to the business of the area along the highway.

There are remaining Agricultural areas in San Pedro City is only about 11.62 ha which are used as commercial piggeries, mostly located in Barangay Antonio. It has been reported that surrounding residential communities complain about odours coming from these piggeries. As reported in the CLUP, there are records of backyard farming activities for crops and fruit bearing trees including livestock and poultry raising.

The table below presents the existing land use distribution in San Pedro City. The existing land use map of San Pedro City is shown in **Figure 2- 7** while the proposed land use in shown in **Figure 2- 8**.

Table 2.7 Existing Land Use Distribution, San Pedro City, 2013

Land Use	Existing Land Use (Ha)	Percentage %
Residential	1,276.92	54.67%
Commercial	113.27	4.85%
Institutional	22.35	0.96%
Industrial	152.72	6.54%
Tourism	91.02	3.90%
Agriculture	11.62	0.50%
Cemetery	12.27	0.53%
Idle Land (Open Spaces and Parks)	273.32	11.70%
River	37.84	1.62%
City Road	288.66	2.36%
National Road	11.22	0.48%
National Road/SLEX	23.86	1.02%
PNR ROW	20.62	0.88%
Total Area	**2,335.69**	**100%**

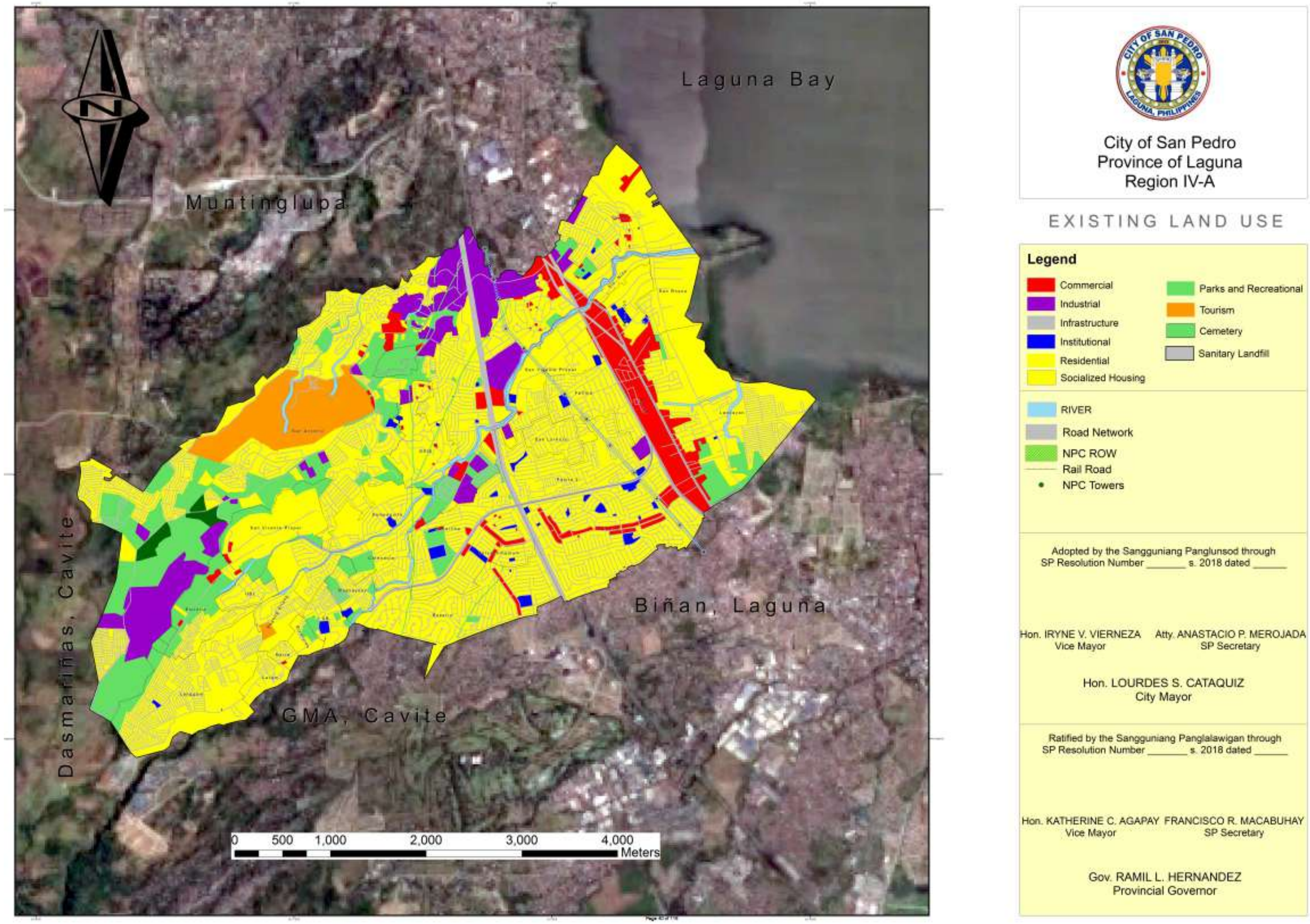


Figure 2- 7 Existing Land Use Map, San Pedro City, 2013

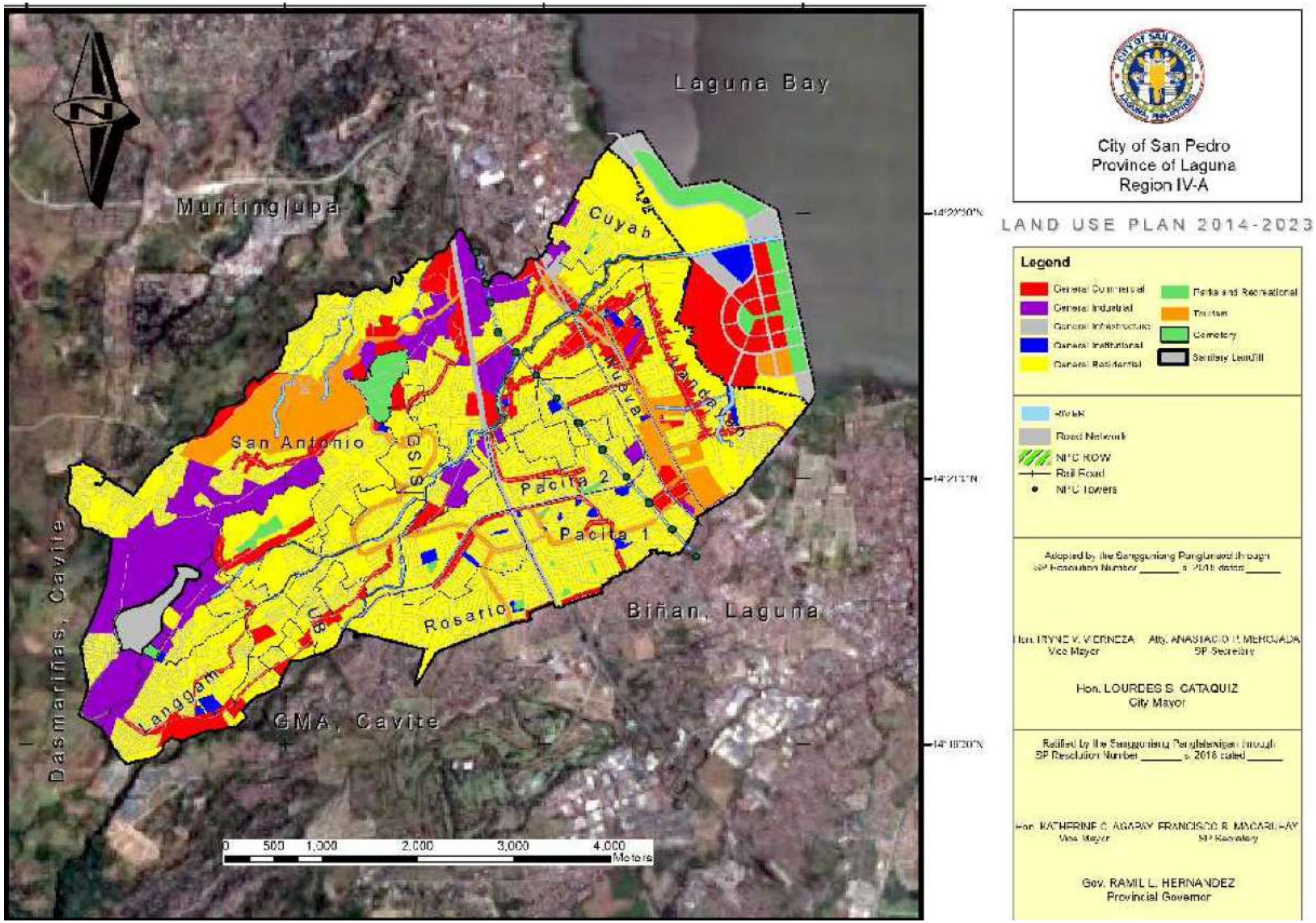


Figure 2- 8 Land Use Plan, San Pedro City, 2014-2023

Biñan City

The proposed project has an interchange in San Pedro/ Biñan which will affect a portion of Barangay Dela Paz. Biñan is one of the smallest cities in Laguna with a land area of approximately 4,350 hectares composed of 24 barangays.

The city has diverse land uses which started to be dominated by agricultural and residential lands many years ago which has now transformed into becoming a growth centre at the Southern portion of Metro Manila. Industrial parks and commercial establishments are growing in numbers which has paved the way to creating a mixed-use type of developments in the city. Dela Paz is one of the Barangays wherein commercial land uses are increasing due to its high accessibility and proximity to national roads.

The Existing Land Use of Biñan City from the 2018-2028 CLUP is shown in the table and figure below. The general land use plan is shown in **Figure 2- 10**.

Table 2.10 Existing General Land Use, Biñan City

Land Use	Existing Land Use (Ha)	Percentage %
Residential	2139.07	49.17%
Commercial	157.15	3.61%
Institutional	88.18	2.03%
Industrial	811.05	18.64%
Agriculture	741.55	0.17%
Mixed-use	46.13	1.06%
Socialize Housing	51.46	1.18%
Parks and Open Spaces	41.12	0.95%
Memorial Parks/Cemeteries	34.94	0.80%
Water Bodies	33.70	0.01%
Idle/Undeveloped	202.65	0.05%
Materials Recovery Facility	3.00	0.07%
Total Area	4350.00	100%

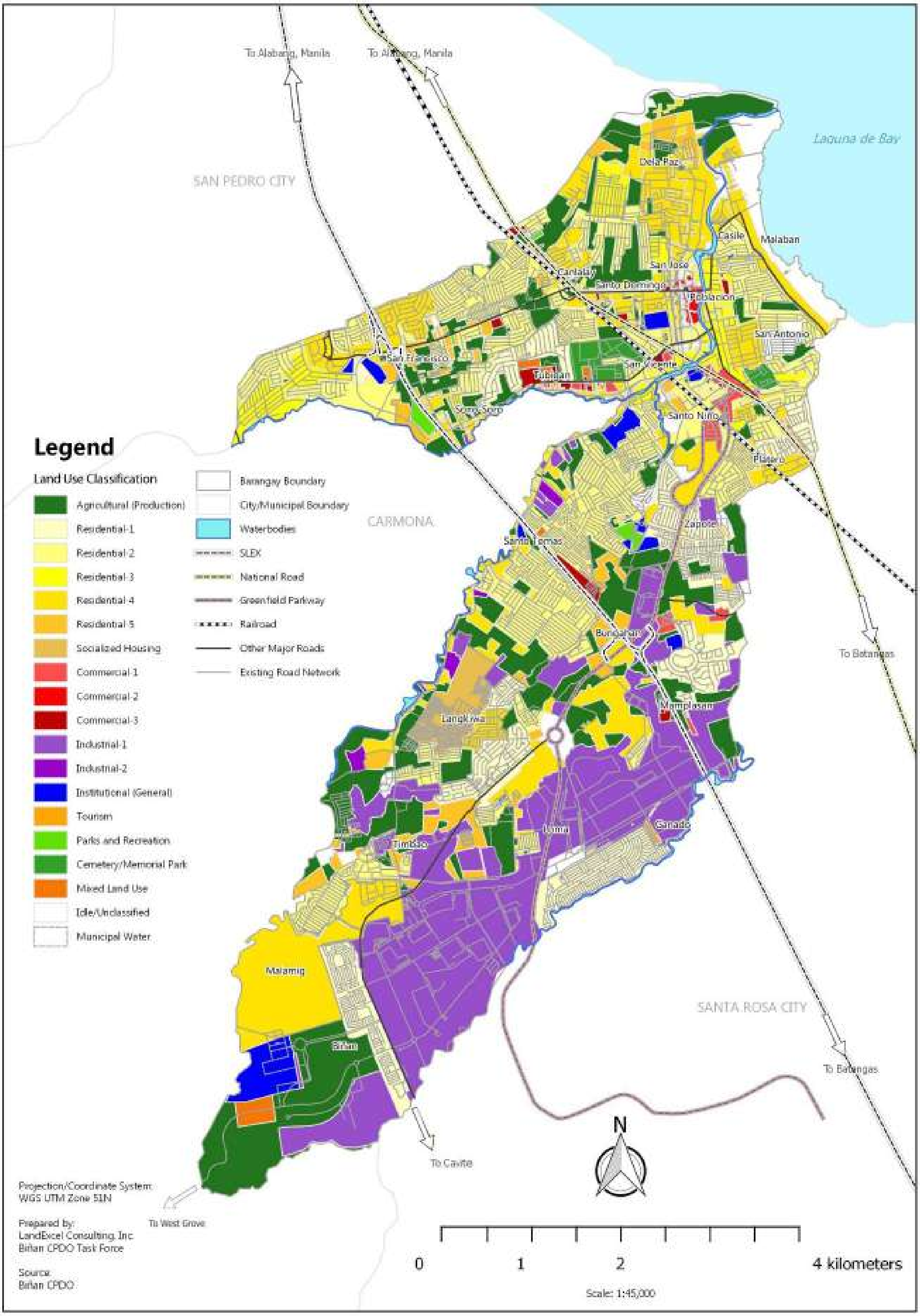


Figure 2- 9 Existing General Land Use Map, Biñan City

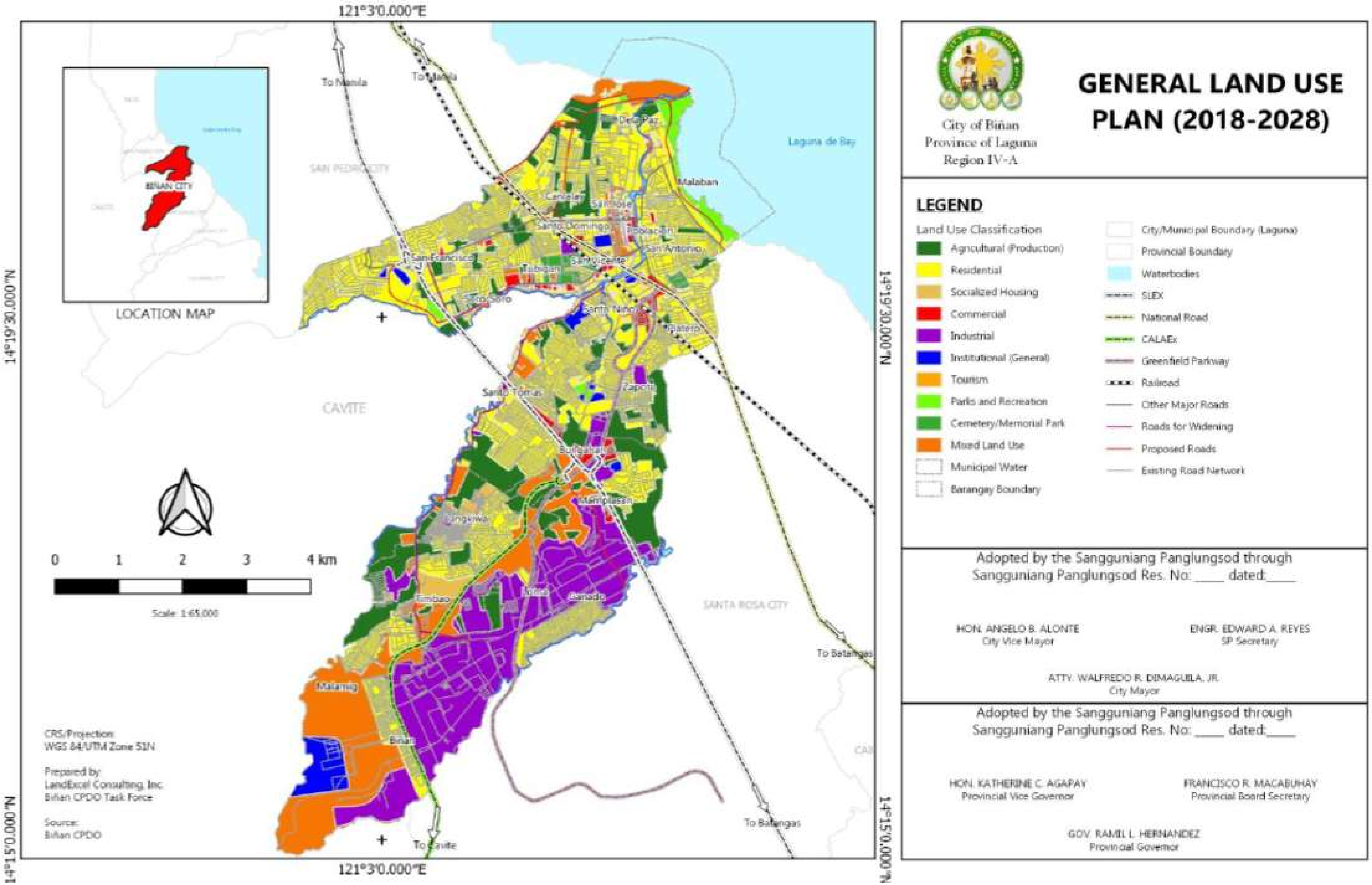


Figure 2- 10 General Land Use Plan, Biñan City, 2018-2028

Santa Rosa City

The LLRN alignment will traverse portions of Barangays Aplaya and Sinalhan in Santa Rosa City. The city is located in the western part of Laguna, 40km South of Metro Manila with a total land area of 5,549 hectares. Residential land use is dominant in the city with combination of low, medium, to high-density housing development. Major roads in Santa Rosa include South Luzon Expressway (SLEX), Old National Highway, Sta. Rosa-Tagaytay Road, San Lorenzo Blvd., Greenfield Parkway, United Blvd. and Nuvali main and spine. Business establishments are mostly concentrated along J.P. Rizal Boulevard, the Old National Road, and the commercial strips along Sta.Rosa – Tagaytay Road below SLEX.

The 2015 Existing Land Use in Santa Rosa City is shown in the table below. Santa Rosa City's existing and proposed land use maps are presented in **Figure 2- 11** and **Figure 2- 12**.

Table 2.4 Existing Land Use, Santa Rosa City, 2015

Land Use	2015 Existing Land Use (Ha)	Percentage %
Residential	2247	40.51%
Commercial	151	2.73%
Institutional	50	0.9%
Industrial	564	10.17%
Agriculture	664	11.97%
Tourism	224	4.03%
Cemetery	30	0.54%
Idle	1361	24.54%
Infrastructure	212	3.83%
Waterways	26	0.47%
Pond	18	0.32%
Total Area	**5549**	**100%**

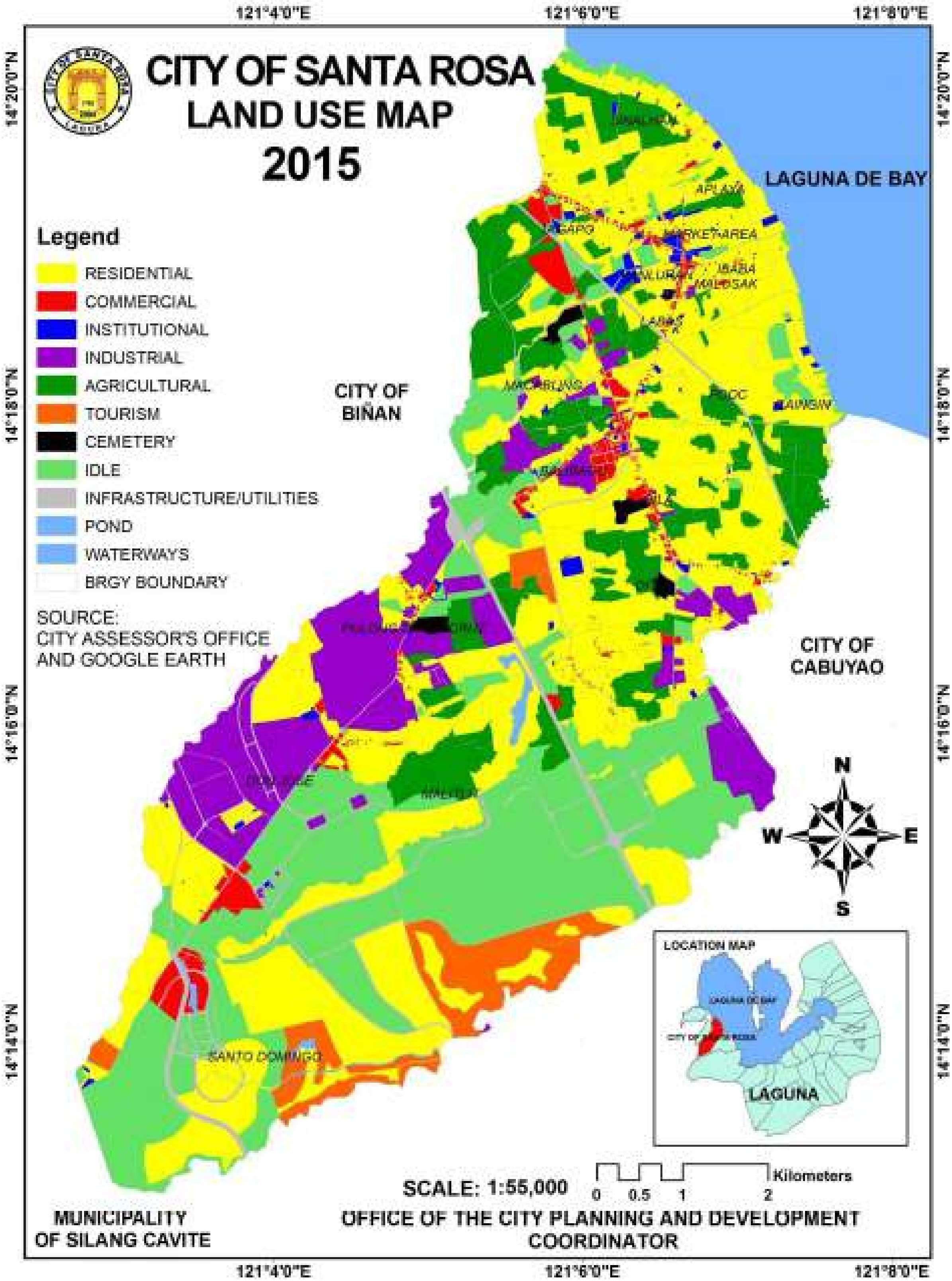


Figure 2- 11 Existing Land Use Map, Santa Rosa City, 2015

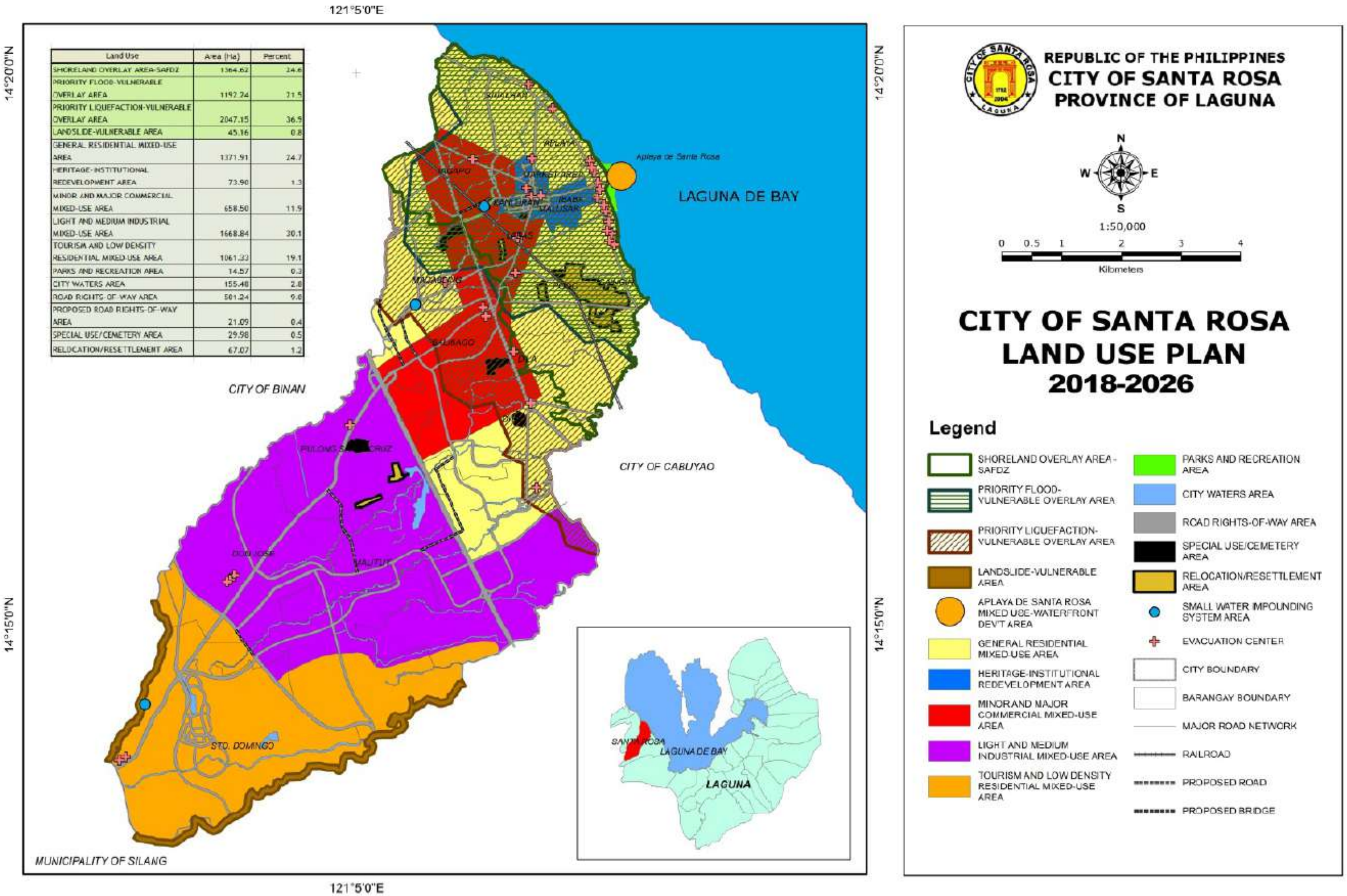


Figure 2- 12 Existing Land Use Map, Santa Rosa City, 2015

Cabuyao City

Cabuyao is a first-class urbanized City in the province of Laguna located at the Southeast of Metro Manila and bounded by Santa Rosa City on the North. Cabuyao is politically subdivided into 18 barangays and the project alignment will cover a portion of Barangay Marinig.

The city has a total land area of 4,330 hectares and land conversion has been observed which is directed towards more of residential areas. In Barangay Marinig, conversion is evident as reported on the CLUP that the previous agricultural areas were already converted to residential areas. Moreover, lakeshore barangays such as Bigaa, Butong, Gulod, and Balaran have shifted from agricultural use to residential use. The 2015 Land Use Distribution of Cabuyao Laguna is shown in the table below.

Table 2.5 Land Use Distribution, Cabuyao City, 2015

Land Use	2015 Existing Land Use (Ha)	Percentage %
Residential	1079.30	24.93%
Institutional	20.54	0.47%
Cemetery	9.66	0.22%
Road	302.09	6.98%
Commercial	55.07	1.27%
Industrial	350.26	8.09%
Waterfront Development Zone	152.49	3.52%
Agricultural	1266.81	29.26%
Strategic Agriculture and Fisheries Development Zone (SAFDZ)	234.45	5.41%
Open Space	859.32	19.85%
Other Uses	-	-
Total Area	**4,330**	**100%**

The 2015 Existing Land Use Map of Cabuyao from the 2016-2026 CLUP of the LGU is shown in **Figure 2- 13** while the proposed land use is depicted in **Figure 2- 14**.

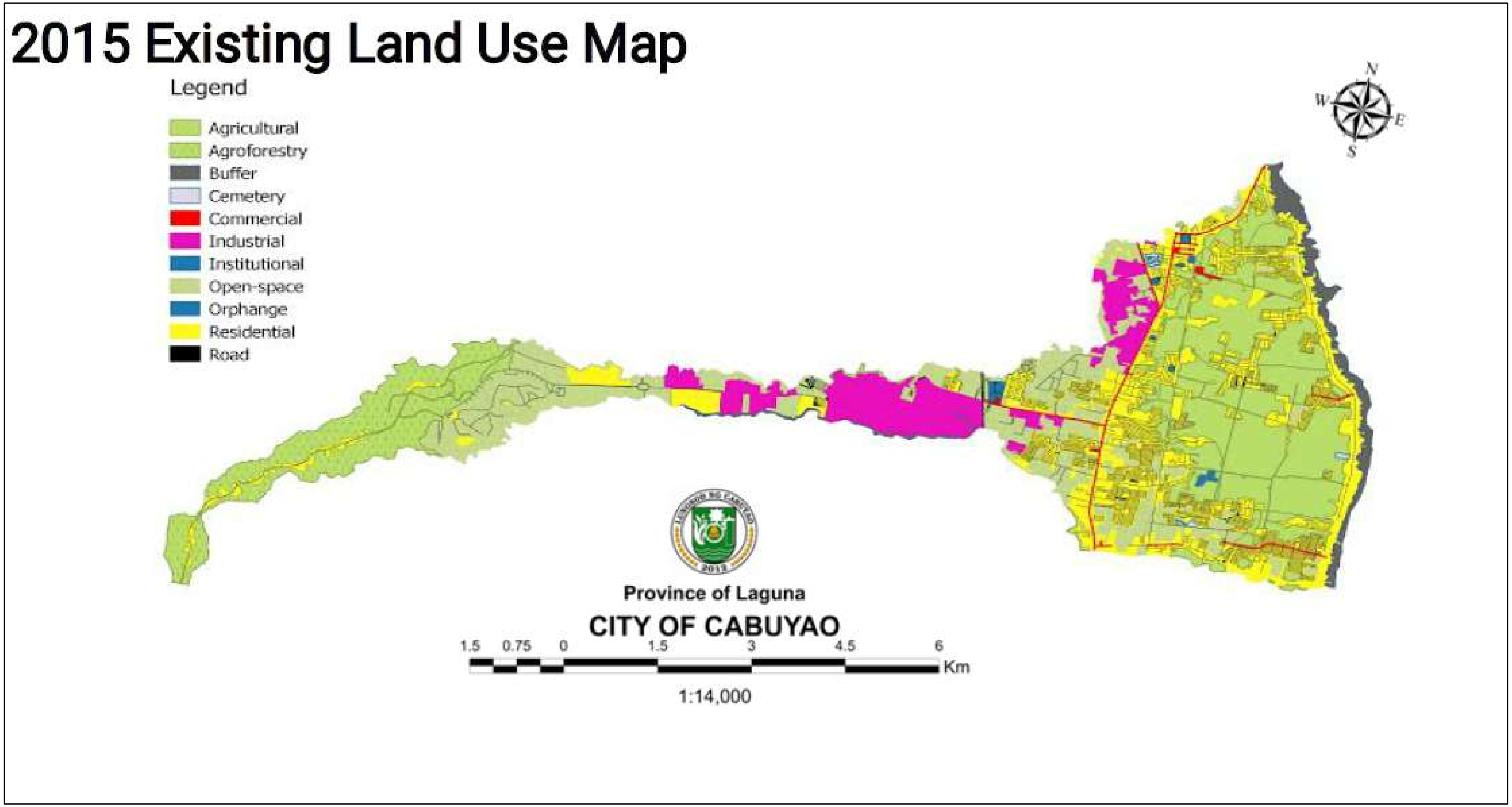


Figure 2- 13 Existing Land Use Map, Cabuyao City, 2015

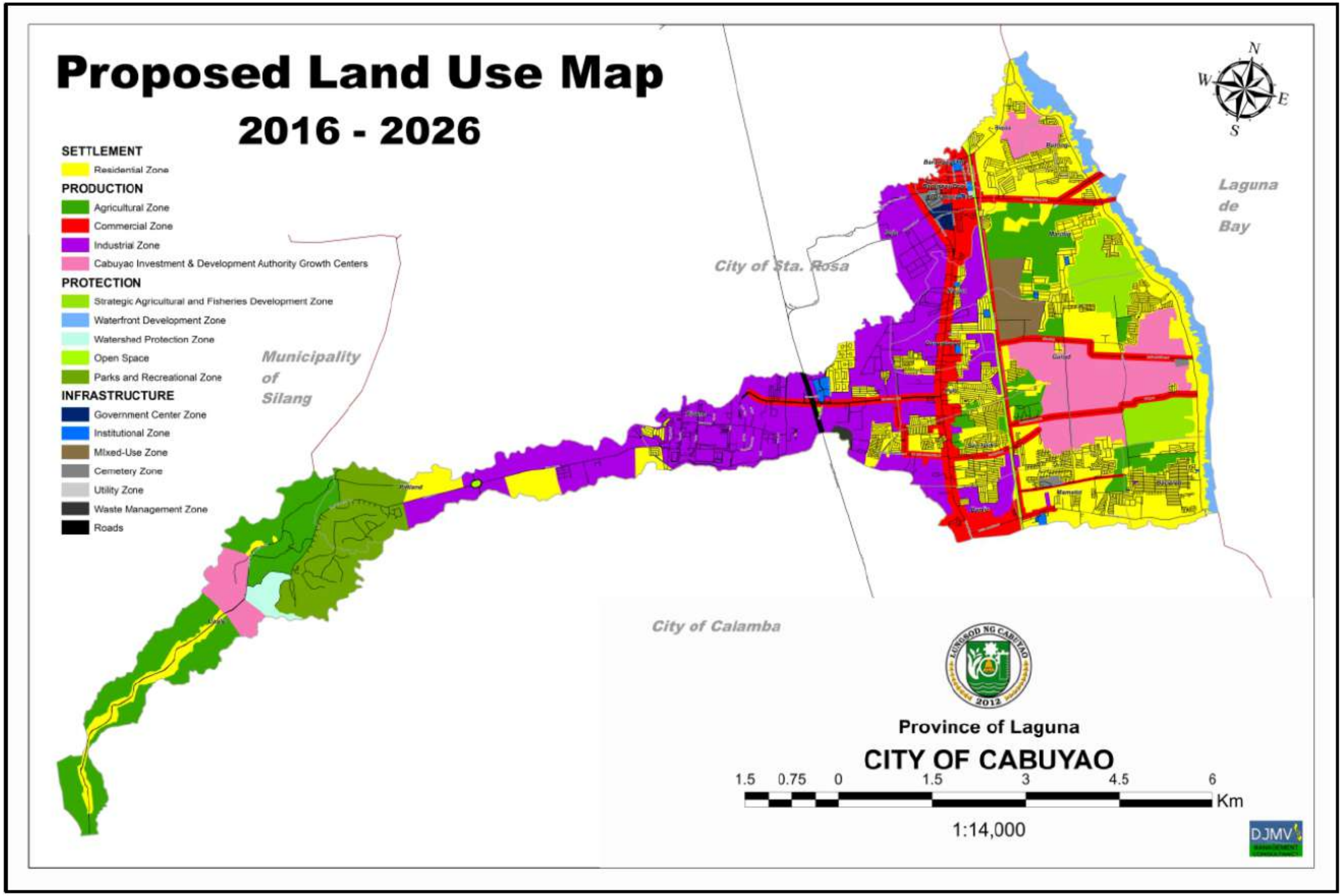


Figure 2- 14 Proposed Land Use Map, Cabuyao City, 2016-2026

Calamba City

In Calamba, the alignment will traverse portions of Barangays Palingon and Bucal. Calamba is a first-class city and was declared the regional centre of CALABARZON by Executive Order No. 246, dated 28 October 2003. In the province of Laguna, Calamba is the most populated, surpassing San Pedro, Sta. Rosa, and Biñan.

The existing land use in Calamba is a mixture of industrial, commercial, residential, and agricultural areas. With the implementation of major transportation projects in the city, it is anticipated that the urban growth of the city will further accelerate. In the past years, the city has shown significant increase in built-up areas brought by the large contribution to rapid urban growth of developments such as Nuvali and Ayala Greenfields.

The existing land use in Calamba City is shown in the table below.

Table 2.8 Existing Land Use, Calamba City, 2015

Land Use	2015 Existing Land Use (Ha)	Percentage %
Open-Idle	3016.22	20.83%
Agriculture	4554.45	31.45%
Residential	4078.18	28.16%
Socialized Housing	80.75	0.56%
Commercial	335.34	2.32%
Agri-Industrial	1.25	0.01%
Industrial	1132.84	7.82%
Institutional	144.72	1.00%
Parks & Recreation	126.05	0.87%
Cemetery	28.18	0.19%
Dumpsite	5.66	0.04%
Makiling Forest Reservation (MFR)	591.94	4.09%
MFR Buffer Zone	384.43	2.65%
Total	**14480**	**100%**

The existing and proposed land use for Calamba City are shown in **Figure 2-15** and **Figure 2-16**.

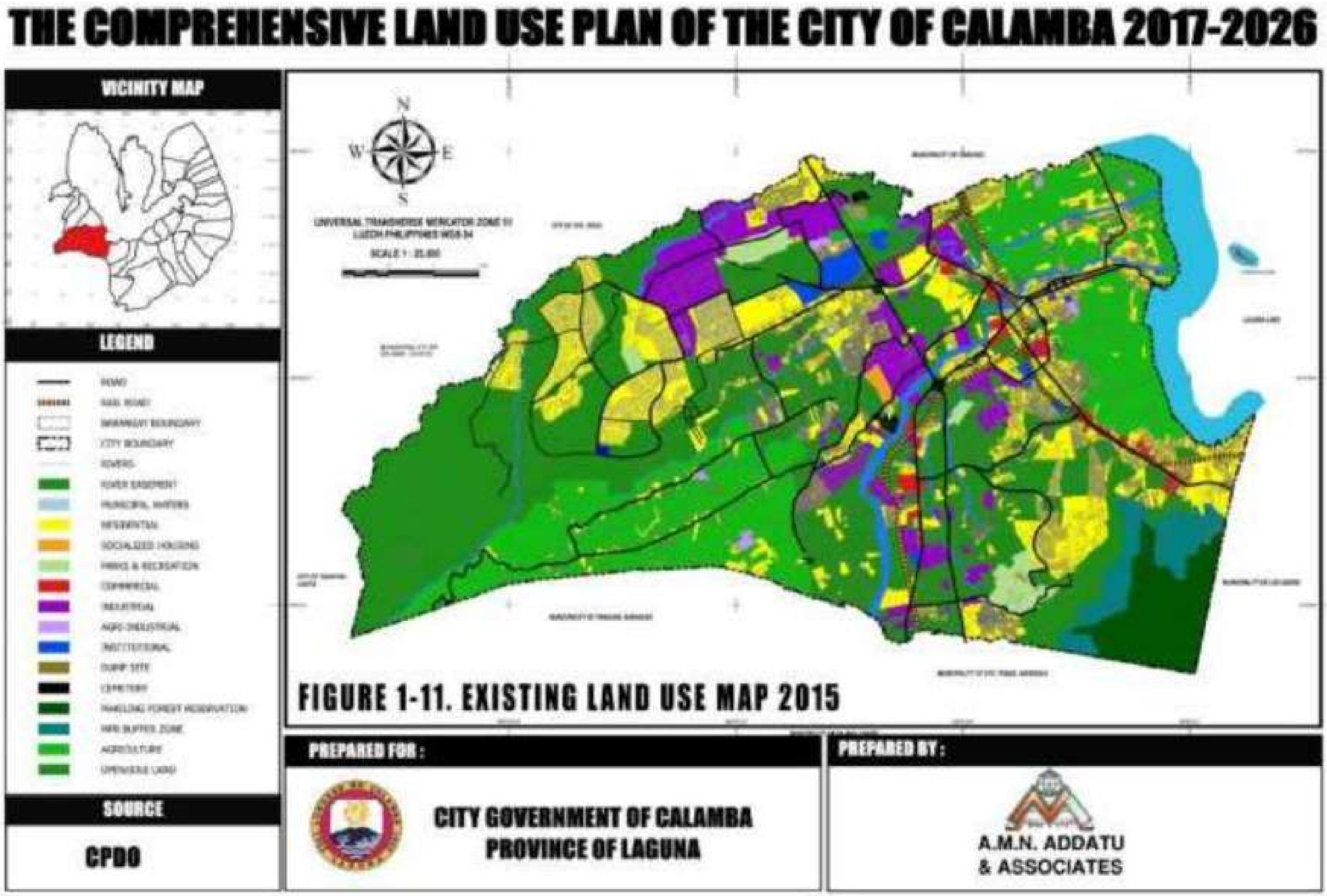


Figure 2- 15 Existing Land Use Map, Calamba City, 2015

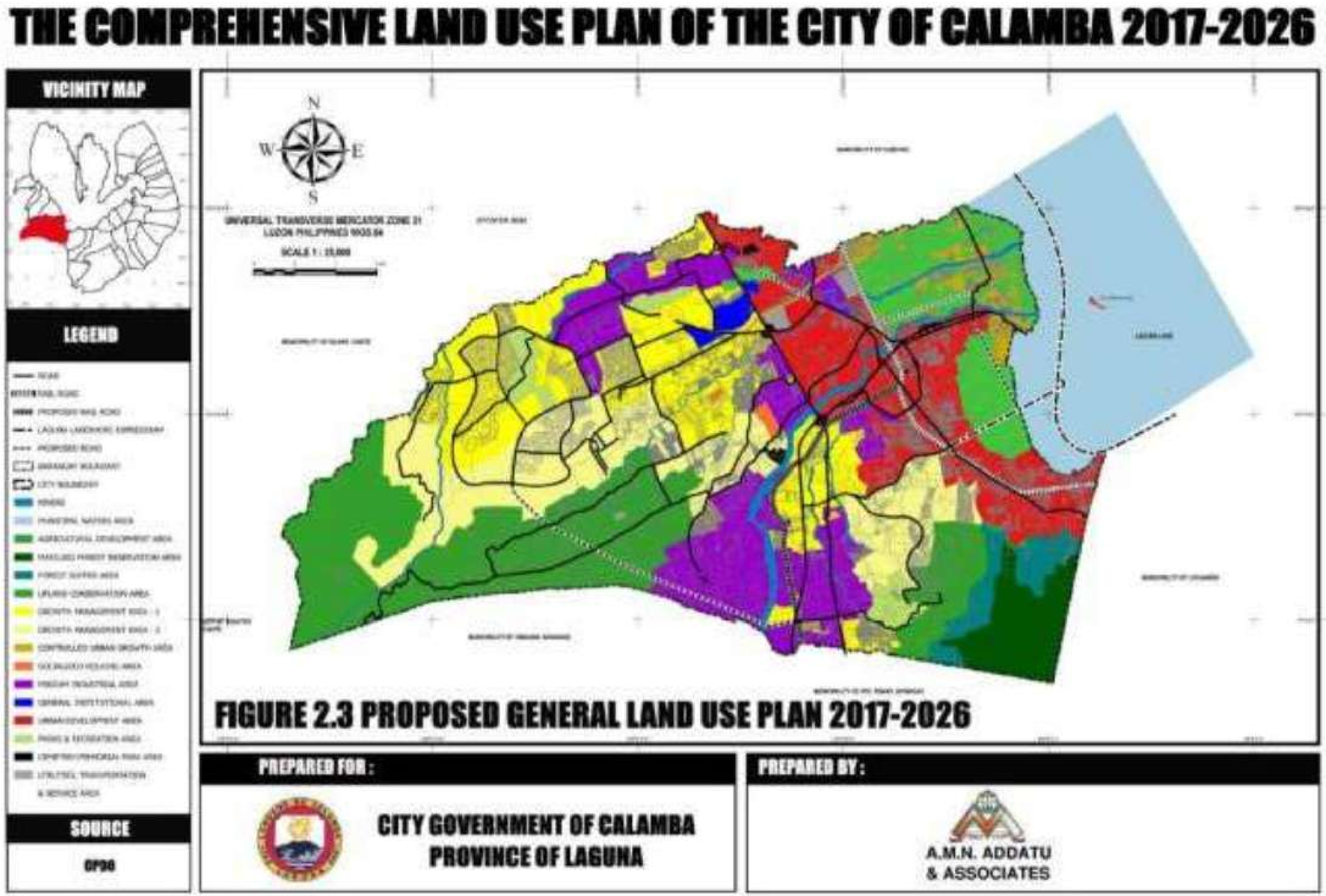


Figure 2- 16 Proposed General Land Use Map, Calamba City, 2017-2026

A) Environmentally Critical Area (ECA)

Under Proclamation No. 2146, series of 1981, guided by the DAO 2003-30, there are 12 categories of Environmentally Critical Areas (ECAs). These ECAs are environmentally sensitive areas where significant environmental impacts are expected if certain types of projects are developed in these areas.

1. All areas declared by law as national parks, watershed reserves, wildlife preserves and sanctuaries;
2. Areas set aside as aesthetic potential tourist spots;
3. Areas which constitute the habitat for any endangered or threatened species of indigenous Philippine Wildlife (flora and fauna);
4. Areas of unique historic, archaeological, or scientific interests;
5. Areas which are traditionally occupied by cultural communities or tribes;
6. Areas frequently visited and/or hard-hit by natural calamities (geologic hazards, floods, typhoons, volcanic activity, etc.);
7. Areas with critical slopes;
8. Areas classified as prime agricultural lands;
9. Recharged areas of aquifers;
10. Water bodies characterized by one or any combination of the following conditions;
    a. tapped for domestic purposes
    b. within the controlled and/or protected areas declared by appropriate authorities
    c. which support wildlife and fishery activities
11. Mangrove areas characterized by one or any combination of the following conditions:
    a. with primary pristine and dense young growth;
    b. adjoining mouth of major river systems;
    c. near or adjacent to traditional productive fry or fishing grounds;
    d. which act as natural buffers against shore erosion, strong winds and storm floods;
    e. on which people are dependent for their livelihood.

B) Land Tenure

Considering that the project alignment will traverse portions of land areas in Taguig, Muntinlupa, San Pedro, Biñan, Santa Rosa, Cabuyao, and Calamba, ROW should be acquired by the proponent in accordance with the Republic Act 7279 or the (Urban Development and Housing Act of 1992) and under Asian Development Bank's (ADB) Policy on Involuntary Resettlement and Indigenous People and aligned with DPWH Right-of-Way Acquisition Manual (DRAM).

The project has conducted a series of consultation meetings and coordination with project stakeholders. It is anticipated that the project will require land acquisition as there are formal and informal, holder and non-holder of tenurial instruments, and businesses in some areas where the alignment will traverse as discussed in the Affidavit of Undertakings (**Appendix Q**). A Resettlement Action Plan has been prepared for the project in anticipation of affected persons that will be displaced and are currently occupying lands that will be used for the construction of LLRN. The RAP includes consultation with affected persons (APs) and other stakeholders, socio-economic survey, and inventory of losses. It presents the resettlement impacts and extent of losses; methods used to assess impacts; socio-economic information and profile of APs; information disclosure and consultation meetings; the applicable policies and legal framework; principles and methodology for asset valuation, compensation, relocation, and rehabilitation; responsibilities in delivering and monitoring entitlements; resettlement costs and financing plan; grievance redress measures; time frame for land acquisition and resettlement; and monitoring and reporting mechanism

Based on the resettlement study conducted, impacts are mostly within the location of interchanges. Out of 564 affected structures, 395 are affected by the interchanges while 169 are affected by the main line. These structures include houses, business establishments, quarantine facility, community facility, and fish cages. A total of 353,900 m2 of land will be acquired. Within these areas are 505 households, 106 businesses owned by 100 APs, eight APs engaged in agricultural farming, 21 fish cages owned by 19 APs, and 89 employees.

The DPWH RMC II UPMO, shall implement the Resettlement Action Plan, including disbursement of compensation to landowners, in coordination with the Resettlement Implementation Committee (RIC), and UPMO Right-of-Way Task Force (URTF). For displaced households that do not own the land, DPWH shall coordinate with DHSUD and the Local Inter Agency Committee (LIAC) of each LGU for their relocation while for affected fish cage owners, fisherfolk and other APs within the lake, DPWH will work with the Laguna Lake Development Authority (LLDA) for the restoration of affected lake-based livelihood.

There are no perceived impacts on Comprehensive Agrarian Reform Program (CARP) lands or areas with Certificate of Ancestral Domain Title (CADT).

C) Visual Aesthetics

Laguna Lake has multiple uses that serve its surrounding communities. Being the largest lake in the Philippines, one of the major uses of the lake is for fisheries and aquaculture. LLDA has a Zoning and Management Plan that ensures equitable distribution of the lake's fishery resources. The 2019 Laguna de Bay Fishery Zoning Map is shown in the image below.

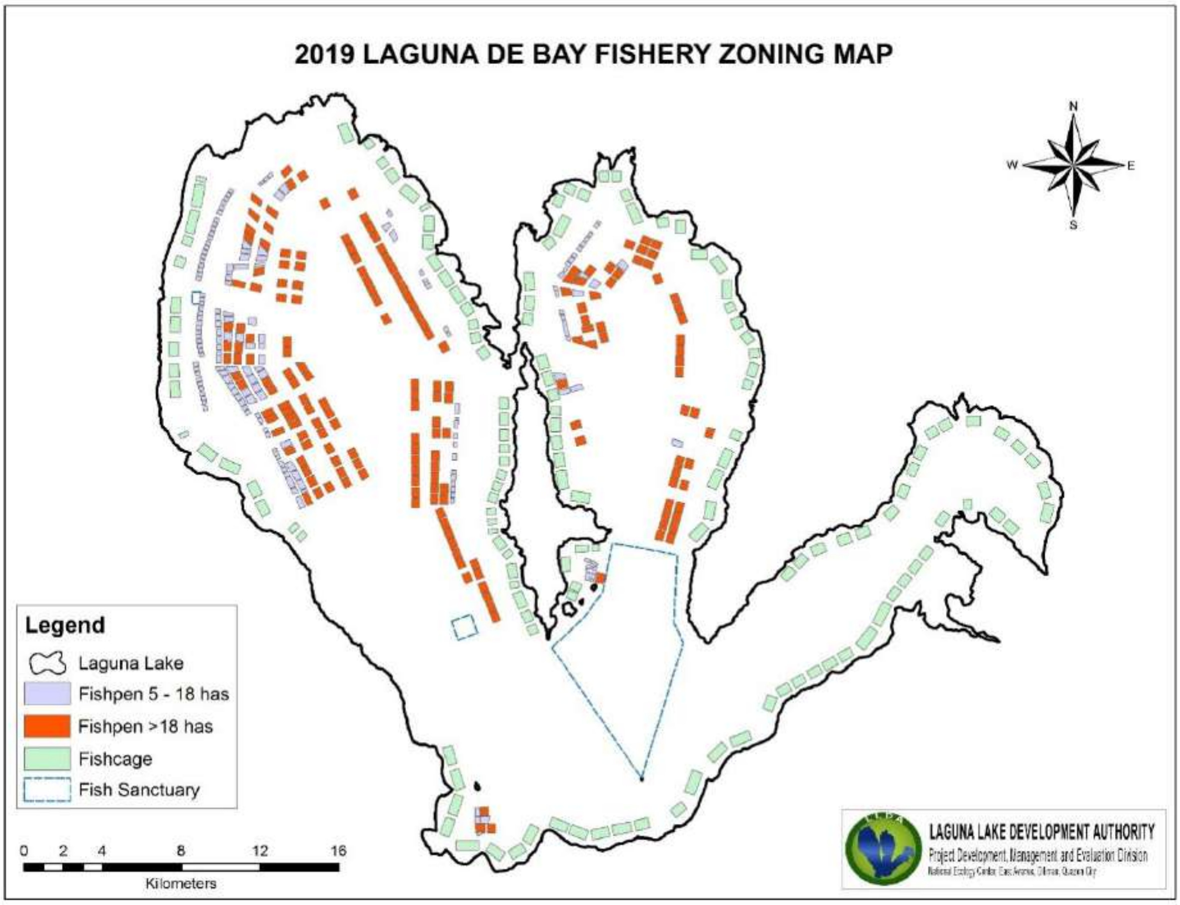


Figure 2- 17 Laguna de Bay Fishery Zoning Map, 2019

Communities along the lake consider fishing as their major source of livelihood. The lake is a home to variety of organisms and as reported by LLDA, the western part of the lake is the most profitable for capture fisheries and aquaculture. Given the current situation, the lake can still sustain fisheries but is already threatened by contamination from pollution, as a result of varying activities around the lake.

In terms of recreation, the Laguna Lake also is classified as a non-contact recreation and activities are only for fishing, boating, and sailing. However, there are some communities that use the lake for swimming. There are also some lakeshore resorts that extract hot spring waters.

On the northeast side, the lake has the views of the Sierra Madre mountain ranges, while the Caliraya volcanic plateau is on the east, and mountains of Laguna and Batangas such as Mt. Banahaw and Mt. Makiling are on the south and southeast.

Table 2.9 Summary of Environmentally Critical Areas (ECA) Along LLRN Project

Technical Description of ECA Categories	Project falls within the ECA description	Relevance to the Project Site
Areas declared by law as national parks, watershed reserves, wildlife preserves, and sanctuaries	No	There is no declared national parks, watershed reserves nor wildlife preserves and sanctuaries within and in the vicinity of the project site. The nearest areas include the 2.0 km Mount Makiling Forest Reserves (MMFR) located at Los Banos Laguna under 1910 Proclamation 106 and the Las Pinas-Paranaque Critical Habitat and Ecotourism Area (LPPCHEA) which is 8.96 km from the alignment, under Presidential Proclamation 1412 issued on April 22, 2017.
Areas set aside as aesthetic, potential tourist spots	No	Most of the areas along the alignment are within the areas covered with water lilies along the shoreline of Laguna Bay; A&D, and build-up areas.
Areas which constitute the habitat for any endangered or threatened species of indigenous Philippine wildlife (flora and fauna)	No	There is no habitat along the alignment which constitute the habitat for any endangered or threatened species
Areas of unique historic, archaeological, geological, or scientific interests	No	There is no any unique historic, archaeological, geological, or scientific interest in the area
Areas which are traditionally occupied by cultural communities or tribe	No	The proposed project site is not within any ancestral domain inhabited by indigenous peoples or cultural communities.
Areas frequently visited and or hard-hit by natural calamities Geological hazard areas	Yes	The vicinity of the project may be susceptible to various natural hazards as with majority of the Philippines, the project is also susceptible to seismic and volcanic hazards. Also, project site is in an area affected by at least 2 to 3 typhoons annually.

Technical Description of ECA Categories	Project falls within the ECA description	Relevance to the Project Site
Flood-prone areas Areas frequently visited or hard-hit by typhoons Areas prone to volcanic activities / earthquakes		
Areas with critical slope	No	The area is flat to relatively rolling
Technical Description of ECA Categories	Project falls within the ECA description	Relevance to the Project Site
Areas classified as prime agricultural lands	No	Most of the alignment is viaduct and the rest are with embankments
Recharge areas of aquifer	No	The project is not within or in the vicinity of aquifer recharge areas.

Technical Description of ECA Categories	Project falls within the ECA description	Relevance to the Project Site
Water bodies characterized by one or any combination of the following: tapped for domestic purposes within controlled and/or protected areas declared by appropriate authorities which support wildlife and fishery activities	No	There is no declared protected area along the alignment
Technical Description of ECA Categories	Project falls within the ECA description	Relevance to the Project Site
Mangrove areas characterised by one or any combination of the following conditions: With primary pristine and dense young growth Adjoining mouth or major river system Near or adjacent to traditional productive fry or fishing grounds Which act as natural buffers against shore erosion, strong	No	There is no mangrove in the project site. The area is within the shoreline of freshwater Laguna Lake

Technical Description of ECA Categories	Project falls within the ECA description	Relevance to the Project Site
winds and storm flood On which people are dependent for their livelihood, pursuant to and taking into consideration Republic Act No.7161 which prohibits the cutting of mangrove species		
Coral Reefs: characterised by one or any combination of the following conditions: With 50% and above live coralline cover Spawning and nursery grounds for fish Which act as a natural breakwater of coastline	No	The alignment of the project is along the lakeshores of Laguna de Bay and there is no coral reefs

2.1.2 Geology/Geomorphology

2.1.2.1 Methodology

Geologic assessment comprised of collation and interpretation of existing mappings, including topographic, geologic, flood maps, landslide susceptibility maps, and existing ground investigation information. Technical reports regarding the geologic conditions of the project area, other geology-related resources; and result of field inspection are also considered. Field inspection comprised of geological and geohazard mapping of the area where information such as local site geology is obtained. Mapping includes identification of rock types inherently underlying the project area and vicinity.

2.1.2.2 Nature/ Source of Information

The geological assessment commenced with literature research of all available geological, seismological, hydrological, and hydrographical reports and maps covering the project area previously conducted at the Mines and Geo-Sciences Bureau (MGB), and the Philippine Institute of Volcanology and Seismology (PHIVOLCS). Topographic maps covering the western shores of Laguna de Bay particularly areas from Taguig City to Calamba and their vicinity were acquired from the National Mapping and Resource Information Agency (NAMRIA). Climatological data was gathered from the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA). Previous ground investigation reports were also used as reference.

2.1.2.3 Baseline Environmental Conditions

Regional Geologic Setting

Tectonic Setting

The Philippine archipelago is located at the convergence between the Eurasian Plate (also referred as Sunda Plate) and the Philippine Sea Plate. The tectonics in the region is complex with 80mm – 100mm/year plate movement accommodated by the subduction zone to the east and west of the Philippine mainland. To the east, the Philippine Sea Plate is subducting westward underneath the Eurasian Plate along the East Luzon Trough and the Philippine Trench. To the west, the Eurasian Plate is subducting eastward along the Manila Trench, Negros Trench, Sulu Trench and Cotabato Trench underneath the Philippine Sea Plate, see **Figure 2-18**.

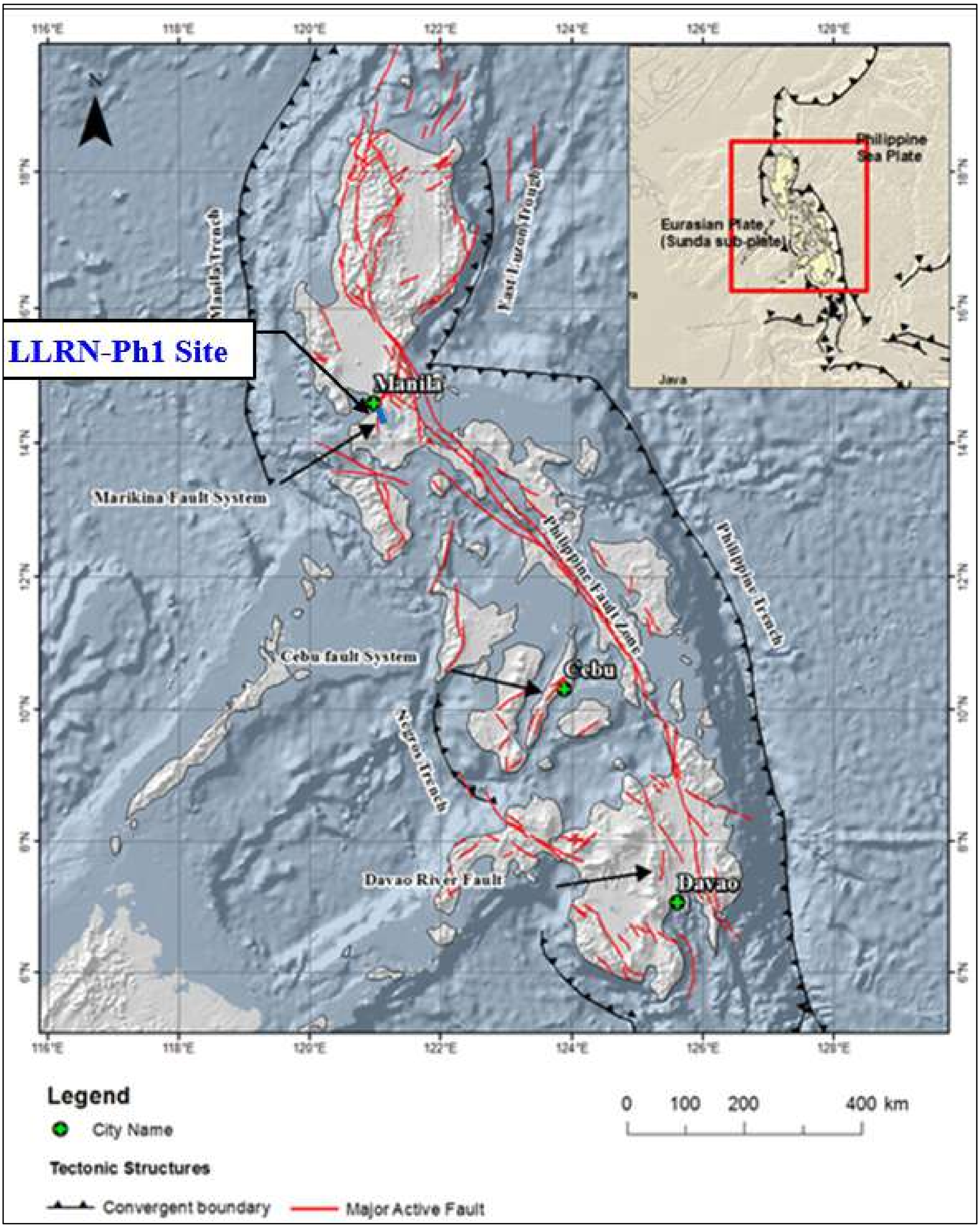


Figure 2- 18 Tectonic Setting of the Philippines

As the motion of the subducting Philippine Sea Plate along the Philippines Trench is oblique, the convergence is partitioned into trench-normal and trench parallel motion. The trench-normal convergence is mainly accommodated by the subduction along Philippine trench. The trench-parallel convergence is taken up by the Philippine Fault System across the Philippine archipelago behind the Philippine Trench, and other crustal active fault across the Philippines.

The distribution of active faults and trenches near LLRN-PHASE 1 is shown in **Figure 2-19**.

The proposed alignment runs sub-parallel to the Marikina Fault System/ West Valley Fault System for much of its length with the northern portion situated only about 500 m to the east of the fault while the southern portion is located up to about 12 km away from it.

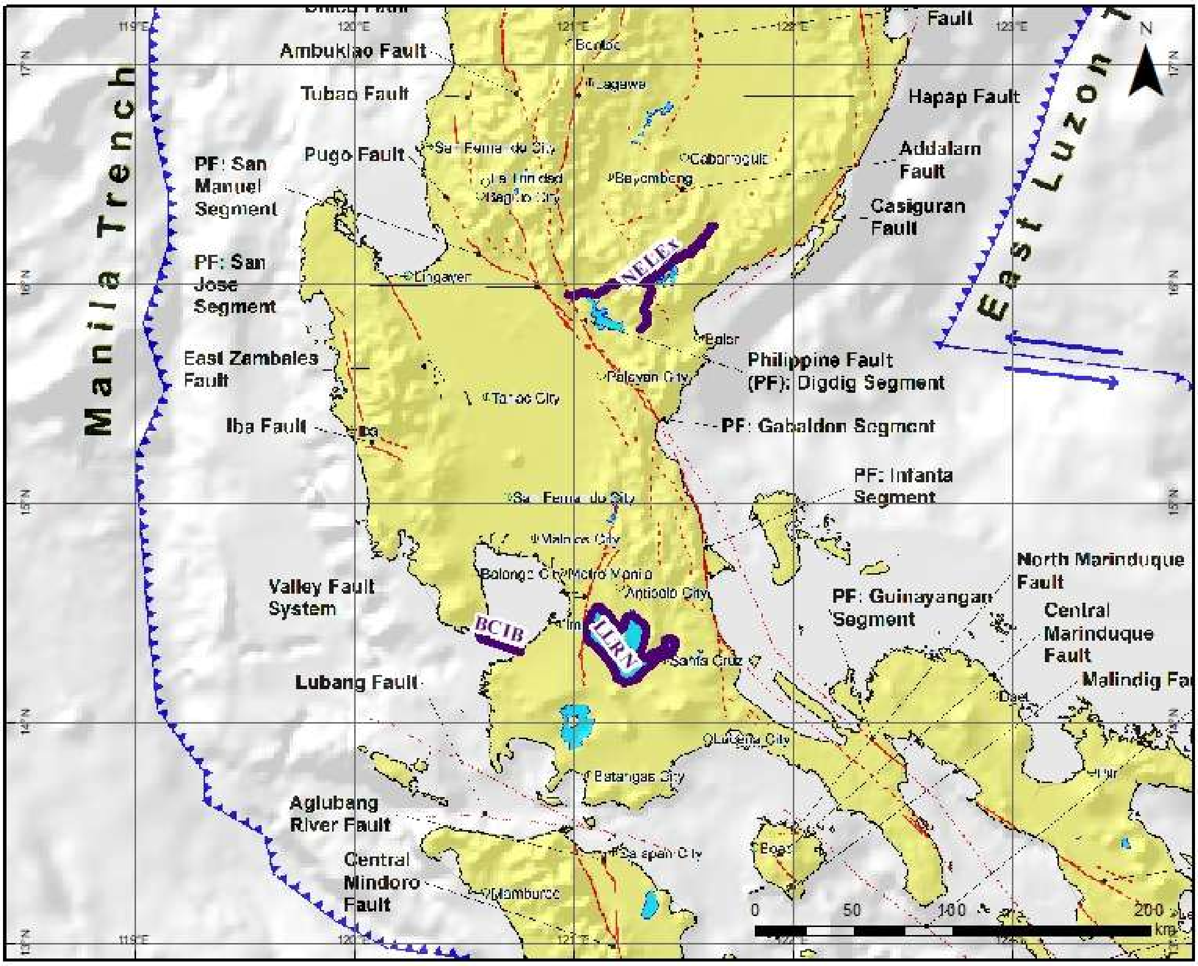


Figure 2-19 Distribution of major tectonic structures and active faults in the project site

Stratigraphy and Geology

Based on the 'Geology of the Philippines' published by the Mines and Geosciences Bureau (MGB) in 2010, the project are falls within Stratigraphic Group 1 (SG1) – Ilocos-Central Luzon Basin. It covers the sedimentary basins of Ilocos, Central Luzon Basin West and Central Luzon Basin East. The underlying lithologies include igneous and sedimentary rocks. The arrangement of the lithologies is indicated in **Figure 2-21** and **Figure 2-22**, which presents sedimentary formations and volcanic activities during Paleogene to Neogene Period.

The stratigraphic column indicates that the Barenas-Baito Formation is the basement of the unit. It consists of andesite flows, pyroclastic rocks, siltstone, sandstones, conglomerates with limestone lenses. The youngest unit is the Guadalupe Formation (Pleistocene) which consists of two members, namely, the Alat Conglomerate and Diliman Tuff. Of these two members, the bedrock that underlies the alignment is the Diliman Tuff.

The source of the pyroclastic material belonging to the Diliman Tuff could be associated to the materials erupted by the two nearest caldera which are the Laguna caldera in the southeast and Taal caldera in the south. However, by comparing the geochemical composition of the pyroclastic rocks in Metro Manila and the type of pyroclastic lava flows extruded by these two calderas, it was observed that the composition of the pyroclastic rocks in Metro Manila is intermediate between the two near calderas (Arpa, et al., 2004).

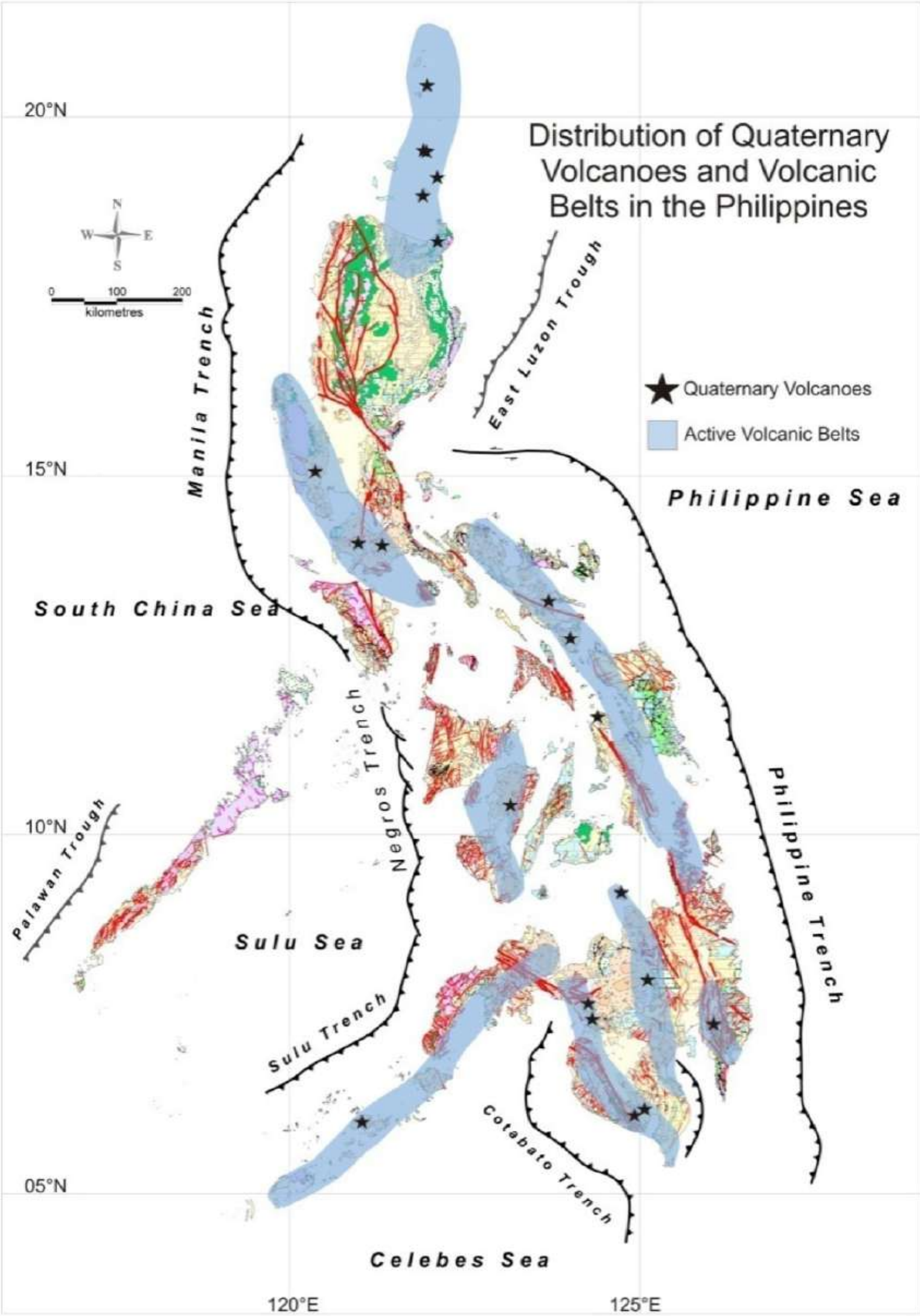


Figure 2- 20 Generalized distribution map of active volcanoes and volcanic belts in the Philippines (Source: MGB)

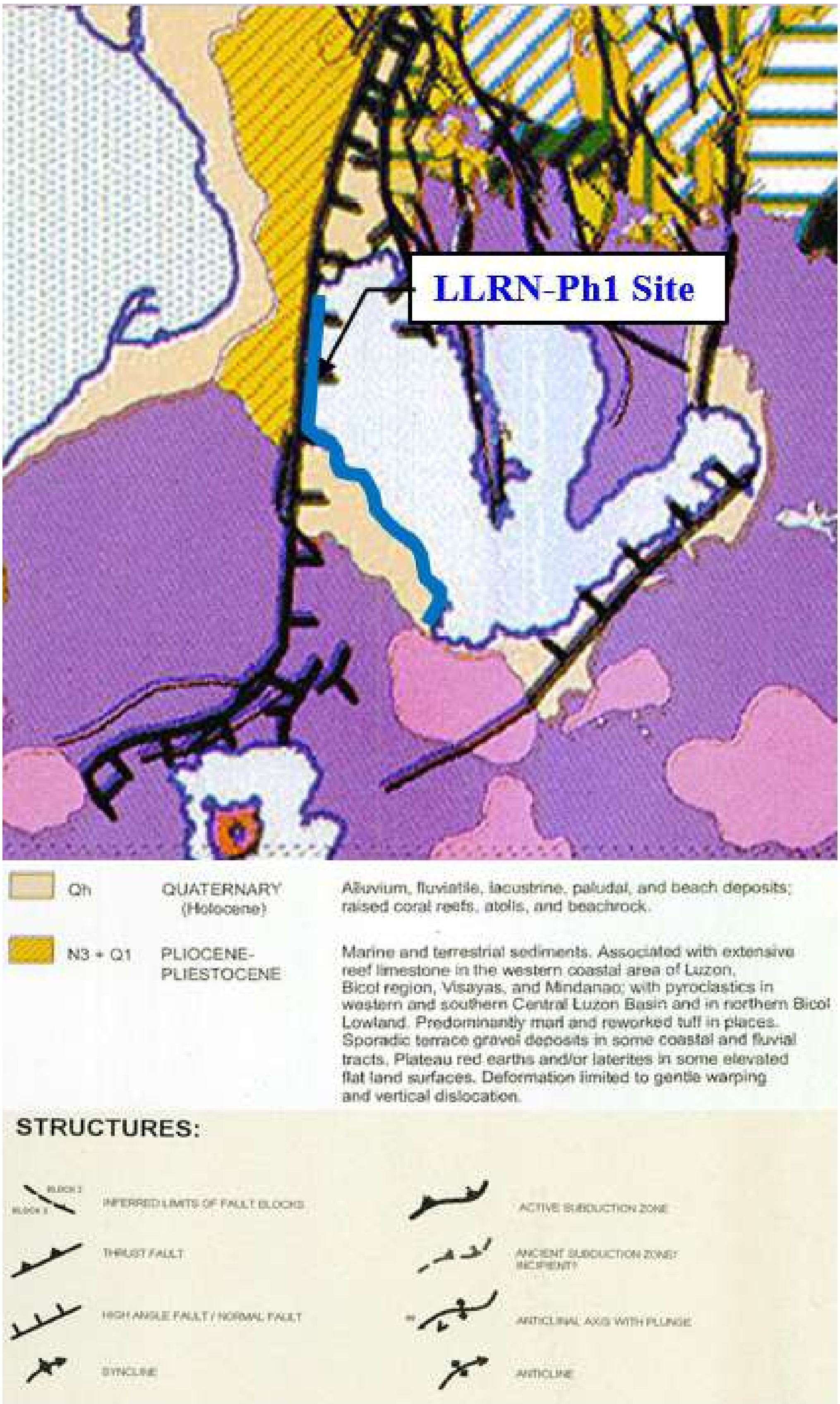


Figure 2- 21 Extract of Geologic and Tectonic Map of the Philippines at LLRN - PH1- project (Source: MGB)

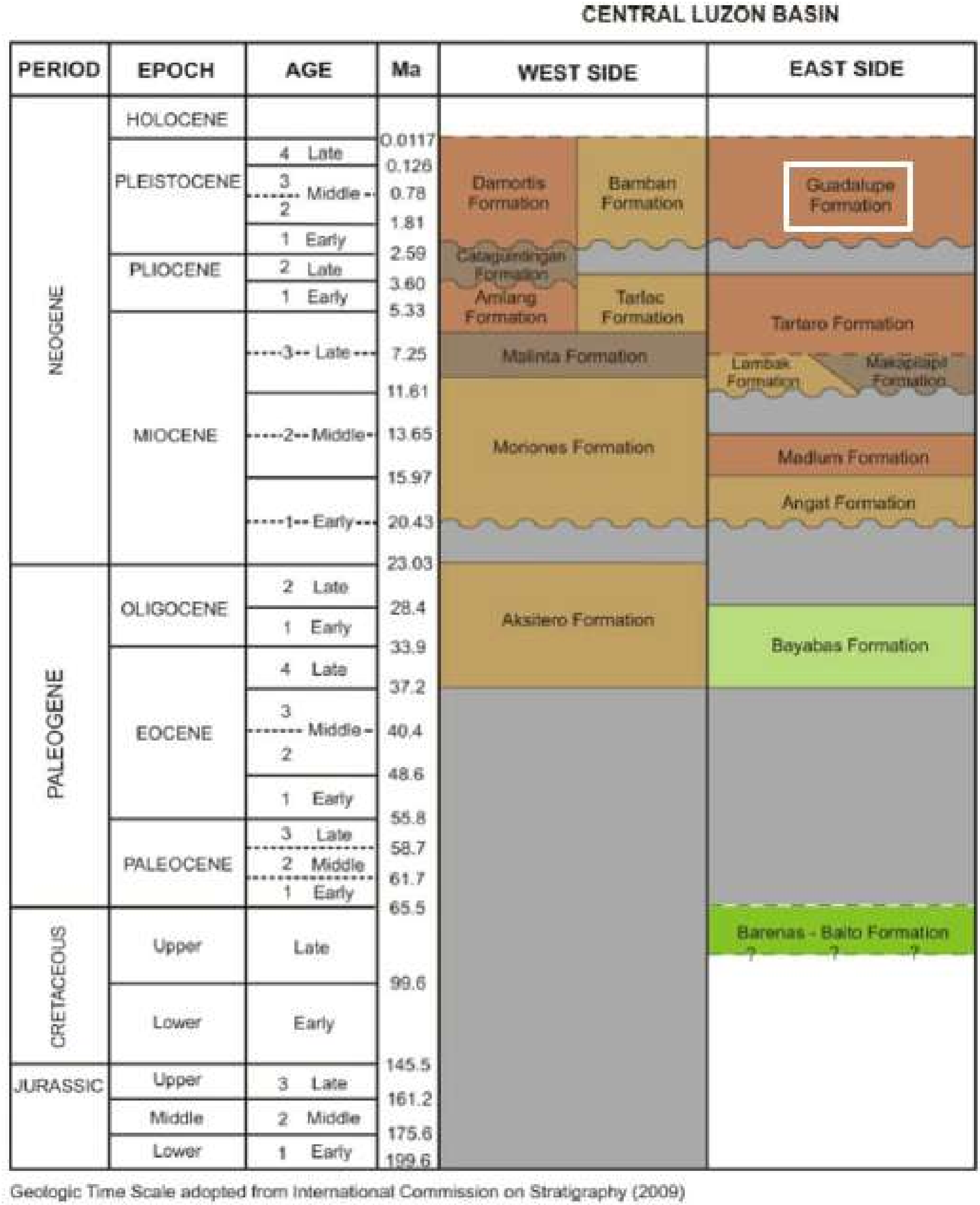


Figure 2- 22 Stratigraphic Column for Central Luzon Basin (Source: MGB)

Geological Structures

As presented in the published maps (**Figure 2-21**), the project region is mainly influenced by the West Valley Fault System located 500m to the east of the alignment's northern portion and 12km to the east of its southern portion. Lubang-Verde Passage Fault System (or Lubang Fault) located approximately 70 kilometers to the south, and the Philippine Fault Zone located approximately 60 kilometers to the east of the project. According to Aurelio (2000), the Philippine Fault Zone was formed through shear partitioning mechanism which is the consequence of oblique convergence between the Philippine Sea Plate and Eurasian Plate. While the Lubang-Verde Passage Fault, influences the transition from the subduction along the Manila Trench to the collision in the Mindoro-Palawan-Panay area. The following major geological structures potentially influence the LLRN - PH1 project:

- **Valley Fault system (VFS)**

It was originally named "Marikina Valley Fault System", then renamed later by PHIVOLCS as the VFS. Recent findings by the PHIVOLCS indicate that the fault is an active, right-lateral strike-slip fault. It is located 500m to the east of the alignment's northern portion and 12km to the east of its southern portion.

- **Lubang-Verde Passage Fault System**

It is a west-northwest-trending, left-lateral strike-slip fault located offshore between Batangas peninsula and Mindoro Island, which is situated approximately 70 kilometers to the south of the LLRN - PH1 project. It transforms into a thrust/left-lateral transgressional fault and cuts the southern portion of the Manila Trench accretionary prism.

- **Philippine Fault Zone**

The Philippine Fault Zone is a major left-lateral strike-slip fault zone with a mapped length of about 1,250 kilometers from northern Luzon to southern Mindanao. a dominant tectonic feature in the Philippines. Movement on the Philippine Fault Zone accommodates part of the oblique convergence between the Philippine Sea Pate and the Eurasian Plate and hence the fault is a major earthquake source of the archipelago. The fault zone is relatively active and has been responsible for many large earthquakes (magnitude greater than 7) in historical records, including the 1990 Luzon earthquake with magnitude of 7.7 (MGB, 2010).

The fault system is generally split into the Northern Segment (NW Luzon to Lamon Bay), Central Segment (Bondoc Peninsula to Leyte), and Southern Segment (Mindanao and the Moluccas). The project is situated approximately 60 kilometers to the west of the fault system between the Northern Segment and Central Segment near the Lamon Bay, where is a transition from north-trending branches of strike-slip faults in the Northern Segment to a relatively simple, well-defined faults in the Central Segment.

- **Manila Trench**

The Manila Trench is located west of Luzon and this is a deep ocean trough that represents the surface expression of the eastward-dipping subduction of the Eurasian Plate. The subduction has produced an accretionary prism as shown in **Figure 2-23** which is composed of sediments and builds the landform from the northern Luzon to Lubang Island.

To the south of the Manila Trench, the plate boundary has transformed into a Collision Zone of Mindoro-Panay (MGB, 2010).

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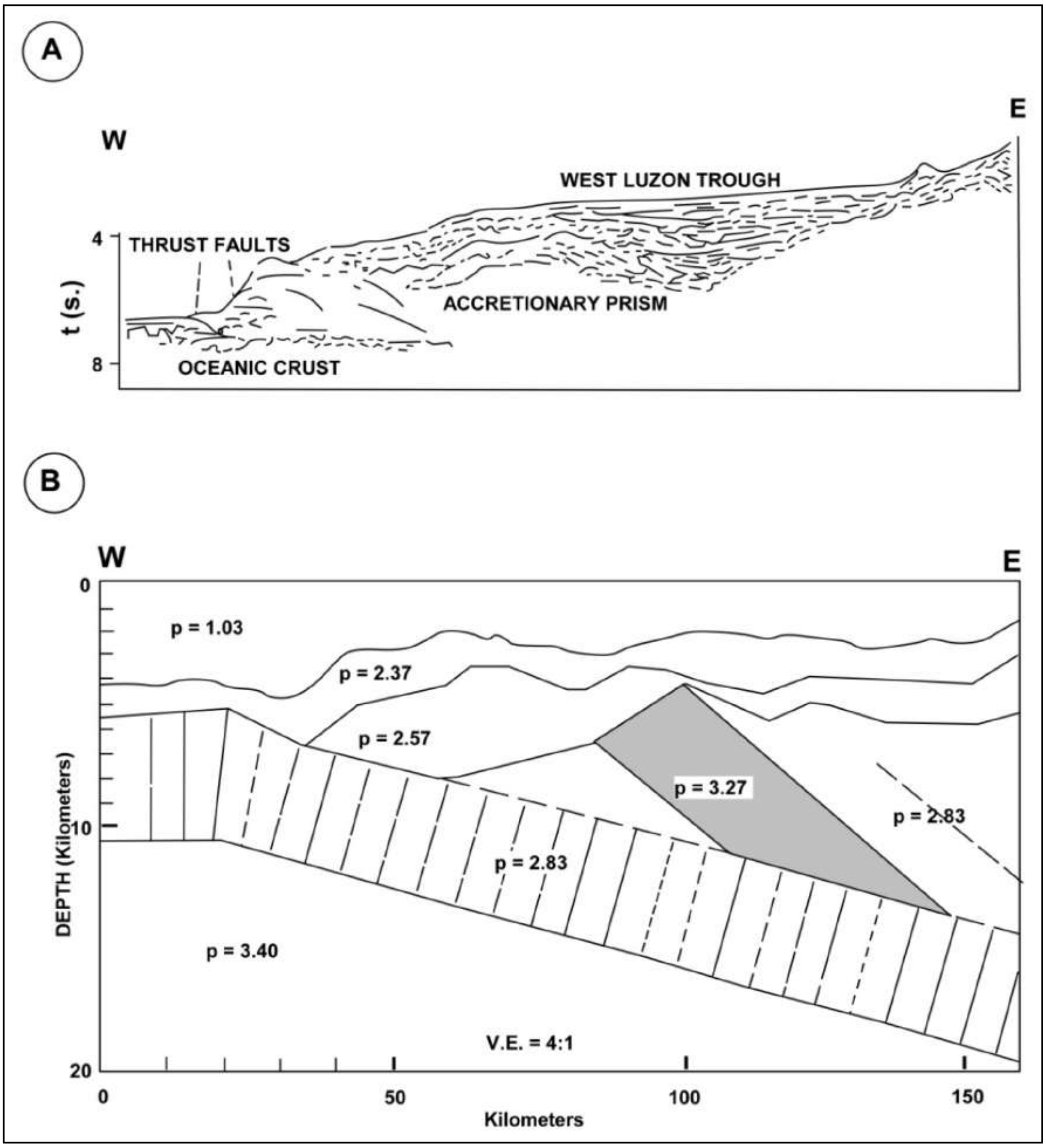

Figure 2- 23 Structure of the accretionary prism of the Manila Trench from seismic profiles (A), and of the subducting slab and over-riding plate established from gravimetric data (B). (MGB, 2010)

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- **Philippine Trench**

This is a major structural feature is located to the east of the Philippine archipelago that accommodates west dipping subduction of the northwest moving Philippine Sea Plate (MGB, 2010). The trench has a length of approximately 1,300 kilometers, extending from the central Luzon to the Island of Mindanao. The inferred trace of the trench is approximately located 400 kilometers to the east of the LLRN - PH1 project.

Geomorphology

The proposed LLRN - PH1 alignment follows is located along the western lakeshore of Laguna de Bay. From the geomorphological map from MGB, the project area lies along the alluvial plains of the rivers draining from the Marikina-Pasig River, and Taal Volcano.

The whole alignment is surrounded by features of higher elevation such as the Central Plateau in Metro Manila at its west and the Taal Ignimbrite Field to the southwest. The structural feature that demarcates the Central Plateau from the alluvial plains is the West Valley Fault. Based on the terrain, the West Valley Fault extends towards the Taal Ignimbrite Field on the south.

Located south of the alignment is the inactive Mount Makiling with the highest peak at 1,090m. Its last eruption was during the Holocene. Mt. Makiling is formed within the Macolod Volcanic Complex that was formed to be an across-the-arc extension region, a pull-apart type structure related to the sinistral movements of the Philippine Fault to the northeast and the Sibuyan Sea Fault to the southwest (Forster and others, 1990).

To the east of the alignment is the largest volcano-tectonic depression in Luzon formed by caldera eruptions and extension tectonics. Collapse structures bounding this lake suggest that itis probably a relic of a much larger ancient caldera system. Graben tectonics divided the lake into three bays. The East and Middle bays are separated by the Jala-Jala peninsula, which hosts three domes including Mt. Sembrano. Talim Island (represented by elongated red feature in **Figure 2-24**), intruded by the Mt. Sangunsalaga dome and the Binangonan peninsula, isolates the Middle from the West bay.

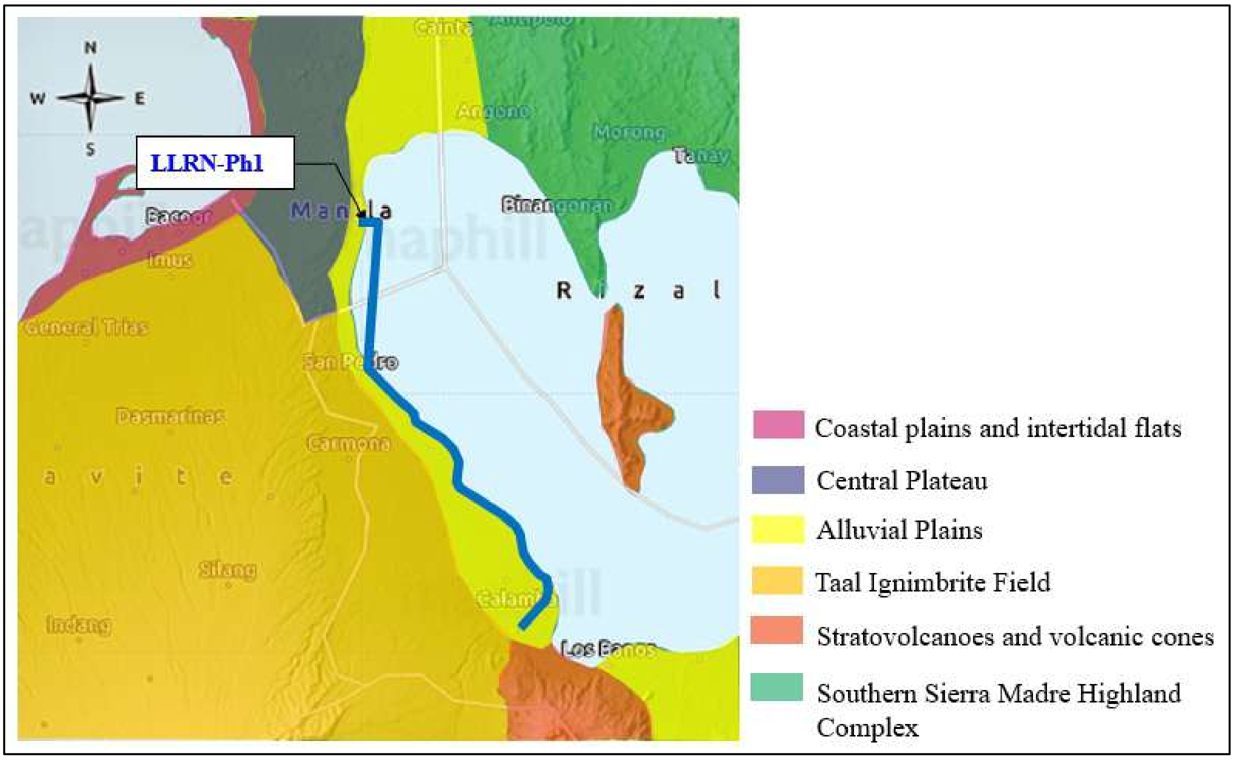

Figure 2-24 Geomorphological map of Metro Manila, Cavite, and Laguna (Source: PHIVOLCS)

Topography

The topography along the proposed alignment of LLRN - PH1 is relatively flat indicative of the alluvial deposits brought by streams flowing from the higher elevation region such as the Central Plateau and Taal Volcano. The landing points at the north and embankment areas in the south are flat and that land is typically used for cultivation of rice and other crops.

The recent topographic survey along the project area showed that the lakeshore area has an elevation of 1.25m from the MSL. The highest elevation is located at 10m in Sucat landing point as observed in the following figures.

See **Appendix P . Topographic** Maps for more detailed maps.

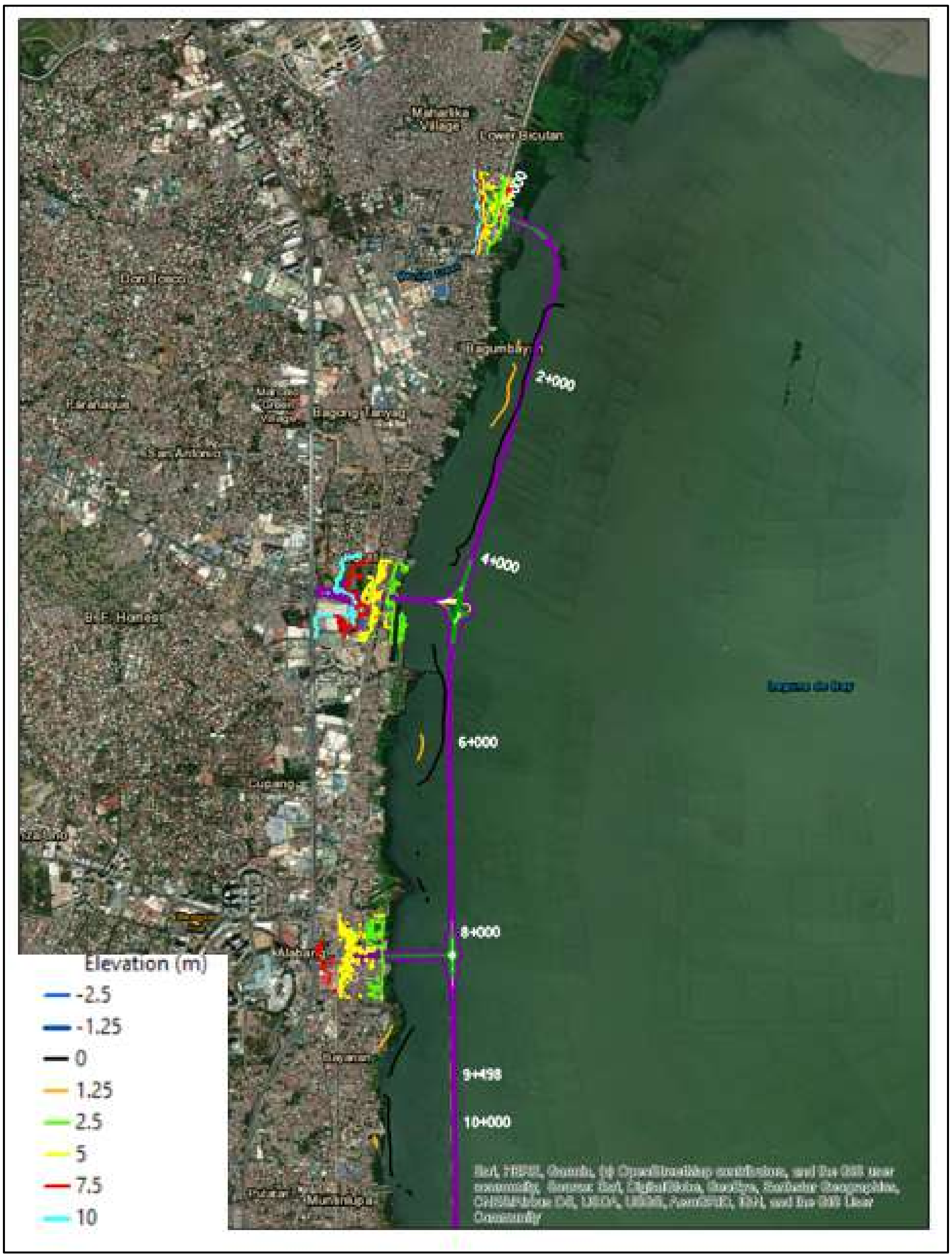

Figure 2- 25 Topographic map along LLRN - PH1 based on 2020 topographic survey (1)

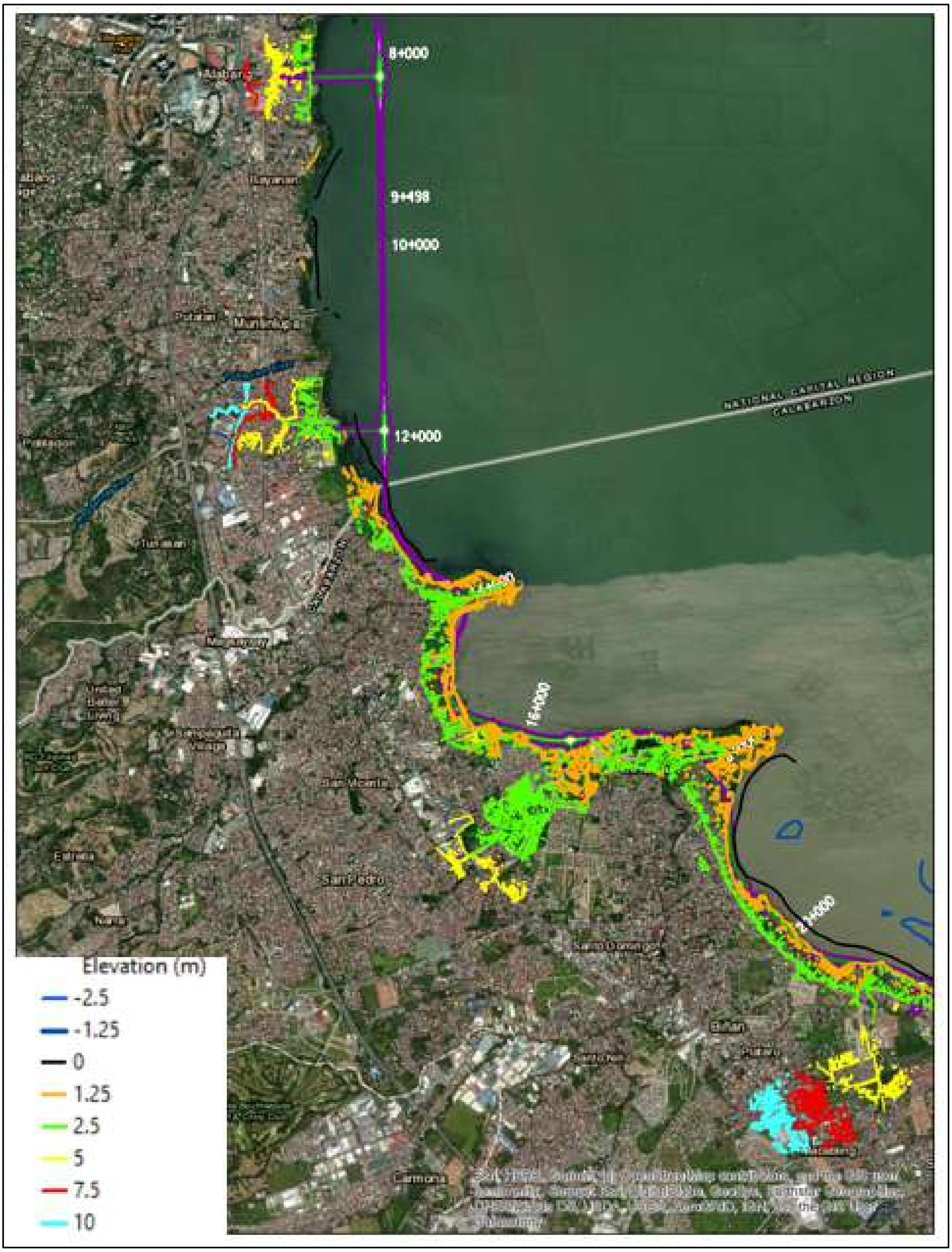

Figure 2- 26 Topographic map along LLRN - PH1 based on 2020 topographic survey (2)

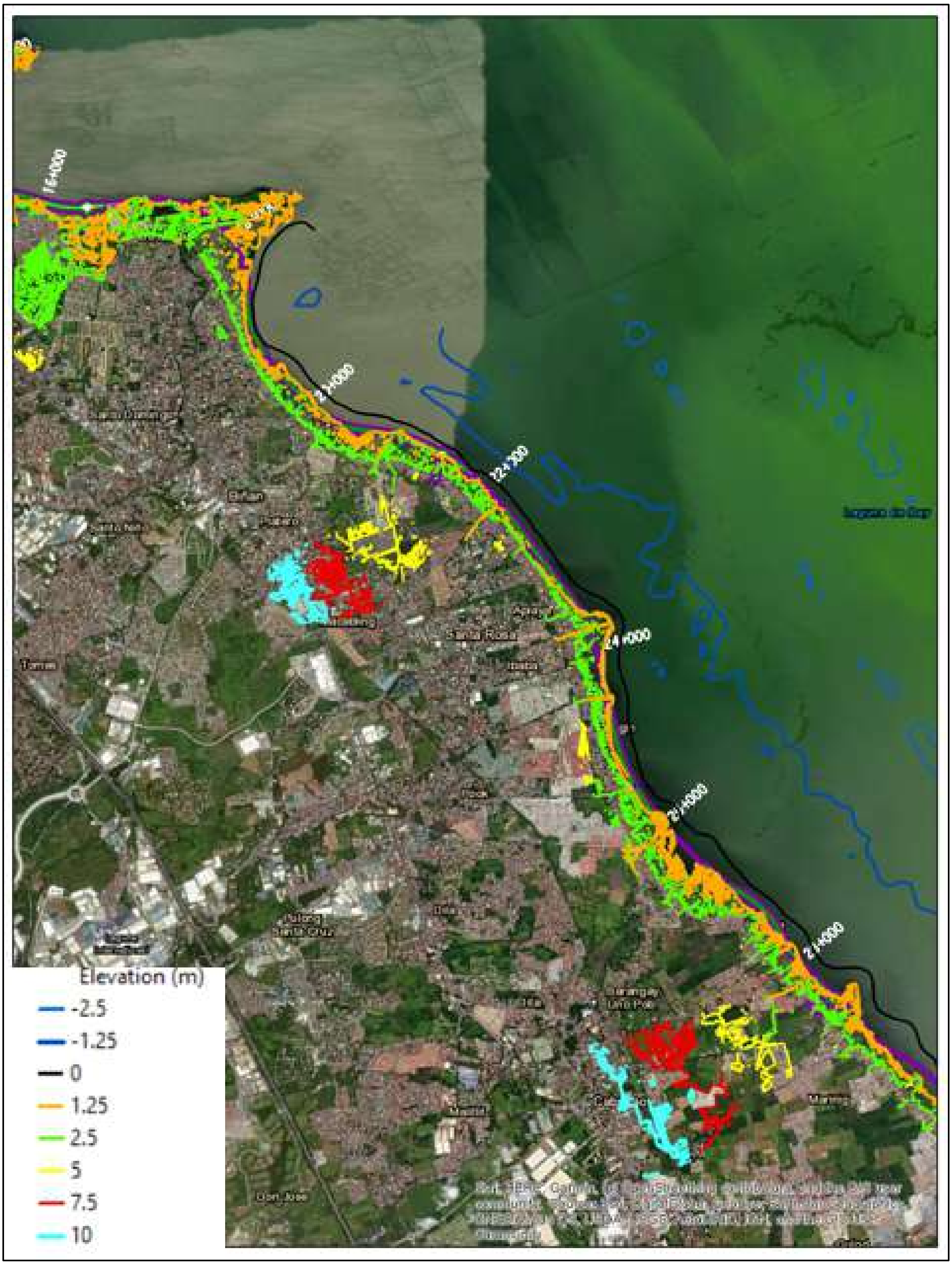

Figure 2- 27 Topographic map along LLRN - PH1 based on 2020 topographic survey (3)

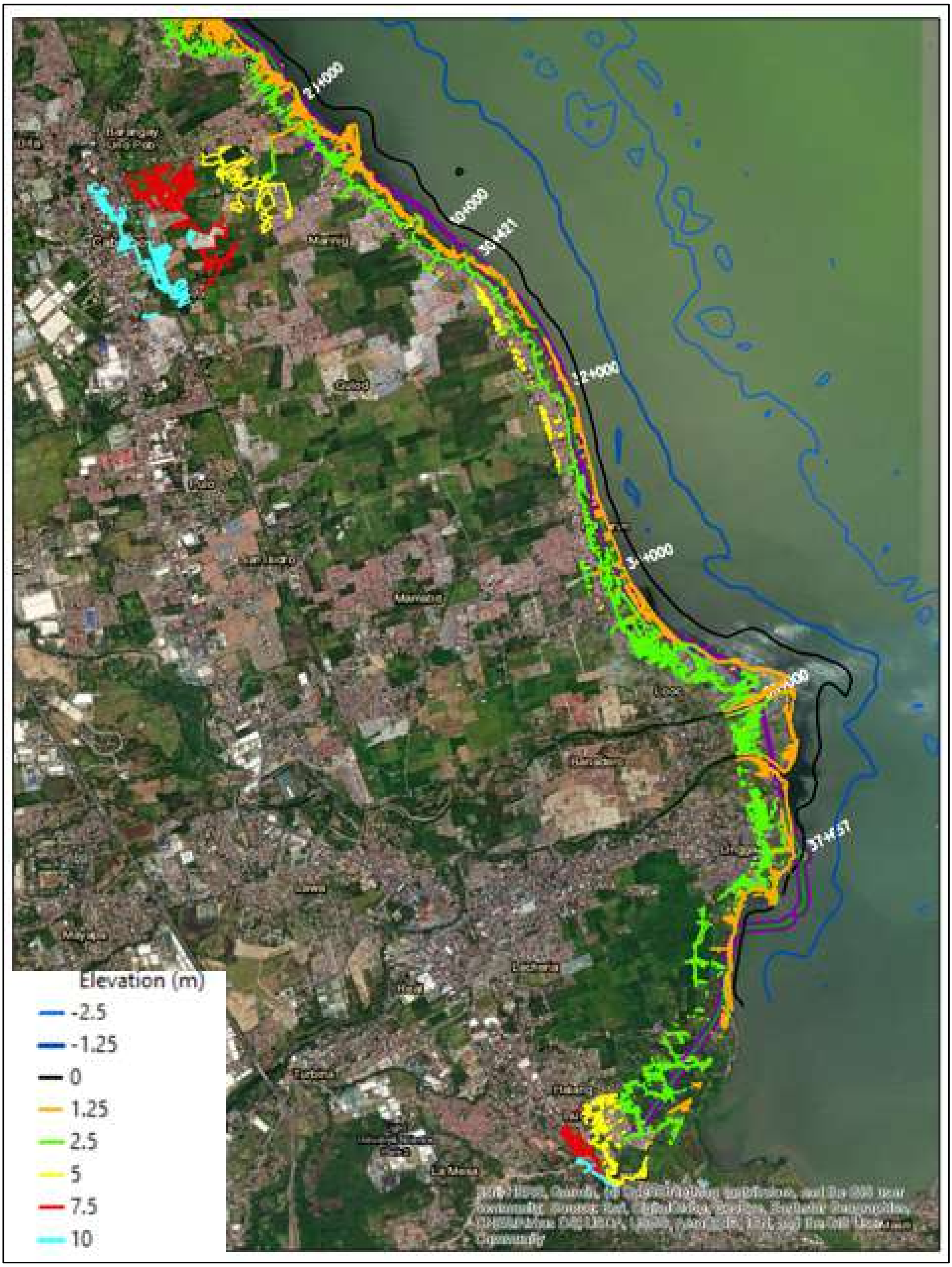

Figure 2- 28 Topographic map along LLRN - PH1 based on 2020 topographic survey (4)

Bedrock Lithology

Based on the 1:50,000-scale geological maps for the San Pedro and Calamba quadrangle published by MGB in 1983 and 1996 respectively (**Figure 2- 29**), the bedrock of the that can be observed along the proposed alignment is the Diliman Tuff of the Guadalupe Formation (**Figure 2- 30**).

Results of the ground investigation campaign conducted last 2020 are discussed in the next section of this report. From the results of the ground investigation campaign, the bedrock at the northern section was observed at about 41m depth. The southern portion of the alignment in Laguna showed that the bedrock is quite deep and was not observed even at 50m deep boreholes.

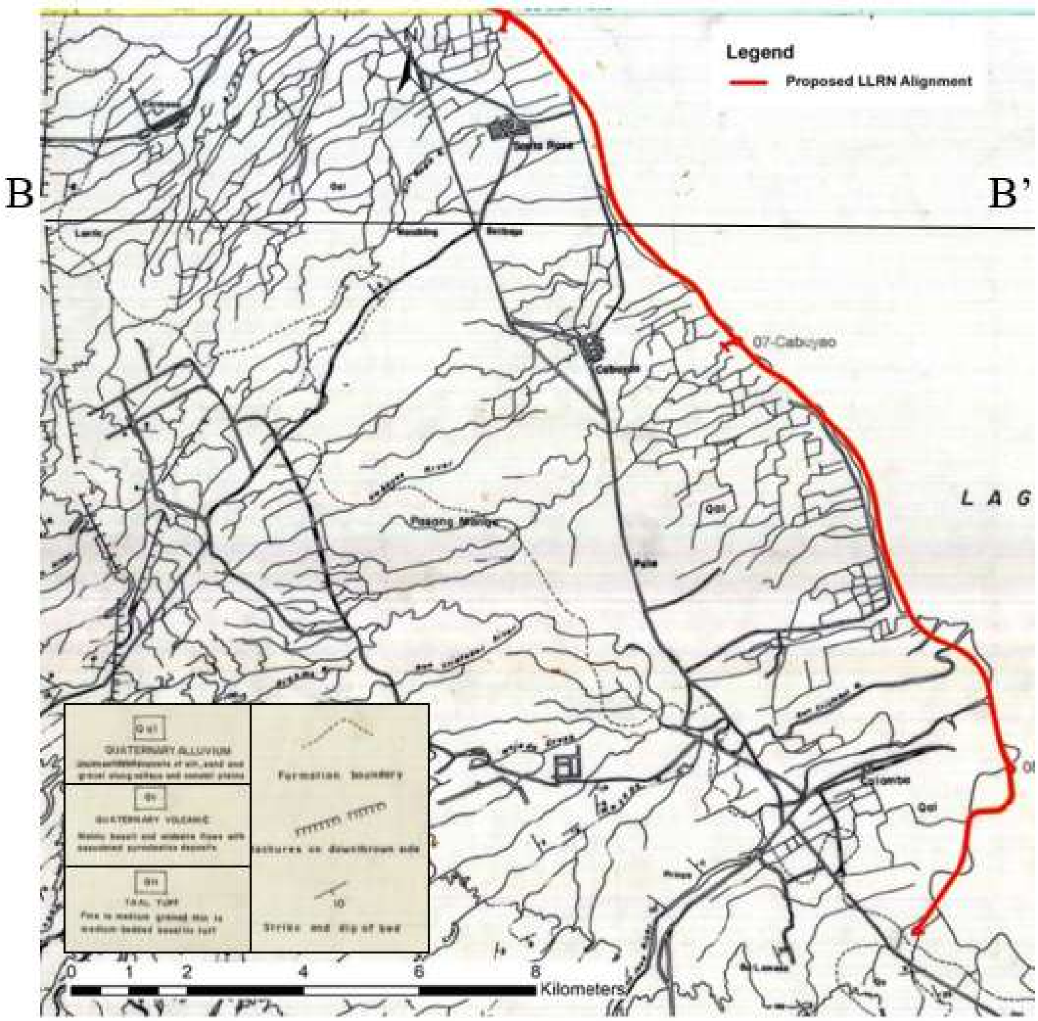

Figure 2- 29 1:50,000-scale Geological map of the project area [Sheet Nos. 3263 III] top and [Sheet Nos. 3262 IV] bottom (Source: MGB)

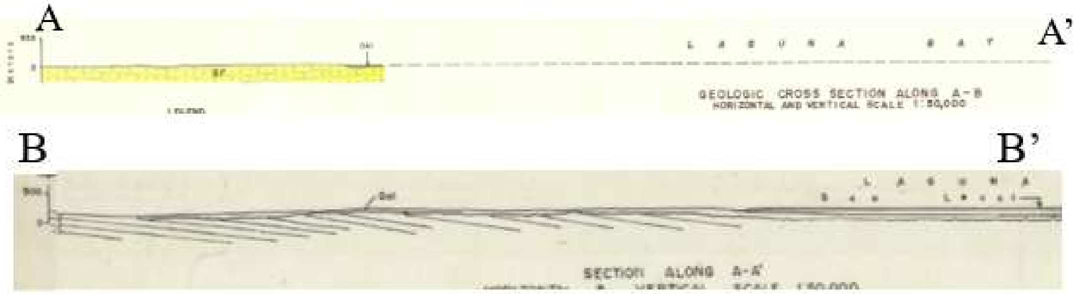

Figure 2-30 Geological Cross Sections along A-A' (top) and B-B' (bottom)

Surficial Deposits

Based on the 1:50,000-scale geological maps for the San Pedro and Calamba quadrangle published by MGB in 1983 and 1996 respectively (**Figure 2-29**), the surficial deposit along the proposed alignment is Quaternary Alluvium (**Figure 2-30**).

The succeeding sections of describe in detail the results of the ground investigation campaign conducted as part of this project in 2020. From the results of the ground investigation campaign, the surficial deposits consist of alternating sands and clays of different densities. It was also noted that the southern portion of the alignment in Laguna showed that the surficial deposit is quite deep that extends to about 50m deep.

2.1.3 Geological Hazard Assessment

2.1.3.1 Seismic-Related Hazard

One of the most predominant hazards in the Philippines is earthquake-related, also known as seismic hazards. Owing to the complex tectonic setting of the country, numerous active faults and other geologic structures crisscross the archipelago. The active faults and subduction zones are usually the loci to produce ground tremors of large enough magnitude to endanger surrounding communities. The earthquake-related geohazards include ground shaking, ground rupture, liquefaction, lateral spreading, etc. This section addresses the different impacts caused by earthquake on the proposed project considering the present tectonic and geological conditions of the area.

2.1.3.2 Seismicity

The Philippines archipelago is dissected by several major faults. Review of tectonic setting and various active fault traces (provided by PHIVOLCS) suggests that the seismic hazard of proposed LLRN - PH1 is mainly contributed by subduction (both inter- and intra-slab) of the Eurasian Plate along Manila Trench, active faulting along the Valley Fault System and the Philippine Fault Zone. There have been many large historical earthquakes (magnitude greater than 6) that have occurred near the Site.

The seismic hazard at LLRN - PH1 is largely contributed from Marikina Valley Fault System and Philippine Fault Zone (Infanta and Guinayangan Segment). The location of the active faults and past earthquake events are shown in following Figures. Historical earthquakes documented near LLRN - PH1 include the 1658- (Mw=5.9), 1771- (Mw=5.4), 1743- (Mw = 6.6), 1830- (Mw = 6.3) and 1937-earthquake (Mw = 7.6) as presented in **Figure 2- 31**.

The 1658- and 1771- earthquakes were documented to occur in Manila and they were associated with Valley Fault System. The 1830- and 1937-earthquakes, occurring about 40-50km to the east of LLRN - PH1, were related to the Infanta and Guinayangan Segments of the Philippine Fault Zone.

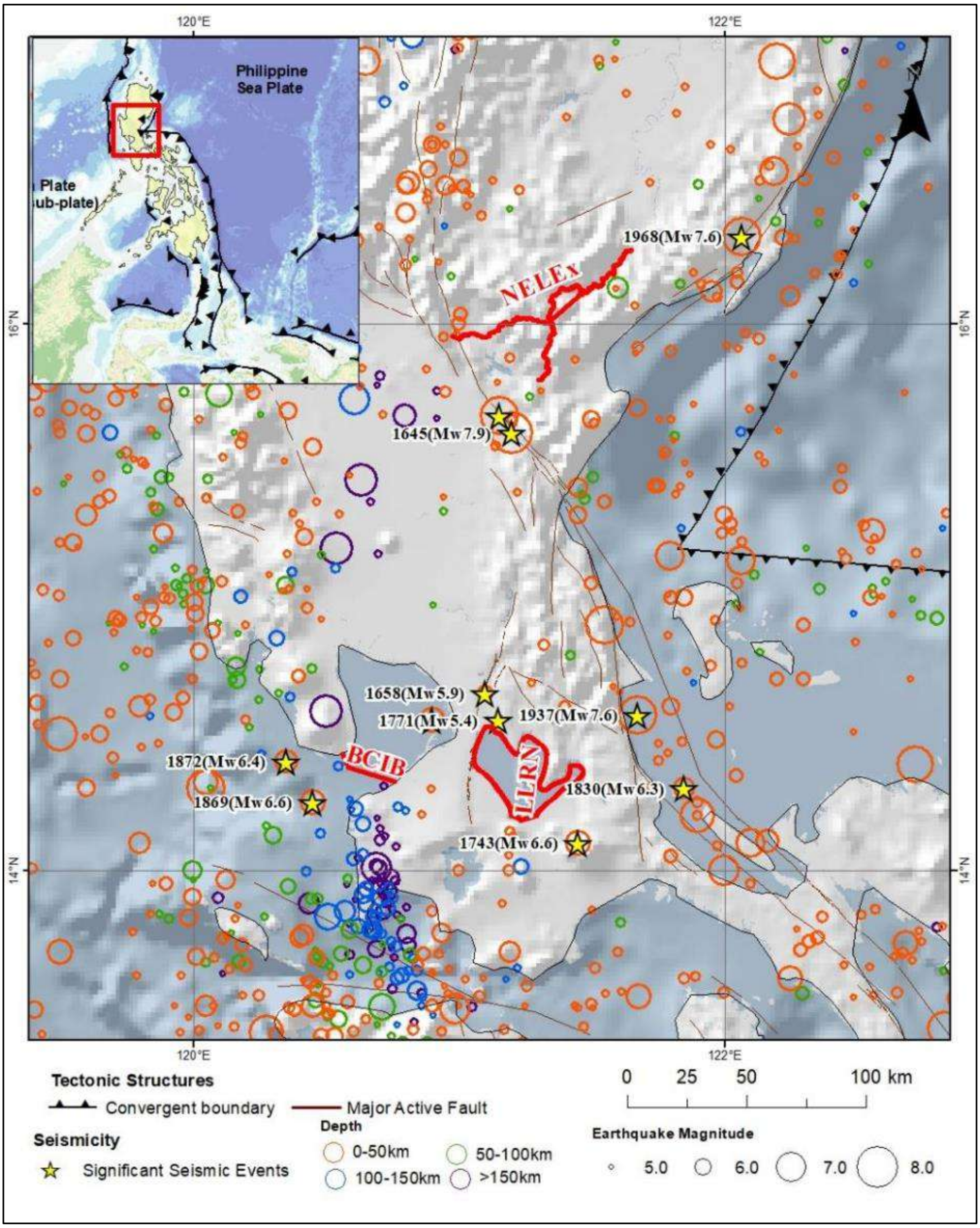

Figure 2- 31 Seismicity compilation map of National Capital Region (NCR) in year 2016 (Source: PHIVOLCS)

2.1.3.3 Ground Rupture and Fault Creep

Ground rupture or fissures can be a major risk to the civil structures. This type of ground displacement usually occurs on pre-existing faults and relatively rare on entirely new fault.

The ground rupture hazard is high when a civil structure or building is near a known active fault, which will significantly affect the stability of the structures or even complete failure or collapse. Fault creep is less hazardous than fault rupture, but the ground offset at very low slip rate can be still able to result in significant damage to infrastructure.

The active fault map developed by the Philippines Institute of Volcanology and Seismology (PHIVOLCS) indicates that the proposed alignment is in close proximity to the N-S trending active fault, namely the West Valley Fault in Valley Fault System (**Figure 2-30**).

Indeed, the proposed alignment runs sub-parallel to the fault for much of its length with the northern portion situated only about 500 m to the east of the fault while the southern portion is located up to about 12 km away from it.

Figure 2-32 Extent of active fault near proposed alignment (PHIVOLCS, 2019)

2.1.3.4 Ground Acceleration

Ground shaking is the most noticeable effect of earthquakes and it is also one of the most destructive to rigid civil projects. Vibrations transmitted by seismic waves in vertical and horizontal directions cause significant stresses within concrete and steel structures that are inherently stiff materials. Ground movements that exceed the allowable thresholds of dynamic movement of these structures result in instability and damage, which may ultimately lead to collapse and destruction. One of the most active earthquake generators in the country is the Philippine Fault Zone which has a history of producing large magnitude earthquakes of ≥M7.0.

Ground motion, as it relates to movement that will be affected on objects above ground, can be represented as the peak ground acceleration (PGA) which is the movement experienced on the ground, and spectral acceleration (SA) which is approximately movement experienced by a structure elevated above ground such as buildings or bridges.

The mandated agency, PHIVOLCS, has developed a Philippine Earthquake Model (PEM) which gives PGA maps by Probabilistic Seismic Hazard Analysis (PSHA) for the whole country. Based on these maps, the location of the LLRN - PH1 will likely experience 0.4g, 0.5g, and 0.5g for rock site areas at return periods of 500, 1000 and 2500 years, respectively (**Figure 2-33** to **Figure 2-35**). For areas with stiff soils, it is modelled that the LLRN - PH1 location will have an expected PGA of 0.4g in 500-year return period events.

PEM also gives the SA maps of different structural periods and indicates that SA of 0.2s, 0.5s, 0.8s, 1.0s and 3.0s for LLRN - PH1 are 1.6g, 1.5g, 1.1g, 1.0g and 0.1-0.15g respectively at the stiff soil at 500-year return period (**Figure 2-36** to **Figure 2-41**)

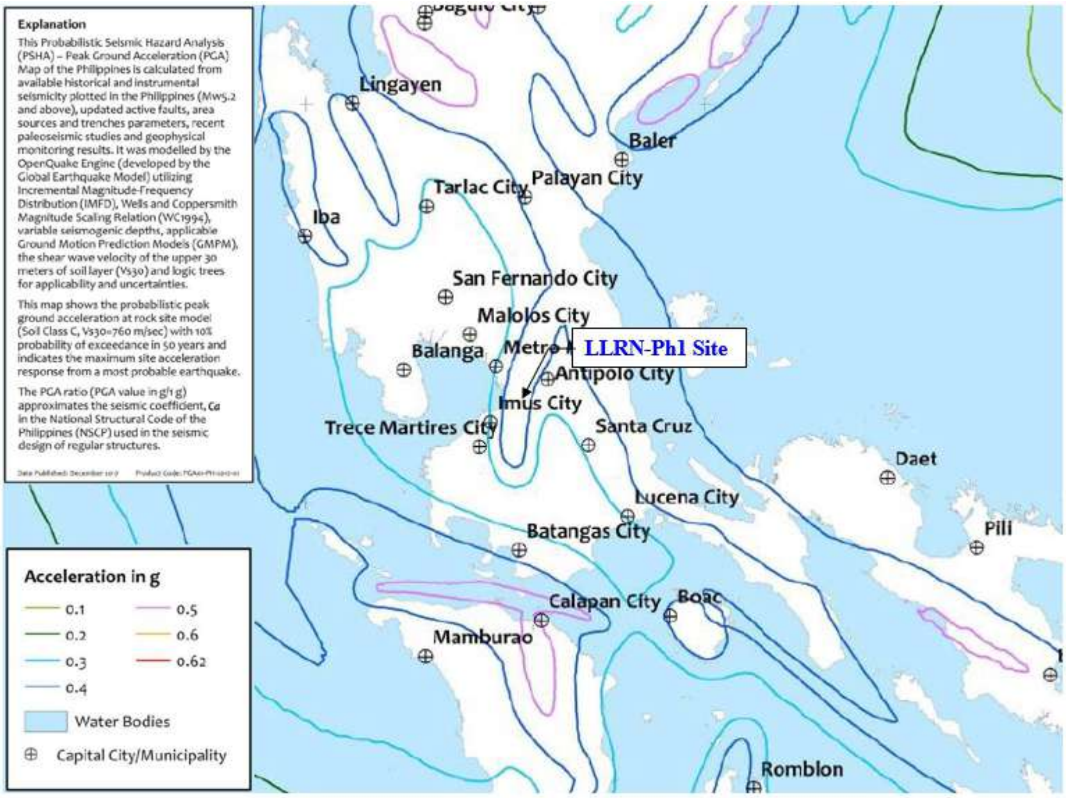

Figure 2- 33 Extract of the peak ground acceleration map of the Philippines for rock sites at 500-year return period (Source: PHIVOLCS)

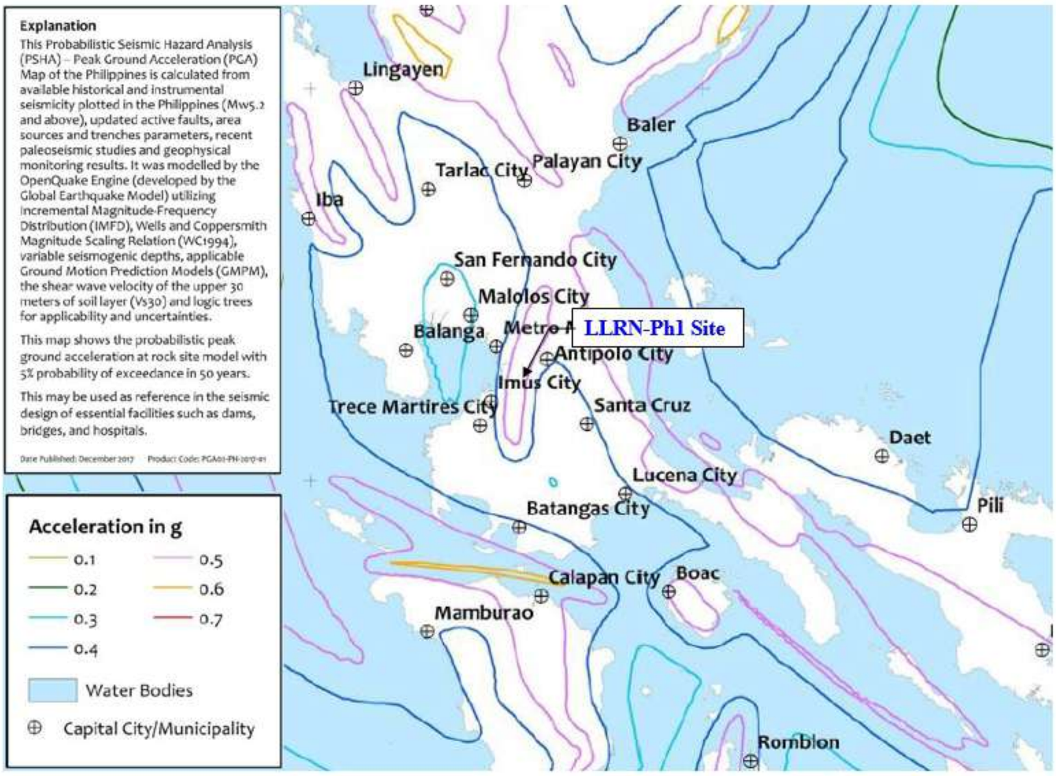

Figure 2- 34 Extract of the peak ground acceleration map of the Philippines for rock sites at 1000-year return period (Source: PHIVOLCS)

Figure 2- 35 Extract of the peak ground acceleration map of the Philippines for rock sites at 2500-year return period (Source: PHIVOLCS)

Figure 2- 36 Extract of the peak ground acceleration map of the Philippines for stiff soils at 500-year return period (Source: PHIVOLCS)

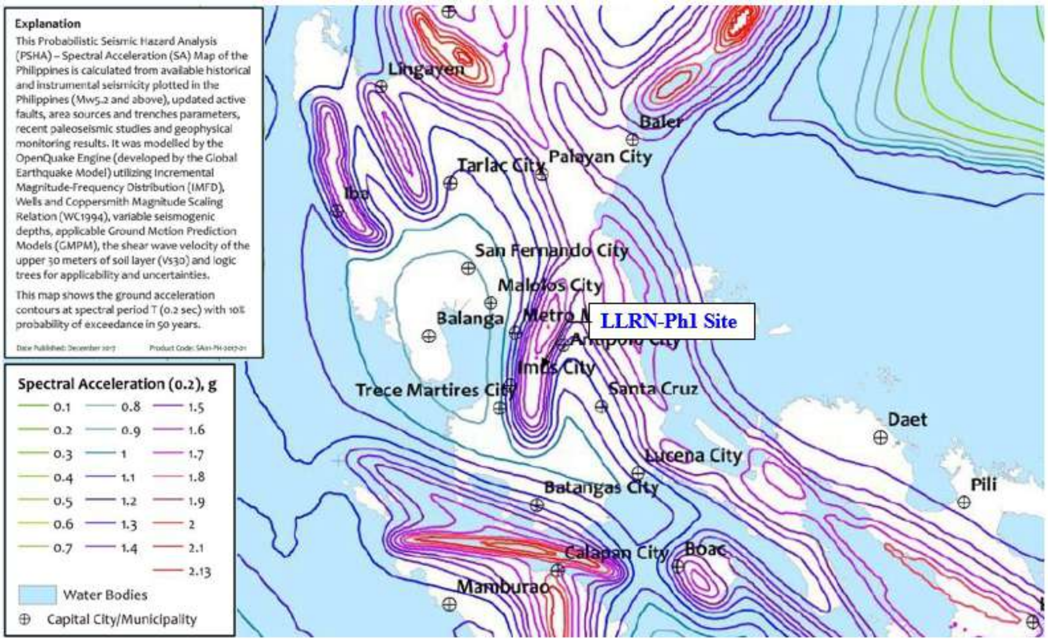

Figure 2- 37 Extract of the spectral acceleration map of the Philippine by PHIVOLCS SA (0.2 seconds) at 500-year return period on stiff soil

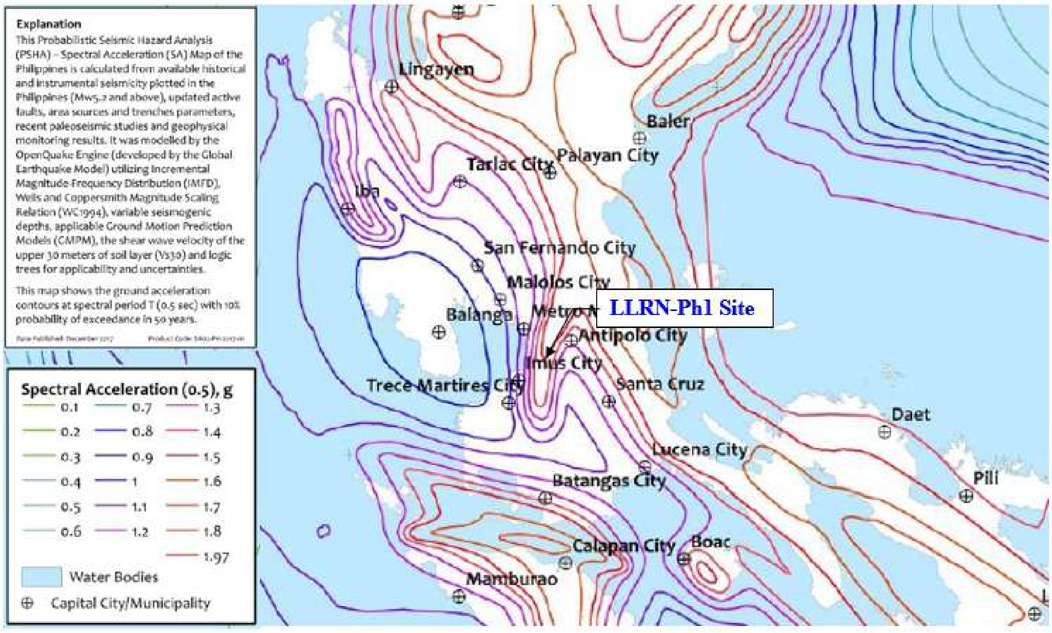

Figure 2- 38 Extract of the spectral acceleration map of the Philippine by PHIVOLCS SA (0.5 seconds) at 500-year return period on stiff soil

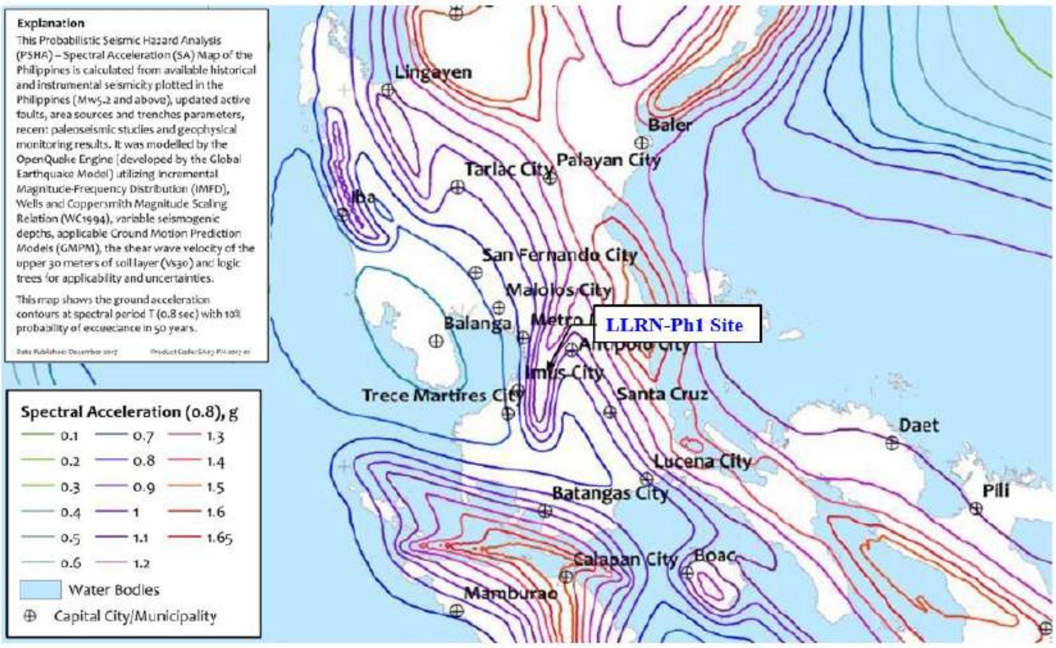

Figure 2- 39 Extract of the spectral acceleration map of the Philippine by PHIVOLCS SA (0.8 seconds) at 500-year return period on stiff soil

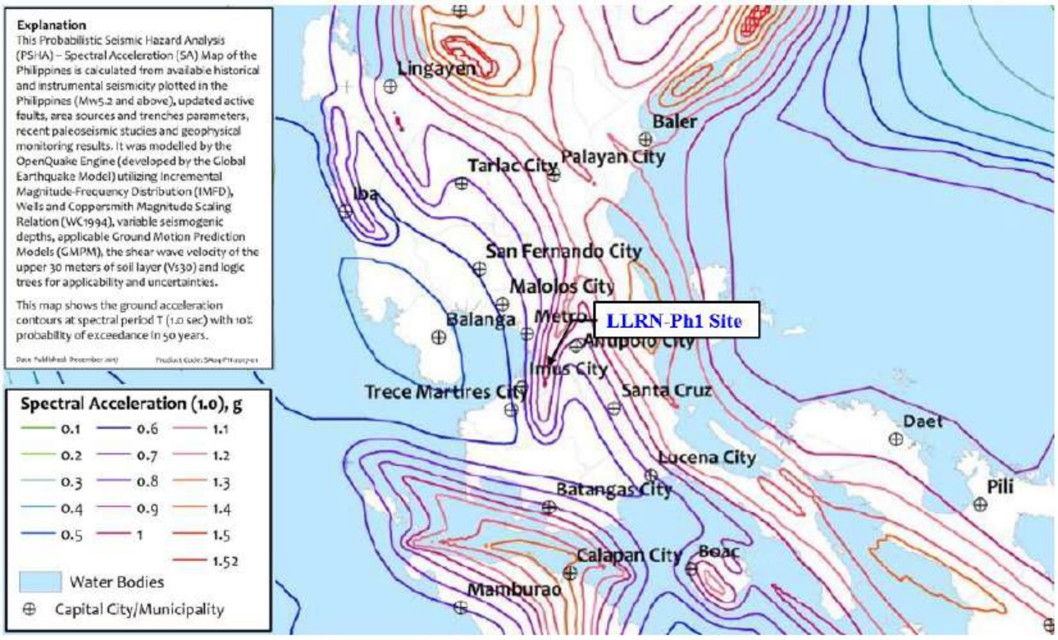

Figure 2- 40 Extract of the spectral acceleration map of the Philippine by PHIVOLCS SA (1.0 seconds) at 500-year return period on stiff soil

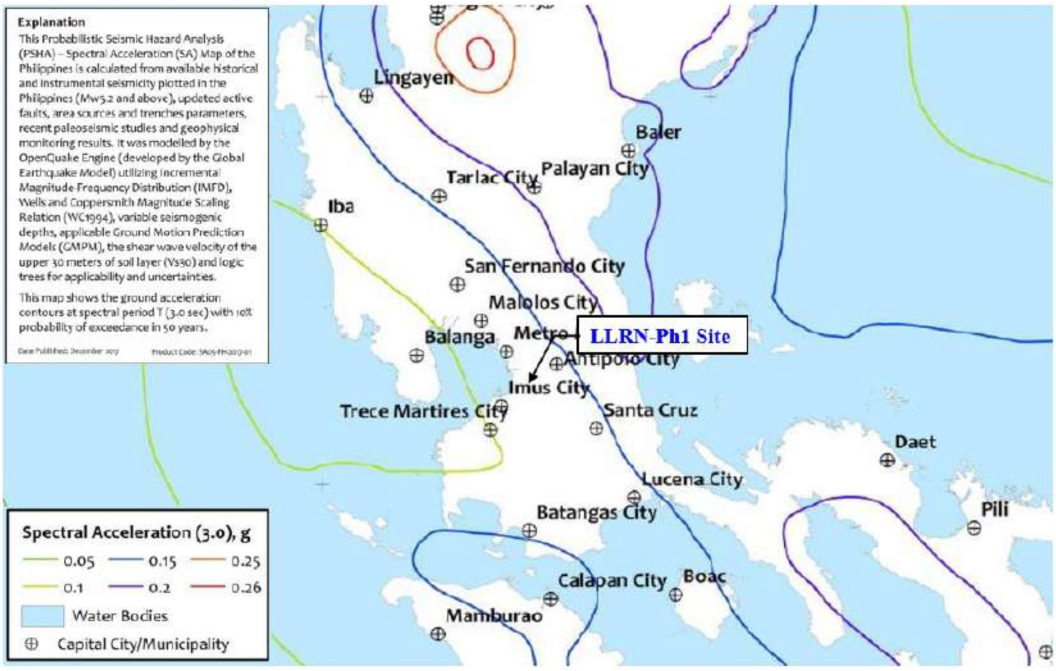

Figure 2- 41 Extract of the spectral acceleration map of the Philippine by PHIVOLCS SA (3.0 seconds) at 500-year return period on stiff soil

2.1.3.5 Liquefaction

Liquefaction is conventionally defined as the substantial loss of strength of a saturated cohesionless soil, typically because of earthquake-induced ground shaking. Loss of soil strength causes large differential settlements and can induce large forces in the structure.

DPWH Guide Specifications – LRFD Bridge Seismic Design Specifications 2013 (BSDS/2013) specifies the method of liquefaction assessment. Preliminary liquefaction assessment was carried out for the project based on the available GI information.

The available GI information suggests the presence of loose silty sand, which is susceptible to liquefaction. Preliminary liquefaction assessment has been conducted and the depth of liquefaction is generally up to 20m among the existing boreholes BH1 to BH10, and the liquefiable layer extends locally to 25m in depth at BH03.

The results of the SPT, Particle Size Distribution Analysis, and Atterberg's Limit Tests together with the consideration of a magnitude 7.6 earthquake and a peak ground acceleration of 0.6g as indicated in the Preliminary Design Response Spectrum in the next subsection were used in the assessment of liquefaction. Using the method developed by Idris & Boulanger (2008), results show that MS01 has a liquefiable layer at around 14 to 19m from the seabed surface.

The assessment of the 2020 GI information from BH01, BH02 and BH03, which were located at the southern portion of the alignment revealed that the upper 20m layer is susceptible to liquefaction with the considered seismic parameters. **Table 2.** shows the summary of susceptible layers for each borehole. FOS values less than 1.0 indicates liquefiability.

Table 2.10 Summary of susceptible layers to liquefaction per borehole

BH No	Depth		Layer Thickness (m)	Soil Type	FOS
	From	To			
BH01	3.00	4.00	1.00	SP	0.211
	13.50	15.00	1.50	SM	0.579
	16.50	18.00	1.50	Sand	0.603
BH02	1.00	2.00	1.00	SP-SM	0.203
	2.00	3.00	1.00	SP-SM	0.215
	3.00	4.00	1.00	SM	0.461
	4.00	5.00	1.00	Sand	0.554
	5.00	6.00	1.00	SM	0.531
	6.00	7.50	1.50	Sand	0.315
	9.00	10.50	1.50	Sand	0.104
	12.00	13.50	1.50	SM	0.144
	13.50	15.00	1.50	SM	0.169
	16.50	18.00	1.50	SM	0.312

BH No	Depth		Layer Thickness (m)	Soil Type	FOS
	From	To			
BH03	9.00	10.50	1.50	SM	0.382
	10.50	12.00	1.50	Sand	0.578
	12.00	13.50	1.50	SM	0.511
	15.00	16.50	1.50	Sand	0.905
	18.00	19.50	1.50	SP-SM	0.499
MS-01	13.00	14.50	1.50	SM	0.202
	16.00	17.50	1.50	SM	0.187
	17.50	19.00	1.50	SM	0.212

Furthermore, it can be seen in **Table 2.10** the types of soil which can undergo liquefaction are predominantly of sand and silty sand materials, which seem to match with the nature of Aeric Fluvaquents soil.

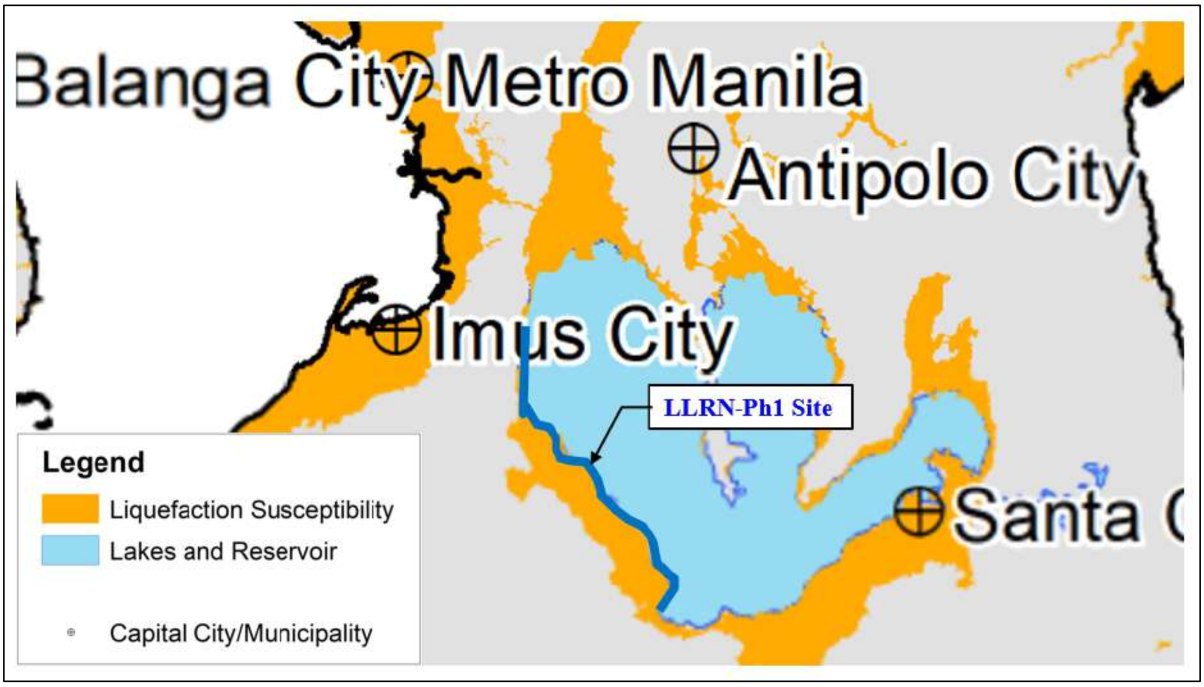

Figure 2- 42 Liquefaction Susceptibility Map (Source: PHIVOLCS)

2.1.3.6 Lateral Spreading

Liquefaction-induced lateral spreading is defined as lateral displacement of gently sloping induced by liquefaction and this may impact the stability of the viaduct and embankment. This phenomenon typically occurs on the gentle sloping ground near a waterfront which is widely underlain by considerable thickness of liquefiable soils. Along the LLRN - PH1 alignment, the site is underlain by liquefiable soils located in a gently sloping terrain adjacent to a waterbody that may be prone to lateral spreading.

2.1.3.7 Seiches

Seismic activity has the potential to generate hydrological hazards, including tsunamis and seiches. These two terms are defined as:

- **Seiche**

A seiche is an oscillating standing wave set up by external forces (e.g. wind or earthquake ground motion) in an enclosed or semi-enclosed water body such as a lake. Seiches travel back and forth across the water body at regular periods determined by the depth and size of the water body. Seiches can continue after the originating force has ceased.

The difference between a tsunami and a seiche is generally poorly defined, and at times used interchangeably in literature when referring to seismically generated waves within an enclosed water body. In this report we will refer to waves set up in the lake due to direct disturbance of the lake floor as a tsunami (e.g. landslides, submarine slumps, and fault rupture of the lakebed would be direct changes to the lakebed). Waves set up in the lake by an external agent (e.g. seismic waves propagating from a distant earthquake) will be referred to as a seiche. Waves generated by co-seismic tilting of the lakebed shall also be classified as a seiche in this report.

In accordance with the definitions provided above, the chance of a large, damaging tsunami impacting the LLRN - PH1 alignment is considered to be relatively low. The Marikina Valley Fault System and Philippine Fault Zone are located west and east of Laguna de Bay respectively and have the potential to generate significant seismic hazards for LLRN - PH1. However, neither of these fault zones fall within the lake footprint and so cannot generate a tsunami from fault rupture. The lake is very shallow, and the surrounding terrain is relatively flat, and so aerial or submarine landslides of large enough volume to generate a significant tsunami are considered unlikely. Local failures from the surrounding hillside may generate minor tsunami-like waves.

Seiches generated by ground shaking is possible in Laguna Lake as the lake is surrounding by a few seismic sources which can generate intense ground motion. For example, a seiche event in 18 July 1880 was documented in PHIVOLCS (2012) and this event was associated with a M7.6 earthquake along the Philippine Fault Zone. Nonetheless, the amplitude of seiches is typical small unless resonance occurs if the frequency of the seismic waves matches one of the natural periods of oscillation of the waterbody.

As the depth of the waterbody is typically small in comparison to the wavelength, seiches are generally characterised by shallow waves. The velocity of the wave is given by the term $(gh)^{1/2}$, where g is the acceleration due to gravity and h is the water depth. The natural oscillation period of an enclosed, rectangular basin can be estimated from Merian's formula as shown in **Figure 2- 43** (Sheffner, 2008):

$$T_n = \frac{2L}{n\sqrt{gh}}$$

Where:

L = length of the basin

n = number of nodes in the standing wave

g = acceleration due to gravity i.e. 9.81 m/s

h = water depth

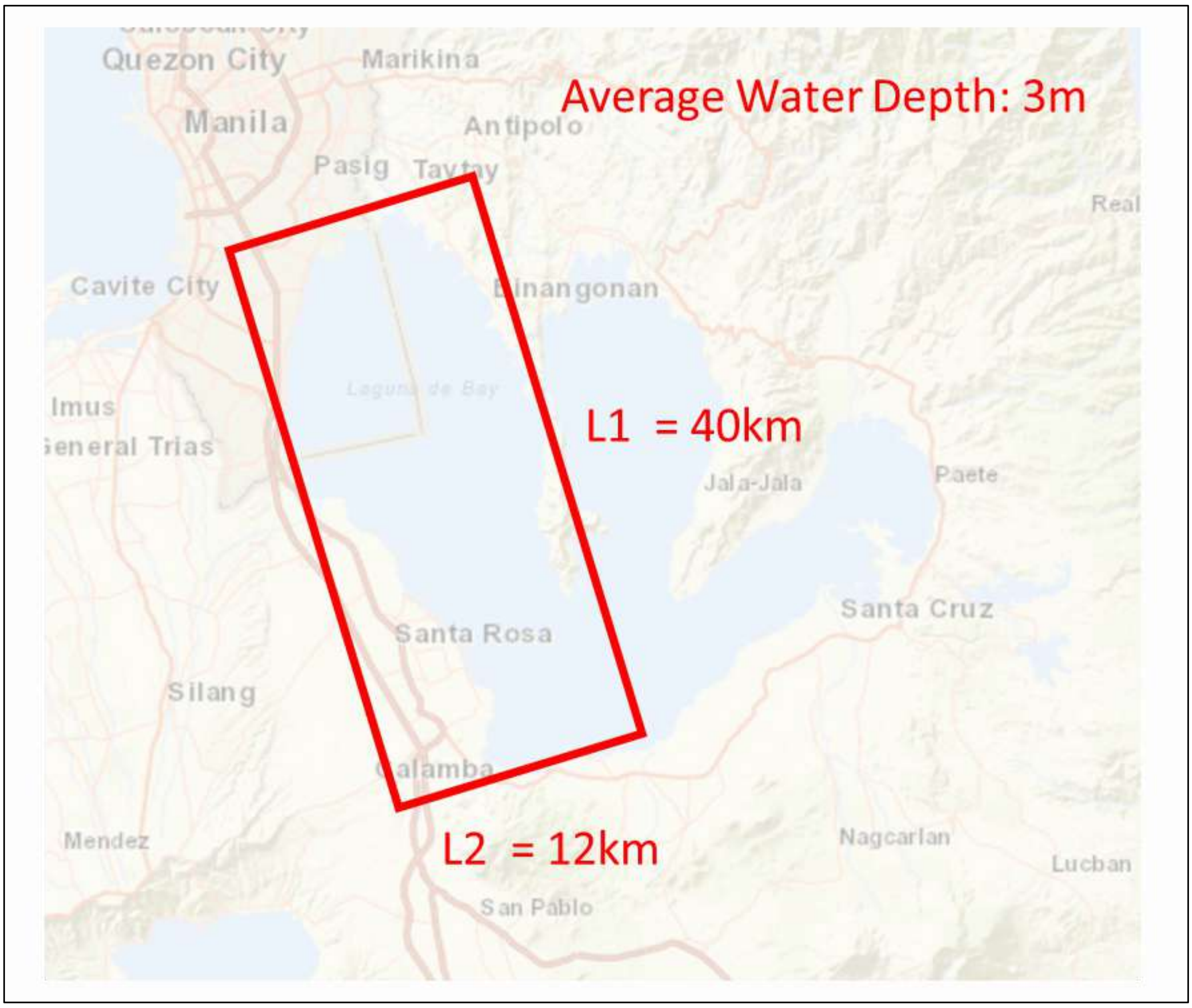

Figure 2- 43 Assumptions for Merrian's Formula

In addition, according to the PHIVOLCS Earthquake Intensity Scale[18], the occurrence of seiches is only mentioned under the most intense category: Completely Devastating (Intensity X). The effects of such an intense earthquake are described as *"practically all man-made structures are destroyed. Massive landslides and liquefaction, large scale subsidence and uplifting of landforms and many ground fissures are observed. Changes in river courses and destructive seiches in large lakes occur. Many trees are toppled, broken and uprooted"*. Based on a report "*Enhancing Risk Analysis Capacities for Flood, Tropical Cyclone Severe Wind and Earthquake for Greater Metro Manila Area*" (Badilla, et al, 2014), the maximum intensity in Greater Metro Manila Area was estimated to be of VIII during a West Valley Fault Scenario earthquake event. Hence, the occurrence of earthquake intensity of X within Laguna de Bay is highly unlikely.

Overall, the preliminary assessment contained above does not suggest that tsunamis or seiches within the lake will affect the feasibility of the LLRN - PH1 project. As mentioned in

[18] PEIS, website: https://www.phivolcs.dost.gov.ph/index.php/earthquake/earthquake-intensity-scale

other sections, the vertical highway alignment and structures have considered wave impacts and the risk of overtopping in relation to a storm-surge scenario, during a time of elevated water levels due to flooding. The highway is elevated to minimize overtopping within allowable thresholds, and the embankment slope angle and rock armour protection system are designed to mitigate any adverse impacts from such a wave. Similar measures are considered adequate at this stage for the hazards discussed in this section. However, the nature of the assessment is simplified, and more detailed numerical modelling should be undertaken to confirm these assumptions during Detailed Engineering Design – considering a combination of actual anticipated ground movement, water levels, slope instability, etc.

2.1.3.8 Volcanic Hazards

The Philippine Mobile Belt, which comprises most of the landmass in the Philippine Archipelago, is a geological amalgamation of ancient and young volcanic island arcs brought together by the tectonic movement of adjacent crustal plates. Adding to this, the country is situated along the major plate boundary between the Philippine Sea Plate and Eurasian Plate which constitute a segment of the Pacific Ring of Fire. This geologic setting resulted to the formation of numerous volcanic centres within the country, both active and inactive. Thus, the country is also very susceptible to volcanic hazards such as lava flows, pyroclastic flows, debris flow and avalanches, lahar, ashfall, tsunami, volcanic projectiles, volcanic gases, and volcanic earthquakes.

Ash Fall

The map of active volcanoes in the Philippines published by PHIVOLCS shows that the nearest active volcanic centres to the LLRN - PH1 project is the Taal Volcano and the Pinatubo Volcano, which is located approximately 30 kilometres to the southwest and 105 kilometres to the north northwest respectively. The closest potentially active volcano is San Cristobal which is about 31 kilometres southeast to the proposed alignment.

The dangers posed by volcanoes are associated with volcanic eruption. Hazard from volcanic eruption depends upon the magnitude of its explosion and distance to the eruption centre. Hazards associated with volcanic eruptions include pyroclastic flows and base surges, lava flows, lahars and the ash or tephra fall.

Considering the distance of the project to the active volcanoes, it is expected that the only volcanic hazard that could impact the development is ashfall. These fine materials are carried by the wind and the distances travelled by these are strongly influenced by wind and climate patterns, as well as the nature of the volcanic eruption. The far-reaching ash fall hazard may be a nuisance and reduce air quality but would not seriously affect the proposed project. Taking this into account, the final design of the LLRN - PH1 project will ensure that structures will not easily accumulate the ash fall on roofs and other civil works. Taal Volcano is closely monitored, and one would likely receive a few weeks warning of a possible eruption.

2.1.3.9 Mass Movement

One of the most ubiquitous geologic hazards in the Philippines are landslides or, technically, mass movements. This is mainly due to the variable topography with large areas of moderate to steep slopes, the lack of vegetative cover, thick weathering mantle and soils and the prevalence of geologic structures that contribute to the general weakness of rock and soil.

According to the landslide susceptibility map published by MGB, the proposed LLRN - PH1 alignment will be running through a relatively flat terrain at the western lakeshores of Laguna de Bay where the susceptibility to landslide is insignificant (**Figure 2-44**). Hence, it is expected that the hazards from mass movements would not significantly affect the proposed structures onshore. the DED will take into consideration the in-situ and site-specific geotechnical parameters that will be obtained during the detailed geotechnical investigation to ensure slope stability.

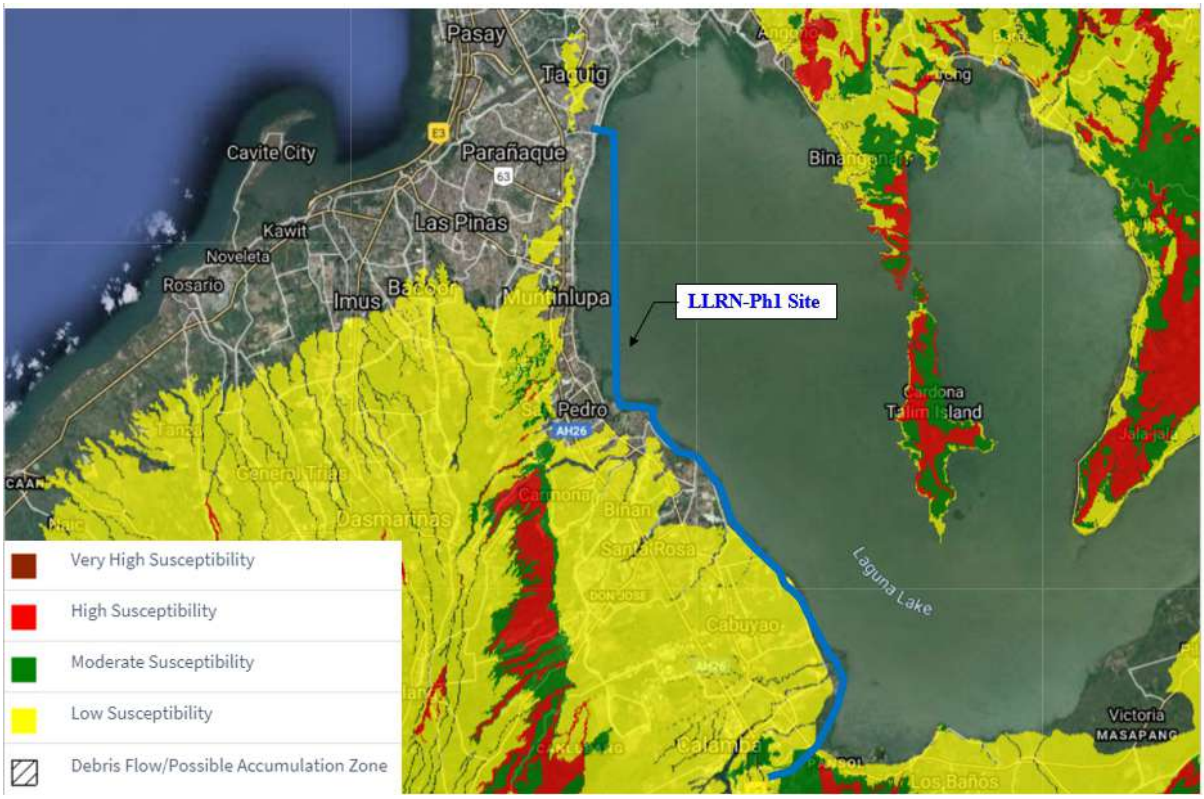

Figure 2-44 Landslides susceptibility map of MGB

2.1.3.10 Flooding Hazard

Flooding is a widespread hazard that is especially frequent in highly urbanized areas. Based on the flood susceptibility map published by the MGB (**Figure 2-45**), the alignment will transact areas where there are moderately to very high susceptible to flooding. This would suggest that the flooding in this area is mainly due to the rise of Laguna Lake.

Figure 2- 45 Flooding susceptibility map of MGB

Considering the susceptibility of the area to flooding, the final design for the approach of the LLRN - PH1 project will ensure that there is efficient flow and removal of surface water by establishing appropriate drainage canals. The elevation of the area and the proximity to the sea will also be considered in design and planning.

2.1.4 Pedology

Based on the Soil Survey Report for Rizal and Laguna published by the Bureau of Soils and Water Management (BSWM), the whole alignment is generally underlain by the Calumpang Series and Aeric Fluvaquents **Figure 2- 46**.

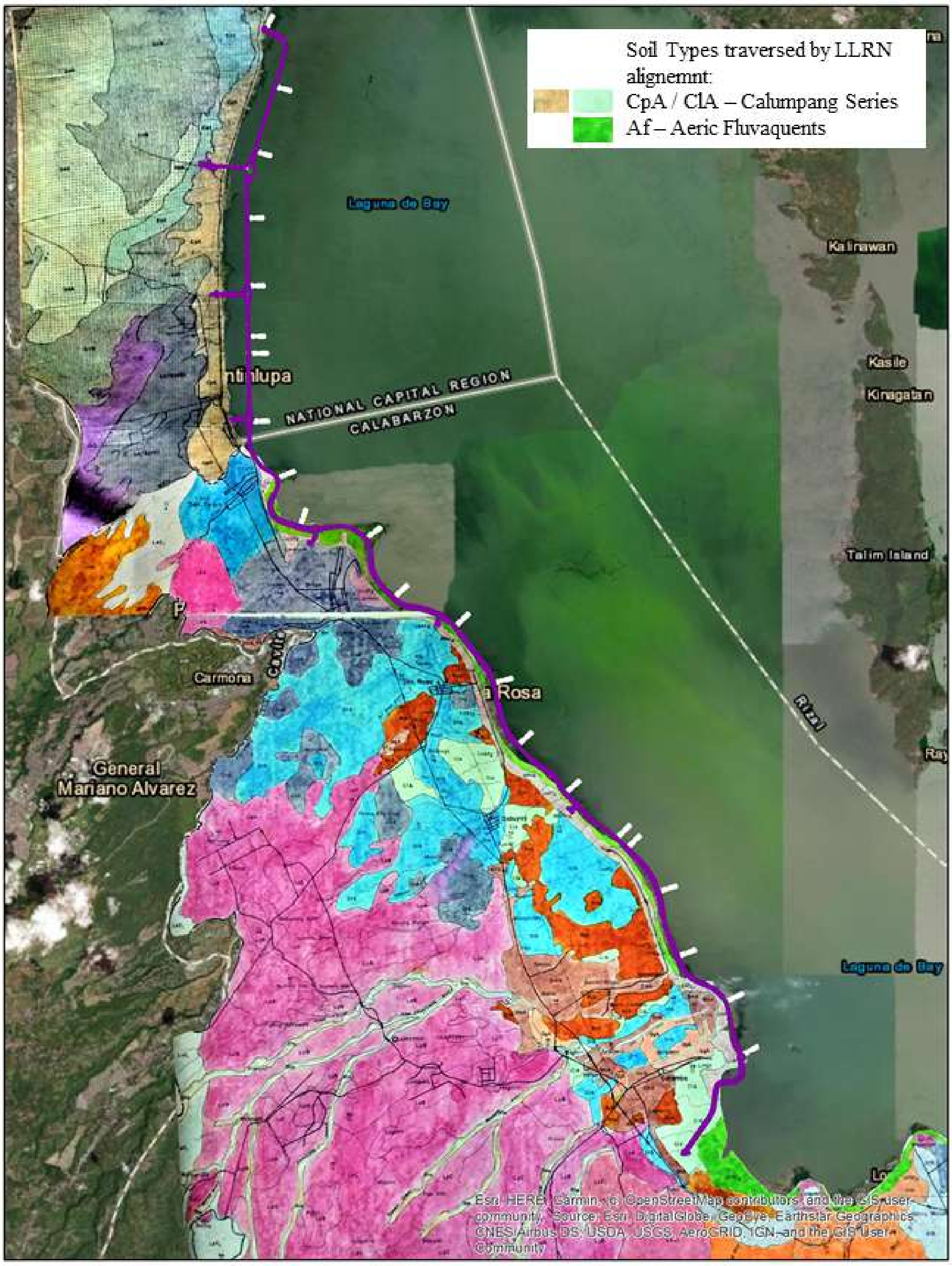

Figure 2- 46 Published Soil Type Map along the LLRN - PH1Alignment adapted from BSWM

The Aeric fluvaquents belongs to the great group of Fluvaquents. Soils under these Fluvaquents have an Aquic soil moisture regime and an isohyperthermic temperature regime. The soils are mixture of alluvial sediments of sand, silt and clay incorporated sometimes with plant residues and lacustrine shells. The soil texture is fine, loamy, poorly drained, saturated and under water most of the time.

On the other hand, the soils in Calumpang Series is a member of the fine clayey, montmorillonite isohyperthermic family of Aeric Tropaquepts. They are very deep, poorly drained soils occurring on nearly level to level slopes (0.0 to 2.0 percent) on minor alluvial plain landscapes. They are developed from fine clayey, alluvial sediments deposited usually over tuffaceous rock or adobe. It is poorly drained soil with moderate hydraulic conductivity and the basic infiltration rates.

Structural Features

From the geologic maps presented, the Diliman Tuff is generally horizontally bedded. However, pair of synclines and anticlines trending northeast was observed in Sucat and Alabang interchanges. Synclines and anticlines trending northeast to east were also observed in Tunasan and San Pedro interchanges. The most notable feature near the alignment is the West Valley Fault that is a north south trending right-lateral strike-slip fault. This fault has a normal component were the downthrown side was observed dipping to the east.

2.1.5 Terrestrial Ecology

2.1.5.1 Methodology

Conduct of terrestrial (flora and fauna) biodiversity assessment is to be able to evaluate the significant impacts of the project to the environment, especially the ecosystem covered by the proposed project development. The study presents the results of the terrestrial biodiversity assessment conducted on 28 January-01 March 2021 following the proposed LLRN alignment. Assessment starts at Taguig, Muntinlupa, San Pedro, Biñan, Sta. Rosa, Cabuyao, Calamba to Los Baños.

This report provides a thorough study focusing on the existing flora and fauna of the project area and key species for conservation, with the intention of identifying potentially significant environmental impacts, and in identifying appropriate mitigating measures.

The Philippines is one of the mega-diverse countries containing two-thirds of the earth's biodiversity and between 70% and 80% of the world's plant and animal species. Due to its diverse habitats, endemism in the country is very high covering at least 25 genera of plants and 49 percent of terrestrial wildlife. The country ranks fourth in bird endemism. However, it is also one of the world's hotspots, with a wide range of threatened terrestrial ecoregion, with at least 700 threatened species. The proposed alignment of the Project will traverse to a relatively high density residential and commercial areas in Metropolitan Manila and Province of Laguna. The most notable ecological area near the proposed project alignment is the Mount Makiling Forest Reserve (MMFR) which is approximately 2.0 - km away and the Las Piñas-Paranaque Critical Habitat and Ecotourism Area (LPPCHEA), now known as the Las Piñas-Parañaque Wetland Park (LPPWP), the Laguna de Bay and the Tadlac Lake (also known as Alligator Lake) with approximately 8.96 - km away fro the main project alignment.

Mt. Makiling's beauty and ecological importance have been recognized for a long time. In 1910, the government issued Proclamation 106, establishing the Mt. Makiling Forest Reserve (MMFR). MMFR spans a total of 4,244 hectares that lies within the 65 - km southeast of Metro Manila. MMFR caters diverse flora from a large number of endemic families, genera and species that include many fascinating forms. Rabor (1977) as cited by Replan (2020), reported at least 50 species of mammals, 120 bird species, six species of amphibians, 19 types of reptiles and several varieties of fish inhabiting the reserve. The area also contains at least 7,000 insect species. There are also some introduced species from several parts of the world but have already naturalized after lengthy years of existence in the area. MMFR also serves as a habitat for a number of threatened species in the wild as per International Union for Conservation of Nature (IUCN) and Department of Environment and Natural Resources Administrative Order (DENR-DAO) 2007-01.

The Las Piñas-Parañaque Critical Habitat and Ecotourism Area (LPPCHEA), now known as the Las Piñas-Parañaque Wetland Park (LPPWP), is the first declared critical habitat in the country under Presidential Proclamation 1412 issued on April 22, 2007. The proclamation is meant to underscore the conservation and protection of threatened local and migratory wild birds as well as the area's wetland condition. Among these threatened species of birds are the endemic Philippine Duck (*Anas luzonica*) and Chinese Egret (*Egretta eulophotes*) – both listed Vulnerable under the International Union for the Conservation of Nature (IUCN). On January 31, 2008, Presidential Proclamation 1412-A was issued amending the former, to include the protection of important habitats in the area such as the lagoons, mudflats, mangrove forest, and other wetland ecosystems. Aside from the above-mentioned species, the LPPWP is also home to an array of resident and migratory birds. Per the Asian Waterbirds Census (AWC) data collected from the year 2004 to present, around 84 species of birds including 47 species of waterbirds were recorded on site, with earlier reported sightings of about 5000 heads of birds per day. Also found on site is around 36 hectares of mangrove forest represented by 12 species and associates. This is said to be the densest mangrove community along Manila Bay. One hundred fourteen (114) hectares of mudflats and lagoons which serve as a critical feeding and roosting ground for waterbirds are also among the variety of habitats boasted by this urban ecosystem. Having recognized the LPPWP's importance not only locally but in the global ecological perspective as well, the then critical habitat was designated as a wetland of international significance by the Ramsar Convention on March 15, 2013. Five years after, by virtue of Republic Act No. 11038, otherwise known as the Expanded National Integrated Protected Areas System (ENIPAS) Act of 2018, the area was established as a Protected Area and now managed by the LPPWP Protected Area Management Board (PAMB).

Laguna de Bay is the largest lake in the Philippines with a total surface area of approximately 900 square km. Laguna de Bay located east of Metro Manila between the provinces of Laguna to the south and Rizal to the north. The Lake's only outlet controls the flow to the Pasig River that discharges into Manila Bay. During the dry season, the lake water level may fall to a minimum elevation of 10.5 - m (corresponding to mean sea level), leading to the intrusion of seawater. With this flow reversal also highly polluted water from the Metro Manila area is carried to the lake. Its dominant use at present is for fishery, both open water fishing and aquaculture. It is also part of the flyway of migratory birds for shelter and food.

As to the above-mentioned important biodiversity sites which constitute the habitat for any endangered or threatened species of Indigenous Philippine wildlife (Flora and Fauna), it is of interest to note that the Project will not traverse any habitat of endangered or threatened species of Indigenous Philippine wildlife. Identified nearest protected area is the Mount Makiling Forest Reserve (MMFR) located at Los Baños, Laguna which is about 2.0-km from the alignment while LLPCHEA as critical habitat for migratory birds and vast mangrove stands which is 8.96 km away from the project alignment (see **Figure 2-47**).

Figure 2- 47 Map showing critical habitats near the LLRN alignment (QGIS 3.14.16)

2.1.5.2 Baseline Environmental Conditions

Terrestrial Flora

Project site characteristics

The project alignment traversed a developed, disturbed, and maintained areas and is surrounded by heavy industrial facilities, residential areas, and infrastructures (see land cover map below). Hence, it is expected that no actual or significant difference in terms of data gathering during the dry or wet season. Also, species composition from plant diversity assessment does not solely rely on physical factors, specifically climate or weather data, or does not arrest the fact that there are more diverse species during the wet season only.

Coordination Meeting

Coordination meeting was conducted with the concerned LGUs and solicited some assistance prior to the actual field assessment along LLRN project.

Figure 2- 48 Coordination meeting in Brgy. Aplaya, Sta. Rosa, Laguna.

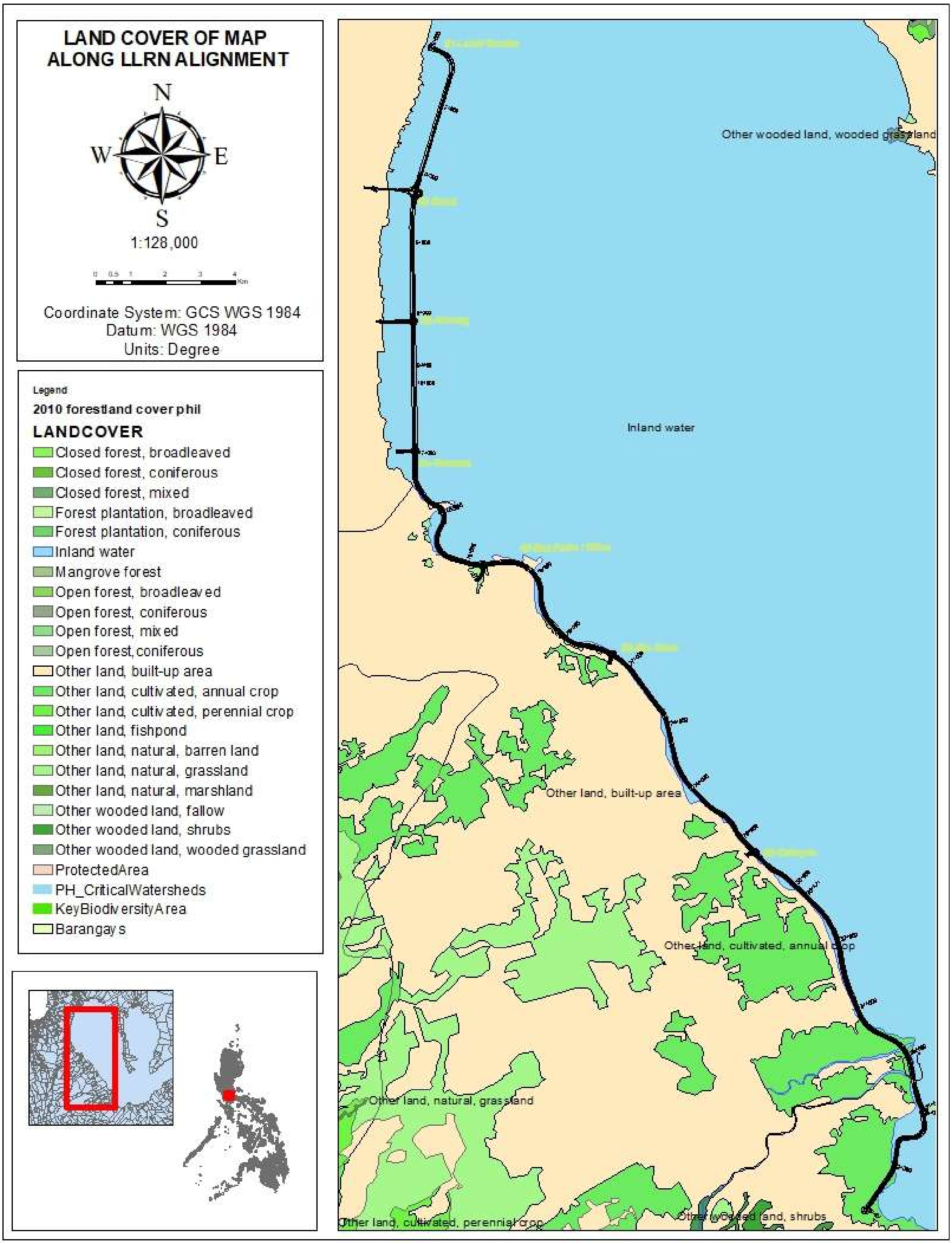

Figure 2.49 Land Cover Map along the LLRN alignment

Flora Assessment

Modified belt-transect method (BAMS, 20017) wherein twenty (20) quadrats (at most 3 sampling plots per municipality) measuring 20m x 20m were laid out along the 40km transect alignment at every 250 m interval of LLRN alignment. Nested quadrat sampling technique was used to assess and characterize the structure and species composition. For large woody plants whose diameter is equal or greater than 10 cm, measurements of diameter at breast-height (dBH), merchantable height (MH), and total height (TH) were done inside the 20 m x 20 m quadrat. Frequency of shrubs, poles, and saplings inside the 5 m x 5 m quadrat was counted to account for the intermediate species, while percentage cover of understorey species (grasses and other plants below 1 m in height) inside the 1 m x 1 m quadrat was determined. For this study, the terrestrial ecology assessment was conducted from January 21- February 2, 2021.

Information gathered in the field were tabulated and analyzed to characterize floral composition within the study area. The relative density, relative dominance and relative frequency values for each tree species were determined to obtain their Importance Value (IV), which is the standard measurement in ecology to determine the rank relationships of species. Also, the relative frequency, relative density and relative dominance indicate different aspects of the species importance in a community. Importance values were determined using the following formula:

$$\text{Density} = \text{number of individuals} \div \text{project area}$$

$$\text{Relative Density} = \frac{\text{density for a species}}{\text{total density for all species}} \times 100$$

$$\text{Frequency} = \frac{\text{number of plots in which species occur}}{\text{total number of plots sampled}}$$

$$\text{Relative Frequency} = \frac{\text{frequency value for a species}}{\text{total frequency for all species}} \times 100$$

$$\text{Dominance} = \frac{\text{basal area or volume for a species}}{\text{area sampled}}$$

$$\text{Relative Dominance} = \frac{\text{dominance for a species}}{\text{total dominance for all species}} \times 100$$

$$\text{Importance Value} = \text{Relative Density} + \text{Relative Frequency} + \text{Relative Dominance}$$

Diversity indices (Shannon, Simpson's and Evenness) for each sampling quadrats were generated using Paleontological Statistical software package for education and data analysis (PAST version 3.12). Moreover, endemism and ecological status of the different species were assessed to determine the ecological importance of the vegetation in the area. Plant classification followed the latest Angiosperm Phylogeny Group classification (APG IV, 2016) while the common names adapted that of Rojo (1998).

Figure 2.50 Some photos of tree flora assessment along LLRN alignment.

Figure 2.51 Some photos of ground cover assessment along LLRN alignment

Diversity Indices

Diversity indices are the measure of species diversity about richness in a forest community. The indices calculated for this study included Shannon Wiener Index of Biodiversity (H’) and Index of Evenness (J’) and Dominance.

i. Species Richness

It is the number of different species represented in an ecological community, landscape or region. Species richness is simply a count of species, and it does not take into account the abundances of the species or their relative abundance distributions.

ii. Shannon Diversity Index (1949)

$$H' = \sum_{i=1}^{S} pi \ln pi$$

Where:

H’ = Species diversity index
S = The number of species
Pi = The proportion of individuals of each species belonging to the with species of the total number of individuals

iii. Simpson's Diversity Index

$$SID = 1 - D$$

Where:

N = the total number of organisms of all species
n = the total number of organisms of a particular species

iv. Index of Evenness Index (Pielou, 1966)

$$e = H / \ln S$$

Where:

H = Shannon – Wiener diversity index
S = total number of species in the sample

Results and Analysis

The Project will not pass through any protected area, reserved forest area, or natural forest area. The most notable ecological area near the project alignment is the MMFR which is approximately 2-km away (see Figure _). The project alignment encompasses large amounts of developed, disturbed, and maintained areas. It is surrounded by heavy industrial facilities, residential areas, and infrastructures.

Recorded plant species were predominantly grasses, shrubs and followed by few species of sparse trees. A total of 26 tree species representing 11 families belonging to 103 individuals were encountered from 20 sampling plots with an additional four species from opportunistic sampling outside the established plots. Most dominant species were *Eucalyptus camaldulensis, Nauclea orientalis (L.)* L, *Ficus ulmifolia* Lamk and *Pithecellobium dulce* (Roxb) Benth. Likewise, a total of 89 individuals from 26 species and 17 families of tree saplings and poles were recorded in the site. Dominant species were *Olax imbricata* Roxb. and *Melanolepis multiglandulosa* (Reinw. Ex Blume) with 14 and 10 individuals respectively. Floristic composition was mainly confined to shrubs and ground cover species. These are mostly weed species triggered by abundant moisture as brought about by continued monsoon rains. Also, due to the wet season effects, there is a large increase in the number of vascular flora and abundance of ground cover species. Few numbers of both endemic and threatened tree species were encountered in the transect plots. Tree flora species richness and abundance can be observed in Annex_.

Figure_2.52 Some of the species observed in the site : (a) *Psidium guajava* (Bayabas), (b) *Cananga odorata* (Ilang-ilang), (c) *Albizia saman* (Rain Tree), (d) *Lagerstroemia speciosa* (Banaba), (e) *Syzygium cumini* (Duhat), (f) *Ficus septica* (Hauili), (g) *Acacia mangium* (Mangium), (h) *Azadirachta indica (Neem* Tree), (i) *Tamarindus indica* (Sampaloc), (j) *Terminalia catappa* (Talisai), (k) *Pithecellobium dulce* (Kamachile), (l) *Mangifera indica* (Mangga), (m) *Pterocarpus indicus* (Narra), (n) *Delonix regia* (Fire Tree), and (o) *Vitex parviflora* (Molave).

Figure 2.53 Some of the ground cover species present in the area. (A) *Bidens pilosus*, (B) *Arivela viscosa*, (C) *Ruellia brittoniana*, (D) *Eleusine indica*, (E) *Zehneria indica*,(F) *Peperomia pellucida*, (G) *Mimosa pudica*, (H) *Commelina benghalensis*, (I) *Tridax procumbens*.

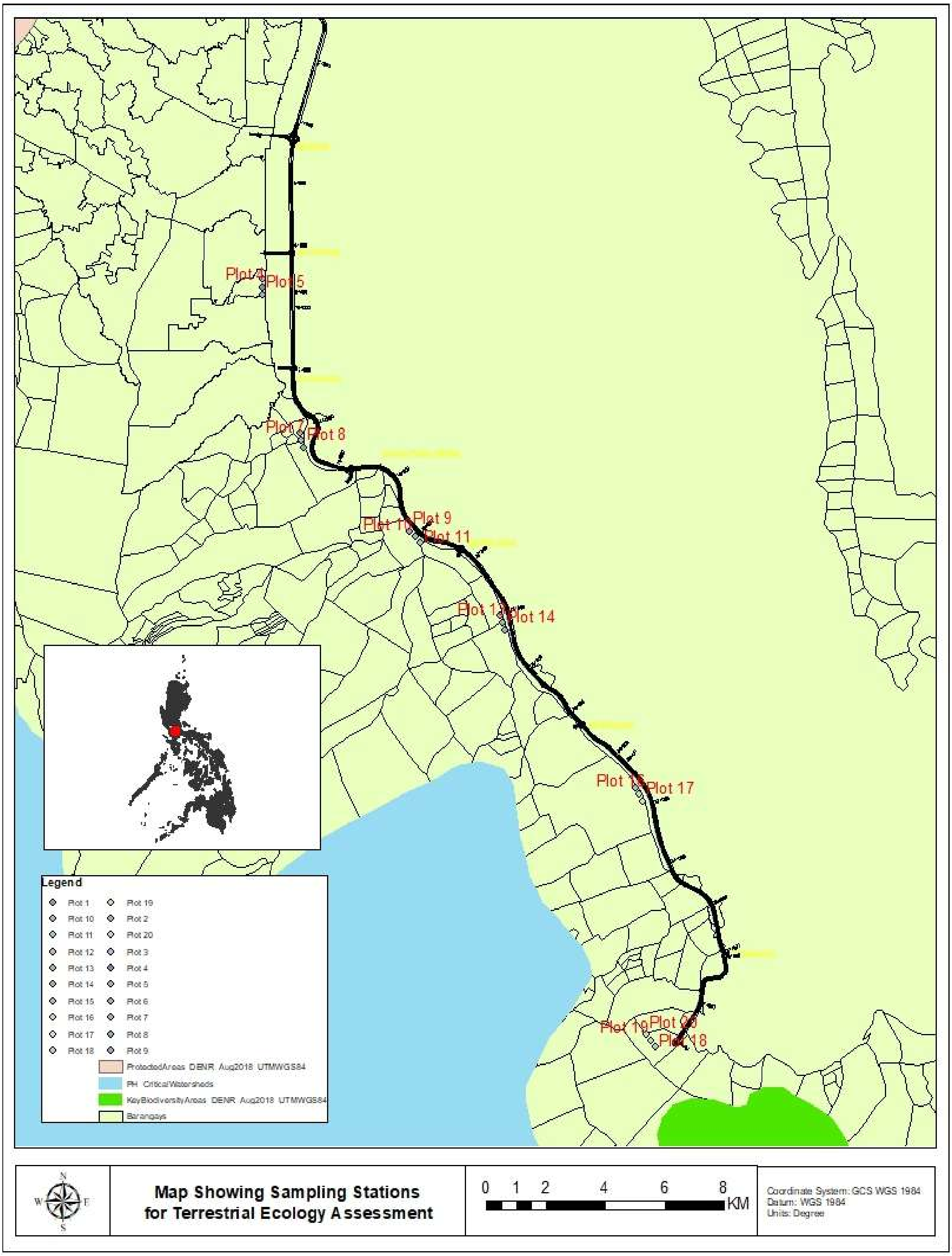

Figure 2.54 Map showing sampling stations for terrestrial ecology assessment.

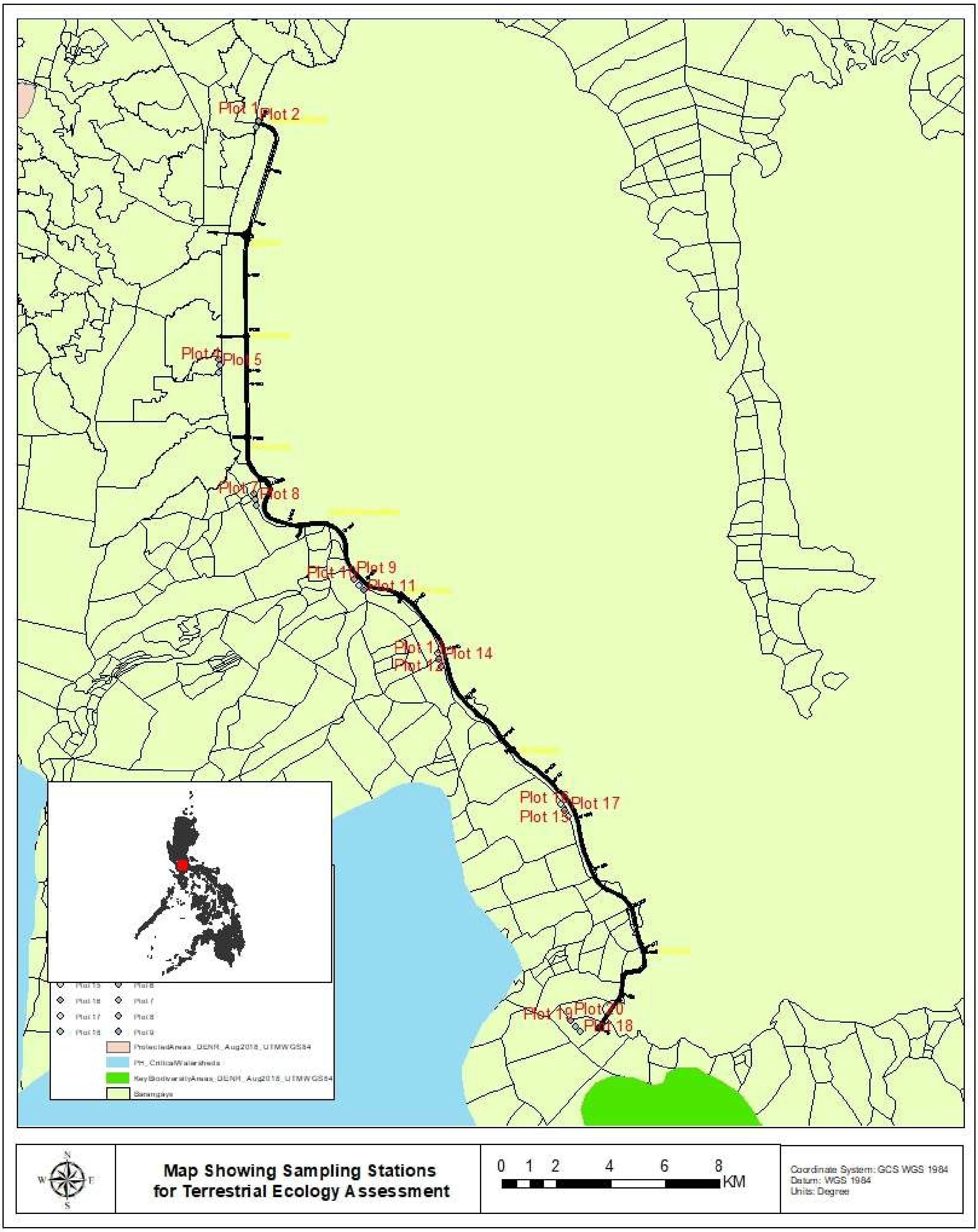

Figure 2.55 Map showing sampling stations for terrestrial ecology assessment.

Table 2.11 Locations of the established sampling plots along LLRN

Plot	Coordinates		Municipality	Barangay	Impact Area*
	Easting	Northing			
1	291235.00 m E	1602815.00 m N	Taguig	Lower Bicutan	DIA
2	291158.00 m E	1602585.00 m N	Taguig	Upper Bicutan	IIA
3	289980.37 m E	1593996.49 m N	Muntinlupa	Bayanan	IIA
4	289947.28 m E	1594039.11 m N	Muntinlupa	Bayanan	IIA
5	290016.54 m E	1594184.78 m N	Muntinlupa	Bayanan	IIA
6	291233.32 m E	1589370.09 m N	San Pedro	San Roque	IIA
7	291299.21 m E	1589298.80 m N	San Pedro	San Roque	IIA
8	291304.00 m E	1589292.00 m N	San Pedro	San Roque	IIA
9	294614.40 m E	1585869.54 m N	Biñan	San Antonio	IIA
10	294687.51 m E	1585904.60 m N	Biñan	San Antonio	IIA
11	294906.88 m E	1585558.86 m N	Biñan	Sinalhan	IIA
12	297606.97 m E	1583432.55 m N	Sta Rosa	Aplaya	DIA
13	297727.03 m E	1582736.62 m N	Sta Rosa	Kaingin	IIA
14	297709.35 m E	1582552.48 m N	Sta Rosa	Kaingin	IIA
15	300169.86 m E	1579495.73 m N	Cabuyao	Marinig	DIA
16	300752.00 m E	1578848.00 m N	Cabuyao	Marinig	DIA
17	301543.76 m E	1578278.29 m N	Cabuyao	Gulod	IIA
18	302906.00 m E	1575048.00 m N	Calamba	Uwisan	IIA
19	304330.00 m E	1572006.00 m N	Calamba	Lingga	IIA
20	302948.29 m E	1569564.63 m N	Calamba	Bucal	DIA

*IIA- Indirect Impact Area, DIA- Direct Impact Area

Vegetation and Plot Profiles

The established transects were identified and selected based on the presence of vegetation units across the proposed alignment, including the presence of major landscape features such as small ecological units. Additionally, the presence of high value species such as those endemics, threatened plant and tree species located either on a patch of forest or aggregate within the proposed alignment also served as a basis for selecting sampling sites. The selected transect or sampling sites are the areas with remaining forest or vegetation formation based on present satellite imagery and ground reconnaissance survey.

These transects are very close to human habitation and located proximate along the proposed LLRN wherein it is largely distinct from the surrounding environment. Two of the 20 sampling plots were located in Taguig City while the other 18 sampling plots were located from the stretch of Muntinlupa City and Calamba City (3 sampling plots each). The entire transect is situated primarily in built up areas and are very near to human habitations. These sites are highly disturbed by varied human activities.

The vegetation was described per transect with 20 nested quadrats (20mx20m) each at an interval of 250 m, with the flora at each of these quadrats recorded in detail. The flora records provided the names for use in the vegetation descriptions and contributed to the flora species lists and frequency of occurrence data. Several parameters relating to the individual quadrats were used to assist in both the description of vegetation types and the determination of flora distribution (particularly in terms of defining associated habitats). The following transects are described in detail in terms of vegetation profile, location, and other aspects of biological information.

Sampling Plot No. 1 and 2

Plot 1 and 2 is in Taguig City near the Laguna Lake. Trees that were present in the area are trees planted in plot box along the road and patches of trees in some residential houses. The area is mostly devoid of vegetation and only patches of disturbed grasses and weeds growing along the alignment due to pavements. A total of six genera belonging to four families were present in the area. These include *Albizia saman* (Jacq.) Merr., *Lagerstroemia speciosa* (L.) Pers., *Delonix regia* (Boj. ex Hook.) Raf., *Leucaena leucocephala* (Lam.) de Wit, *Azadirachta indica* and A. Juss., *Mangifera indica* L.. Most dominant family is Fabaceae. For tree flora with less than 10cm DBH present in the established 5mx5m plot, species of banaba, datiles, ipil-ipil, santol, kalios, is-is, hauili, malunggay were present. Plot 1 revealed that the most dominant ground cover species was *Tridax procumbens* L. (coat buttons) from family Asteraceae, an invasive species covering 80% of the 1mx1m plot while Melon Daga (*Zehneria indica* (Lour.) Keraudren) was the most dominant ground cover species covering 70% of the sampling plot. As mentioned above, the selected sampling sites are the areas with remaining forest or vegetation formation based on present satellite imagery and ground reconnaissance survey, hence the cover.

Figure 2.56 Panoramic view of flora assessment showing sampling Plot 1 and 2 in Taguig City

Sampling Plot No. 3, 4 and 5

Plot 3 to 5 were established in Muntinlupa City. These sampling plots were inside the local government tree park beside local offices along the Laguna Lake. The tree vegetation in Plot 3 is relatively denser among other plots since it was established along the periphery of the park . A total of 14 individuals belonging to six species were observed in this plot to include *Albizia saman* (Jacq.) Merr., *Lagerstroemia speciosa* (L.) Pers., *Pithecellobium dulce* (Roxb) Benth., *Delonix regia* (Boj. ex Hook.) Raf., *Gmelina arborea* Roxb., and *Nauclea orientalis* (L.) L. Most dominant species is *G. arborea*. Plot 4 on the other hand, is the densest plot which is located at approximately about 100 meters away from Plot 3. It has a total of 27 individuals belonging to 5 genera. Flora species include *Sesbania grandiflora* (L.) Pers., *Eucalyptus camaldulensis* Dehnh., *Vitex parviflora* Juss., *Pterocarpus indicus* Willd. and *Acacia mangium* Willd. Most dominant species was River red gum (*E. camaldulensis* Dehnh.) with 19 individuals or 70.37% of the total count. Lastly in Plot 5, there were only two individuals of the same species were encountered which is *Terminalia cattapa* L. perhaps the site was inundated by overflowing Laguna de Bay brought about by the 2019 typhoons.

For intermediate or understorey flora with DBH less than 10cm (5mx5m plot), species of *Nauclea orientalis* (L.) L. (one individual) is present in Plot 3, four *Vitex parviflora* Juss. were encountered in Plot 4, while one *Terminalia cattapa* L. and three *Moringa oleifera* Lamk. were observed in Plot 5. As to the ground cover (1mx1m), species of *Cyperus rotundus* L. (75%), leaf litter (10%) and bare soil (15%) were observed in Plot 3. For Plot No. 4 and 5, no ground cover (100% soil) was observed because of the semi-close canopy and was exposed to disturbance from park goers.

Figure 2.57 Panoramic view of flora assessment showing sampling plot 3,4, and 5 in Muntinlupa City.

Figure 2.58 A photo showing ground cover in Plot 3 and 4 (Munitinlupa Plot 1 and 2).

Sampling Plot No. 6, 7 and 8

Three plots were established in San Pedro City- plot 6 to 8. These sampling plots were located also alongside of Laguna Lake (see Figure _). Vegetation as compared to other plots is thinner in terms of tree flora. Plot 6 has a total of six individuals belonging to two species to include *Albizia saman* (Jacq.) Merr., and *Pithecellobium dulce* (Roxb) Benth. Likewise, Plot 7 has only one species which is *A. saman* while Plot No. 8 has no tree vegetation but predominantly covered by grasses and weeds.

From the established 5mx5m plot, bare soil was observed in Plot 6 (no saplings and poles), 14 *Hibiscus tiliaceus* were present in Plot 7, while no saplings were recorded in Plot 8. As to the ground cover (1mx1m plot), no ground cover but bare soil in Plot 6 whereas species of *H. tiliaceus* (3%), *Thysonolaena latifolia* (Roxb. ex Hornem.) Hondawere (20%), *Euphorbia sp.* (50%), *Cleome viscosa* (2%) and 25% bare soil in Plot 7. Lastly in Plot 8, 70% of the ground cover were occupied by *T. latifolia* while the remaining 30% were covered by *Pennisetum purpureum* Schumach.

Figure 2.59 Panoramic view of assessment sampling plot 6,7 and 8 in San Pedro City.

Sampling Plot No. 9, 10 and 11

Plot 9, 10 and 11 were established in Biñan, Laguna (see **Figure 2.60**). A total of seven tree flora species were observed in all plots to include *Psidium guajava* L., *Ficus septica* Burm. f. *Mangifera indica* L., *Albizia saman* (Jacq.) Merr., *Premna odorata* Blanco, *Tamarindus indica* L., and *Pithecellobium dulce* (Roxb) Benth- most of which were horticultural species. It was observed that the all sites were predominantly covered by poles, saplings and weeds.

For intermediate/underground species, three malunggai (*Moringa oleifera* Lamk) and one ornamental plant were present in Plot 9, there are 10 individuals of *Melanolepis multiglandulosa* (Reinw. Ex Blume), one *P. guajava* L. and three individuals of endemic Is-is (*Ficus ulmifolia* Lamk) were present in Plot 10. Meanwhile, trees with less than 10cm dbh revealed a total of 2 species belonging to 5 individuals were observed in Plot 11. These include *Leucaena leucocephala* (Lam.) de Wit and *Carica papaya* L with four and one count, respectively.

Ground cover assessment revealed that no ground cover was observed in Plot 9 since the plot was located along the road. Plot 10 has a variety of ground cover of which 50% of the cover was dominated by *Zehneria indica* (Lour.) Keraudren, *Ipomea aquatica* constitutes 10% of the plot, 8% *was Biophytum sensitivum (L.) DC., 20% (5% each) includes F. ulmifolia, Eleusine indica, Acalypha indica* L*.,* and *Commelina benghalenis.*

Figure 2.60 Panoramic view of assessment sampling plot 9, 10 and 11 in Biñan, Laguna.

Sampling Plot No. 12, 13 and 14

These plots were located in Sta. Rosa City (see **Figure 2.61**). From the 20x20m plot, assessment revealed a total of five tree flora species belonging to 18 individuals to include *Nauclea orientalis* (L.) L., *Persea gratissima* Gaertn., *Syzygium cumini* (L.) Skeels, *Muntigia calabura* L., *Cananga odorata* (Lamk.) Hook. f. & Thoms and the two *Ficus* sp. Dominant species is *N. orientalis.* Plot 12 was inhabited solely by 12 standing *N. orientalis* while 3 species were both present in Plot 13 and 14.

For the 5m x5m plot, two small *N. orientalis* were present in Plot 12, seven species were present in Plot 13 to include *Annona muricata* L., *Jathropa curcas* L., *Durio zibethinus* Murr., *Citrofortunella microcarpa* (Bunge) Wijnands, *Averrhoa bilimbi* L., *Annona squamosa* L and *Ficus ulmifolia* Lamk. Likewise, four horticultural species were present in Plot 14 which includes *Caesalpinia pulcherrima* (L.) Swartz, *Carica papaya* L. *Psidium guajava* L, and *Moringa oleifera* Lamk.

Ground cover assessment revealed that 80% of the ground is dominated by *Thysonolaena latifolia* while 20% was covered by *Pennisetum purpureum* in Plot 12. Plot 13 was barely soil while Plot 14 was quite similar with Plot 12 with ground cover constituting 45% each of *Thysonolaena latifolia and Pennisetum purpureum,* and 10% *Zehneria indica* (Lour.) Keraudren. Consequently, the ground cover in this transects coincide with the general trend that the disturbed areas are dominated with more understorey and ground cover species which are mostly opportunistic and light tolerant species.

Figure 2.61 Panoramic view of assessment sampling plot 12, 13 and 14 in Sta. Rosa City.

Sampling Plot No. 15, 16 and 17

Plots 15-17 were established along lakeshore of Laguna Lake in Cabuyao City (see **Figure 2.62**). From the 20x20m plot, assessment revealed a total of seven tree flora species belonging to 13 individuals to include *Pithecellobium dulce* (Roxb) Benth., *M. indica, Swietenia macrophylla* King, *P. guajava, Terminalia catappa* L., *Syzygium cumini* (L.) Skeels, and *Muntigia calabura* L.

Intermediate species (5m x5m sampling plot) was dominated by agricultural crops and fruit trees such as papaya, kamoteng kahoy, torch ginger, malunggai, bayabas, kamchile, manga and avocado. Other species include small datiles, ipil-ipil, kalios, and palmera.
Ground cover assessment in Plot 15 is dominantly covered *Eleusine indica* (L.) Gaertn. (50%), *Cyperus rotundus* L. (10%), *Biophytum sensitivum* (L.) DC. (10%) and 30% bare soil. Seventy percent (70%) of Plot 16 were barely top soil and 30% were covered by Napier grass while Plot 17 were completely bare soil.

Figure 2.62 Panoramic view of assessment sampling plot 15, 16, and 17 located in Cabuyao City

Sampling Plot No. 18, 19 and 20

Lastly, plots 18-20 were established few kilometers away the foot of Mt. Makiling, Laguna Lake, and a subdivision in Calamba City, respectively (see Figure_). From the 20x20m plot, assessment revealed a total of three flora species belonging to seven individuals to include *Artocarpus heterophyllus* Lam., *Mangifera indica* L., and *Terminalia catappa* L.

Agricultural crops and fruit trees were observed in the 5mx5m plot to include pomegranade, *Psidium guajava* L., *Annona muricata* L., a locally known "malaokra', *Muntigia calabura* L. and *Datura metel* L. Other small tree species observe in these plots were *Leucaena leucocephala* (Lam.) de Wit, and *Albizia saman* (Jacq.) Merr.

Ground cover assessment in Plot 18 is dominated by *Ipomea aquatica and Cyperus rotundus* L. with 70% and 30% cover, respectively whereas in Plot 19 has only 20% cover (5% each) by *Eleusine indica* (L.) Gaertn., *Murdania nudiflora* (L.) Brenan, *Peperomia pellucida* (L.) Kunth and *Cyperus kyllingia* Endl and the rest were bare soil. Plot 20 on the other hand, was covered by *Zehneria indica* (Lour.) Keraudren, *Pennisetum purpureum* Schumach., *Saccharum spontaneum* L., *Euphorbia hirta* L., *Centrosema pubescens* Benth., *Eleusine indica* (L.) Gaertn. and *Mimosa pudica* L.

Figure 2.63 Panoramic view of assessment sampling plot 18, 19 and 20 in Calamba City

Table 2.12 Top 5 tree flora species most frequently occurring species in the LLRN transect

Rank	Scientific Name	Common Name	No. of site encountered
1	Pithecellobium dulce (Roxb) Benth.	Kamachile	4
2	Mangifera indica L.	Mangga	4
3	Terminalia catappa L.	Talisai	3
4	Albizia saman (Jacq.) Merr.	Rain Tree	3
5	*Lagerstroemia speciosa* (L.) Pers.	Banaba	2

Table 2.13 Top 5 most dominant ground cover species observed in the LLRN transect

Rank	Scientific Name	Common Name	No. of site encountered
1	Thysonolaena latifolia (Roxb.)	Tambo	4
2	Zehneria indica (Lour.) Keraudren	Melo daga	3
3	Eleusine indica (L.) Gaertn.	Paragis	3
4	Pennisetum purpureum Schumach.	Napier	3
5	*Tridax procumbens L.*	Coat buttons	2

Importance Value

The relative density, relative dominance and relative frequency values for each tree species in all the transect plots were determined to obtain their Importance Value (IV), a standard measure in ecology that determines the rank relationships of species. High Importance values of species indicate a composite score for high relative species dominance, density and frequency.
Based on the computed IV (Table_) the three (3) most important species (with the highest IV) are *Eucalyptus camaldulensis* (59.51), *Pithecellobium dulce* (41.68), and *Albizia saman* (25.74). Most of the tree species documented in the project alignment are agroforestry species planted in the remaining patches of vegetation in the area. This implies low conservation value of the area, particularly in areas that are highly disturbed.

Table 2.14 Importance value of all tree flora species observed along the transect.

Common Name	Scientific Name	Importance Value
Rain Tree	*Albizia saman (Jacq.) Merr.*	**25.74441318**
Banaba	*Lagerstroemia speciosa (L.) Pers.*	6.817228687
Fire Tree	*Delonix regia (Boj. ex Hook.) Raf.*	11.61451268
Ipil-Ipil	*Leucaena leucocephala (Lam.) de Wit*	3.430273752
Neem Tree	*Azadirachta indica A. Juss.*	3.675160337
Mangga	*Mangifera indica L.*	27.426257
Kamachile	*Pithecellobium dulce (Roxb) Benth.*	**41.67683958**
Gmelina	*Gmelina arborea Roxb.*	13.77833938
Bangkal	*Nauclea orientalis (L.) L.*	25.59879329
Mangium	*Acacia mangium Willd.*	4.531477374
Smooth Narra	*Pterocarpus indicus Willd.*	3.379711874
Molave	*Vitex parviflora Juss.*	5.798386837
River red gum	*Eucalyptus camaldulensis Dehnh.*	**59.51213816**
Katurai	*Sesbania grandiflora (L.) Pers.*	4.611380626
Talisai	*Terminalia catappa L.*	12.88908722
Guava	*Psidium guajava L.*	7.934685306
Hauili	*Ficus septica Burm. f.*	3.35008915
Alagau	*Premna odorata Blanco*	3.32848151
Sampaloc	*Tamarindus indica L.*	5.389255663
Avocado	*Persea gratissima Gaertn.*	3.32848151
Duhat	*Syzygium cumini (L.) Skeels*	6.972074436
Datiles	*Muntigia calabura L.*	7.952466593
Ilang-ilang	*Cananga odorata (Lamk.) Hook. f. & Thoms.*	3.508545176
Ficus sp	*Ficus sp.*	4.395304227
Nangka	*Artocarpus heterophyllus Lam.*	3.356616458
	TOTAL	**300**

Opportunistic sampling

Apart from the species recorded from the quadrat sampling, additional four (4) species (not present in the quadrats) to include *Tabebuia rosea*, Ficus religiosa L., *Ficus nota* (Blanco) Merr. and *Cassia fistula* L. were recorded from the opportunistic survey. Hence, a total of 103 individuals of trees belonging to 30 species were encountered in the whole project alignment. The large number of vascular flora recorded reflects a number of factors: (1) Wide and linear nature of the project site intersecting a wide variety of plant communities and therefore vegetation types; (2) The relatively large number of intensively sampled quadrats across the alignment; and (3) the timing of the field surveys following substantial wet season species that were available for recording; approximately 50% of the species recorded were annual or weekly perennial flora and ephemeral species.

Species Diversity

Based on the number and abundance of all the species, Paleontological Statistical software package for education and data analysis (PAST version 3.12) was used to compute for diversity indices including Shannon (H'), Evenness (J') and Simpson's (D) index for all the sampling plots. Shannon Index gives an estimate of species richness and distribution. Evenness Index tells us how evenly species and/or individuals are distributed inside a plot or quadrat. Simpson's Index gives the probability of getting different species when two individuals were drawn (with replacement) inside a plot.

Table 2.15 Fernando and Castillo's Biodiversity Scale (1996)

Relative Values	Shannon-Weiner Index (H')	Evenness
Very High	3.5-4.0	0.75-1.0
High	3.0-3.49	0.5-0.74
Moderate	2.5-2.90	0.25-0.49
Low	2.0-2.49	0.15-0.24
Very Low	1.99 and below	0.14 and below

As per diversity classification range developed by Fernando et al. (1996), flora diversity of along LLRN was 1.278 which implied an exceptionally low diversity from 26 total species richness. It is of interest to note that there were very low species diversity in all sites (relative values ranging from 0.682-1.906 H'). The relevant abundance of rare and common species is called evenness. The results in **Table 2.15** revealed the evenness of each sampling sites assessed. Areas dominated by one or a few species have a low evenness while those that have a more even distribution of species have high evenness. Species diversity includes both species richness and evenness. Areas with large number of species that are evenly distributed are most diverse and areas with few species that are dominated by one species are the least diverse.

Table 2.16 showed the evenness of flora within the survey areas. Sta Rosa sampling site seems to have less evenness as compared to the rest of the sampling sites. This implied that only few species are dominant in these areas hence this can be considered least diverse areas. This implied that only few species are dominating in these areas hence, least diverse areas. There is increasing evidence for the negative impacts of urbanization on biodiversity, most directly in the form of habitat loss and fragmentation (Pickett and Cadenasso 2009). The number of species and individuals present in each transect plot was primarily the reason for very low/low value of Shannon index. Also, the species diversity per transect suggests introduction, disturbance, and invasion.

Table 2.16 Diversity and evenness values of flora per site

Sampling Site	Shannon Index	Evenness
Taguig	1.792	1
Muntinlupa	1.906	0.795
San Pedro	0.682	0.985
Binan	0.839	0.971
Sta. Rosa	1.116	0.646
Cabuyao	1.818	0.934
Calamba	0.796	0.725
Average	1.278	0.865

Biodiversity Value

The ecological or biodiversity value of an area is always measured in terms of species richness and in the number of endemic and threatened species present. Species that are of botanical importance (endemic, threatened, native etc.) are listed below. The geographical distribution of plant species has been extremely useful for assessing biodiversity values of regions, countries, and islands. Species confined to a particular site should be given particular conservation management strategies, as they are more vulnerable to disturbance due to their narrow range. As to the conservation status[19] of species is based on the most recent recommendations of the Philippine Plant Conservation Committee (PPCC) of the Biodiversity Management Bureau (BMB), DENR officially issued as DENR Administrative Order No. 2019-09 better known as ''The Updated National List of Threatened Philippine Plants and their Categories'. The listing of threatened species of the IUCN red list was also used as reference.

Species Distribution and Conservation Status

Of the total 30 taxa identified to species level, two (2) Philippine endemic species were observed to include *Ficus nota* (Blanco) Merr and *Ficus ulmifolia* L. These species are confined only in the country. These trees should be prioritized for species conservation. Other

[19]*Source:* **"DAO 2019-09 updated checklist (2011) pursuant to "Wildlife Resources Conservation and Protection Act 9147"** defines the different threatened categories as follows:

Critically Endangered Species (CE) - refers to a species or subspecies facing extremely high risk of extinction in the wild in the immediate future. This shall include varieties, formae or other infraspecific categories.
Endangered Species (EN) - refers to a species or subspecies that is not critically endangered but whose survival in the wild is unlikely if the causal factors continue operating. This shall include varieties, formae or other infraspecific categories.
Vulnerable Species (VU) - refers to a species or subspecies that is not critically endangered nor endangered but is under threat from adverse factors throughout its range and is likely to move to the endangered category in the future. This shall include varieties, formae or other infraspecific categories.
Other Threatened Species (OTS) - refers to a species or subspecies that is not critically endangered, endangered nor vulnerable but is under threat from adverse factors, such as over collection, throughout its range and is likely to move to the vulnerable category in the near future. This shall include varieties, formae or other infraspecific categories.
Other Wildlife species (OWS) - refers to non-threatened species of plants that have the tendency to become threatened due to destruction of habitat or other similar causes as may be listed by the Secretary upon the recommendation of the National Wildlife Management Committee. This shall include varieties, formae or other infraspecific categories.

IUCN defines the different threatened categories as follows:
Critically Endangered (CR) - A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future, as defined by any of the criteria (A to E) as described below.
Endangered (EN) - A taxon is Endangered when it is not Critically Endangered but is facing a very high risk of extinction in the wild in the near future, as defined by any of the criteria (A to E) as described below.
Vulnerable (VU) - A taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future, as defined by any of the criteria (A to E) as described below.

species observed in the site were Philippine native trees with nine (9) species that are known for their soil and water conservation capacities and characteristics of easily thriving in areas near bodies of water like rivers or streams. Meanwhile, 16 species observed in the plots were introduced species (see Table below).

Table 2.17 Distribution status of the observed tree flora in the site.

Source: Plants of the World Online (POWO). Royal Botanic Gardens. Kewscience. Retrieved from www.plantsoftheworldonline.org

No.	Common Name	Scientific Name	Distribution	Conservation Status
1	Is-is	*Ficus ulmifolia L.*	Endemic	*Least Concern* Vulnerable***
2	Tibig	*Ficus nota (Blanco) Merr.*	Endemic	*Least Concern*
3	Avocado	*Persea gratissima Gaertn.*	Introduced	*Least Concern*
4	Bo tree	*Ficus religiosa L*	Introduced	*Least Concern*
5	Datiles	*Muntigia calabura L.*	Introduced	*Least Concern*
6	Duhat	*Syzygium cumini (L.) Skeels*	Introduced	*Least Concern*
7	Fire Tree	*Delonix regia (Boj. ex Hook.) Raf.*	Introduced	*Least Concern*
8	Gmelina	*Gmelina arborea Roxb.*	Introduced	*Least Concern*
9	Golden Shower	*Cassia fistula L.*	Introduced	*Least Concern*
10	Guava	*Psidium guajava L.*	Introduced	*Least Concern*
11	Ipil-Ipil	*Leucaena leucocephala (Lam.) de Wit*	Introduced	*Least Concern*
12	Kamachile	*Pithecellobium dulce (Roxb) Benth.*	Introduced	*Least Concern*
13	Mahogany	*Swietenia macrophylla King*	Introduced	*Vulnerable**
14	Mangga	*Mangifera indica L.*	Introduced	*Least Concern*
15	Mangium	*Acacia mangium Willd.*	Introduced	*Least Concern*
16	Nangka	*Artocarpus heterophyllus Lam.*	Introduced	*Least Concern*
17	Neem Tree	*Azadirachta indica A. Juss.*	Introduced	*Least Concern*
18	Pink trumpet tree	*Tabebuia rosea*	Introduced	*Least Concern*
19	Rain Tree	*Albizia saman (Jacq.) Merr.*	Introduced	*Least Concern*
20	River red gum	*Eucalyptus camaldulensis Dehnh.*	Introduced	*Least Concern*
21	Sampalok	*Tamarindus indica L.*	Introduced	*Least Concern*
22	Alagau	*Premna odorata Blanco*	Native	*Least Concern*
23	Banaba	*Lagerstroemia speciosa (L.) Pers.*	Native	*Least Concern*
24	Bangkal	*Nauclea orientalis (L.) L.*	Native	*Least Concern*
25	Hauili	*Ficus septica Burm. f.*	Native	*Least Concern*
26	Ilang-ilang	*Cananga odorata (Lamk.) Hook. f. & Thoms.*	Native	*Least Concern*
27	Katurai	*Sesbania grandiflora (L.) Pers.*	Native	*Least Concern*
28	Molave	*Vitex parviflora Juss.*	Native	*Endangered***
29	Smooth Narra	*Pterocarpus indicus Willd.*	Native	*Endangered* Vulnerable***
30	Talisai	*Terminalia catappa L.*	Native	*Least Concern*

<accessed on 14 February 2021>
**Based on IUCN 2020-03*
***Based on DAO 2017-11*

Threatened Species

The conservation status of species is based on the most recent recommendations of the Philippine Plant Conservation Committee (PPCC) of the Biodiversity Management Bureau issued as DENR Administrative Order No. 2017-11 better known as ''The National List of Threatened Philippine Plants and their Categories'. The listing of threatened species of the IUCN red list was also used as reference.

Four (4) species recorded from project alignment are listed under either the Philippine Red List (DAO 2017-11) or the IUCN Red List of Threatened Species (2020-03). Noteworthy, among the list are endangered (En) Smooth Narra (*Pterocarpus indicus*) on IUCN and Vulnerable in DAO, Is-is (F*icus ulmifolia*), an endemic species recorded during opportunistic survey is categorized as vulnerable under IUCN 2019-1, Mahogany (*Swietenia macrophylla)* vulnerable based on IUCN 2020-03 and Molave (*Vitex parviflora)*, a premium tree species which are specifically used in railroad ties classified as endangered based on DAO 2017-11. The transect plots where the threatened species occurred were included to guide the PAMB in their species conservation efforts. Though Narra is widely seen in the whole country, the basis of listing is because of its low population in the wild. Further, Narra is one of the notable tree species in the alignment, hence, appropriate management and monitoring strategies to ensure the continued survival of its population should be developed in the Environmental Management Plan (EMP)

Invasive Alien Species

Alien or exotic invasive species (IAS) as defined during the Convention on Biological Diversity (CBD) include any "*alien or exotic species that are intentionally or unintentionally introduced by human in native habitats and these take space and spread at the expense of native species*".

Due to the imminent threat posed by these exotic species over native species, Article 8 of the CBD states the need to: "Prevent the introduction of alien invasive species which threaten ecosystems, habitats, and species and control or eradicate them upon the event of bioinvasion". Such alien plant species that smothers and pre-dominate natural habitats are collectively termed as bioinvasive species.

The increasing rate of damage and effects of biological invasion (bioinvasion) are realized in most countries that have been engaging themselves to the use of exotic tree species either for massive production (plantation) or for reforestation efforts towards regaining local forest vegetation. Following the definition of the CBD, the proposed LLRN Project area has one invasive plant species recorded based from the plant assessment surveys. This species is *Pennisetum purpureum* Schumach. Likewise, some notable IAS were observed that has high potential to be IAS in the future were also listed in the table below.

Table 2.18 Invasive alien species (IAS) documented in the project site.

Common Name	Scientific Name	Family Name	IUCN 2021-3
Napier	*Pennisetum purpureum*	Poaceae	Least Concern
Paragis	*Eleusine indica***	Poaceae	Least Concern
Mutha	*Cyperus rotundus* L.**	Cyperaceae	Least Concern
Busikad	*Cyperus kyllingia* Endl.**	Fabaceae	Least Concern

Source: CABI invasive species compendium
*****IAS in other countries but not yet in the Philippines*

Diameter Class Distribution

The classes of the Diameter at Breast Heights (DBHs) of the inventoried trees were classified by 10cm intervals as instructed in FMB Technical Bulletin No.3 "Measurement Standards and Procedures in the Conduct of Inventory for Standing Trees". Figure below shows the tree diameter size class distribution in the project site as compared to the FMB's DBH classes. The group of the most inventoried trees is in Class 20cm (44 individuals or 42.72 % of the total inventoried population). Followed by Class 10cm (30 individuals or 29.13 % of the total inventoried population). Other DBH Classes are: Class 30cm (17 individuals or 16.50 % of the total inventoried population), Class 40cm (6 individuals or 5.83 % of the total inventoried population), Class 50cm (4 individuals or 3.88 % of the total inventoried population), Class 60cm (1 individual or 0.97 % of the total inventoried population) and Class 100cm (1 individual or 0.97 % of the total inventoried population).

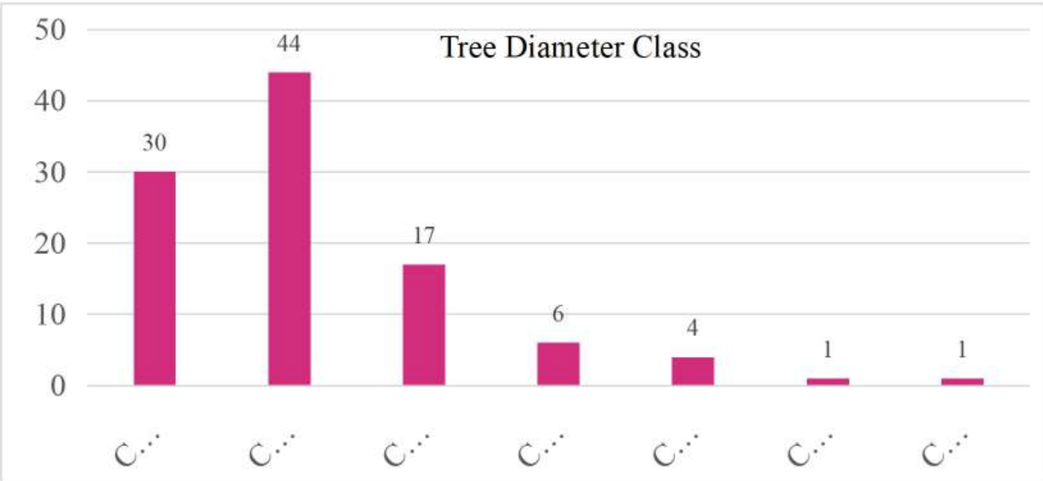

Figure 2.64 Diameter class distribution of recorded tree flora along LLRN

Estimate of the Relative Age of Tree Population

The Diameter at Breast Heights (DBHs) of the inventoried trees were grouped according to Richards' Ideal Distribution as young trees (0 – 20.32 cm), established (20.33 – 43.18 cm), maturing (43.19 – 60.96 cm), and mature trees (more than 60.96 cm); and then analyzing the expressed diameter size class distribution, then it provides an estimate of the relative age of a tree population. Figure below shows the tree diameter size class distribution in the project site as compared to the ideal proposed by Richards (1983). Relatively, the age of the most inventoried trees is in young phase (60 individuals or 58.25 % of the total inventoried population). The other phases have the following individuals and percentages: established phase (37 individuals or 35.92 % of the total inventoried population), maturing phase (5 individuals or 4.85 % of the total inventoried population), and mature phase (1 individual or 0.97 % of the total inventoried population).

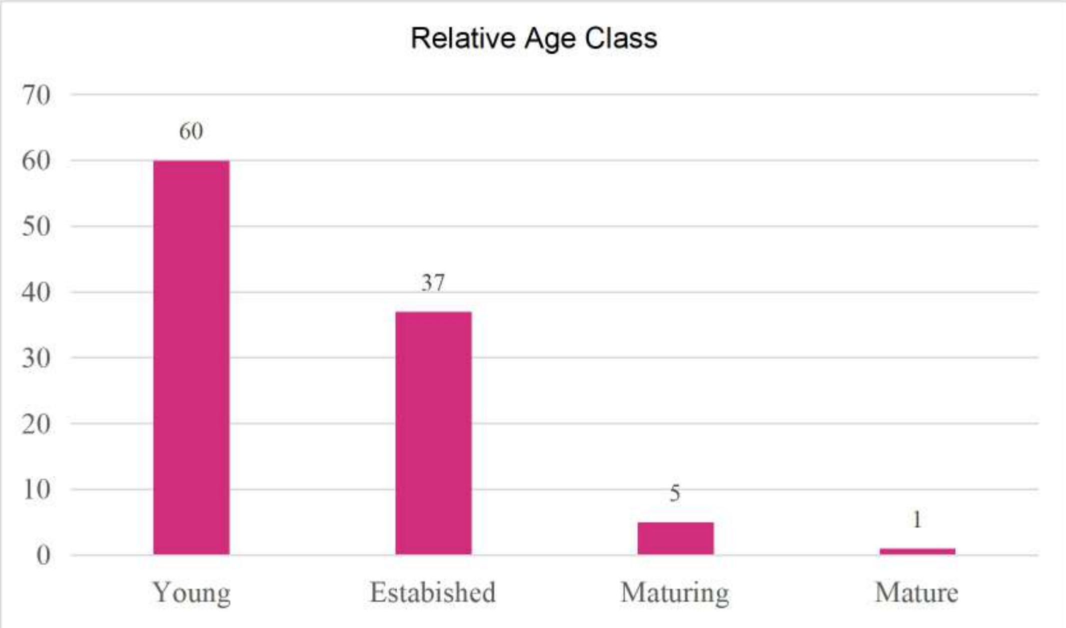

Figure 2.65 Relative age class distribution of recorded tree flora along LLRN

Economic Uses and Importance of Significant Flora

In terms of economic uses and importance, some plants and trees recorded in Project site have potential for medicinal, ornamental, field fodder and timber purposes (**Table 2.19**). Most of the floral species recorded are tree species with known economic and human use values (tangible products) such as source of timber, fruits, medicines, ornamentals and fuel wood. These include members of the families of Anacardiaceae, Meliaceae, Moraceae, Lamiaceae, and Fabaceae.

Table 2.19 Economic uses and importance of some significant flora recorded in the project site.

Species	Family Name	Economic Uses and Importance
Ficus nota	Moraceae	Timber, paper production and being a shade provider are its primary uses, although its seeds and fruits are edible.
Ficus ulmifolia	Moraceae	The fruits are edible but have little flavor; sometimes eaten with sugar and cream. The hard and rough leaves are used to clean household materials.
Swietenia macrophylla	Meliaceae	Timber: Wood are used in house construction. Fruits are medicinal.
Species	**Family Name**	**Economic Uses and Importance**
Muntingia calabura	Muntingiaceae	Tree is used to create fences for farms. Fruits

		such as berries are edible and sweet. Good for reforestation
Mangifera indica	Anacardiaceae	The fruits are eaten raw and prepared into jams, etc. Young shoots are used as a vegetable and as a spice; the leaves are used in traditional medicine against fever.
Pterocarpus indicus	Fabaceae	Its uses include high-end joinery, flooring, furniture, cabinetry, paneling, novelties and specialty items and carved pieces such as furniture feet and finials. The wood is also used for interior house and boat trim, sporting goods, musical instruments, caskets and turnery. Specialized uses include the manufacture of cases for scientific instruments.

Terrestrial Fauna

Avifauna

Simple Line Transect method measuring 2-km consists of a person walking from point A to point B along a defined path was established. Bird counting per individual birds (of each species) were seen and heard within a certain distance from their path (on both sides). Distance from the path was consistent to avoid bias (when comparing with other transect). A continuous observation through a paced walk was done to avoid double counts of individuals. All surveys were carried out early morning (0530-0900) and late in the afternoon (1500-1700) for five consecutive days from January 28- February 1, 2021.

Classification and nomenclature of bird species. DENR Administrative Order (DAO) 2019-09, 2014 Convention on International Trade of Endangered Species (CITES), 2017 International Union for Conservation of Nature (IUCN), Kennedy et al. 2000, Birdlife International Data Zone, and Biodiversity Management Bureau (BMB) Data Sheet 2014 were used.

Ethnobiological accounts. For species that may have not been encountered or observed during the survey period, interviews with some locals of the concerned area were conducted to consider small mammals, reptiles, or amphibians. A digital camera with high optical zoom (50x), a recorder and a field guide to Philippine Birds were used for verification of specimens. *Biodiversity Indices.* Biodiversity indices such as the Shannon Diversity (H'), Pielou's Evenness (E) and Species Richness were computed and analyzed. The obtained values of H' and E were interpreted according to the Fernando Biodiversity Scale (1998).

Species Richness (SR) - based on the total number of species recorded in the study sites.

Species Diversity Index - based on Shannon Weiner's Formula (1963)
H = pi (ln pi) , where ln = natural logarithm
Evenness Index (E) - E = H/Hmax , where Hmax = proportional abundance calculated by natural logarithm of SR.

Distribution and Status. The birds' distribution and conservation status were determined using the updated IUCN Red List of Threatened Species, Appendices of CITES of Wild Flora and Fauna, and DAO No. 2019-09 "Establishing the List of Terrestrial Threatened Species and other Categories, and the List of other Wildlife Species pursuant to Republic Act no. 9147."

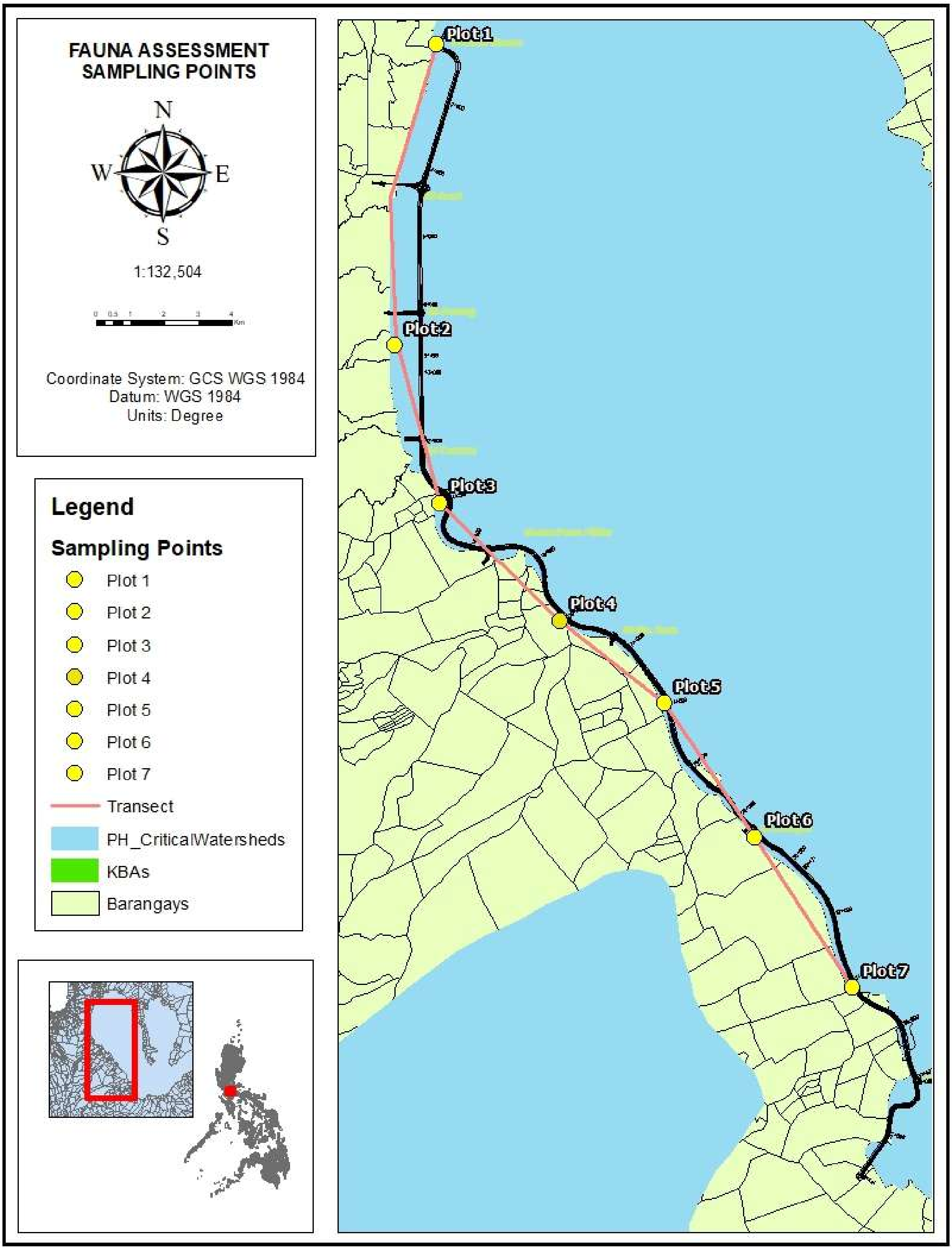

Figure 2.66 Map showing fauna assessment sampling points along LLRN

Guild Richness and Abundance. When determining how guild richness responded to environmental changes (McCune and Mefford, 1999), calculations of total richness of each guild (columns of data matrices) at each site (rows of data matrices) were determined.

Reptiles and Amphibians. Active search for reptiles and amphibians was done systematically within the sampling sites and in its immediate vicinity. For each species observed and heard, the name of the species, and number of individuals are recorded. Double counting of the individuals of the same species was definitely avoided.

Mammals. For non-volant mammals such as rodents, interview with local informants was also undertaken to generate significant information relative to the presence/absence of mammal species in the area. For volant mammals, bats were trapped using mist nets which were established along the transect every 250m.

Fauna Composition and Diversity

In terms of spatial biodiversity and sustainability, birds are one of the core indicators due to its broad range of ecosystems and scope of food chain thus affecting the population of other species (integrating changes at other level). It also has a readily available data collected by volunteers and professionals, available population size, trends and conservation status. This taxonomic group plays a vital role among other wildlife species in terms of seed dispersal and eventual succession of secondary growth forest

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Weather condition during the survey is fair but two days prior to the assessment there were rain event. The survey covers the four groups of wildlife-vertebrates which include the avifauna, mammals, amphibian, and reptiles. Prior to the conduct of sampling, general habitat assessment was undertaken to consider priority sites for observation.

Transect survey was employed in the conduct of faunal assessment within the project area. Species not encountered during the period of field assessment is generated through ethnobiological interview with local informants to obtain other important information on the presence of other wildlife species not encountered throughout the survey. Photo documentation of observed wildlife was also undertaken for further species verification when necessary.

Studies of relationship between bird species and environmental variables were mainly concentrated on landscape-level, habitat level and human-level (Ke et al., 2010; Yuan et al., 2014). Likewise, in terms of spatial biodiversity and sustainability, birds are one of the core ecological indicators due to its broad range of ecosystems and scope of food chain. Such phenomenon affects the population of other species due to integrating changes at other level (Verslujis et al. 2018). This taxonomic group plays a vital role among other wildlife species in terms of seed dispersal and eventual succession of secondary growth forest, among others. It is expected that the land use change will have an impact on the diversity and population of birds (Ang, C. et al. 2016).

Species Composition and Density

Avifauna. A total of 534 individuals belonging to 21 species representing 14 families of avifauna were observed. Most dominant family based on species richness are Ardeidae group or group of egrets and herons.

Table 2.20 Checklists of birds species observed along the LLRN alignment

							2014 CITES	DAO 2019-09	IUCN 3.1 2020-03
No.	**Family Name**	**No.**	**Common Name**	**Scientific Name**	**Species Authority**	**Distribution**	**Conservation Status**		
1	Alcedinidae	1	White-collared Kingfisher	*Halycon chloris*	Boddaert, 1783	Native (Resident)	NL	NL	LC
2	Apodidae	2	Glossy Swiftlet	*Collocalia esculenta*	Linnaeus, 1758	Native (Resident)	NL	NL	LC
3	Ardeidae	3	Little Egret	*Egretta garzetta*	Linnaeus, 1766	Migratory	NL	NL	LC
		4	Great Egret	*Ardea alba*	Linnaeus, 1758	Migratory	NL	NL	LC
		5	Black Crown Night Heron	*Nycticorax nycticorax*	Linnaeus, 1758	Migratory	NL	NL	LC
		6	Intermediate Egret	*Ardea intermedia*	Wagler, 1827	Migratory	NL	NL	LC
4	Artamidae	7	White-breasted Woodswallow	*Artamus leucorynchus*	Linnaeus, 1771	Native (Resident)	NL	NL	LC
5	Columbidae	8	Domesticated Pigeon	*Columba livia domestica*	Gmelin, 1789	Native (Resident)	NL	NL	LC
		9	Zebra Dove	*Geopelia striata*	Linnaeus, 1766	Native (Resident)	NL	NL	LC
6	Dicaeidae	10	Red-keeled Flowerpecker	*Dicaeum australe*	Hermann, 1783	Endemic	NL	NL	LC
7	Hirundinidae	11	Barn Swallow	*Hirundo rustica*	Linnaeus, 1758	Migratory	NL	NL	LC
		12	Tahiti Swallow	*Hirundo tahitica*	Gmelin, 1789	Resident	NL	NL	LC
8	Laniidae	13	Brown Shrike	*Lanius cristatus*	Linnaeus, 1758	Native (Resident)	NL	NL	LC
		14	Long-tailed Shrike	*Lanius schach*	Linnaeus, 1758	Native (Resident)	NL	NL	LC
9	Laridae	15	Whiskered Tern	*Chlidonias hybrid*	Linnaeus, 1759	Migratory	NL	NL	LC
		16	Common Tern	*Sterna hirundo*	Linnaeus, 1758	Migratory	NL	NL	LC
							2014	DAO	IUCN 3.1

No.	Family Name	No.	Common Name	Scientific Name	Species Authority	Distribution	Conservation Status CITES	2019-09	2020-03
10	Locustellidae	17	Striated Grassbird	*Megalurus palustris*	Horsfield, 1821	Native (Resident)	NL	NL	LC
11	Nectariniidae	18	Olive-backed Sunbird	*Cynnyris jugularis*	Linnaeus, 1766	Native (Resident)	NL	NL	LC
12	Passeridae	19	Eurasian Tree Sparrow	*Passer montanus*	Linnaeus, 1758	Native (Resident)	NL	NL	LC
13	Pycnonotidae	20	Yellow-vented Bulbul	*Pycnonotus goiavier*	Scopoli, 1786	Native (Resident)	NL	NL	LC
14	Rhipiduridae	21	Philippine Pied Fantail	*Rhipidura nigritorquis*	Sparrman, 1788	Endemic	NL	NL	LC

Table 2.21 Avifauna species present in all sampling

No.	Family Name	Common Name	Scientific Name
1	Ardeidae	Little Egret	*Egretta garzetta*
2	Hirundinidae	Barn Swallow	*Hirundo rustica*
3	Laniidae	Brown Shrike	*Lanius cristatus*
4	Passeridae	Eurasian Tree Sparrow	*Passer montanus*
5	Pycnonotidae	Yellow-vented Bulbul	*Pycnonotus goiavier*

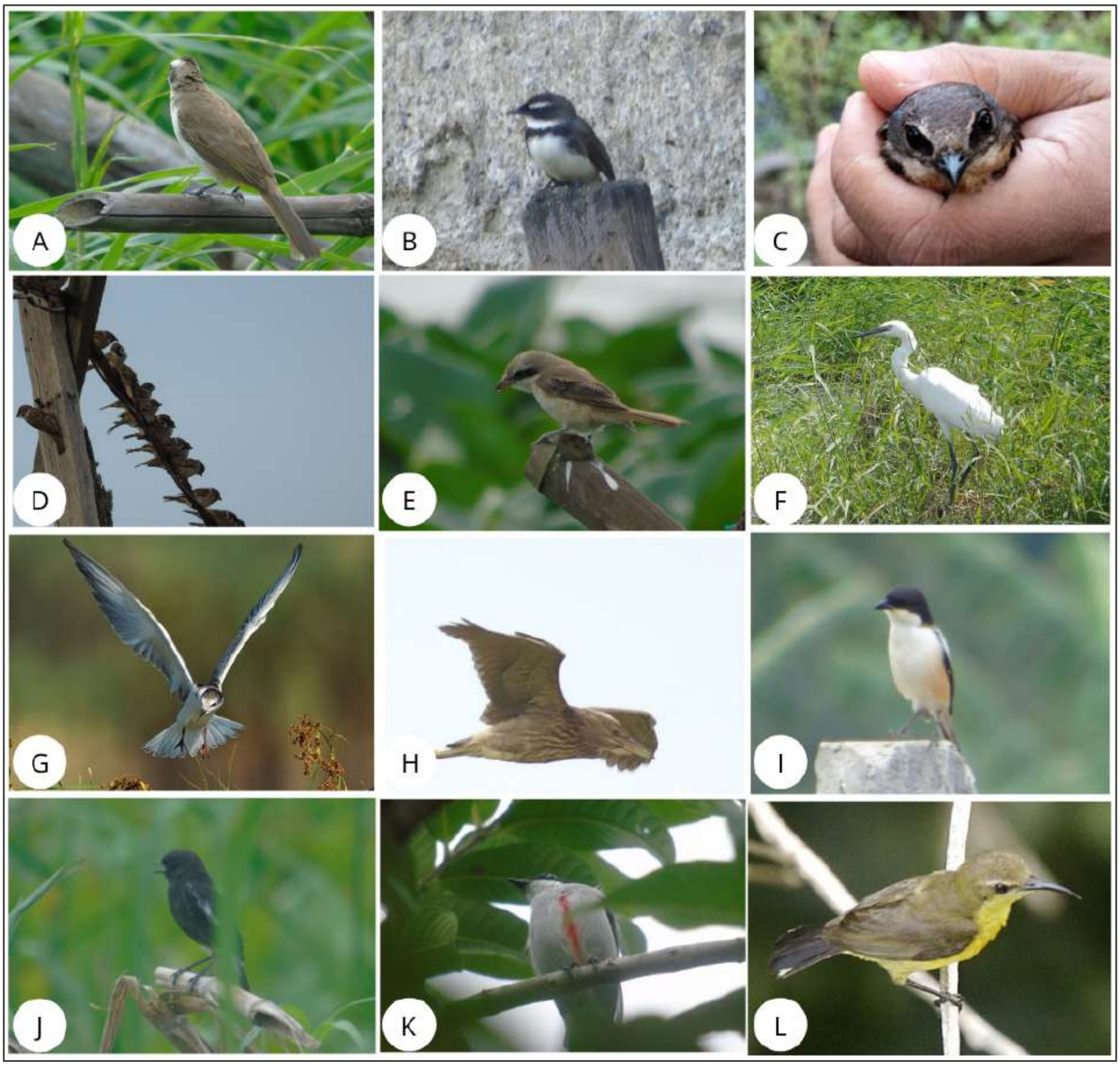


Figure 2.67 Some of the bird species observed in the site to include a. Yellow-vented bulbul (*Pycnonotus goiavier*), Philippine pied fantail (*Rhipidura nigritorquis*), c. Barn swallow (*Hirundo rustica),* d. Eurasian tree sparrow (*Passer montanus*), e. Brown shrike (*Lanius cristatus*), f. Little Egret (*Egretta garzetta*), g. Common tern (*Sterna hirundo*), h. Black-crowned night heron (*Nycticorax nycticora),* i. Long-tailed shrike (Lanius schach), j. Pied bushchat (*Saxicola caprata*), k. Red-keeled flowerpecker (*Saxicola caprata*), l. Olive-backed sunbird (*Cynnyris jugularis*)

Table 2.22 Species density and abundance

Common Name	Scientific Name	Taguig	Muntinlupa	San Pedro	Binan	Sta. Rosa	Cabuyao	Calamba	Total
White-collared Kingfisher	*Alcedo atthis*	1	-	-	-	4	-	-	5
Barn Swallow	*Hirundo rustica*	80	10	1	4	25	5	12	137
Tahiti Swallow	*Hirundo tahitica*	-	-	1	-	-	5	-	6
Brown Shrike	*Lanius cristatus*	1	1	-	-	-	-	-	2
Common Tern	*Sterna hirundo*	8	1	2	7	9	4	6	37
Whiskered Tern	*Chlidonias hybrid*	2	3	1		6	3	5	20
Eurasian Tree Sparrow	*Passer montanus*	15	18	3	4	12	25	34	111
Yellow-vented Bulbul	*Pycnonotus goiavier*	1	2	1	2	2	1	4	13
Little Egret	*Egretta garzetta*	2	1	1	1	12	3	35	55
Intermediate Egret	*Ardea intermedia*	-	-	-	-	15	-	22	37
Great Egret	*Ardea alba*	1	2	1	-	-	-	33	37
Black Crown Night Heron	*Nycticorax nycticorax*	1	-	-	-	2	1	2	6
Glossy Swiftlet	*Collocalia esculenta*	-	6	-	-	-	-	-	6
Domesticated Pigeon	*Columba livia domestica*	-	6	2	-	6	-	22	36
Zebra Dove	*Geopelia striata*	-	-	-	-	2	-	-	2
Philippine Pied Fantail	*Rhipidura nigritorquis*	-	1	1	-	-	-	-	2
White-breasted Woodswallow	*Artamus leucorynchus*		-	2	-	-	-	-	2
Olive-backed Sunbird	*Cynnyris jugularis*	-	-	-	-	1	3	-	4
Red-keeled Flowerpecker	*Dicaeum australe*	-	-	-	-	1	-	-	1
Striated Grassbird	*Megalurus palustris*	-	-	-	-	-	-	15	15
TOTAL		**112**	**51**	**16**	**18**	**97**	**50**	**190**	**534**

Species Distribution, Conservation Status, and Population Trends

Table 2.23 shows species distribution of avifauna in the area. Such information could yield into best mitigation and environmental impact framework which can be used as guiding principle in managing this group of organisms. Of the total birds observed, about 47.82% are resident, 33.33% are migratory, 9.09% is introduced and 18.18% are endemic. Bird endemicity is primarily determined by defined geographical area. Endemic species exhibits a strong dependency on climatic conditions as a result of their limited distribution. Under such circumstances, changes in climatic conditions may cause not only the extinction of local populations, but of whole species (Peers et al. 2016). Using the database provided by the Biodiversity Management Bureau (2014), endemic species observed are Red-keeled flowerpecker and Philippine pied fantail

Table 2.23 Species distribution of the observed avifauna along LLRN proposed project site.

No.	Distribution	Count	Species Name
1	Endemic	2	Red-keeled Flowerpecker, Philippine Pied Fantail
2	Migratory	7	Little Egret, Great Egret, Black Crown Night Heron. Intermediate Egret, Barn Swallow, Whiskered Tern, Common Tern
3	Native (resident)	11	White-collared Kingfisher, Glossy Swiftlet, White-breasted Woodswallow Domesticated Pigeon, Zebra Dove Brown Shrike, Long-tailed Shrike Striated Grassbird, Olive-backed Sunbird,Yellow-vented Bulbul, Tahiti Swallow
4	Introduced	1	Eurasian Tree Sparrow

It is of interest to note that every species observed in the area are neither listed in the Appendix of the CITES of Wild Fauna nor in DAO 2019-09 and IUCN 3.1 (2021). Both standards suggested that all observed species were listed as Least Concern (LC).

In terms of global population trends as per IUCN Redlist 2021, the current trends of 8 observed species were declining to include White-collared Kingfisher, Glossy Swiftlet, Black Crown Night Heron, Intermediate Egret, Barn Swallow, Brown Shrike, Long-tailed Shrike and Eurasian Tree Sparrow. Such population trend is thought to be decreasing as a result of conversion of land-uses and urbanization. Meanwhile, six species are at stable status to include White-breasted Woodswallow, Zebra Dove, Red-keeled Flowerpecker, Whiskered Tern, Olive-backed Sunbird and Philippine Pied Fantail. Three species are currently proliferating which include Little Egret, Domesticated Pigeon, and Yellow-vented Bulbul, while the global population trend of the remaining four species are still unknown due to data limitation such as Great Egret, Tahiti Swallow, Common Tern and Striated Grassbird.

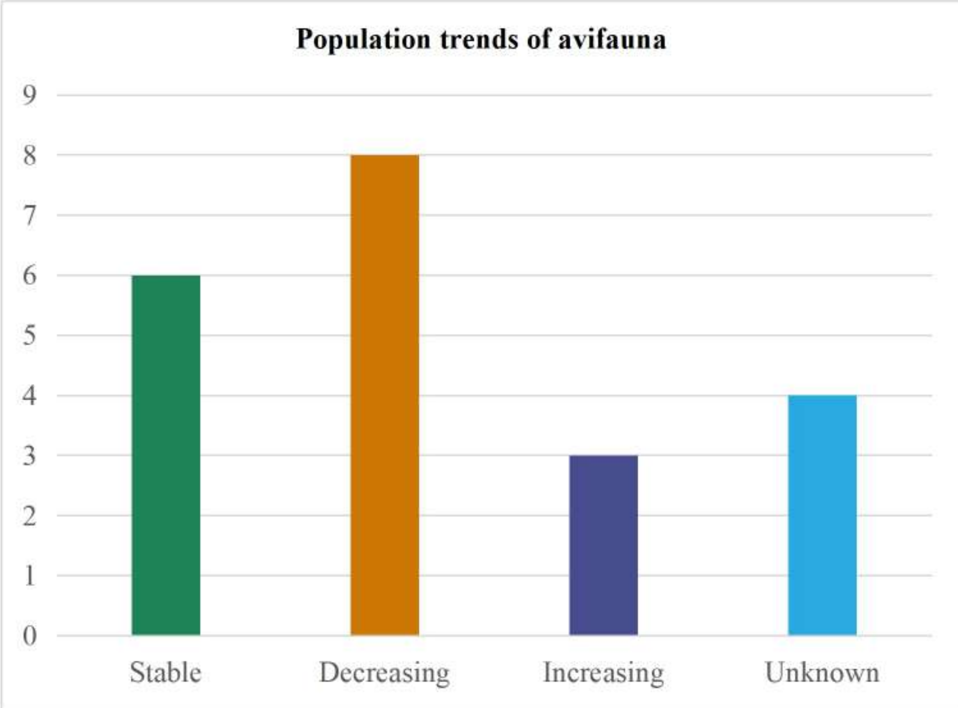


Figure 2.68 Population trends of avifauna species in the site.

Feeding Guilds

There was a total of 5 (nine) feeding guilds type were identified among the avifauna species recorded. These are carnivores, Frugivore, Frugivore-Nectarivore-Granivore, Granivore, Insectivore, and Insectivore-Nectarivore-Frugivore. Majority of the birds observed in the area belonged to insectivore group (10 species) followed by carnivore or meat eating birds with 6 species. Such results could be explained by existing land-use such agricultural lands and the lake itself Insectivorous bird species dominates the area favoring their feeding guilds/diet due to wide distribution of available forage materials (Zakaria et al. 2009). Likewise, in terms of bird frequency, birds with gran whereby built-up areas mostly human settlements. Specific details on the diversity feeding guilds of birds can be observed in the table below.

Table 2.26 Feeding guilds of avifauna species recorded in the area.

No.	Feeding Guild	Count	Species
1	Carnivore	6	White-collared Kingfisher, Little Egret, Great Egret, Black Crown Night Heron, Intermediate Egret, Common Tern
2	Granivore	3	Domesticated Pigeon, Zebra Dove, Eurasian Tree Sparrow
3	Insectivore	10	Glossy Swiftlet, White-breasted Woodswallow, Barn Swallow,

No.	Feeding Guild	Count	Species
			Tahiti Swallow, Brown Shrike, Long-tailed Shrike, Whiskered Tern, Striated Grassbird, Philippine Pied Fantail
4	Frugivore	1	Red-keeled Flowerpecker
5	Insectivore-Nectarivore-Frugivore	1	Olive-backed Sunbird

The fauna species observed in the area are noted to be common in lowland areas an in wide range of habitats including highly urbanized areas. Whereas, the Long-Tailed Shrike is commonly observed in rural areas especially in agricultural areas which presence of this species within the study area is maybe incidental which came from adjacent area.

Volant and non-volant mammals

Mist netting, cage trapping and ethnobiological accounting for bats and rodents in the area were conducted. Sampling for Murids (rats and mice) were done using live traps with roasted coconut and peanut butter as bait. Traps were set in locations where the mammals are suspected to pass through such as near ground holes, fallen logs and thick litter fall. Cage trapping was done for three days but no rodents were caught. However, reported species gathered through ethnobiological accounting are the Common Rousete (*Rousettus* sp.) and Common House Rat (*Rattus rattus*). According to key informants, the Common Rousete are commonly observed during dusk hour flying around the study area, while rat species are commonly seen along the drainage canals and within households. These species are native in the country. Conservation status of these species with reference to the IUCN Red List is under Least Concern (LC) in the category.

Figure 2.69 Photographs showing setting up of mist nets

Figure 2.70 Photographs showing setting up of cage traps for murids

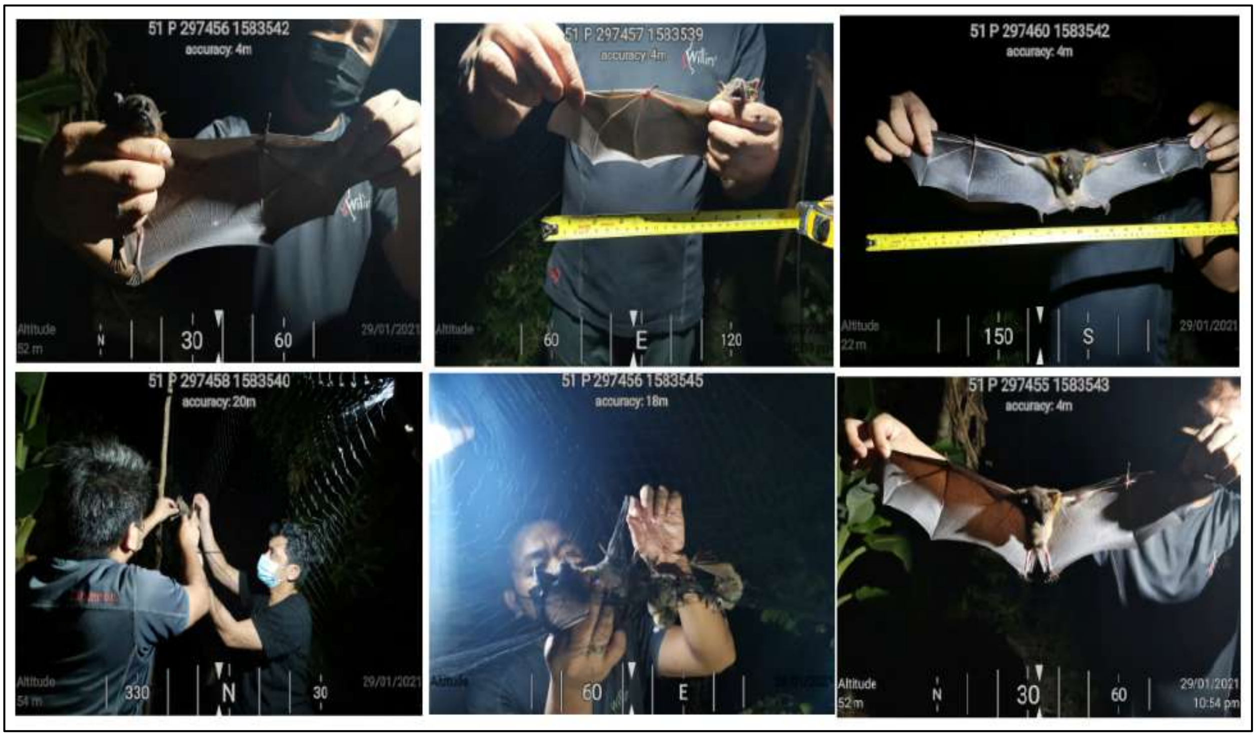


Figure 2.71 Photographs showings bats being removed from the mistnets

Mist netting collected one species of bat called *Ptenochirus jagori wherein 22 individuals* were caught and eventually released after two sampling per observation period (February 28-Feb 1 at 9PM and 11PM). However, ethnobiological accounts have noted the presence of bats (Megachiropterans and Microchiropterans) which only appear in the area during fruiting season of trees (particularly lanzones and chico) and are very minimal during regular days. The result agreed with the findings of Ingle (1992), the most common bat species in lowland forest of Makiling, are the Greater musky fruit bat (*Ptenochirus jagori), Golden-capped fruit bat (Acerodon jubatus)* and Lesser short-nosed fruit bat (*Cynopterus brachyotis)*. Both species are of least concern according to IUCN and could thrive in disturbed areas except for *A. jubatus which is an endangered species*.

Amphibians and Reptiles

These species group are highly seasonal and are sensitive to weather conditions mainly because of their ectothermic conditions. To ensure that the survey will not be underestimated, the team conducted the opportunistic sampling during early and mid-morning where skinks and lizards are most active and during after dusk where amphibians are out to breed, as well as other nocturnal reptiles which are active at nighttime.

A total of seven species of amphibians and reptiles have been noted with two (2) frogs, and two (2) lizards (**Table 2.27**). The species were listed from opportunistic sampling and ethnobiological accounts. Anuran (frog) species belonging to two (2) families were also noted to occur in the area, such as the banded bullfrog (*Kaloula pulchra*). The said species is sensitive to changes in habitat weather conditions and temperatures within 27–29 °C (Encyclopedia of Life). *Rhinella marina* is a known invasive and pest species which prefers wet habitats overlapping with native species (Mayer et al., 2017). These observed species are known to occur in a variety of habitats including highly disturbed areas.

Table 2.27. Species opportunistic sampling and ethnobiological accounts

Scientific Name	Common Name	IUCN Status[a]	CITES	DAO 2019-09	Distribution[b]	Observation
BUFONIDAE ***Rhinella marina*** **(Linnaeus, 1758)**	Cane toad	LC	-	-	Introduced	Seen
MICROHYLIDAE ***Kaloula picta*** **(Dumeril & Bibron, 1841)**	Banded bullfrog	LC	-	-	Introduced	Ethno
SCINCIDAE ***Lamprolepis smaragdina***	Emerald tree skink	LC	-	-	Resident	Seen
GEKKONIDAE ***Gekko gecko***	Tokay gecko	LC	-	-	Resident	Ethno

Figure 2.72 Photo of a cane toad observed in the area.

Arthropods

In assessing the diversity of arthropods in the site, use of pitfall traps were conducted to collect arthropods. use of sweep nets, and opportunistic sampling were conducted to collect arthropods. For arthropods, four plots were established. As result, a total of 7 families from pitfall traps, 5 families from sweep nets, and 5 families from opportunistic sampling of arthropods were identified. Dominant family in all plots was Formicidae or the family of ants order Hymenoptera.

Ground dwelling arthropods

Using the modified Fernando biodiversity scale, the diversity index of the ground dwelling arthropods in the site is very low in all transects (**Table 2.28**). The E value shows that the distributions of families were moderately even. The Simpson's index of dominance of Formicidae is 0.497, 0.367 and 0.309 from Transects I to III, respectively. The concentration of family Formicidae, the most dominant families in all transects is moderately high. Transect I is 46% similar with Transect II, Transect II is 29% similar with transect III, and Transect III is 47% similar with Transect I, which means that the species composition substantially differs between transects. It is of interest to note that there were no dragonflies and damselflies, particularly those that were listed as threatened, observed in the area perhaps due to the season.

Table 2.28 Biodiversity indices of ground dwelling arthropods

Index	Transect Pitfall traps	Sweep nets	Opportunistic
Shannon Diversity (H')	1.17	1.12	1.59
Shannon Evenness (E)	0.563	0.694	0.723
Family Richness	8	5	9
Simpson Dominance	0.504	0.416	0.341

Table 2.29 List of families of ground dwelling arthropods observed in all plots using pitfall traps

PLOT 1	PLOT 2	PLOT 3	PLOT 4
Formicidae	Formicidae Termitidae	Gryllidae Scarabeidae Formicidae Staphylinidae Apidae	Formicidae Nitidulidae

Table 2.30 List of families of ground dwelling arthropods observed in all plots using sweepnets

PLOT 1	PLOT 2	PLOT 3	PLOT 4
Formicidae **Gryllidae**	Formicidae Lycosidae Gryllidae	Formicidae Cicadellidae Termitidae	Formicidae Gryllidae

Table 2.31 List of families of ground dwelling arthropods observed in all plots during opportunistic sampling

PLOT 1	PLOT 2	PLOT 3	PLOT 4
Formicidae **Tettigonidae** **Staphylinidae** **Nitidulidae** **Araneidae**	Formicidae Chrysomelidae	Formicidae Tettigonidae Staphylinidae	Formicidae Gryllidae Cicindellidae

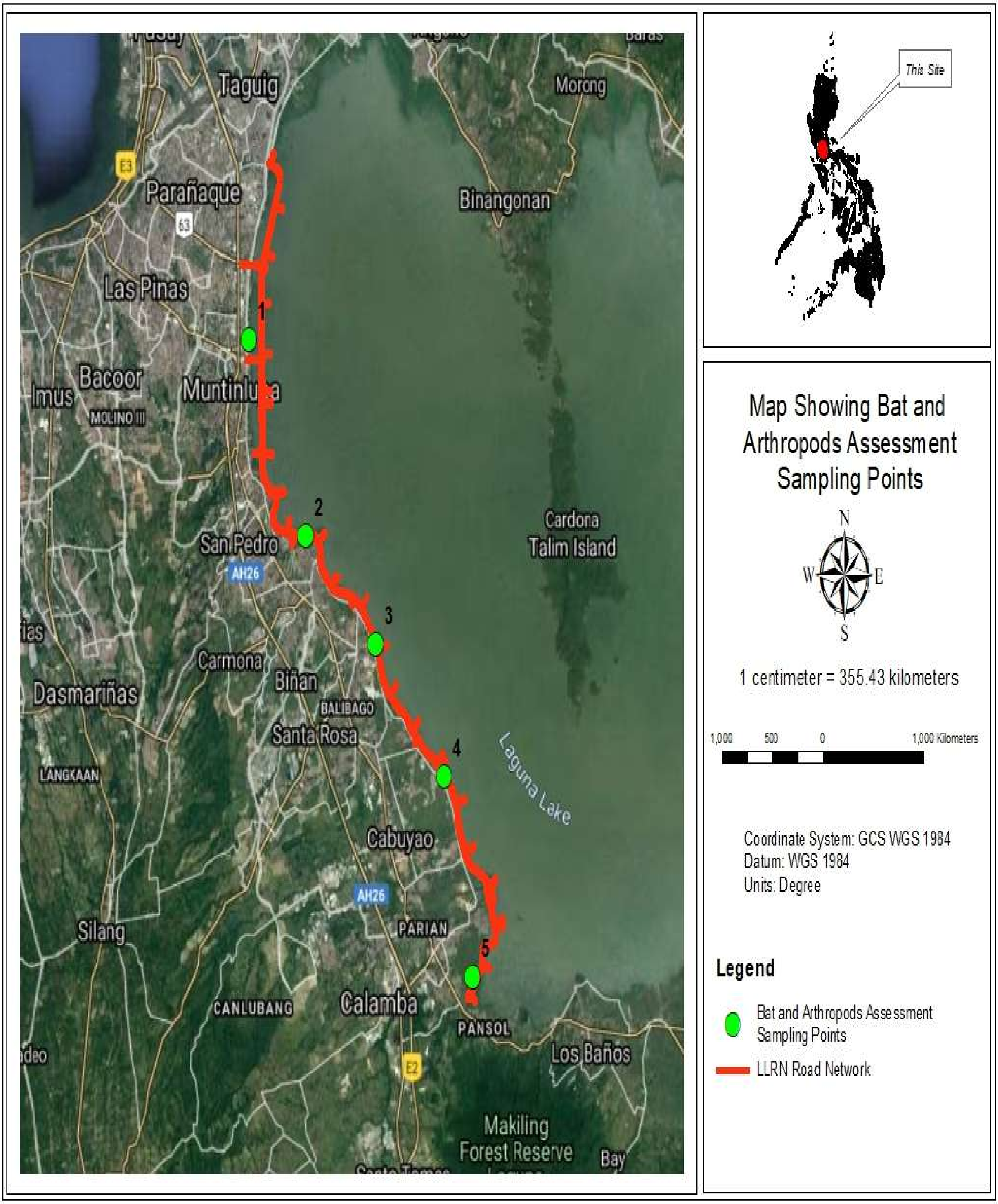


Figure 2.73 Map showing bats and arthropods assessment sampling points.

Figure 2.74 Some of the photographs during ground dwelling arthropods survey and analysis of samples.

2.1.5.3 Potential Impacts and Options for Prevention, Mitigation or Enhancement

Pre-construction and Construction Phase

Vegetation Removal and Loss of Habitat.

- The proposed alignment of LLRN will not traverse through any protected area, reserved forest area, or any natural forest area. The project alignment will pass through a highly built-up area, disturbed, and maintained areas and it is within the vicinity of heavy industrial facilities, residential areas, commercial establishments and infrastructure therefore, removal of vegetation cover along the route is minimal.

- The most notable ecological area is the MMFR which is approximately 4 km from Calamba City. Although clearing of vegetation will be required along project alignment, specifically when infrastructure will be established such as borrow pits, laydown areas/construction yard, water bores, and access tracks, majority of plants recorded at the Project site were weeds species common to disturbed and degraded areas. Few numbers of both endemic tree species were encountered in the transect plots.

- Four (4) species recorded from project alignment are listed under either the Philippine Red List (DAO 2017-11) or the IUCN Red List of Threatened Species (2020-03) to include are endangered (CR) Smooth Narra (*Pterocarpus indicus*) (IUCN), Is-is (F*icus ulmifolia*), Mahogany (*Swietenia macrophylla)* and Molave (*Vitex parviflora*) as vulnerable under IUCN 2020-03. Hence, appropriate management and monitoring strategies to ensure the continued survival of its population should be developed within a Biodiversity Management Plan (BAP) within an overarching Environmental Management Plan (EMP).

- Site preparation activities will also bring damage to grasslands/marshland and some tree patches which serve as shelter and food for existing wildlife species. Such activities can lead to loss of habitats particularly for birds, especially those which are migratory. The effects during pre-construction will increase or magnify during the construction period. This may result in the disappearance of some species which will not be able to withstand the perturbations brought about by the entry of equipment added by people trampling over the habitats of wildlife. Other disturbances which will affect species are dust and noise pollution which may drive fauna away from their habitats.

- Related to the abovementioned activities, it may have the potential to introduce additional weeds to the area and to spread existing population of introduced flora along the length of the proposed alignment. A complete census/inventory of flora along the alignment shall be conducted after the completion of parcellary survey under the Detailed Engineering Design to determine the total counts of trees that will be potentially affected during pre-construction and construction activities. The list of affected trees will be submitted to EMB and DENR for application of tree cutting permit. Vegetation clearing will be kept to the minimum necessary for safe construction and operation of the project, particularly in areas adjacent to vegetation of higher conservation significance. The design of the alignment will be refined, taking into account the locations of significant vegetation types and populations of significant flora, with the objective of avoiding these through final design.

- Before the onset of clearing activities, a tree cutting permit will be secured from the DENR. Preparation of a detailed plan for the management of affected flora will be drafted by DOTr. Proper assessment of the mature trees will be conducted to determine appropriate method of removal, to recommend whether for transfer/earth ball or cut. As usual process, earth balling of trees (if there are any) will be coordinated with the DENR and concerned LGUs including the site where the earth bald trees will be transplanted. Mature trees will be transplanted carefully to designated receiving areas. A detailed plan for transfer/earth balling of mature trees shall be prepared prior to removal. The detailed plan shall include proper handling of the uprooted tree and preparation of the recipient site to ensure high survival rate of the trees. A system to periodically monitor and maintain survival of these species shall be set in place to assure high survival rate. DOTr will coordinate with the DENR and LGUs for the identification of relocation area for the potential trees that will be transplanted or transferred.

- Biodiversity offsetting shall be secured. Tree planting activities will be conducted to replace trees and vegetation that were removed and affected by site clearing. Native/endemic/indigenous species of trees, shrubs, and grasses should be cultivated/grown in nurseries. Such condition was set to restore habitats of wildlife at the buffer zone which will be delineated at the side of the project site. Buffer areas near or adjacent to the construction sites shall be established for wildlife. Survival rate will also be monitored and replacement as necessary. During construction, tree planting activities can be conducted where possible and regular monitoring of replanted trees will be conducted to check for survival. In the case where trees fail to survive, trees will be offsetted as necessary.

- Impacts to marginal habitats, for instance the margin between the lake shore and the land. Loss of marginal aquatic vegetation will be a key impact that requires mitigation.

Threat to Existence and / Or Loss of Important Local Species.

- Vegetation clearing is unavoidable during pre-construction and construction phase. This may affect the existence of the five (2) flora species that were found to be Philippine endemics or have natural habitat confined only in the country to include Is-is (*Ficus ulmifolia)* and Tibig (*Ficus nota)* and some threatened species such as Smooth Narra (*Pterocarpus indicus*), Is-is (F*icus ulmifolia*), Mahogany (*Swietenia macrophylla)* and Molave (*Vitex parviflora*). Noteworthy among the list are critically endangered (CR) *P. indicus* (IUCN 2020-03), and a premium tree species which is specifically used in railroad ties, *V. parviflora*) (DAO 2017-11). Consequently, vegetation clearing may also affect the fauna species in the area including the 21 bird species and two bats, two amphibians and two reptiles.

- To mitigate impacts to the existence of important local species, indigenous and native remnant species growing in the Project site will be emphasized for conservation and protection planning in response to the conservation status reported in this report. This is one practical way of choosing rehabilitation species since these kinds have already acclimatized in the area and have proven its capacity to grow given the existing environmental conditions.

- Wildlings of threatened species that thrived in the area, if any, will be collected before construction and placed in the nursery and will be given priority during nursery operation to be used for rehabilitation of areas that will be affected by the Project.

Threat to Abundance, Frequency and Distribution of Important Species.

- The construction of the LLRN will result in the clearing of vegetation which may cause an adverse effect on the insects, wildlife or other organisms that depend on the vegetation as a source of food for insects, wildlife, or other organisms. Results of the plant diversity assessment revealed that the project area has very low biodiversity index value. Loss of habitat during land and site preparations prior to construction will result to the decrease in abundance and frequency of observed wildlife. Endemic species which may not be able to withstand disturbances (e.g., construction of structures, depots) may not thrive in the area.

- To mitigate the impacts of the Project, wildlings of threatened species will be collected before construction which will be used as planting materials. These will be managed in the nursery and will be given priority during nursery operation to be used for rehabilitation of areas that will not be affected by the Project. Buffer areas near or adjacent to construction sites should be established where wildlife can fly, feed, overwinter (for migratory birds) or roosts.

Hindrance to Wildlife Access.

- The amphibians and migratory waterbirds (such as egrets and herons) will be mostly affected during pre-construction and construction phase. If the grassland/marshland is cleared, the area will dry up and access routes will be closed to these taxa. This may result in the disappearance of some species from the affected areas. Alternate access routes or corridors for amphibians and avifauna may be set aside inside work sites to allow wildlife to traverse. Translocation by a suitably experienced biodiversity specialist should be undertaken during land clearance activities. Species should be translocated to nearby suitable habitat outside of the construction footprint. One (1) species of fruit bat will also be affected. This bat may have just been flying through from their feeding area returning to their roosts when caught in the net. Majority of the areas are either intentionally cleared or occupied for residential pretensions.

- A Construction Management Plan and Biodiversity Management Plan will be prepared and strictly implemented accordingly to minimize unnecessary removal of vegetation, generation of noise, vibration, illumination, and vehicular movement. This is to avoid disruption of animal activities and also to minimize the ecological impact of construction activities in the vicinity to ecologically significant areas. All hired construction workers will be provided with training and orientation on the Construction Management Plan mainstreaming the potential ecological impacts of construction activities.

Road Kills.

- During construction phase, road kills may potentially occur within first few months of the operation. This will continue until wildlife has adapted to the new environmental condition and becomes familiar with the river crossings as their point of access across the project alignment. To mitigate this impact, speed limits during construction should be implemented. Walls should be installed on both sides of the project alignment if possible. These walls can redirect fauna species to the crossings where they can pass through.

Operation Phase

Vegetation Removal and Loss of Habitat.

- In this phase of the project, no vegetation removal and clearing are expected. Tree planting activities will be conducted to replace trees and vegetation that were removed and affected by site clearing. Also, a regular monitoring of flora and fauna at sensitive area and survival of replanted trees will be conducted.

Threat to Existence and/or Loss of Important Local Species.

- During the operation phase, no vegetation removal and clearing are expected so there would be no threat to the existence and/or loss of important local flora species. As an additional consideration, implementation of vegetation management plan will be enforced including but not limited to the minimal use of herbicide and machineries. Regular maintenance of Right of Way (ROW) to control vegetation may involve the use of mechanical methods, such as mowing or pruning machinery, in addition to manual hand clearing and herbicide use, all of which can disrupt wildlife and their habitats. Noise, vibration, illumination, and vehicular movement can disrupt animal activities. Workers are provided training on ecological impact of construction activities.

Threat to Abundance, Frequency and Distribution of Important Species.

- As previously mentioned, no vegetation removal and clearing are expected during operation phase. For landscaping of open areas, use local or endemic species as much as possible.

Hindrance to Wildlife Access.

- The open and disturbed areas will be re-vegetated to allow wildlife to traverse. Additional measures include minimize noise, vibration, illumination and vehicular movement in consideration to the existing fauna at significant area/s.

Table 2.32 Summary of impacts and corresponding mitigation measures

List of Key Impacts	Project Phase				Discussion/Proposed mitigation activities
	Pre-	Construction	Operation	Abandonment	
Loss of habitat	✓	✓			• Delineate areas to be cleared both on the pans and on the ground prior to clearing works • Ancillary and temporary facilities should not be located within the remaining habitats • Enhance degraded and remaining habitats
Threat to existence and/ or loss of important local species	✓	✓			• Implement a no hunting policy
Threat to abundance, frequency and distribution of important species	✓	✓			• Implement a no hunting policy • Avoid and prevent construction delays
Hindrance to wildlife access	✓	✓			• Minimize clearing works within water body/gully crossings • Avoid construction delays • Prioritize these crossings as the tree planting sites • Minimize artificial lighting in the crossings without compromising road safety and night driving
Road kills	✓	✓			• Implement speed limits during construction • Walls should be installed on both sides of the project alignment to prevent fauna entering and crossing the project area

Table 2.32 Impact Management Plan (IMP)

Project Phase		Issues / Potential Impacts	Options for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Commitment/Guarantee
CONSTRUCTION PHASE	Terrestrial Flora -	Vegetation removal	- Tree cutting permit from the DENR shall be secured prior to any clearing activities. Cutting clearance from the Municipal/City Agricultural Office (M/CAO) of affected municipalities and city and Philippine Coconut Authority (PCA) shall also be secured whenever applicable. - Inventory and geotagging of affected trees will be conducted; this follows DENR requirement for tree cutting permit - To compensate for the removed vegetation, the requirement of MAO 2012-02 for tree replacement ratio of 1:100, will be complied with.	Proponent	Part of the Project Cost	Project development budget, Contractor's contract
	Project	Issues / Potential	Options for Prevention or	Responsible	Cost	Commitment/Guarantee

Phase	Impacts	Mitigation or Enhancement	Entity		
	Threat to existence and/ or loss of important local species	- Tree cutting permit from the DENR shall be secured prior to any clearing activities. - Offset planting using same species that will be removed or indigenous species shall be conducted following DENR preferred replacement ratio. - Monitor replacement planting to ensure growth and survival			
	Proliferation of invasive species	- Revegetation of cleared and opened areas using indigenous species - Generate list of invasive species and avoid its reintroduction on site	Proponent	Part of the Project Cost	Project development budget, Contractor’s contract
Project Phase	**Issues / Potential Impacts**	**Options for Prevention or Mitigation or Enhancement**	**Responsible Entity**	**Cost**	**Commitment/Guarantee**

	Terrestrial Fauna	- Loss of habitat - Threat to existence and/ or loss of important local species - Threat to abundance, frequency and distribution of important species - Hindrance to wildlife access - Road kills	- Delineate areas to be cleared both on the pans and on the ground prior to clearing works - Ancillary and temporary facilities should not be located within the remaining habitats - Enhance degraded and remaining habitats - Implement a no hunting policy - Avoid and prevent construction delays - Minimize clearing works within water body/gully crossings - Avoid construction delays - Prioritize these crossings as the tree planting sites - Minimize artificial lighting in the crossings without compromising road safety and night driving - Implement speed limits during construction	Proponent	Part of the Project Cost	Project development budget, Contractor's contract
OPERATION PHASE	Terrestrial Flora -	Proliferation of invasive species	- Revegetation of cleared and opened areas using indigenous species - Generate list of invasive species and avoid its reintroduction on site	Proponent	Part of the Project Cost	Project development budget, Contractor's contract
	Terrestrial Fauna	- Hindrance to wildlife access	- Minimize artificial lighting in the crossings without	Proponent	Part of the Project	Project development budget, Contractor's contract

		- Road kills	compromising road safety and night driving - Walls should be installed on both sides of the project alignment to prevent fauna entering and crossing the project site		Cost	
ABANDONMENT PHASE	Terrestrial Flora	Proliferation of invasive species	- Revegetation of cleared and opened areas using indigenous species - Generate list of invasive species and avoid its reintroduction on site	Proponent	Part of the Project Cost	Project development budget, Contractor's contract

2.2 The Water

2.2.1 Hydrology/Hydrogeology

Laguna Lake is the largest lake in the Philippines with a surface area of around 900 km^2 at normal water level at an elevation of 12.5 m. The average depth of the lake is around 2.5m with a corresponding estimated volume of the lake water of about 2,250,000 m^3.

The Laguna Lake Basin consists of 24 sub-basins and these sub-basins include around 100 streams that drain into the lake with only one outlet (i.e., Napindan Channel through the Pasig River that drains the lake waters to Manila Bay). Outside of the Marikina River Basin (which is the largest tributary among the sub-basins but is a man-induced tributary to the lake), Pagsanjan River Basin and the Sta. Maria River Basin are the two largest tributaries.

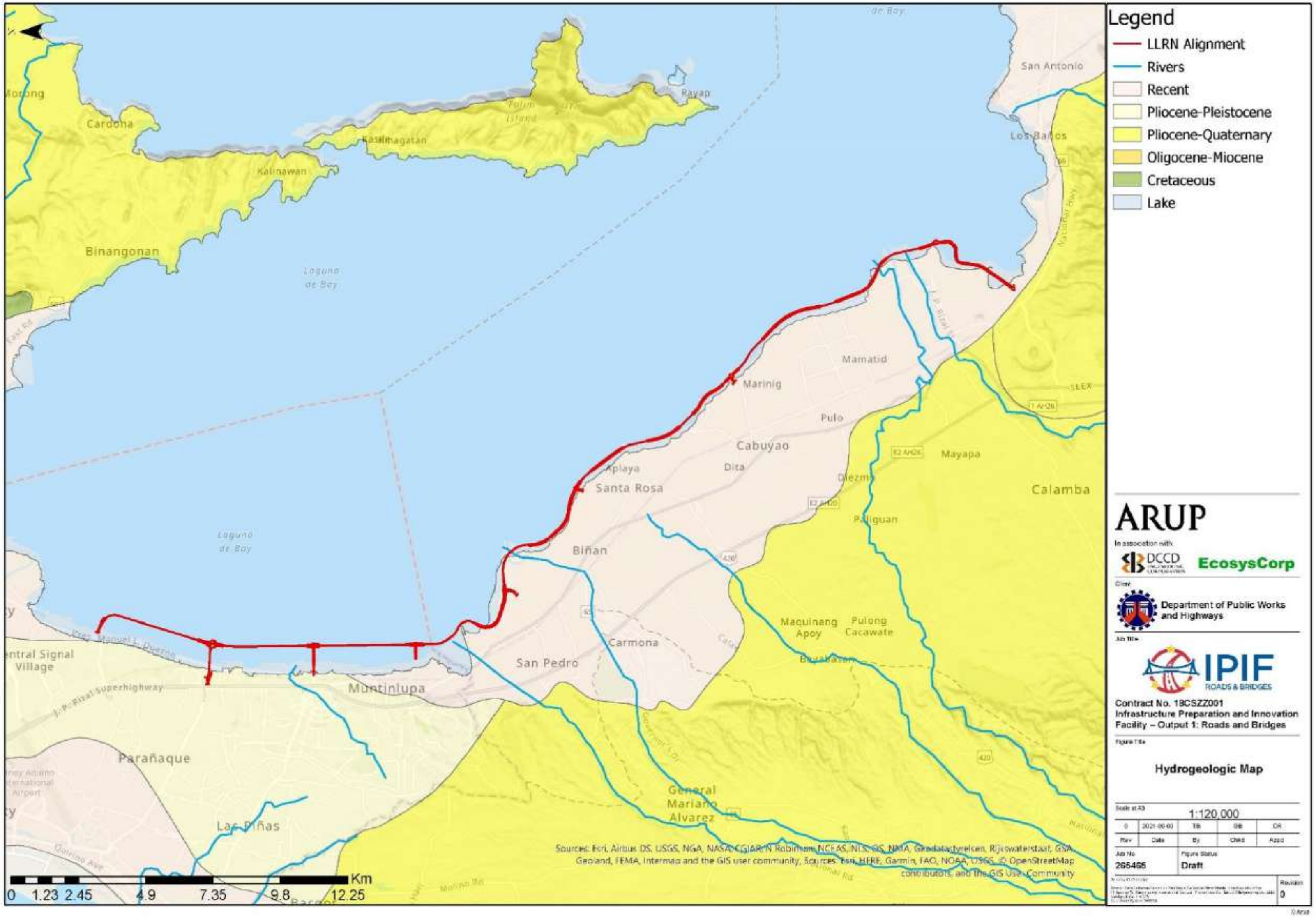


Figure 2- 49 Hydrogeologic Map

Table 2.33 Along the Laguna Lake shoreline, there are list of rivers that interface with the LLRN - PH1 mainline. Provision of clearance to minimise the blockage of river mouth and effect on the upstream in each river were considered. Existing rivers, creeks and nearby tributaries are listed in **Table 2.33**.

Table 2.33 LLRN - PH1 Project Rivers, Creeks and Nearby Tributaries

Interchanges	Municipality	Water Body
Lower Bicutan	Taguig	Mauling Creek
Sucat	Muntinlupa	Sucat River Buli River
Tunasan	Muntinlupa	Tunasan River
Alabang	Muntinlupa	Alabang River Pasong Diablo River Bayanan Creek Poblacion River Magdaong River
San Pedro	San Pedro, Laguna	San Pedro River San Isidro River
Biñan	Biñan, Laguna	Lidayan River Canlalay River Biñan River
Sta. Rosa	Sta. Rosa, Laguna	Sta Rosa River Tatlong Hari St. River Cherry Blossom St. River
Cabuyao	Cabuyao, Laguna	Cabuyao River Bigaa Cabuyao River
Calamba	Calamba, Laguna	San Cristobal River San Juan River

Based on the water quality criteria of the DENR Administrative Order No. 34, Laguna Lake is classified as Class C water, which means the lake is intended for fish propagation, secondary recreation activities (e.g., boating), and industrial water supply. Due to urbanization within the lake region, the lake serves as a multi-purpose waterbody. The existing lake uses include consumptive uses such as those for domestic water supply and irrigation, and non-consumptive uses such as for hydropower generation, aquaculture, navigation, and recreation, as outlined in **Table 2.34**.

Table 2.34 Existing Usage of Laguna Lake

Irrigation	Source of irrigation for various agricultural farmlands in the lakeshore towns of Laguna and Rizal and some areas of Cavite; Approximately 10% (at the maximum) of the volume of the lake at normal level can be utilized for irrigating the farmlands
Potable water supply	Maynilad Water Services, Inc. currently operates 150 MLD Putatan Water Plant 1 and an additional 150 MLD plant (Putatan WTP 2) is being constructed/commissioned. Manila Water Company Inc. has also recently commissioned the 100 MLD Cardona Water Treatment Plant (current supply of 24 MLD/Phase 1) to help augment the water supply for the East Zone.
Fisheries and aquaculture	Most of the fish-pen and fish-cage structures are in the west side of the lake due to more suitable conditions. Aquaculture is dominant compared to artisanal fishing. This industry is the biggest economic user of Laguna Lake. However, at present, over-crowding of fish-cages and fish-pen structures contributed to the pollution of the Lake, hence decreasing quantity of harvests.
Industrial cooling	2.04 billion m^3 of lake water yearly is utilized by several industrial facilities around the lake
Electricity	From the DOE's list of existing power plants (as of 30 June 2015), the total dependable capacity of the 3 plants below is 758 Megawatts: Kalayaan Hydroelectric Power Plant – 720 megawatts Caliraya Power Plant – 28 megawatts Botocan Power Plant – 10 megawatts
Recreation	Includes boating, fishing, and sailing, but on a limited scale. Some of the residents use the lake for swimming.
Reservoir for floodwaters	Manggahan Floodway and Napindan Hydraulic Control System (NHCS) functions as a temporary floodwater reservoir to mitigate flooding especially in the low-lying areas in Metro Manila. NHCS also controls the waters from Pasig River (and from Manila Bay) and the inflow of saline waters.
Transport route	Navigational routes were set by LLDA to avoid conflicts among travellers, fish cultivators, and other users. Lakeshore communities operate motorized/non-motorized watercraft as a means of transportation. Also, there are barges plying the lake to transport barrels of oil and oil products to various supply depots
Waste sink	Due to urbanization within the lake region, the lake has also become a huge waste sink for various treated and untreated wastes coming from households, industries, cropland areas, livestock, and poultry production as well as fishery activities.
Intermittent farming	Some lakeshore areas are being utilized for cultivating water spinach (kangkong) particularly during low water level periods

The normal water level at the lake is 12.5 m. Recorded water levels under extreme conditions are shown in **Table 2.35.**

Table 2.35 Laguna Lake Water Level, 1919-2009

Year	Water Level (m)
1919	14.62
1972	13.96
1978	13.49
2009	13.93

Areas along the lake are usually flooded during extreme conditions/ typhoon occurrences or even heavy rains. Bathymetry studies showed that from the 1960s to 1990s, the lake became shallower by 30 cm. Also, in 1999 studies conducted by LLDA- National Institute for Geological Sciences (LLDA-NIGS) showed that the sedimentation rate was estimated at 1.03 to 1.20 cm/yr. These lake changes were attributed to flooding occurrences, as well the siltation of the existing waterways. Hence, to address flooding issues, Laguna Lake Expressway Dike Project (LLED) was previously proposed, however, was not implemented. The LLED was supposed to act as a flood control dike and as it goes inland, a bypass road would be connected to the existing ground terrain.

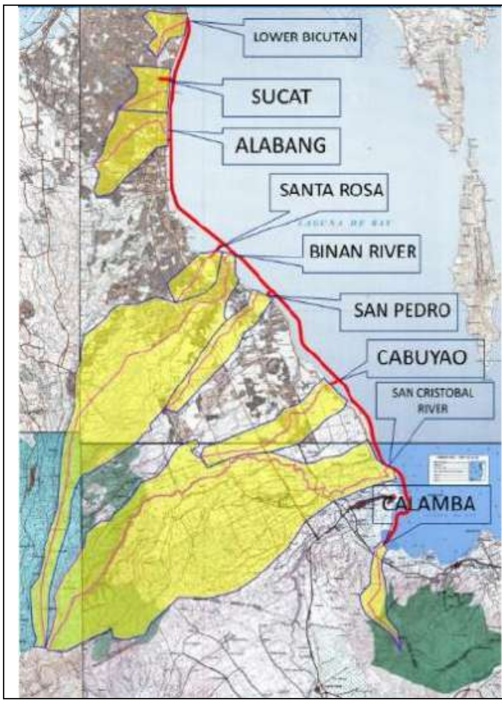
From another study, entitled Data collection survey conducted for Paranaque Spillway in Metro Manila (JICA, 2018)[20], the recorded maximum level of Laguna lake was 14.03m (in 1972) from 1946-2016. Level reached to 13.83 due to influence of monsoon rains, in 2012 and 13.85m when the typhoon Ondoy hit Metro Manila in 2009.

From this same report, flooding usually happened during monsoon rains and typhoons. It was noted that there are approximately 246 days that Laguna Lake reached 12.42-14-03m surface area level in 71 years.

2.2.1.1 Existing watercourse and catchment identification

Delineation of the catchment area was performed using the map acquired from NAMRIA (National Mapping and Resource Information Authority) which has scale of 1:50,000. The maps labelled as Manila were used for the project. Certain catchment basin parameters like catchment area, basin slope and stream length were acquired using both NAMRIA and topographic maps conjunctively.

[20] Data collection survey conducted for Paranaque Spillway in Metro Manila, JICA, 2018, retrieved on August 2021 from https://openjicareport.jica.go.jp/pdf/12308284_02.pdf



WATERSHED INFORMATION

LOCATION	CATCHMENT AREA (KM^2)	WATERCOURSE LENGTH (m)	AVE. BASIN SLOPE (%)
LOWER BICUTAN	4.306	3340.172	0.988
SUCAT	6.719	3389.317	0.826
ALABANG	14.617	6294.273	0.83
SANTA ROSA	6.476	4144.816	0.458
BINAN RIVER	79.187	30353.008	1.776
SAN PEDRO	12.02	9876.769	0.557
CABUYAO	16.485	10200.228	0.814
SAN CRISTOBAL RIVER	132.281	31982.539	1.813
CALAMBA	6.001	8035.487	9.943

Figure 2- 50 Watershed Information

(01) Lower Bicutan – The proposed roundabout connection will be situated in C6 road and an existing drainage structures of Reinforced Concrete Pipe Culvert (RCPC) are located both sides of the road.

(02) Sucat – The proposed T-Intersenction connection will be situated in the crossroads of Meralco Ave., Manuel L. Quezon st. and East of the service road and an existing drainage structures of Reinforced Concrete Pipe Culvert (RCPC) are located both sides of the road (Meralco Ave., Manuel L. Quezon road and east of the service road.

(03) Alabang – The proposed roundabout will connect to the existing Montillano st. and an existing drainage structures of Reinforced Concrete Pipe Culvert (RCPC) are located both sides of the road.

(04) Tunasan – It is not necessary to put a drainage system with a 100-meter slip road, this has to be done by LGU who planned to connect to LLRN-Tunasan.

(05) San Pedro/Biñan – An existing unnamed waterways/creek/swamp will be directly crossed by the alignment and an existing drainage structures of Reinforced Concrete Pipe Culvert (RCPC) are located both sides of the road (Manila South road and other unnamed roads).

(06) Santa Rosa – The proposed alignment will connect to the road junction of Maharlika main thoroughfare and Rizal St. A lateral drainage structures (MH, RCPC) are located beneath the concrete sidewalk and at Rizal st. are located on one side.

(07) Cabuyao – The proposed alignment will cross the headwater of a tributary of Cabuyao river and an existing drainage structures of Reinforced Concrete Culvert are located both sides of the road of Manila South road, JP Rizal st., unnamed road and private road.

(08) Calamba – The proposed alignment will directly cross the unnamed waterway/creek and an existing drainage structures of Reinforced Concrete Culvert are located both sides of the road of the Manila South road, other unnamed road and private roads.

2.2.2 Hydrodynamic Impact Assessment

In order to evaluate the potential hydrodynamic impact by LLRN which would construct a number of embankments in Laguna Lake to support the proposed roads, the Delft3D-FLOW model is adopted to evaluate relative performance in term of the hydrodynamics for the scenarios "without project" and "with project" cases under typical meteorological condition. The hydrodynamic condition during adverse weather is not considered in this assessment.

2.2.2.1 Key Settings for Hydrodynamic Model

Laguna Lake is approximately 920 km^2 in area and receive water from rainfall or neighbour areas. A number of watercourses discharge fresh water into Laguna Lake which also discharges to Manila Bay via Pasig River as shown in **Figure 2.91.**

Figure 2.91 Location of LLRN

The total length of Pasig River with its upstream (Napindan Channel) is more than 20 km and the river has an average width of about 50 m. Moreover, the average bathymetries of the open sea of Manila Bay is about 500 m, which is much deeper than that at Pasig River and Laguna Lake (average 1.3m and 2.8m in depth respectively). Considering such long, narrow, and shallow watercourse connecting Laguna Lake and Manila Bay, the hydrodynamic model would cover Laguna Lake with suitable level of features to the proposed embankments of the LLRN.

Model Grid Layout

The hydraulic model consists of about 3,586 active grids covering the whole Languas Lake of about 920 km^2. The smallest grid of the model is about 110 m × 120 m located at the area near the embankments, while the largest grid is about 2,400 m × 350 m or 2,100 m × 560 m at the eastern part of Laguna Lake those are far away from the proposed embankment of as shown in **Figure 2.92**. The hydrodynamic model is divided by 10 equal thickness layers and the coordinate system of the grids are under PRS92 Zone 3. **Figure 2.93** shows the proposed LLRN alignment and embankment overlay on the model grid.

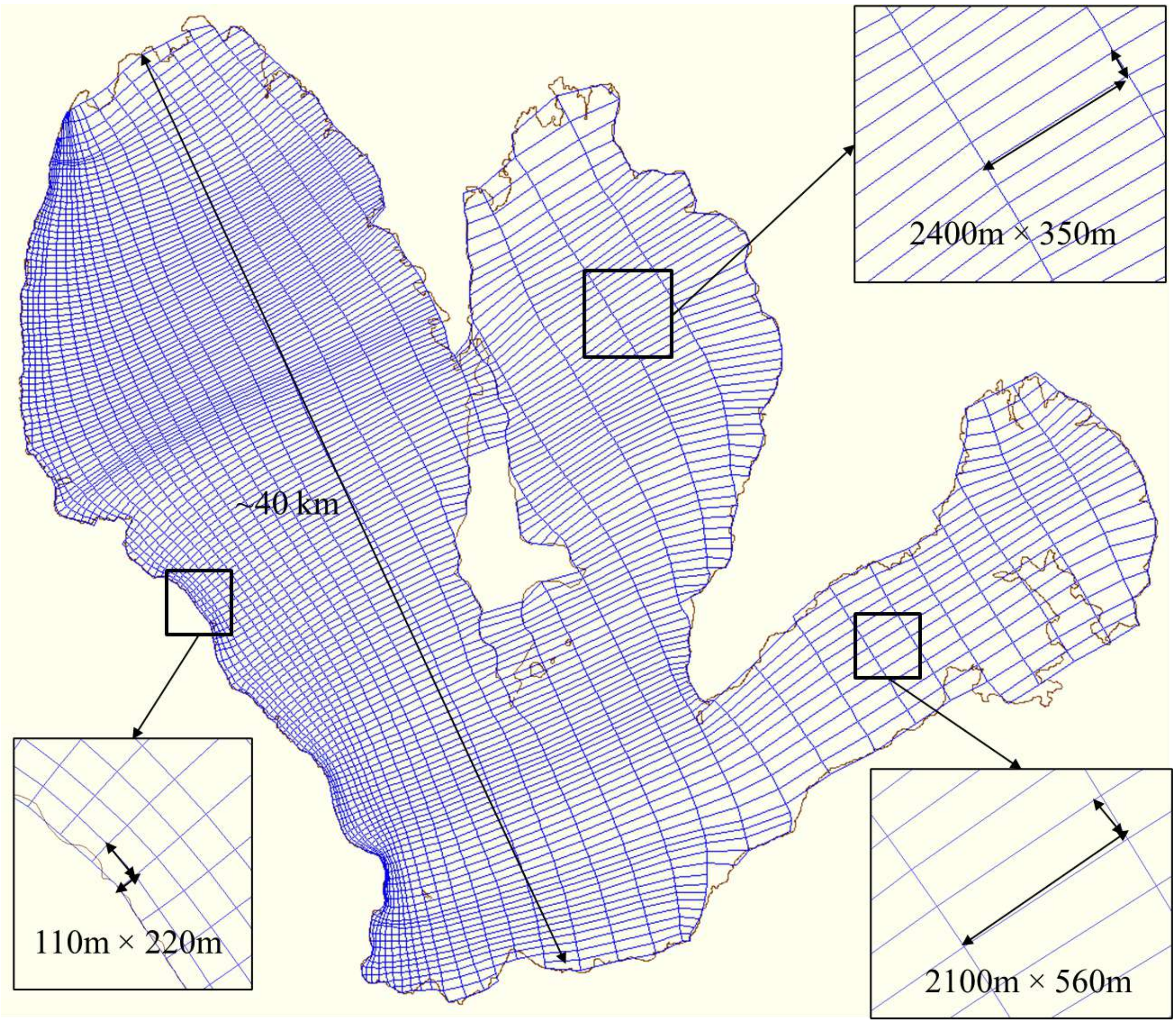


Figure 2.92 Model Grid Resolution

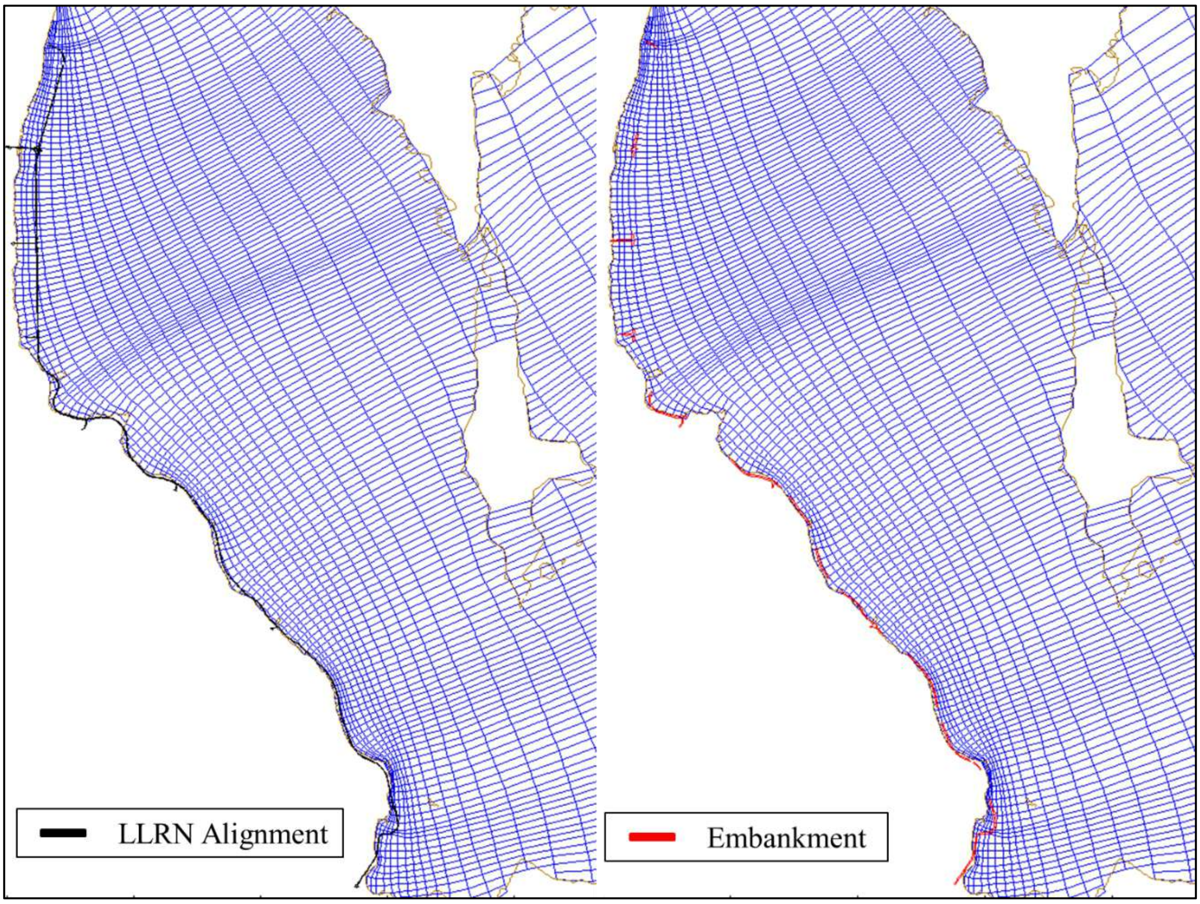


Figure 2.93 LLRN Alignment, Embankment and Model Grid

Model Grid Layout

The bathymetric data for Laguna Lake make reference to the study in "Modeling of Storm Surge and Flood Hazard Around Laguna De Bay, Philippines" 21 and interpolated into the computational grid shown in **Figure 2.94.** The water depth of entire Laguna is about several meters.

[21] https://osf.io/5zcep/download

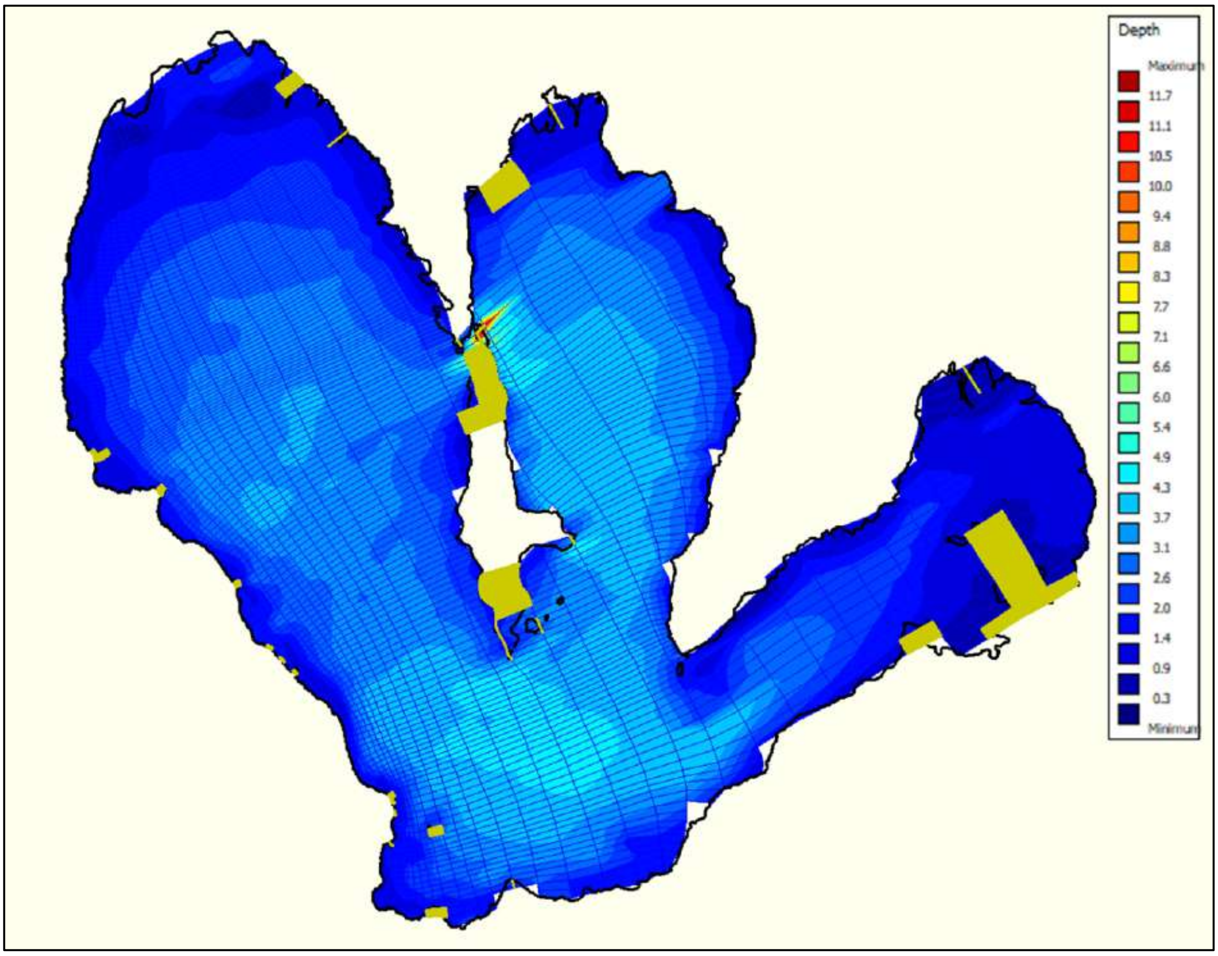


Figure 2.94 Bathymetric (Water Depth)

Time Frame

To assess the potential impact from the establishing of embankment such as the current flow velocity change, the model is set for a month (December, See Section 1.2.7) which has the highest suspended solid (SS) discharge from the watercourses within the model domain.

A time step of 0.1 minute is used to achieve the courant numbers of less than $4\sqrt{2}$, which is recommended by Section 10.4.2 in Delft3D-FLOW user manual. A sensitivity test model with smaller time step of 0.05 minute is run as a trial to identify the difference between the time step of 0.1 and 0.05 minute. Results indicate that there is no significant difference with time steps of 0.1 minute. For achieving a more efficiency modelling, a time step of 0.1 minute is therefore adopted for all scenarios.

Physical Parameters

According to the record in annual Report 2019 by Laguna Lake Development Authority, the highest flow rate of the surrounding watercourse catered by Laguna Lake appeared in December (see Appendix I). Therefore, the physical parameters in December are adopted in the hydrodynamics model as listed in **Table 2.41**, including wind speed, prevailing wind direction, temperature, salinity, and bottom roughness. The meteorological data refers to the meteorological record from 1980 to 2017 of the nearest weather stations at Pasay City (about

5 km from the north section LLRN). The discharge flow rates of the watercourse discharging into Laguna Lake are listed in **Table 2.42.**

Table 2.41 Physical Parameters

Parameters	Unit	Value	Reference
Ambient Temperature	(ºC)	27	Pasay City meteorological record (1980-2017)
Wind Speed	(m/s)	5	
Wind Direction	(angel to North)	90	
Bottom Roughness	Manning coefficient	0.015	Herrera etc 2014[22]
Salinity	‰	0.5	On site Measurements (conducted in 2020)
River Flow Rate	m/s	See Appendix 1	Annual Report 2019 by Laguna Lake Development Authority [23]

Table 2.42 Discharge Flow Rates for Watercourse Discharging into Laguna Lake

ID in Figure 5	ID in Annual Report 2019	Name	Flow Rate (m^3/s)	Salinity (‰)	Temperature (ºC)	Suspended Solid (g/m^3)
R3	SB-3	Angono	0.138	0.368	32.2	45.7
R5	SB-5	Baras	0.009	0.386	29.1	7.64
R7	SB-7	Pilillia	0.031	0.335	30.2	21.3
R8	SB-8	Jala-jala	0.097	0.349	28.1	56
R9	SB-9	Sta Maria	0.768	0.349	28.1	56
R10	SB-10	Siniloan	0.159	0.343	32.1	37.2
R11	SB-11	Pangil	0.057	0.378	26.1	45
R12	SB-12	Caliraya	0.333	0.36	29.4	38.4
R13	SB-13	Pagsanjan	1.853	0.36	29.4	38.4
R14	SB-14	Sta Cruz	0.402	0.36	29.4	38.4
R15	SB-15	Pila	0.149	0.36	29.4	38.4
R16	SB-16	Calauan	0.486	0.36	29.4	38.4

[22] "Hydrodynamic Investigation of a shallow Tropical Lake Environment (Laguna Lake, Philippines) and Associated Implications for Eutrophic Vulnerability", Eugene C. Herrera, Kazuo Nadaoka, Ariel C. Blanco, Emiterio C. Hernandez 2014
[23] https://llda.gov.ph/

ID in Figure 5	ID in Annual Report 2019	Name	Flow Rate (m^3/s)	Salinity (‰)	Temperature (°C)	Suspended Solid (g/m^3)
R17	SB-17	Los Baños	0.193	0.36	29.4	38.4
R18	SB-18	San Cristobal	0.360	0.36	29.4	38.4
R19	SB-19	San Juan	0.759	0.36	29.4	38.4
R20	SB-20	Cabuyao	0.264	0.36	29.4	38.4
R21	SB-21	Biñan	0.135	0.36	29.4	38.4
R22	SB-22	San Pedro	0.135	0.36	29.4	38.4
R23	SB-23	Muntinlupa	0.035	0.36	29.4	38.4
R24	SB-24	Taguig	0.037	0.36	29.4	38.4

Note: *The flow rates refer to Annual Report 2019 by Laguna Lake Development Authority. The temperature, salinity and suspended solid concentration of R3 to R11 are based on the on-site measurements taken in October 2020 to January 2021. The averaged values of the measurement results for R3 to R11 are adopted to the rivers R12 to R24 which are located much further away.*

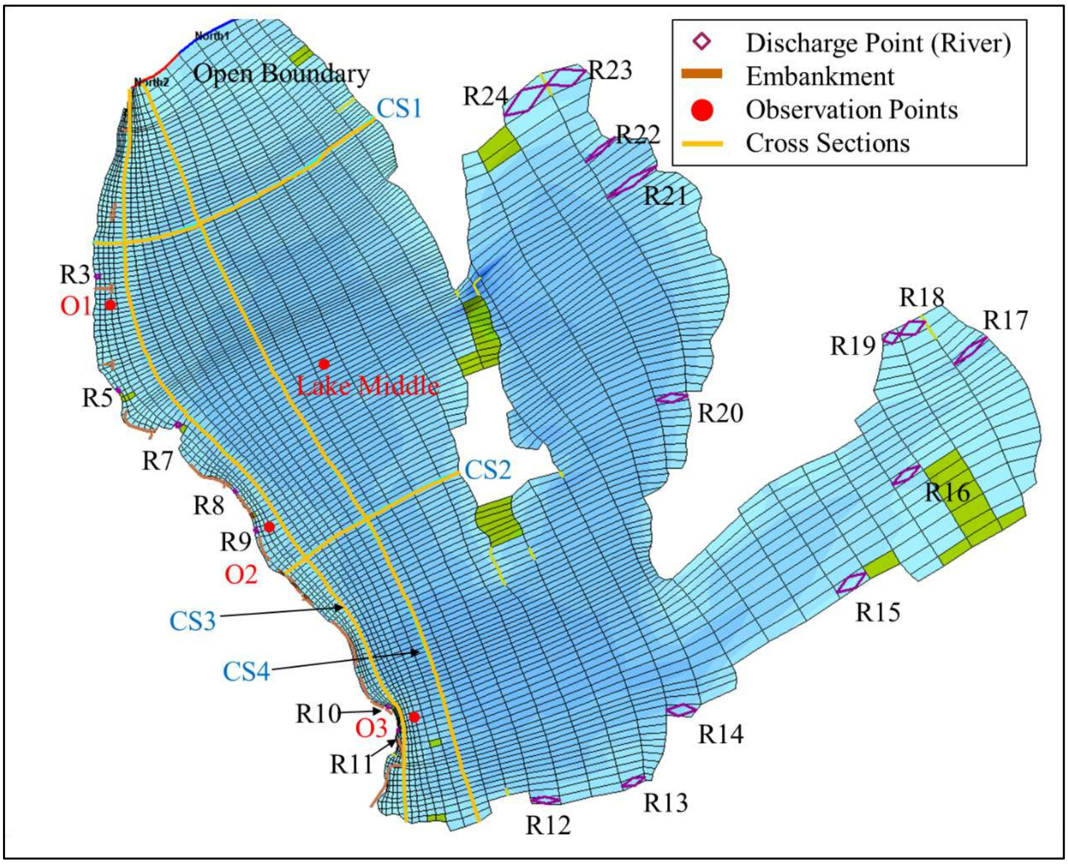


Figure 2.95 Discharge Points and Observation Points

Boundary Conditions

The open boundary of the hydrodynamic model is located at the western north of the Laguna Lake and is divided into 2 boundary segments. The boundary segments are set as "Water Level" and the forcing types of the model are Astronomic. The open boundaries of the model were extracted from Delft Dashboard24 using TPXO Global Tidal Models v7.2. Total 13 astronomical constituents with their respective amplitude and phase are used for the boundary conditions and including M2, S2, N2, K2, K1, O1, P1, Q1, MF, MM, M4, MS4, and MN4. Constant salinity is adopted in the model for all scenarios (constant transport conditions). The on-site measurement results of the salinity (0.3‰ – 0.5‰) at the Laguna Lake are applied in the transport conditions for all open boundaries.

Relative Performance in Suspended Solids

Delft-WAQ is used to evaluate the relative performance in term of dispersion for suspended solid caused by the proposed embankments of the LLRN. The flow condition and the dispersion of WAQ model is driven by the results of Delft-FLOW, which simulates the current velocity.

The boundary conditions of WAQ (temperature, salinity, and concentration of suspended solids) are adopted constant values based on the on-site water quality measurement taken in the middle of Laguna Lake.

WAQ model was run with constant initial value and the modelling was repeat until the suspended solid concentration became stable by using residual map of the nth run as the initial map of n+1th run. The simulation period of WAQ covered 1 month, i.e. two spring-neap cycles. The first spring-neap cycle was used for spin-up purpose while the modelled results were only based on the second spring-neap cycle.

Results and Discussion

Different "dry points" and "thin dam" are used to represent the current block of the proposed embankments as shown in **Figure 2.96.**

[24] https://publicwiki.deltares.nl/pages/viewpage.action?pageId=42401894

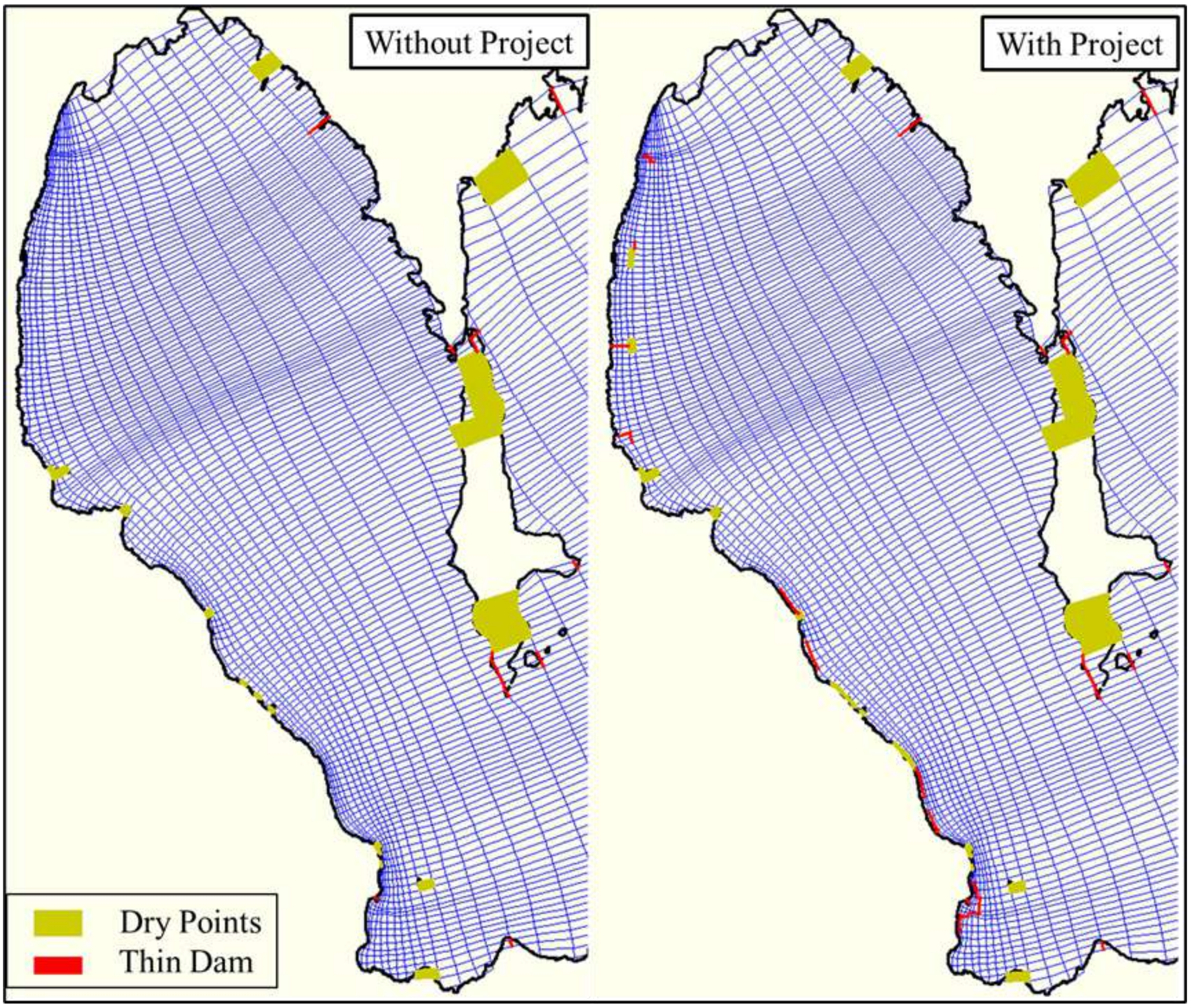


Figure 2.96 "Without Project" and "With Project"

Overall Momentary Flow and Accumulated Flow across Laguna Lake

The timeseries plots of instantaneous discharge (momentary flow) and cumulative discharge (accumulated flow) are compared between the "Without project" and "With project" scenarios at 4 transects, namely "CS1", "CS2", "CS3", and "CS4" as indicated in Figure 5. "CS1" and "CS2" are the transects from east to west while "CS3", and "CS4" are from north to south. The time series plots are presented in **Figure 2.97** to Figure **2.100** . Generally, there are no significant changes between "without project" and "with project" for four transects of both east-west direction and north-south direction.

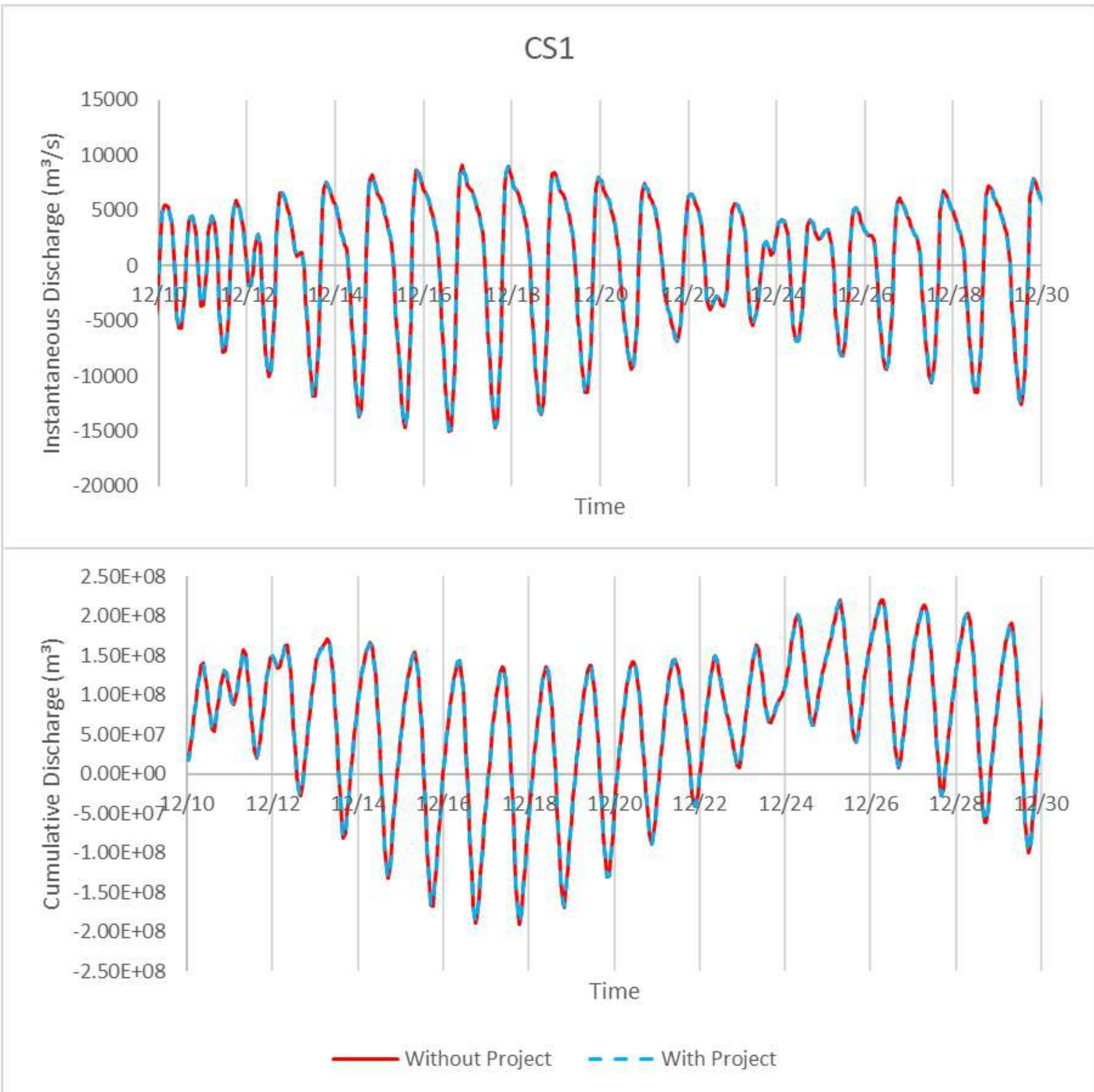


Figure 2.97 Instantaneous Discharge and Cumulative Discharge at "CS1"

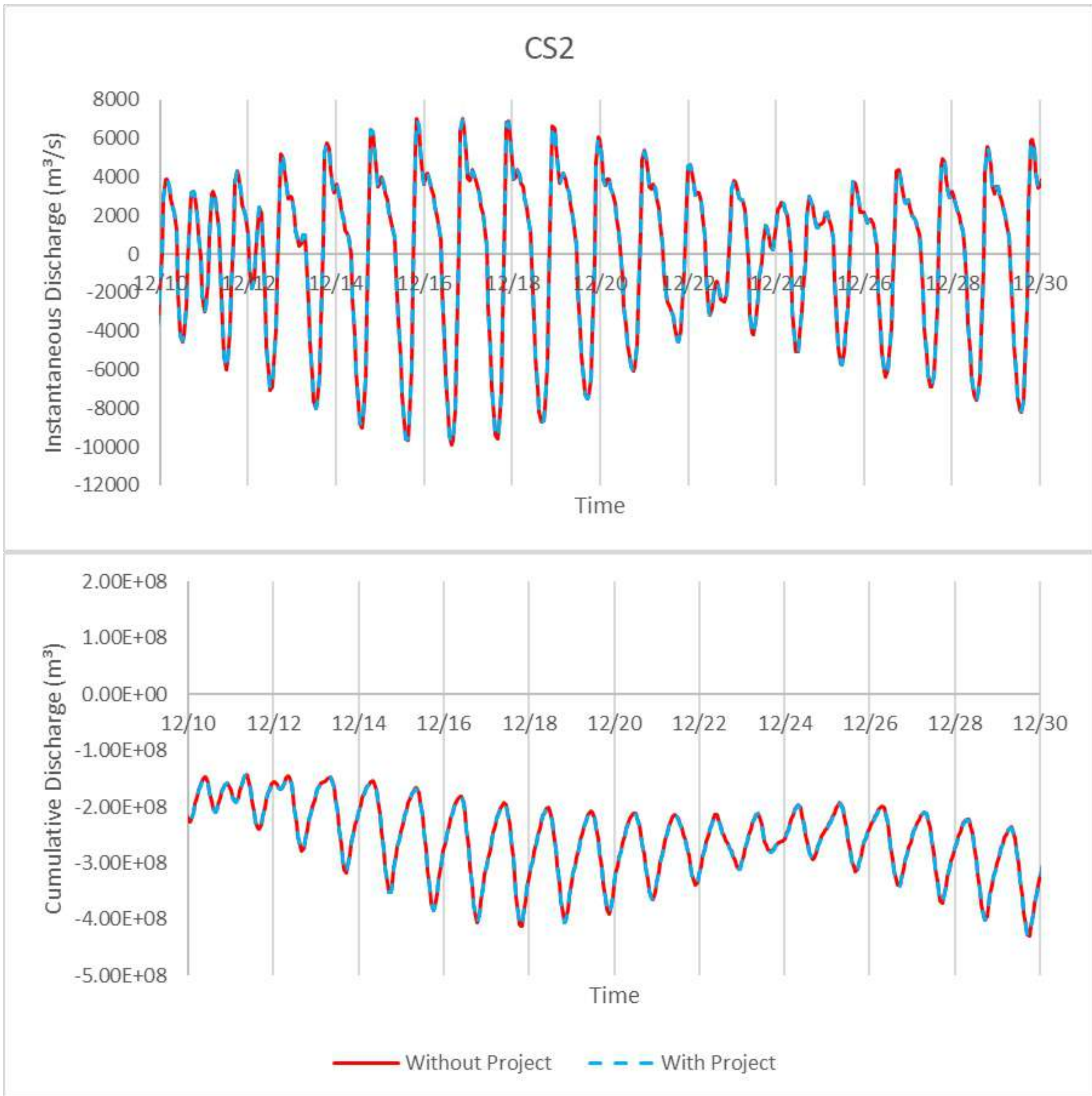


Figure 2.98 Instantaneous Discharge and Cumulative Discharge at “CS2”

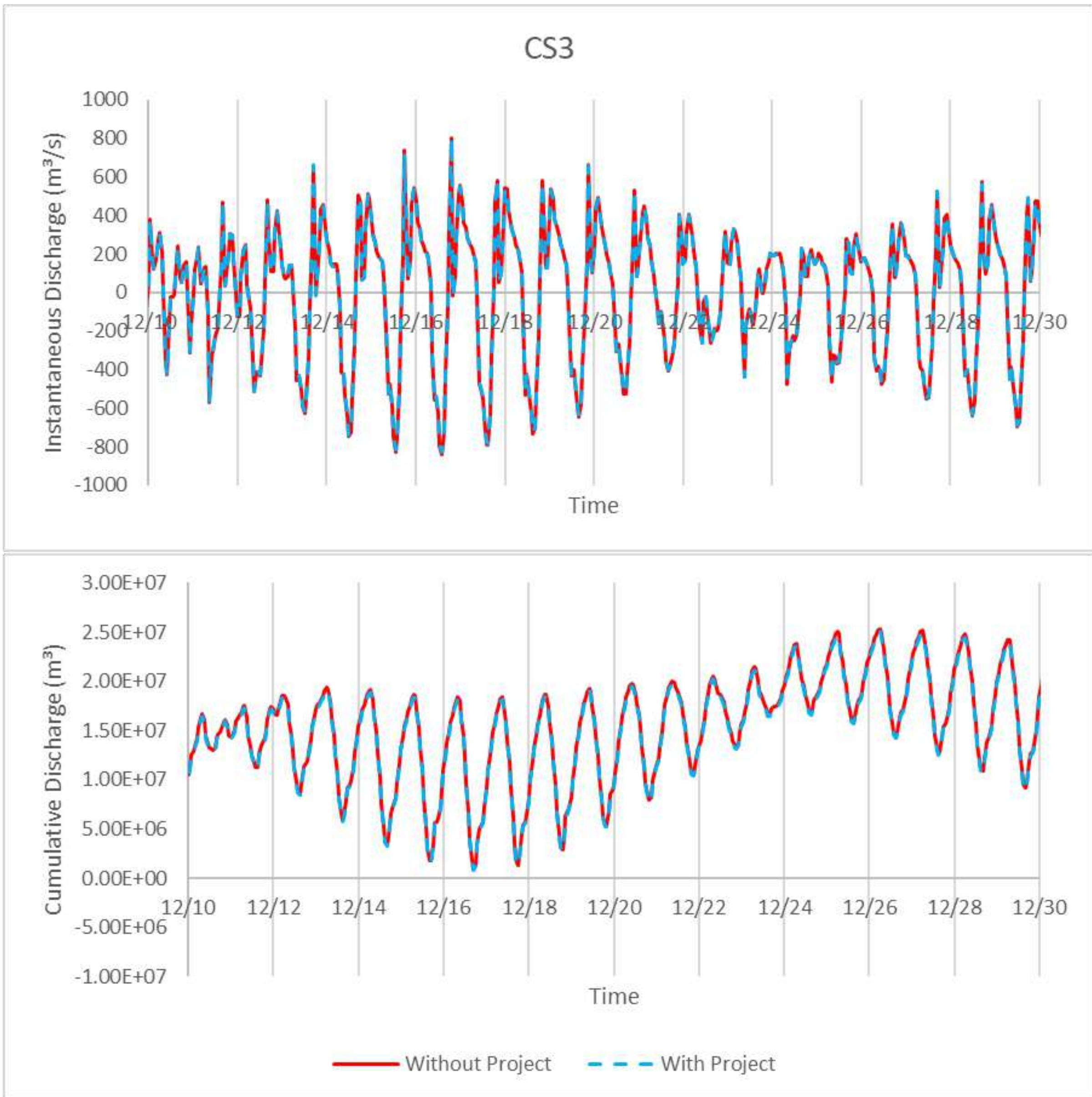


Figure 2.99 Instantaneous Discharge and Cumulative Discharge at "CS3"

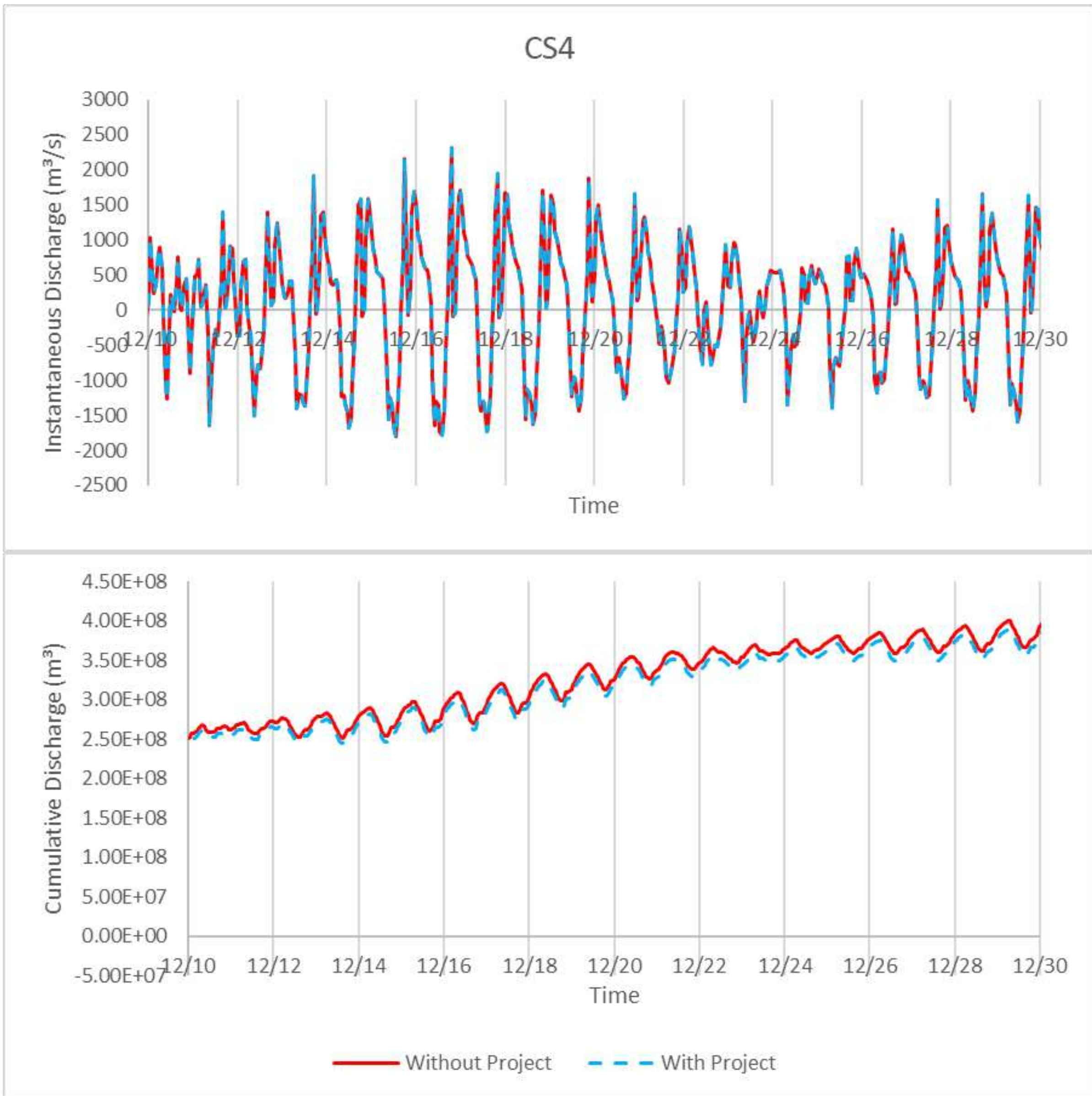


Figure 2.100 Instantaneous Discharge and Cumulative Discharge at “CS4”

Overall Dispersion of Suspended Solids

The contour plots of maximum depth averaged suspended solids for “without project” and “with project” are presented in **Figure 2.101** and indicate no significant changes in the concentration of suspended solid throughout the Laguna Lake.

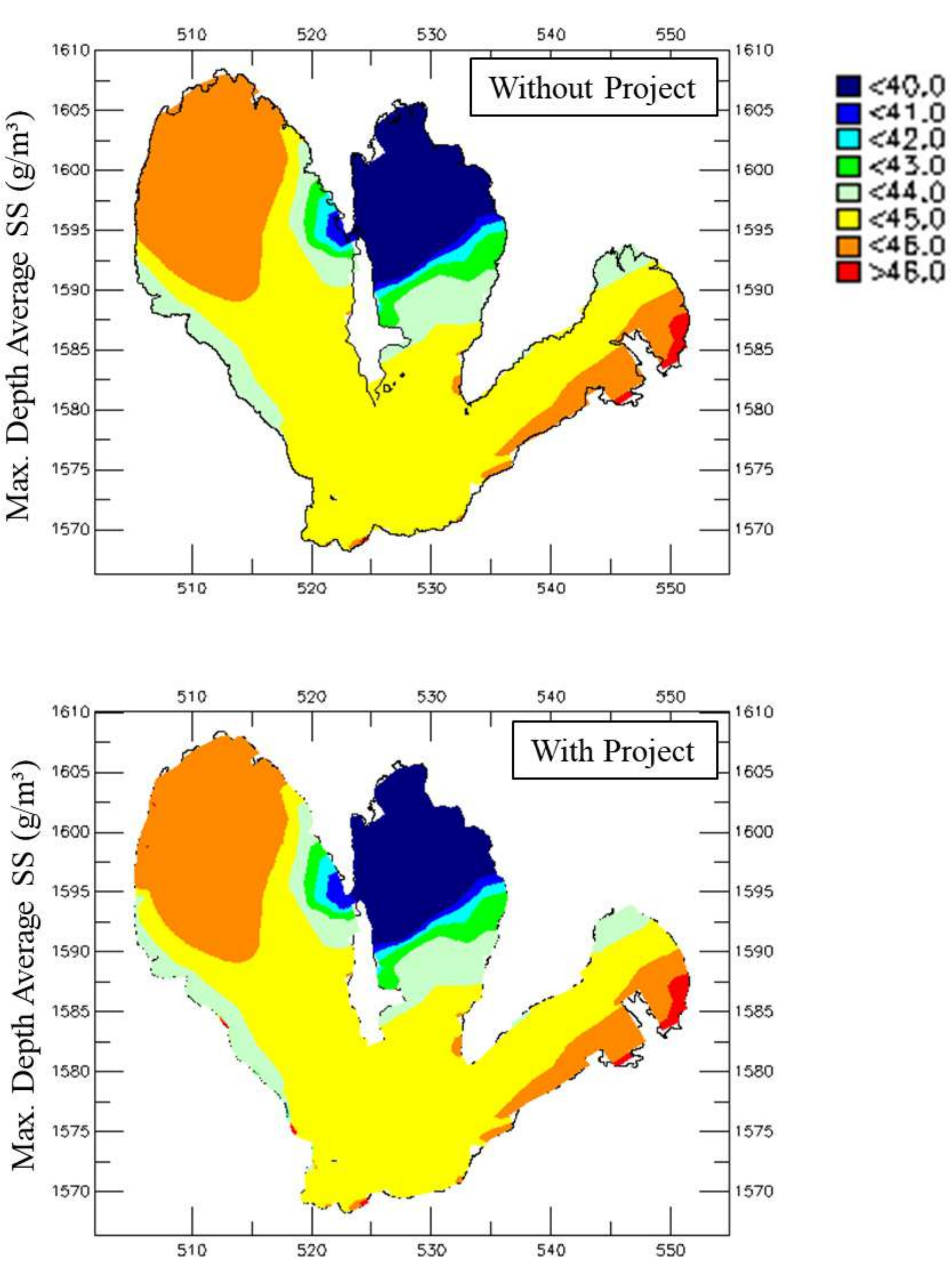


Figure 2.101 Contour Plot for Max. Depth Average Suspended Solid

An Observation Point Away from Embankments

An observation point, "Lake Middle" further away from the region of the embankments (**marked in Figure 2.102**) is selected to check the impact in term of water level, depth averaged current velocity and concentration of depth average suspended solids by the proposed embankments. As shown in **Figure 2.102** and **Figure 2.104**, the water level of the lake is from -0.1 to 0.35 m and the depth average current velocity is up to 0.23 at the point "Lake Middle". There are no significant changes between "Without project" and "With project" scenarios for both water level and depth averaged current velocity.

The concentration of depth average suspended solids at "Lake Middle" ranges from 45 to 45.6 g/m³ which is around the value of open boundary and there are no significant changes between "Without project" and "With project" scenarios. Therefore, no adverse impact caused by the Project on the water level and current speed as well as water quality in term of suspended solid concentration at areas far away from the embankments.

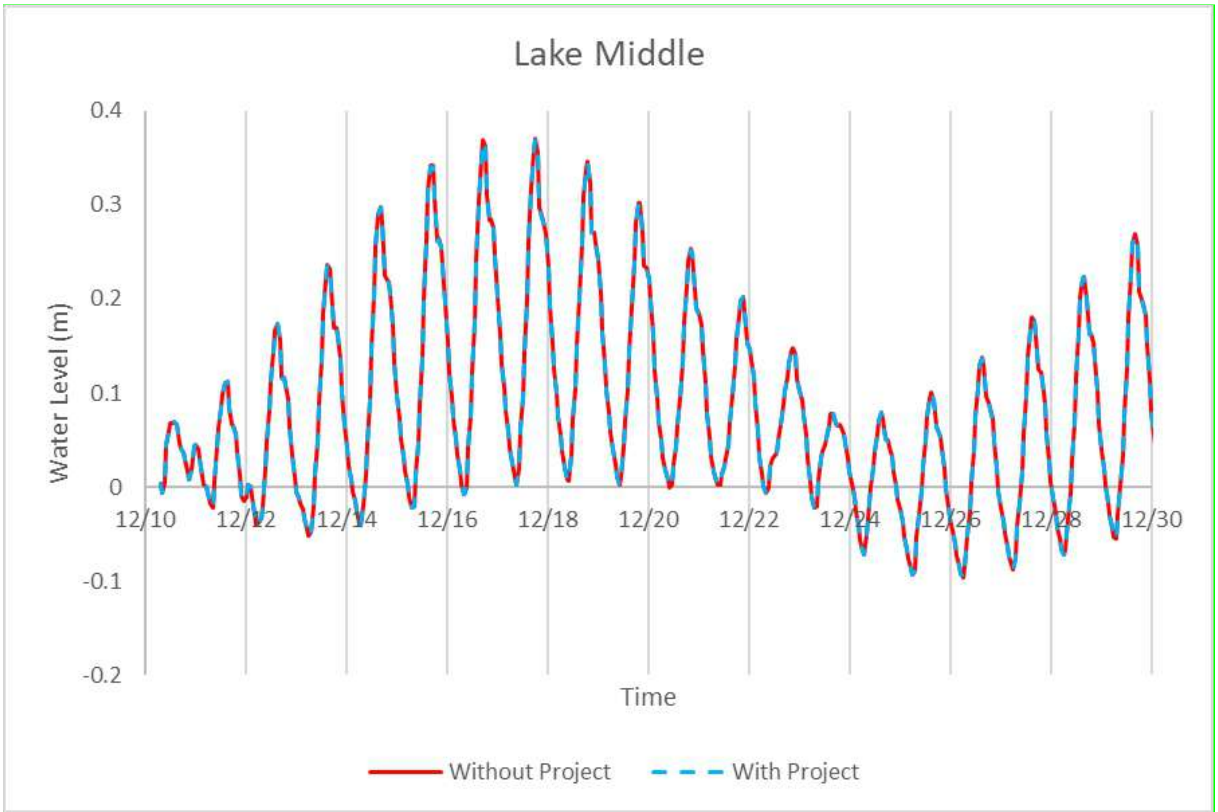


Figure 2.102 Water Level at "Lake Middle"

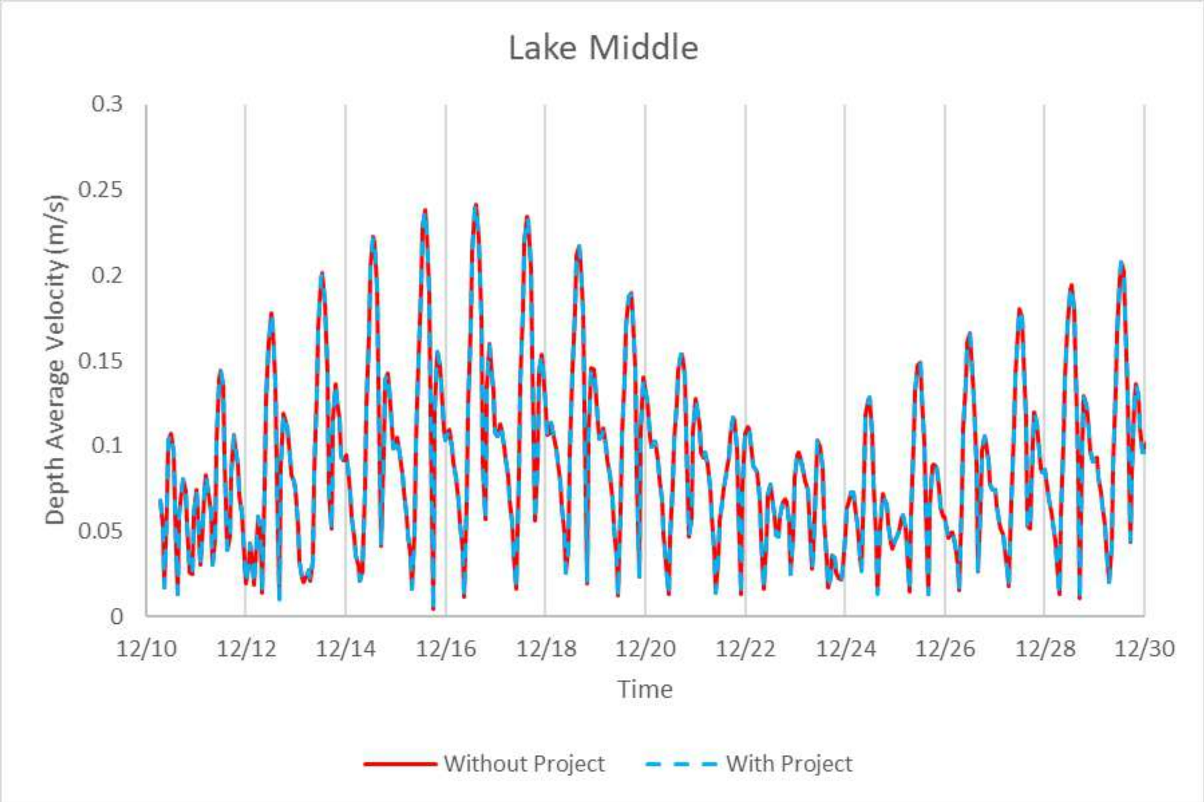


Figure 2.103 Depth Average Current Velocity at "Lake Middle"

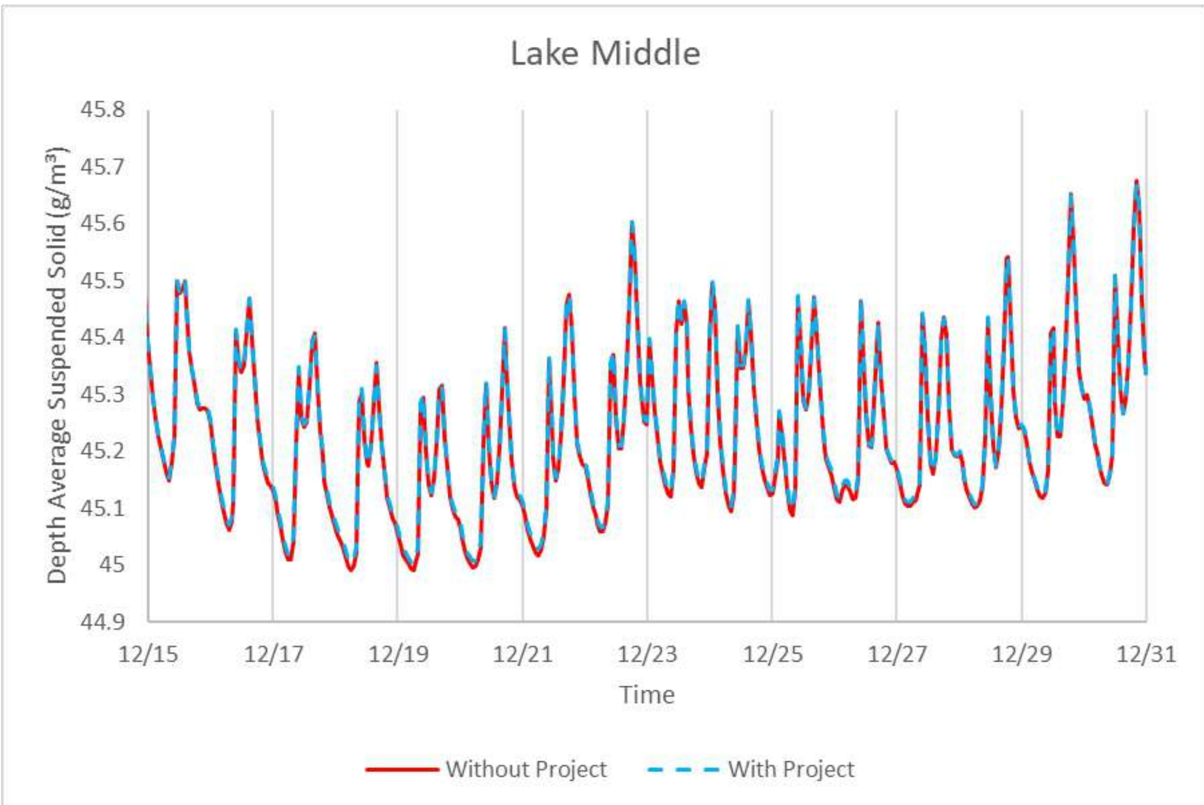


Figure 2.104 Depth Average Suspended Solids at "Lake Middle"

Observation Points Close to Embankments

Three observation points, “O1”, “O2” and “O3” are selected to evaluate the impact in term of depth averaged current velocity and concentration of depth average suspended solids by the proposed embankments for the area close to the embankment of LLRN. As shown in **Figure 2.105** , “O1”, is located just next to a T-shape embankment at the northern portion of LLRN and closed to the discharge point, “R3”. “O2”, is near two elongated embankments at the middle portion of LLRN and closed to the discharge point, “R9”. “O3” is near to a number of elongated embankments at the southern portion of LLRN and closed to the discharge points, “R10” and “R11”.

The time series plots of depth average velocity and concentration of depth average suspended solids at these 3 observation points for “without project” and “with project” scenarios are presented in Figures 10a, 10b, 11a, 11b, 12a, and 12b.

As “O1” is very close to the T-shape embankment, significant changes are observed both in depth average velocity and concentration of depth average suspended solids at between “without project” and “with project”.

For “O2”, which is near to 2 elongated embankments, there are no significant changes in depth average velocity. The time series variation of depth average suspended solids is changed slightly between “without project” and “with project” but no increase for the highest concentration within the model period.

For “O3”, there are no significant changes of depth average velocity and depth average suspended solids.

As “O2” and “O3” are located beyond the embankments align parallel to the coastline of Laguna Lake, the changes of hydrodynamic condition in term of current speed as well as water quality in term of suspended solid are not obvious.

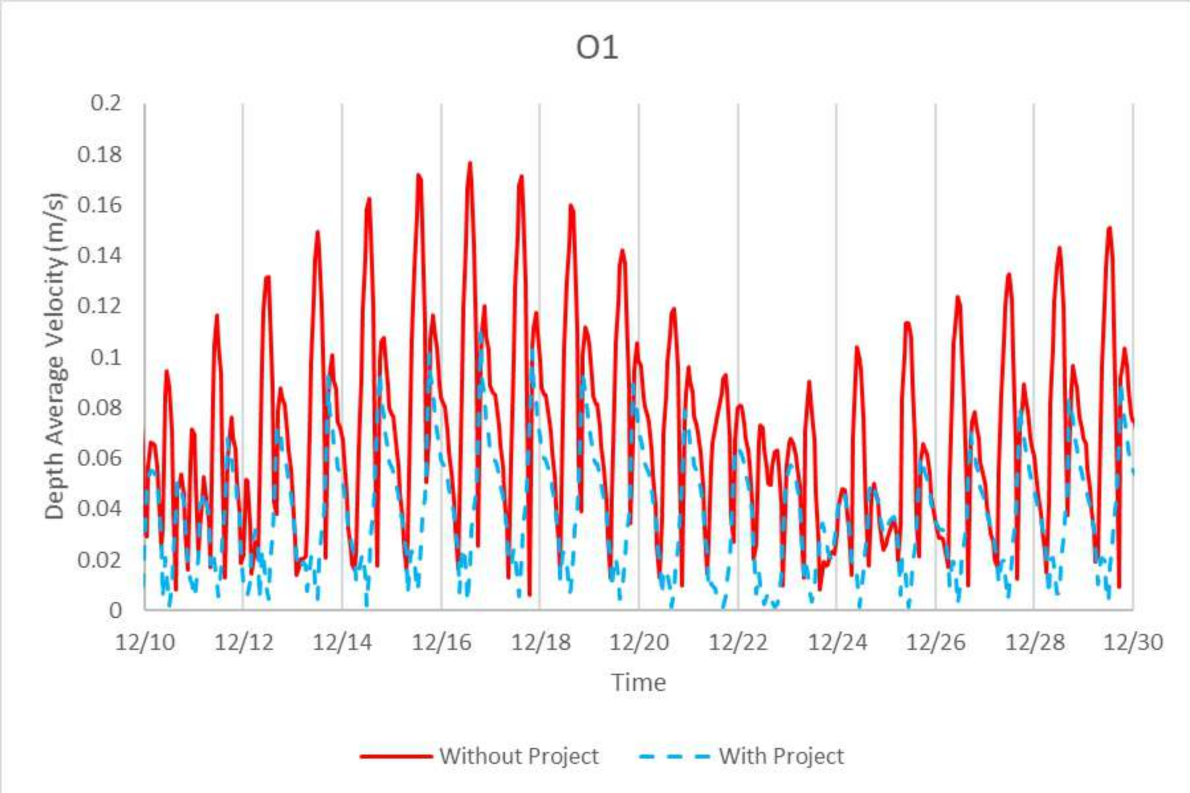


Figure 2.105 Depth Average Current Velocity at "O1"

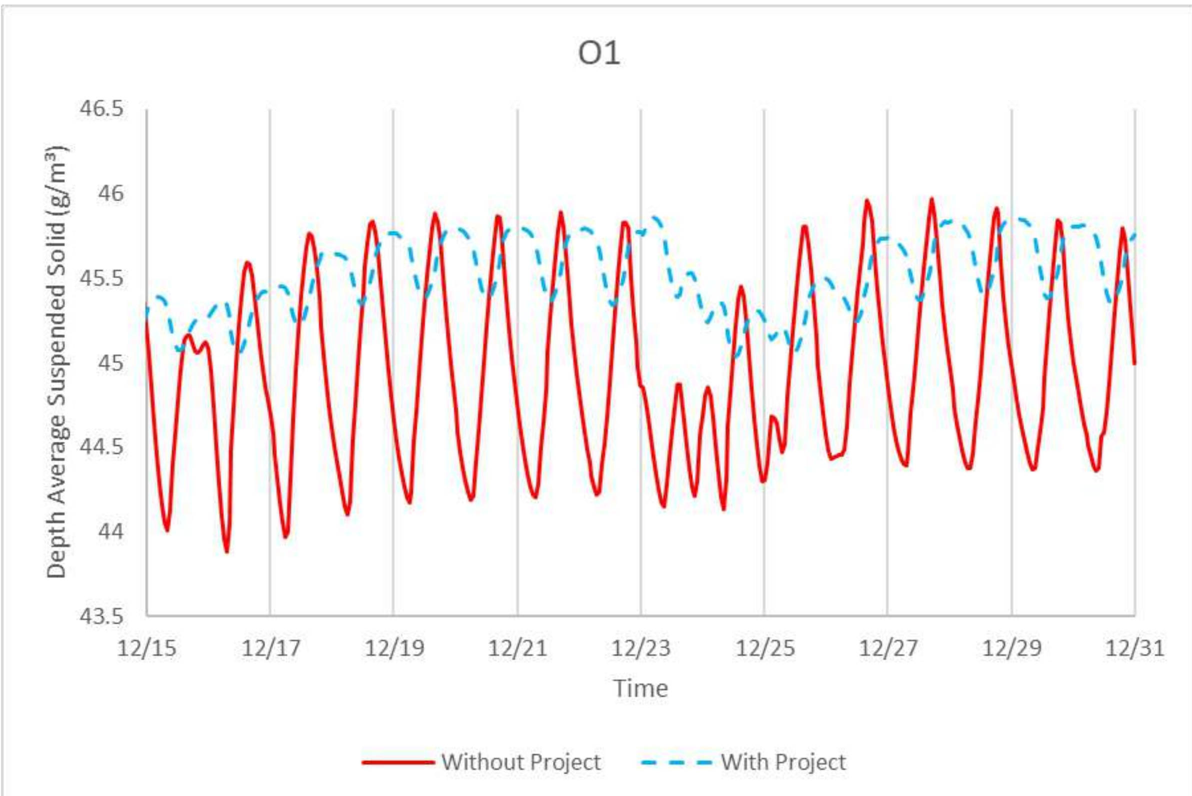


Figure 2.106 Depth Average Suspended Solids at "O1"

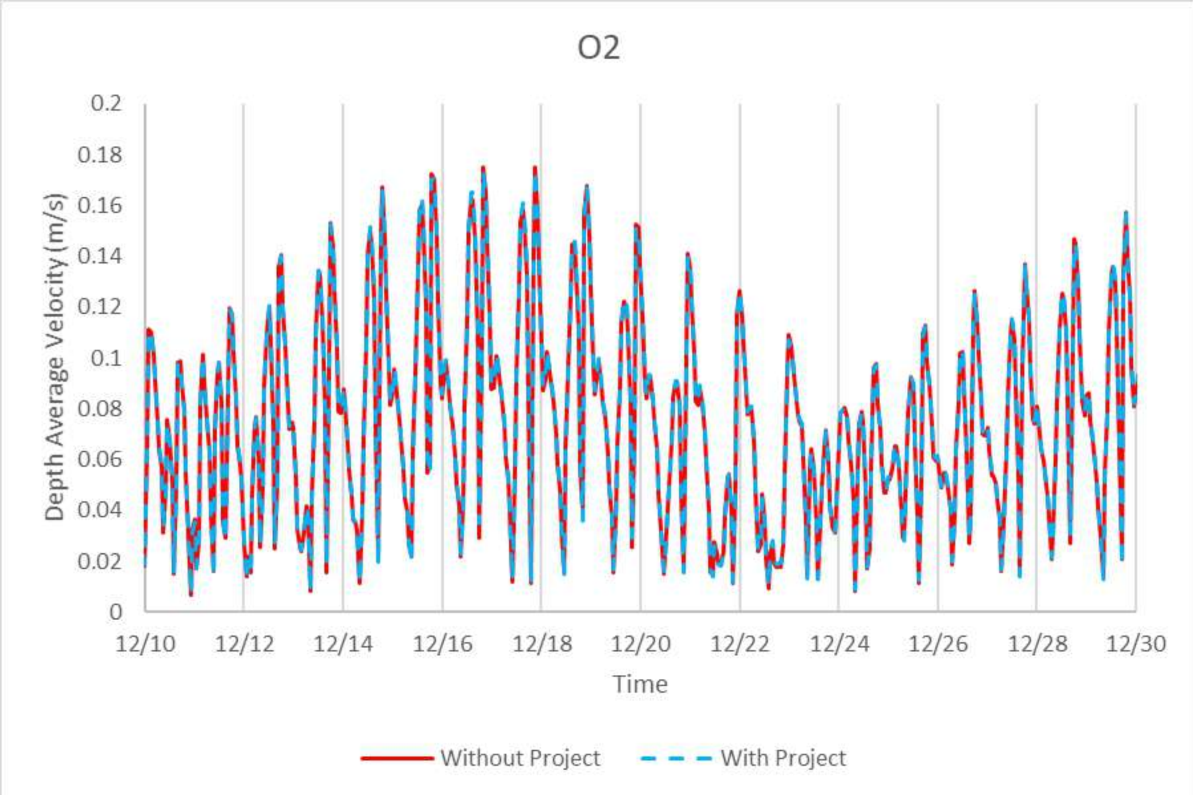


Figure 2.107 Depth Average Current Velocity at "O2"

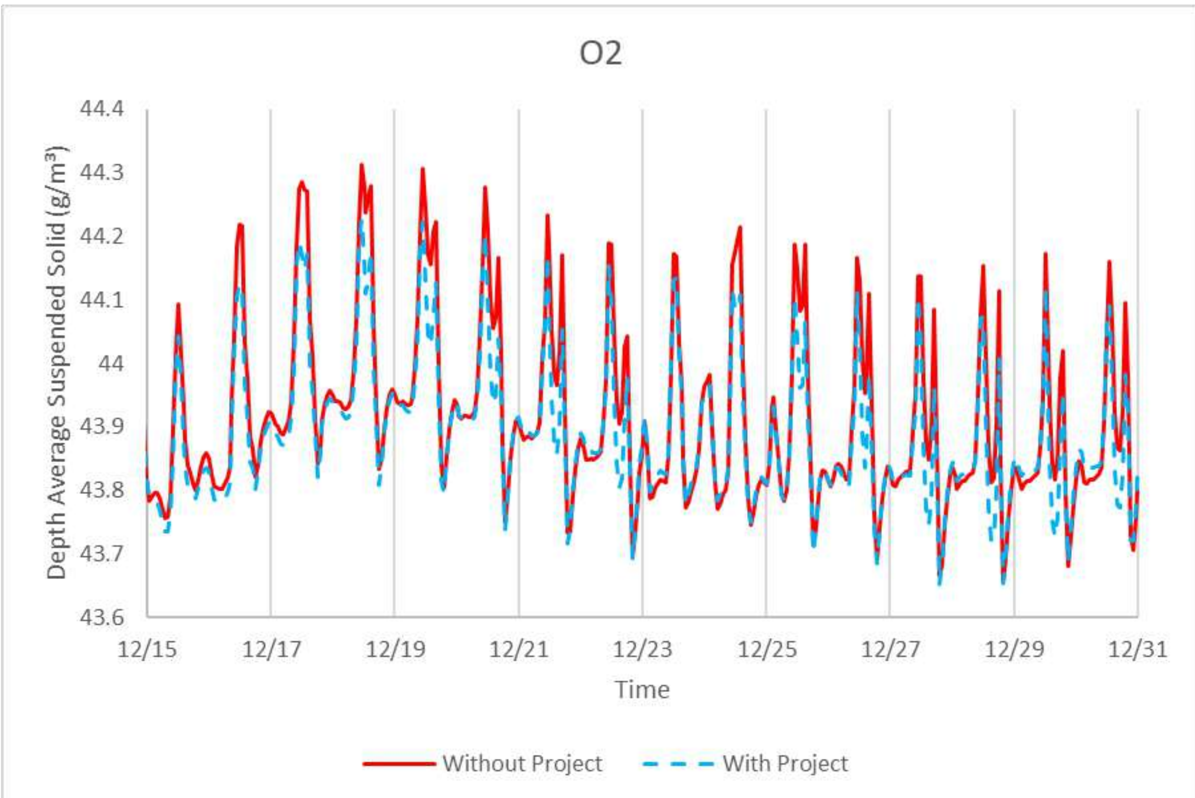


Figure 2.108 Depth Average Suspended Solids at "O2"

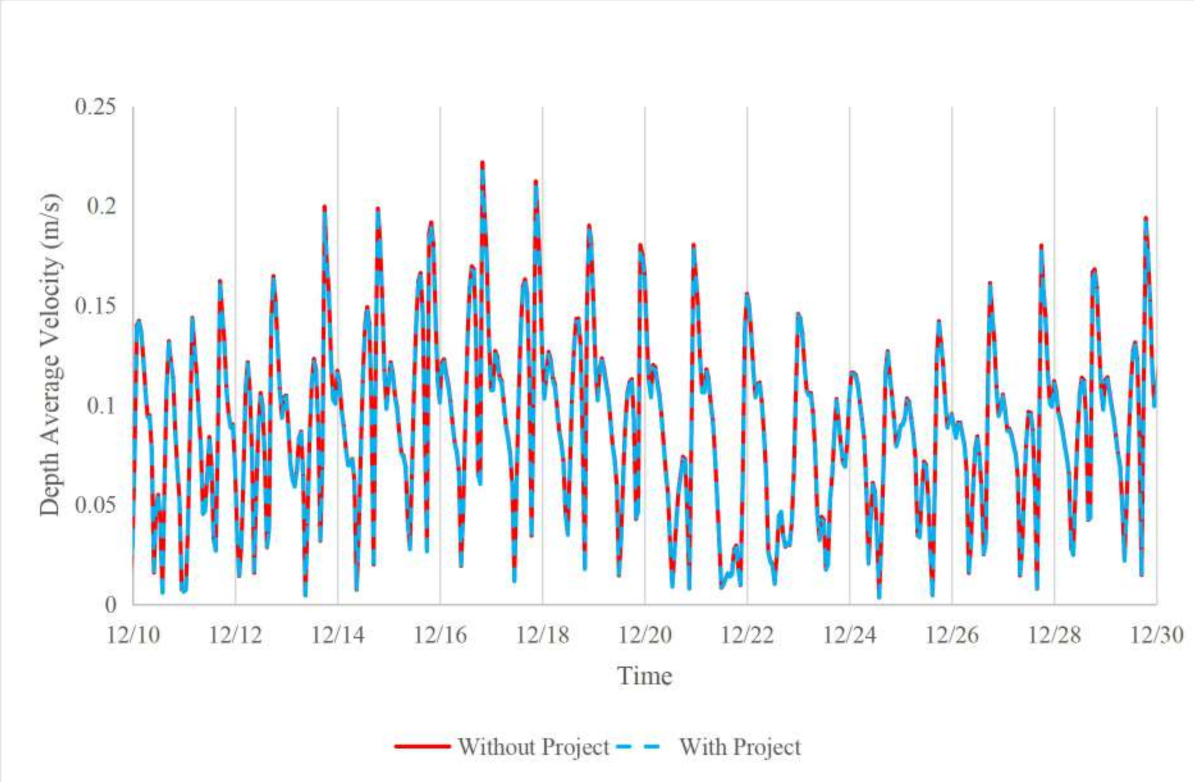


Figure 2.109 Depth Average Current Velocity at "O3"

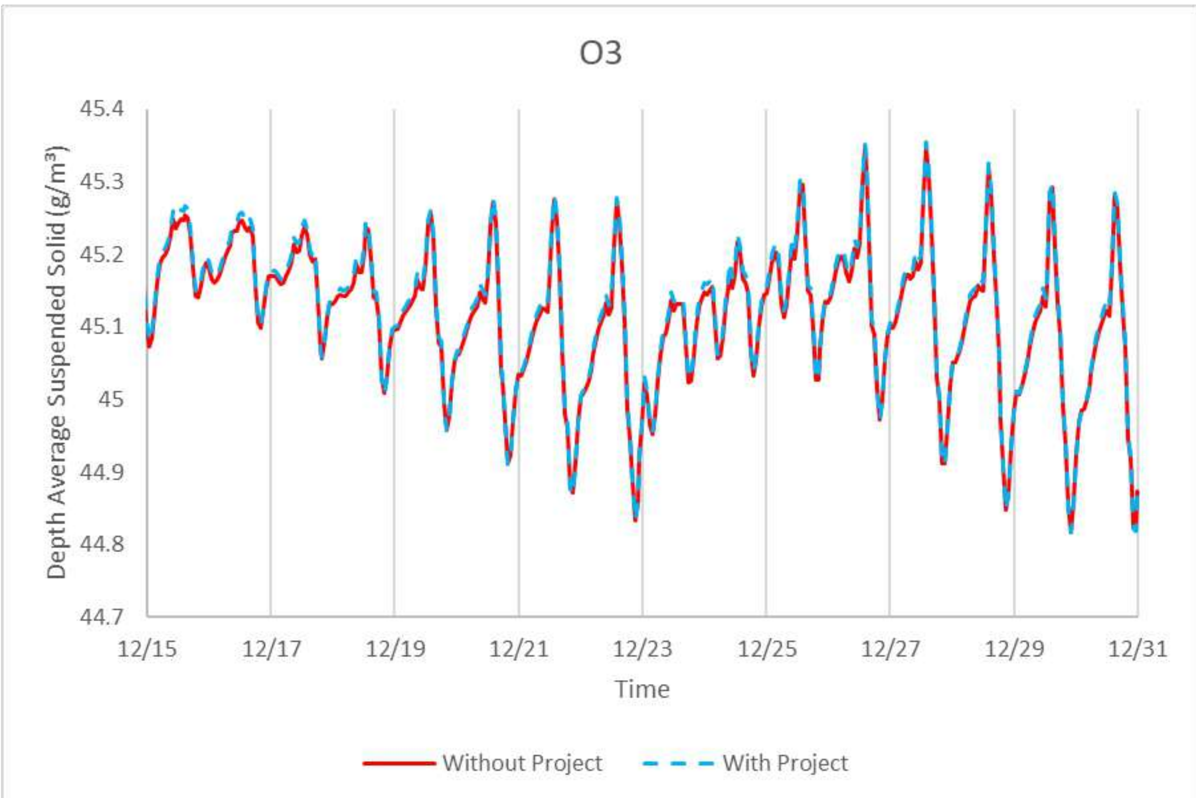


Figure 2.110 Depth Average Suspended Solids at "O3"

Vector Plots at Observation Points Closed to Embankments

In order to illustrate the changes in current flow at different distances from the embankment, depth average vector plots in both of ebb and flood tide are shown in Figures 13a -13c for three regions including northern portion, middle portion, and southern portion of LLRN.

Due to the blockage of the proposed embankments, the current flow both in velocity and directions are changed obviously for the area very close to the proposed embankments. However, the changes would diminish as the distance from embankments increases to few hundred meters.

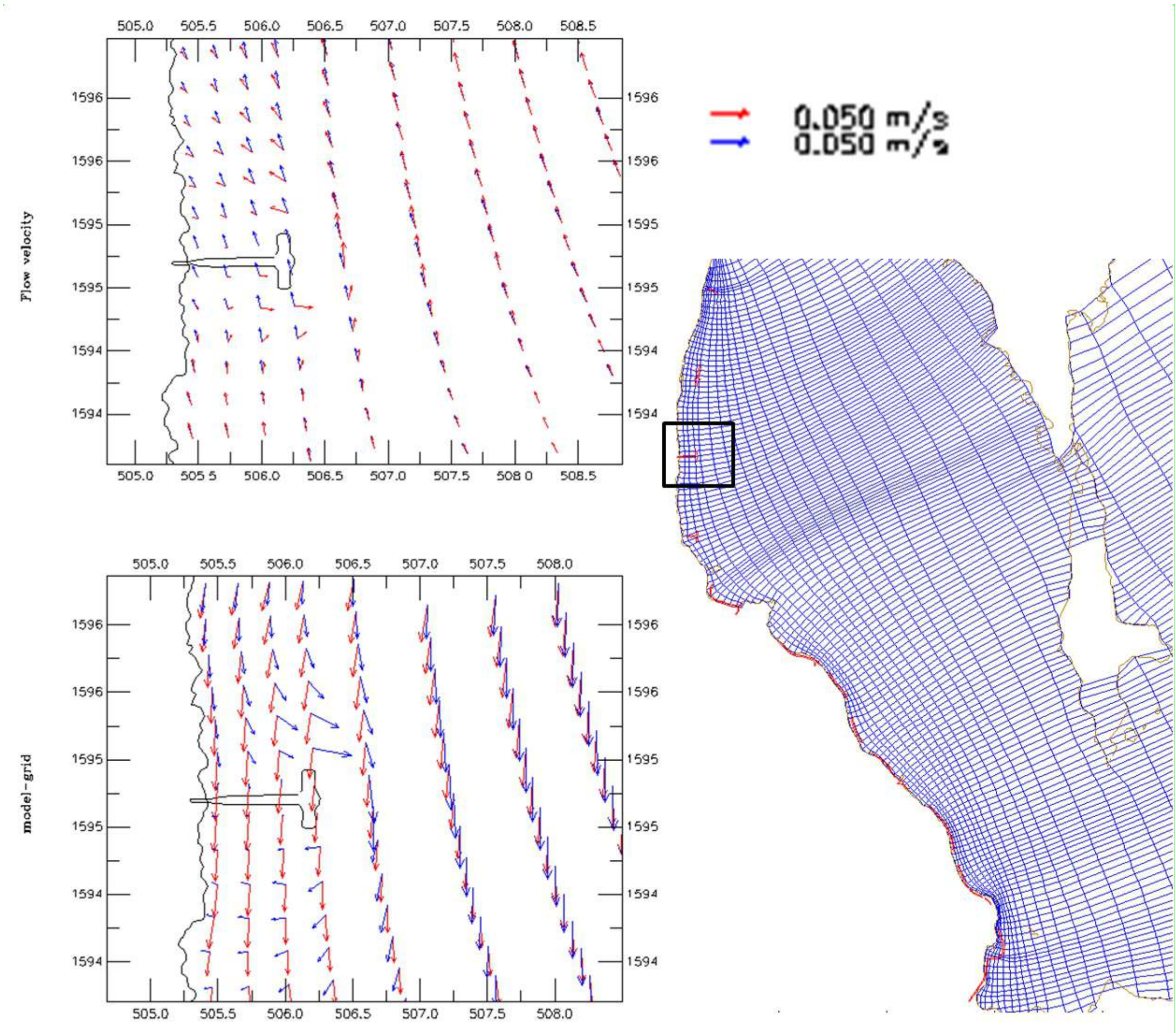


Figure 2.111 Depth Average Current Vector Plot-a

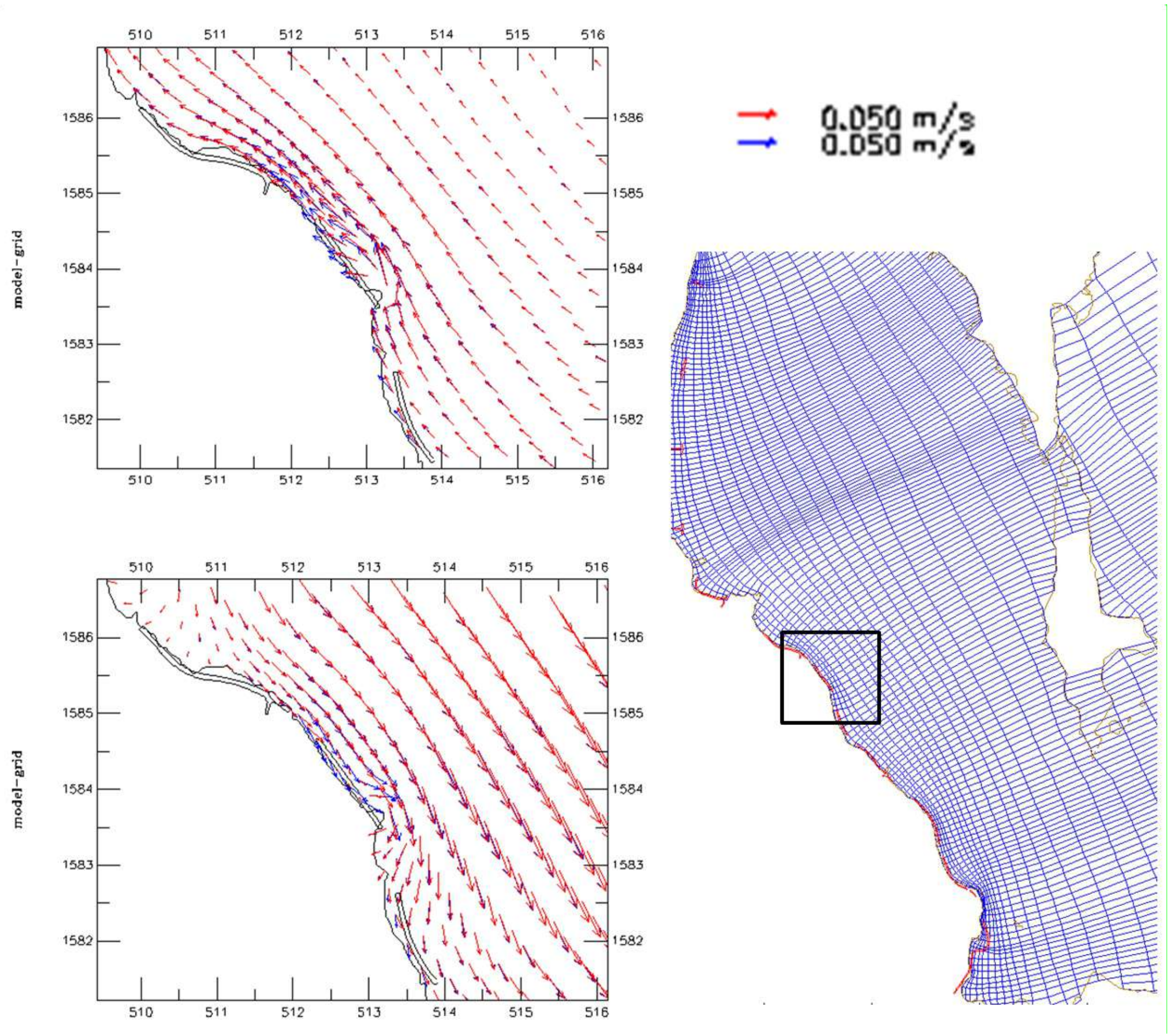


Figure 2.112 Depth Average Current Vector Plot-b

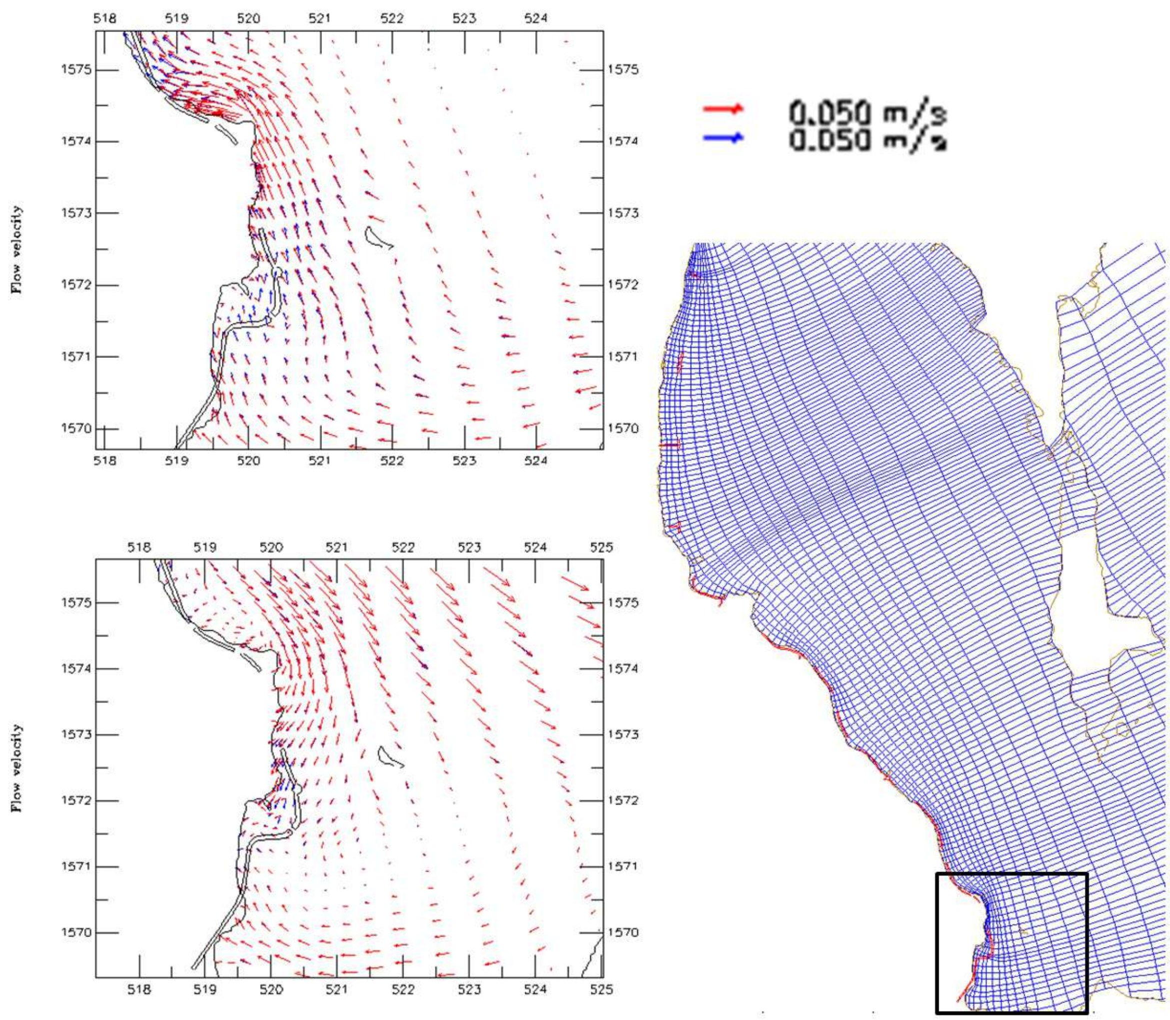


Figure 2.113 Depth Average Current Vector Plot-c

2.2.2.2 Hydrodynamic Modelling Conclusion

Hydrodynamic models and water quality model for suspended solids for “without project” and “with project” scenarios are conducted for a period of about 30 days under typical meteorological conditions and typically highest river flow rates. Relative values for these 2 scenarios are used to evaluate the relative performance in term of hydrodynamics and water quality impact caused by LLRN.

Modelling results indicate that the difference in the momentary flow and accumulated flow crossing the Laguna Lake in both east-west direction and north-south direction for the “without project” and “with project” scenarios would be insignificant. Hence, it is considered the overall hydrodynamic impacts to the entire laguna Lake caused by LLRN during the typical meteorological condition are insignificant. The general current flow and the dispersion of suspended solids are the same for “without project” and “with project” scenarios at the regions far away from the embankment of LLRN.

However, due to the presence of the embankments along the LLRN alignment, there would be some inevitable changes in the local velocity at areas around the embankments. The subsequent detailed engineering design could consider opportunities for further refining of the scheme for the embankments as necessary.

2.2.2.3 Potential Impacts and Options for Prevention, Mitigation or Enhancement

Change in drainage morphology/ inducement of flooding/ Reduction in stream volumetric flow

Like many areas in the Philippines, areas at the vicinity of Laguna Lake is frequently visited by typhoons particularly during the Habagat season. As discussed in **Section 2.3.1.10** of this report, nearby LGUs at Laguna Lake is considered to be at low to highly susceptible to flooding.

As discussed in Sections **1.4.4 Viaduct** and **1.4.5 Embankment** of the Project Components and shown in **Figure 1-33**, **Figure 1-37** and **Figure 1-39**, bridges with wide openings are provided along the embankment at various locations for the creeks, rivers and streams to have no adverse effect to the water flow into the lake.

While LLRN cannot mitigate the flood of the entire Laguna Lake in general, there will be land drainage mitigation measures to be implemented. There are significant number of openings placed throughout the onshore embankment to meet the "status quo" of the flood risk along the shoreline areas of the lake. The permeable embankments will have box culverts at suitable intervals, and sufficient drainage channels along the toe of the embankment to avoid inland water being trapped by the embankment and to allow water from the surface water runoff to pass through the embankment to the lake so as not to aggravate the flood level. Further details and figures are discussed in **Section 1.4.7.4** and shown in **Figure 1-71** and **Figure 1-72** of this report. A more detailed design configuration of these openings will be studied in the DED stage.

From the hydrodynamic models and water quality model for suspended solids for "without project" and "with project" scenarios are conducted for a period of about 30 days under typical meteorological conditions and typically highest river flow rates. Relative values for these 2 scenarios are used to evaluate the relative performance in term of hydrodynamics and water quality impact caused by LLRN.

Modelling results indicate that the difference in the momentary flow and accumulated flow crossing the Laguna Lake in both east-west direction and north-south direction for the "without project" and "with project" scenarios would be insignificant. Hence, it is considered the overall hydrodynamic impacts to the entire laguna Lake caused by LLRN during the typical meteorological condition are insignificant. The general current flow and the dispersion of suspended solids are the same for "without project" and "with project" scenarios at the regions far away from the embankment of LLRN.

However, due to the presence of the embankments along the LLRN alignment, there would be some inevitable changes in the local velocity at areas around the embankments. The subsequent detailed engineering design could consider opportunities for further refining of the scheme for the embankments as necessary.

Change in stream lake water depth

At this early feasibility design stage, there will be no change in water depth expected during the implementation of the project. However, further study during the detailed engineering design could be considered especially once design has been finalized by the contractor.

Depletion of water resources/ competition in water use

As to the water facility, the area is served by Manila Water Company Inc. LLRN is not perceived to be depleting the water resources or be competing in the water use of the lake or block any of the existing water concessionaires, farmers, industries from accessing the lake as some sections are in viaduct and the embankment is permeable, has access gates, culverts that ensure that there will be no adverse effect on the water flow. DPWH should ensure at the construction stage that no intake or outtake pipes will be affected.

Design Assumptions and Considerations

The design principles for storm drainage include the following:

- The drainage catchment area of proposed alignment covers the proposed ROW width at mainline and each junction. The project should have a drainage system capable of handling a storm event as specified in the design frequency.
- The storm drainage layout takes into consideration the following:
  - Shortest route to the outfall
  - Optimizing use of available surface gradient
  - Conveyance system by gravity flow
  - Minimum overflow travel time to minimize roadway flooding
- The potential volume loss due to construction of the proposed shoreline embankment against the total flood plain volume is estimated to be less than 0.1% and hence considered negligible.

Loss due to Shoreline Embankment (km^2)*	0.884 [14.6km (L) x 55m (W) x 1.1]
Estimated Percentage Loss (%)	0.097

* Including 10% buffer

The existing drainage systems at each landing point may need to be upgraded based on the hydrological analysis performed considering the drainage catchment area of the respective site.

2.2.3 Water Quality

A baseline water quality assessment is required to gauge the current status of the water bodies that will be traversed by the project alignment. A water quality sampling was conducted 23-24 October 2020 and 18 November 2020 to establish a baseline study, particularly for the physical and bacteriological characteristics of the upstream and downstream of water bodies affected by the project. This assessment aims to recommend mitigating and enhancement measures to address any identified impacts on water quality.

Water quality is defined by the Republic Act No. 9275 or the Philippine Clean Water Act of 2004 (CWA 2004), which is an act for the protection and preservation of water bodies in the country. Pursuant to Section No. 32 of this national legislation, the Department of Environment and Natural Resources (DENR) promulgated the Implementing Rules and Regulations (IRR) of the CWA 2004 under Administrative Order No. 10, series of 2005 (DAO 2005-10) to facilitate the water quality management and abatement of water pollution in the Philippines's water resources.

Compliance of the water quality results in this assessment are compared to the limitations provided under the DENR Administrative Order (DAO) DAO 2016 – 08 "Water Quality Guidelines and General Effluent Standards" and its updated guidelines in DAO 2021-19 for select parameters. Parameters that were used to compare with the standard were consist of physicochemical properties, inorganic non-metallic and bacteriological parameters, and metal. For groundwater sampling, DAO 2016 – 08 and potable water guidelines listed under DOH 2017-0010 or the Philippine National Standards for Drinking Water of 2017 were used as guidelines in comparing and analysing the baseline groundwater sampling results.

2.2.3.1 Methodology

Primary Data Source: Grab samples were obtained from 28 water sampling stations throughout the vicinity of the project area. Freshwater and groundwater sampling were performed on 23-24 October 2020 and 18 November 2020.

Groundwater Sampling. The eight (8) groundwater sampling sites were strategically taken from water pumps located near the proposed alignment.

Surface Water Sampling. There are five (5) water channels sampled for freshwater quality. The remaining 15 water quality sampling stations were strategically placed areas in Laguna Lake that are near the alignment.

2.2.3.2 In-situ measurements

Hand-held meters were used to determine the availability of dissolved oxygen in surface water, ambient temperature, conductivity, and pH of the ground, rivers, and bay. The pH levels were determined using the Myron L Company pH Meter PT2, conductivity readings were obtained using the Trans Instruments Conductivity Meter HC3010, and the instrument used in analysing dissolved oxygen is the Horiba DO meter OM-71. All equipment was calibrated prior to the sampling date to ensure the validity and reliability of data (Annex D).

2.2.3.3 Sampling and Handling Procedures

The sampling and handling techniques for all water bodies are based on the Water Quality Monitoring Manual for Ambient Water Quality Monitoring issued by the Environmental Management Bureau of DENR (2008).

Groundwater

Groundwater samples were obtained from the main sources of water supply. Sampling containers were directly filled with water from the hose/ faucets connected to the main source. For deep wells, grab sampling was conducted.

Freshwater

Grab samples were collected by submerging the containers, facing downward, at a depth the water level of the stream permits. After filling with water, containers were slowly lifted against the water flow. Filling and handling techniques for other parameters followed the EMB Guidelines.

2.2.3.4 Field Surveys and Sampling Areas

Groundwater

Table 2.36 Groundwater Sampling Stations

Sampling Station ID	Sampling Areas	Coordinates (WGS 1984)	
		Latitude	Longitude
GW-1 **Lower Bicutan, Taguig**		14°29.415" N	120°3.794" E
GW-2 **Sucat, Muntinlupa**		14°27.236" N	120°3.143" E

Sampling Station ID	Sampling Areas	Coordinates (WGS 1984)	
		Latitude	Longitude
GW-3 **Alabang, Muntinlupa**		14°25.103" N	120°3.113" E

<table>
<tr><th rowspan="2">Sampling Station ID</th><th rowspan="2">Sampling Areas</th><th colspan="2">Coordinates (WGS 1984)</th></tr>
<tr><th>Latitude</th><th>Longitude</th></tr>
<tr><td>GW-4
Tunasan, Muntinlupa</td><td>
</td><td>14°23.196” N</td><td>120°3.268” E</td></tr>
<tr><td>GW-5
Malabanan, Binan</td><td>
</td><td>14°21.148” N</td><td>120°4.518” E</td></tr>
</table>

Sampling Station ID	Sampling Areas	Coordinates (WGS 1984)	
		Latitude	Longitude
GW-6 Sinalhan, Sta. Rosa		14°19.8378” N	121°6.5732” E
GW-7 Marinig, Cabuyao		14°16.7464” N	121°8.6407” E

Sampling Station ID	Sampling Areas	Coordinates (WGS 1984)	
		Latitude	Longitude
GW-8 Palingon, Calamba		14°12.9563" N	121°11.3593" E

Figure 2- 51 Groundwater Sampling Map

Surface Water

Table 2.37 Surface Water Sampling Stations

Sampling Station ID	Sampling Areas	Coordinates (WGS 1984)	
		Latitude	Longitude
SW-1	 	14°29'5.38"N	121° 4'31.48"E
SW-2	 	14°27'8.40" N	121°4'1.46" E

Sampling Station ID	Sampling Areas	Coordinates (WGS 1984)	
		Latitude	Longitude
SW-3	 	14°25'14.5" N	121°03'40.2" E
SW-4	 	14°23'7.96"N	121° 3'59.66"E
SW-5	 	14°22'12.80"N	121° 4'7.52"E

Sampling Station ID	Sampling Areas	Coordinates (WGS 1984)	
		Latitude	Longitude
SW-6	 	14°21'29.03"N	121° 4'38.62"E
SW-7	 	14°21'19.09"N	121° 5'26.82"E
SW-8	 	14°20'13.08"N	121° 6'44.13"E

Sampling Station ID	Sampling Areas	Coordinates (WGS 1984)	
		Latitude	Longitude
SW-9		14°19'2.49"N	121° 7'28.61"E
SW-10	 	14°18'0.50"N	121° 7'53.82"E
SW-11	 	14°17'7.40"N	121° 8'42.70"E

Sampling Station ID	Sampling Areas	Coordinates (WGS 1984)	
		Latitude	Longitude
SW-12	 	14°15'49.67"N	121°10'16.50"E
SW-13	 	14°13'50.36"N	121°11'15.14"E
SW-14	 	14°12'50.63"N	121°11'31.36"E

Sampling Station ID	Sampling Areas	Coordinates (WGS 1984)	
		Latitude	Longitude
SW-15	 	14°11'36.26"N	121°10'35.78"E
SW-16	 	14°27'25.7"N	121°07'16.7"E
SW-17		14°22'49.41"N	121° 8'53.30"E

Sampling Station ID	Sampling Areas	Coordinates (WGS 1984)	
		Latitude	Longitude
SW-18	 	14°20'58.68"N	121°11'36.71"E
SW-19	 	14°17'32.65"N	121°11'41.69"E
SW-20	 	14°12'43.15"N	121°13'24.13"E

Figure 2- 52 Surface Water Sampling Stations Map

Figure 2- 53 Groundwater and Surface Water Sampling Map

2.2.3.5 Data Analysis

Parameters used for all water samples and its methodologies for sampling and analysis are summarized in **Table 2.38** . The parameters used are categorized into its physicochemical properties, inorganic non-metallic, bacteriological and metals and major cations. Results from the sampling activities are compared to DAO 2016-08 and DAO 2021-19standards.

The samples were analysed according to the following guidelines below:

- Standard Methods for the Examination of Water and Wastewater 23rd Edition, from the American Public Health Association (APHA) and the American Water Works Association (AWWA);
- Method 200.7: Determination of Metals and Trace Elements in Water and Wastes by Inductively Coupled Plasma-Atomic Emission Spectrometry, Revision 4.4, by Cincinnati, OH, from United States Environmental Protection Agency (USEPA) in 1994;
- Method 6010B: Inductively Coupled Plasma Atomic Emission Spectroscopy, Revision 2 from USEPA in 1996; and
- Environmental Protection Agency (EPA) 9213: Potentiometric Determination of Cyanide in Aqueous Samples and Distillates with Ion-Selective Electrode, Revision 0, in 1996.

It is important to note that turbidity, salinity, COD, TDS, and Vanadium do not have DAO 2016-08 Standards and DAO 2021-19 only updated standards for Ammonia, Boron, Copper as Dissolved Copper, Fecal Coliform, Phosphate, and Sulfate.

Table 2.38 Methodologies for Water Sampling and Analysis

Parameter	Methods for sampling and analysis
Physicochemical Properties	
pH	In situ APHA 4500-H
Temperature	In situ APHA 2550 B
True Colour	APHA 2120B
Oil and Grease (O&G)	APHA 5520B
Turbidity	APHA 2130B
Salinity	APHA 2520
Biochemical Oxygen Demand (BOD)	APHA 5210B
Chemical Oxygen Demand (COD)	APHA 5220D
Total Dissolved Solids (TDS)	APHA 2540C
Total Suspended Solids (TSS)	APHA 2540D
Dissolved Oxygen (DO)	In situ APHA 4500-O G
Inorganic non-metallic parameters	

Parameter	Methods for sampling and analysis
Chloride	APHA 4500-Cl
Nitrate	EPA 352.1
Phosphate	APHA 4500-PD
Free Cyanide	EPA 9213
Ammonia	APHA 4500-NH3 F
Bacteriological Parameters	
Fecal Coliform	APHA 9221 E
Metals and Major Cations	
Arsenic (As)	APHA 3120 B
Cadmium (Cd)	APHA 3120 B
Hexavalent Chromium (Cr+6)	APHA 3500-Cr B
Lead (Pb)	APHA 3120 B
Mercury (Hg)	7470A Mercury (CVAA)
Nickel (Ni)	APHA 3120 B
Zinc (Zn)	APHA 3120 B
Vanadium (Va)	APHA 3120 B

Groundwater

The groundwater sources of the project site are classified as Class A, which are suitable for domestic use and potable water. However, further treatment of the water is required for it to be a source of drinking water.

Results from the sampling activities are compared to DAO 2016-08 standards for Groundwater Class A, DAO 2021-19 and Potable water guidelines listed under DOH 2017-0010 or the Philippine National Standards for Drinking Water of 2017.

Surface Water

The Laguna Lake samples for this project site are classified as Class C, as currently, this water body is used by the residents for raising livestock, fish and other aquaculture products and recreational activities such as boating, and for agriculture purposes such as irrigation. Results from the sampling activities are compared to DAO 2016-08 and DAO 2021-19 standards for Surface Water Class A.

2.2.3.6 Baseline Environmental Conditions

Groundwater

Results for the groundwater sampling are presented in **Table 2.39** and **Annex D**. The test results were checked against the DAO 2016-08 Class A Water and DAO 2021-19 and DOH 2017-0010 Standards.

Table 2.39 Groundwater Sampling (Class A) Results

Parameters	DAO 2016-08 Standards for Class A	DAO 2021-19 Standards for Class A	DOH 2017-10 Drinking Water Standards	GW-1	GW-2	GW-3	GW-4	GW-5	GW-6	GW-7	GW-8
				24 October 2020			23 October 2020				
	Physicochemical Properties										
pH	6.5-8.5	-	6.5-8.5	6.47	6.45	7.09	7.05	6.9	7.46	7.65	8.53
Temperature	26-30°C	-	-	28.4	28.8	29.5	31.2	27.6	28.6	31.8	30.1
Color (TCU)	50	-	10	5	25	5	5	5	5	5	35
O&G	1.00	-	-	ND	ND	ND	ND	ND	ND	ND	ND
Turbidity (NTU)*	-	-	5	ND	8	ND	1.6	ND	8.4	ND	2.3
Salinity (Units)*	-	-	-	ND	0.914	0.726	0.726	0.266	0.808	0.352	0.477
BOD (mg/L)	N/A	-	-	8.79	11.5	8.19	7.59	8.49	11	2.43	6.67
COD (mg/L)*	-	-	-	30	32	22	26	18	24	21	31
TDS (mg/L)*	-	-	600	661	995	841	831	360	1030	471	608
TSS (mg/L)	50.0	-	-	ND	ND	ND	ND	ND	ND	ND	13.0
DO (mg/L)	N/A	-	-	0.19/ND	0.13/ND	0.23	0.26	0.88	0.28	0.31	0.32
	Inorganic Non-Metallic Parameters										
Chloride (mg/L)	250	-	250	75.5	191	252	176	6	175	23.5	30.5
NO_3-N (mg/L)	7.000	-	50.00	ND	ND	ND	ND	ND	0.0110	ND	ND
Phosphate (mg/L)	0.500	0.025	-	0.65	2.22	0.108	0.0912	0.0912	0.0782	0.118	0.455
Cyanide (mg/L)	0.070	-	0.5	ND	ND	ND	ND	ND	ND	ND	ND
Ammonia (mg/L as N)	0.050	0.06	-	2.9	4.78	ND	0.281	ND	0.289	0.593	1.42
	Bacteriological Parameters										
Fecal Coliform (MPN/ 100mL)	<1.1	50	-	>23	16	2.2	<1.1	9.2	23	16	23
	Metals and Major Cations										
Arsenic	0.010	-	0.01	<0.00697	0.00728	<0.00697	<0.00697	<0.00697	<0.00697	<0.00697	<0.00697

Parameters	DAO 2016-08 Standards for Class A	DAO 2021-19 Standards for Class A	DOH 2017-10 Drinking Water Standards	GW-1	GW-2	GW-3	GW-4	GW-5	GW-6	GW-7	GW-8
				24 October 2020			23 October 2020				
(mg/L)											
Cadmium (mg/L)	0.003	-	0.003	ND	ND	ND	ND	ND	ND	ND	ND
Hexavalent chromium (mg/L)	0.010	-	-	ND	ND	ND	ND	ND	ND	ND	ND
Lead (mg/L)	0.010	-	0.01	<0.00365	<0.00365	<0.00365	<0.00365	<0.00365	<0.00365	<0.00365	<0.00365
Mercury (mg/L)	0.001	-	0.001	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090
Nickel (mg/L)	0.020	-	0.07	<0.00973	<0.00973	<0.00973	<0.00973	<0.00973	<0.00973	<0.00973	<0.00973
Zinc (mg/L)	2.000	-	5.000	<0.00712	<0.00712	<0.00712	<0.00712	<0.00712	<0.00712	<0.00712	<0.00712
Vanadium*	-	-	-	<0.140	<0.140	<0.140	<0.140	<0.140	<0.140	<0.140	<0.140
	** - No DAO 2016-08 Standard* *ND – None detected* *N/A – Not Applicable (According to DAO 2016-08)* *Red text indicates exceedances in DAO Standards* *Orange text indicates exceedances in Drinking Water Standards*										

Temperature

Figure 2.75 shows the stations that most of the stations comply with DAO standards, aside from GW4, GW7, and GW8, which are all above the range. Temperature does not have any drinking water standards.

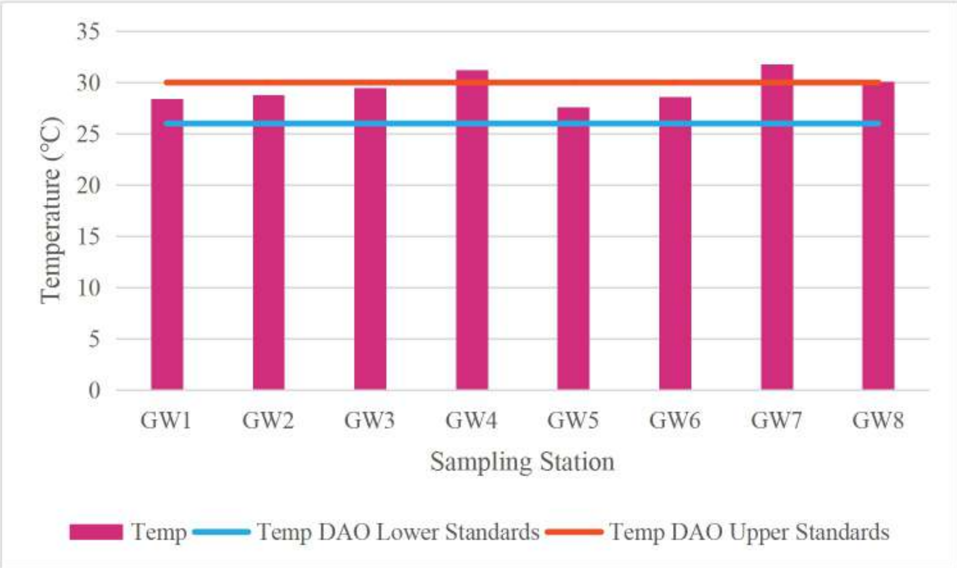


Figure 2.75 Ground water sampling results for Temperature Level

True Color

True Color in water quality is mostly affected by dissolved and suspended solids, such as organic matter and sediments. Both stations GW2 and GW8 are above Drinking Water Standards, while the remaining stations comply with this standard. Despite this, all stations comply with DAO standards. True color values are shown in **Figure 2.76**

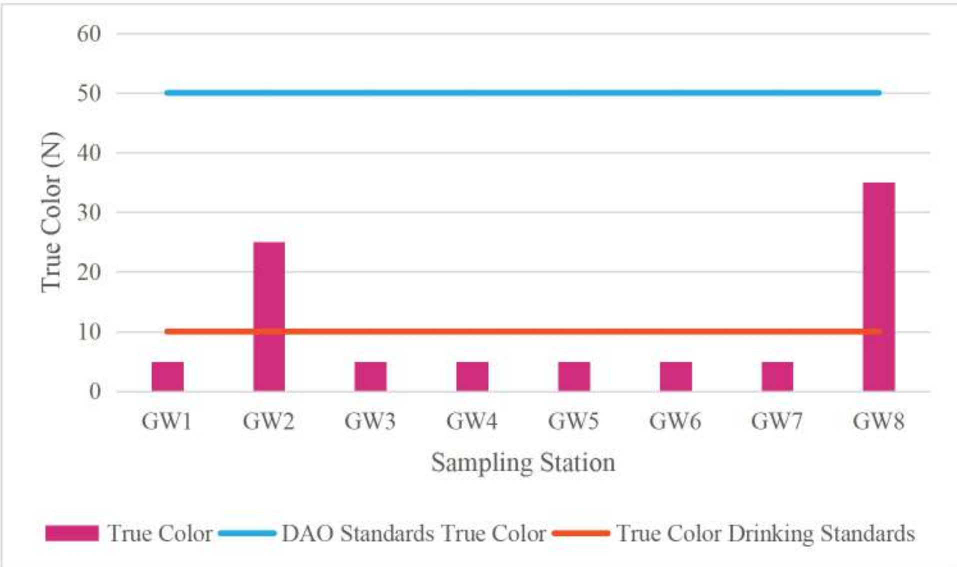


Figure 2.76 Ground water sampling results for True Color

Turbidity

Highly turbid drinking water may pose as a risk towards human health when consumed. Heavy rainfall is the most common cause of turbidity in groundwater. **Figure 2.77** shows that half of the groundwater stations have undetected values, however, two (2) stations still exceed drinking water standards.

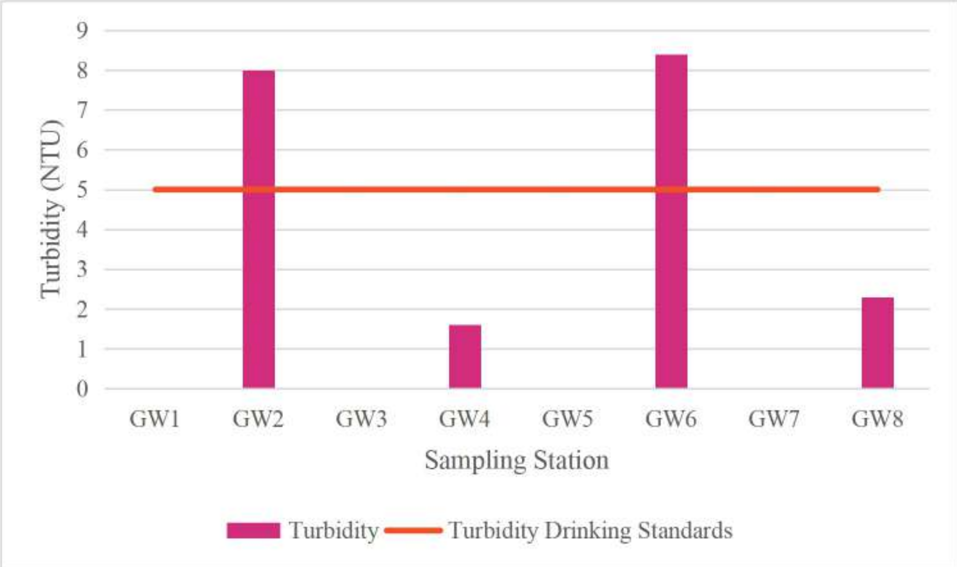


Figure 2.77 Ground water sampling results for Turbidity

Total Dissolved Solids (TDS)

TDS is a measure of the amount of dissolved organic and inorganic material are in water. This includes metals, minerals, and organic material. Minerals from rocks is a common natural source of TDS, while pesticides and old pipes are anthropogenic sources towards water bodies. High amounts of TDS may lead to health concerns as the dissolved solids may be highly toxic. **Figure 2.78** show the stations that majority of the stations are above Drinking Water Standards, specifically GW1-GW4, and GW6.

Figure 2.78 Ground water sampling results for TDS

Ammonia (NH3)

Ammonia in groundwater can be caused by decay of organic matter, or through agricultural in rural areas, and industrial processes in more urbanized locations. Higher concentrations of ammonia increase the toxicity of the water body and may pose as health risks. **Figure** 2.79 show the stations that are out of the acceptable range. Stations SW1, SW2, SW3, SW6, SW7, SW13, SW15, and SW17 are above acceptable standards. No water monitoring station are the acceptable range.

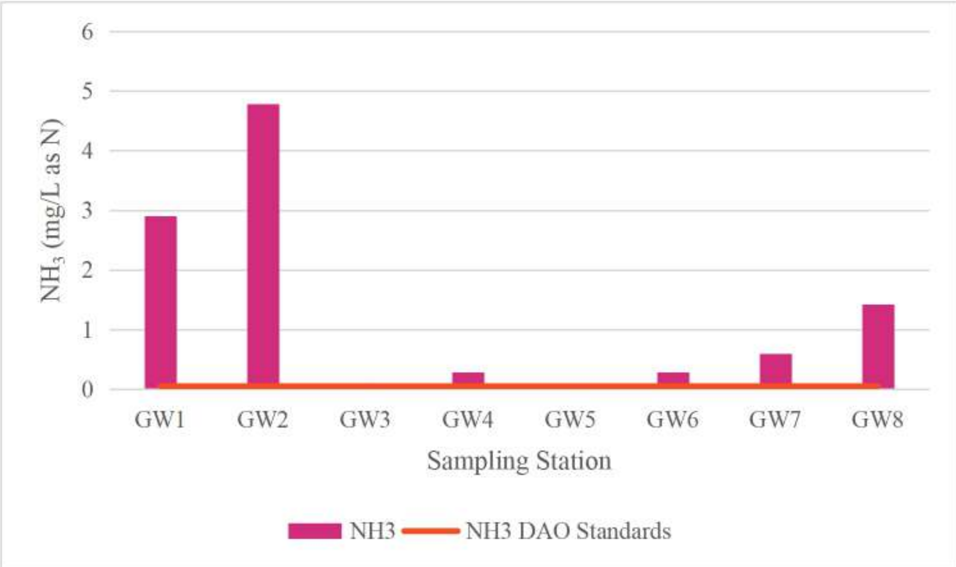


Figure 2.79 Ground water sampling results for NH_3

Chloride

Chloride is produced naturally and combine with different elements to form various salts. Increased levels can be attributed to atmospheric deposition, fertilizers, and waste from septic tanks. **Figure 2.80** show the stations that are out of the acceptable range. All stations comply with DAO standards apart from GW3, which slightly exceeds the limit.

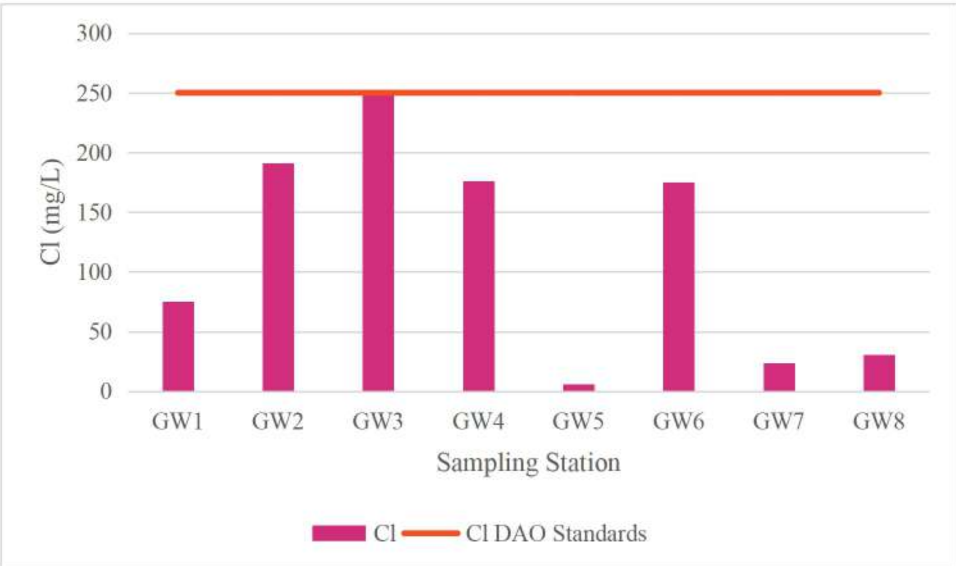


Figure 2.80 Ground water sampling results for Chloride

Phosphate

Phosphate is commonly found in organic waste, and the production and use of detergent, surface treatment, among many others. Higher levels in groundwater can be leaked from the soil, all the way to aquifers. **Figure 2.81** show that stations GW1 and GW2 both exceed DAO standards. The rest of the sampling stations resulted to values complying with set standards.

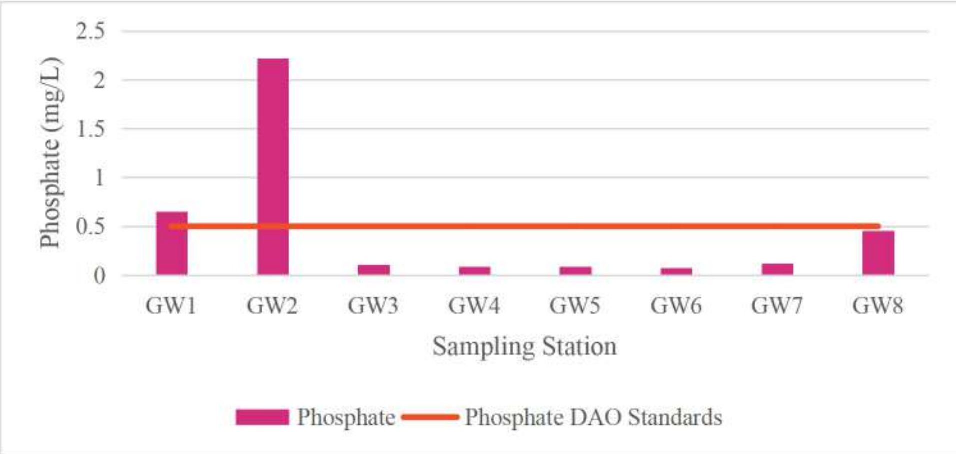


Figure 2.81 Ground water sampling results for Phosphorus

Fecal Coliform

High levels of fecal coliform in drinking water may lead to various health hazards and illnesses. The main source of this pollutant is from sewage waste and septic tank leakage. **Figure 2.82** shows the sampling results in the groundwater monitoring stations. Among the eight (8) stations, only GW4 fell within DAO standards, while the remaining stations exceeded standards, with GW6 and GW8 resulting to the highest values at 23 MPN/100mL, and GW 1 at >23 MPN/100mL.

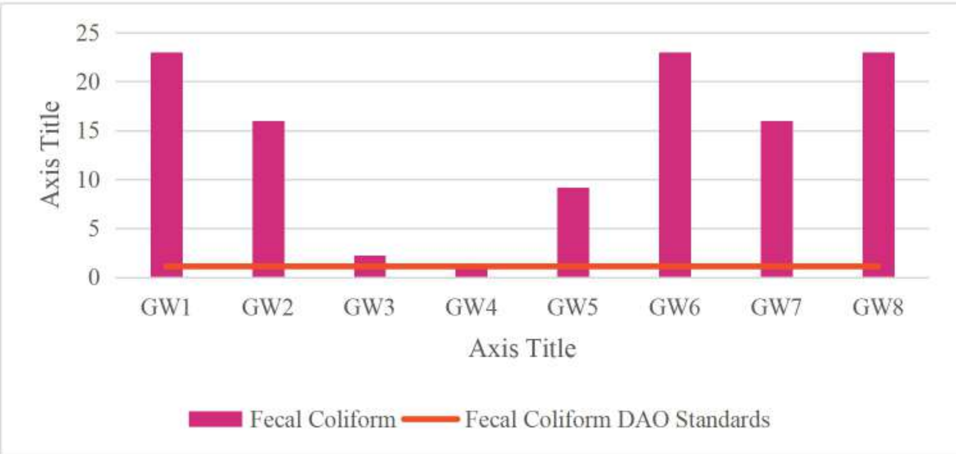


Figure 2.82 Ground water sampling results for Fecal Coliform

Surface Water

Results for the freshwater sampling are presented in

Table 2.40 and **Annex D**. The test results were checked against the DAO 2016-08 and DAO 2021-19 Water Quality Standards for Class C

Table 2.40 Surface Water Sampling (Class C) Results

Parameters	DAO 2016-08 Standards for Class C	DAO 2021-19 Standards for Class C	SW-1 18 Nov 2020	SW-2 18 Nov 2020	SW-3 18 Nov 2020	SW-4 18 Nov 2020	SW-5 23 Oct 2020	SW-6 18 Nov 2020	SW-7 23 Oct 2020	SW-8 18 Nov 2020	SW-9 23 Oct 2020	SW-10 18 Nov 2020	SW-11 18 Nov 2020	SW-12 18 Nov 2020	SW-13 23 Oct 2020	SW-14 18 Nov 2020	SW-15 23 Oct 2020	SW-16 18 Nov 2020	SW-17 18 Nov 2020	SW-18 18 Nov 2020	SW-19 18 Nov 2020	SW-20 18 Nov 2020
	Physicochemical Properties																					
pH	6.5-9.0	-	8.03	7.83	8.02	7.88	6.84	7.64	6.85	7.89	7.52	7.76	7.73	7.92	7.36	7.86	7.74	8.3	8.3	8.43	8.35	8.6
Temp	25-31 °C	-	31.2	33.3	32.2	29.6	29.1	31.6	30.2	28.1	30	28	27.5	26.4	32.1	26.1	30.6	29.2	31.2	29	27.6	27.1
Color (TCU)	75	-	40	30	40	40	10	40	25	35	5	35	35	35	25	40	40	30	40	40	40	35
O&G mg/L	2.00	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.52	ND	ND	ND
Turbidity (NTU)*	-	-	29	28	55	40	6.8	24	13	50	19.3	50	75	75	6.7	45	ND	38	45	45	50	55
Salinity (Units)*	-	-	0.407	0.539	0.368	0.358	0.386	0.331	0.335	0.349	0.531	0.334	0.319	0.347	0.343	0.378	0.467	0.5	0.45	0.369	0.466	0.385
BOD (mg/L)	7.00	-	33.1	37.3	36.7	34.3	11.8	37.3	29.6	24.7	24.8	28.3	31.3	21.7	17	26.5	54.9	34.3	29.5	30.1	30.7	27.1
COD (mg/L)*	-	-	45	48	48	47	40	45	48	49	75	48	48	45	33	39	105	46	42	45	48	45
TDS (mg/L)*	-	-	502	640	448	457	509	409	446	431	671	409	427	416	476	468	639	620	539	451	539	464
TSS (mg/L)	80.0	-	27.2	37.3	45.7	35.5	7.64	16.3	21.3	56	24.6	41.3	51	91.3	37.2	45	9.5	48	56.5	35.9	52.7	54.3
DO (mg/L)	>5.00	-	6.2	5.64	5.8	6.41	ND	5.62	0.23	6.71	ND	5.03	4.17	7.38	0.27	5.86	0.32	7.92	8.24	7.92	7.68	5.37
	Inorganic Non-Metallic Parameters																					
Chloride (mg/L)	350	-	185	270	165	156	54	131	50	163	110	141	135	156	93.5	171	60	251	228	166	221	179
Nitrate (mg/L)	7.000	-	1.19	0.731	1.22	2.54	0.689	0.753	0.0801	1.13	0.0478	1.52	1.06	1.21	ND	1.14	0.132	0.945	0.961	1.54	0.919	0.957
Phosphate (mg/L)	0.500	0.025	0.182	ND	0.176	0.228	0.87	0.255	1.15	0.204	1.17	0.224	0.269	0.17	0.74	0.167	2.84	0.0867	ND	0.206	0.114	0.159
Cyanide (mg/L)	0.100	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.151	ND	ND	ND	ND	ND

Parameters	DAO 2016-08 Standards for Class C	DAO 2021-19 Standards for Class C	SW-1 18 Nov 2020	SW-2 18 Nov 2020	SW-3 18 Nov 2020	SW-4 18 Nov 2020	SW-5 23 Oct 2020	SW-6 18 Nov 2020	SW-7 23 Oct 2020	SW-8 18 Nov 2020	SW-9 23 Oct 2020	SW-10 18 Nov 2020	SW-11 18 Nov 2020	SW-12 18 Nov 2020	SW-13 23 Oct 2020	SW-14 18 Nov 2020	SW-15 23 Oct 2020	SW-16 18 Nov 2020	SW-17 18 Nov 2020	SW-18 18 Nov 2020	SW-19 18 Nov 2020	SW-20 18 Nov 2020
Ammonia (mg/L)	0.050	0.06	0.422	0.103	ND	ND	5.22	0.75	3.76	ND	4.28	0.141	0.314	ND	0.723	ND	1.5	0.164	ND	0.139	ND	ND
	Bacteriological Parameters																					
Fecal Coliform (MPN/ 100mL)	200	50	780	2300	1700	1100	4600	1400	11000	1300	2700	4900	3300	1100	13000	1300	2200	1700	1400	1700	2300	1100
	Metals and Major Cations																					
Arsenic (mg/L)	0.020	-	<0.00416	<0.00416	<0.00416	<0.00416	<0.00416	<0.00416	<0.00416	<0.00416	<0.00416	<0.00416	<0.00416	<0.00416	0.00494	<0.00416	0.00771	<0.00416	<0.00416	<0.00416	<0.00416	<0.00416
Cadmium (mg/L)	0.005	-	<0.000727	<0.000727	<0.000727	<0.000727	<0.000727	<0.000727	<0.000727	<0.000727	<0.000727	<0.000727	<0.000727	<0.000727	<0.000727	<0.000727	<0.000727	<0.000727	<0.000727	<0.000727	<0.000727	<0.000727
Hexavalent chromium (mg/L)	0.010	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.00505	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (mg/L)	0.050	-	<0.00517	<0.00517	<0.00517	<0.00517	<0.00517	<0.00517	<0.00517	<0.00517	<0.00517	<0.00517	<0.00517	<0.00517	<0.00517	<0.00517	<0.00517	<0.00517	<0.00517	<0.00517	<0.00517	<0.00517
Mercury (mg/L)	0.002	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel (mg/L)	0.200	-	<0.00128	<0.00128	<0.00128	<0.00128	<0.00128	<0.00128	<0.00128	<0.00128	<0.00128	<0.00128	<0.00128	<0.00128	<0.00128	<0.00128	<0.00128	<0.00128	<0.00128	<0.00128	<0.00128	<0.00128
Zinc (mg/L)	2.000	-	<0.0102	<0.0102	<0.0102	<0.0102	<0.0102	<0.0102	<0.0102	<0.0102	<0.0102	<0.0102	<0.0102	<0.0102	<0.0102	<0.0102	<0.0102	<0.0102	<0.0102	<0.0102	<0.0102	<0.0102
Vanadium*	-	-	<0.133	<0.133	<0.133	<0.133	<0.133	<0.133	<0.133	<0.133	<0.133	<0.133	<0.133	<0.133	<0.133	<0.133	<0.133	<0.133	<0.133	<0.133	<0.133	<0.133
	-No DAO 2016-08 Standard ND- None Detected Red text indicates exceedances																					

Total Suspended Solids (TSS)

Temperature

Temperature change in water ecosystems can influence the biological activity of organisms, and water chemistry. **Figure 2.83** shows the stations that are out of the acceptable range. Stations SW1, SW2, SW3, SW6, SW7, SW13, SW15, and SW17 are above acceptable standards during the time of sampling.

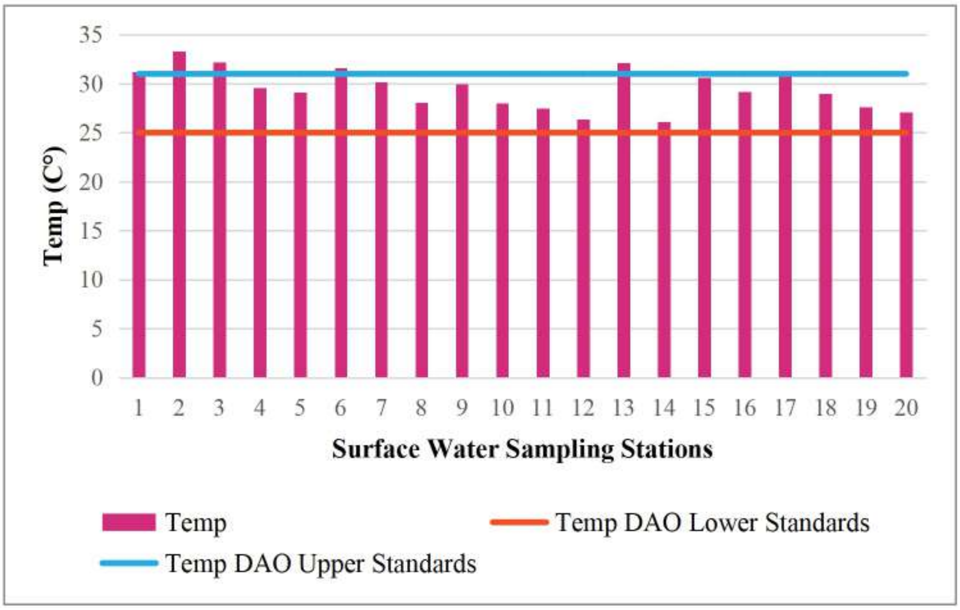


Figure 2.83 Surface water sampling results for Temperature Level

Oil and Grease (O&G)

Oil and grease in all stations were not detected, apart from SW-17 with values of 3.52 mg/L, which complies with DAO standards. Possible source of oil and grease in SW 17 is motor oil from boats

Biological Oxygen Demand (BOD)

BOD is a measure of the amount of the amount of DO required for the decomposition of organic matter from aerobic microorganisms. **Figure 2.84** shows that all water sampling stations have BOD values exceeding DAO standards. It is an indication of pollution loads received by the lake.

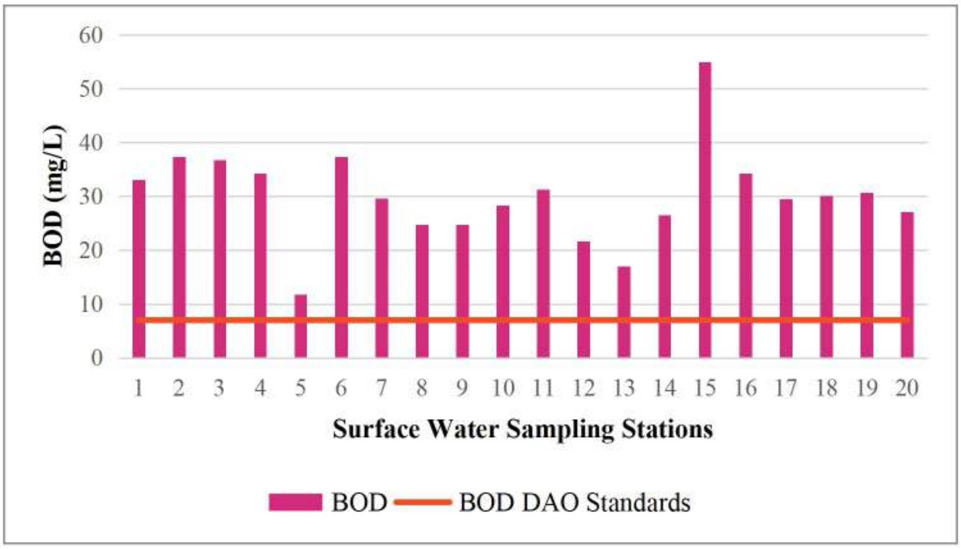


Figure 2.84 Surface water sampling results for BOD Level

Total Suspended Solids (TSS)

TSS values shows the quantity of suspended material in a volume of water. The build-up of these solids may be affected by erosion, decayed organic matter, and urban runoff. Excessive amounts of TSS can degrade water quality essential for aquatic biodiversity and human communities and may increase flood risks. **Figure 2.85** shows that all sampling stations fall under DAO Standards for TSS values apart from SW-12, resulting to 91.3 mg/L.

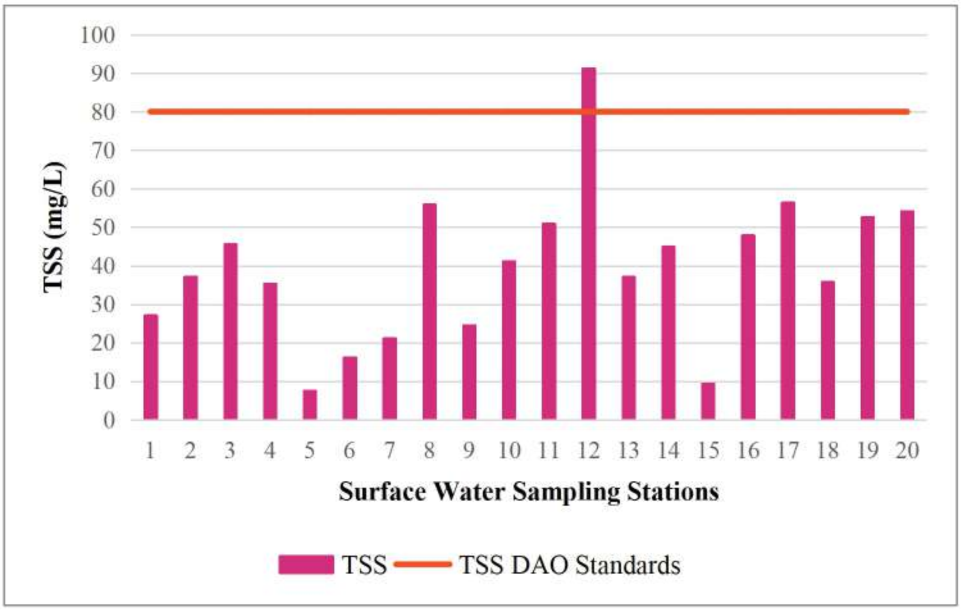


Figure 2.85 Surface water sampling results for TSS Level

Dissolved Oxygen (DO)

Levels of DO measure the concentration of oxygen within water. The absorbed oxygen is important for the growth and reproduction of the reproductive and aerobic processes of aquatic ecosystems. Natural processes and industrial and agricultural run off all influence DO levels in water bodies. Among all water sampling stations, SW7, SW11, SW13, and SW15 have values below DAO standards. The monitoring results are shown in **Figure 2.86.** These insufficient DO concentrations would be detrimental to aquatic organisms that live in these waters.

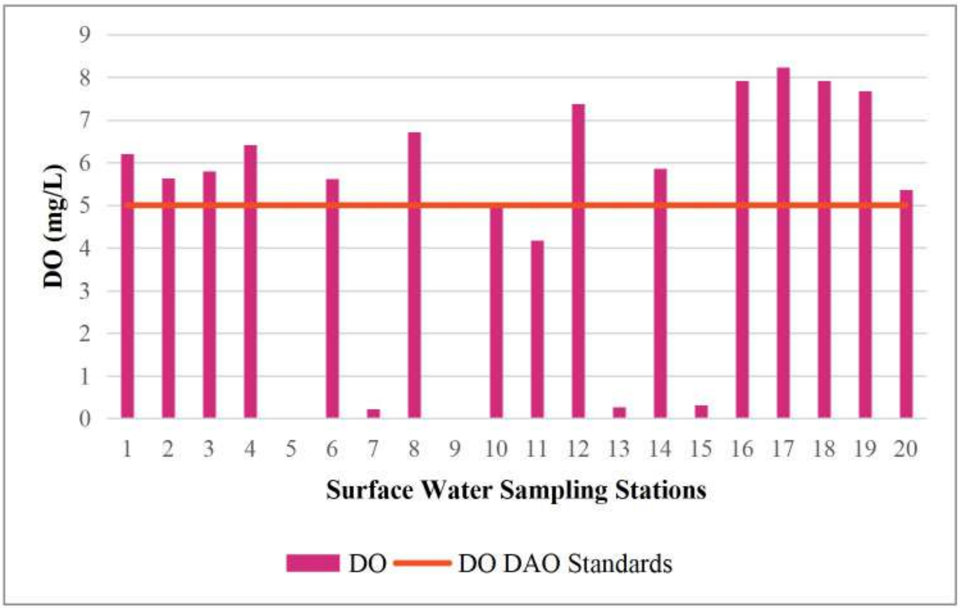


Figure 2.86 Surface water sampling results for DO Level

Phosphate

Phosphate is a nutrient that is required for plant and animal growth. An overabundance of this nutrient may speed up reproduction and growth of algae, causing eutrophication in water bodies. Sources of this nutrient is soil erosion, and organic and industrial wastes. **Figure 2.87** show that all sampling stations comply with DAO standards, apart from stations SW5, SW7, SW9, SW13, and SW15.

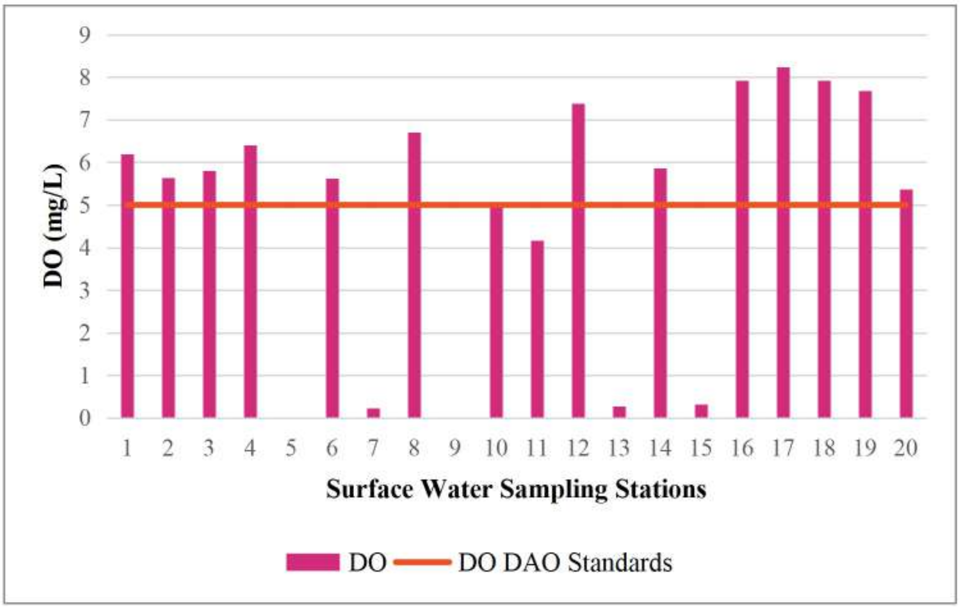


Figure 2.87 Surface water sampling results for Phosphate Level

Cyanide

Higher amounts of cyanide can affect toxicity in aquatic life. Adverse health effects towards human communities may occur with high amounts of contamination. Decomposition of some plants and burning of plastic and cigarettes. **Figure 2.88** shows that all stations did not show cyanide, aside from SW15 with values exceeding standards.

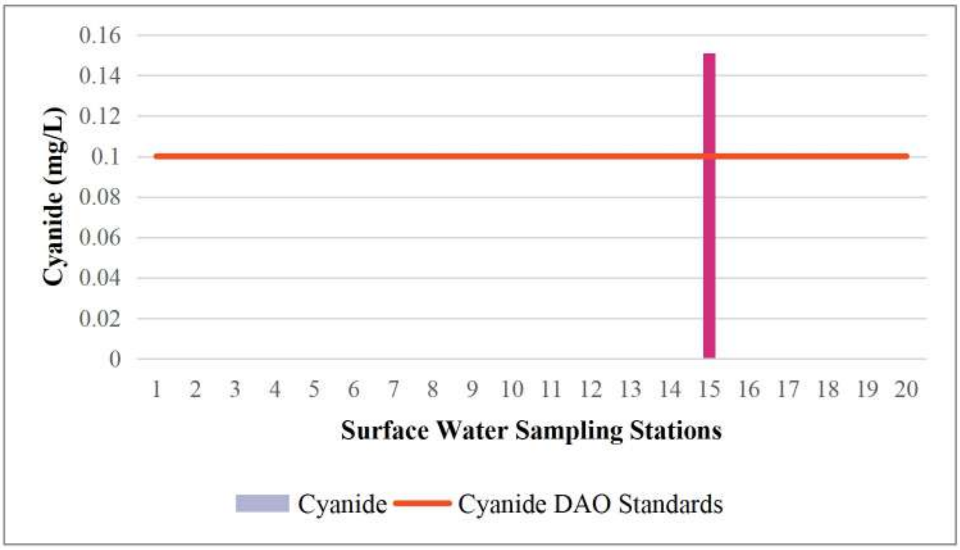


Figure 2.88 Surface water sampling results for Cyanide Level

Ammonia (NH_3)

Ammonia is produced through anthropogenic and natural processes. This may be from fertilizers and other industrial operations, and organic waste break down, among others. Higher ammonia concentrations may lead to potential loss of aquatic organisms as it may increase toxicity. **Figure 2.89** shows that levels of Ammonia exceed standards in most sampling stations. Stations SW3, SW4, SW8, SW12, SW14, SW17, SW19, and SW20 all had undetected levels of Ammonia, while the other stations exceeded DAO standards.

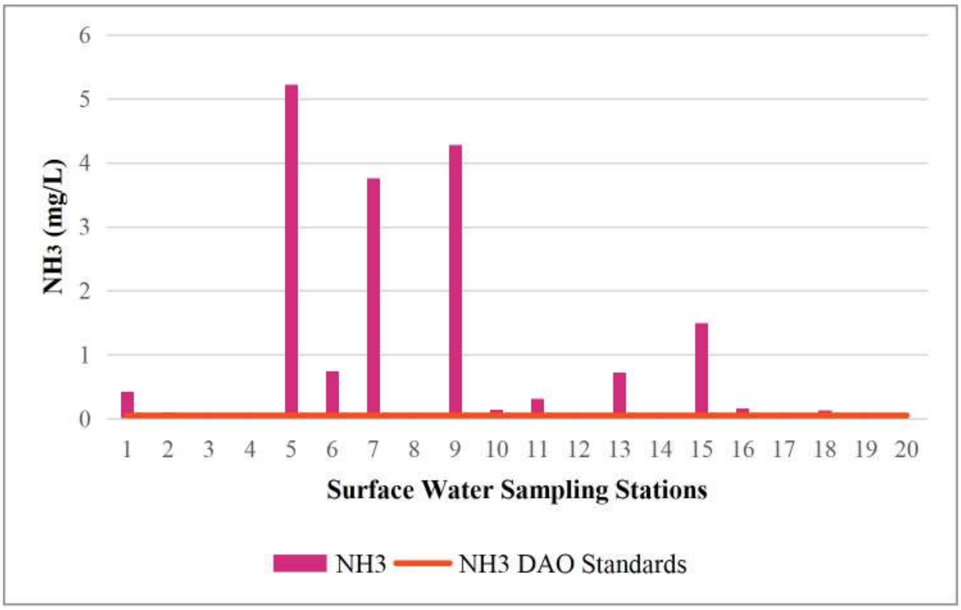


Figure 2.89 Surface water sampling results for Ammonia Level

Fecal Coliform

The amount of fecal coliform bacteria found in water bodies are measured with mg/L of Fecal Coliform. The primary source of fecal coliform is fecal contamination by warm-blooded animals. High levels of fecal coliform may result to a variety of illnesses especially towards human communities. Fecal coliform levels in all water quality stations have values exceeding DAO standards, as seen in **Figure 2.90.**

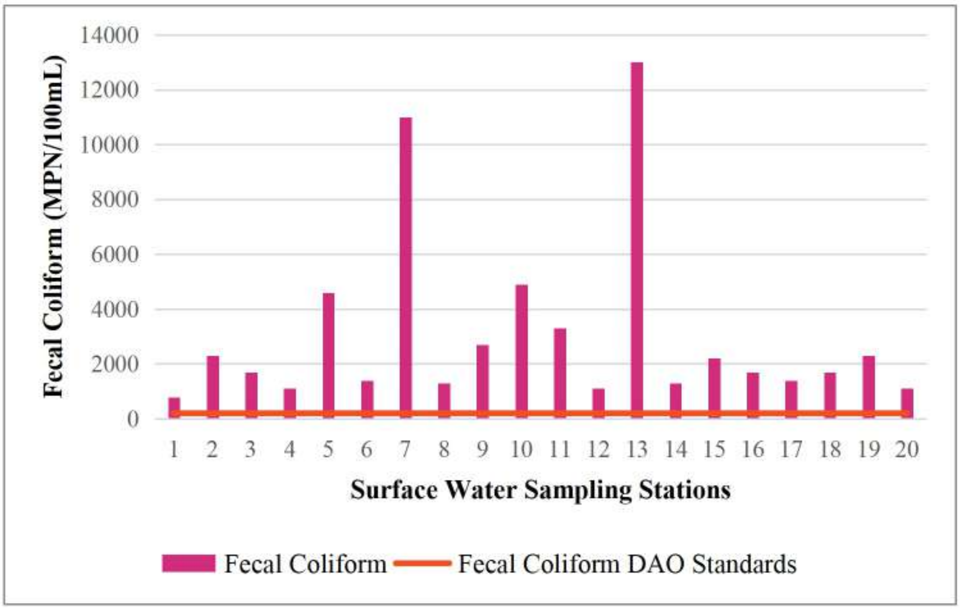


Figure 2.90 Surface water sampling results for Fecal Coliform Level

Sources of Threats at Current Condition/Without the Project

The groundwater is contaminated with phosphorus, ammonia, chloride, and fecal coliform. Pollutant may reach ground water from anthropogenic activities on the surface such as high concentrations of fertilizers in agricultural areas, and spillage of industrial and domestic waste. These products may have be introduced to ground water bodies via seepage through the soil. In this case, the potential source of high concentrations of phosphorus, ammonia, and fecal coliform in groundwater sampling sites can be accounted to underground septic systems. Leakage from septic tanks may also be a potential source of high levels of fecal coliform. High amounts of TDS, turbidity, and true color have been observed in the groundwater monitoring. This may be produced from weathering of minerals and soil, and irrigation.

Majority of freshwater pollution originates on land, in different forms of pollutant, mostly as a result of various human activities. Laguna Lake has also been extensively used for various trades, primarily shipping, aquaculture and tourism. Its waters currently suffer from contamination of phosphate, cyanide in location of SW-15, ammonia, and fecal coliform, which can be inferred as run-off from nearby mixed land uses and commercial establishments that discharge its effluent in the lake. As a result, the physical properties of the freshwater are affected in terms of the TSS (especially in SW-12 in location), temperature, BOD, depletion of dissolved oxygen and fecal coliform. Survey results has been consistent to the monitoring results established by LLDA located at different regions of the lake that is being supplied by the different tributaries and other sources. For the west side of the lake, historical data showed that BOD[25] concentration failed the DAO 2016-08 effluent standards for Class C waters of more than 5mg/l and up to 7 mg/l.

Dissolved Oxygen (DO)[26] levels in the west side of the lake also failed to meet DENR standard of less than 2 mg/l (DAO 2016-08). As a general assessment, highest chloride, and Total Dissolved Solids (TDS) concentration were observed at station near the mouth of Pasig estuary.

2.2.3.7 Potential Impacts and Options for Prevention, Mitigation or Enhancement Plans

Degradation of Water Quality

During the construction works of the project, water quality of receiving streams especially of Laguna Lake will be affected such as increase in TSS and TDS, color and turbidity. Hence, physical properties, such as pH, temperature and DO will also show alterations if significant contamination is present in the waters. This is primarily due to the disturbances during soil excavation activities.

Spillages onsite if left unmanaged will also finds its way in water streams, leading to possible increase in presence of heavy metal as well as excessive oil and grease and other particulate materials. In addition, increase in organic contaminants such as BOD, ammonia, phosphorus will be observed if domestic wastes from construction site is left unaccounted.

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[25] BOD is a measure of the quantity of oxygen consumed by microorganism during the decomposition of organic matter. In a lake system, this is an indication of pollution loads discharged to the lake from its tributary streams.

[26] DO is the amount of oxygen needed by aquatic life to survive (i.e. low DO can cause fish kill).

During the construction and operation phase, proper management of stockpiles and the drainage system should be undertaken. Stockpiles will be covered and will be placed far away from the waterways to avoid impacts brought about by possible rain washing of solids into the water body hence increasing sedimentation.

Project design will be equipped with drains with an appropriate catchment system to prevent the runoff of waste materials into Laguna Lake. Strict implementation of the waste management rules and regulations will be strongly advised.

To mitigate water pollution due general construction activities (i.e. dredging and excavation on water; operation of vessels; installation of columns/ foundations and construction of road structure), the following are proposed to be carried out:

- All project activities will be disclosed through proper information dissemination in the nearby communities and establishments;
- The contractor will be required to comply with the Civil Works Guidelines;
- Locate motor-pool area at least 500 meters away from any body of water;
- The management will establish strategies to ensure the integrity of water and soil, through regular monitoring of the affected and adjacent water bodies prior, during and after the construction phase to monitor the water quality and ensure the continuous conformance to their respective water quality criteria. Water quality monitoring will be conducted on a monthly basis during the construction phase;
- All incident and complaints reports will be properly documents, including all actions taken;
- The LLRN will be designed to meet internationally accepted standards to ensure safe operation;
- Apply appropriate siltation control measures within the buffer of construction areas to prevent any pollution and silt disturbance due to construction activities near the lake;
- Soil debris and other excavated materials should be hauled out from the site; and
- Emergency response procedures will be in place to manage any possible failures.

Whereas, to mitigate water pollution due to hazardous wastes, the following are proposed to be carried out during construction phase:

- Maintenance and proper use of construction materials and heavy vehicles will be implemented. The contractor will ensure that proper training and education will be provided to the staff before conduct of activities;
- The project shall be equipped with oil-water separator to remove oil from effluents prior to discharge to the water bodies;
- Implementation of a proper waste management (handling, storage and disposal) and housekeeping measures to prevent possible contamination in soil. There will be an organized waste storage, where bulk waste oils and lubricants are placed in impermeable area with appropriate secondary containment and label;

- Waste oils, oily water and other hazardous wastes will be collected and disposed offsite by an accredited third-party waste hauler and treater; and
- Emergency and contingency plan in case of spills (health and safety management plan must be in place).

Siltation and Erosion

Siltation, erosion and resuspension of particles in the water resulting from the construction works would negatively affect the water quality particularly in terms of increase in turbidity and TSS. This may aggravate during project land clearing, dredging, including the construction of temporary facilities, the embankment, and viaducts. Particles displaced from land may also lead towards sources of water via surface runoff and/ or excavation dewatering. In cases where contaminated particles or sediments are introduced to the affected water systems, pollutants from soil will potentially be dissolved in the water when turbulence in the water occurs.

To mitigate siltation and erosion, the following are proposed to be carried out during construction phase:

- The management will establish strategies to ensure the integrity of water and soil, through regular monitoring of the affected and adjacent water bodies prior, during and after the construction phase to monitor the water quality and ensure the continuous conformance to their respective water quality criteria. Water quality monitoring will be conducted on a monthly basis during the construction phase;
- Secure appropriate erosion control measures such as additional pavements, concrete walls, sediment and silt traps and barriers especially during heavy rain periods;
- Stockpiles will be placed away from the water courses and protected against natural elements to prevent the transport of soil and sediment;
- The lake water trapped inside piles/ casing / cofferdam will be pumped out to sedimentation tank or settling devices before discharge to reduce the water quality impacts to the lake;
- Soil debris and other excavated materials should be hauled out from the site;
- The waste soil and other debris will be properly handled and disposed on a regular basis; and
- Whenever feasible, conduct immediate re-vegetation of the cleared land to prevent erosion and siltation.

Stream contamination

Runoff from the construction areas may contain suspended solids such as sediments and contaminants, hence would impact near water bodies if uncontrolled. Water pollution may also come from the uncontrolled discharge of debris and rubbish, spillages of liquids stored on-site, such as oil, diesel and solvents, and the release of concrete washings and dust suppression waste waters. This in effect may also alter the water flow of nearby streams, hence possibly increase the risk of flooding.

To mitigate stream contamination, the following are proposed to be carried out during construction phase:

- Implementation of a proper waste management (handling, storage and disposal) and housekeeping measures to prevent possible contamination in soil. There will be an organized waste storage, where bulk waste oils and lubricants are placed in impermeable area with appropriate secondary containment and label;
- All incident and complaints reports will be properly documents, including all actions taken;
- Waste oils, oily water and other hazardous wastes will be collected and disposed offsite by an accredited third-party waste hauler and treater; and
- Emergency and contingency plan in case of spills (health and safety management plan must be in place).

Sewage effluent from construction workforce and solid wastes

Poor waste management would allow domestic wastes and sewages (e.g. biodegradable and non-biodegradable wastes) from construction areas to accumulate on soil and other waterways such as canals, which may be carried into the nearest body of water via surface runoff. These domestic sewage may cause eutrophication in the waters due to excessive nutrient content. Hence to mitigate wastewater from construction and solid waste accumulation, the following are proposed to be carried out:

- Sewage and other domestic discharges will be directed to a local septic tank;
- Temporary sanitary facilities, such as portable chemical toilets, should be employed on-site where necessary to handle sewage from the workforce. A licensed contractor would be responsible for appropriate disposal of waste matter and maintenance of these facilities.
- Implementation of a proper waste management (handling, storage and disposal) and housekeeping measures;
- Conduct training and seminars regarding poper waste management and housekeeping measures;
- The contractor will be required to comply with the Civil Works Guidelines;
- Stockpiles should be distant from the waterways and covered in order to avoid contamination caused by rain washing the solids into the water body and increasing sedimentation;
- Drainage system should be maintained to prevent oil/ lubricant and/or chemical run-off contaminating water bodies (i.e. rivers, lake); and
- Proper storage of chemicals should be implemented to prevent spillage and possible contamination of soil and water.

Change in quality of groundwater sources

Impacts on groundwater may be due to waste materials from contractors' activities that may be left untreated and may penetrate through soil striations. This can also be due to digging activities which may accidentally tap groundwater sources therefore contaminates the water table. If untreated, it may contaminate the water table with fecal coliform or other contaminants as this may not be filtered through the soil nor used as uptake by the flora.

Without proper management, pollution may take place to groundwater, hence below are some proposed measures to be considered during construction phase:

- Proper planning to avoid accidentally tapping or contaminating groundwater sources should be implemented;
- Excessive percolation can be avoided by re-vegetation practices and by proper planning of slopes, drainage pipes and canals and the application of silt and waste barriers.
- Proper waste management and strict adherence to rules and regulations would help in mitigating any effluent entering groundwater sources; and
- Drainage and slopes should not allow excessive surface runoff. Percolation should still happen to recharge groundwater sources (Transportation Research Board, 2005).

Effect to freshwater ecosystem and resources

Most threats on freshwater will be present during construction, while impacts such as surface runoff from the project during operation phase can be controlled through proper management. Potential impacts can be more reasonably mitigated as the extent of construction works within the freshwater environment are restricted to the foundation areas, and thus mitigating measures such as silt curtains can be utilized. Other mitigation measures to be undertaken are:

- Employ well-designed silt curtain scheme installed within the buffer of construction areas to prevent any pollution and silt disturbances;
- Dredging must be confined at the immediate area so that only a small part of the meadow will be affected;
- Engineering modifications will be applied to provide greater surface complexity and minimized impacts on aquatic ecology;
- Proper disposal of debris, hence any debris or concrete waste must be removed as quickly as possible;
- Monitoring and evaluation aquatic habitats to be conducted quarterly or bi-annually to capture changes;
- Strict observance and implementation of Site Protection and Rehabilitation Program and materials handling which provide for soil erosion control measures; and
- Observe best practices in proper construction procedures that promote care and minimal disturbance to the existing environment.

2.2.4 Aquatic Ecology

The objective of the aquatic ecology component of the EIA study is to establish the current status of the aquatic environment and biological resources of Laguna de Bay (west side from Lower Bicutan to Calamba) with as many biological aspects as possible under project time constraints. Field sampling was conducted in December 2020.

The scope of work involved the conduct of a baseline study on the aquatic environment and biological resources particularly on phytoplankton, zooplankton, primary productivity (chlorophyll-*a*), ichthyoplankton (fish eggs and larvae), soft bottom infaunal benthos, aquatic macrophytes, fish and other aquatic life, fisheries (fish capture and aquaculture), and protected areas/sanctuaries were presented in **Table 2.43** below.

Table 2.43 Key Objectives of the monitoring

Survey / Study Type	Description of Receptor	Objectives of the Surveys	Potential Impact/Use for Impact Project Monitoring
Phytoplankton	Phytoplankton – microscopic plantlike organisms in the water column	Phytoplankton study aims to contribute some basic information to the general knowledge on the phytoplankton ecology at the project site. The specific objectives are to determine the species composition, density and relative abundance of phytoplankton in the Laguna Lake. Phytoplankton is a community of microscopic alga that is at the base of the food web. They are an important resource that supports the higher tropic levels of the lake. Understanding the dynamics and production of phytoplankton may contribute to the elucidation of the status of fishery resources and may be the key for better fisheries management since phytoplankton is at the base of the food chain.	Increased turbidity levels and sedimentation/siltation which may interfere with phytoplankton primary production

Zooplankton	Zooplankton-microscopic animal in the water column	This study aims to contribute some basic information to the general knowledge on the zooplankton ecology at the project site. The specific objectives of the investigation are to determine the zooplankton composition and to investigate the density and relative abundance of zooplankton. Since zooplankton is the secondary producer of organic matter living on the phytoplankton in aquatic food chain, its importance to fish production is self evident. Zooplankton plays a major role in the functioning and the productivity of aquatic ecosystems through its impact on the nutrient dynamics and its key position in the food webs. Likewise, zooplankton community is highly sensitive to environmental change as they respond to disturbances in the environment like nutrient loading and fish densities.	Increased turbidity levels and sedimentation/siltation which may interfere with zooplankton secondary production, feeding and respiration
Primary Productivity (Chlorophyll-a)	Primary productivity (chlorophyll-*a*) – amount of organic material produced per unit area per unit times; or simply the product of phytoplankton biomass times phytoplankton growth rate in the water	Primary productivity is important because it is the process that forms the foundation of food webs in most ecosystems. In aquatic ecosystems, primary productivity is driven by the availability of	Increased turbidity levels which tend to limit light penetration essential in the photosynthesis of phytoplankton

	column	nutrients and light and, to a lesser extent, by temperature and other factors. The measurements of plant pigments, especially chlorophyll-*a*, is the only current rapid chemical method available to estimate the amount of living particulate matter.	
Ichthyoplankton (Fish Eggs and Larvae)	Ichthyoplankton – includes planktonic eggs and larvae of fish found in the sunlit zone of the water column.	Ichthyoplankton studies are important for stock assessment purposes. Fish eggs and larvae occurrence and abundance facilitate the location of probable spawning and nursery grounds of fishes. Ichthyoplankton data provide a base for research into population dynamics of major fishery species. Information on ichthyoplankton ecology comprises an important component of stock assessment and fishery management plans (Rutherford, 2002)	Irritation and clogging of gills of fish larvae and juveniles that could lead to their eventual smothering; and would slightly increase the mortality rates among fish larvae/juveniles due to increased turbidity/siltation
Soft Bottom Infaunal Benthos	Soft bottom infaunal benthos - includes animals that burrow into soft sediments of the bottom of the water body	The study aims to evaluate the soft bottom infaunal benthic community along the project site with respect to its composition, density, relative abundance and biomass. The study also aims to contribute some baseline information to the general knowledge of the soft bottom benthos community in	Land clearing/earthmoving, dredging, reclamation/ladfillingand pile driving will produce increased turbidity/siltation/ sedimentation. These construction activities will not only disturb the existing benthic fauna but will entail a complete smothering and burying of all benthic organisms

		the area. These faunal benthic organisms, which are associated with soft bottom substrate, constitute as one of the most abundant major components of the food habits of the many benthic or bottom dwelling fishes and edible invertebrates on the lake. The soft bottom benthic communities are diverse and play an important role as support systems for the aquatic environment. Sediment quality would be useful baseline information given the nature of the potential impacts (i.e. construction pollution and road runoff in operation).	
Fish and Aquatic Invertebrates	Fish – are aquatic vertebrate (with backbone) that have gills and are found in the water column (pelagic) and on the lake bottom (demersal or bottom dwelling). Commercial and subsistence fishers hunt fish in wild fisheries or farm them in ponds or in cages/pens (aquaculture) Aquatic invertebrates - animals without backbone, visible to the naked eye, that live in or near the bottom of the water body	This study will provide baseline information on fish species composition which may be useful in evaluating the status of the fish resources of the lake and in formulating policies for its rational exploitation and proper management of these fish resources. Aquatic invertebrates not only form an integral	Increased Sedimentation/siltation/turbidity due to construction activities can contribute to decrease in local fish population and may have an adverse effect on fish health; and spawning habitat may be smothered Would also cause adult fish to migrate to other suitable areas; however, smaller species that are unable to migrate would be chronically exposed to high turbidity may suffocate as their gills become clogged with sediment Construction activities

		part of the aquatic ecosystem but also serve as important link in the aquatic food chain. These aquatic invertebrates live in the bottom (epibenthic) parts of a body of water. Invertebrates are good integrators of environmental conditions over time and can be used as indicators of water quality and the general "health" of the aquatic environment (Rosenberg and Resh, 1993).	will not only disturb the existing invertebrate fauna but will also entail a complete burying of their habitat
Aquatic Macrophytes	Aquatic macrophytes – includes submerged aquatic vegetation, emergent aquatic vegetation, and floating vegetation	The purpose of this study is to gather information on the presence, distribution and abundance of aquatic plants in the area which may be useful for its proper management. Aquatic vegetation in the lake serves as a homing ground or shelter, a place for egg deposition, and as a source of food to many larval forms of aquatic fauna. Both the floating and benthic rooted forms help cleanse the water of its pollutants.	Some loss of the shoreline vegetation (water lilies and (water spinach or kangkong) will occur along San Pedro where macrophyte beds are present along or within the footprint of the proposed LLRN alignment
Protected Areas Fish Sanctuaries	Fish sanctuary – a protected area in a water body closed to fishing or taking of fish by any method. It is one of the effective tools for conserving fish stock, preserving biodiversity and increasing fish production	The main objective of this study is to evaluate or confirm the presence of fish sanctuaries within the Laguna Lake (particularly along the west side from Lower Bicutan to Calamba).	The fish sanctuaries of Laguna de Bay (particularly those located in Calamba) are unlikely to be encroached by the project. But it is accepted/expected that there may be indirect

			impacts on local water quality (e.g., due to sanitary/domestic wastewater discharges and leakage of oil from work vessels and barges)

A total of eight (8) transect locations (from Lower Bicutan to Calamba) were established for the lake ecological survey at the proposed road alignment represented by two (2) sampling stations each (nearshore which is located alongside of the road alignment and offshore which is located about 1 km from the road alignment); hence, a total of 16 pre-determined stations were sampled and these are shown in **Table 2.44** and are plotted in **Figure 2.114**.

Table 2.44 Lake ecology sampling station data for phytoplankton, zooplankton, ichthyoplankton, primary productivity and soft bottom infaunal benthos

Municipality/ City (Transect Site)	Sampling Station	Coordinates		Sampling Date (2020)	Prevailing Winds	Lake's Surface Water Condition
		Latitude North	Longitude East			
1- Bicutan	LL1 (Nearshore)	14°28'02.24"	121°03'50.17"	21 Dec	NE	Somewhat calm; turbid/murky
	LL2 (Offshore)	14°28'02.08"	121°04'27.37"	21 Dec	NE	Somewhat calm; turbid/murky
2-Sucat	LL3 (Nearshore)	14°26'12.96"	121°03'30.57"	21 Dec	NE	Somewhat calm; turbid/murky
	LL4 (Offshore)	14°26'12.24"	121°04'07.90"	21 Dec	NE	Somewhat calm; turbid/murky
3-Alabang	LL5 (Nearshore)	14°24'13.90"	121°03'30.30"	21 Dec	NE	Somewhat calm; turbid/murky
	LL6 (Offshore)	14°24'13.58"	121°04'09.41"	21 Dec	NE	Somewhat calm; turbid/murky
4-Tunasan	LL7 (Nearshore)	14°22'04.88"	121°03'59.99"	20 Dec	NE	Somewhat calm; turbid/murky
	LL8 (Offshore)	14°22'04.69"	121°04'35.69"	21 Dec	NE	Moderately rough; turbid/murky
5-San Pedro/Biñan	LL9 (Nearshore)	14°20'35.80"	121°05'45.10"	20 Dec	NE	Very rough; turbid/murky
	LL10 (Offshore)	14°20'35.49"	121°06'20.71"	20 Dec	NE	Very rough; turbid/murky
6-Sta. Rosa	LL11 (Nearshore)	14°18'15.27"	121°07'43.52"	19 Dec	NE	Rough; turbid/murky
	LL12 (Offshore)	14°18'14.94"	121°08'18.44"	19 Dec	NE	Rough; turbid/murky
7-Cabuyao	LL13 (Nearshore)	14°15'16.53"	121°10'16.28"	19 Dec	NE	Rough; turbid/murky

	LL14 (Offshore)	14°15'16.35"	121°10'51.38"	19 Dec	NE	Rough; turbid/murky
8-Calamba	LL15 (Nearshore)	14°12'35.44"	121°11'23.75"	19 Dec	NE	Rough; turbid/murky
	LL16 (Offshore)	14°12'34.59"	121°11'58.43"	19 Dec	NE	Rough; turbid/murky

Legend: LLE = Laguna Lake Ecology
Nearshore = Alongside the proposed road alignment
Offshore = About 1 km from the proposed road alignment
NE = Northeasterly winds or “amihan”

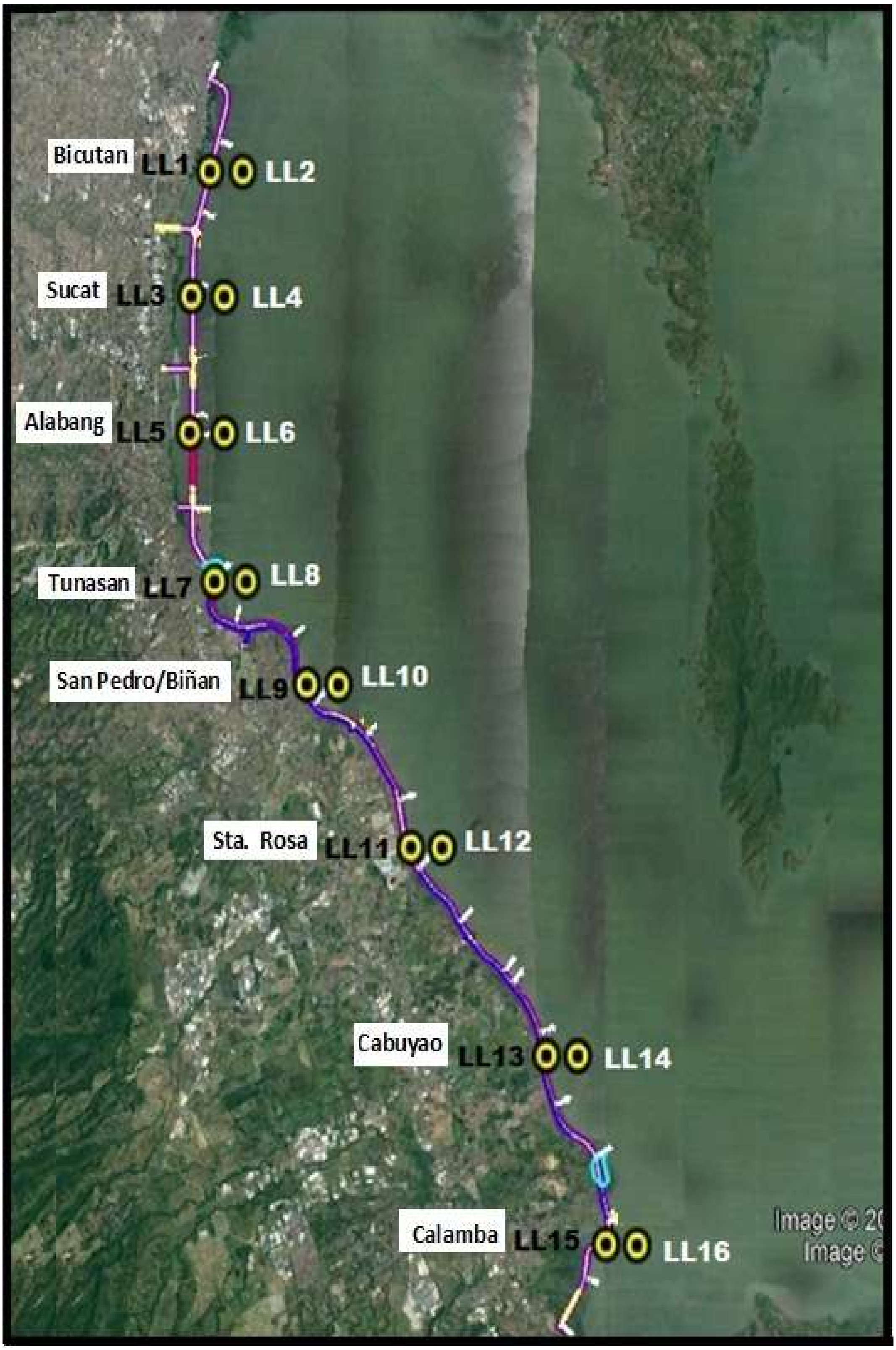


Figure 2.114 Locations of lake ecology sampling stations along the proposed lakeshore road alignment in Laguna Lake

However, the field sampling/data gathering conducted in all these stations is just a snapshot survey of the ecological conditions and the lake biological resources present in the area at the time of sampling. Thus, the results of this baseline study could only furnish an approximation of the sampling period without due consideration to seasonal fluctuation which could affect the species composition, density and relative abundance of the phytoplankton, zooplankton, ichthyoplankton and soft bottom benthic infauna. Habitat community composition within the aquatic environment of the Laguna de Bay area in particular is seen to vary between the dry and wet seasons. This seasonal change in the natural biological environment is precipitated by variations in water characteristics, principally water temperature and rainfall.

Secondary data gathering was also conducted during the study. The data describing the ecological/biological baseline conditions along the project site comes from a number of published and unpublished reports of the previous studies and surveys done in Laguna de Bay.

2.2.4.1 Methodology

Phytoplankton

This study aims to contribute some basic information to the general knowledge on the phytoplankton ecology at the project site. The specific objectives are to determine the species composition, density and relative abundance of phytoplankton in the Laguna Lake. Phytoplankton is a community of microscopic alga that is at the base of the food web. They are an important resource that supports the higher tropic levels of the lake. Understanding the dynamics and production of phytoplankton may contribute to the elucidation of the status of fishery resources and may be the key for better fisheries management since phytoplankon is at the base of the food chain.

Conventional plankton net was used with stainless circular frame and detachable cod ends (specs. 30 cm mouth diameter, 20 µm mesh size and 1 meter length) (**Plate 1**). Phytoplankton samples were collected by vertical hauling of the net from near the bottom to the surface of each station to minimize the effect of variations brought about by diurnal migration of plankton. In this manner, all levels of the water column were sampled (Estudillo, 1979). A calibrated flowmeter was attached to the center of the mouth of the plankton net to obtain an estimate of the volume of water filtered by the net during each haul (see **Plate 1**). For each station, duplicate hauls were obtained for phytoplankton identification and counts. On board, samples were transferred and stored in a 250 ml polyethylene bottle and preserved in 10% formalin (see **Plate 1**). The samples were then brought to the laboratory for analysis at the National Fisheries Research and Development Institute (NFRDI) in Quezon City.

The numerical density of phytoplankton organisms was determined using an aliquot. The samples in the aliquot were, at first, examined microscopically to determine the identity of the components represented and were, later, counted for organisms using a Sedgewick - Rafter cell. The densities of phytoplankton were estimated, and then transformed to number cells per cubic meter of seawater (cells /m^3). The biomasses of phytoplankton samples were determined for each sample using the "wet" displacement volume method (Ahlstrom, 1976). The plankton volume measurement provides a rough measure of planktonic biomass (Smith and Richardson, 1977), and can be considered as an index to the amount of living matter present in the form of one or more of the various kinds of organisms comprising a plankton population (Beers, 1976). The biomasses of plankton samples were estimated, and then transformed to volume in milliliter per cubic meter (mL/m^3).

Plate 1 (a) Phytoplankton sampling by 30 cm mouth diameter, 20 µm mesh size and 1 meter length plankton net, (b) flowmeter attached to the center of the mouth of the net, (c) and phytoplankton sample collected

Zooplankton

This study aims to contribute some basic information to the general knowledge on the zooplankton ecology at the project site. The specific objectives of the investigation are to determine the zooplankton composition and to investigate the density and relative abundance of zooplankton. Since zooplankton is the secondary producer of organic matter living on the phytoplankton in aquatic food chain, its importance to fish production is self evident. Zooplankton plays a major role in the functioning and the productivity of aquatic ecosystems through its impact on the nutrient dynamics and its key position in the food webs. Likewise, zooplankton community is highly sensitive to environmental change as they respond to distrubanes in the environment like nutrient loading and fish densities.

Duplicate zooplankton samples were also taken at each station by hauling conical plankton net (specs. 45-cm mouth diameter, 64 µm and 2 meter length) (**Plate 2**). Similar to that of the phytoplankton, vertical hauling was made from near the bottom to the surface. A calibrated flowmeter was also mounted in the mouth of the net. The samples were then transferred and stored in 250 ml polyethylene bottle and preserved in 10% formalin (see **Plate 2**). The samples were sent to NFRDI laboratory for sorting, counting, identification and recording.

The procedures used in the numerical density and biomass of zooplankton organisms were almost the same to that of the analyses of phytoplankton organisms. Density and biomass of phytoplankton were estimated, and then transformed to number of organisms per cubic meter of water (no. of organisms/m^3) and displacement volume in milliliter per cubic meter (mL/m^3), respectively.

Plate 2 (a) Zooplankton sampling by 45-cm mouth diameter, 64 µm and 2 meter length plankton net and (b) storing of sample in 250 ml polyethylene bottle and preserving in 10% formalin

Primary Productivity (Chlorophyll-*a*)

Primary productivity is important because it is the process that forms the foundation of food webs in most ecosystems. In aquatic ecosystems, primary productivity is driven by the availability of nutrients and light and, to a lesser extent, by temperature and other factors. The measurements of plant pigments, especially chlorophyll-*a*, is the only current rapid chemical method available to estimate the amount of living particulate matter.

Surface water samples (1-liter of surface water) were taken separately for phytoplankton primary productivity analysis (chlorophyll-*a* concentration). The samples were brought to the NFRDI laboratories for processing and analysis. The 1-liter surface water samples were filtered through a Whatman GF/C 2.5–mm glass fiber filter, extracted by 90% acetone for about overnight in a refrigerator, centrifuged, and the chlorophyll-*a* extracts in the supernatant were determined with a spectrophotometer.

Ichthyoplankton (Fish Eggs and Larvae)

Ichthyoplankton studies are important for stock assessment purposes. Fish eggs and larvae occurrence and abundance facilitate the location of probable spawning and nursery grounds of fishes. Ichthyoplankton data provide a base for research into population dynamics of major fishery species. Information on ichthyoplankton ecology comprises an important component of stock assessment and fishery management plans (Rutherford, 2002)

Ichthyoplankton samples were collected at each station using 335 microns bongo net with 50 cm mouth diameter and 2.5 meters length (**Plate 3**). At each station, bongo net was towed horizontally for 10 minutes at an average speed of 2 knots (see **Plate 3**). A flowmeter was attached at the mouth of bongo net for later computation of volume of water filtered during each tow. Collected samples were preserved with 10% formalin after each tow (**Plate 3**). Samples were sorted at the NFRDI laboratory for sorting and direct counting from the whole sample. Sorted fish larvae/juveniles were identified using identification manuals. The abundance was estimated in terms of the number of individual fish eggs and fish larvae per cubic meters (no./m^3) of water filtered by the bongo net.

Plate 3 (a) Operation of 335 microns bongo net with 50 cm mouth diameter and 2.5 meters length for fish eggs and larvae sampling; (b) horizontal tow of the net for 10 minutes; (c) transferring of sample from the bucket to 1-liter capacity plastic bottle; and (d) sieving, storing and preserving of sample with 10% formalin

Soft Bottom Infaunal Benthos

The study aims to evaluate the soft bottom infaunal benthic community along the project site with respect to its composition, density, relative abundance and biomass. The study also aims to contribute some baseline information to the general knowledge of the soft bottom benthos community in the area. These faunal benthic organisms, which are associated with soft bottom substrate, constitute as one of the most abundant major components of the food habits of the many benthic or bottom dwelling fishes and edible invertebrates on the lake. The soft bottom benthic communities are diverse and play an important role as support systems for the aquatic environment.

Sediment samples for infaunal soft bottom benthos study were collected using an Ekman bottom grab sampler (**Plate 4**). Duplicate samples were obtained from each station and sieved through a 0.5 mm wire mesh sieve immediately after the collection. The sediment residues with the organisms retained in the sieve were placed in a plastic container, stained with Rose Bengal and preserved in 10% formalin. Samples were processed in the laboratory of the Zoology Department of the National Museum in Manila where they were washed with tap water to get rid of excess formalin. Sorting of organisms from the sediments was done with the aid of a stereo zoom microscope. Identified organisms were placed in vials containing 70% alcohol and classified to family level, if possible. Specimens sorted from the sediment samples were counted to analyze their density. Density was expressed in terms of individuals per square meter (indv/m^2). An index of diversity of benthic organisms (within major taxonomic group) using Shannon-Weaver Index was computed for the communities found in different stations. Biomass of the benthic fauna for each sampling site was also measured and expressed in wet weight in grams per square meter (wwt g/m^2).

Plate 4 (a) Lowering of Ekman bottom grab sampler for sediment sampling for soft bottom infaunal benthos, (b) hauling of bottom grab sampler with collected sediment, (c) transferring of sediment sample onto plastic basin, and (d) mud sediment sample obtained for sieving

2.6 Fish and Aquatic Invertebrates

This study will provide baseline information on fish species composition which may be useful in evaluating the status of the fish resources of the lake and in formulating policies for its rational exploitation and proper management of these fish resources.

Aquatic invertebrates not only form an integral part of the aquatic ecosystem but also serve as important link in the aquatic food chain. These aquatic invertebrates live in the bottom (epibenthic) parts of a body of water. Invertebrates are good integrators of environmental conditions over time and can be used as indicators of water quality and the general "health" of the aquatic environment (Rosenberg and Resh, 1993).

Fishing activities of local fisherfolks in the area were observed. Fish and other aquatic fauna caught were identified and some were photographed. A visit to a fish landing and public market was also conducted for the different species of fish and other aquatic fauna caught in the area for the preparation of a more comprehensive list of the reported fishes and other aquatic fauna in Laguna Lake. Secondary data gathering from internet search, various survey reports, scientific publications and published and unpublished literatures on fishes and invertebrates of the lake was also conducted.

2.7 Aquatic Macrophytes

The purpose of this study is to gather information on the presence, distribution and abundance of aquatic plants in the area which may be useful for its proper management. Aquatic vegetation in the lake serves as a homing ground or shelter, a place for egg deposition, and as a source of food to many larval forms of aquatic fauna. Both the floating and benthic rooted forms help cleanse the water of its pollutants.

Visual observations and interviews on the presence of aquatic plants in the area were conducted. Species of aquatic plants encountered during the survey were identified and photographed. Other sources for information on aquatic plants in the area were taken from Internet (YouTube Vlogs), publications and technical reports.

2.8 Fisheries

2.8.1 Fish Capture Fishery

The purpose of this study is to gather data/information on fish capture fishery in the lake, including its fish production, number of fishermen and fishing boats, fishing season, fishing gears, and fishes caught in the lake.

Field observations and informal interviews with local residents, particularly the guides, boat operators and local barangay officials, fisherfolks, and persons who were encountered during the survey at each sampling site were conducted to obtain current information on the local fish fishery conditions. Fishing seasonality and other fisheries related issues were asked from interviews of key informants. Secondary data gathering from the various reports, publications, and published and unpublished literatures on the fish capture of the lake was also conducted.

2.8.2Aquaculture Fishery

The purpose of this study is to obtain data/information on the operation and development of the fish pen and fish cage culture practices in the lake, including the species being cultured and its production and also the various problems that hinder its development.

The assessment of aquaculture fishery (fish pens and fish cages) relied heavily on the analysis of secondary data from relevant reports and publications. Reconnaissance activity in some aquaculture sites within the study area was also undertaken during the field survey. The main purpose of this survey was to determine the location and existing conditions of the fish cages and fish pens in the area that will possibly be impacted by the proposed lakeshore road alignment.

2.9 Protected Areas/Fish Sanctuaries

The objective of this study is to evaluate or confirm the presence of fish sanctuaries within the Laguna Lake for critical habitat assessment (CHA). Establishment of sanctuary has become obligatory to protect specific areas from negative fishery impacts, enhance fish diversity, restoration as well as conservation of habitat.

Secondary data and information on protected areas/sanctuaries at the project site were taken from relevant reports and publications provided by the Local Government Units (LGUs) concerned (provincial and municipal ordinances and resolutions), Laguna Lake Development Authority (LLDA) and Bureau of Fisheries and Aquatic Resources (BFAR).

2.2.4.2 Baseline Environmental Conditions

Physical and Biological Environments along the Proposed Lakeshore Road Alignment

Lakeshore fronting the proposed road alignment is densely covered by water hyacinth (*Eichornia crassipes*) and kangkong (*Ipomoea aquatica*). This situation is seen over the municipalities of San Pedro, Biñan and Sta. Rosa in Laguna (**Plate 5**). Water hyacinth is a non-native and invasive (originating from the Amazon River basin in Tropical South America). On the other hand, the place of origin of *Ipomoea aquatic* is not known or quite clear, but is agreed that it is a native in Southeast Asia. India has been suggested as the location of plant's origin. However, *I. aquatica* is highly invasive, forming dense mats over the surface of water bodies.

Plate 5 Vegetation cover along the lakeshore of the proposed road alignment: (a) western side of Laguna Lake-southern area from Taguig Lakeshore Hall, (b) western side of Laguna Lake- southern area from Sucat's Peoples Park, and (c) southern side –wetland along San Juan River and Mt. Makiling **(Photo source: openjicareport.jica.go.jp/pdf/12308284-03)**

The bottom sediment characteristics within the footprint of the proposed road alignment range from muddy (grayish) in Bicutan and Sucat to muddy (grayish) with trace amounts of shell fragments in Alabang, Tunasan, San Pedro/Biñan, Sta. Rosa, Cabuyao and Calamba (**Figure 2.115**). On the other hand, Calamba at offshore Station LL16 exhibits blackish mud bottom sediment (**Plate 6**), All the sediments collected from all the 16 sampling stations were generally characterized by grayish muddy texture (**Table 2.45**). For the sake of convenience, these habitats can be arbitrarily classified into muds, in accordance with the gross physical appearance of the lake bed sediments on which the organisms live. Mud bottom are formed in low energy environments, where the water moves more slowly. The fine particle pack tightly, and circulation of water among them is poor. Oxygen can penetrate only slowly into the sediment and as a result excess organic matter accumulates there unoxidized. Reducing conditions prevail except in a very thin surface layer, and animals living in this environment must either remain in the oxygenated surface layer or develop special adaptations, enabling them to inhabit the aerobic portion of the sediment. These soft bottom habitats are economically and ecologically important. Soft bottom benthic is inhabited by larger burrowing animals such as gastropod and bivalve molluscs, and some shrimps and crabs among others, including great numbers of oligochaete worms and insects (chironomids and tepulids) that live in spaces between sediment particles.

Sediment quality would be useful baseline here given the nature of the potential impacts (i.e. construction pollution and road runoff in operation)

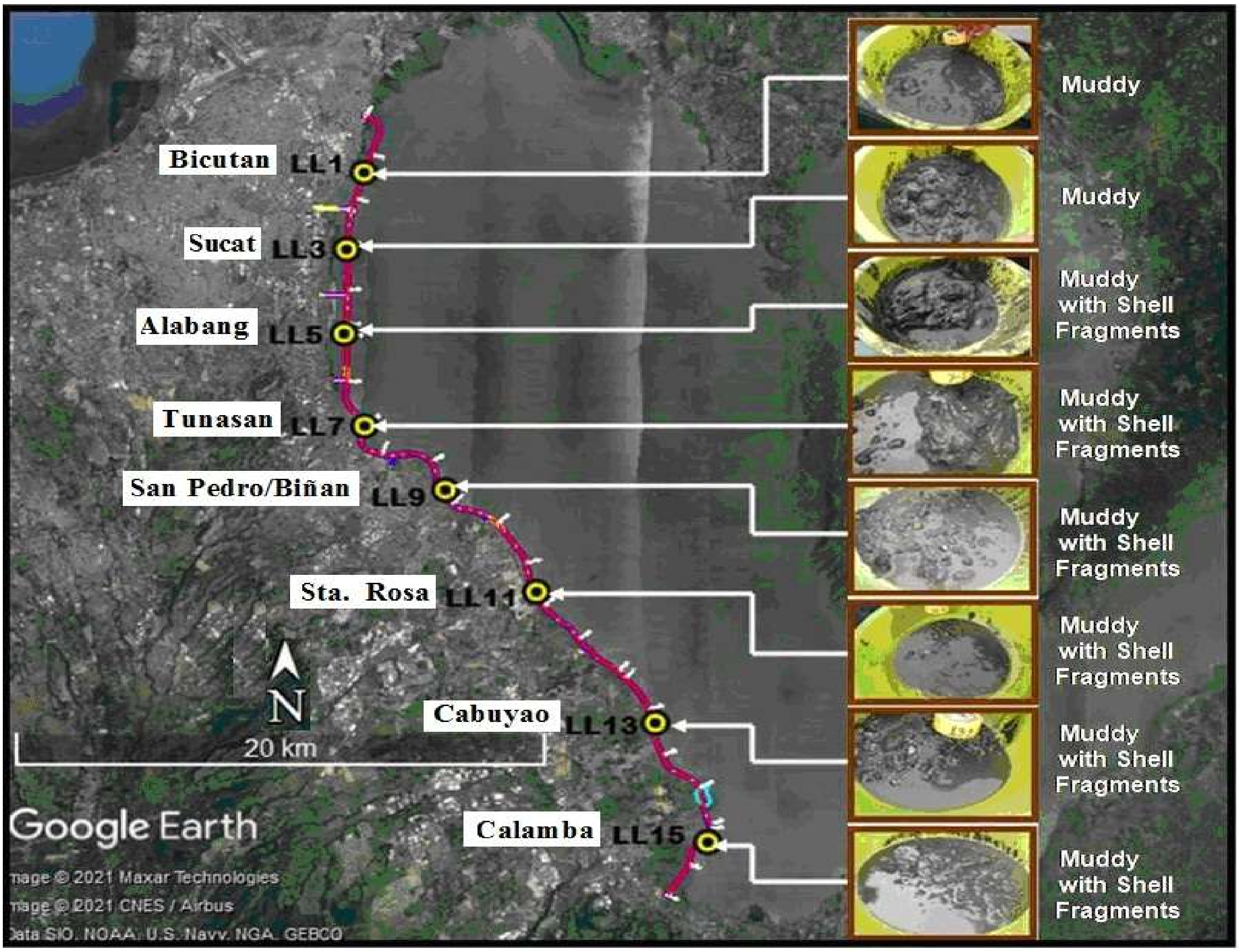


Figure 2.115 Sediment characteristics alongside or within the footprint of the proposed road alignment from Lower Bicutan to Calamba (Nearshore Western Side of Laguna de Bay)

Plate 6 Blackish mud sediment sampled at the offshore Station LL16 in Calamba

Table 2.45 Descriptions of sediment substrates collected at each of the sixteen sampling stations

Municipality/City (Transect Site)	Sampling Station	Type of Substrate
1-Bicutan	LL1 (Nearshore)	Grayish mud
	LL2 (Offshore)	Grayish mud with trace amounts of greenish color on top & blackish sand
2-Sucat	LL3 (Nearshore)	Grayish mud with greenish color on its top & trace amounts of shell fragments
	LL4 (Offshore)	Grayish mud with minor amounts of greenish color on top
3-Alabang	LL5 (Nearshore)	Grayish mud with minor amounts of brownish color on top
	LL6 (Offshore)	Grayish mud with trace amounts of shell fragments
4-Tunasan	LL7 (Nearshore)	Grayish mud with live bivalve *Corbicula* & small amount of browncolor on top of sediment
	LL8 (Offshore)	Grayish mud with plenty of *Corbicula* & trace amounts of blackish sand
5-San Pedro/Biñan	LL9 (Nearshore)	Grayish mud with plenty of *Corbicula*& amounts of sand & pebbles
	LL10 (Offshore)	Grayish mud with minor amount of brown color on top
6-Sta. Rosa	LL11 (Nearshore)	Grayish mud with *Corbicula*& trace amounts of sand and pebbles
	LL12 (Offshore)	Grayish mud with *Corbicula*& trace amounts of blackish sand and shell fragments
7-Cabuyao	LL13 (Nearshore)	Grayish mud with trace amounts of shell fragments & blackish sand
	LL14 (Offshore)	Grayish mud
8-Calamba	LL15 (Nearshore)	Grayish mud
	LL16 (Offshore)	Blackish mud

Plankton

Phytoplankton (or photosynthetic micro-algae) is made up of representatives of at least five (5) very diverse taxonomic groups within the plant kingdom. Like all plants, the photosynthetic phytoplankton converts light energy and carbon dioxide into organic material, and so represent the primary producers forming the base of the food web upon which almost all-aquatic animal life depends. Phytoplankton organisms contribute largely to the primary productivity of the aquatic environment.

In contrast, zooplankton (or animal plankton) are consumer organisms and depend upon the phytoplankton, and to some extent on dead organic matter, for their source of food and energy. Since zooplankton is the secondary producer of organic matter living on the phytoplankton in the aquatic food chain, its importance in fish production is self-evident. It provides the essential food for many of the important fishes such as juveniles, small fish, and economically important aquatic invertebrates like shrimp.

Phytoplankton (Photosynthetic Microalgae)

Phytoplankton Composition and Abundance

The result of this inventory which covers phytoplankton species composition, relative abundance and density are summarized in **Table 45**. The phytoplankton population consists of three (3) major groups: diatoms, green algae and blue-green algae. Blue-green algae with three (3) genera were the most abundant phytoplankton organisms, averaging 83.23% of the total phytoplankton population, followed by the green algae with five (5) genera (averaging 11.81%) and the least were the diatoms with four (4) genera (averaging only 4.96%) (**Figure 3**).

Overall, the phytoplankton organisms in all stations were dominated by the blue-green alga *Microcystis* which ranged from 500,000 to 2,750,000 cells/m^3(average 1,416,667 cells/m^3, or 81.13%), followed by the green alga *Pediastrum* (range from 30,000 to 200,000 cells/m^3 and average 93,021cells/m^3, or 5.33%), green alga *Microspora* (range from 30,000 to 185,000 cells/m^3 and averaged 92,292 cells/m^3, or 5.29%) and diatom *Cyclotella* (range from 25,000 to 135,000 cells/m^3 and average 65,313 cells/m^3, or 3.74%). All the other phytoplankton was poorly represented which ranged from 0.26-1.37%. Photos of the phytoplankton organisms recorded during the survey can be seen in **Plate 7**. This observation on the phytoplankton at the proposed lakeshore road alignment may indicate that the plankton condition of the nearshore and adjacent offshore areas surveyed is the so-called eutrophic ("nutrient rich") plankton type because of the great abundance of the blue-green alga *Microcystis*. This is probably caused by excessive nutrient loading.

Moreover, the above findings is consistent with the results of the plankton investigation in January 2014 conducted during the EIA study (EcosysCorp, Inc., 2014) along the West Bay from Muntinlupa to Los Baños in January 2014, wherein the phytoplankton organisms were also dominated by the blue-green alga *Microcystis*, followed by the green alga *Coelastrum* (229,687 cells/L or 16%), and another blue-green algae *Oscillatoria* and *Spirulina*.

Baseline data for the period 1973-1977, as contained in the 1978 report of the LLDA-WHO, include 62 genera of phytoplankton representing the blue-green algae, green algae, diatoms and dinoflagellates. The dominant species were the blue-green algae *Microcystis*, *Anabaena*, and *Oscillatoria*. The green algae had the highest number (27) of represented genera. The most common were *Scenedesmus* and *Closterium.* There were 22 diatom genera which are almost twice the number of blue-green algal genera. The dominants were *Melosira* and *Stephanodiscus*. Only two (2) dinoflagellate genera appeared in the baseline.

The results of the 4-year monitoring period from 2009 to 2012 by the LLDA showed that the phytoplankton genera found in Laguna de Bay and its tributary rivers belonged to the following major components: blue-green algae, green algae, diatoms and dinoflagellates. The most dominant genera were from blue-green algae and diatoms. The phytoplankton genera which usually had the highest counts during the 4-year monitoring period were *Melosira* sp. (diatom), *Microcystis* (blue-green alga) and *Stephanodiscus* sp. (diatom). The lowest computed annual phytoplankton count in the lake was in Central Bay recorded in 2009 and the highest was obtained in West Bay (Sta. Rosa) in 2012.

Table 2.46 Species composition, density and relative abundance of phytoplankton organisms at the sixteen sampling stations along the proposed lakeshore road alignment in Laguna de Bay (West Bay)

Phytoplankton Organism	Sampling Station																Mean Density (cells /m^3)	Mean Rela-tive Abun-dance (%)
	Bicutan		Sucat		Alabang		Tunasan		San Pedro/Biñan		Sta. Rosa		Cabuyao		Calamba			
	NS LL1	OS LL2	NS LL3	OS LL4	NS LL5	OS LL6	NS LL7	OS LL8	NS LL9	OS LL10	NS LL11	OS LL12	NS LL13	OS LL14	NS LL15	OS LL16		
Diatoms (Bacillario-phyceae)																		
Cyclotella	65,000	95,000	60,000	50,000	45,000	115,000	25,000	30,000	40,000	50,000	80,000	40,000	50,000	135,000	105,000	60,000	65,313	3.74
Gyrosigma	5,000					10,000	15,000							5,000	5,000		8,000	0.46
Navicula			10,000	5,000			10,000	5,000	10,000		5,000		10,000		5,000	5,000	7,222	0.41
Surirella										6,667	5,000	5,000	5,000		5,000	10,000	6,111	0.35
Sub-total	***70,000***	***95,000***	***70,000***	***55,000***	***45,000***	***125,000***	***50,000***	***35,000***	***50,000***	***56,667***	***90,000***	***45,000***	***65,000***	***140,000***	***120,000***	***75,000***	***86,646***	***4.96***
Green Algae (Chlorophycea)																		

Phytoplankton Organism	Sampling Station																Mean Density (cells /m^3)	Mean Rela-tive Abun-dance (%)
	Bicutan		Sucat		Alabang		Tunasan		San Pedro/Biñan		Sta. Rosa		Cabuyao		Calamba			
	NS LL1	OS LL2	NS LL3	OS LL4	NS LL5	OS LL6	NS LL7	OS LL8	NS LL9	OS LL10	NS LL11	OS LL12	NS LL13	OS LL14	NS LL15	OS LL16		
Closterium										3,333	5,000	5,000			5,000		4,583	0.26
Microspora	180,000	110,000	60,000	95,000	70,000	80,000	50,000	40,000	50,000	66,667	90,000	30,000	75,000	185,000	165,000	130,000	92,292	5.29
Pediastrum	170,000	200,000	50,000	55,000	50,000	65,000	30,000	40,000	65,000	63,333	140,000	50,000	80,000	135,000	95,000	200,000	93,021	5.33
Scenedesmus	15,000	20,000		5,000				5,000	5,000				10,000	5,000	5,000		8,750	0.50
Staurastrum	10,000			5,000													7,500	0.43
Sub-total	***375,000***	***330,000***	***110,000***	***160,000***	***120,000***	***145,000***	***80,000***	***85,000***	***120,000***	***133,333***	***235,000***	***85,000***	***165,000***	***325,000***	***270,000***	***330,00***	***206,146***	***11.81***
Blue Green Algae (Cyanophyceae)																		
Nostoc	20,000	15,000								6,667	10,000				15,000	10,000	12,778	0.73

Microcystis	2,500,000	1,250,000	625,000	1,000,000	1,125,000	1,250,000	375,000	500,000	875,000	1,666,667	2,750,000	2,000,000	1,750,000	2,125,000	1,000,000	1,875,000	1,416,667	81.13
Spirulina	10,000	5,000	5,000	15,000		5,000	5,000	5,000	15,000	3,333	15,000	25,000	20,000	60,000	75,000	95,000	23,889	1.37
Sub-total	***2,530,000***	***1,270,00***	***630,000***	***1,015,000***	***1,125,000***	**1,255,000**	**380,000**	**505,000**	**890,000**	**1,676,667**	**2,775,000**	**2,025,000**	**1,770,000**	**2,185,000**	**1,090,000**	**1,980,000**	**1,453,334**	**83.23**
Total Phytoplankton	**2,975,000**	**1,695,000**	**810,000**	**1,230,000**	**1,290,000**	**1,525,000**	**510,000**	**625,000**	**1,060,000**	**1,866,667**	**3,100,000**	**2,155,000**	**2,000,000**	**2,650,000**	**1,480,000**	**2,385,000**	**1,746,125**	**100.00**
Phytoplankton Biomass (Wet Displacement Volume in mL/m^3)	**12.50**	**10.00**	**10.00**	**11.00**	**10.00**	**11.00**	**7.50**	**9.00**	***10.00***	**10.00**	**15.00**	**12.50**	**11.00**	**15.00**	**10.00**	**12.00**	**11.03**	

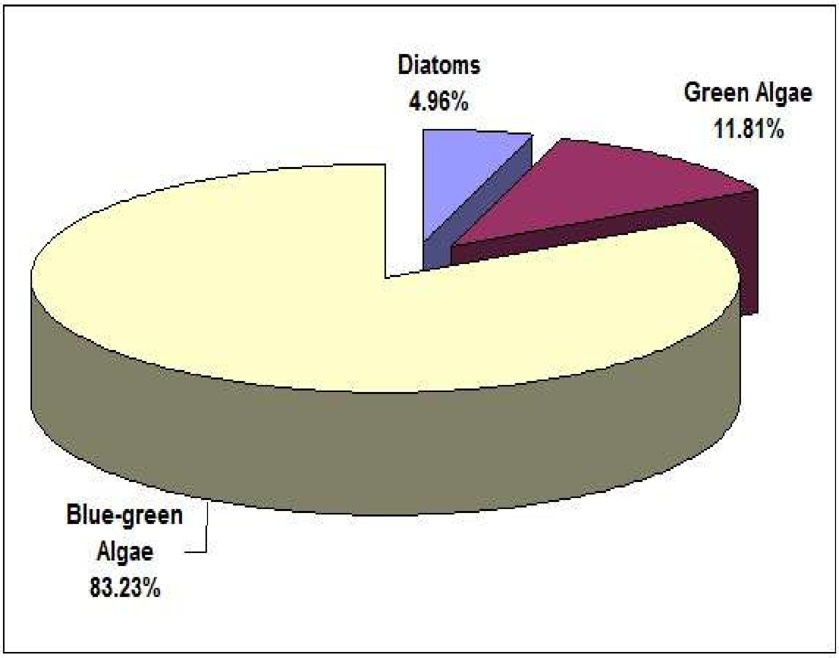


Figure 3 Mean relative abundance of major phytoplankton groups

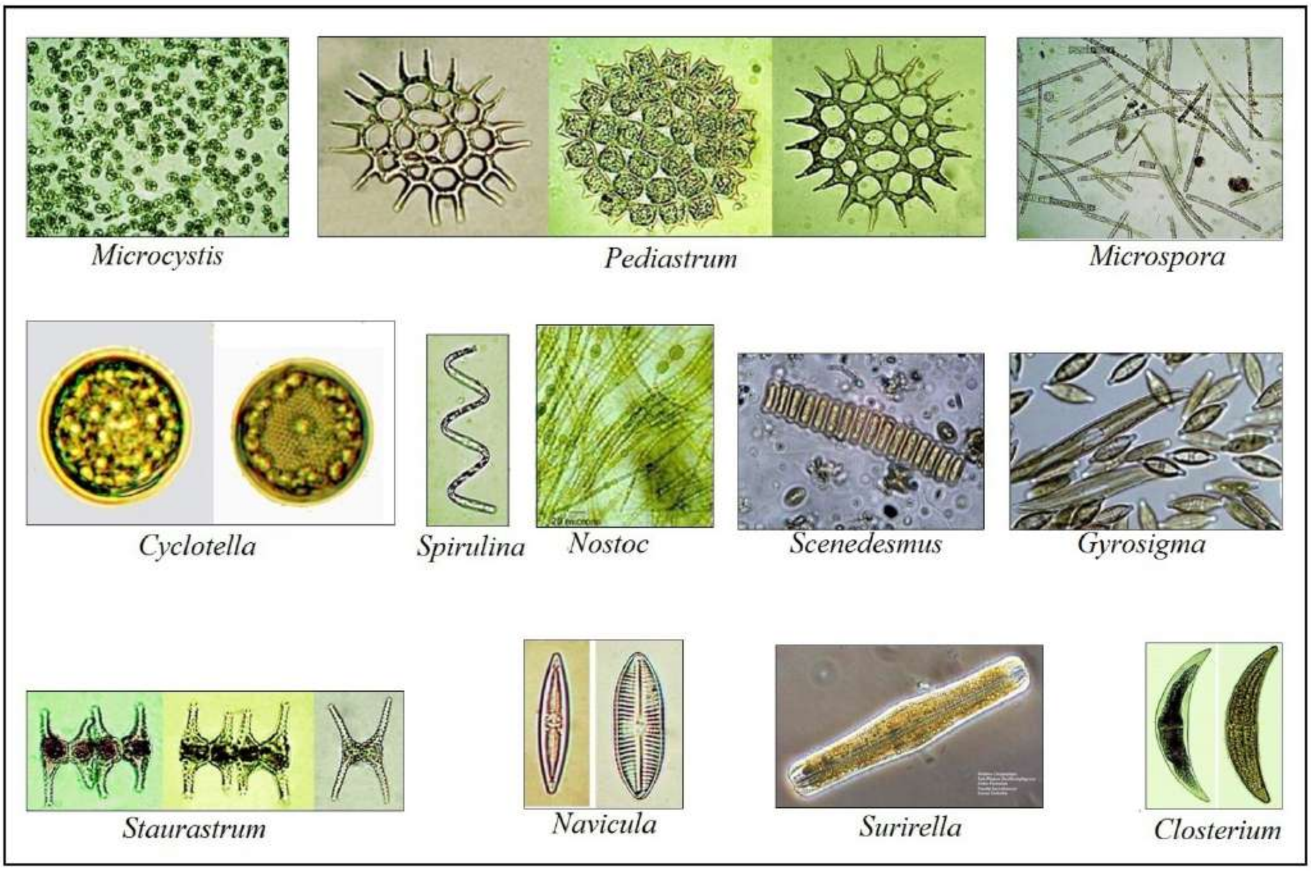


Plate 7 Photos of the phytoplankton organisms collected during the baseline survey (Photomicrography by Val Borja)

Phytoplankton Density

Total phytoplankton numbers in the nearshore stations ranged from 510,000 to 3,100,000 cells/m^3 with an average of 1,653,625 cells/m^3, which is somewhat lower compared to the offshore stations which ranged from 625,000 to 2,650,000 cells/m^3 with an average of 1,766,458 cells/m^3 (**Table 2.47**). An overall average of 1,728,542 cells/m^3 was estimated for all the 16 stations (nearshore and offshore stations combined) sampled (see **Table 2.47**). This abundant phytoplankton serves as food for a rich zooplankton population. A higher concentration of growth promoting nitrogen compound may be responsible for the greater abundance of phytoplankton populations in the area.

Table 2.47 Total number of phytoplankton estimated at the sixteen sampling stations in Laguna de Bay

Transect Location	Sampling Station	Phytoplankton **Total Number of Phytoplankton (cells/m^3)**	**Average Total Number of Phytoplankton (cells/m^3)**
Bicutan	LL1 (Nearshore)	2,975,000	2,335,000
	LL2 (Offshore)	1,695.000	
Sucat	LL3 (Nearshore)	810,000	1,020,000
	LL4 (Offshore	1,230,000	
Alabang	LL5 (Nearshore)	1,290,000	1,407,500
	LL6 (Offshore)	1,525,000	
Tunasan	LL7 (Nearshore)	510,000	567.500
	LL8 (Offshore)	625,000	
San Pedro/Biñan	LL9 (Nearshore)	1,060,000	1,463,334
	LL10 (Offshore)	1,866,667	
Sta. Rosa	LL11 (Nearshore)	3,100,000	2,627,500
	LL12 (Offshore)	2,155,000	
Cabuyao	LL13 (Nearshore)	2,000,000	2,325,000
	LL14 (Offshore)	2,650,000	
Calamba	LL15 (Nearshore)	1,480,000	1,932,500
	LL16 (Offshore)	2,385,000	
Range	**Nearshore**	**Overall Average**	**1,709,792**
		510,000 – 3,100,000 (average = 1,653,125)	
	Offshore	**625,000 – 2,650,000 (average = 1,766,458)**	

Legend: Nearshore = Alongside the proposed road alignment
Offshore = About 1 km from the proposed road alignment

The highest total phytoplankton count was recorded in Sta. Rosa at nearshore Station LL11 (3,100,000 cells/m^3) (**Figure 2.116**). The next highest was observed in Bicutan at nearshore Station LL1 and Cabuyao at offshore Station LL14 (2,975,000 cells/m^3 and 2,650,000 cells/m^3, respectively), followed by Calamba at offshore Station LL16 (2,385,000 cells/m^3), and Cabuyao at nearshore Station LL13 (2,000,000 cells/m^3). Tunasan at nearshore Station LL7 and offshore at Station LL8 have relatively the least total phytoplankton numbers (510,000 and 625,000 cells/m^3, respectively).

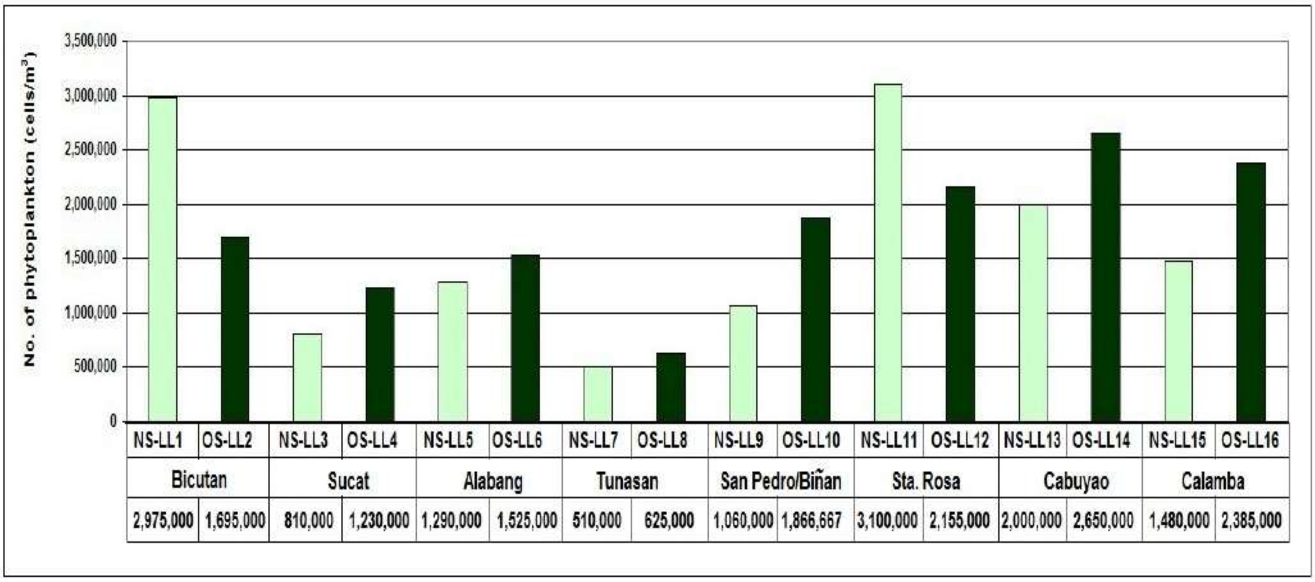


Figure 2.116 Variation of individual density of total phytoplankton at each of the sixteen sampling stations in Laguna de Bay (West Bay)

Based on the average (nearshore and offshore stations when combined), the total phytoplankton number was observed to be highest in Sta. Rosa (average 2,627,500 cells/m^3) (**Figure 2.117**). This was followed by Bicutan (average 2,335,000 cells/m^3), Cabuyao (average 2,325,000 cells/m^3) and Calamba (average 1,932,500 cells/m^3). All other stations have a total phytoplankton numbers below the average of 1,500,000 cells/m^3. Tunasan had the lowest average total phytoplankton (567,500 cells/m^3).

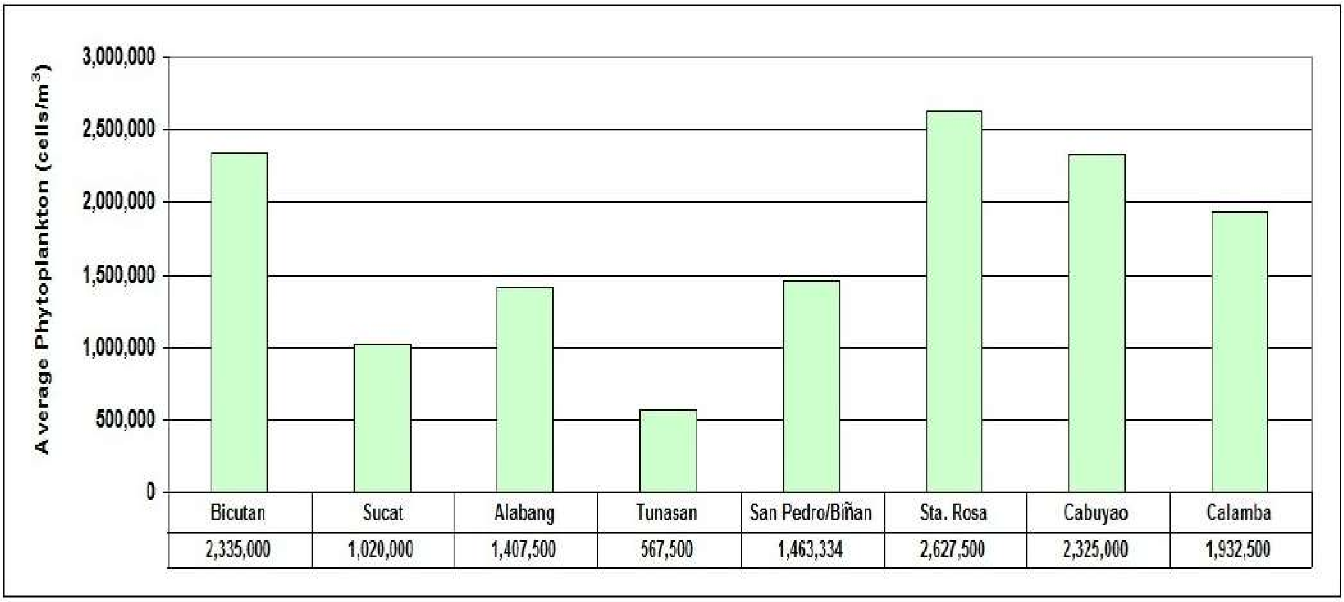


Figure 2.117 Variation of average total phytoplankton at each of the eight transect locations (nearshore and offshore sampling stations combined) in Laguna de Bay (West Bay)

Phytoplankton Biomass

Biomasses (displacement volumes) of the phytoplankton samples in the nearshore stations ranged from 7.50 to 15.00 mL/m^3 with an average of 10.75 mL/m^3, which is slightly lower compared to the offshore stations which ranged from 9.00 to 15.00 mL/m^3 with an average of 11.31 mL/m^3 (**Table 2.47**). An overall average of 11.03 mL/m^3 was estimated for all the 16 stations (nearshore and offshore stations combined) sampled at the project site (see **Table 2.48**).

Table 2.48 Phytoplankton biomass (displacement volume) estimated at the sixteen sampling stations in Laguna de Bay

Transect Location	Sampling Station	Phytoplankton Biomass Displacement Volume (mL/m³)	Phytoplankton Biomass Average Displacement Volume (mL/m³)
Bicutan	LL1 (Nearshore)	12.50	11.25
	LL2 (Offshore)	10.00	
Sucat	LL3 (Nearshore)	10.00	10.50
	LL4 (Offshore	11.00	
Alabang	LL5 (Nearshore)	10.00	10.50
	LL6 (Offshore)	11.00	
Tunasan	LL7 (Nearshore)	7.50	8.25
	LL8 (Offshore)	9.00	
San Pedro/Biñan	LL9 (Nearshore)	10.00	10.00
	LL10 (Offshore)	10.00	
Sta. Rosa	LL11 (Nearshore)	15.00	13.75
	LL12 (Offshore)	12.50	
Cabuyao	LL13 (Nearshore)	11.00	13.00
	LL14 (Offshore)	15.00	
Calamba	LL15 (Nearshore)	10.00	11.00
	LL16 (Offshore)	12.00	
		Overall Average	**11.03**
Range	**Nearshore**	**7.50 – 15.00 (average = 10.75)**	
	Offshore	**9.00 – 15.00 (average = 11.31)**	

Legend: Nearshore = Alongside the proposed road alignment
Offshore = About 1 km from the proposed road alignment

Inter-station comparison showed that the highest biomasses were observed at Station LL11 situated nearshore of Sta. Rosa and Station LL14 situated offshore of Cabuyao (15.0 mL/m^3 each), followed by a distant place Station LL1situated nearshore of Bicutan and Station LL12 offshore of Sta. Rosa (12.50 mL/m^3 each) (**Figure 2.117**). The remaining stations have biomass values with below 12.0 mL/m^3. The nearshore of Tunasan at Station LL7 obtained the lowest phytoplankton biomass (7.50 mL/m^3).

Variation of the plankton biomass at each of the stations sampled (see **Figure 2.117**) showed similar general trend to that of the total number of phytoplankton (see **Figure 2.116**), wherein the higher displacement volumes at Stations LL11, LL14, LL1 and LL12 were observed consistent with the higher numbers of total phytoplankton at these stations. This indicates that the variates increase and decrease together, *i.e.*, with high phytoplankton more plankton biomass may be expected and with low phytoplankton, less biomass. This relationship may be explained on the basis of the major role of the phytoplankton groups. The blue-green algae in particular may have contributed effectively to phytoplankton displacement volume in view of their abundance/dominance.

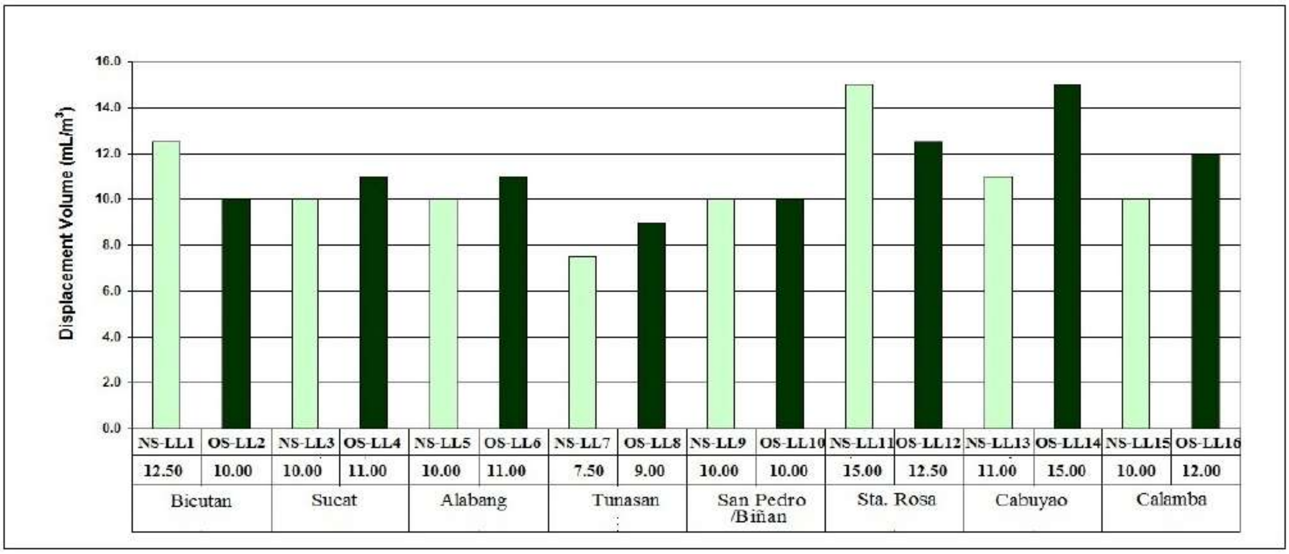


Figure 2.117 Variation of phytoplankton biomass (displacement volume) at each of the sixteen sampling stations in Laguna de Bay (West Bay)

Based on the average (nearshore and offshore stations combined), the plankton biomass was observed to be highest in Sta. Rosa (average 13.75 mL/m^3) (**Figure 2.117**). This was followed by Cabuyao (average 13.00 mL/m^3), Bicutan (average 11.25 mL/m^3) and Calamba (average 11.00 mL/m^3). All other stations have only a plankton biomass below 11.00 mL/m^3. Tunasan had the lowest phytoplankton biomass (average 8.25 mL/m^3). Variations in the average plankton biomass by transect location (see **Figure 2.118**) showed similar general trend to that of the average total phytoplankton (see **Figure 2.116**).

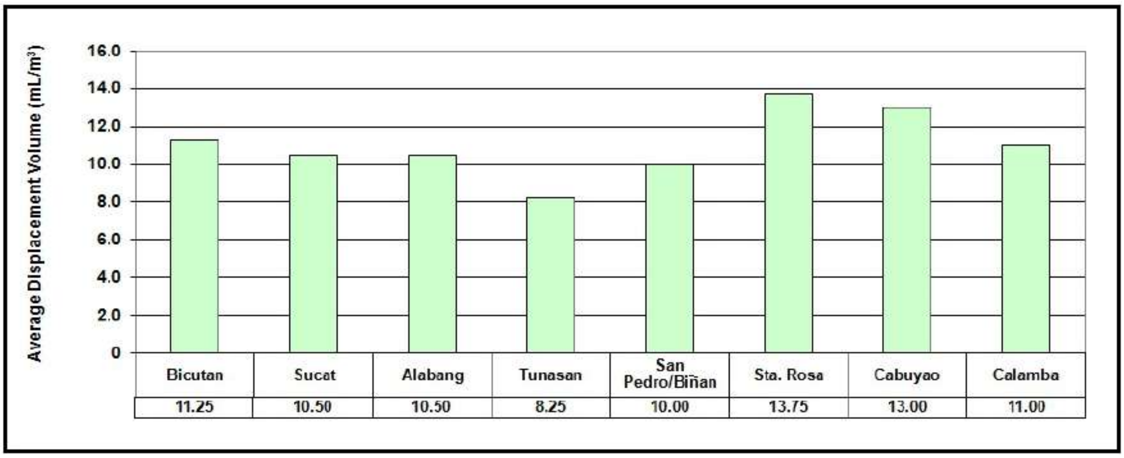


Figure 2.118 Variation of average phytoplankton biomass (displacement volume) at each of the eight transect locations (nearshore and offshore sampling stations combined) in Laguna de Bay (West Bay)

Zooplankton (Animal Plankton)

Zooplankton Composition and Abundance

Only three (3) major taxonomic groups were documented in the zooplankton population (**Table 2.49**). The most abundant were the cladocerans (averaging 48.47%) with four (4) taxa, then followed by copepods (averaging 44.85%) with only two (taxa), while the least were the rotiferans (averaging 6.68%) with three (3) taxa (**Figure 2.119**).

Overall, the zooplankton organisms in all stations were dominated by the combined immature stages copepodite and adult copepod which ranged from 10,000 to 275,000 organisms/m^3 (averaged 153, 878 organisms/m^3, or 36.25%), followed by the cladoceran *Bosmina* which ranged from 30,000 to 515,500 organisms/m^3 (averaged 123,990 organisms/m^3, or 29.21%), and copepod nauplius larvae which ranged from 5,000 to 100,000 organisms/m^3 (averaged 36,500 organisms/m^3, or 8.60%). All the other zooplankton organisms were poorly represented in the samples collected which ranged from 1.77 to 7.12% relative abundance. Photos of the zooplankton organisms recorded during the survey can be seen in **Plate 8**.

The above observation did not coincide with the findings of the zooplankton investigation in January 2014 conducted along the West Bay during the EIA study by the EcosysCorp, Inc., (2014), wherein the most abundant major zooplankton group was the protozoan ciliate represented solely by *Paramecium* (averaging 58%), then followed by the phytoflagellate represented solely by *Euglena* (averaging 36%). The least was the cladoceran represented solely by *Daphnia* (averaging 6%).

According to the LLDA, zooplankton in the lake manifest a seasonal abundance. During the time of their peak performance between 1973 to 1977, their densities reached as high as 2,850 indv/L in summer. Dense populations however, were short-lived because of heavy predation by fish. The summer communities at that time comprised of the copepods, primarily *Cyclops* and *Diaptomus*; and the cladocerans, *Bosmina*, *Diasphanosoma*, *Moina*, *Bosminopsis*, and *Alona*.

The zooplankton data of the LLDA for the 1990s show a total of 36 species belonging to 23 genera. Of the three (3) most commonly represented groups found, the rotifers were the most diverse with 17 species. These, however, generally had small populations. Cladocerans with nine (9) species ranked second to the rotifers. This group manifested sporadic high densities in 1990, 1991, 1995, and 1996. Copepods had only four 94) species but ranked first in terms of density and persistence. The group comprised of the juvenile stages (nauplii), and copepodids of *Arctodiaptomus*, *Thermocyclops,* and *Mesocyclops*. In 1990, a maximum of 1,616 indv/L was recorded in West Bay around the mouth of the Pasig River.

The results of the 4-year monitoring period from 2009 to 2012 carried out by the LLDA showed that the zooplankton population in Laguna de Bay belonged to three (3) major groups: rotifers, cladocerans and copepods. Of these major groups of zooplankton in the lake, the most abundant were the copepods and the most diverse were the rotifers. The copepods comprised of their immature stages.

Table 2.49 Species composition, density and relative abundance of zooplankton organisms at the sixteen sampling stations along the proposed lakeshore road alignment in Laguna de Bay (West Bay)

Zooplankton Organism	Sampling Station																Mean Density (organisms /m^3)	Mean Relative Abundance (%)
	Bicutan		Sucat		Alabang		Tunasan		San Pedro/Biñan		Sta. Rosa		Cabuyao		Calamba			
	NS LL1	OS LL2	NS LL3	OS LL4	NS LL5	OS LL6	NS LL7	OS LL8	NS LL9	OS LL10	NS LL11	OS LL12	NS LL13	OS LL14	NS LL15	OS LL16		
Cladocera																		
Bosmina	30,000	80,000	50,000	115,000	515,500	215,000	110,000	105,000	200,000	53,333	35,000	50,000	175,000	40,000	80,000	130,000	123,990	29.21
Ceriodaphnia				25,000	20,000			15,000	40,000	6,667		25,000	70,000		40,000		30,208	7.12
Moina	15,000			105,000	10,000	30,000	40,000	10,000	20,000	3,333		20,000		5,000	20,000	10,000	24,028	5.66
Diaphanosoma															20,000	35,000	27,500	6.48
Subtotal	***45,000***	***80,000***	***50,000***	***245,000***	***545,500***	***245,000***	***150,000***	***130,000***	***260,000***	***63,333***	***35,000***	***95,000***	***245,000***	***45,000***	***160,000***	***175,000***	***205,726***	***48.47***
Copepoda																		
Copepod Nauplius Larvae	100,000	50,000		50,000	90,000	5,000	35,000				5,000		15,000	5,000	10,000		36,500	8.60
Copepodite/Adult Copepod	115,000	80,000	75,000	135,000	275,000	630,000	105,000	105,000	120,000	126,667	35,000	80,000	105,000	10,000	180,000	145,000	153,878	36.25

Zooplankton Organism	Sampling Station																Mean Density (organisms /m^3)	Mean Relative Abundance (%)
	Bicutan		Sucat		Alabang		Tunasan		San Pedro/Biñan		Sta. Rosa		Cabuyao		Calamba			
	NS LL1	OS LL2	NS LL3	OS LL4	NS LL5	OS LL6	NS LL7	OS LL8	NS LL9	OS LL10	NS LL11	OS LL12	NS LL13	OS LL14	NS LL15	OS LL16		
Sub-total	***215,000***	***130,000***	***75,000***	***185,000***	***365,000***	***635,000***	***140,000***	***105,000***	***120,000***	***126,667***	***40,000***	***80,000***	***120,000***	***15,000***	***190,000***	***145,000***	***190,378***	***44.85***
Rotifera																		
Filinia	10,000			5,000													7,500	1.77
Lecane																10,000	10,000	2.36
Keratella					10,000	20,000					5,000		15,000	5,000		10,000	10,833	2.55
Sub-total	***10,000***			***5,000***	***10,000***	***20,000***					***5,000***		***15,000***	***5,000***		***20,000***	***28,333***	***6.68***
Total Zooplankton (no. of organisms/m^3)	**270,000**	**210,000**	**125,000**	**435,000**	**920,500**	**900,000**	**290,000**	**235,000**	**380,000**	**190,000**	**80,000**	**175,000**	**380,000**	**65,000**	**350,000**	**340,000**	**424,437**	**100.00**
Zooplankton Biomass (wet displacement volume in mL/m^3)	**5.00**	**5.00**	**4.00**	**6.50**	**7.50**	**7.50**	**5.0**	**4.00**	**5.00**	**3.33**	**2.50**	**4.00**	**7.50**	**2.50**	**7.50**	**6.50**	**5.21**	

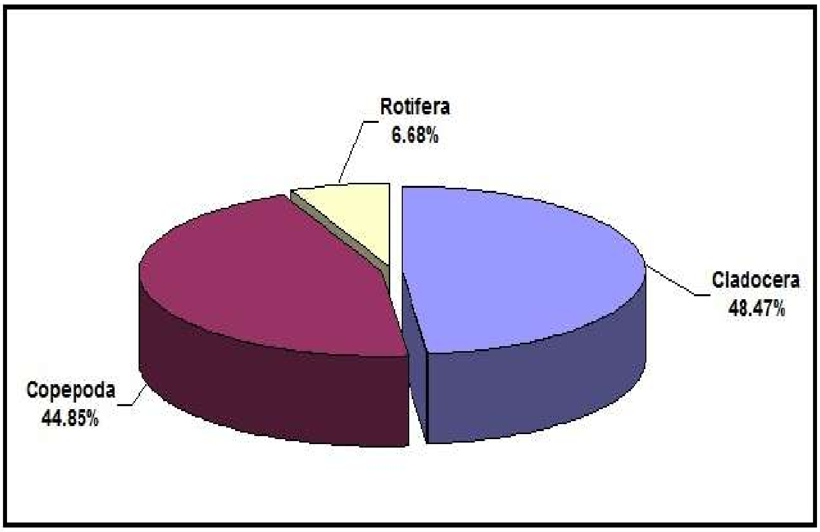


Figure 2.119 Mean relative abundance of major zooplankton groups

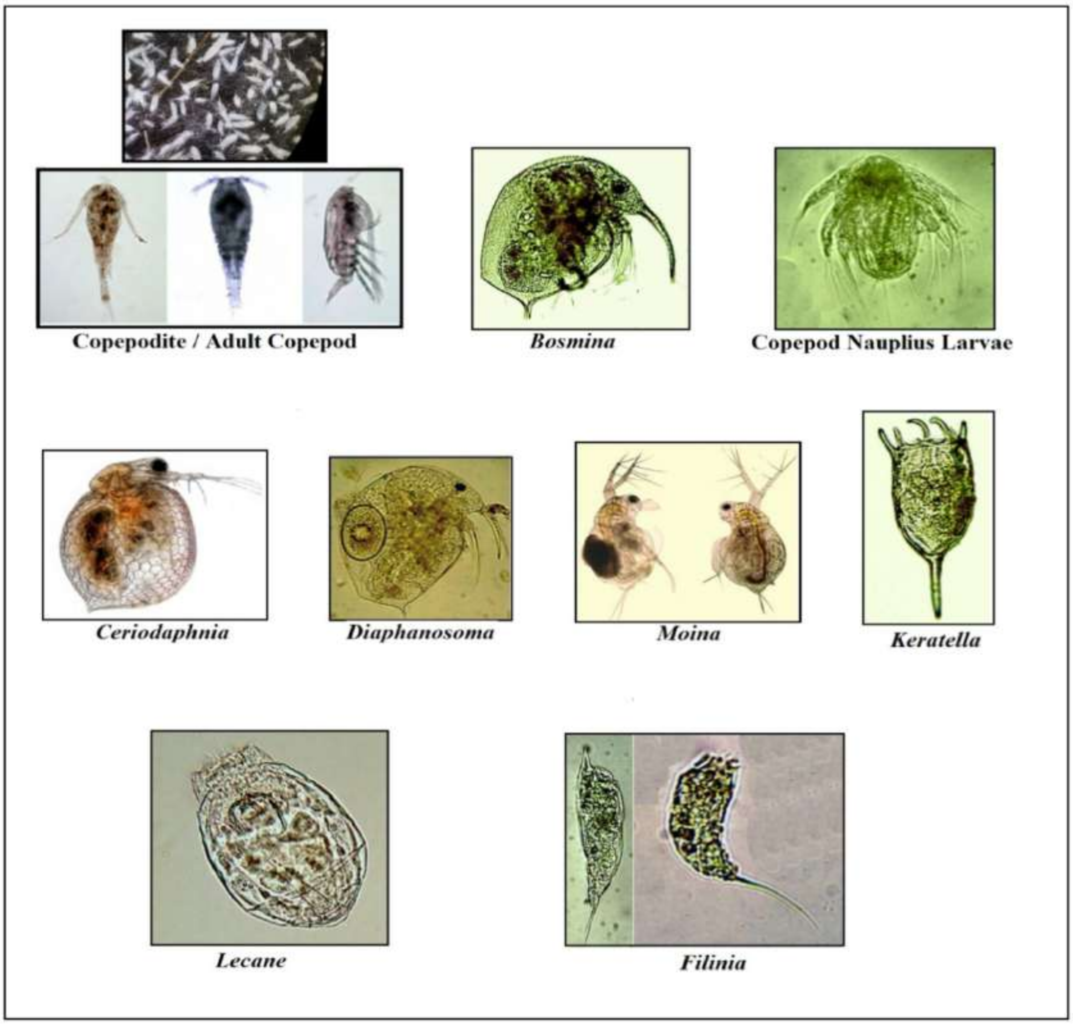


Plate 8 Photos of the zooplankton organisms collected during the baseline survey (Photo source: Internet and Photomicrography by Val Borja)

Zooplankton Density

The total zooplankton numbers in the nearshore stations ranged from 80,000 to 920,500 organisms/m^3 with an average of 349,438 organisms/m^3, which is slightly higher compared to the offshore stations which ranged from 65,000 to 900,000organisms/m^3 with an average of 318,750 organisms/m^3 (**Table 2.50**).

An overall average of 334,094 zooplankton organisms/m^3 was estimated for all the 16 stations (nearshore and offshore stations combined) sampled at the project site (see **Table 2.50**) which is very much lower compared to the overall average total phytoplankton (1,709,792 cells/m^3) (see **Table 2.49**). This indicates that the total plankton organisms during this survey were dominated by phytoplankton (averaging 84% of the total plankton catches), while the zooplankton accounted for only 16%. This trend was comparatively similar to that obtained during the EIA study in January 2014 (phytoplankton averaging 97% while zooplankton accounted for only 3%). Like the Laguna de Bay plankton (east side - phytoplankton 98% while the zooplankton 2%), the overall plankton organisms in the Caliraya Lake were also dominated by phytoplankton (97%, while the zooplankton accounted for only 3%) (APCC, 2007). The preponderance of phytoplankton is to be expected, since as already mentioned earlier that they represent the primary producers forming the base of the food web.

Table 2.50 Total number of zooplankton estimated at the sixteen sampling stations in Laguna de Bay

Transect Location	Sampling Station	Zooplankton	
		Total Number of Zooplankton (organisms/m^3)	Average Total Number of Zooplankton (organisms/m^3)
Bicutan	LL1 (Nearshore)	270,000	240,000
	LL2 (Offshore)	210,000	
Sucat	LL3 (Nearshore)	125,000	280,000
	LL4 (Offshore	435,000	
Alabang	LL5 (Nearshore)	920,500	910,250
	LL6 (Offshore)	900,000	
Tunasan	LL7 (Nearshore)	290,000	262,500
	LL8 (Offshore)	235,000	
San Pedro/Biñan	LL9 (Nearshore)	380,000	285,000
	LL10 (Offshore)	190,000	
Sta. Rosa	LL11 (Nearshore)	80,000	127,500
	LL12 (Offshore)	175,000	
Cabuyao	LL13 (Nearshore)	380,000	222,500
	LL14 (Offshore)	65,000	
Calamba	LL15 (Nearshore)	350,000	345,000
	LL16 (Offshore)	340,000	
		Overall	**334,094**

Range	**Nearshore**	**Average**
		80,000 – 920,500 (average = 349,438)
	Offshore	**65,000 – 900,000 (average = 318,750)**

Legend: Nearshore = Alongside of the proposed road alignment
Offshore = About 1 km from the proposed road alignment

Inter-station comparison showed that the highest total zooplankton count was recorded in Alabang at nearshore Station LL15 (920,500 organisms/m^3) (**Figure 2.120**). The next highest was also observed in Alabang at the offshore Station LL6 (900,000 organisms/m^3) followed by the offshore Station LL4 along Sucat (435,000 organisms/m^3). All other stations have density values below 400,000 zooplankton organism/m^3. Offshore Station LL14 situated in Cabuyao and nearshore Station LL11 in Sta. Rosa have the lowest total numbers of zooplankton (65,000 and 80,000 organisms/m^3, respectively) owing to poor representation of cladocerans and copepods.

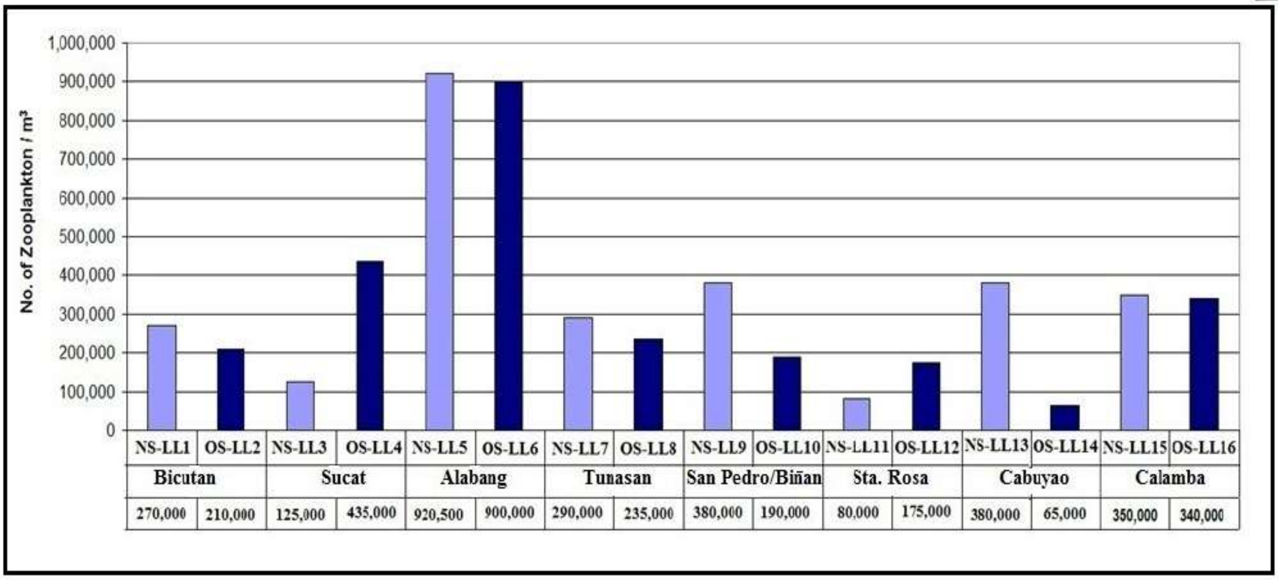


Figure 2.120 Variation of individual density of total zooplankton at each of the sixteen sampling stations in Laguna de Bay (West Bay)

Based on the average (nearshore and offshore stations combined), the total zooplankton number was observed to be highest in Alabang (average 910,250 organisms/m^3) followed by Calamba (average 345,000 cells/m^3) (**Figure 2.121**). All other transect locations have an average total zooplankton numbers between 200,000 and 300,000 organisms/m^3. Sta. Rosa had the poorest zooplankton count (average 127,500 organisms/m^3).

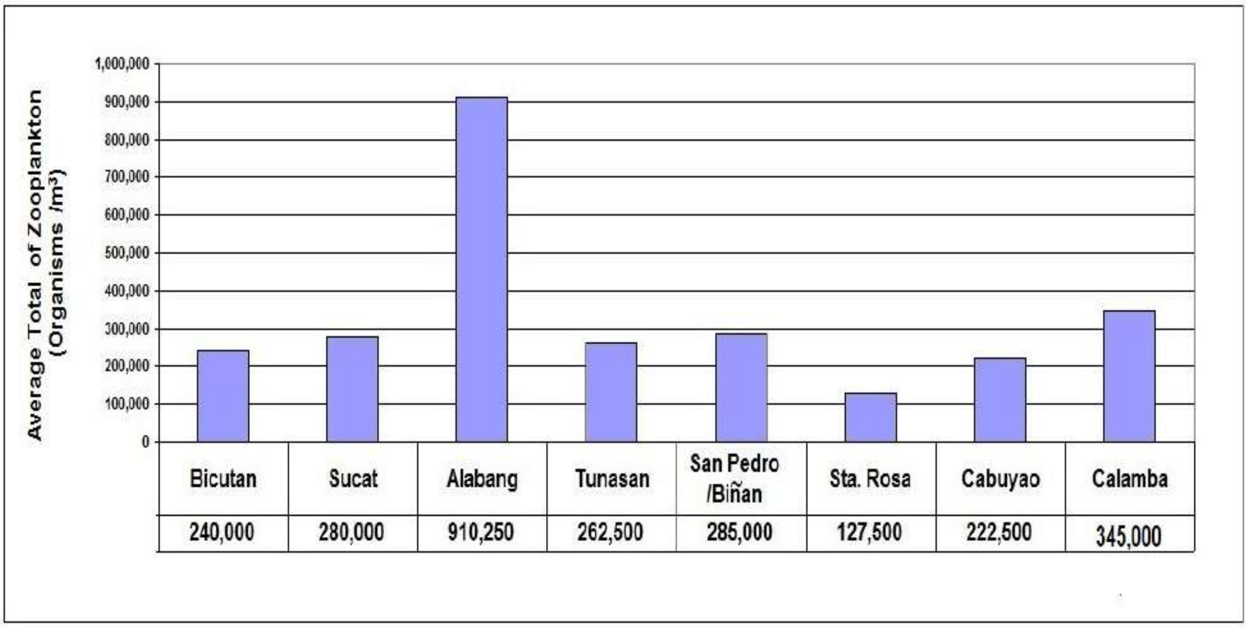


Figure 2.121 Variation of average density of total zooplankton at each of the eight transect locations (nearshore and offshore sampling stations combined) in Laguna de Bay (West Bay)

Zooplankton Biomass

Biomass of the zooplankton samples collected in the nearshore stations ranged from 2.50 to 7.50 mL/m^3 with an average of 5.50 mL/m^3, which is comparable to the offshore stations which also ranged from 2.50 to 7.50 mL/m^3 with an average of 4.92 mL/m^3 (**Table 2.51**). An overall average of 5.21mL/m^3 was estimated for all the 16 stations (nearshore and offshore stations combined) sampled at the project site (see **Table 2.51**).

Table 2.51 Zooplankton biomass (displacement volume) estimated at the sixteen sampling stations in Laguna de Bay

Transect Location	Sampling Station	Zooplankton Biomass	
		Displacement Volume (mL/m^3)	Average Displacement Volume (mL/m^3)
Bicutan	LL1 (Nearshore)	5.00	5.00
	LL2 (Offshore)	5.00	
Sucat	LL3 (Nearshore)	4.00	5.25
	LL4 (Offshore	6.50	
Alabang	LL5 (Nearshore)	7.50	7.50
	LL6 (Offshore)	7.50	
Tunasan	LL7 (Nearshore)	5.00	4.50
	LL8 (Offshore)	4.00	
San Pedro/Biñan	LL9 (Nearshore)	5.00	4.17
	LL10 (Offshore)	3.33	

Sta. Rosa	LL11 (Nearshore)	2.50	3.25
	LL12 (Offshore)	4.00	
Cabuyao	LL13 (Nearshore)	7.50	5.00
	LL14 (Offshore)	2.50	
Calamba	LL15 (Nearshore)	7.50	7.00
	LL16 (Offshore)	6.50	
Range	**Nearshore**	**Overall Average**	**5.21**
		2.50 – 7.50 (average = 5.50)	
	Offshore	**2.50 – 7.50 (average = 4.92)**	

Legend: Nearshore = Alongside of the proposed road alignment
Offshore = About 1 km from the proposed road alignment

Inter-station comparison showed that the highest zooplankton biomasses were observed at Stations LL5 and LL6 situated nearshore and offshore of Alabang, Stations LL13 situated nearshore of Cabuyao and LL15 situated nearshore of Calamba (7.50 mL/m^3 each), followed by Station LL4 situated offshore of Sucat and Station LL16 situated offshore of Calamba (6.50 mL/m^3 each) (**Figure 2.121**). The remaining stations have biomass values of 5.00 mL/m^3 and below. Station LL14 situated offshore of Cabuyao and Station LL11 situated nearshore of Sta. Rosa have the lowest zooplankton biomasses (2.50 mL/m^3 each).

Variation of the zooplankton biomass at each of the stations sampled (see **Figure 2.121**) showed similar general trend to that of the total number of zooplankton (see **Figure 2.122**), wherein the higher displacement volumes at Stations LL5, LL6, LL13, LL15, LL4, and LL16 and the lower displacement volumes at Stations LL14 and LL11were observed consistent with the higher and lower numbers of total zooplankton at these stations. This indicates that the variates increase and decrease together, *i.e.*, with high zooplankton more plankton biomass may be expected and with low zooplankton, less biomass may also be expected. This relationship may be explained on the basis of the major role of the zooplankton groups. The cladocerans and copepods in particular may have contributed effectively to plankton displacement volume in view of their relatively larger dimensions and numerical abundance/dominance.

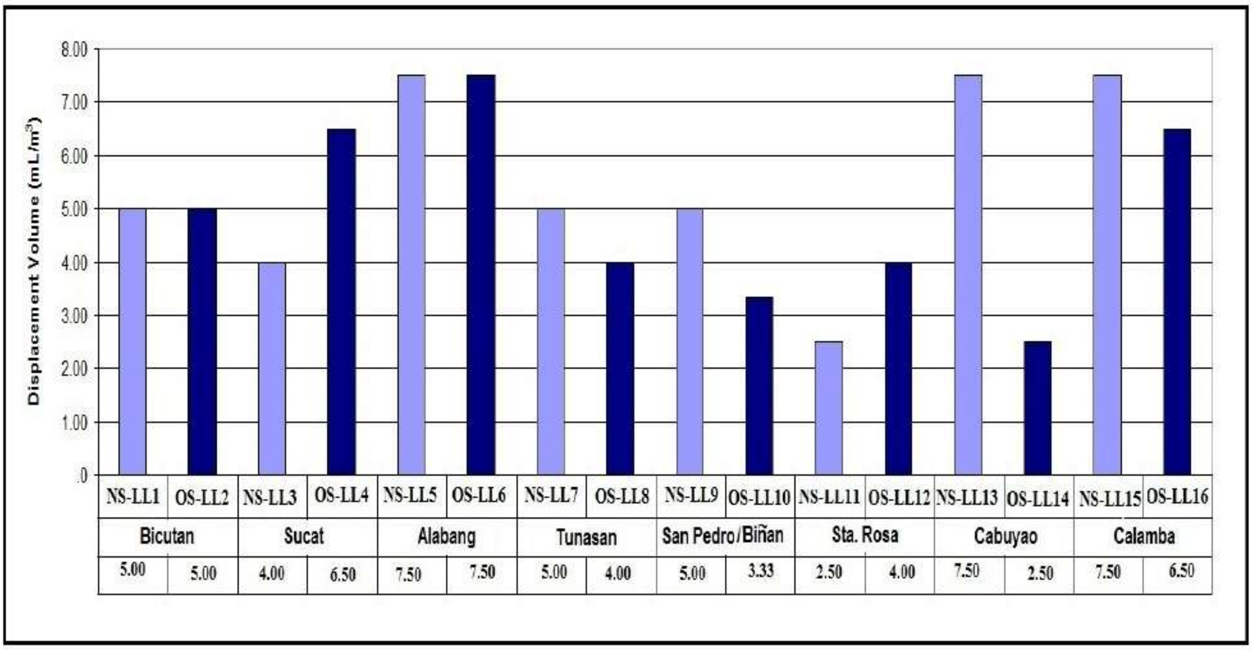


Figure 2.122 Variation of zooplankton biomass (displacement volume) at each of the sixteen sampling stations in Laguna de Bay (West Bay)

Based on the average (nearshore and offshore stations combined), the plankton biomass was observed to be highest in Alabang (average 7.50 mL/m^3) followed by Calamba (average 7.00 mL/m^3) and Sucat (average 5.25 mL/m^3) (**Figure 2.123**). All other transect locations have an average displacement volumes between 4.00 and 5.00 mL/m^3. Sta. Rosa had the lowest average biomass (displacement volume) of 3.25 mL/m^3. Variations in the average displacement volume by transect location (see **Figure 2.123**) showed similar general trend to that of the average total zooplankton (see **Figure 2.120**).

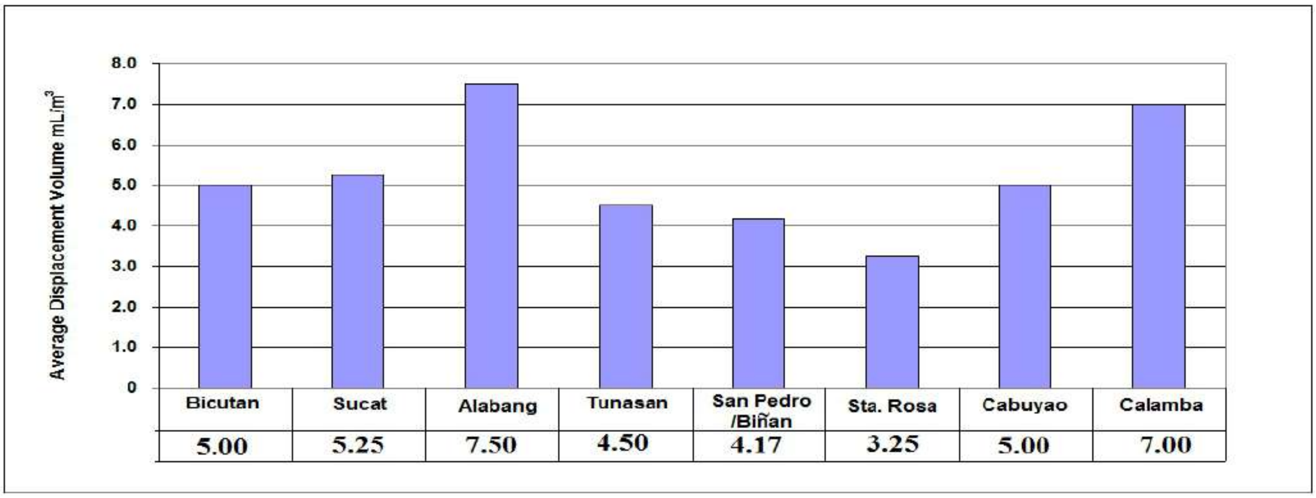


Figure 2.123 Variation of average zooplankton biomass (displacement volume) at each of the eight transect locations (nearshore and offshore sampling stations combined) in Laguna de Bay (West Bay)

Primary Productivity (Chlorophyll-*a* Concentration)

One of the most adequate quantitative indicators of phytoplankton development is primary productivity (Sorokin, 1990). Chlorophyll-*a* could be used as an indicator of algal biomass or the living part of suspended matter. Primary production is illustrated by phytoplankton biomass, which is often expressed in chlorophyll-*a* estimation (Delesalle *et al*., 1993; McGlone *et al*., 1995). Chlorophyll-*a* concentration was employed in characterizing the phytoplankton biomass in this study.

Across the nearshore surface water, chlorophyll-*a* concentrations ranged from 0.095 to 1.073 mg/m^3 with an average of 0.613 mg/m^3, which is somewhat lower compared to the offshore surface water which ranged from 0.123 to 1.104 mg/m^3 with an average of 0.716 mg/m^3 (**Table 2.52**). An overall average of 0.665 mg/m^3 was estimated for all the 16 stations (nearshore and offshore stations combined) sampled at the project site (see **Table 2.52**).

Table 2.52 Chlorophyll-*a* Concentration (mg/m^3) Estimated at the Sixteen Sampling Stations in Laguna Lake

Transect Location	Sampling Station	Chlorophyll-*a* Individual Concentration (mg/m^3)	Chlorophyll-*a* Average Concentration (mg/m^3)
Bicutan	LL1 (Nearshore)	0.231	0.177
	LL2 (Offshore)	0.123	
Sucat	LL3 (Nearshore)	0.095	0.145
	LL4 (Offshore	0.194	
Alabang	LL5 (Nearshore)	0.856	0.869
	LL6 (Offshore)	0.882	
Tunasan	LL7 (Nearshore)	0.301	0.592
	LL8 (Offshore)	0.882	
San Pedro/Biñan	LL9 (Nearshore)	0.856	0.980
	LL10 (Offshore)	1.104	
Sta. Rosa	LL11 (Nearshore)	1.073	1.006
	LL12 (Offshore)	0.939	
Cabuyao	LL13 (Nearshore)	0.751	0.825
	LL14 (Offshore)	0.898	
Calamba	LL15 (Nearshore)	0.738	0.724
	LL16 (Offshore)	0.709	
		Overall Average	**0.665**
Range	**Nearshore**	**0.095-1.073 (average = 0.613)**	
	Offshore	**0.123-1.104 (average = 0.716)**	

Legend: Nearshore = Alongside of the proposed road alignment
Offshore = About 1 km from the proposed road alignment

The highest chlorophyll-*a* level was recorded in San Pedro/Biñan at offshore Station LL10 (1.104 mg/m^3) (**Figure 2.124**). The next highest was observed in Sta. Rosa at nearshore Station LL11 and offshore Station LL12 (1.073 mg/m^3 and 0.939 mg/m^3, respectively), followed by Cabuyao at offshore Station LL14 (0.898 mg/m^3), Alabang at offshore Station LL6 (0.882 mg/m^3), and Tunasan at offshore Station LL8 (0.882 mg/m^3). Relatively higher chlorophyll-*a* levels were also noted in the nearshore waters of Alabang and San Pedro/Biñan at Stations LL6 and LL9 (0.856 mg/m^3 each), respectively. Sucat at the nearshore Station LL3 had the lowest chlorophyll-a value of 0.095 mg/m^3 (see Figure 1).

Variation in chlorophyll-*a* level by sampling station (see **Figure2.124**) more or less coincided with that of the variation pattern of the total phytoplankton (see **Figure 2.116**). It has been traditionally assumed that chlorophyll-*a* associated with high standing crop of phytoplankton is an index of primary production and is supporting the reproduction and growth of zooplankton, which in turn, provide an energy supply for higher tropic level (*i.e.* fish larvae) in the water.

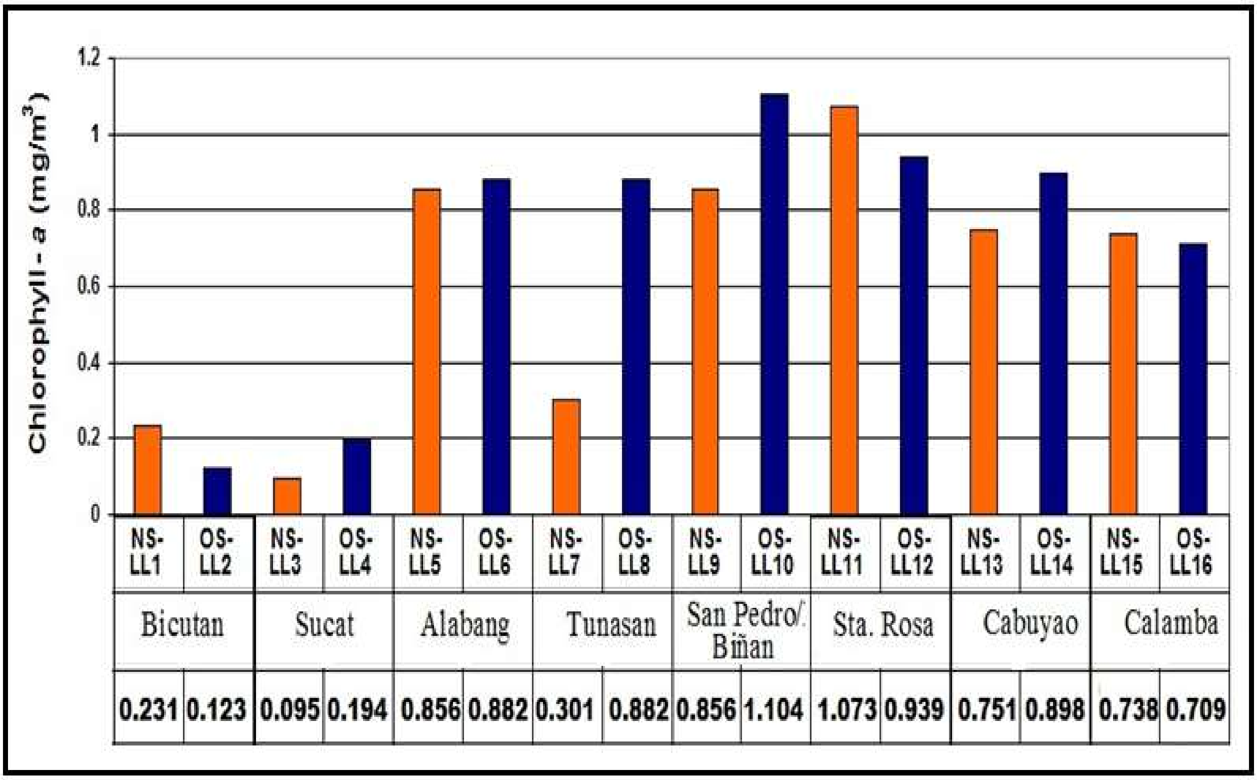


Figure 2.124 Variation in chlorophyll -*a* concentration at each of the sixteen sampling stations in Laguna Lake

Legend: NS (Nearshore) = Alongside of the proposed road alignment
OS (Offshore) = About 1km from the proposed road alignment

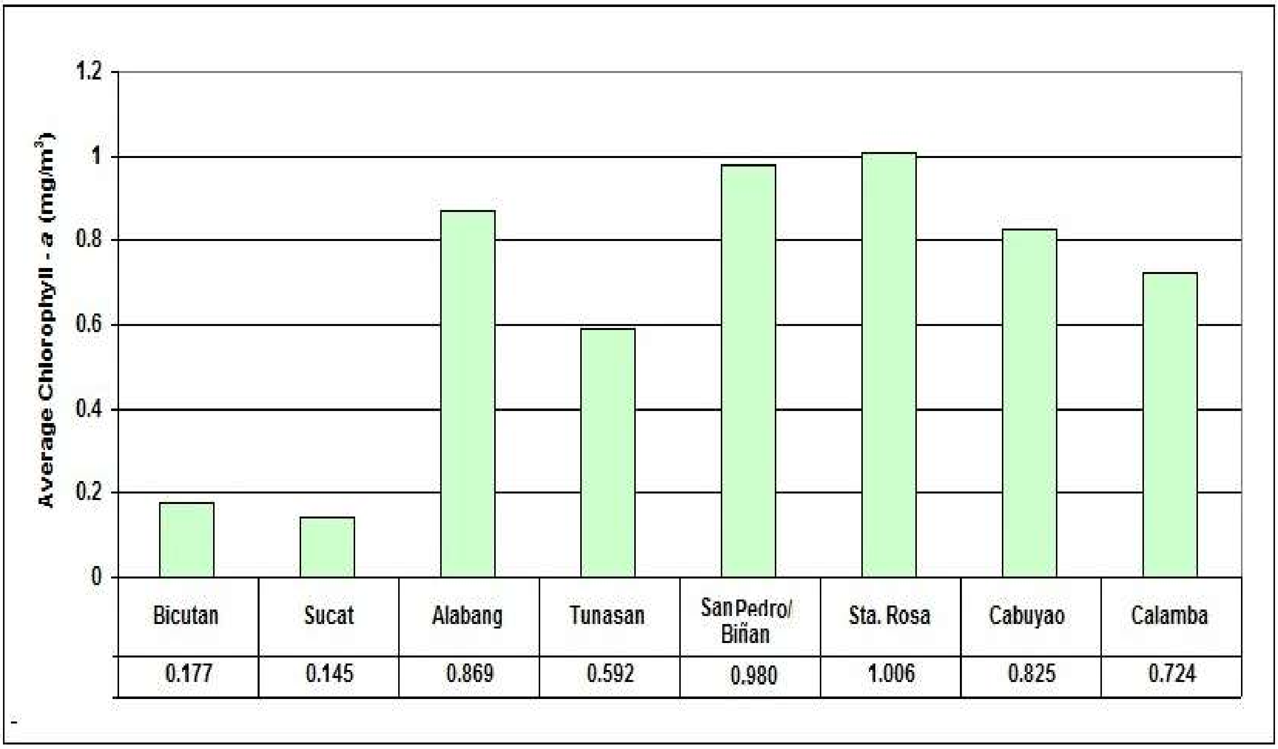


Figure 2.125 Variation in average chlorophyll -*a* concentration at each of the eight transect locations (nearshore and offshore sampling stations combined) in Laguna Lake

Based on the average (nearshore and offshore stations when combined), the trend for chlorophyll-*a* is that the higher levels during the survey were observed to be concentrated in Sta. Rosa (average 1.006 mg/m^3), San Pedro/Biñan (average 0.980 mg/m^3), Alabang (average 0.869 mg/m^3), Cabuyao (average 0.825 mg/m^3) and Calamba (0.724 mg/m^3); while the relatively lower chlorophyll-*a* levels were concentrated in Sucat and Bicutan (average 0.145 and 0.177 mg/m^3, respectively) (**Figure 2.125**). This variation pattern of the average chlorophyll-*a* level by transect location (see **Figure 2.125**) seemed to coincide clearly with that of the variation pattern of the average total phytoplankton (see **Figure 2.121**).

Comparison of chlorophyll-*a*values in the present study with those obtained in other areas is difficult because of a number of factors such as light, temperature, nutrient, and grazing among others. Nevertheless, the range of chlorophyll-*a* values from other sites in the Philippines like, for example in the same area in Laguna Lake (from Bicutan to Los Baños) in 2014, were compared with the values obtained in the present study (**Table 2.53**). The chlorophyll-*a* concentrations obtained in the present study appeared lower (0.10 to 1.10 mg/m^3) than those obtained in 2014 that ranged from 0.45 to 2.68 mg/m^3 (EcosysCorp, Inc., 2014). Similarly, the present chlorophyll-*a* levels were also lower than those obtained in Lake Mainit (including surrounding rivers and tributaries) that ranged from 0.29 to 2.56 mg/m^3 (Tumanda *et al*., 2004). In Taal Lake, a relatively high chlorophyll-*a* concentrations were reported for the samples collected from the fish cage areas (0.77 to 1.16 mg/m^3), whereas samples collected from rivers were generally within the range for open waters (0.51 to 0.79 mg/m^3) (UPLB Foundation Inc., 1996).

Table 2.53 Comparison of chlorophyll-*a*content in different locations

Place	Chlorophyll-*a* (mg/m^3)	References
Laguna Lake (Bicutan to Calamba)	0.10-1.10	December 2020 (Present Baseline Study)
Laguna Lake (Bicutan to Los Baños)	0.45-2.68	Previous EIA Baseline Study EcosysCorp, Inc. (January 2014)
Lake Mainit, Agusan del Norte (Northern Mindanao)	0.29-2.56	Tumanda et al. (2004)
Taal Lake (a) Fish cage area (b) Open waters	0.77-1.16 0.51-0.79	UPLB Foundation, Inc. (1996)

Figures 2.126 and **2.127** shows thechlorophyll-*a* data available from the LLDA for the years 1998 and 1999, respectively. Overall, these indicate the lake is hypertrophic (Lasco and Espaldon, 2005). However, there are many conceivable factors at the local level that lead to variance from the general trend of primary production in the lake (Lasco and Espaldon, 2005). Biomass production in the lake is seasonal. The chlorophyll-*a* data show that the dry season tends to have a higher production. The four (4) bays are spatially differentiated with East bay consistently exhibiting relatively higher biomass per season and per year. West bay tended to equal the primary production of Central bay only in the dry season. On an annual basis, however, West Bay is slightly less productive (11 percent). South Bay had the lowest primary production (**Figure 2.126**).

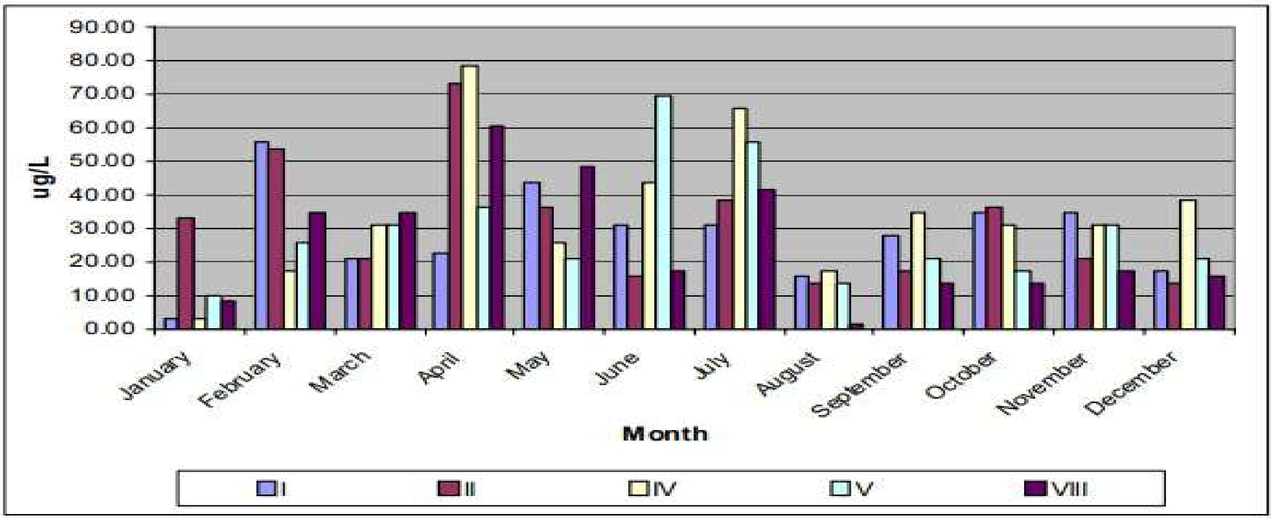


Figure 2.126 Chlorophyll-*a* in Laguna de Bay from the LLDA, 1998 (Figure taken from Lasco and Espaldon, 2005)

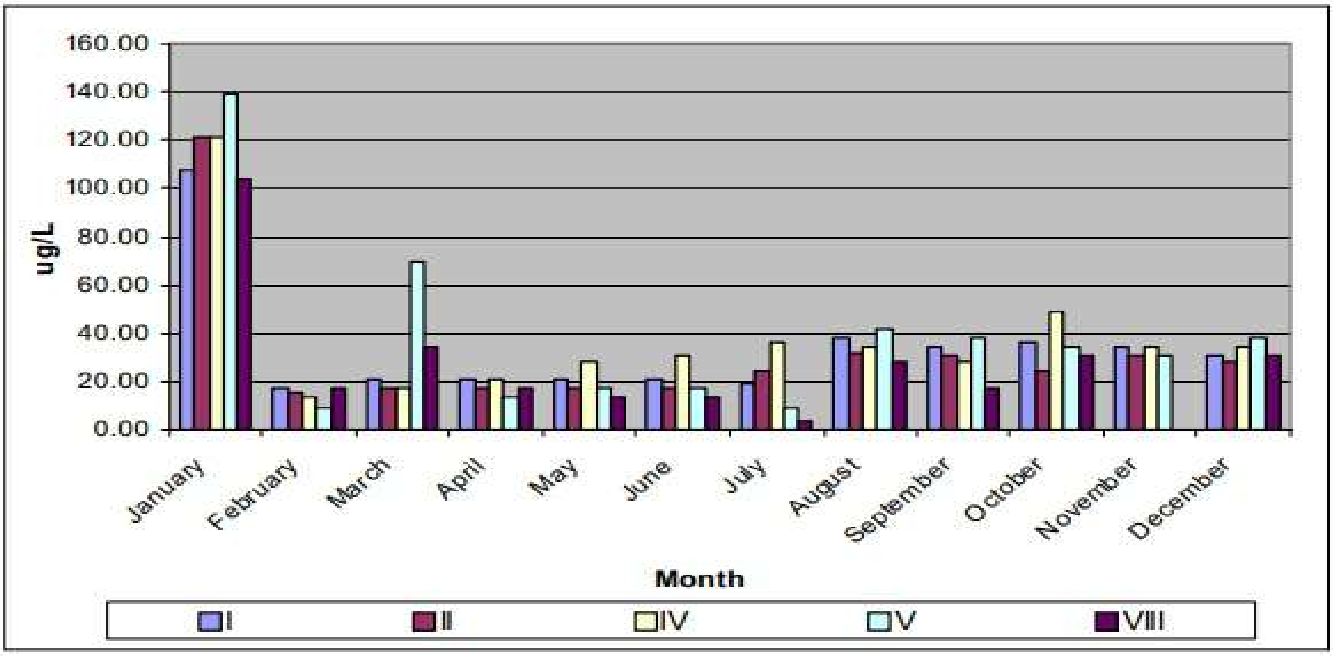


Figure 2.127 Chlorophyll-*a* in Laguna de Bay from the LLDA, 1999 (Figure taken from Lasco and Espaldon, 2005)

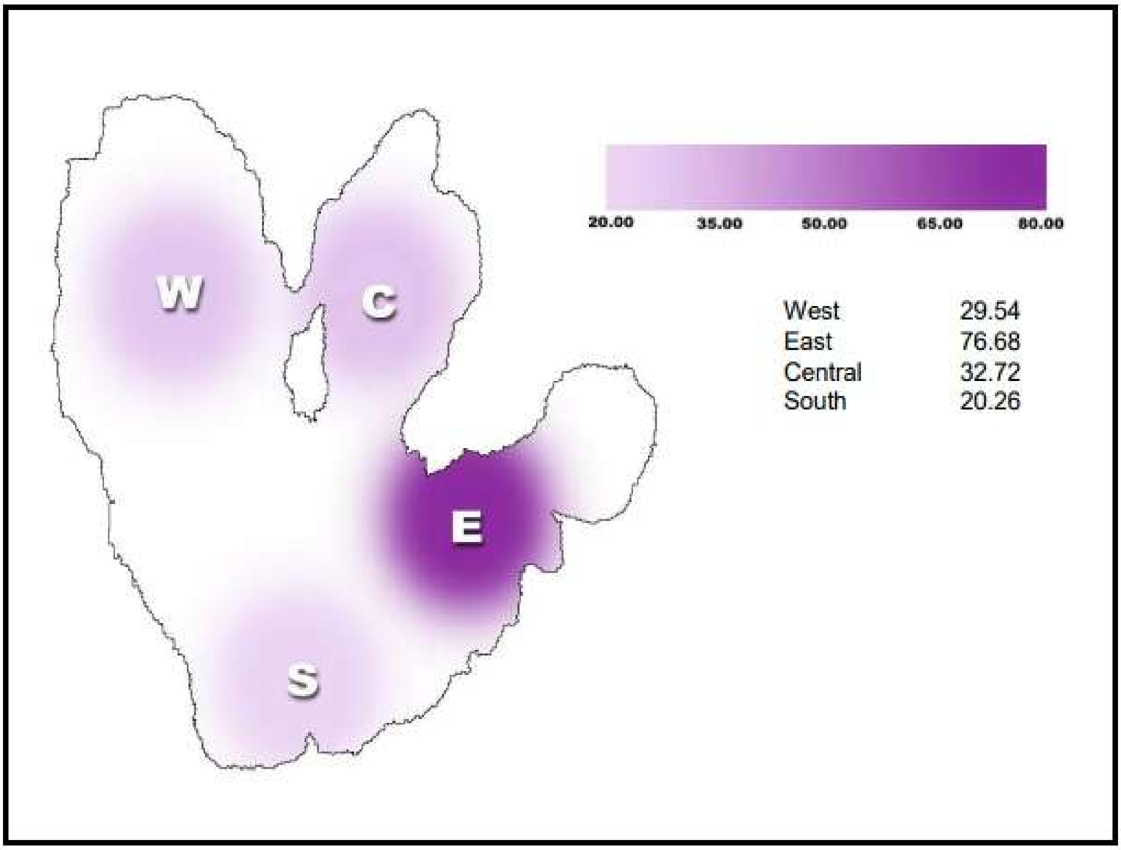


Figure 2.128 Chlorophyll-*a* levels (ug/L) in Laguna de Bay from the LLDA, 1999 (Figure taken from Lasco and Espaldon, 2005)

Ichthyoplankton (Fish Eggs and Fish Larvae)

Fish eggs were found absent in the majority of the sampling stations (**Plate9**). Density of fish eggs in nearshore stations ranged from 0 to 10 ind/m^3 while in offshore stations ranged from 0 to 14 ind/m^3 (**Table 2.54**). On the contrary, fish larvae were found present in all sampling stations with density much higher compared to fish eggs. Abundance of fish larvae was observed in nearshore stations with 21 to 195 ind/m^3 (average of 95 ind/m^3), higher compared to offshore stations with 25 to 104 ind/m^3 (average of 57 ind/m^3) (see **Table 2.54**). Thus, in general, populations of fish larvae are denser in nearshore, as compared to those of the offshore areas.

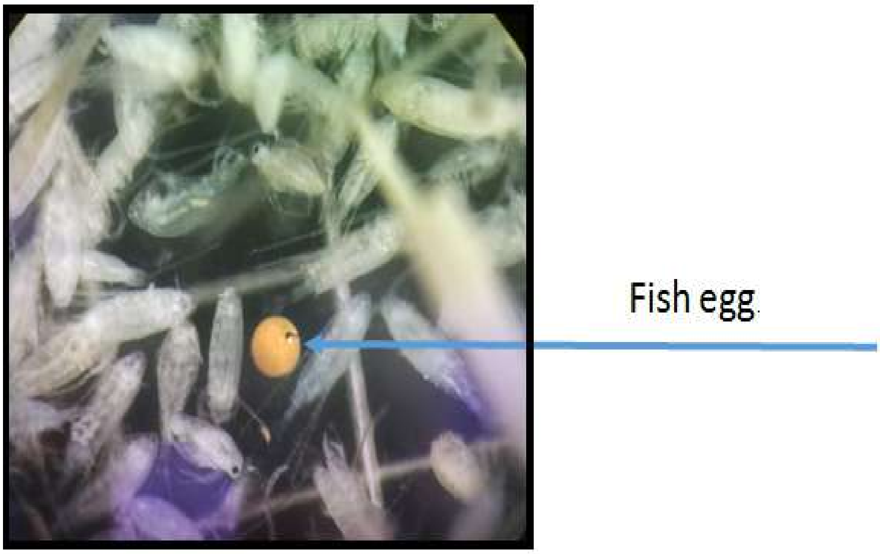


Plate 9 An assortment of zooplankton copepods and a fish egg collection in Laguna de Bay (Photomicrography by Val Borja)

Table 2.54 Density of fish eggs and fish larvae estimated at the sixteen sampling stations in Laguna de Bay

Transect Location	Sampling Station	Fish Eggs		Fish Larvae	
		Density (no. ind/m^3)	Average (no. ind/m^3)	Density (no. ind/m^3)	Average (no. ind/m^3)
Bicutan	LL1 (Nearshore)	0	0	23	37
	LL2 (Offshore)	0		51	
Sucat	LL3 (Nearshore)	0	0	118	96
	LL4 (Offshore	0		74	
Alabang	LL5 (Nearshore)	0	0	192	113
	LL6 (Offshore)	0		34	

Transect Location	Sampling Station	Fish Eggs		Fish Larvae	
		Density (no. ind/m^3)	Average (no. ind/m^3)	Density (no. ind/m^3)	Average (no. ind/m^3)
Tunasan	LL7 (Nearshore)	0	7	53	63
	LL8 (Offshore)	14		72	
San Pedro/Biñan	LL9 (Nearshore)	10	8	54	40
	LL10 (Offshore)	5		25	
Sta. Rosa	LL11 (Nearshore)	0	0	195	115
	LL12 (Offshore)	0		35	
Cabuyao	LL13 (Nearshore)	0	0	21	42
	LL14 (Offshore)	0		63	
Calamba	LL15 (Nearshore)	0	0	100	102
	LL16 (Offshore)	0		104	
Range	**Nearshore**	**0-10**		**21-195 (average = 95)**	
	Offshore	**0-14**		**25-104 (average = 57)**	

Legend: Nearshore = Alongside of the proposed road alignment
Offshore = About 1 km from the proposed road alignment

The presence of fish eggs was observed only at one (1) station in Tunasan at offshore Station LL8 (14 ind/m^3) and two (2) stations in San Pedro/Biñan at nearshore Station LL9 and offshore Station LL10 (10 and 5 ind/m^3, respectively) (**Figure 2.129**); their concentrations aggregate in these stations.

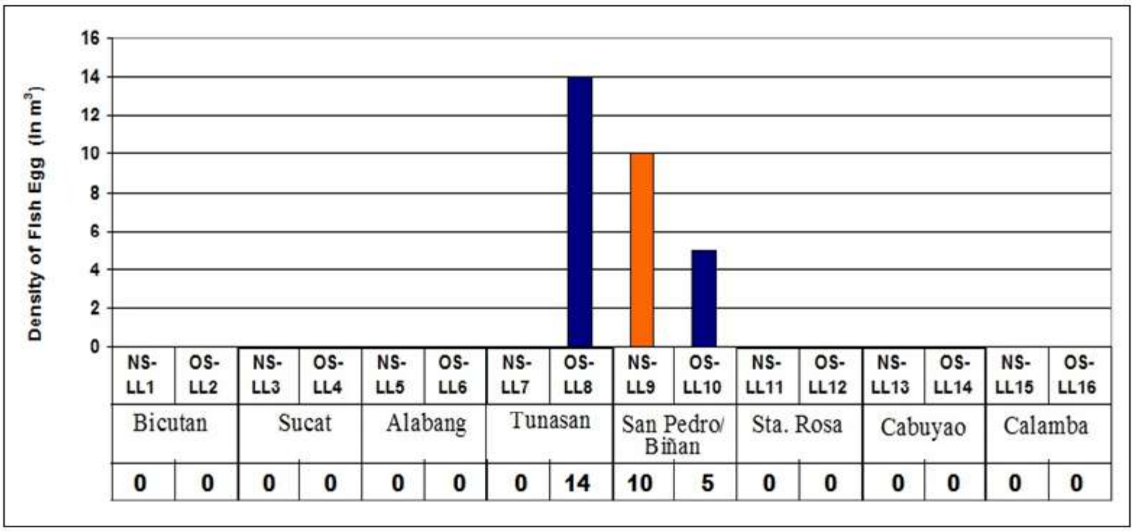


Figure 2.129 Variation in density of fish eggs at the sixteen sampling stations in Laguna de Bay

Legend: NS (Nearshore) = Alongside the proposed road alignment
OS (Offshore) = About 1km from the proposed road alignment

The higher concentrations of fish larvae were usually found along nearshore areas (along the proposed road alignment) particularly in Sta. Rosa at Station LL11 (195 ind/m^3), Alabang at Station LL5 (192 ind/m^3), Sucat at Station LL3 (118 ind/m^3) and Calamba at Station LL15 (100 ind/m^3) (**Figure 2.130**). Similarly, high abundance of fish larvae was noticed at the offshore Station LL16 in Calamba with 104 ind/m^3.

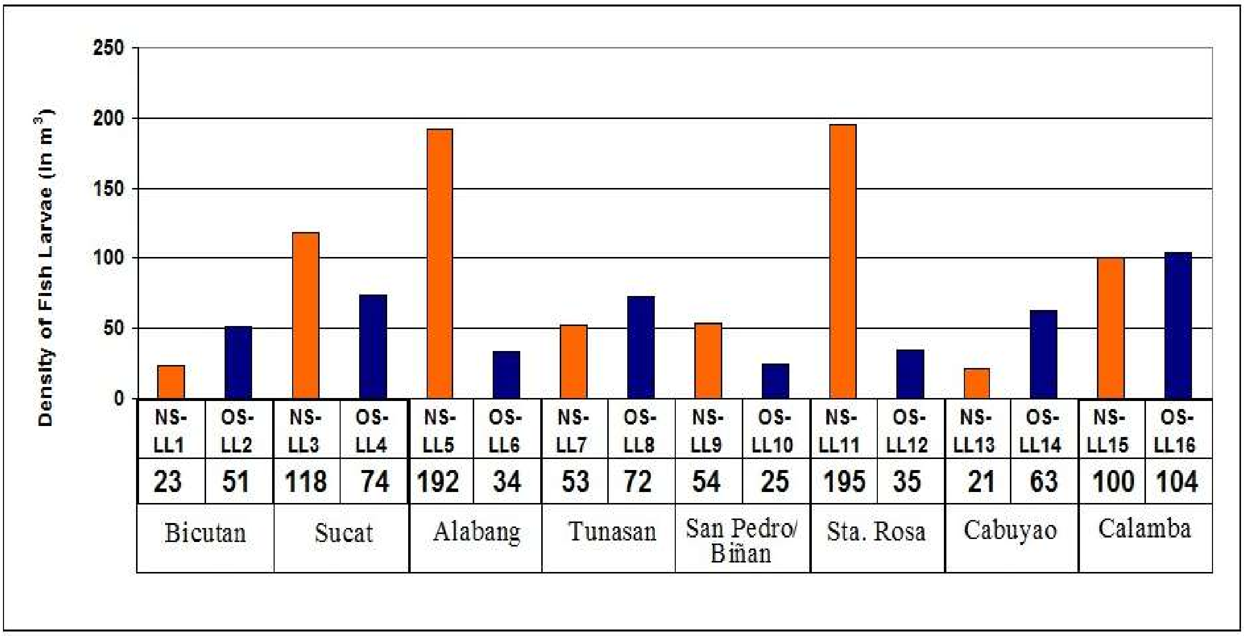


Figure 2.130 Variation in density of fish larvae at the sixteen sampling stations in Laguna de Bay

Legend: NS (Nearshore) = Alongside of the proposed road alignment
OS (Offshore) = About 1km from the proposed road alignment

Based on the average (nearshore and offshore stations when combined), the trend for fish larvae density is that the higher concentrations of fish larvae were observed in Sta. Rosa (average 115 ind/m^3), Alabang (average 113 ind/m^3), Calamba (average 102 ind/m^3) and Sucat (average 96 ind/m^3) (**Figure2.131**). They were found to be in lower concentrations in Bicutan, San Pedro/Biñan and Cabuyao (average 37, 40 and 42 ind/m^3, respectively).

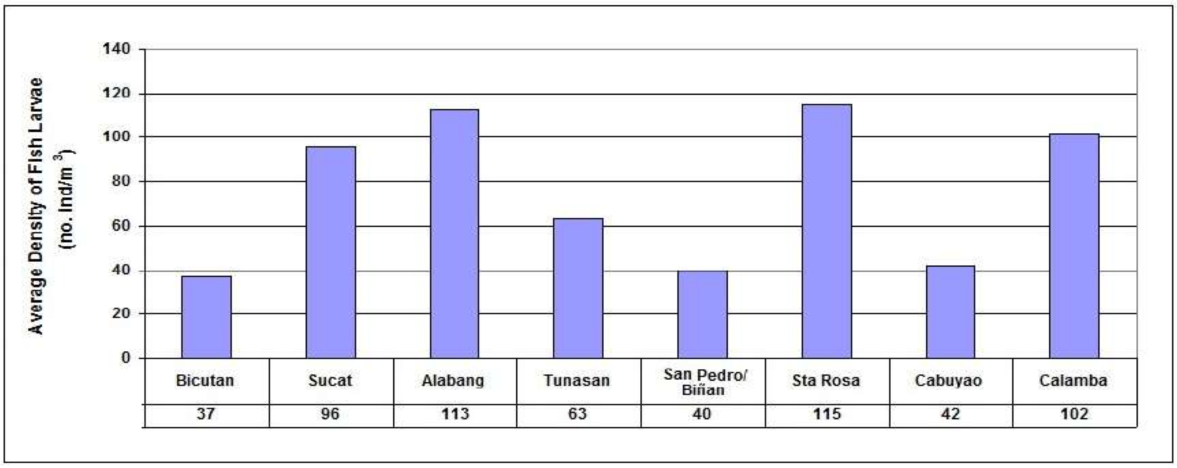


Figure 2.131 Variation in average density of fish larvae at each of the eight transect locations (nearshore and offshore sampling stations combined) in Laguna Lake

A total of 234 fish larvae individual specimens representing five (5) families/groups were collected in the project site (**Table 2.55**). It was obvious that the fish larvae family was dominated by Cyprinidae (carps) which comprises 88.5% of the total population, followed by Gobiidae (gobies), unidentified fish larvae, Terapontidae (grunters) and Hemiramphidae (halfbeaks/spipefish) with 4.7%, 3.4%, 3.0% and 0.4%, respectively (**Figure 2.131**). Some photos of these identified fish larvae families collected can be seen in **Plate10**.

Table 2.55 Species composition and total number (actual counts) of fish Larvae at the sixteen sampling stations in west Laguna de Bay

Transect Location	Sampling Station	Fish Larvae Family					Total
		Cyprinidae	Gobiidae	Terapontidae	Hemiramphidae	Unidentified	
Bicutan	LL1 (Nearshore)	2	1	1		1	5
	LL2 (Offshore)	9		1		2	12
Sucat	LL3 (Nearshore)	22		2			24
	LL4 (Offshore	14		1			15
Alabang	LL5 (Nearshore)	39					39
	LL6 (Offshore)	5	2				7
Tunasan	LL7 (Nearshore)	9	1				10
	LL8 (Offshore)	16					16
	LL9 (Nearshore)	10	1				11

Transect Location	Sampling Station	Fish Larvae Family					Total
		Cyprinidae	Gobiidae	Terapontidae	Hemiramphidae	Unidentified	
San Pedro/Biñan	LL10 (Offshore)	5					5
Sta. Rosa	LL11 (Nearshore)	32					32
	LL12 (Offshore)	7					7
Cabuyao	LL13 (Nearshore)	4					4
	LL14 (Offshore)	10		2			12
Calamba	LL15 (Nearshore)	12			1	4	17
	LL16 (Offshore)	11	6			1	18
	Total	**207**	**11**	**7**	**1**	**8**	**234**

(*) =Too small to identify/damage samples

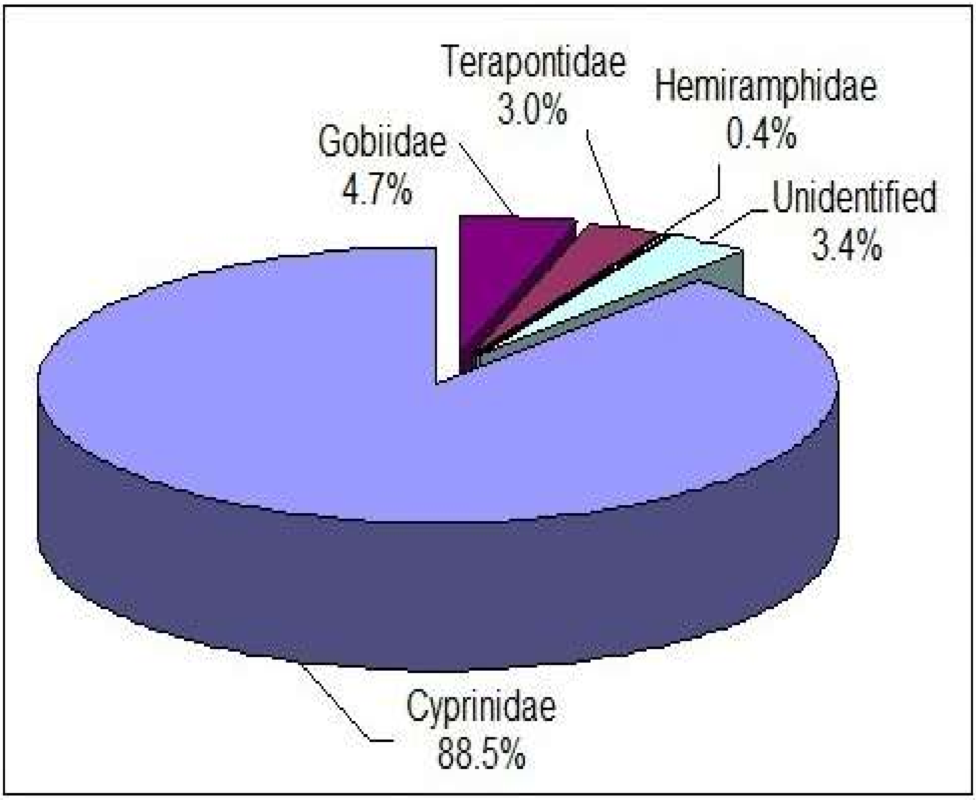


Figure 2.132 Relative abundance of fish larvae family at the sixteen sampling stations in west Laguna de Bay

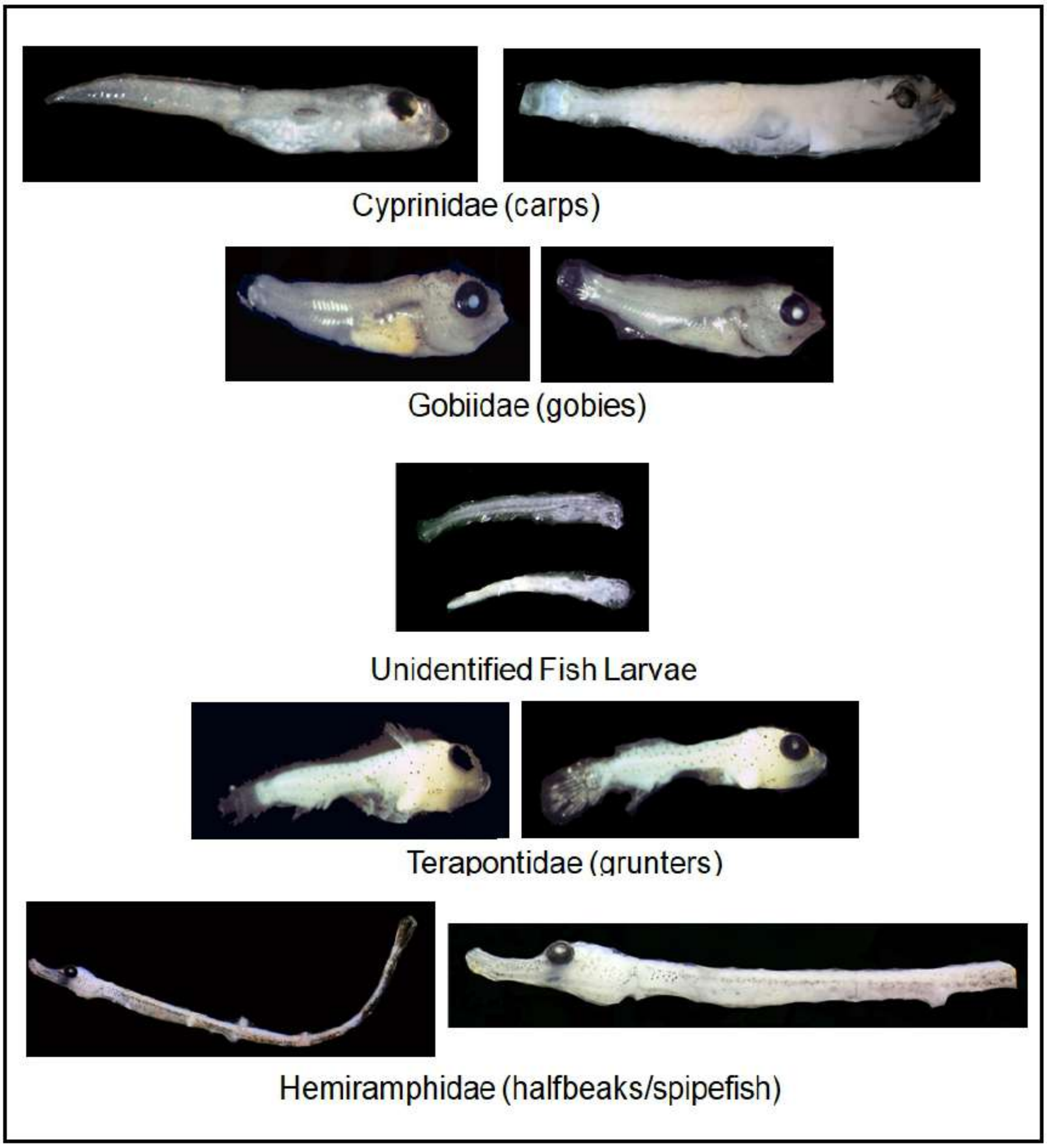


Plate 10 Pictures of fish larvae family collection carried out in west Laguna de Bay (Photomicrography by Val Borja)

In addition to fish larvae, an abundance of shrimp larvae (**Plate 11**) was found in the ichthyoplankton samples collected in Calamba and Cabuyao, particularly at the offshore Stations LL14 and LL16, respectively. They were not observed in all the other stations sampled.

Plate 11 Pictures of shrimp larvae and zooplankton copepods collection carried out in West Laguna de Bay (Photomicrography by Val Borja)

Soft Bottom Infaunal Benthos

Benthos is one of the important links in the food chain of the fishes in Laguna de Bay. Infaunal benthos are bottom dwelling animals living within, rather than on, the surface of the substrate. This group of organisms plays a very important role in the overall productivity of the area. These fauna, which are associated with soft bottom substrate, constitute as one of the most abundant major components of the food habits of many benthic and bottom fishes and commercially important invertebrates. These benthic organisms are also useful indicators of perturbations in the environment. Since they are considered as accumulators of suspended or deposited particles, these organisms play a crucial role in the transfer and storage of pollutants in the food chain.

Composition and Abundance of Soft bottom Infaunal Benthos

A total number of 364 benthic organisms were obtained from 32 samples taken at eight (8) transect locations represented by two (2) sampling stations each. The mean number of individuals per station was 46. These organisms were represented by10 animal taxa belonging to three (3) major taxonomic groups, namely, Annelida (Oligochaeta), Mollusca (Gastropoda and Pelecypoda) and Arthropoda (Crustacea and Insecta). The various animal groups were represented in varying number of taxa.

Table 2.56 presents the species composition, density and relative abundance of the major taxonomic groups sampled at each station. The data on mean relative abundance of the major groups was graphically presented in **Figure 22**. The most important groups of soft bottom fauna taken belong to the mollusks comprising 91% while the oligochaetes and arthropods shared only 6% and 3%, respectively. The bulk of the mollusk collections were represented by a composition of 50% of pelecypods and 41 % of gastropods. The gastropods were represented by five (5) species, 40% of which belongs to *Melanoides* sp. This species is ovoviviparous and parthenogenetic commonly occurring in streams, rivers, irrigation canals and stagnant ponds. The other four (4) species were *Thiara* sp., *Tarebia* sp., *Bellamya* sp. and *Planorbis s*p. The gastropod, *Bellamya* sp. belongs to Viviparidae or pond snails. Some species of *Bellamya* bury themselves in the mud or sand if there are unfavorable conditions like drought, etc. The pelecypods were solely dominated by the presence of *Corbicula* sp., locally known as "tulya", attaining 40% of the mollusk collection.

The arthropod collections were exemplified by only one (1) taxon of crustacean under Tanaidacea and two (2) taxa of insects, namely, *Chironomous* sp. and *Tipula* sp. The chironomids were the most commonly encountered insect nymphs. The chironomids (flies) are extremely diverse in habitat and may be found on almost any substratum in the freshwater (cited by Bryce and Hobart, 1971 in Guide to Freshwater Invertebrate Animals, unknown author and year). The oligochaetes, which feed principally on pieces of leaves and other vegetation, particles of matter, and soil (Engemann and Hegner, 1981) were mostly found in the muddy area with plant debris. Photos of some freshwater benthic organisms collected at the project site are shown in **Plate 12.**

Table 2.56 Species composition, density, and relative abundance of the major taxonomic groups at each sampling station

Taxa	Transect Location/Sampling Station																	
	Bicutan		Sucat		Alabang		Tunasan		San Pedro/Biñan		Sta. Rosa		Cabuyao		Calamba		Mean Density (no./m^2)	Mean Relative Abundance (%)
	NS LL1	OS LL2	NS LL3	OS LL4	NS LL5	OS LL6	NS LL7	OS LL8	NS LL9	OS LL10	NS LL11	OS LL12	NS LL13	OS LL14	NS LL15	OS LL16		
Phylum Annelida																		
Class Oligochaeta	88.89	22.22		44.45	44.44	22.22		88.89	44.45		66.67			22.22	44.44	22.22	31.94	6.32
Phylum Mollusca																		
Class Bivalvia																		
Family Corbiculidae																		
***Corbicula* sp.**							88.89	266.67	1444.45		466.67	1000.00		22.22			205.56	40.68
Class Gastropoda																		
Family Thiaridae																		
***Thiara* sp.**	44.45	22.22	22.22	22.22	88.89	88.89		44.44	22.22				44.44	22.22			26.39	5.22
***Melanoides* sp.**	88.89	44.45	133.34	88.89	155.56	511.11	88.89	267.67	200.00		177.78	133.33	733.33	511.11	66.67	88.89	205.62	40.67
***Tarebia* sp.**													155.5	22.22			11.11	2.20

Taxa	Transect Location/Sampling Station																Mean Density (no./m^2)	Mean Relative Abundance (%)
	Bicutan		Sucat		Alabang		Tunasan		San Pedro/Biñan		Sta. Rosa		Cabuyao		Calamba			
	NS LL1	OS LL2	NS LL3	OS LL4	NS LL5	OS LL6	NS LL7	OS LL8	NS LL9	OS LL10	NS LL11	OS LL12	NS LL13	OS LL14	NS LL15	OS LL16		
													6					
Family Viviparidae																		
***Bellamya* sp.**			22.22						22.22								2.28	0.55
Family Planorbidae																		
***Planorbis* sp.**	66.67			22.22	22.22												6.94	1.37
Phylum Arthropoda																		
Subphylum Crustacea																		
Class Malacostraca																		
Order Tanaidacea									22.22								1.39	0.27
Class Insecta																		
Order Diptera																		
Family Chironomidae																		

Taxa	Transect Location/Sampling Station																Mean Density (no./m^2)	Mean Relative Abundance (%)
	Bicutan		Sucat		Alabang		Tunasan		San Pedro/Biñan		Sta. Rosa		Cabuyao		Calamba			
	NS LL1	OS LL2	NS LL3	OS LL4	NS LL5	OS LL6	NS LL7	OS LL8	NS LL9	OS LL10	NS LL11	OS LL12	NS LL13	OS LL14	NS LL15	OS LL16		
***Chironomous* sp.**										66.67	22.22	44.44		44.44		22.22	12.50	2.47
Family Tipulidae																		
***Tipula* sp.**															22.22		1.39	0.27
Total (no. ind/m^2)	**288.90**	**88.89**	**177.78**	**177.78**	**311.11**	**622.22**	**177.78**	**666.67**	**1755.56**	**66.67**	**733.34**	**1177.78**	**933.33**	**644.43**	**133.33**	**133.33**	**505.56**	**100.00**
Species Diversity (H')	**1.35**	**1.04**	**0.74**	**1.21**	**1.17**	**0.56**	**0.69**	**1.18**	**0.57**	**0.00**	**0.96**	**0.51**	**0.63**	**0.83**	**1.01**	**0.87**		
Biomass (wwt g/m^2)	**28.22**	**4.22**	**52.67**	**9.34**	**34.44**	**133.55**	**187.77**	**349.55**	**1854.89**	**1.33**	**549.77**	**964.67**	**322.00**	**64.89**	**13.55**	3.33		

Legend: NS (Nearshore) = Alongside of the proposed road alignment
OS (Offshore) = About 1km from the proposed road alignment

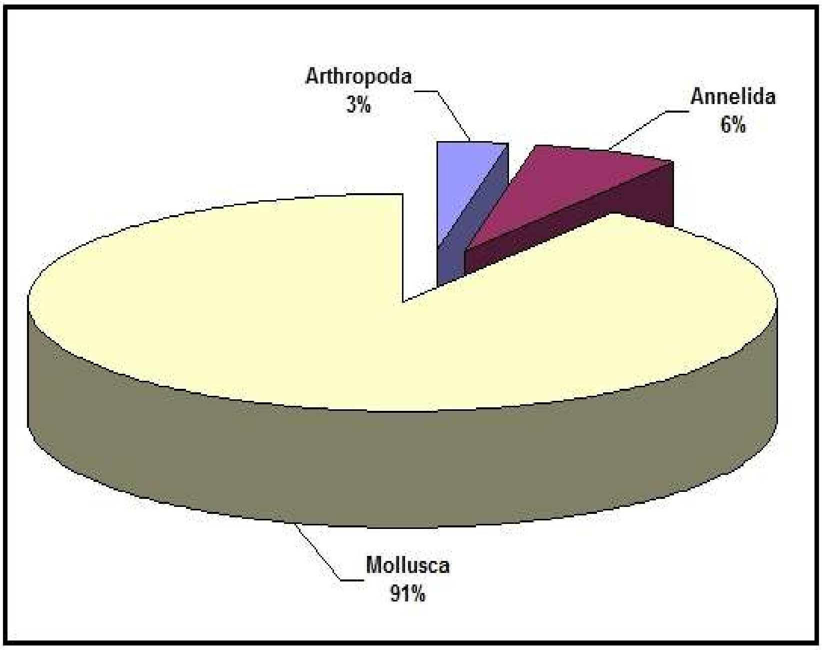


Figure 2.133 Mean relative abundance (%) of major soft bottom benthic infaunal groups sampled at all stations

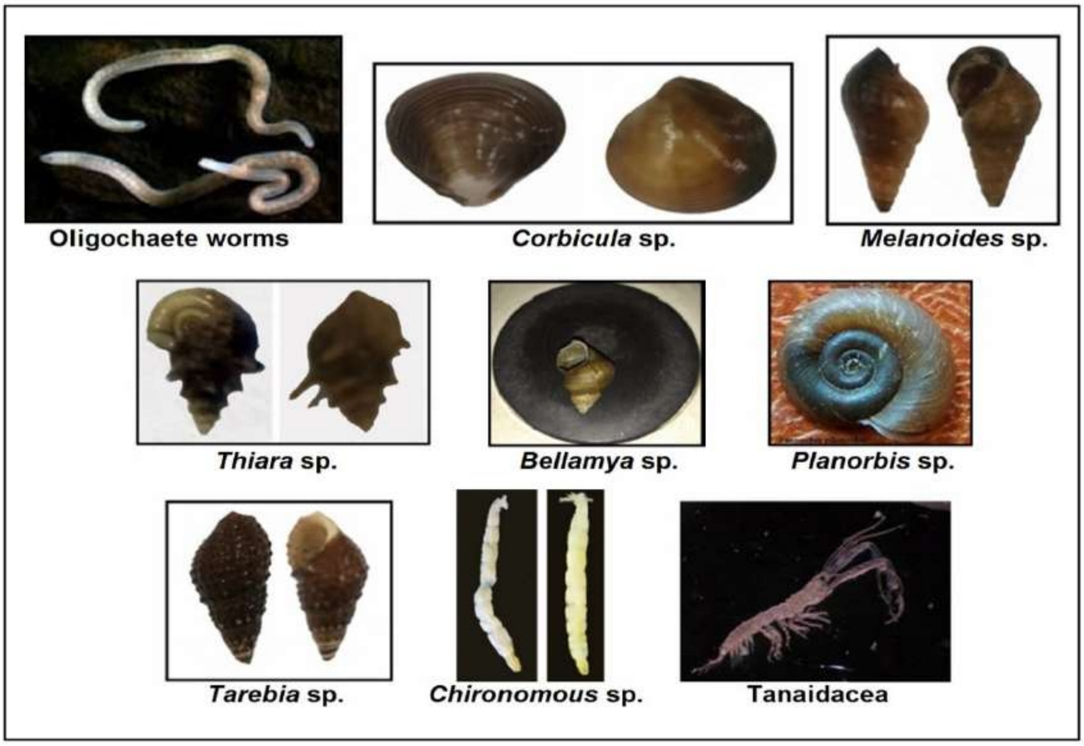
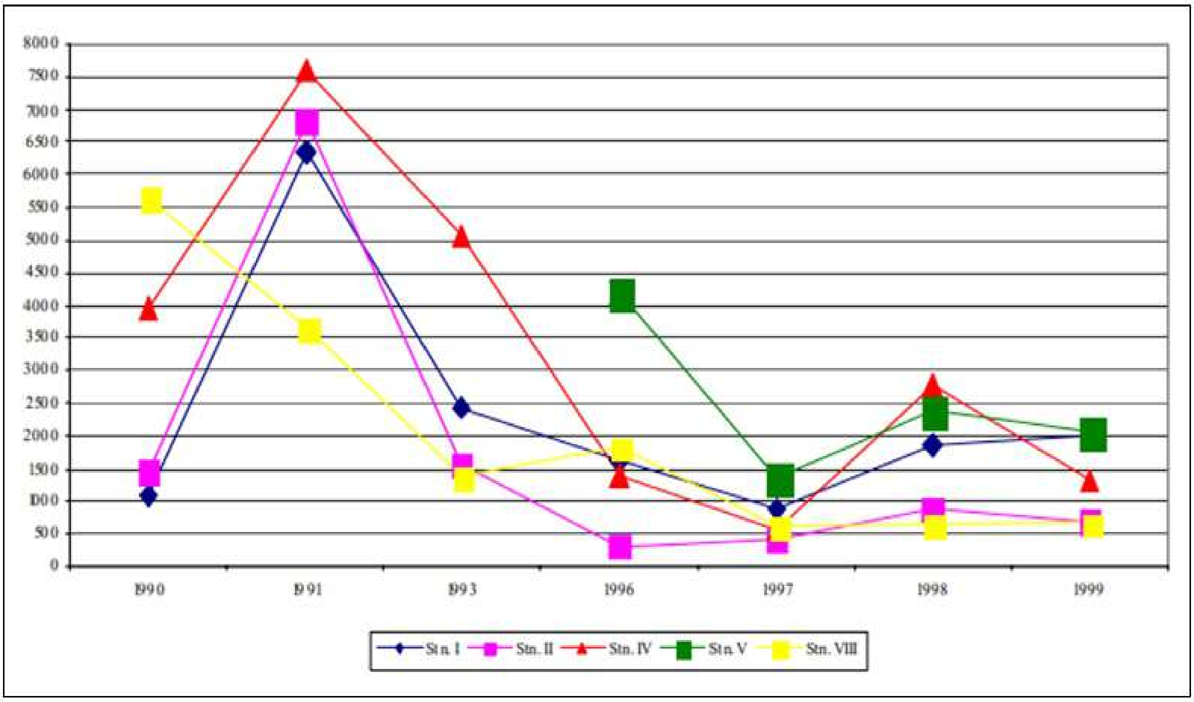


Plate 12 Photos of soft bottom benthic infauna organisms collected (Photo source: (Photomicrography by Val Borja, and Internet)

According to the LLDA-WHO (1978), the benthic community of Laguna de Bay is composed of about 22 genera consisting of mollusks, oligochaetes, ostracods, nematodes, insect larvae, water arachnids, crustaceans, and juveniles of fish. *Thiara* sp. and *Cypricercus* sp. are the most common and are cosmopolitan in distribution. They also show seasonality with peaks common during the dry season. Lasco and Espaldon (2005) reported that in 1998, the peak of abundance was observed in July around the mouth of the Pasig River. This seemingly delayed peak abundance could be due to the El Niño that hit the country in1997-1998. A downward trend was observed from 1990 to 1997. Benthos counts however increased in 1998. The annual average for benthic fauna is presented in **Figure 2.133**. Benthic fauna of the lake comprise of the following in decreasing abundance: oligochaetes, ostracods, molluscans and dipterans. The nematodes and chordates are practically negligible. Their density over the entire lake from 1975 to 1977 averaged approximately 3,000 ind/m^2. At that time, West Bay exhibited higher densities than Central bay (4,000 ind/m^2 vs. 2,000 ind/m^2). Oligochaetes were represented by the genera, *Branchuira*, *Limnodrilus*, and *Tubifex*. Their populations reached their peak in the summer months. *Limnodrilus* and *Tubifex* were common inhabitants of the West bay. Ostracods consisted primarily of the genus *Cypicernus*. Peak population densities generally occurred during the cool months. The mollusks reported were *Corbicula*, *Lymnaea*, *Pleurocea*, *Promenetus*, *Tarebia*, and *Amnicola.* Their populations usually grew in the second half of the year, with *Lymnaea* and *Amnicola* dominating. Dipteran representatives were mainly of chironomid and midge larvae. None of the information accessed revealed the season in which their populations increased.

Figure 2.134 Annual average of benthic fauna in Laguna Lake, 1990-1999 (Figure taken from Lasco and Espaldon, 2005)



Density of Soft Bottom Infauna

The density of benthic organisms ranged from 66.67 to 1755.56 ind/m^2 (see **Table 2.56)**. The mean density for all the stations was 505.56 ind/m^2. The highest density of benthic organisms was found at the nearshore Station LL9, situated at San Pedro/Biñan and characterized by grayish mud associated with clam shells, *Corbicula* sp. with 1,444.45ind/m^2 **(Figure 2.135)** which were the most abundant organisms found. *Melanoides* sp. belonging to gastropod shell was also commonly found in nearshore Station LL9. Second in density of benthic organisms was obtained at offshore Station LL12 located at Sta. Rosa with grayish muddy substrate having a density of 1177.78 ind/m^2 consisted mostly of *Corbicula* sp. The Station LL13 found at nearshore of Cabuyao, with muddy bottom, ranked third having a density of 933.33 ind/m^2 predominated by gastropod *Melanoides* sp. In descending order, stations with densities above 500 ind/m^2 were LL11, located nearshore of Sta. Rosa, LL8 offshore of Tunasan, LL14 situated at the offshore of Cabuyao, and LL6 offshore of Alabang. The remaining stations have low densities ranging only from 66.67 ind/m^2 to 311.11 ind/m^2. The Station LL10, located offshore of San Pedro/Biñan had the least density due to the presence only of few chironomid.

The muddy bottom which was consisted of eroded soil in the study area could also be the reason for having a relatively poor density of soft bottom organisms considering also that the sites served easily as catch basin for the eroded soil as evidenced by the collected sediment samples. Among the adverse effects on the environment of soil runoff, is the increased sedimentation. The soil runoff empty into the lake and these carry an unknown quantity of suspended sediments which affects the population density of benthic organisms. The sediment chokes aquatic life and reduces photosynthesis of plankton, thus reducing fishery production (Alcala, 1991).

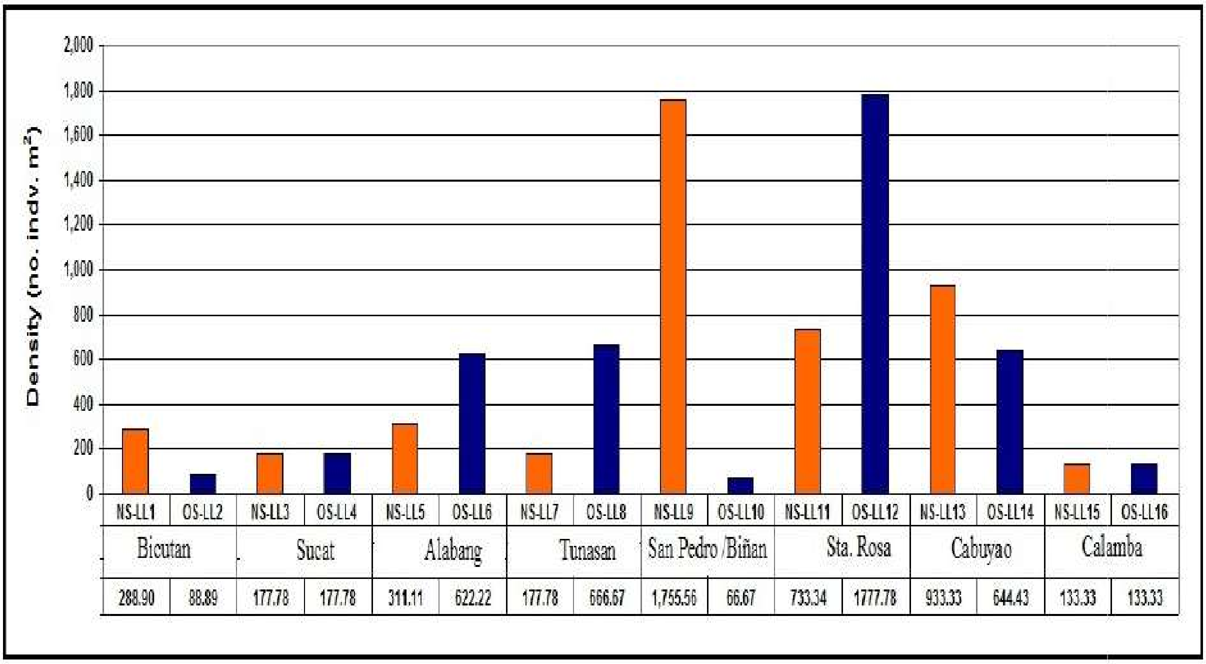


Figure 2.135 Variation in density (no. of indv/m^2) of soft bottom infauna fauna at the sixteen sampling stations in Laguna de Bay

Legend: NS (Nearshore) = Alongside of the proposed road alignment
OS (Offshore) = About 1km from the proposed road alignment

Based on the average (nearshore and offshore stations when combined), the average density of benthos was observed to be highest in Sta. Rosa (average 955.56 ind/m^2), followed closely by San Pedro /Biñan (average 911.115 ind/m). The stations with average densities above 400 ind/m^2 were Alabang (average 466.67 ind/m$^{2)}$ and Tunasan (422.23 ind/m^2). Low average densities were found in Bicutan (188.90 ind/m^2), Sucat (177.78 ind/m^2) and Calamba (133.33 ind/m^2) (**Figure 25**).

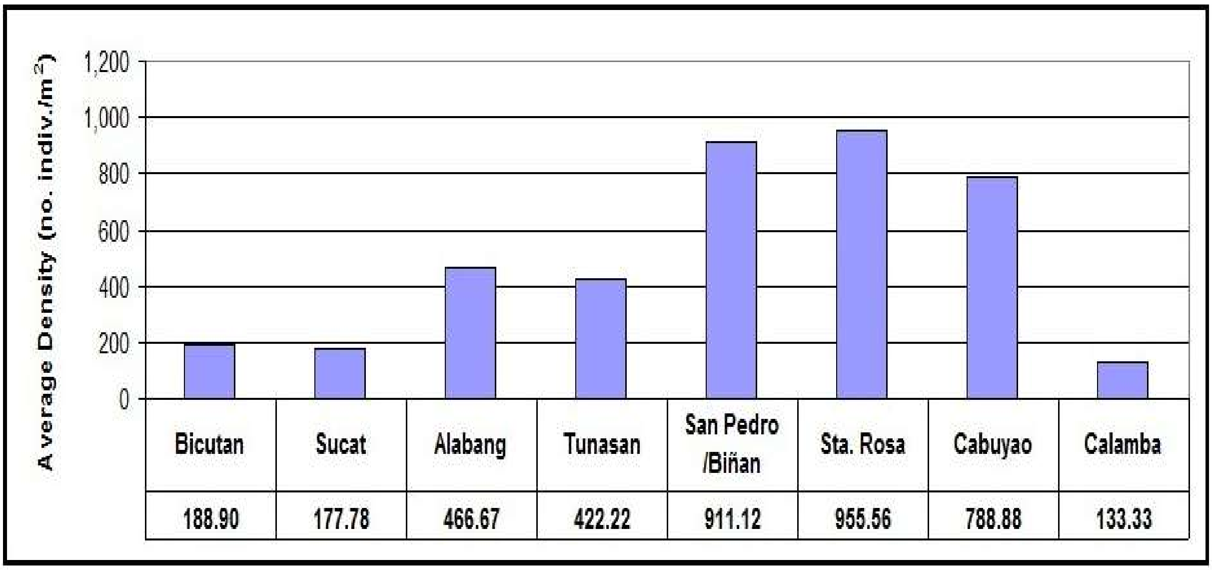


Figure 2.136 Variation in average density of soft bottom fauna at each of the eight transect locations (nearshore and offshore sampling stations combined) in Laguna Lake

Diversity Indices of Soft Bottom Benthic Infauna

An index of diversity of benthic organisms (within major taxonomic group) using Shannon-Weaver Index was computed for the communities found in different stations in the project area. The index both measures the variety and number of individuals per taxa. The species diversity (H') ranged only from 0.00 to 1.35. The mean species diversity for all the stations was 0.83 **(Figure 2.137)**. The Station LL1 located nearshore of Bicutan attained with highest diversity (1.35), followed in descending order by Stations LL4 in offshore area of Sucat (1.21), LL8 in offshore area of Tunasan (1.18), LL5 in nearshore area of Alabang (1.17), LL2 in offshore area of Bicutan (1.04) and LL15 in nearshore area of Calamba (1.01). Other stations have only a diversity values below 1.00. Station LL10, at offshore area of San Pedro//Biñan had a value of 0.00 diversity owing to poor representation of organisms. The low diversity of fauna indicates highly stressful environment.

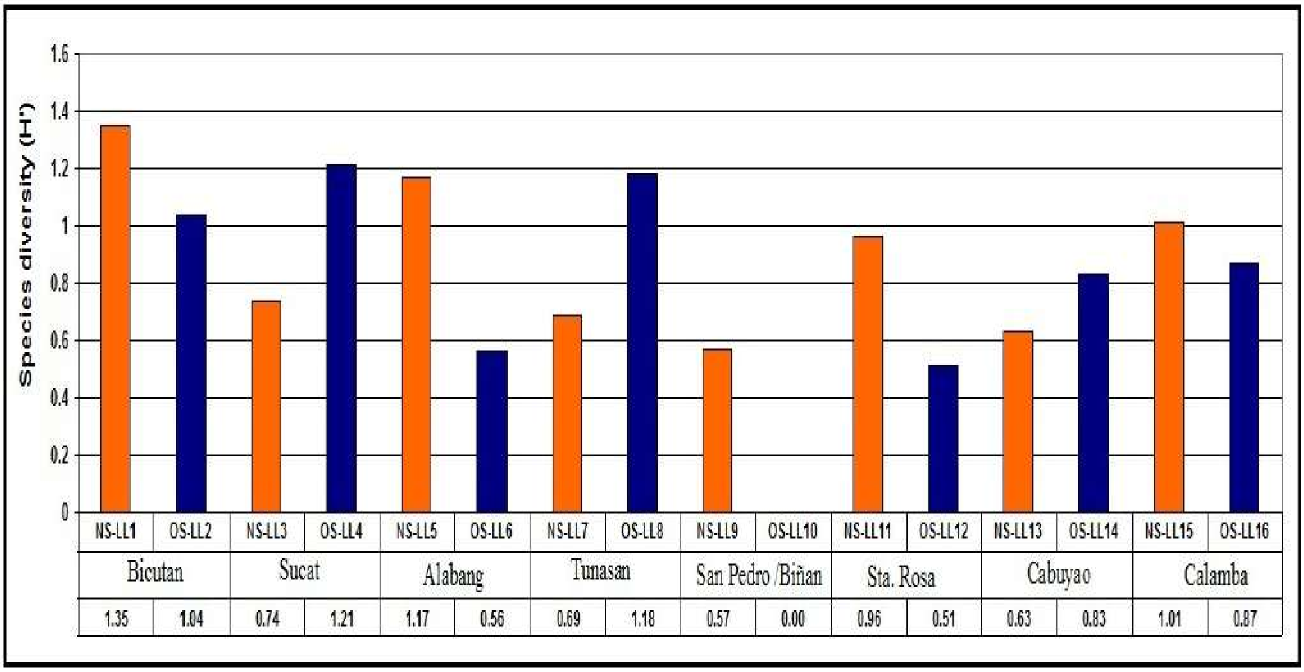


Figure 2.137 Variation in species diversity (H') of soft bottom infauna at the sixteen sampling stations in Laguna Lake

Legend: NS (Nearshore) = Alongside of the proposed road alignment
OS (Offshore) = About 1km from the proposed road alignment

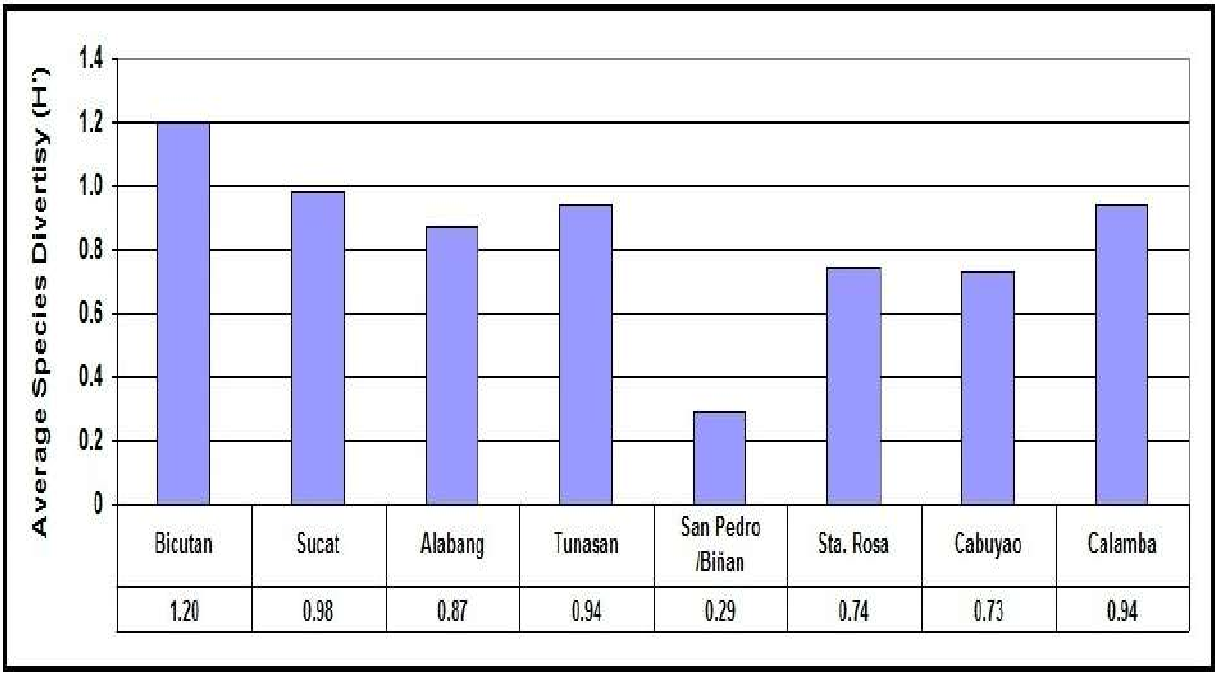


Figure 2.138 Variation in average diversity of soft bottom infauna at Each of the Eight Transect Locations (Nearshore and Offshore Sampling Stations Combined) in Laguna Lake

Based on the average (nearshore and offshore stations when combined), the average species diversity (H') of benthos was observed to be highest in Bicutan (1.20). All other stations have only a diversity values below 1. San Pedro//Biñan had the poorest average of diversity (0.29) owing to poor representation of organisms.
(**Figure 2.138**).

Biomass of Soft Bottom Benthic Infauna

Macroinvertebrate biomass (weight of organisms per unit area) is a useful quantitative estimation of standing crop. Biomass of the benthic organisms at all sampling stations is also shown in Table 13 and graphically presented in Figure 28. The biomass ranged from 1.33 to 1,854.89 wwt g/m^2. The mean biomass recorded for all the stations was 285.89 wwt g/m^2. Inter-station comparison showed Station LL9 situated nearshore of San Pedro/Biñan with the highest biomass due to the collection of numerous *Corbicula* sp., followed at a distant place by Station LL12, 964.67 wwt g/m^2 at offshore of Sta Rosa owing also due to the abundance of *Corbicula* sp. The remaining stations have biomass values with below 500 wwt g/m^2. The offshore of San Pedro/Biñan Station LL10 obtained the least value due to the collection only of an insect nymph, *Chironomous* sp.

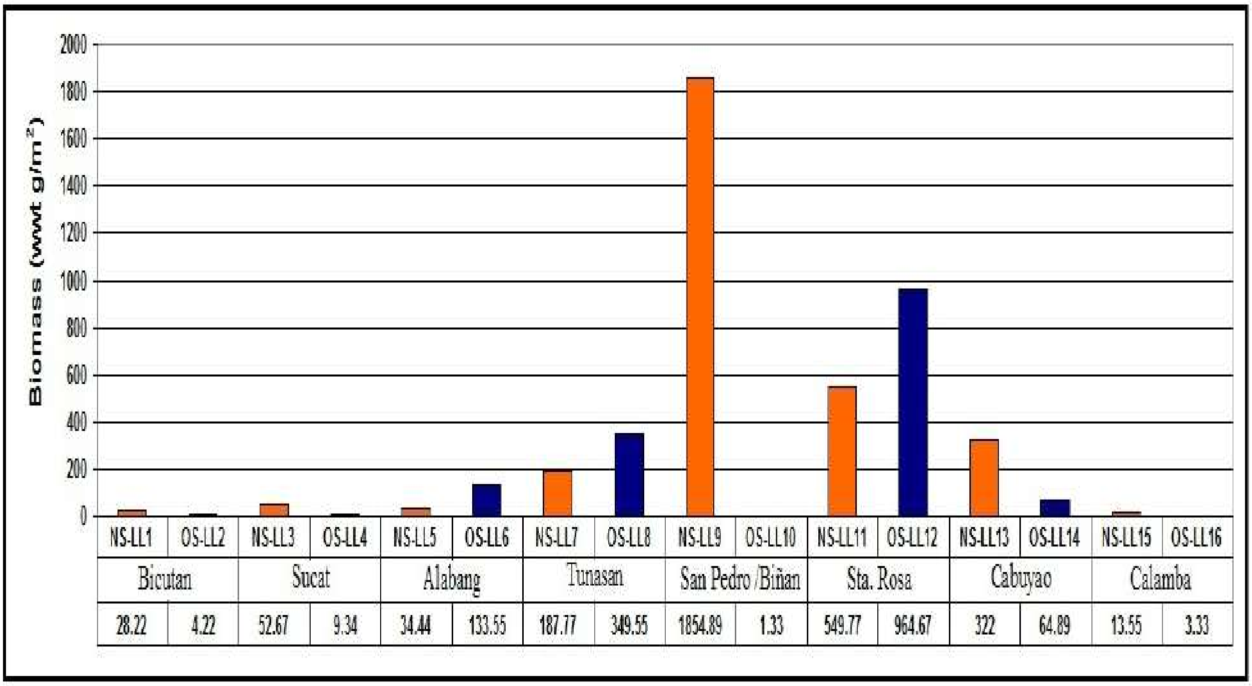
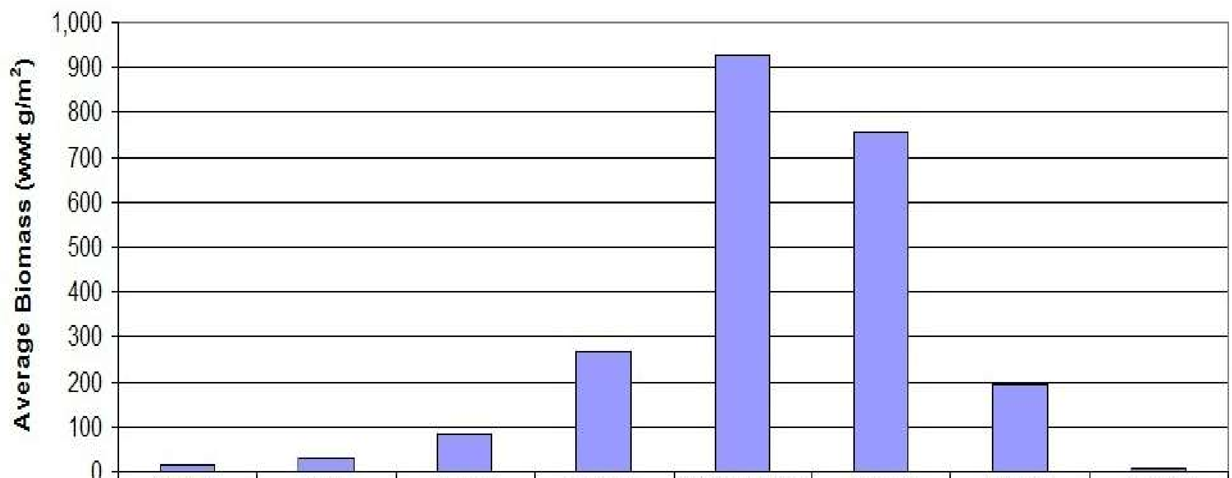


Figure 2.139 Variation in biomass (wwt g/m^2) of soft bottom infauna at the sixteen sampling stations in Laguna Lake

Legend: NS (Nearshore) = Alongside of the proposed road alignment
OS (Offshore) = About 1km from the proposed road alignment

Based on the average (nearshore and offshore stations when combined), the biomass of benthos was observed to be highest in San Pedro/Biñan (average 928.11 wwt g/m^2) followed by Sta. Rosa (average 75.22 wwt g/m^2). In descending order the stations with low biomass values were Tunasan (average 268.66 wwt g/m^2), Cabuyao (average 193.45 wwt g/m^2), Alabang (average 84.00 wwt g/m^2). The stations with low average biomass owing to their low densities of organisms were found in Sucat and Bicutan with 31.01 wwt g/m^2 and 16.22 wwt gm^2, respectively (**Figure 2.140**).



Bicutan	Sucat	Alabang	Tunasan	San Pedro /Biñan	Sta. Rosa	Cabuyao	Calamba
16.22	31.01	84.00	268.66	928.11	757.22	193.45	8.44

Figure 2.140 Variation in average biomass of soft bottom fauna at each of the eight transect locations (nearshore and offshore sampling stations combined) in Laguna Lake

Fishes of Laguna de Bay

The finfish resource in the open waters of Laguna de Bay before fish pen development is varied and made up of 23 species, belonging to 16 families and 16 genera (LLDA/WHO, 1978) (**Table 2.57**). The dominant species were the perch *Therapon plumbeus* (ayungin) and the white goby *Glossogobius giurus* (biyang puti) which represent about 93% of the open water fish harvests (Delmendo and Gedney, 1974). The other dominant fish species on the lake consist of the carp *Cyprinus carpio* (karpa), sea catfish *Arius* sp. (kanduli) and freshwater catfish *Clarias batrachus* (hito) (LLDA/WHO, 1978). None of these species consume algae. About 2/3 of the lake fish population is omnivorous (eats both plants and animals) and 1/3 are predators or carnivores. These species consume approximately 7% of the primary production of the lake (Delmendo, 1968; ADB, 1984). Because of the absence of herbivores in this group, only a relatively small part of the algae present in the lake was utilized and converted into fish flesh. The introduction of fish pen culture of milkfish *Chanos chanos* (bañgos), a herbivore (only eats plants), has changed substantially the situation in the lake (LLDA/WHO, 1978).

The presence of brackishwater species such as tarpon *Megalops cyprinoides* (buan-buan), halfbeak *Hemimramphus* sp. (kansuswit), freshwater eel *Anguilla mauritiana* (igat), tarpon *Megalops cyprinoides* (buan-buan) and mullet *Mugil cephalus* (talilong/banak) can be attributed to their migratory behavior (see **Table 2.57**). Their presence however indicates that, prior to the pollution of the Pasig River, migratory species from Manila Bay entered the lake through the Pasig River, the only outlet of the Laguna de Bay to the sea, stretching for 25.2

kilometers The Pasig River is technically a tidal estuary, as the flow direction depends upon the water level difference between Manila Bay and Laguna de Bay. During the rainy months of June to December each year, fish from Laguna de Bay are carried by floodwaters to the Pasig River. Unfortunately, during the dry summer months of March to May, the river is virtually dead because the water becomes stagnant with the much-reduced flow. **Figure 2.141** shows the Pasig River which provides the entry of migratory fish species to Laguna de Bay.

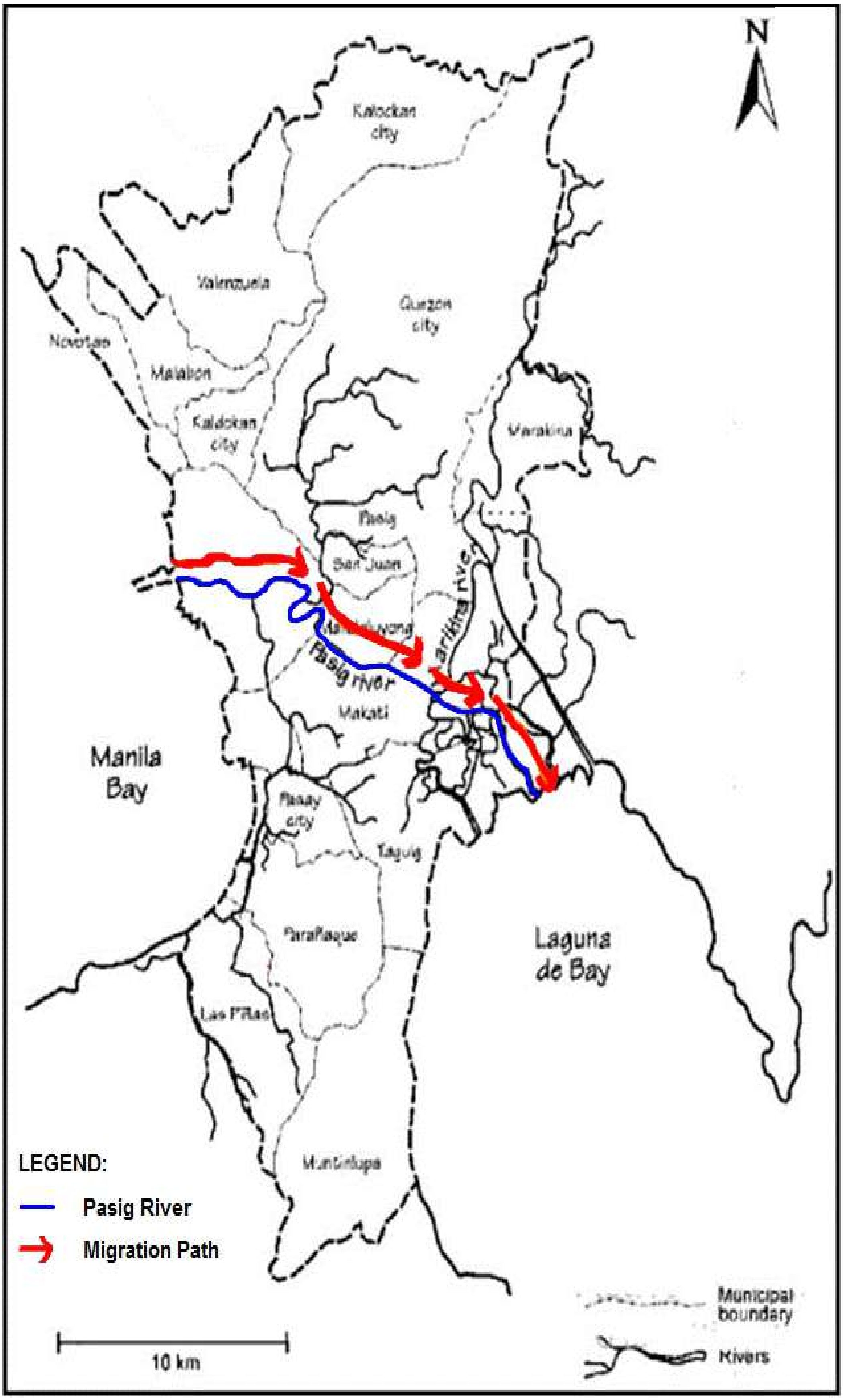


Figure 2.141 The Pasig River showing migration path of migratory fish species from Manila Bay to Laguna de Bay

Meanwhile, some of the species listed in **Table 2.57** are no longer present in the lake. Mr. Marvyn N. Benaning of Tempo (www. Tempo.com.ph/2012/09/17-indigenous-fish-species-laguna-de-bay-now-extinct/) reported that 17 fish species in Laguna de Bay are now extinct - that's what the fisherfolks say. According to the report, the 17 fish species that have disappeared after the construction of the Napindan Hydraulic Control Structure (NHCS) in 1982, which stopped the entry of saltwater from Manila Bay through the Pasig River, were climbing perch(martiniko), eel (igat), *Caranx* (talakitok), rock goby (biyang bato), halfbeak (kansuswit), sleeping goby (biyang tulog), white goby (biyang puti), tarpon (buan-buan), goby (dulong), mullet (talilong), snakehead (dalag), sneaker (papalo), tawes (tawes), spade fish (kitang), eel goby (baliga), snakehead (plasalid), and another kind of plasalid known as three spot. Furthermore, it was reported that the six (6) durable fish species that are still present in the lake are sea catfish (kanduli), native catfish (hito), carp (karpa), milkfish (bañgos), silver perch (ayungin) and *Tilapia* spp. (tilapia).

Table 2.57 Fish species found in Laguna de Bay before fish pen development in 1971 (Data source: LLDA/WHO, 1978)

Scientific Name	Common English Name	Common Local Name	IUCN Conservation Status
1. *Anabas testudineus*	Climbing perch	Martiniko	Least concern
2. *Anguilla mauritiana* (synonym of *A. marmorata)*	Mottled eel	Igat	Least concern (LC)
3. *Arius manillensis*	Sea catfish	Kanduli	Not evaluated (NE)
4. *Caranx* sp.	Caranx	Talakitok	
5. *Chanos chanos*	Milkfish	Bañgos	Not listed on any conservation registry
6. *Chronophorus melanocephalus*	Rock goby	Biya	
7. *Clarias batrachus*	Freshwater catfish	Hito	Least concern (LC)
8. *Cyprinus carpio*	Carp	Karpa	Critically endangered (CR)
9. *Hemiramphus* sp.	Halfbeak	Kansuswit	
10. *Glossogobius biocellatus*	Sleeping goby	Biyang tulog	Least concern (LC)
11. *Glossogobius giuris*	White goby	Biyang puti	Least concern (LC)
12. *Megalops cyprinoides*	Tarpon	Buan-buan	Least concern (LC)
13. *Micogobius lacustris*	Goby	Dulong/bulong	No evaluated (NE)
14. *Mugil* cephalus	Mullet	Talilong/banak	Least concern (LC)
15. *Ophicephalus striatus*	Snakehead	Dalag	Least concern (LC)
16. *Ophiocara aporos*	Sleeper	Papalo	
17. *Pontius javanicus*	Tawes	Tawes	
18. *Scatophagus argus*	Spadefish	Kitang	Least concern (LC)
19. *Taenioides* sp.	Eel goby	Baliga	

Scientific Name	Common English Name	Common Local Name	IUCN Conservation Status
20. *Leiopotherapon plumbeus*	Silvery therapon	Ayungin	Vulnerable (VU)
21. *Tilapia mossambica*	Tilapia	Tilapia	Not threatened (NT)
22. *Trichogaster pectoralis*	Snakehead	Plasalid/guoramy	Least concern (LC)
23. *Trichogaster tricopterus*	Three spot	Plasalid/guoramy	

Vallejo (1986) reported a total of 25 species of fish belonging to 25 genera and 17 families from Laguna de Bay. Five (5) species namely, *Carassius auratus* (goldfish), *Areochromis aureus* (blue tilapia), *Ophisternon bengalensis* (swamp eel), *Taenioides grac*ilis (slender eel goby) and *Doryichthysbrachyurus* (short-tailed pipefish), were also reported as new records from the lake.

Mercene (1990) reported that there are eight (8) common species in Laguna de Bay. These are *Glossogobius giurus* (biyang puti), *Therapon plumbeus* (ayungin)*, Ophicephalus striatus* (dalag), *Ophiocara aporos* (papalo), *Mirogobius lacustris* (dulong), *Anabas testudineus* (martiniko), *Arius macrocephalus* (hito) and *Arius manilensis* (kanduli).

Nasino (1994) reported that the commercially important fishes caught in the lake were *Tilapia* spp., *Leiopotherapon plumbeus* (ayungin), *Arius manilensis* (kanduli), *Glossogobius giurus* (biyang puti), *Aristichthys nobilis* (bighead carp), *Channos channos* (bañgos), *Ophicephalus striatus* (dalag), *Cyprinus carpio* (karpa), *Trichogaster* sp. (gourami), *Clarias* sp. (hito) and *Mirogobiuslacustris* (dulong).

The stock assessment of the major fishery resources in the lake done by Palma and Pol (1997) showed that the open water catch was composed of 13 species, including the shrimp commonly found in the lake. Of the fish species, the most commonly caught were *Tilapia* sp. (tilapia), *Hemiramphus nobilis* (kansuswit) and *Arius manilensis* (kanduli).

The baseline survey on fishes during the EIA study conducted by EcosysCorp. Inc., in January 2014 in the open waters of Laguna de Bay (West Bay) showed that there are seven (7) fish species most commonly caught in the area, namely: martiniko, karpa, biya, dalag, ayungin, tilapia and plasalid (**Table 2.58**). These aquatic resources are probably pollution-tolerant species. However, it was further reported that according to some of the local fisherfolks interviewed, the fish species martiniko, goby and plasalid are not anymore abundant and their populations are already declining.

Table 2.58 List of fish species found in the open waters of Laguna de Bay (West Bay) recorded during the January 2014 EIA study

Scientific Name	Common English Name	Common Local Name	Remarks
1. ***Anabas testudineus***	Climbing perch	Martiniko	Few (declining in population)
2. ***Cyprinus carpio***	Carp	Karpa	Still abundant
3. ***Micogobius lacustris***	Gobies	Biya	Few (declining in population)
4. ***Ophicephalus striatus***	Mudfish	Dalag	Still abundant
5.***Leiopotherapon plumbeus***	Silvery therapon	Ayungin	Still abundant
6. ***Tilapia nilotica***	. Tilapia	Tilapia	Very abundant
7. ***Trichogaster pectoralis***	. Snakehead/guoramy	Plasalid/gorami	Few (declining in population)

Source: EIA Study Report (EcosysCorp, Inc., 2014)

Added to the fish species present in Laguna de Bay are three (3) invasive and/or introduced alien fish species, the janitor fish (*Hypostomus plecostomus*), which acts as vacuum cleaner of the lake bed, and the equally voracious predatory knife fish (*Chitala ornata*) as well as the black-chin tilapia *Sarotherodon melanotheron* (**Plate13**).

The janitor fish is endemic/native in South America and was introduced to the Philippines through the aquarium fish industry. The proliferation of the janitor fish in Laguna de Bay, and Pasig and Marikina Rivers as well was due to the 1995 flood that occurred in Pila, Laguna brought by typhoon "Rosing" which has affected an aquarium fish breeding facility in the area. This has resulted to spillover of individual fish along the east section of Laguna de Bay. Because of poor recovery and absence of exploitation and / or utilization of the fish, populations increase in size, and individuals live longer, grow larger and developed increased productive potential. During rainy season, from June to November, the fish from Laguna de Bay are carried by floodwaters to the Pasig and Marikina Rivers (Adelaida Palma, Tanay Fisheries Station, BFAR, pers. comm., 2003). The fish then has been able to establish itself successfully in waters which are too badly polluted. Janitor fish has been observed to thrive up to Manila particularly along the riverbanks fronting Malacaňang and Plaza Lawton (Nenita de los Santos, Project Development Officer IV, Pasig River Rehabilitation Commission, pers. comm., 2003). Their presence is much more abundant and widespread in Marikina River than in Pasig River which certainly affects the abundances of soft bottom benthic organisms at the site (Lichel Technologies Inc., 2003).

The knife fish was introduced in the Philippines also through the ornamental fish trade. It occurs naturally in swamps, lakes and rivers of Southeast Asia and South America. Often regarded as the "big bully" in the aquarium, knife fish is known for its aggressiveness and highly carnivorous nature. One (1) kilogram knife fish which at present has no economic value as food fish can consume up to seven kilos of other fish species including small fishes, indigenous fishes, shrimps, and mollusks, among others (FishFiles, 2013). In the stock assessment study conducted by the BFAR and LLDA, the volume of knife fish in the catch composition of the eight (8) major fishing gears used in fishing operations in the lake has been reduced significantly from 40.35% in 2012 to 15.60% in 2018 (agriculture. com.ph/2018/03/11/campaign-vs-knife fish-intensified/). One of the strategies of BFAR IV-A in the containment of knife fish is to explore the economic utilization. Under this is the use of knife fish as a raw material in pos- harvest. The knife fish is now used as a raw material in nuggets, kikiam, siomai, fish ball, fish kropeck and fish patties (longdom.org/proceedings/utilization-of-knifefish-chitala-ornata-in-the-development-of-value-added-products). The government also discovered that it can be used as ingredients for fish meal for tilapia growers. Nowadays, knife fish caught in the lake are landed to Binangonan (Rizal) fish port for export to Thailand. According to a fish dealer, the knife fish is used as raw material for making fish ball.

The black-chin tilapia *Sarotherodon melanotheron* locally called "tilapiang gloria" or "tilapiang arroyo" was named after former President Gloria Macapagal-Arroyo probably because of its small size and mole or dark pigmentation under its lower jaw. This species was first reported in the coastal waters of Manila Bay and in the river tributary of Hagonoy, Bulacan (Ordonez *et al*., 2015). The extreme high volume of catch of this tilapia could be misinterpreted to be a good thing. However, this event could be alarming since the black-chin tilapia *Sarotherodon melanotheron*, is considered invasive and may even mean harm to the overall health of the lake. This species which is native to tropical West Africa is a demersal fish usually found in fresh to brackish waters (Campbell, 1987). This species has a wide tolerance for salinities and can travel freely in fresh and marine environments (Trewevas, 1983). This invasive fish species, which scientists say is implicated in the decline of native fish, which is taking over Queensland's freshwater catchments, and authorities conceded they are powerless to stop the spread (www.abc.net.au/news/2016-08-12/tilapia-infestation-in-south-east-queensland/7690180). Reports on the negative impact on the introduction of this tilapia species include predation of seeded milkfish (bañgos), other species of tilapia and possibly giant tiger shrimp. This is probably because of the carnivorous nature of the fish, which feed on other smaller fish larvae. Indeed, introduction of invasive species poses a serious threat to the natural ecosystem of an area (Ordonez *et al*., 2015). According to the news, the black-chin tilapia was introduced into the waters of Bataan several years ago, but it was not known who brought it into the country. The species could have been kept in an aquarium and later was released into the waters of Bataan and Bulacan until they reproduced in the wild. And now, the black-chin tilapia is considered a pest by fishpond owners in Bataan. Though, there was a report that fish growers and farmers in Bataan were using black-chin tilapia for sea bass which is being cultured (newsinfo.inquirer.net/439663/Gloria-an-abomination-in-bataan-fishponds).

Plate 13 (a) Janitor fish/*Hypostomus plecostomus*, (b) knifefish / *Chitala ornata*) and c) black-chin tilapia/*Sarotherodon melanotheron* (Source: Google)

There has also been a decline in species diversity over time. Looking back over historical records, 33 species have been recorded in the lake at different times. Now only five (5) of the nine (9) indigenous species remain, and all five (5) of the migratory species that used to arrive annually in the lake have disappeared. At present, catches are dominated by exotic aquaculture species (Lasco and Espaldon, 2005).

From the results of the current baseline study on fishes at the nearshore shallow water region along the proposed lakeshore road alignment and adjacent offshore/open water region (West Bay), it could be noted that the fish catches are made up of 19 species, belonging to 14 families and 17 genera (**Table 2.59**). Tilapias (including tilapiang gloria), kanduli, bañgos and Imelda/maya-mayang tabang/mamali are the most dominant/abundant species. Aside from these species, dalag, African hito and gorami, knife fish and janitor fish are also abundantly caught. On the other hand, common carp (karpa), ayungin, freshwater hito, and igat are not so abundant.

There was a report that the common carp or karpa (*Cyprinus carpio*) and *Tilapia mossambica* which have been introduced to the lake has not been established in the lake (only found in small numbers) which may be explained by the high abundance of predatory fish in the lake, mostly goby and snakehead (dalag) (fao.009/3/c5908e/c5908EO2.htm).

Table 2.59 Fish species observed, reported and recorded during the current baseline study

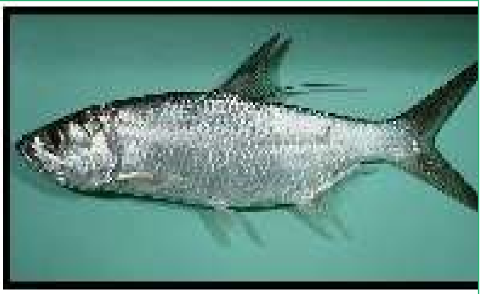
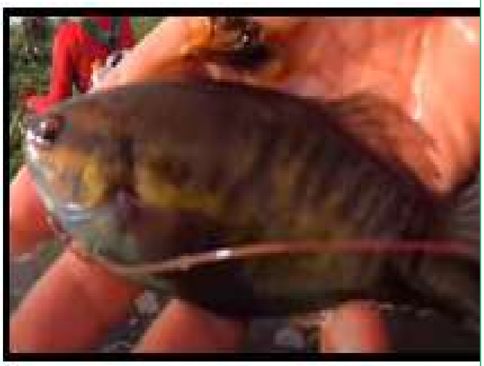
Fish Species/ Scientific Name	Common Name English	Common Local Name	Residency Status/ Occurrence	Global IUCN Conservation Status
Family Ciclidae				
***Tilapia nilotica* (currently as *Oreochromis niloticus*)** 	Nile mouthbrooder tilapia/giant tilapia	Tilapia/plapla	Introduced (non-native) Common	Least concern (LC)
***Tilapia mossambica* (currently as *Oreochromis mossambicus*)**	Mozambique mouthbrooder tilapia	Tilapia	Introduced (non-native) Common	Near threatened (NT)

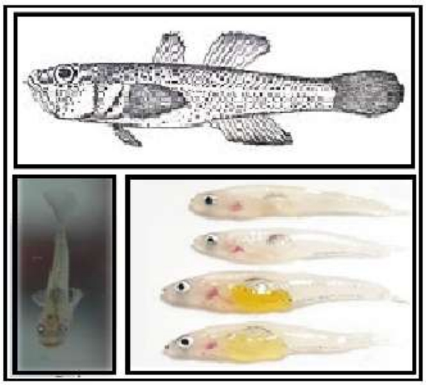
Fish Species/ Scientific Name	Common Name English	Common Local Name	Residency Status/ Occurrence	Global IUCN Conservation Status
				
Sarotherodon melanotheron 	Black-chin tilapia	Tilapiang arroyo/gloria	Introduced (non-native) Common	Least concern (LC); or no special status
Family Cyprinidae				
Cyprinus carpio 	Common carp	Karpa	Introduced (non-native) Declining	Critically endangered (CR)
Aristichthys nobilis	Bighead carp/"bighead"	Maya-mayang tabang/Imelda /mamali	Introduced (non-native) Common	Not threatened (NT)

Fish Species/ Scientific Name	Common Name English	Common Local Name	Residency Status/ Occurrence	Global IUCN Conservation Status
				
Family Ariidae				
Arius manillensis 	Sea catfish	Kanduli	Endemic (native) Common	Not evaluated (NE)
Family Chanidae				
Chanos chanos 	Milkfish/bañgos	Bangus	Introduced (non-native) Common	Not listed on any conservation registry
Family Clariidae				
Clarias batrachus	Freshwater catfish	Hito	Introduced (non-native) Declining	Least concern (LC)

Fish Species/ Scientific Name	Common Name English	Common Local Name	Residency Status/ Occurrence	Global IUCN Conservation Status
				
Clarias gariepinus  	African catfish	African hito	Introduced (non-native) Common	Least concern (LC)
Family Channidae				
Ophicephalus striatus	Snakehead	Dalag/bakuli	Introduced (Native) Common	Least concern (LC)

Fish Species/ Scientific Name	Common Name English	Common Local Name	Residency Status/ Occurrence	Global IUCN Conservation Status
				
Family Pterapontidae				
Leiopotherapon plumbeus  	Silvery therapon/silver perch	Ayungin	Endemic (Native) Declining	Vulnerable (VU)
Family Megalopidae				
Megalops cyprinoides	Indo-Pacific tarpon *	Buwan-buwan	Migratory (Native) Declining	Least concern (LC)

Fish Species/ Scientific Name	Common Name English	Common Local Name	Residency Status/ Occurrence	Global IUCN Conservation Status
				
Family Mugilidae				
Mugil cephalus 	Flathead mullet	Talilong/banak	Migratory (Native) Declining	Least concern (LC)
Family Osphronemidae				
Trichogaster pectoralis 	Snakehead guoramy	Plasalid/ goramy	Introduced (non-native) Common	Least concern (LC)
Family Gobiidae				
Glossogobius giurus (currently as G. giuris)	White goby	Biyang puti	Endemic (Native) Declining	Least concern (LC)

Fish Species/ Scientific Name	Common Name English	Common Local Name	Residency Status/ Occurrence	Global IUCN Conservation Status
 ***Micogobius lacustris* (currently as *Gobiopterus lacustris*)** 	Goby	Dulong/bulong	Endemic (native) Common	Not evaluated (NE)
Family Anguillidae				
***Anguilla mauritiana* (synonym *A. marmorata*)**	Freshwater eel	Palos/igat/ igat tabang	Endemic (native) Common	Least concern (LC)

Fish Species/ Scientific Name	Common Name English	Common Local Name	Residency Status/ Occurrence	Global IUCN Conservation Status
				
Family Loricariidae				
Pterygoplichthys disjunctivus/ Pterygoplichthys pardalis 	Sailfin catfishes/janitor fish**	Janitor fish	Introduced (non-native) Common	Not evaluated (NE)
Family Notopteridae				
Chitala ornata	Clown knife fish	Knifefish	Introduced (non-native) Common	Least concern (LC)

Fish Species/ Scientific Name	Common Name English	Common Local Name	Residency Status/ Occurrence	Global IUCN Conservation Status
				

Note:- Species listing was based mainly from interviews of key informants (local fisherfolks/fishing boat operators), market and fish landing surveys, observation of fish catch from actual fishing operations, desktop Internet search and secondary data/information from relevant reports/publications

(*) = Habitat: amphidromus-they migrate from the river/lake to the sea/estuaries, and from the sea/estuaries to the river/lake

(**) = Previously reported as *Hypostomus plecostomus*, but actually belong to the genus *Pterygoplichthys* which consisted of two species - *Pterygoplichthys disjunctivus* and *Pterygoplichthys pardalis,* both species can be found in the Laguna de Bay (Chaves et al., 2006)

Conservation Status of the Above Fish Species

The International Union for the Conservation of Nature and Natural Resources (IUCN) list Mossambique tilapia (*Tilapia mossambica*) as "near threatened while the bighead carp (*Aristichthys nobilis*) is "not threatened".

IUCN classifies black-chin tilapia (*Sarotherodon melanotheron),* white goby (*Glossogobius giurus*), freshwater eel (*Anguilla mauritiana*), snakehead guoramy (*Trichogaster pectoralis*), flathead mullet (*Mugil cephalus*), mudfish (*Ophicephalus striatus*), freshwater catfish (*Clarias batrachus*), and African catfish (*Clarias gariepinus*), Nile tilapia (*Tilapia nilotica*), and clown knifefish (*Chitala ornata)* under the "least concern" category, while milkfish (*Chanos chanos*) is not listed on any conservation registry. Least concern (LC) category of those species evaluated as not being a focus of species conservation (or species evaluated with a lower risk of extinction)

Moreover, the silver perch (*Leiopotherapon plumbeus*) is under "vulnerable" category. On the other hand, the only species listed in **Table 2.59** which is considered "critically endangered" globally is the introduced (non-native) common carp (*Cyprinus carpio*) (fisshbase.se/summary/Cyprinus-carpio.html).

Froese and Pauly (2018a) list *Cyprinus carpio* as native to Armenia, Azerbaijan, China, Georgia, Kazakhstan, Mongolia, Turkey, Uzbekistan, Austria, Bulgaria, Czech Republic, Hungary, Moldova, Russia, Serbia, Slovakia, Ukraine. *C. carpio* was introduced to Lake Mainit, Mindanao [Pauly et al. 1990; Mercene, 1997; Labajo and Nuñeza, 2003; De Guzman et al., 2008];including Kalinawan River [De Guzman et al. 2008], lakes Naujan and Taal [Mercene, 1997]; Laguna de Bay [Palma et al., 2005]; Lake Paoay, Ilocos Norte; Magat River, Nueva Viscaya; Lake Bato and Lake Buhi, Camarines Sur; Cagayan River, Isabela [Herre, 1953]; Lake Buluan [Yap et al., 1983]; and Lake Lanao [Mercene, 1997; Mamaril, 2001; Ismail et al., 2014]. Collected from CLSU fish pond, Nueva Ecija and Lake Taal Laurel, Batangas as a living specimen [Central Luzon State University, 1996]. Recorded from Candaba Swamp and Pampanga River [Paz-Alberto et al., 2009] (fws.gov/fisheries/ans/erss/higrisk/ERSS-Cyprinus-carpio_Final.pdf).

Residency Status

A total of 19 fish species were recorded from this present survey. Majority of these fish species were introduced (12 species) to the Laguna Lake due to the impacts of aquaculture and from land-based aquaculture facilities and ornamental fish trade (escapees). Endemic (native) species accounted to five (5) and two (2) migratory fish species. An endemic species is one which is native or naturally found only in a specific geographic area or region; not found in other places.

It is of interest to note that one (1) additional endemic species reported in the past is the *Neotethus ctenophorus* (Aurich 1937), which has a restricted geographic range and is known only from its type locality in Laguna de Bay. According to Internet search, there have been no confirmed records of this species in Laguna de Bay despite various ichthyological surveys in the past several decades. It is suspected that this species is possibly extinct due to various anthropogenic threats (species on the brink.org/species/neostethus-ctenophorus).
N. ctenophorus is listed as critically endangered (CR) (iucnredlist.org/species/128710699/128710736).

Critical Habitat Assessment (CH) for the Silver Perch *Leiopotherapon plumbeus* (Ayungin)

a. Introduction

Asian Development Bank (ADB) defines a Critical Habitat (CH): "A subset of both natural and modified habitat that deserves particular attention. Critical habitat includes areas with high biodiversity value, including habitat required for the survival of critically endangered or endangered species; areas having special significance for endemic or restricted-range species; sites that are critical for the survival of migratory species; areas supporting globally significant concentrations or numbers of individuals of congregatory species; areas with unique assemblages of species or that are associated with key evolutionary processes or provide key ecosystem services; and areas having biodiversity of significant social, economic, or cultural importance to local communities".

Critical habitat is a description of the most significant and highest priority areas of the planet for biodiversity conservation. It takes into account both global and national priority-setting systems and builds on the conservation biology principles of 'vulnerability' (degree of threat) and 'irreplaceability' (rarity or uniqueness). Critical habitat assessment is an analysis of the significant areas for biodiversity and conservation.

CH assessment used the approach set out in the 2019 IFC updates to Performance Standard No 6 Guidance Note (IFC, 2019). Habitats identified in the screening report were assessed if qualified under any of the CH criteria and if these will be affected by the project.

CH criteria are as follows and form the basis of any CH assessment:

- Criterion 1: Critically Endangered (CR) and/or Endangered (EN) species
- Criterion 2: Endemic or restricted-range species
- Criterion 3: Migratory or congregatory species
- Criterion 4: Highly threatened and/or unique ecosystems
- Criterion 5: Key evolutionary processes

Criterion 1, 2 and 3 relate to significance of species (i.e., threatened, restricted-range, and/or migratory) and have thresholds which are based on the risk of extinction of species as designated by the IUCN Red List status for each species. Criterion 4 and 5 relate to ecosystems and evolutionary processes and do not utilise thresholds.

b. Methods

Field assessments were conducted in December 2020 in order to document and validate fish species assemblage in the area. The assessments involved interview of key informants (local fisherfolks/fishing boat operators), a visit to a fish landing/market, and observation of fish catch from actual fishing operations, desktop Internet searches, and gathering secondary data/information on the conservation status of the various species found in the lake from relevant reports/publications, mainly using the IUCN Red List of Threatened Species.

The IUCN Red List is set up precise criteria to evaluate the extinction risk of thousands of species and subspecies. These criteria are relevant to all species and all regions of the world (en.wikipedia.org/wiki/IUCN_Red_List).

c. Findings of the CH Assessment- *Leiopotherapon plumbeus*

1. General Information

Based on the present assessment conducted, the silver perch *Leiopotherapon plumbeus* (ayungin) has been identified as present in Laguna de Bay. It is indigenous to Laguna de Bay and it is claimed to have been introduced to other water bodies including Naujan Lake in Mindoro, Taal Lake in Batangas and Sampaloc Lake in Laguna (philstar.com/business/agriculture/2017/07/15/12723995/reviving-ayungin-culture-laguna).

It is estimated to have undergone a decline in abundance of 38.4% over the past ten years based on fisheries catch statistics between 2008 and 2018. This decline is likely to continue due to overfishing, pollution, sedimentation, impacts of introduced alien invasive species, and habitat degradation. Therefore, this species is assessed as Vulnerable (VU) (academia.edu/469374021/Leiopotherapon_plumbeus_ THE_IUCN_RED_LIST_OF_THREATENED_SPECIES). A taxon is Vulnerable (V) when the best available evidence indicates that it meets any of the Vulnerable Criteria A to E for Vulnerable, and it is therefore considered to be facing a high risk of extinction in the wild (smsdocs.s3.amasonawas. com/RedListGuidelines.pdf).

2. Geographic Range

This species is endemic to the Philippines and is widespread in Luzon (Herre 1953). It is believed that this species is known only from Luzon (**Figure 2.142**). This is a commercially exploited species and traded around the major lakes in Luzon (Canoy et al., 2019). It is now used for stock enhancement of selected rivers and lakes in the Philippines. The government's stock enhancement programs may extend its geographic range.

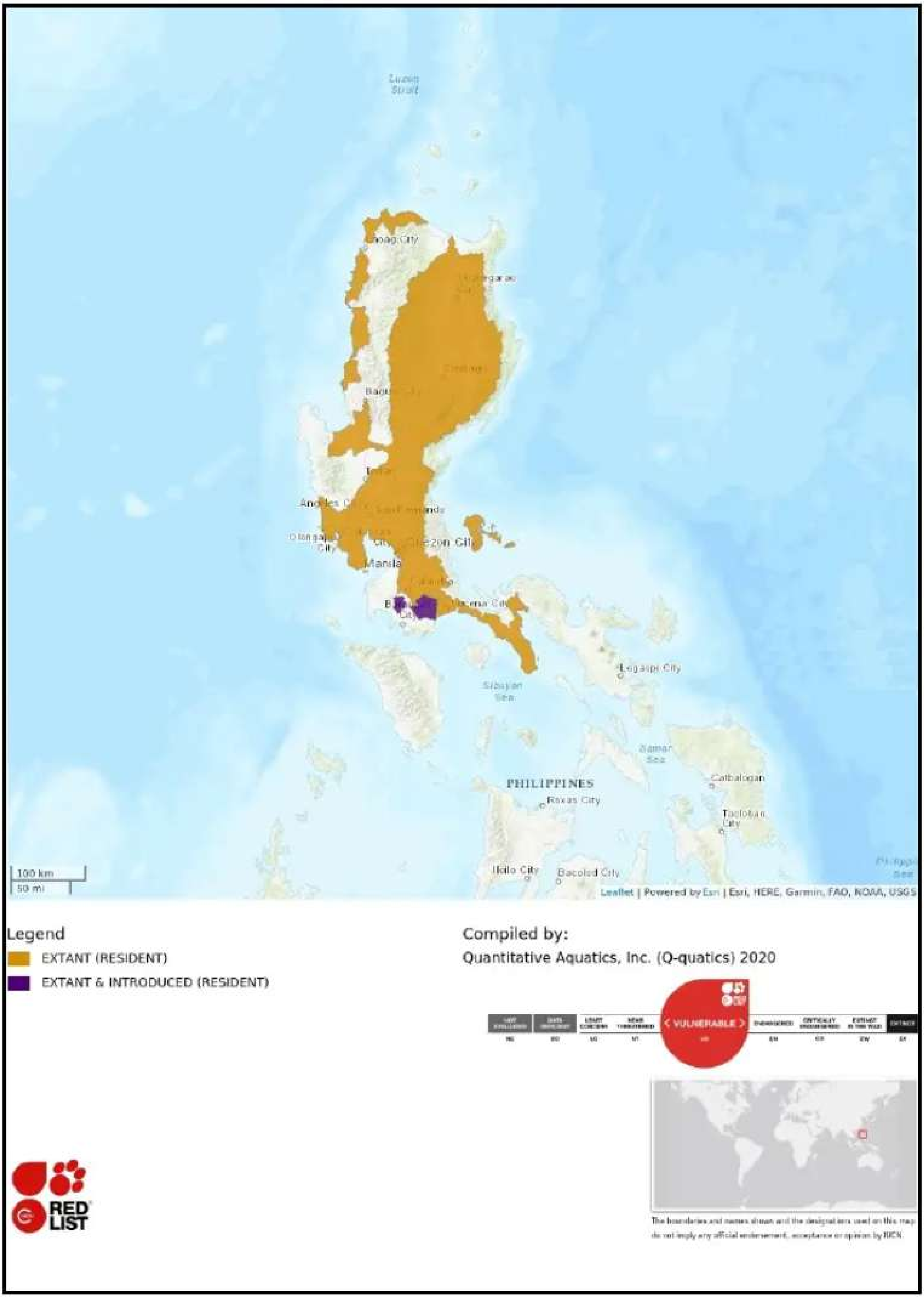


Figure 2.142 Distribution map of *Leiopotherapon plumbeus*

3. Conservation Measures

Stock enhancement programs have been implemented by the Philippine government agencies to restore depleted stocks and improve inland water fisheries production. Academic and research institutions have also initiated research interventions to conserve this species (academia.edu/469374021/Leiopotherapon_plumbeus_THE_IUCN_RED_LIST_OF_THREATENED_SPECIES).

d. Conclusion

Based on the results of the assessment, the conservation status of *Leiopotherapon plumbeus* is Vulnerable (V) - Criterion 1 and 2, endemic to the Philippines and widespread in Luzon.

Aquatic Invertebrates

Little is known about the invertebrate macrofauna of Laguna de Bay since interest has mainly concentrated on the commercially fished species, notably shrimps of the genus *Macrobrachium*, the Manila clam, *Corbicula fluminea* and snails of the genera *Pomacea*, *Thiara,* and *Melanifera* (**Plate 14**) (http://opus.ub.unihohenheim.de/voltexte/2003/35/pdf/Richter-03.pdf)

However, the information obtained during the present inventory of aquatic invertebrate fauna in the lake show a total of nine (9) species classified into one (1) pelecypod mollusc (bivalve), five (5) gastropod molluscs or snails (univalve), and three (3) species of freshwater shrimps (**Table 2.60**).

Table 2.60 List of aquatic invertebrates of Laguna de Bay

Scientific Name	Description	Common Name	Non-native / Native	IUCN Conservation Status (Global)
1. *Corbicula fluminea (synonym of Corbicula manilensis*	Bivalve mollusc	Asiatic clam/tulya	Native	Least concern (LC)
2 . *Melania* tuberculata	Gastropod mollusc	Snail / suso	Native	Least concern (LC)
3 . *Thiara* sp. (probably *T. scabra*)	Gastropod mollusc	Snail / suso	Native	
4 . *Pomacea canaliculata*	Gastropod mollusc	Snail / kuhol	Introduced (Non-native)	Least concern (LC)
5 . *Bellamya* sp.	Gastropod mollusc	Snail / kuhol	Native	
6 . *Neritina* sp.	Gastropod mollusc	Snail / kuhol	Native	

Scientific Name	Description	Common Name	Non-native / Native	IUCN Conservation Status (Global)
7, 8. *Macrobrachium lanceifrons*	Freshwater prawn/shrimp	Hipong tabang	Native	Not listed on any conservation registry
8. *Caridina gracilirostris*	Freshwater prawn/shrimp	Hipong tabang	Native	Not evaluated (NE)
9. *Metapenaeus affinis*	Freshwater prawn/sshrimp	Hipong tabang	Native	No evaluated (NE)

Note:- Species listing was based mainly from interviews of key informants (local fisherfolks/fishing boat operators), desktop internet search, and data from relevant reports/publications

The identified bivalve/clam is *Corbicula fluminea (synonym of Corbicula manilensis)* locally called *tulya* (**Plate14**). , Freshwater clams or tulya (the size of a 25 centavo coin) are sold to markets or selling them to locals as food or delicacy. The freshly gathered tiny clams are usually rinsed, then tossed in garlic, salt, chilli or any combination of spices.

Plate 14 Bivalve molluscs *Corbicula fluminea* (synonym of *Corbicula manilensis* locally called tulya (Photo source: Internet)

In addition to the freshwater clams, five (5) species of gastropod snails are also found along Laguna de Bay, namely, *Melania* sp.,*Thiara* sp, *Pomacea canaliculata* ., *Bellamya* sp. and *Neritina* sp. (**Plate15**). The snails of the Family Melanidae in the Laguna de Bay were being gathered as feed for duck raising industry. Connected with this industry is the making of balut.

Results of actual enumeration survey of all snail dredgers, duck raisers and daily sampling of landed catch of snails from selected areas of the lake undertaken by Mercene (1987) in 1982 showed that, there were 677 dredgers with an average catch of 364 kg/day. The annual production was estimated at 64,154 MT valued at PhP14,804,912 (at PhP0.23/kg). The snails withdrawn from the lake were all fed to 440,787 ducks raised by 2,369 duck farmers. Monthly feed requirement of ducks is 7,269 MT of snails or 0.5 kg/duck/day. The culture of snails (melanid) in the laboratory was also undertaken for a 10-month period. Sexual maturity was reached at about five (5) months old, at a length of 9 mm. Reproduction showed an average of 13 snails per month of 39 to 130 snails per year. The growth of snails depends upon the age. In the experiment, 10 to 11 mm snails showed very low growth or practically no growth at all. However, snails measuring 6 to 8 mm gave the highest growth, at an average of 2.3 mm per month.

A significant decrease in snail population of the lake has been reported which was due to rampant snail dredging to sustain the duck industry. Snail dredging has also been reported to be also one cause of the alarming decline in the population of the sea catfish (*Arius manillensis*) which used to constitute the fishery of Laguna de Bay.

When the Laguna Lake Development Authority (LLDA) prohibited the gathering of shells for feeding ducks to prevent over exploitation, the duck raisers shifted to commercial feeds, which are much more expensive than shells. Because the native duck (itik) only had a 50 percent egg production rate and the commercial feeds were expensive, many of the duck raisers lost money and had to give up their projects (agriculture-com-ph/2018/10/26/three-new-philippine-mallard-lines-developed/).

Sacks of molluscs including various species of snails and freshwater clams are harvested from nearby lakes and fed to ducks (**Plate 16**). A sack costs about PhP300, providing ducks with vital calcium for egg-laying (thepoultrysite.com/articles/time-to-give-a-duck-the-Philippines-duck-industry).

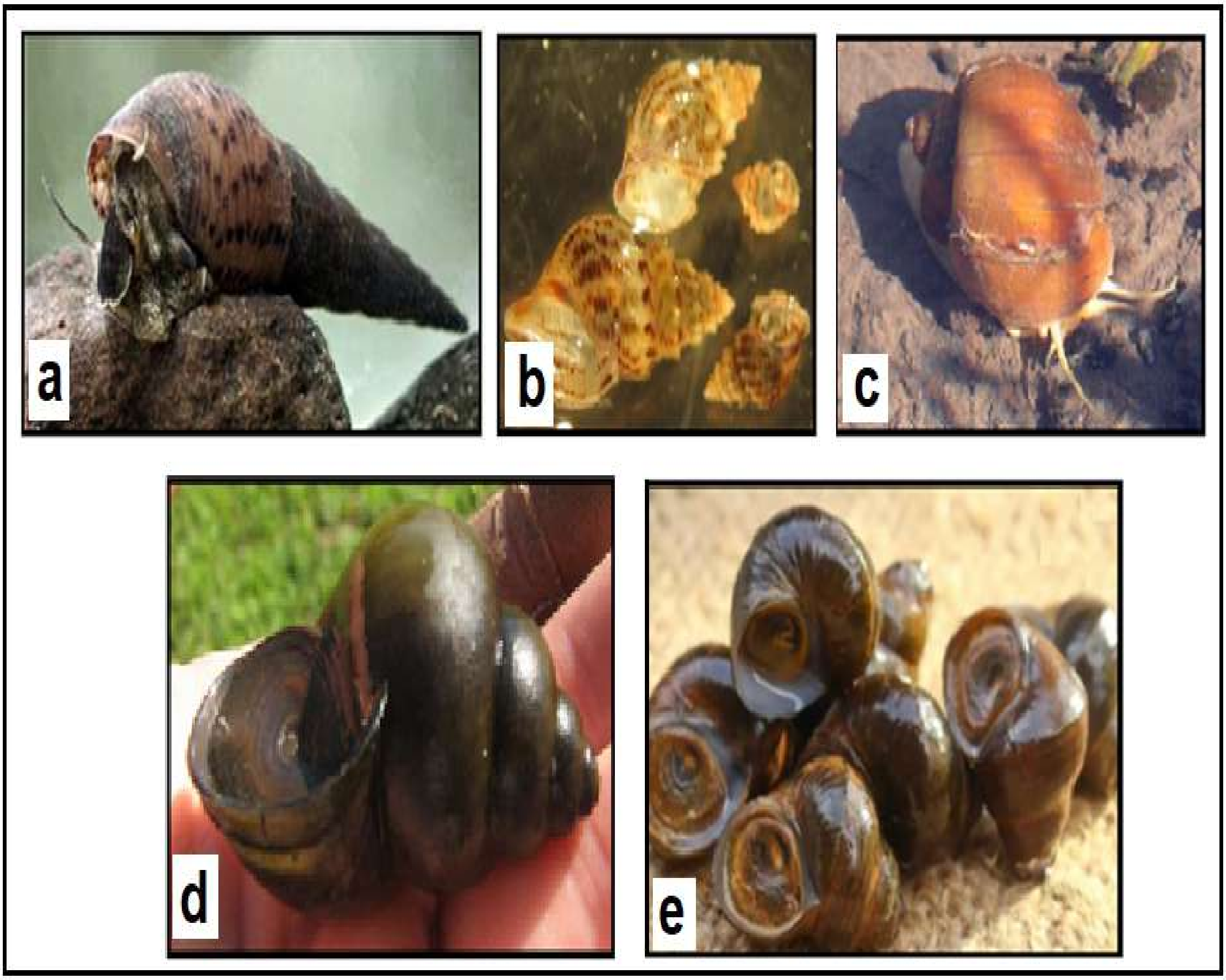


Plate 15 Freshwater snails (a) *Melania* sp. (probably *M. tuberculata*) , (b) *Thiara* sp. (probably *T. scabra*), (c) *Pomacea* sp. (probably *P. canaliculata*), (d) *Bellamya* sp., and (e) *Neritina* sp. (Photo source: Internet)

Plate 16 Sack of various species of snails including freshwater clams as feed for ducks (Photo source: thepoultrysite.com/articles/time-to-give-a-duck-the-Philippines-duck-industry).

In Laguna de Bay, three (3) families of shrimps/prawns occur, namely, the Palaemonidae, represented by *Macrobrachium lanceifrons*, the Atyidae, represented by *Caridina gracilirostris* , and the Penaeidae, represented by Metapenaeus affinis ((fao.org/3/ac741t/AC741T23.htm) (**Plate 17**). Of these species, *M. lanceifrons* is the most common, *C. gracilirostris* is also common but, due to their very small size, these prawns are only collected when they occur in swarms at certain periods of the year. *M. affinis* is rare in the lake. They were reported to be abundant along the project site in the nearshore shallow portion of the lake where water lilies and kangkong are abundant. The shrimp is harvested commercially in Laguna de Bay. There was also a report that two (2) to three (3) hours nighttime fishing operation along the lakeshore at the project site with the use of 300 pieces of shrimp pots/traps (bubo) could catch up to 10 kilos of shrimp. The shrimp is sold for PhP80 up to PhP150 a kilo in the public market.

Plate 17 Crustacean shrimp *Macrobrachium* sp. caught by shrimp pot/trap (traditional bubo sa hipon) in Laguna Lake (Photo source: YouTube Vlogs)

Aquatic Macrophytes

Aquatic macrophytes in the lake range from the submersed, floating to the emergent species. These serve as a homing ground or shelter, a place for egg deposition, and as a source of food to many larval forms of aquatic fauna. Both the floating and benthic rooted forms help cleanse the water of its pollutants. An overgrowth of floating macrophytes may control the density of phytoplankton. Rooted macrophytes absorb minerals and heavy metals from the sediments and stabilize the substratum (Aguilar 2003 as cited by Zafaralla et al., 2005). They form a part of the transition zone between the aquatic and the terrestrial ecosystem. When aquatic macrophytes decay they contribute to soil formation, a cause for the rapid shoaling of the lake especially where *Eichornia crassipes* (water lily or water hyacinth) grows luxuriantly.

Twenty-four (24) species of aquatic angiosperms were reported for Laguna de Bay in a 1961 Philip. J. Biol. publication (cited in WHO / LLDA, 1978).

The lake vegetation generally has a low diversity of vascular plants, usually consisting of species that often have very wide distribution range (Lasco and Espaldon, 2005). Pancho (1972) as cited by Lasco and Espaldon (2005) recorded 19 families and 24 genera and species of aquatic angiosperms (**Table 2.61**). Two (2) dominant and economically important species here are *Eichornia crassipes* and *Pistia stratiotes*. These arecharacterized by generally rapid population growth and can disrupt navigation, interfere with fisheries, and affect fish and other aquatic animals by lowering oxygen and pH of the water.

Table 2.61 Checklist of the aquatic angiosperms of Laguna Lake, 1972

Species	Family	Local Name	Distribution	Non-native / Native	IUCN Conservation Status
***Nelumbo nucifera* Gaertn.**	Nymphaeaceae	Baino, Sacred Lotus	Trop. continental Asia, Malesia, N Australia	Native	Not evaluated (NE)
***Nymphaea nouchii* Burm.f.**	Nymphaeaceae	Labas, Lauas, Lotus lily	SE Asia to New Guinea	Native	
***Polygonum tomentosum* Willd.**	Polygonaceae	Subsuban	Trop. Asia & Africa	Native	
***Ceratophyllum demersum* L.**	Ceratophyllaceae	Arigman	Temp. & Tropic regions	Native	Least concern (LC)
***Nasturtium indicum* (L.) DC.**	Brassicaceae	-	Trop. Asia & Malesia	Native	Least concern (LC)
***Myriophyllum spicatum* L.**	Haloragaceae	Lomot ilog	Warm & Temp. regions	Native	Least concern (LC)
***Ludwigia adcendens* (L.) Hara**	Onagraceae	Sigang-dagat	Pantropic	Native	Least concern (LC)
***Nymphoides indica* (L.) O. Kuntze**	Gentianaceae		Trop. Africa & Asia, Malesia, Australia, Polynesia	Native	Least concern (LC)
				Native	Least concern (LC)
***Ipomoea aquatica* Forssk.**	Convolvulaceae	Kangkong	Trop. Africa & Asia, Malesia, Australia	Native	Least concern (LC)
***Limnophila rugosa* (Roth) Merr.**	Scrophulariaceae	Tala, Taramhapan	India, Malesia, Polynesia	Native	Least concern (LC)
***Bacopa monnieri* (L.) Pennell**	Scrophulariaceae	Olasimang aso	Pantropic	Native	Least concern (LC)
***Potamogeton malaianus* Miq.**	Potamogetonaceae	Damong-kulot	India to China, Japan, Java, Sumatra, Borneo	Native	Least concern (LC)
***Eichornia crassipes* (Mart.) Solms**	Pontederiaceae	Water hyacinth	Native of Brazil; now widespread in tropics	Native	Not found in IUCN Red List
***Scirpus grossus* L.f.**	Cyperaceae	Tikiu, Tikug	India, Indo-China, Malesia to Bonin Island	Native	Least concern (LC)
***Panicum repens* L.**	Poaceae	Luya-luyahan	Trop. & Subtropics	Native	No threat

Species	Family	Local Name	Distribution	Non-native / Native	IUCN Conservation Status
***Leersia hexandra* Sw.**	Poaceae	Barit	Pantropic	Native	No threat
***Lemna persilla* Torrey**	Lemnaceae	Liya	Pantropic	Native	
***Spirodela polyrrhiza* (L.) Schleid.**	Lemnaceae	Liyang-laot	Pantropic	Native	No threat
***Pistia stratiotes* L.**	Araceae	Kiapo	Pantropic	Native	Least concern (LC)
***Najas graminea* Delile**	Najadaceae		Africa, trop. Asia, Taiwan, Japan	Native	Least concern (LC)
***Hydrilla verticillata* (L.f.) Royle**	Hydrocharitaceae	Lumot-lumotan	Europe, Africa, Asia, Malesia, Australia	Native	Least concern (LC)
***Vallisnera natans* (Lour.) Hara**	Hydrocharitaceae	Sintas-sintasan	SE Asia, Malesia, Australia	Native	Least concern (LC)
***Ottelia alismoides* (L.) Pers.**	Hydrocharitaceae	Damong ilalim	Africa, Asia, Malesia, Australia	Native	Least concern (LC)
***Typha angustifolia* L.**	Typhaceae	Balangot	Temp. & trop. regions	Native	Least concern (LC)

According to Lasco and Espaldon (2005), "around the mid-1980s, a tremendous decrease in their population occurred. *E. crassipes* (water lily) and *Hydrillaverticillata* (dugman) were strongly decimated. The former used to threaten the economic gains of fishpen owners during the monsoon season because of the losses incurred when fishpens were knocked down by the wind-blown thickets of the plant. Today, one no longer finds this type of a threat, because floating macrophytes are virtually gone except in the outskirts, primarily of South bay and East bay. Such a diminution in a usual component of the aquatic biota could have tremendous impact on associated fauna, but this has not been investigated. Submersed macrophytes are not an exception. These used to cover the bottom of the shallow lake to the extent that plants' parts are among the materials that entangle the rudder of motorized boats along with plastic and the like. Today, this kind of a problem no longer causes as much nuisance."

Helicopter flight surveys made during the conduct of the Comprehensive Water Quality Management Project for Laguna de Bay by WHO/LLDA (1975-1978) noted that only the following species are of major importance along the shallow shoreline:

Plate 18a. Observed Species with major importance

Najas graminea 	**Water nymph**
Vallisneria gigantean	Lusay or eel grass

	
Hydrilla verticillate 	Dugman
Eichornia crassipes 	Water lily or water hyacinth

Photo source: Internet

Among these aquatic macrophytes, the water hyacinth (*E. crassipes*) is found all over the lake and in the river mouths. Its quantity is estimated to be about 5,000 metric tons of biomass (wet weight) containing about 8 metric tons of nitrogen and 2 metric tons of phosphorus (Michell *et al*., 1974 as cited in WHO/LLDA, 1978).

The area covered with aquatic macrophytes in 1977 is presented in **Figure 2.143**. This map needs updating considering that around 43 years have already passed since the map was constructed.

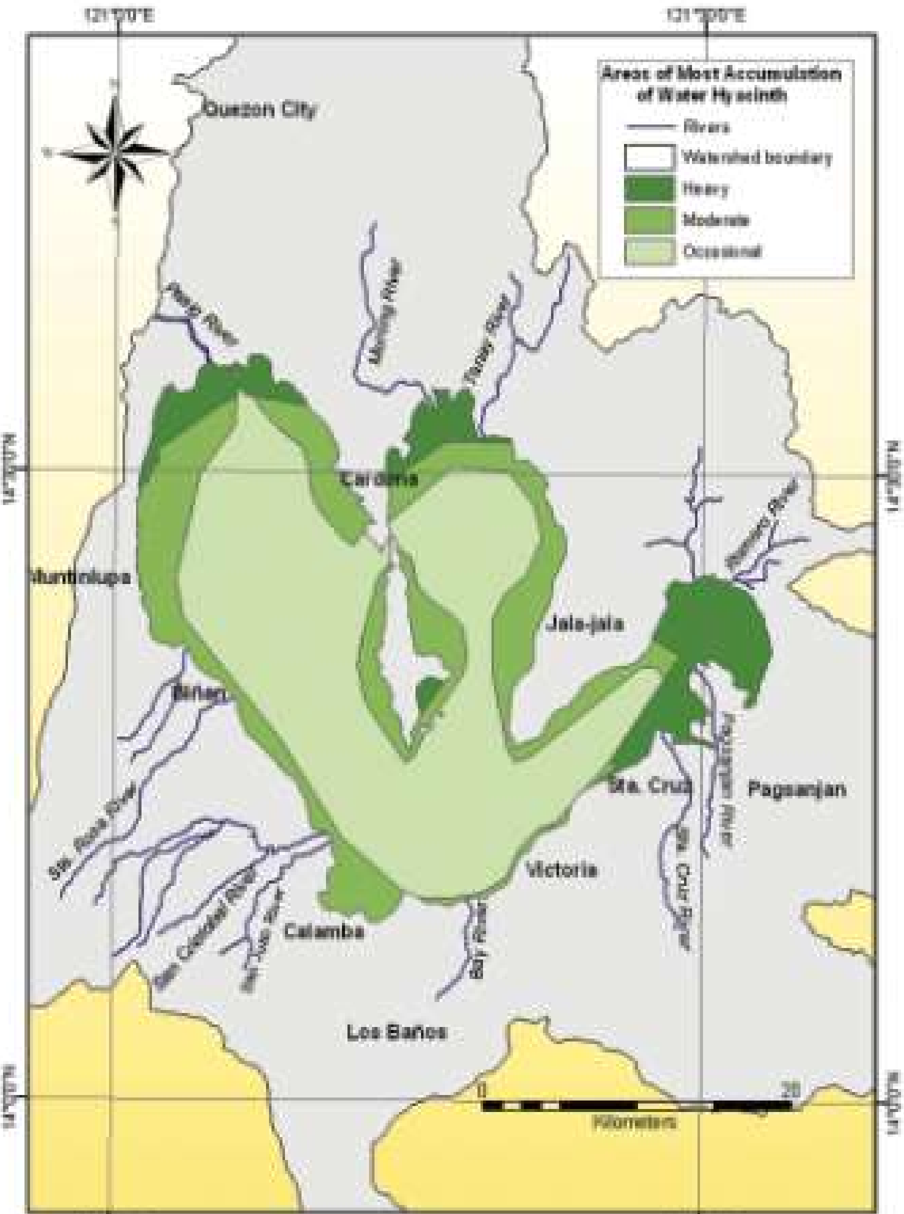


Figure 2.143 Areas of most frequent accumulation of aquatic macrophytes in Laguna de Bay, June – October 1977 (Figure taken from Lasco and Espaldon, 2005)

There was a report noting that there used to be 13 kinds of aquatic plant life in the Laguna de Bay, now, only two (2) were left, the water spinach or kangkong (*Ipomoea aquatica*) and the water hyacinth or water lily (*Eichornia crassipes*) (**Plate 18)** (PRRP – RRS, undated).

In the project area, at the time of the present survey, the only major aquatic plant lives along the lakeshore were the water hyacinth (*E. crassipes*) and water spinach or kangkong (*I. aquatica*). Kangkong is a vegetable that is good for health and it is also a source of income for the local. It was observed being grown along the lakeshore (panabi) of Brgy. San Roque in San Pedro, Laguna (see **Plate 18**). The harvest of kangkong is sold in public markets all over Metro Manila (**Plate 19**).

Plate 18b (a) water hyacinth or water lily (*Eichornia crassipes*) and (b) water hyacinth and kangkong (*Ipomoea aquatica*) in Brgy. San Roque, San Pedro (Photo source: a. Internet, b. EcosysCorp, Inc., 2014)

Plate 19 Harvesting of kangkong (*Ipomoea aquatica*) in Laguna de Bay (Photo source: Internet)

Water hyacinth ((*Eichornia crassipes*) is a native of South Americas. It was introduced into many parts of the world, including the Philippines in 1912, as an ornamental garden pond plant due to its beauty. But today it is considered as a pest as 10 plants could produce well over 650,000 offspring within eight (8) months. In Laguna de Bay, water hyacinth is considered a nuisance. These plants now cover some 20% of the lake's surface area (Gaia Discovery, 2009).

According to Davies (undated), too much water hyacinth (*Eichornia crassipes*) is detrimental for several reasons:

- Obstruction of water ways and causing damage to fishing structures such as fish corrals (baklad) and fish pens;
- Reduction of oxygen levels in the water;
- Reduced light penetration which reduces phytoplankton production; and
- Reduced light penetration which leads to decreased mortality of bacteria and viruses pathogenic to humans;

However, some cover is advantageous because water hyacinth concentration act as fish attraction devices by (Davis, undated):

- Providing areas of shade for fish; and
- Providing refuge for fish food organism.

To reduce these problems, water hyacinth can be controlled by the following measures (Davies, undated):

- Reduction of the fish pen area will reduce calm areas which favor water hyacinth; and
- Mechanical removal by harvesters, especially in creeks used as access to the lake by some fishermen. There are already signs that the LLDA are doing this.

Control of herbicides. This is not a very satisfactory method of control since herbicides may kill non-target organism. If water lily is killed by this method, the dying plants must be removed or else their decay will remove all the oxygen in the water.

Opening of the Hydraulic Control Structure (HSC) to allow saltwater into the lake. However, it is not absolutely certain that the salinity will be enough to kill the plants. There should be research initiated to determine the salinity at which water hyacinth is killed and controlled.

Fisheries

Types of Fishery

Fisheries, which includes capture fisheries and aquaculture (fish pens and fish cages), is the dominant use of the Laguna Lake. An estimated 13,000 fishermen depend on the lake for their livelihood. The Laguna Lake produces about 80,000-90,000 MT of fish in a year (llda,gov.ph/existing-lake-uses/). Thus, the lake is classified as a Class C water body. This means its water quality needs to be suitable for fishery based on the DENR Administrative Order No.2016-08.

Capture Fisheries (or Open Water)

(a) Annual Fishery Production

Fish capture operations in the lake is mainly for sustenance purposes rather than for commercial endeavors (Delmendo, 1977). Generally, the quality of fish obtained in the lake is quite poor due to the small size of the fish caught (Delmendo, 1977).

Open water fishing has been carried out in the lake for a considerable time. The fish yield greatly declined in the 1960's with the advent of small motorized boats which replaced sailing craft, the widespread use of small mesh monofilament nets and the use of illegal types of fishing such as poisoning (LLDA, 1985). In 1961 to 1964, the commercial fishery of the lake consisted of finfish, shrimps and molluscs (clams and snails). The lake's estimated annual fishery production varies. Available information on fish production based on researches and published data/reports are presented below.

Laguna de Bay Basin Technical Report 2016 (Laguna de Bay Technical Working Group-LLDA/World Bank/WAVES): The average fish catch in the 78,627 hectares allocated to open water fisheries is 7,663 kilograms per fisherman per year. West Bay yielded the highest fish catch, followed by the East Bay and the Central Bay. **Table 2.62** presents details on open water fisheries in the Laguna Lake based on the LLDA data.

Table 2.62 Annual average fish catch by open water fishermen in Laguna de Bay in 2014

Location	Open Water Area (Hectare)	No. of Fishermen (2010 Data)	Average Catch (All Species) per Fisherman (kg/year)
West Bay	43,983	6,839	10,607
Central Bay	20,574	3,364	3,766
East Bay	14,069	2,936	7,309
Total	**78,627**	**13,139**	**7,663**

Source: Laguna de Bay Basin Technical Report 2016 (Laguna de Bay Technical Working Group-LLDA/World Bank/WAVES)

(b) Number of Fishermen

In a 1968 survey, there were about 8,000 full-time and 2,000 part-time fishermen who utilized the lake as a communal fishing area (WHO/LLDA, 1978).

A socioeconomic survey conducted in 1996 (Palma 1997) showed that there are 3,055 fishermen. The Bureau of Agricultural Statistics (BAS) in 1991 reported a total of 6,833 fishermen operating in the lake, showing 50.4 percent decline in the fishermen population within the five- year period (**Figure 2.144**). This decreasing trend in the number of fishermen has been observed over the 37 years when the first major fisheries assessment was conducted. From the 13,000 fishermen operating in the lake in the study of Delmendo in 1963, Delos Reyes (1995) noted a 60 percent decline in 1973, two (2) years after the establishment of fishpen in the lake. The number of fishermen operating in the lake again decreased to 8,620 in 1983 primarily due to the decrease in the lake productivity (Pacardo 1993).

In 2010, the total number of fishermen engaged, either full-time or part-time, in open water fisheries is estimated at 13,139. The West Bay showed the highest number of fishermen, followed by the Central Bay and the East Bay (6,839, 3,364 and 2,936, respectively (see **Table60**).

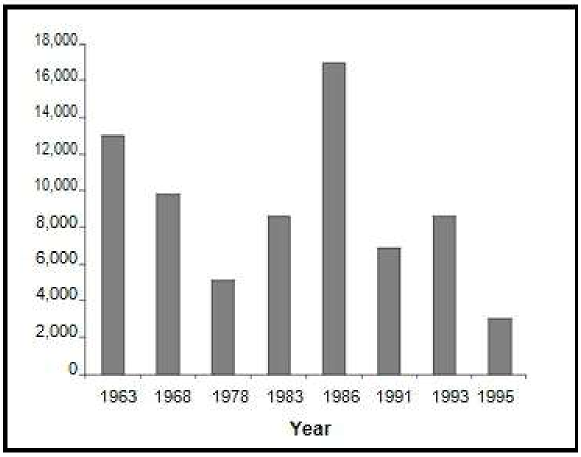


Figure 2.144 Fishermen population in the Laguna Lake Basin, 1963-1995 (Source: Lasco and Espaldon, 2005)

(c) Fishing Season

Fishing and gathering of fish and other aquatic products are extremely heavy along the west side of the Laguna de Bay. Fishing operations take place round the clock. The fishing's peak season is usually during "taglinaw", *i.e*. from March to October, coinciding with summer period and southwest monsoon season ("habagat"). The lean period is from November to February, coinciding with the northeast monsoon season ("amihan") when rough water conditions in the area make fishing difficult.

(d) Fishing Boat

Except for a few operators, the lake fisheries are mainly exploited by traditional fishing methods typical of small village fishery operations. The fishing crafts are small non-motorized or paddle driven wooded dugouts (**Plate 20**) or narrow beam boats with outriggers powered by inboard motors (**Plate 21**).

Lasco and Espaldon (2005) reported that in 1978, 80% of the fishermen owned boats while 12% had no boats. The boats are either motorized or non-motorized. The motorized boats range from 1.83 m to 17.37 m (6 ft. to 57 ft.) using from one (1) piston engine of Briggs Stratton or Kohler to six (6) pistons of Isuzu or Toyota engines. The 2,863 motorized boats and 1,624 non-motorized boats are listed by municipalities in **Table 2.63**. Increases in the number of boat owners (99.5%) and in the number of motorized boat were noted in 1995 which added to the fishing pressures in the lake.

Results of the actual observations and interviews in the present survey revealed that in most fishing operations, there are usually about 1-2 persons aboard one (1) fishing boat. The number of fishers operating a fishing gear per fishing operation highly depends on the type and size of the boat/fishing gear. The lake is heavily fished as evidenced by the existence of more than 10,000 fishermen operating on the lake (www.fao.org/3/c590bc/c5908E02.htm).

Plate 20 Non-motorized or paddle driven boats observed in the area (Photo source: EcosysCorp., Inc., 14 January 2014)

Plate 21 (a and b) Fishing operations of local fisherfolks using gill net ("pante") as observed during the baseline survey, 19 December 2020; and (c and d) water hyacinth and fishing boats in Laguna de Bay (Photo source: Internet)

Table 2.63 Number and type of fishing boats by municipality

Municipality	Type of Boat	
	Non-Motorized	Motorized
Jalajala	51	177
Pililla	94	114
Tanay	21	32
Baras	3	24
Morong	58	55
Cardona	218	413
Binangonan	274	152
Angono	10	36
Taguig	41	49
Muntinlupa	19	25
Total- Rizal Province	**789**	**1,077**
San Pedro	43	40
Biñan	17	11
Sta. Rosa	40	142
Cabuyao	59	123
Calamba	85	289
Los Baños	48	88
Bay	38	148
Victoria	11	25
Pila	23	24
Sta. Cruz	142	203
Pagsanjan	11	3
Lumban	73	48
Kalayaan	64	44
Paete	12	24
Pakil	73	49
Pangil	70	52
Siniloan	20	110
Mabitac	6	2
Total - Laguna Province	**835**	**1,425**
Grand Total	**1,624**	**2,502**

Source: Lasco and Espaldon (2005)

(c) Fishing Gears

In 1968, the number of different types of fishing gear used in the lake was estimated at 43 (WHO/LLDA (1978). The most common fishing gears were fish corrals/traps (baklad), gill nets (pante) and push nets (sakag).

Lasco and Espaldon (2005) reported that there are 20 types of fishing gears operate in Laguna de Bay. Sixty-five percent (65%) are categorized as active (non-stationary), and thirty-five percent (35%) are classified as passive (stationary) gears (**Table2.64**). The highly productive or major gears are gill net, fish corral, motorized push net, fyke net, fish traps, fish pots, and long line (Mercene, 1987). However, in the 1996 survey (Palma, 1997), the longline was replaced by manual seine/fish shelter as a major fishing gear. The motorized push net, motorized drive-in net, and the manual push net were found to be the most efficient gears. Most of the gears are operated throughout the year while others are seasonal in use. Specific type of gear is required for different species and fishing season. The operation of multiple gears, which included the combination of gill net and fish corral; gill net and fish pot; gill net and fyke net; gill net and fish trap; gill net and longline; gill net and spear; gill net, fish corral, and fish pot; gill net, fyke net, and fish pot; and gill net, scissor net, and fish trap.

Table 2.64 Types of fishing gears operating in Laguna de Bay

Type of Gear	English Name	Local Name
Active (Non-stationary) Gear	Cast net	Dala
	Cover pot	Sukob, salakab
	Drag seine	Pukot
	Dredge	Kaladkad, pangahig
	Gill net	Pante
	Harpoon, spear	Salapang, pana
	Lift net	Salambaw
	Manual drive-in net	Dayakos, Biyakos
	Manual push net	Sakag
	Motorized drive-in net	Harikit
	Motorized push net	Suro
	Pole and line	Biwas
	Scissors net	Salap
Passive (Stationary) Gear	Drift long line	Kitang
	Fish corral	Baklad
	Fish pot	Bubo, saklet
	Fyke net	Skylab
	Manual seine, fish shelter	Sapyaw, Takibo, bumbon
	Fish trap	Roborat, patanga
	Shrimp brush shelter	Gatang-gatang

Source: Lasco and Espaldon (2005)

It was reported in 2010 that the most commonly used fishing gear by the capture (or open water) fishermen in the Laguna de Bay are the gill net (pante) and fish corral (baklad) [Laguna de Bay Basin Technical Report 2016 (Laguna de Bay Technical Working Group-LLDA/World Bank/WAVES)].

The fishing gears/methods operating within a distance of 500 m from the lakeshore as observed during the EcosysCorp., Inc. 2014 survey in selected areas along the west side of the lake is summarized in **Table 2.65** The most commonly used fishing gear is the stationary baklad or fish corral which generally operates within a distance of 200-300 m from the shore and primarily target assorted species of fishes and other aquatic life such as shrimps. However, Cabuyao has no baklad. The next most commonly used gear in the area is the gill net (pante) followed by push net (sakag) and pole and line/hook and line (binwit). Fishing for recreation and for home consumption was also reported mainly with the use of pole and line (binwit) which used to catch commercially important fishes such as tilapia, dalag, karpa, kanduli, and gourami.

Table 2.65 Types of fishing gear/method used along the shore of Laguna de Bay (West Bay), January 2014

Fishing Gear/Method	Observation Site			
	Muntinlupa	San Pedro	Cabuyao	Los Baňos
1. Fish corral (baklad)	X	x	-	x
2. Gill net (pante)	X	x	x	x
3. Cast net (dala)	X	x	x	-
4. Push net (sakag)	X	x	x	x
5. Hook and line (biwas / binwitl)	X	x	x	x
6. Pole and line (biwas or binwil)	X	x	x	x
7. Scoop/dip net (panalok)	X	x	x	x
8. Spear gun (pana)	x	x	x	x
9. Shrimp pot (bubo sa hipon)	x	x	x	x
10. Fish pot (bubo sa isda)	x	x	x	x
11. Fish aggregating device (bunbon-water hyacinth)	x	x	x	x

Source: EcosysCorp., Inc. (2014)
Legend: (x) = Present (-) = Absent

Results of the present 2021 survey showed that there are 15 fishing gears/methods used by fishermen operating along the proposed lakeshore road alignment; namely, gill nets (pante), fish traps (bubo sa isda), shrimp pots (bubo sa hipon), cast net (dala), spear gun (pana), longline (kitang), bunbon-water hyacinth (fish aggregating device), fish corral (baklad), enclosing net (takibo or dayakos), trawl (kaladkad), fish net (lambat/pukot), pole and line fishing (biwas), cover pot (salakab), electro fishing (koryente), and air gun (tiksay) (**Plate 22**).

Brief description of major gears

1. Gill net (pante) - a selective gear and its catch depends on its mesh size and the kind of material which is either a nylon multi-filament or monofilament. The catch composition was composed of tilapia, bighead carp, manila catfish, silver perch, common carp, milkfish, gourami, and white goby.

2. Fish trap/pot (bubo sa isda)- a baited gear of different shapes and sizes made of woven bamboo splints or net provided or metal frame box with chicken wire with a one-way valve for entrance of fish and a trap door for removing the catch. The catch composition

includes shrimp, silver perch, white goby, tilapia, catfish, snakehead, manila catfish, gouramy, and common carp.

3. Shrimp trap/pot (bubo sa hipon) – a baited gear made of woven bamboo splints and fine mesh net with a one-way valve for entrance of shrimp and a trap door for removing the catch. It is set in shallow portions of the lake where vegetation (water hyacinth and kangkong) is present.

4. Cast net (dala)-also called a throw net. It is circular net with small weights distributed around its edge. The main catch composition includes tilapia and Manila catfish.

5. Spear gun (pana) – the spear gun is provided at the tip with pointed blades and is being operated by means of a gun style trigger mechanisms (gatilyo). The catch composition includes tilapia, snakehead and catfish.

6. Long line(kitang) - a passive and selective gear that catches only few fish species compared to other major gear. The catch composition includes goby, Manila catfish, snakehead, and freshwater catfish.

7. Bunbon or manual seine/fish shelter-water hyacinth - this is a combination of fish shelter consisting of water hyacinth which serves as the fish aggregating device; and the manual seine used to enclose the shelter and catch the fish. The catch composition includes snakehead, tilapia, gouramy, freshwater/native catfish, African catfish, Manila catfish, common carp, bighead carp, and shrimp.

8. Fish corral (baklad)- stationary gear made of either nets or bamboos. The size and shape of the gear varies depending on the type of species to be caught. The catch composition consisted of tilapia, bighead, common carp, silver perch, Manila catfish, freshwater catfish, milkfish, shrimp, white goby, snakehead, and gouramy.

9. Enclosing net (takibo or dayakos) – a seine net surrounds the fish and hold them in an enclosed area until they are hauled. It is commonly operated in shallow water with hyacinth/kangkong. The catch composition includes tilapia, African catfish, freshwater catfish, Manila catfish, common carp, gouramy bighead carp, knife fish, janitor fish, snakehead and shrimp.

10. Trawl (kaladkad) – involve pulling a fishing net on the bottom through the water behind a boat. The catch composition includes tilapia, gouramy, African catfish, Manila catfish, common carp, bighead carp, knife fish, janitor fish, and shrimp.

11. Seine net (lambat/pukot)- fish swimming in the water are surrounded by a wall of netting supported by floats and hauled along the side of a boat. It commonly catches tilapia, milkfish, Manila catfish, knife fish, janitor fish, goby, bighead carp, common carp, and shrimp.

12. Pole and line (biwas) - this gear is a hook and line tied to a pole or to a small wood or bamboo stick set in shallow portions of the lake where vegetation is present. The hook is baited with different organisms such as frogs, earthworms and small fish. It commonly catches snakehead, catfish and tilapia.

13. Cover pot (salakab) – an entrapping device made of bamboo splints devoid of non-return valve with the opening lowermost to cover fish. The gear is use for catch snakehead and catfish.

14. Electro fishing (koryente) – uses electric current to temporarily stun fish and is particularly effective when in stream habitat is complex (e.g. abundant woody debris/vegetation that may snag a large seine net. It commonly catches tilapia, snakehead, catfish, gouramy, and eel.

15. Air gun fishing (tiksay) - use of air rifles fitted with a small harpoon that is tied to a nylon string around a plastic tube. When the trigger is pulled, the harpoon hurtles toward the targeted fish; the harpoon is then reeled in. The gear is used to catch giant tilapia, milkfish, African carp, freshwater carp, snakehead and catfish.

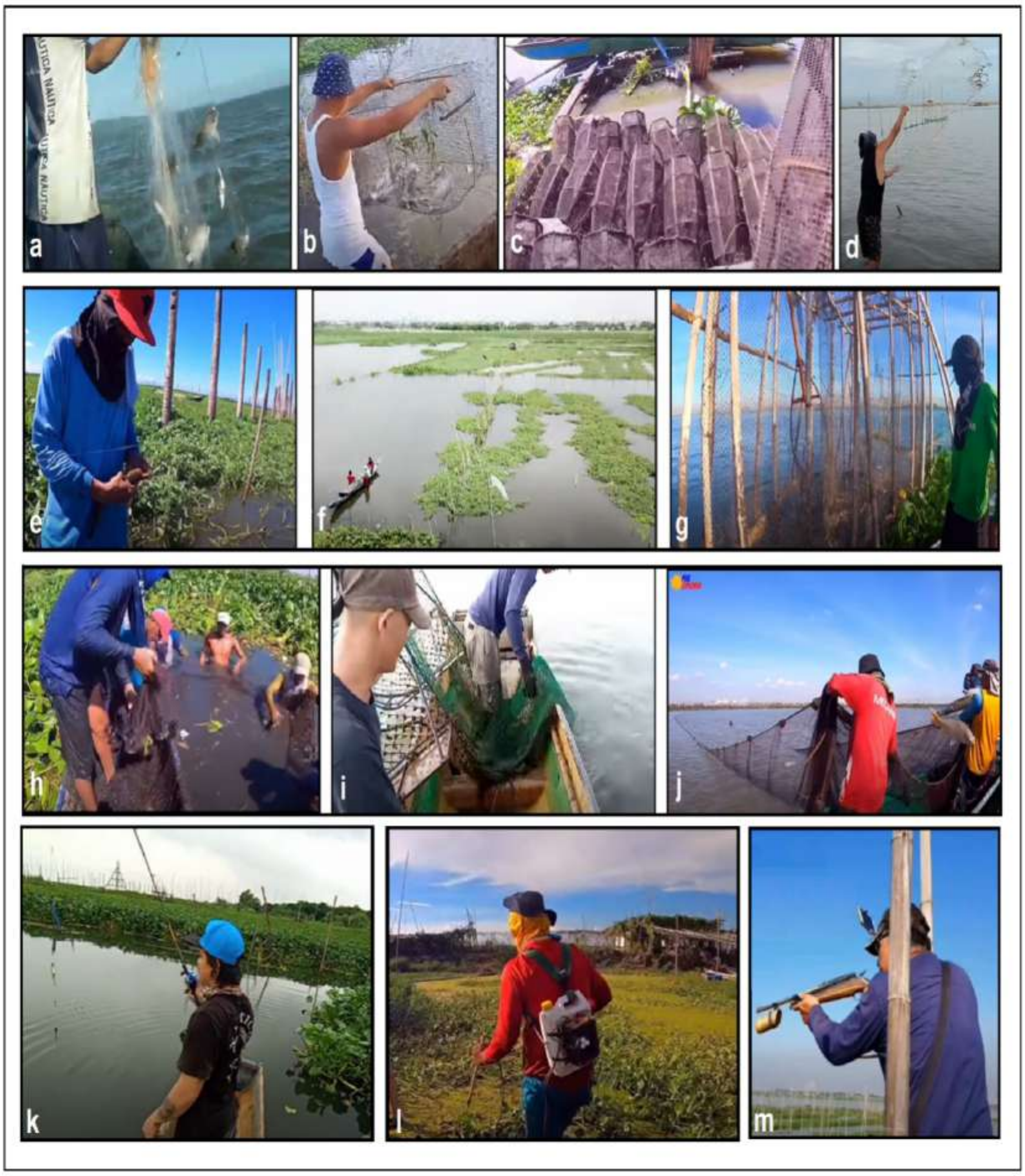


Plate 22 Some fishing gears/methods used by fishermen at the project site: (a) Gill net, (b) fish trap, (c) shrimp pot, (d) cast net, (e) longline, (f) bunbon-water hyacinth/fish aggregating device, (g) fish corral, (h) enclosing net, (i) trawl net, (j) seine net or lambat/pukot, (k) pole and line, (l) electrofishing, and (m) airgun fishing or tiksay (Photo source: Internet (YouTube Vlogs)

Of these fishing gears, only the stationary gear, fish corral (baklad), will be impacted by the proposed lakeshore road alignment. Along or within the footprint of the proposed alignment there are about 13 fish corrals identified that will be directly affected by the project construction and are all located only in the lakeshore areas between Alabang and Tunasan as seen from satellite images. The coordinates of the fish corrals are shown below and their approximate locations are plotted in the map (**Figure 2.145)**.

1. Lat. 14º23’41.73N and Long. 121º03’30.17E
2. Lat. 14º23’41.83N and Long. 121º03’31.41E
3. Lat. 14º23’40.84N and Long. 121º03’32.88E
4. Lat. 14º23’28.86N and Long. 121º03’33.72E
5. Lat. 14º23’23.29N and Long. 121º03’31.64E
6. Lat. 14º23’22.77N and Long. 121º03’33.21E
7. Lat. 14º23’19.13N and Long. 121º03’32.80E
8. Lat. 14º23’15.30N and Long. 121º03’31.59E
9. Lat. 14º23’14.63N and Long. 121º03’34.29E
10. Lat. 14º23’12.54N and Long. 121º03’29.73E
11. Lat. 14º23’06.29N and Long. 121º03’30.30E
12. Lat. 14º23’05.89N and Long. 121º03’32.84E
13. Lat. 14º23’05.44N and Long. 121º03’35.63E

Data source: Google Earth Map

Figure 2.145 Approximate locations of the stationary fish corrals (baklad) along or within the footprint of the proposed lakeshore road alignment (Alabang-Tunasan)

Important Fishes Caught in the Lake

An assessment survey of some commercially important fishes in Laguna de Bay was conducted from 1994 to January 1996 by Nasino (1999) from six (6) fish landing centers around the lake which served as basis for the assessment. Results of the survey showed that there were six (6) fishing gears used by fishermen; namely, pante, baklad, suro, kitang, takibo and bubo sa isda, The commercially important fish species caught in the lake were: tilapia, ayungin, kanduli, biya, bighead carp (Imelda/mamali or maya-mayang tabang), bañgos, karpa, gourami, hito, and lacustrine goby or dulong.

Tilapia was reported to be the dominant fish species caught and can be found everywhere. For example, in five (5) selected barangays in Calamba City, tilapia (53%) was reported as the most dominant fish species, followed by mamali (19%), kanduli (7%), ayungin (7%), hipon (4%), bangos (3%), karpa (2%), tilapia / kanduli (2%), gourami (2%), and ayungin / gourami (1%) (LakeHEAD – Yaman ng Lawa Eco-learning Center Project, undated).

It was also reported that Brgy. Sampiruhan (Calamba City) caught mostly mamalifrom baklad (fish corral). There are also tilapias caught from pante (gill net) and kanduli from both fishing gears. Barangay Lingga caught tilapia and ayungin from gill net. Barangay Pansol caught tilapia only from using gill net. Barangay Masili caught mostly tilapia from gill net and also hipon using bubo sa hipon (shrimp pot). Barangay Sukol caught tilapia, ayungin and kandulifrom gill net (LakeHEAD – Yaman ng Lawa Eco-learning Center Project). A salakab (cover pot) was also reported to catch tilapia in Barangay Lingga.

Results of the present 2021 survey showed that apparently tilapias (**Plate 23**)are also the dominant fish species caught by various fishing gears along the proposed project site, followed by bañgos (see **Plate23**), bighead carp or mamali, knife fish, kanduli, hipon, dalag, African catfish (hito) and gourami. Seemingly, the common carp (karpa), ayungin, freshwater catfish (hito), white goby (biyang puti), and lacustris goby (dulong) are not so abundant.

The small fish species lacustri goby (dulong or bulong) and freshwater shrimp (hipon) are currently sold in the public market for PhP 150 and PhP 75 per kilo, respectively (**Plate 24**); while snakehead/mudfish (dalag) is sold at PhP 300 per kilo (**Plate 25**).

Photo source: a and b (Internet (YouTube Vlogs); c and d (during the survey on 19 December 2020)

Plate 23 (a) Tilapia caught by air gun fishing, (b) tilapia caught by gill net, and (c and d) milkfish also caught by gill net

Plate 24 (a) Market vendor, (b) small fish species lacustri goby /dulong, and (c) freshwater shrimp/hipon

Plate 25 Snakehead or mudfish (dalag)

Aquaculture (Fish pen and Fish cage)

Aquaculture or raising of fish in controlled environment such as fishpens and fishcages has been practiced in Laguna de Bay over the years. The background of fishpen and fish cage culture in Laguna de Bay is described or reviewed in detail by Israel (2008):

1) By definition, a fishpen is an artificial and stationary water enclosure for the culture of fish and other aquatic animal species. It is made up of bamboo poles, wood, screen, and other construction materials intentionally arranged to prevent the escape of fish (**Plate 26**). A fish cage is an artificial and stationary or floating water enclosure smaller than a fishpen but made up of similar construction materials (**Plate 27**). In Laguna de Bay, a fish pen is further defined as having a water surface area of more than one (1) hectare while a fish cage has a water surface area of one (1) hectare or less. A fish cage in the lake generally has a net bottom while a fishpen has none.

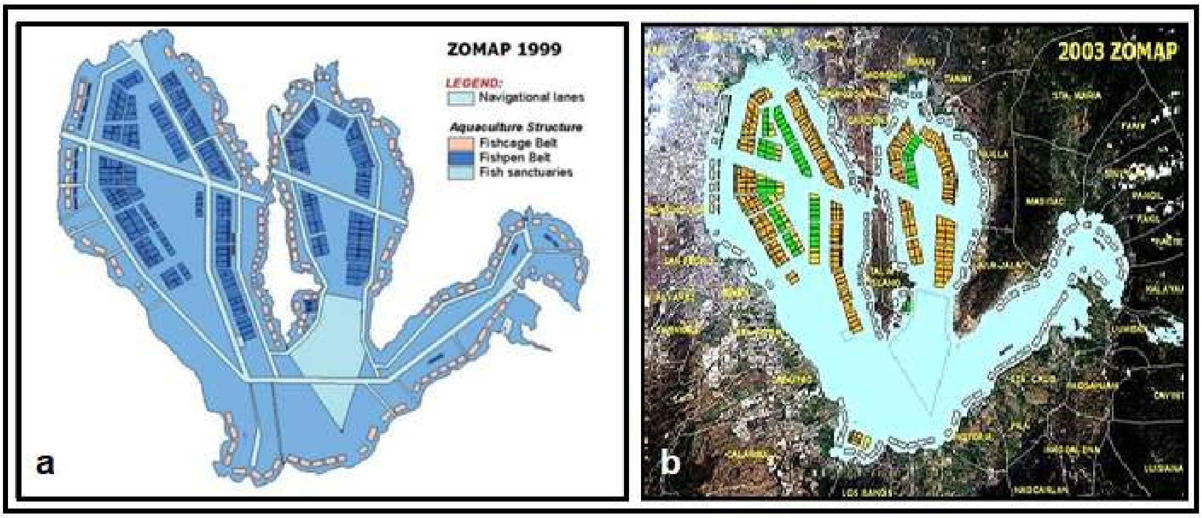
Plate 26 Typical Example of a Fishpen in Laguna de Bay (Alabang)

Plate 27 A typical example of a fish cage in Laguna de Bay - (a) Alabang and (b) Bicutan, 21 December 2020

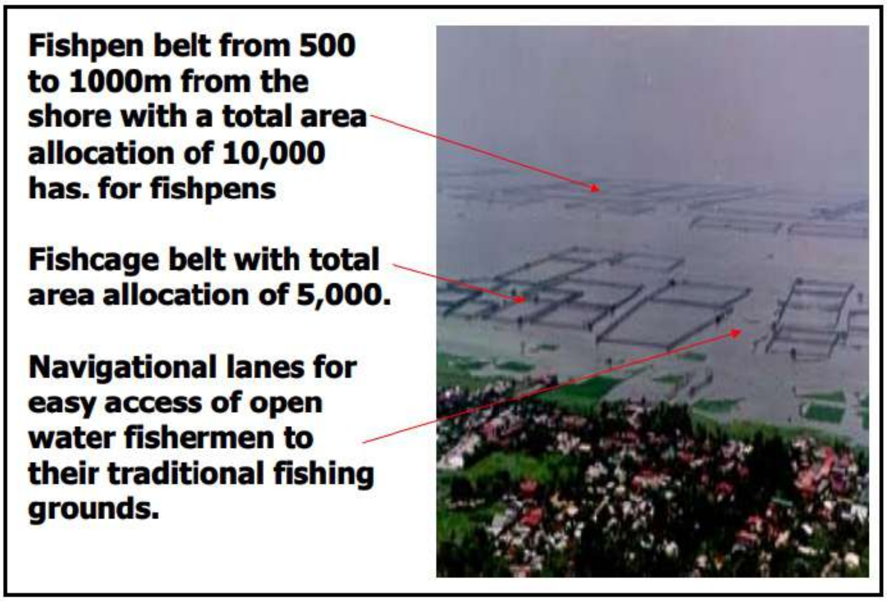
2) Fish pen in Laguna de Bay was first experimented in 1965 by the Philippine Fisheries Commission but the project did not make much headway and was later abandoned (Mane, 1987, 1982). In 1970, the Laguna Lake Development Authority (LLDA) successfully demonstrated the commercial culture of milkfish in fishpens in its pilot project in Cardona, Rizal. The LLDA's project showed that milkfish production in fishpens generated more than four (4) times than those in brackishwater fishponds. As a result of this high productivity, fishpen milkfish production grew by leaps and bounds in the following years and proliferated in many municipalities bordering the lake. From only 38 hectares in the 1970's, fishpens in Laguna de Bay increased to more than 30,000 hectares in 1983, reducing the water areas available for open fishing and navigation (Nepomuceno, 2004; Santos-Borja and Nepomuceno, 2003).

3) Fish cage culture in Laguna de Bay was first attempted in the early 1970's, also in the LLDA fish pen pilot project in Cardona, Riza (Garcia and Medina, 1987). In 1977, the cage culture of Nile tilapia started to develop as a commercial enterprise in the lake. The tilapia fish cage industry noticeably grew in 1981 particularly along the Binangonan and Cardona side of Talim Island in Rizal and greatly expanded elsewhere in the lake in the succeeding years.

4) Fish pen and fish cage culture in Laguna de Bay are generally practiced within the fish pen and fish cage belts specified by the Laguna de Bay Fishery Zoning and Management Plan (ZOMAP). The fish pen belt is located in the west and central bays while the fish cage is situated in the coastal areas all over the lake (**Figure 33**). The ZOMAP allocates a maximum of 10,000 hectares for the practice of fish pen culture and 5,000 hectares for fish cage culture, areas for sanctuary and navigational lanes and the rest for open water fishing (**Figure 34**). According to LLDA information, the area of 15,000 hectares allowed for fish pens and fish cages, which comprised about 17% of the total area of Laguna de Bay, is based on the carrying capacity of the lake.



Source: (a) LLDA and (b) laguna-uosm2005.weebly.com/fish.html
Figure 2.146 (a) Laguna de Bay Fishery Zoning and Management Plan (ZOMAP) 1999 and (b) revised 2003 ZOMAP



Source: Santos-Borja (2005)
Figure 2.147 Salient features of the Laguna de Bay fishery Zoning and Management Plan (ZOMAP)

A survey (Israel, 2008) of fish pen and fish cage operators and their operations was conducted in 2007 covering two (2) municipalities and one (1) city around Laguna de Bay which have fishpen and fish cage operations. These are Binangonan in Rizal, Biňan in Laguna, and Muntinlupa City in Metro Manila. The analysis of the study shows that fish pen and fish cage culture in Laguna de Bay has an important economic and social contributions to the lake municipalities and to the country. In particular, it significantly contributes to fish production, income, employment, and generation of public revenues. Furthermore, it helps in the supply of cheaper fish to Metro Manila where a large segment of urban poor population resides.

The zoning for fish pens and fish cages is subdivided into six (6) clusters or zones covering and fronting lakeshore communities. Fishpens and fish cages placed along the western coastal communities of the Laguna de Bay (from Bicutan to the municipality of Los Baňos), where the proposed site for the LLRN project is located, belongs to Zones A and B (**Table 2.66**). However, no fishpens and fishcage are operating along the lakeshore of the municipality of Cabuyao. The total absence of both fishpen and fish cage operations in Cabuyao was also noted during the present survey in December 2020.

Based on the 2006 data presented (see **Table 2.66**), there are more registered fish cage operators (total of 710 with surface area of 509 hectares) than registered fishpen operators (total of 212 with surface area of 4,852 hectares) along the proposed project site (Zones A and B). Overall, there are a total of 922 registered operators (comprising 45% of the total number of operators for the whole Laguna de Bay) at the project site covering a total surface area of 5,361 ha (comprising 41% of the total surface area).

Table 2.66 Registered fishpen and fishcage operators and area of fishpens and fishcages in Laguna de Bay, by zone and municipality, 2006

Zone/Municipality	Fish Pens		Fish Cages		Total	
	Operator (No.)	Area (Ha)	Operator (No.)	Area (Ha)	Operator (No.)	Area (Ha)
Zone A	**176**	**3,951**	**506**	**429**	**682**	**4,380**
Muntinlupa City	107	2,179	218	168	325	2,347
Taguig City	43	994	223	203	266	1,197
San Pedro	26	778	65	58	91	836
Zone B	**36**	**901**	**204**	**80**	**240**	**981**
Biñan	26	650	76	35	102	686
Sta.Rosa	2	100	8	3	10	103
Calamba City	8	150	43	25	51	174
Los Baños	0	0	58	14	58	14
Pila	0	0	19	4	19	4
Zone C	**0**	**0**	**126**	**22**	**126**	**22**

Sta. Cruz	0	0	28	7	28	7
Pakil	0	0	92	15	92	15
Kalayaan	0	0	6	0	6	0
Zone D	**95**	**3,018**	**247**	**142**	**342**	**3,160**
Cardona Main	41	1,099	70	46	111	1,145
Zone/Municipality	**Fish Pens**		**Fish Cages**		**Total**	
	Operator (No.)	**Area (Ha)**	**Operator (No.)**	**Area (Ha)**	**Operator (No.)**	**Area (Ha)**
Tanay	6	210	17	12	23	222
Pililla	26	664	80	30	106	695
Jala-jala	22	1,045	80	53	102	1,098
Zone E	**68**	**1,734**	**188**	**134**	**256**	**1,868**
Binangonan Main	8	1,734	188	134	256	1,868
Zone F	**80**	**2,513**	**328**	**190**	**408**	**2,703**
Binangonan Talim	58	1,746	130	87	188	1,833
Cardona Talim	22	767	198	103	220	870
Total	**455**	**12,117**	**1,599**	**998**	**2,054**	**13,115**

Source: Israel (2008)

However, the figures shown in **Table 67** indicate that the limit of 10,000 hectares for fishpens in Laguna de Bay has been exceeded since 2003. In this year, the LLDA started registering fishpens that were operating outside the fish pen belt designated by the ZOMAP. Although a moratorium on the registration of new fish pens was imposed since 2005, the figure show that the number of fish pen operators and the area of fish pens continued to increase in 2006. In this year, the maximum limit of 10,000 hectares for fishpens was exceeded by 2,117 hectares while the area coverage of fish cages was below the maximum limit of 5,000 hectares. The strict implementation and the lack of access to capital among the less privileged sector of the population have been identified as the main reason for the limited practice of fish cage culture (Israel, 2008).

Table 2.67 Number of registered fish pen and fish cage operators and area of fishpens and fishcages in Laguna de Bay, 2000 – 2006

Year	Fishpen		Fishcage		Total	
	Operator (No.)	Area (Ha)	Operator (No.)	Area (Ha)	Operator (No.)	Area (Ha)
2000	299	8,180	871	4,556	1,170	12,736
2001	230	7,051	1,018	1,050	1,248	8,101
2002	232	6,870	1,370	770	1,602	7,640
2003	363	10,064	1,546	854	1,909	10,918

2004	362	10,393	1,758	986	2,120	11,379
2005	365	10,174	1,808	1,111	2,173	11,285
2006	455	12,117	1,599	998	2,054	13,115
Average Annual Growth Rate (%)	**9.91**	**8.40**	**11.55**	**-12.46**	**10.38**	**3.41**

Source: Israel (2008)

Corporations, sole proprietorships, and cooperatives are allowed to put up fishpens in Laguna de Bay while sole proprietorships and cooperatives, particularly representing the poor sector of the populations are allowed to put up fish cages (**Table 2.68**). Data and information indicate that corporations dominated fishpen culture, sole proprietorhips dominated fish cage culture, and cooperatives formed only a small percentage of fish pen and fish cage culture in Laguna de Bay (Israel, 2008).

Table 2.68 Registered fish pen operators and area of fish pens in Laguna de Bay by type of ownership, 2006

Type of Ownership	Fishpen Operators and Fishing Areas			
	No. of Operators	% to Total	Area (Ha)	% to Total
Corporation	258	57	10,795	89
Sole Proprietorship	164	36	823	7
Coorperative	33	7	499	4
Total	**455**	**100**	**12,117**	**100**

Source; Israel (2008)

Lately, it was published by the DENR (undated) that the lake's carrying capacity allow up to 9,000 hectares for aquaculture, but fish pens and fish cages are occupying 12,375.18 hectares of the surface water, showing a total of 3,375 hectares of excess areas for demolition. Data from the LLDA show that there are a total of 1,018 registered or legitimate fishpen and fishcage operators in Laguna Lake, covering a total of 9,519 hectares. Of this number, 713 are fishcage operators, while 305 are fish pen operators. Additionally, unregistered operators number to 2,261, occupying 2,856 hectares. In all, a total of 3,246 structures (both registered and unregistered) can be found in the lake area, consisting of 358 fishpens and 2,890 fishcages which show a mix of corporations and individual owners (https://www.denr.gove.ph/index.php/news-events/press-releases/485-lopez-to-sit-down-with-laguna-lake-fishpen-operators-before-permit-moratorium).

As regards to presence of aquaculture structures along or within the footprint of the proposed LLRN road alignment, a number of fish cages/fish pens were identified that will be directly affected by the project as seen from satellite images. They are all located only in the lakeshore areas between Lower Bicutan and Sucat, between Sucat and Alabang, and between

Alabang and Tunasan. Their approximate locations are plotted in **Figures 2.148- 2.150**, respectively.

Data source: Google Earth Map

Figure 2.148 Approximate locations of fish cages/fish pens along or within the footprint of the proposed road alignment (between Lower Bicutan and Sucat)

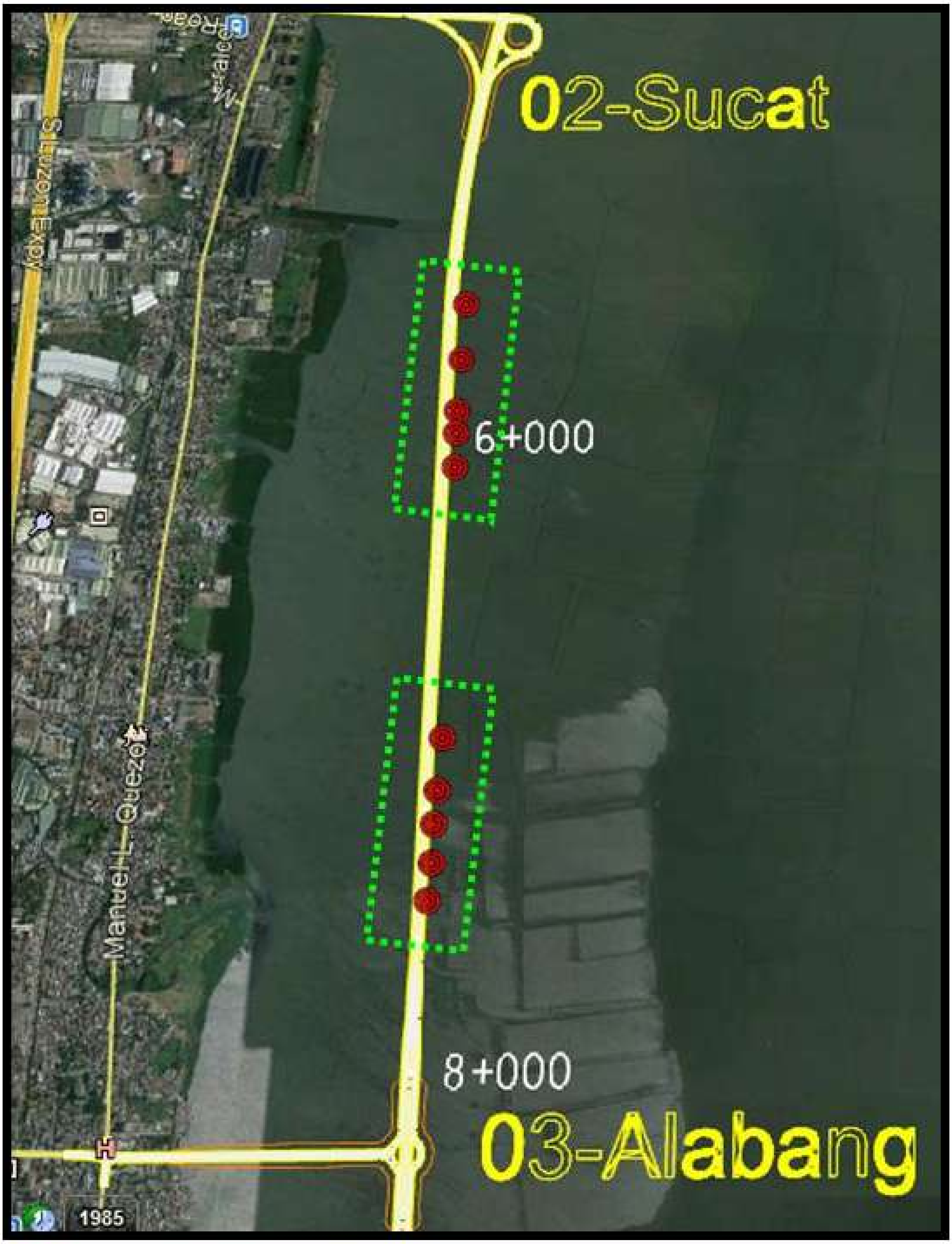


Figure 2.149 Approximate locations of fishcages along or within the footprint of the proposed road alignment (between Sucat and Alabang)


03-Alabang
9+498
10+000
12+000
04-Tunasan
1985

Figure 2.150 Approximate locations of fishcages along or within the footprint of the proposed road alignment (between Alabang and Tunasan)

Among the fish species being cultured included mainly milkfish/bañgos (*Chanos chanos*), tilapia (*Tilapia* spp.) and bighead carp (*Aristichthys nobilis*). Survey results show that the majority of fish pen operations in Laguna de Bay raised only bañgos but some also raised tilapia and/or carp in polyculture with milkfish (**Table 2.69**). Fish cage operations, on the other hand, usually raised carp and/or tilapia in either monoculture or polyculture but occasionally milkfish is also raised with either or both species (**Table 2.70**).

Also based on the study (see **Table 2.69**), majority of fish pen operations along the project site particularly in Biňan and Muntinlupa raised mainly bañgos (**Plate 28**). For fish cage operations (see **Table 2.70**), Biňan raised only carp while Muntinlupa raised tilapia and carp.

Table 2.69 Fish species grown in fish pen operations in Laguna de Bay, by municipality, 2007

Species	Binangonan		Bińan		Muntinlupa City		All	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)
Milkfish only	4	20	16	80	18	90	38	63
Tilapia only	0	0	0	0	0	0	0	0
Carp only	6	30	2	10	0	0	8	13
Milkfish &Tilapia	1	5	0	0	1	5	2	3
Milkfish & Carp	5	25	1	5	1	5	7	12
Tilapia & Carp	2	10	1	5	0	0	3	5
Milkfish, Tilapia & Carp	2	10	0	0	0	0	2	3
Total	**20**	**100**	**20**	**100**	**20**	**100**	**60**	**100**

Source: Israel (2008)

Table 2.70 Fish species grown by fish cage respondents in Laguna de Bay, by municipality, 2007

Species	Binangonan		Bińan		Muntinlupa City		All	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)
Milkfish only	0	0	1	2	0	0	1	1
Tilapia only	3	8	0	0	15	38	18	15
Carp only	16	40	39	98	9	23	64	53
Catfish only	1	3	0	0	0	0	1	1
Milkfish &Tilapia	0	0	0	0	3	8	3	3
Milkfish & Carp	2	5	0	0	0	0	2	2
Tilapia & Carp	13	33	0	0	12	30	25	21
Milkfish, Tilapia &	5	13	0	0	1	3	6	5

Carp								
Total	**40**	**100**	**40**	**100**	**40**	**100**	**120**	**100**

Source: Israel (2008)

Photo source: Santos-Borja (2005)

Plate 28 Harvest of milkfish (bañgos) in a fish pen in Laguna de Bay

The majority of fishpen and fish cage operations in Laguna de Bay use the extensive method of culture which depends mainly on the natural food in the lake for feeding the fish. However, there are also operations that utilize either the semi-intensive or intensive method which uses supplemental feed in addition to natural food (Israel. 2008).

The bañgos stocked in fishpens and fishcages in the Laguna de Bay originates from fry sourced from local fry gatherers, local hatcheries, and foreign fry producers. The fishpens and fishcages in the lake that grow tilapia get their fry and fingerling from tilapia hatcheries and nurseries around the lake and other area. Most of these hatcheries are located in Laguna while a few are in Rizal. The fishpens and fishcages that raise carp get their fry and fingerling from the few hatcheries operating around the lake. The municipality of Binangonan, Rizal, where 9 bighead carp hatcheries operate, was the main producer of big-head carp fry and fingerling in 2007 (Israel, 2008).

Fishpen and fish cage culture in Laguna de Bay has been facing various problems that hinder its development. These problems may be classified as technical, production, economic, social, environmental, and institutional problems. For the environmental, the individual problems are also described by Israel (2008):

1) Occurrence of algal bloom – algal bloom causes fish mortality or fish kill as stocks die of asphyxiation due to oxygen depletion. The fishes that were surveyed have a tainted flesh and mud-like taste (**Plate 29**).

Plate 29 Algal bloom in tilapia fish pens (Photo source: PEMSEA/LLDA, 2013)

2) Proliferation of water hyacinth – water hyacinth crowd fish pens and fish cages and cause various problem including fish mortality, destruction of pen and cage structures, and obstruction of navigation.

3) Invasion of alien spaces - the proliferation of alien fish species, particularly janitor fish of late, has caused problems. This fish destroys nets and competes for natural food and living space with cultures species.

4) Occurrence of fish diseases – cultured fish in the Laguna de Bay is affected by various diseases that cause fish mortality or fish kill which in turn reduce the financial viability of aquaculture operations.

5) Deterioration of water quality – the worsening water quality in Laguna de Bay, which is caused mainly by water pollution, results to fish diseases, fish mortality, and reduced fish quality.

6) Siltation and sedimentation – siltation and sedimentation have made Laguna de Bay shallow and reduced the living space for the fish and other aquatic animals as well as navigational space for man.

PEMSEA/LLDA (2013) reported that one of the most important native fishes in the Lake is the ayungin (*Therapon plumbeus*). The highest total catch in 2013 is in the Central Bay, while the lowest is in the East Bay. This can be attributed to the high concentration of the invasive clown knife fish (*Chitala ornata*) in the East Bay, which prey on ayungin. Clown knife fish eggs also attach to cultured fish cages and fish pens and once hatched, will feed on the fry and fingerlings of big head carp and bañgos. The proliferation of knife fish has caused significant declines in cultured and native fish production.

Critical Habitat Assessment (Fish Sanctuary)

Fisheries Administrative Order No. 110 establishing a fish sanctuary in Laguna de Bay to be known as the Laguna de Bay Fish Sanctuary. The Order provides for the establishment of a fish sanctuary in a defined area of the body of water Laguna de Bay. All fishing is prohibited in the area.

Establishment of sanctuary has become obligatory to protect specific areas from negative fishery impacts, enhance fish diversity, restoration as well as conservation of habitat.

To ensure the maintenance of open fishing ground, the LLDA has designated fish sanctuaries covering around 30,000 hectares in Muntinlupa City, 5000 hectares in Jala-jala and Talim Island in Rizal and Laguna Bay, and 127 hectares in Brgy. Tabon, Binangonan, Rizal (**Figure 2.151**). With the assistance of Bureau of Fisheries and Aquatic Resources (BFAR), regular lake seedings are conducted in these sanctuaries [LLDA "Ibalik and Diwa ng Lawa" (llda.gov.ph/fisheries-development-program/)].

Source: Santos-Borja (2005)
Figure 2.151 Locations of the fish sanctuaries in Laguna de Bay

On 31 October 2011, a lakeshore area in Calamba covering five (5) hectares was declared as protected area for the fish through the City Ordinance No. 495 series of 2011 (CLUP, City of Calamba, Final Report, Volume 1, 2017-2026).

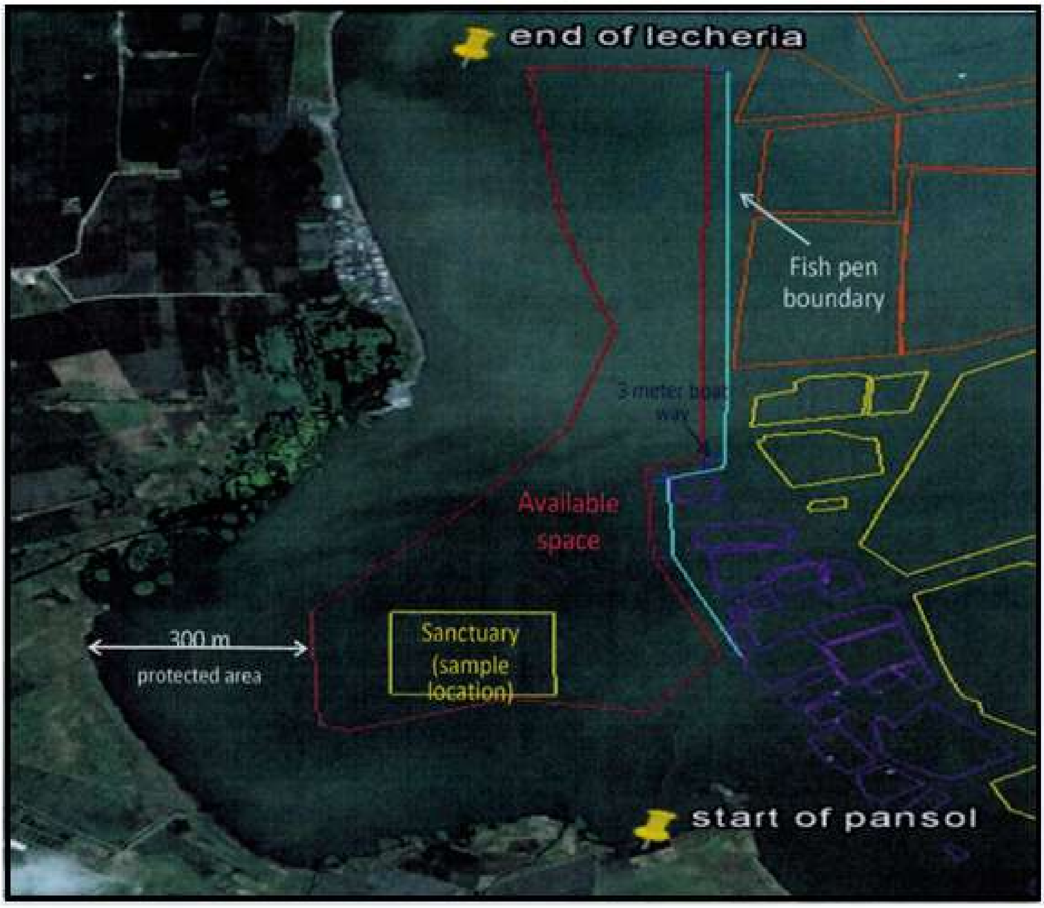
City Ordinance No. 495 prohibits the following activities in the Fishery Refuge and Sanctuary area:

1) Catching of fish in any manner;
2) Throwing of waste of any form to include allowing discharging of wastewater;
3) Throwing of industrial wastes and used oil;
4) Quarrying of stones, gravel, sand, etc., without the permission of the City Mayor, City Council and other concerned government agencies;
5) Construction of structures without the permission of the City Mayor and City Council;
6) Use of the Protected Area as swimming grounds for ducks, turkey, etc.; and

7) Introduction of fish species without clearance from the Bureau of Fisheries and Aquatic Resources (BFAR) or City Agriculture Office.

On 17 July 2013, the Calamba City Yankaw Fish Garden Sanctuary was launched in the lakeshore of Laguna de Bay through the City Agricultural Services Department (CASD), Fishery and Aquatic Resource Management Council (FARMC), in collaboration with the LakeHEAD (Lake, Health, Environment, Agriculture and Development Project). The garden sanctuary is located along the lakeshore area of Brgy. Bucal (**Figure 2.152**).

LakeHEAD is a trans-sector integrated research project organized by researchers from Research Institute for Humanities and Nature – Kyoto, Japan; University of the Philippines Los Baňos (Natural Science, Agro-biodiversity and Socio-economics); University of the Philippines Manila, College of Medicine and Public Health (Human Ecological Diseases; and Laguna Lake Development Authority (Laguna Lake Watershed Planning, Monitoring and Regulatory Works) to develop strategies of ecological risk management for sustainable food production, health security and watershed planning in the Laguna Lake region. LakeHEAD is funded by Research Institute for Humanities and Nature (RIHN) –Kyoto, Japan and is headed by Dr. Ryohei Kada. The Yaman ng Lawa Ecology Learning Center is a sub-component of the LakeHEAD project.



Source: LakeHEAD
Figure 2.152 Location map of fish Sanctuary in Barangay Bucal, Calamba City (Laguna de Bay)

Based on this information, it appears that there are no fish sanctuaries along or on the footprint of the LLRN project (west side between Lower Bicutan and Calamba) and, therefore it is not expected to cause any significant impact on fish sanctuaries of the Laguna de Bay. The closest fish sanctuary is located off Brgy. Bucal (Calamba City), approximately 200-300 meters away from the proposed alignment. The sanctuary is an alternative community-based response to reduce the economic impacts of fish kill and fish ecology degradation to poor open water fishing communities. Based on the initial drawing of the route of the proposed LLRN project, the fish sanctuaries of Laguna de Bay are unlikely to be encroached by the project. If this is correct, the impacts on the fish sanctuaries from the project construction activities are likely to be minimal. But it is accepted/expected that there may be indirect impacts on local water quality (e.g., due to sanitary/domestic wastewater discharges and leakage of oil from work vessels and barges). However, such potential discharge is not constant and, therefore, it is not expected to cause any chronic impact on the water quality and biological communities in the project area. Whether the fish sanctuaries are impacted depends on the management of sanitary/domestic wastewater/treatment.

Accidental oil spills could potentially impact these fish sanctuaries. Impact to these protected areas can be minimized by controlling movement of any spill by containment and/or dispersion. Therefore, Oil Spill Contingency Plans should be prepared and made readily available.

There will be both construction and operation impacts on water quality that will need to be mitigated (e.g. pollution prevention in construction and treatment of runoff in operations).

2.2.4.3 Potential Impacts and Options for Prevention, Mitigation or Enhancement

This section provides an assessment of the probable impacts of the proposed road network project along the west shoreline of Laguna Lake from Lower Bicutan to Calamba on the aquatic ecology and environment and their aquatic communities such as the phytoplankton, primary productivity, zooplankton, ichthyoplankton, primary productivity, soft bottom infaunal benthos, fishes, macroinvertebrates, macrophytes, capture and aquaculture fisheries, and protected area (fish sanctuary), Each identified impact is categorized according to its development phase: i) pre-construction phase, ii) construction phase; and iii) operation phase. The corresponding mitigating measures are presented in *italics* for each significant negative impact identified. All these potential impacts and mitigating measures by project phase are summarized in **Table 28**.

The construction of this proposed lakeshore road project could lead to potential impacts on the generation of siltation (sediment deposition) and turbidity (sediment suspensions) and removal or loss of, or physical disturbance or disruption to, lake bottom habitats, flora and fauna due to potential environmental effects of dredging, reclamation and landfilling operations and piling for embankment and lake viaduct structures. Likewise, construction of lake viaduct will generate noise and vibration, particularly from pile driving activity from Lower Bicutan to Tunasan and mixed shoreline viaduct and embankment from Tunasan to Calamba. Pile driving is a method used to install piles for marine and inland water construction projects using high-energy impact hammers. There is a growing concern about the potential effect of construction-related underwater sounds and vibrations on fishes (Dahl et al., 2015; Popper et al., 2014).

Moreover, the proposed construction of the lakeshore road project has also the potential to impact the aquatic ecology and environment through:

- Accidental oil spills from construction vessels and barges;
- The disruption on shoreline and open water fishing activities and fish cage and fish pen operations, fish sanctuary and kangkong farming; and
- The addition of substantial artificial hard substrates (solid structures) on the lake bottom in the form of concrete piles and armour rocks.

Plankton Communities and Primary Productivity

a) Pre- Construction Phase

Land clearing, ground preparation and earthworks for the construction of temporary facilities, land viaduct, ramps, roundabout junction and casting yards and dredging for barge access can contribute to increased sedimentation and turbidity at the project site especially during wet season unless properly controlled. Impacts upon pelagic organisms will be minimal, temporary and localized both for primary production (phytoplankton) and secondary production (zooplankton) in the pelagic zone. These construction impacts may temporarily interfere with phytoplankton productivity and zooplankton feeding and respiration within a few hundred meters of dredging activity and could affect more sensitive larvae far away.

These impacts of sedimentation and turbidity on the nearshore water bodies can be mitigated by installing adequate temporary erosion control measures (siltation ponds, silt/sediment traps and berms and re-routing of surface run-off around the facilities) and silt screen. The installation of these mitigating measures could reduce turbidity to an environmentally acceptable level before discharging into the receiving water bodies and may be also considered to prevent dispersion of turbid waters during construction.

b) Construction Phase

The major impact of embankment and viaduct road construction on plankton would be the expected increase in turbidity (levels of suspended solids) in the water column along the project area. Turbidity would tend to limit light penetration in the water column which is essential in photosynthesis, a vital process in phytoplankton primary production. Increased turbidity would also lead to the irritation and clogging of gills of fish larvae and juveniles (ichthyoplankton) that could lead to their eventual smothering (Hirsch *et al*., 1978). This adverse condition would slightly increase the mortality rates among fish larvae/juveniles including other planktonic organisms. Being planktonic, fry or juvenile cannot avoid turbidity impacts because of their inability to swim against water currents. However, these impacts, while significant, are localized and temporary. Turbidity of the water column is expected to decrease to normal levels immediately following the completion of the dredging, reclamation, landfilling and pile driving activities.

To mitigate the impact among phytoplankton and zooplankton organisms, pelagic fish larvae/juveniles including phytoplankton photosynthetic activities (primary production), the use of geotextile silt curtains is recommended. Geotextile silt curtains should be used during the construction period to reduce turbidity and therefore, impact on adjacent aquatic communities.

Bilge water discharges from construction vessels may also cause damage to plankton communities. Bilge water discharges contain polycyclic aromatic hydrocarbons (PAH). These are carcinogens and are implicated in diseases of aquatic organisms and subsequent human health problems (EPA, undated). Photosynthesis is depressed in phytoplankton exposed to petroleum. Growth of phytoplankton is also readily depressed by wide range of petroleum hydrocarbons, including both whole oils as well as specific compounds. These included blue green algae, green algae, diatoms, dinoflagellates, and chrysophytes. Effects on growth vary widely, depending on the oil or compound used and on the algal species, but generally growth lag or lethality has been noted in the range of 1-10 mg/L (e.g., Mommaerts-Billiet, 1973; Pulich et al., 1974; Soto et al., 1975; Prouse et al., 1976; Batterton et al., 1978; Hsiao, 1978; Mahoney and Haskin, 1980).

To minimize this impact on these pelagic communities, the proponent must not allow construction vessels from discharging bilge water at the construction site, or possibly by establishing treatment for bilge water. There is a very effective technology currently available on the market to clean bilge water before it is discharged into the aquatic environment (https://www.oecd.org/sti/ind/48365856.pdf).

Another source of impacts to plankton communities during construction relates to possibility of accidental oil spills.The expected effects of accidental oil spills are similar to that of the effects of bilge water discharges from construction vessels in which, as a whole, insignificant due to the transient nature and short generation time of most plankton.

If there is an accidental oil spill it could not be mitigated. However, over time, new planktonic organisms will replace the population lost during the oil spill period. The extent and duration of the spill will also determine the extent of damage to plankton communities.

Impact on plankton communities might be reduced by controlling movement of oil spill and/or dispersion. Oil Spill Contingency Plans should be prepared and made readily available.

(c) *Operation Phase*

No impacts are expected to results from the normal operations of the embankment and lake viaduct road project on the plankton communities and primary productivity of the surrounding waters.

Therefore, no mitigation is required.

4.3 Benthic Communities

(a) Pre- Construction Phase

The land clearing and earthmoving activities will not only disturb the existing benthic infauna but will entail some smothering of infaunal benthic invertebrates present at the project site. Dredging for barge access will produce only localized turbidity plumes. Therefore, impacts are insignificant in scope.However, benthic organisms can easily re-colonize in undisturbed areas. Benthic re-colonization should be quite rapid and occur within a few months after construction. Therefore, the impact of the construction activities is minimal, temporary and considered localized. There will not be a significant/noticeable impact on the aquatic food chain.

A well planned land clearing and earthmoving operations should be implemented. Temporary erosion control measures (silt/sediment traps, installation of erosion mats, rip-rap silt fences, and berms) should be used to reduce siltation and high turbidity to an environmentally acceptable level.

(b) Construction Phase

Benthic habitats are susceptible to impacts during construction activities. Benthic habitat elements include mud bottom epifauna and infauna. One of the significant impacts of the proposed lake viaduct and embankment road project concerns the faunal benthic communities of the dredging, reclamation/landfilling and piling areas. These construction activities will not only disturb the existing benthic fauna but will entail a complete smothering and burying of all benthic organisms present in the dredging, reclamation/landfilling and piling area. There is no known remedy for this impact as the project construction activities, which are deemed very important, will be permanent in the area. However, benthic organisms can easily re-colonize in undisturbed and unreclaimed areas. Benthic re-colonization should be quite rapid and occur within a few months after construction, depending on the type of environment and biology of the animals affected. Complete recovery rates of soft bottom benthic communities are partly a function of habitat type and depth and could be attained within a year or two. Therefore, the expected negative impacts of these activities are expected to be minimal, short-term and localized

Moreover, based on the findings of the study, there were very low density and diversity of soft bottom benthic infaunal benthos in areas surveyed. Hence, the impact of the proposed project on the soft bottom benthos community will be minimal.

For these benthic communities the construction phase at the dredging, reclamation, landfilling and piling areas will destroy them and cannot be mitigated. After dredging, reclamation/landfilling and piling activities have ceased, it is desirable to monitor the re-colonization rate and recovery of species diversity and abundance in the perturbed area (s), and to identify the changes in the surrounding habitats.

Feeding activities and respiration of bottom dwelling organisms such as the commercial clams, snails and shrimps of the surrounding areas along the immediate vicinity of the construction site will also be impacted by siltation and turbidity plumes associated with sediment re-suspension of loose to dense muds during the dredging, reclamation, landfilling and piling activities.

Increased siltation and turbidity plumes can be reduced and the level of fine particles could also be greatly reduced by the use of geotextile silt screens during the construction activities. This could help in mitigating the impact on surrounding benthic communities not directly impacted by the construction activities.

The choice of appropriate reclamation procedure and provision of siltation ponds, armour rocks or precast concrete with geomembrane, and silt curtains can further help reduce turbidity plume problems. Utmost care should be taken to prevent dispersion of very fine mud/clay away from the working area. Full construction of revetment or containment structure and armouring (with provision of granular bedding material and geomembrane or geotextile filter) around the reclamation boundary prior to filling and installation of silt curtain around dredging and piling areas can adequately prevent this. All these measures must be appropriately integrated in the environmental management system.

It is essential that these activities are monitored vigorously and comprehensively to provide effective feedback to future engineering and management decisions and to provide guidance for developing or refining appropriate corrective measures. Engineering measures will be taken if excessive siltation/ sedimentation and turbidity occur as a result of construction.

Heavily contaminated sediments during an accidental oil spills are likely to have an adverse effect on local populations of bottom dwelling species such as clams and snails which are unable to swim into unpolluted areas. There are documented instances of oil spills in which shellfish have been killed in significant numbers (e.g. clams following the Arrow and Amoco Cadiz spills). However, there is also evidence that bottom dwelling wild fish species such mud fish, catfish, eel and tilapia are able to detect and avoid-contaminated waters.

Impact on benthic communities might be reduced by controlling movement of oil spill and/or dispersion. Oil Spill Contingency Plans should be prepared and made readily available.

(b) Operation Phase

Impact of embankment and lake viaduct road project normal operations on the bottom benthic communities at the project site and of the surrounding waters will be none.

Therefore, no mitigation is required.

4.4 Fishes and other Aquatic fauna

(a) Pre- Construction Phase

Sedimentation and turbidity can also contribute to decreases in local fish populations. Because fish can readily disperse, many species may simply relocate when sediment load is increased (Barton, 1977). For species that remain in the disturbed area, elevated levels of sediment may have an adverse effect on fish health. Increased sedimentation and turbidity can reduce dissolved oxygen in the water column, and in extreme cases may cause a thickening of the gill epithelium and reduce respiratory function (Horkel and Pearson, 1976; Goldes et al., 1988; waters, 1995).

As sedimentation occurs, spawning habitat also may be smothered. This is especially true for substrate spawners (Muncy et al., 1979). If sedimentation occurs after spawning, then oxygen supply to eggs and sac fry in the substrata may be decreased due to reductions in the water circulation (Waters, 1995; Argent and Flebbe, 1999). Consequently, sedimentation decreases available spawning habitat, reduces spawning activity, and increases egg and larvae mortality (Alabaster and Lloyd, 1982; Ryan, 1991)

Soil erosion and increased siltation and turbidity in the project area will be minimal and temporary and will be encountered only during wet season and during construction activities. A well planned land clearing and earthmoving operations should be implemented. Temporary erosion control measures (silt/sediment traps, installation of erosion mats, rip-rap silt fences, and berms) and geotextile silt curtains should be used during the construction period to reduce siltation turbidity and therefore, impact on adjacent aquatic communities.

(b) Construction Phase

The impacts of construction on highly mobile organisms such as fish would be localized, temporary and minimal because they are the least affected as they are capable of avoiding a disturbed area. Increased siltation and turbidity generated by construction activities such as dredging, reclamation, land filling and pile driving would cause adult fish in the area to migrate to other suitable areas. However, smaller species that are unable to migrate would be chronically exposed to high turbidity may suffocate as their gills become clogged with sediments. This impact is expected to occur within the construction site and immediate vicinity (within the radius of 0.1-0.2 km from the construction site). However, as the construction activities are not continuous (per segment), impact on the fish resources is expected to be minimal or insignificant, short duration and site specific.

To mitigate the impact among smaller species, use of geotextile silt curtains is recommended.

As to potential impacts of noise from construction phase (e.g. from pile driving), there is a lack of robust scientific evidence on the sensitivity and effects of underwater noise upon fish and an almost complete absence of data for invertebrates. In particular, there is a lack of data on behavioral thresholds, response distance and sound exposure levels. A study suggested that construction activities such as associated with offshore wind farms could potentially affect fish species behavior over a significant area centered on the source (marine.gov.scot/datafile/misc.MERP/08/Document/Noise%20Conference%20Abstract.pdf).

Impact on the fish resources is expected to be minimal or insignificant, short duration and site specific.

Therefore, no mitigation is required.

Meanwhile, there is evidence that man-made sound could have an impact on fish catches. For example, during seismic surveys in the Barents Sea, commercial trawl and longline catches of Atlantic cod and haddock have been shown to fall by as much as 50 to 80% (Engås et al. 1996; Løkkeborg and Soldal 1993 as cited by U.S. Department of the Interior-Bureau of Ocean Energy Management, 2012). Reductions in Catch Per Unit Effort (CPUE) were observed for both types of fishing gear. Catch reductions of similar magnitude (52%) have also been demonstrated in the hook-and-line fishery for rockfish on the California coast (Skalski et al. 1992 as cited by U.S. Department of the Interior-Bureau of Ocean Energy Management, 2012). In contrast, catches by other methods (gill nets) have shown an increase during exposure to seismic sound (Løkkeborg et al. 2012a, b as cited by U.S. Department of the Interior-Bureau of Ocean Energy Management, 2012).). It is evident that both gear-and species specific effects may occur. The effectiveness of different fishing gear depends on different patterns of fish behavior. Fish catches may fall because of behavioral changes affecting the vulnerability of fishes to capture, not just because fishes have left an area (U.S. Department of the Interior-Bureau of Ocean Energy Management, 2012).

Such an impact on the fish resources at the project site is expected to be minimal or insignificant, short duration and site specific. Besides, the construction activities however are not continuous (per segment).

Therefore, no mitigation is required.

Assessment shows that accidental oil spills during construction activities have generally significant impacts on fish population. Significant impacts generally occur in shallow waters with poor water circulation. Heavy loss of pelagic fish eggs/larvae can occur if present in the area of an oil spill. Modeling studies indicate that large numbers of fish larvae would have to be destroyed to affect recruitment (Reed et al., 1984 and Hurlbut et al., 1981 as cited in GESAMP, 1993). The possibility exists for impacts on stock spawning in the event of major spills in shallow water area of the lake having poor water circulation. However, only small proportions of any pelagic fish eggs and larvae population will likely to be impacted, with relatively small resource losses (GESAMP, 1993).

The effects of oil spills on stocks of fish populations could be at risk if the spill:

- was very large;
- coincided with spawning periods; or
- entered grounds of species whose spawning is restricted to small areas or to physically contained areas.

The impact of an oil spill event on fishes might be reduced by controlling movement of any spill which originates from the project site by containment and/or dispersion at sea. Therefore, oil spill contingency plans should be prepared and made readily available.

(c) Operation Phase

Normal operations of the embankment and viaduct road project are not expected to pose a threat to fish and invertebrate communities such as shrimps. The embankment and lake viaduct structures which are made up of rock boulders and concrete piles, respectively could, in fact, acts as artificial hard substrates that could attract colonization for a variety of fishes and other aquatic life and provide shelter to a number of organisms. The hard substrates will also provide food and protection for numerous and diverse aquatic organisms but will also serve as attachment or substrate for attached forms; thus, these artificial hard structures will enhance the aquatic habitat in the lake.

Therefore, a positive or beneficial impact upon fish and other aquatic life at the project site are expected because of the creation of artificial hard substrata on the lakebed. But only if this is designed carefully to provide suitable habitat and under consultation with an aquatic ecologist with extensive knowledge of species present in the lake.

There are habitat creation techniques that can be applied to mitigate for the losses of marginal habitats and underwater structures should be designed to maximise benefit for aquatic species.

Impact of operations on the fisheries resources will be viewed as beneficial impact. Therefore, no mitigation is required.

(c) Decomissioning/Abandonment Phase

Significant impacts on fish and other aquatic species will occur when LLRN structures are removed because of habitat loss and it cannot be mitigated.

4.5 Fish Capture Fishery

(a) Pre- Construction Phase

The major impact would be the turbidity created by suspension of sediments and removal/loss of bottom habitat, and noise during dredging operations to the shallow waters for barge access. Most of this would be produced in the shallow water and could consequently impact demersal (bottom dwelling) fishes and possibly destroy shrimp breeding/nursery areas for some time. Pelagic fish would be impacted temporarily. All potential impacts are classified as adverse, but localized and insignificant in scope.

Turbidity plumes can be reduced and the level of fine particles greatly reduced by the use of silt screens during the dredging operation. This could help in mitigating the impact of surrounding benthic communities not directly removed by the dredging. Turbidity will be detrimental to both larval fishes and shrimp. Reduction of turbidity would reduce impact on these organisms.

(b) Construction Phase

Duringconstruction, temporary and minor disruption of fishing activities on some fisherfolks is anticipated. It is expected that there will be exclusive zone during the construction period which may hinder local fisherfolks from conducting regular fishing. A required safety exclusion zone along the construction area is to be recommended. This will not reduce their income since they can move to the adjacent fishing ground. If construction is done during the northeast monsoon season or *amihan* (November - February) which coincides with rough water conditions, almost no impact to fishing is expected because most of the fishing activities are done during *taglinaw*, *i.e*. from March to October, coinciding with summer period and southwest monsoon season (*habagat*). Likewise, construction activities are not continuous (will be conducted per segment) so that that there will be fishing areas wherein fisherfolks would have access to the lake.

The expected impacts to capture fisheries along the project site, are as a whole insignificant, temporary (short-term), and site specific.

A required safety exclusion zone along construction area is recommended, that is 0.1 km. However, there must be a passageway for the fisherfolks to pass through the LLRN project during the construction phase.

Commercially exploited fishes and invertebrates may be harmed as a result of toxicity and smothering due to accidental oil spill. Fishes may become contaminated or may become tainted and smothered by oil from the water or sediments in which they live via absorption through the gills and skin, or through eating contaminated prey species. Commercial catches may also become externally contaminated from contact with oil-fouled fishing gear. If oil reaches the lake bottom, then species living in fine muddy sediments will be at particular risk of tainting because fine sediments can absorb and retain greater quantities of oil than coarse sediments. The greatest impact of oil spill is likely to be found along the shoreline/nearshore area.

Major oil spills may result in loss of fishing opportunities with boats unable or unwilling to fish due to the risk of fouling of boats and fishing gear. Exclusion zones, where fishermen are banned from fishing for particular species, may be imposed until the target species has been declared taint-free. In these circumstances, there will be temporary financial loss to fishermen. Local fisherfolks, may also suffer temporary food shortage.

Mitigating measure of this potential impact from accidental oil spill could be reduced by controlling movement of oil spill by containment and/or dispersion. Therefore, oil spill contingency plans should be prepared and made readily available.

Meanwhile, impacts on existing fish corral or *baklad* operation in the area are expected since there are approximately 13 existing fish corrals that will be directly affected by the project. These are all located along or within the footprint of the proposed road alignment between Alabang and Tunasan.

To mitigate this impact, a more detailed inventory (actual physical counting) on the presence of the fish corral (baklad) along the proposed route of the LLRN project is recommended. The affected fish corrals need to be relocated The affected owner of this structure must be compensated for the lost of the structure.

(b) Operation Phase

With the operation of the proposed road project, fishing operations in the shoreline and nearshore open waters can now be done all throughout the year since the fishing ground during the lean months (from November to February), which coincides with rough water conditions making fishing difficult, will now be protected by the embankment and viaduct road structures from the big waves brought about by the strong northeast monsoon winds (*amihan*). This is a positive impact.

To reduce the impact to the fishery, fishery basin facilities are planned to be incorporated along the LLRN mainline. Each fishery basin would be sized to fit the local fish boat demand and have adequate navigation clearance to connect between the basin and Laguna Lake

4.6 Aquaculture Fishery

(a) Pre-Construction Phase

Significant impacts of pre-construction activities to aquaculture operations in the lake are unlikely due to the distant location of the aquaculture structures (fish pens and fish cages) from the proposed construction of temporary facilities, land viaduct, ramps, roundabout junction and casting yards and dredging activity for barge access.

Therefore, no mitigation is required.

(b) Construction Phase

Oil spills may contaminate fixed aquaculture equipment and facilities (such as fish pens and fish cages) and tainting of cultivated fish stocks. Apart from making the gear messy and awkward to handle, contact with fouled gear can contaminate the produce and render it unsuitable as food. Free swimming fish can detect oil and might be in a position to avoid it, but caged fish cannot avoid an affected area and thereby stand a high risk of being contaminated or tainted by soluble or dispersed oil fractions following a spill.

A study conducted by Andalecio et al. (2014) on the extent of response and recovery of the aquaculture sector (fishponds, fish pens, fish cages, and seaweed farms) of Guimaras province from the effects of M/T Solar 1 oil spill showed that, the toxicity of hydrocarbon contamination, specifically, polycyclic aromatic hydrocarbons (PAHs) resulted to instantaneous fish kills, low survival, increased input expense, marketing problems, and decreased fish and shellfish demand due to product quality and safety concerns. After 2.6 years from the date of the spill incident, aquaculture farms did not find any problem with water quality. The aquaculture systems have totally recovered from the effects of the oil spill and have returned to normal operation.

Mitigating measure of this potential impact could be reduced by controlling of oil spill. Therefore, oil spill contingency plans should be prepared and made readily available.

Of specific relevance to aquaculture fisheries is the early notification of oil spills to fish farmers and fishermen, giving them as much opportunity as possible to protect fish cages and other facilities, normally using oil spill booms. Consideration may also be given to harvesting the resource before impact.

Contamination of fixed fishing gear and fish farming equipment may be avoided by the use of dispersants. However, the use of dispersants in aquaculture areas increases the risk of tainting of cultivated stocks by dispersed oil droplets.

In conclusion, the two main approaches to protection of aquaculture facilities are oil spill booming, and tackling slicks before they reach aquaculture areas using containment/recovery or dispersants. In some situations a harvesting activities may be appropriate.

There are a number of fish pen/fish cage structures installed along or within the footprint of the proposed route of the LLRN project. Hence, they are to be directly affected by the construction of this project.

To mitigate the impact on the aquaculture structure, a more detailed inventory (actual physical counting) on the presence of the structure along the proposed route of the LLRN project is recommended. The affected fish pens/cages need to be relocated. The affected owner/operator of the structure must be compensated for the lost of the structure.

(c) Operation Phase

Expected impacts, are as a whole, insignificant or minimal.

Therefore, no mitigation is required.

4.7 Macrophytes

(a) Pre- Construction Phase

Water lilies and kangkong could be adversely impacted during dredging operations for barge access. Dredging will remove substrate and vegetation and cannot be mitigated. Turbidity and sedimentation may affect benthic communities located at a considerable distance from the dredging activity.

Impacts to the surrounding areas can be minimized by the use of silt curtains and dredging activity during calm water conditions.

(b) Construction Phase

Significant impacts of the construction activities to marsh vegetation (mainly water lilies and water spinach or kangkong) along the shorelines of the proposed road alignment are unlikely due to the distant location of the macrophytes from the proposed road alignment, except that portion of the shoreline along San Pedro where macrophyte beds are present along or within the footprint of the alignment as seen from satellite images. Some loss of this nearshore habitat will occur during construction activities. This impact cannot be mitigated.

Similarly, significant or direct impacts of construction activities to kangkong farms along Muntinlupa, Sta. Rosa and San Pedro areas will not occur due to distant location of the farms from the alignment. However, deteriorating water quality is a threat to present kangkong farms located at a considerable distance from the dredging, reclamation, landfilling and piling activities, as a result of turbidity plumes.

Measures to mitigate or minimize this impact should be taken as the use of silt curtains and dredging during calm water conditions.

Marsh environments are among the most sensitive freshwater habitat to oil spills due to the minimal water flow or little water movement. Oil spills may blanket areas of the shoreline and kill organisms mainly through smothering (which is a physical effect) rather than through acute toxic effects. For example, lush marsh vegetation is used as nurseries for shellfish and fish, as a food source for many organisms, and a home for fish, birds, amphibians and reptiles. In addition to their function as nursery areas, also provide food chain support (e.g. nutrient input from dead leaves) for nearshore fisheries. Marsh vegetation of water lilies and kangkong are very common in the shallow areas along the shorelines at the project site, and these aquatic macrophytes can thus be classified as highly vulnerable to oil spills. Depending on the degree of oiling, short-term effects on the aquatic plants can be expected, particularly when the above-ground plant parts are in direct contact with floating oil. However, there is no evidence of significant long-term or persistent effects, unless the plants are completely covered with oil or below-ground plant parts are affected by oil penetration into the sediment. Marsh vegetation, especially root systems, is easily damaged by fresh oil spills. The affected habitat may take years to restore.

This impact can be mitigated or minimized by controlling movement of any spill which originates from the project construction site. Therefore, oil spill contingency plans should be prepared and made readily available.

(c) Operation Phase

Normal operations of the LLRN project are not likely to result in impacts.

Therefore, no mitigation is required.

Table 2.71 Summary of impacts on aquatic ecology and fisheries and corresponding mitigation measures by project phase

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures
A. Pre-Construction			
Land clearing, ground preparation and earthworks for the construction of temporary facilities, land viaduct, ramps, roundabout junction and casting yards and dredging for barge access	Aquatic Ecology • Plankton communities and primary productivity (increased sedimntatioin/ turbidity)	• Impacts will be minimal, temporary and localized both for primary production (phytoplankton) and secondary production (zooplankton) in the pelagic zone	• Impacts on the receiving water bodies can be mitigated by installing adequate temporary erosion control measures (siltation ponds, silt/sediment traps and berms and re-routing of surface run-off around the facilities) and silt screen to prevent dispersion of turbid waters
	• Benthic communities	• Land clearing / earthmoving activities will disturb and smother the existing benthic faunal invertebrates; dredging for barge access will produce localized turbidity plumes.	• Well planned land clearing and earthmoving operations should be implemented. Temporary erosion control measures should be used to reduce siltation and high turbidity
	• Fishes and other aquatic fauna	• Sedimentation and turbidity can also contribute to decreases in local fish populations and may have an adverse effect on fish health; can reduce dissolved oxygen in the water column and in extreme cases may cause a	• Soil erosion and increased siltation/turbidity will be minimal and temporary and will be encountered only during wet season and during construction activities. Well planned land clearing and earthmoving operations should be implemented. Temporary erosion control

		thickening of the gill epithelium and reduce respiratory function; and spawning habitat also may be smothered	measures and geotextile silt curtains should be used during the construction period to reduce siltation/turbidity and therefore, impact on adjacent aquatic communities
	• Macrophytes	• Dredging for barge access will remove substrate and vegetation (e.g. kangkong) and cannot be mitigated. Turbidity and sedimentation may also affect benthic communities located at a considerable distance from the dredging activity.	• Impacts to the surrounding aquatic environment can be minimized by the use of silt curtains and dredging activity during calm water conditions.
	Fisheries • Fish capture	• Major impact would be the turbidity created by suspension of sediments and removal/loss of bottom habitat, and noise during dredging operations to the shallow waters for barge access. This could consequently impact demersal (bottom dwelling) fishes and possibly destroy shrimp breeding/nursery areas for some time. Pelagic fish would be impacted temporarily. Turbidity will be detrimental to both larval	• Turbidity plumes can be reduced by the use of silt screens during the dredging operation

		fishes and shrimp.	
	• Aquaculture	• Significant impacts are unlikely due to the distant location of the fish pens and fish cages from the proposed construction of temporary facilities, land viaduct, ramps, roundabout junction and casting yards and dredging activity for barge access	• No mitigation is required
B. Construction			
Embankment and viaduct construction activities	Aquatic Ecology • Plankton communities and primary productivity, -Dredging, reclamation, landfilling, pile driving	• Increase turbidity levels which may interfere with phytoplankton productivity and zooplankton feeding and respiration; tend to limit light penetration essential in photosynthesis; trritation and clogging of gills of fish larvae and juveniles that could lead to their eventual smothering; and would slightly increase the mortality rates among fish larvae/juveniles including other planktonic	• Use of geotextile silt curtains is recommended

	Bilge water discharges from construction/ cargo/delivery vessels and barges - Accidental oil spills	organisms • Depress photosynthesis and growth of phytoplankton exposed to wide range of petroleum hydrocarbons, including both whole oils as well as specific compounds • Effects of accidental oil spills are similar to that of the effects of bilge water discharges. If there is an accidental oil spill it could not be mitigated	• Proponent must not allow construction vessels from discharging bilge water, or possibly by establishing treatment for bilge water • Impact might be reduced by controlling movement of oil spill and/or dispersion. Oil Spill Contingency Plans should be prepared and made readily available
	•Benthic communities - Dredging, reclamation, landfilling, pile driving	• Will not only disturb the existing benthic fauna but will entail a complete smothering and burying of all benthic organisms present at the dredging, reclamation, landfilling, and pile driving areas. No known remedy for this impact; however, benthic organisms can easily re-colonize in undisturbed and unreclaimed areas. Therefore, negative impacts of these activities	• Construction phase will destroy them and cannot be mitigated. After construction activities have ceased, it is desirable to monitor the re-colonization rate and recovery of species diversity and abundance in the perturbed area (s), and to identify the changes in the surrounding habitats. • Use of geotextile silt screens. This could help in mitigating the impact on

		are expected to be minimal, short-term and localized • Feeding activities and respiration of bottom dwelling organisms such as the commercial clams, snails and shrimps of the surrounding areas along the immediate vicinity of the construction site will also be impacted by siltation and turbidity plumes	surrounding benthic communities not directly impacted by the construction activities. • Choice of appropriate reclamation procedure and provision of siltation ponds, armour rocks or precast concrete with geomembrane, and silt curtains can further help reduce turbidity plume problems. • Full construction of revetment or containment structure and armouring (with provision of granular bedding material and geomembrane or geotextile filter) around the reclamation boundary prior to filling and installation of silt curtain around dredging and piling areas can adequately prevent this.
	-Accidental oil spill	• Heavily contaminated sediments during an accidental oil spills are likely to have an adverse effect on local populations of bottom dwelling species such as clams and snails which are unable to swim into unpolluted areas. However, there is also evidence that bottom dwelling wild fish species such mud fish, catfish, eel and tilapia	• Impacts might be reduced by controlling movement of oil spill and/or dispersion. Oil Spill Contingency Plans should be prepared and made readily available

		are able to detect and avoid-contaminated waters	
	• Fishes and other aquatic fauna -Siltation/tur-bidity -Noise/vibrations (e.g. pile driving)	• Increased siltation and turbidity generated by construction activities such as dredging, reclamation, land filling and pile driving would cause adult fish in the area to migrate to other suitable areas. However, smaller species that are unable to migrate would be chronically exposed to high turbidity may suffocate as their gills become clogged with sediments. Impact on the fish resources is expected to be minimal or insignificant, short duration and site specific. • There is a lack of robust scientific evidence on the sensitivity and effects of underwater noise upon fish and an almost complete absence of data for invertebrates (in particular, on behavioral thresholds, response distance and sound exposure levels). Therefore, impact on the fish resources is expected to be minimal or insignificant, short duration and	• To mitigate the impact among smaller species, use of geotextile silt curtains is recommended • No mitigation is required

		site specific. • However, there is evidence that man-made sound could have an impact on fish catches (Catch-per-Unit Effort or CPUE). Both gear- and species specific effects may occur. The effectiveness of different fishing gear depends on different patterns of fish behavior. Fish catches may fall because of behavioral changes affecting the vulnerability of fishes to capture, not just because fishes have left an area	
	• Macrophytes -Dredging, reclamation, landfilling, pile driving - Turbidity	• Significant impacts of the construction activities to water lilies and water spinach or kangkong are unlikely due to the distant location of these macrophytes from the proposed road alignment, except that a particular portion of the shoreline along San Pedro where macrophyte beds are present along or within the footprint of the alignment. Some loss of this shoreline vegetation will occur. This impact cannot be mitigated	• No need for mitigation of impact • Measures to mitigate or minimize this impact should be taken as the use of silt curtains and dredging during calm water

	- Accidental oil spill	• Similarly, significant or direct impacts of construction activities to kangkong farms along Muntinlupa, Sta. Rosa and San Pedro areas will not occur due to distant location of the farms from the alignment. However, deteriorating water quality is a threat to kangkong farms from the dredging, reclamation, landfilling and piling activities, as a result of turbidity plumes. • Marsh environments are among the most sensitive freshwater habitat to oil spills due to the minimal water flow (classified as highly vulnerable to oil spills). Oil spills may blanket this shoreline habitat and kill organisms (fish, shellfish. birds, amphibians and reptiles) mainly through smothering	conditions. • Controlling movement of any spill which originates from the project site. Therefore, Oil Spill Contingency Plans should be prepared and made readily availabl*e*.
	Fisheries • Fish capture - Dredging, reclamation, landfilling, pile	• Temporary and minor disruption of fishing activities on some fisherfolks; however, if construction is done during the NE	• A required safety exclusion zone along construction area is recommended, that is 0.1 km. However, there must be a passageway for the fisherfolks to pass

	driving	monsoon season or *amihan* (November - February) which coincides with rough water conditions, almost no impact to fishing is expected because most of the fishing activities are done during *taglinaw*, *i.e.* from March to October, coinciding with summer period and SW monsoon season (*habagat*)	through the LLRN project during the construction phase.
		• Construction activities are not continuous (will be conducted per segment) so that that there will be fishing areas wherein fisherfolks would have access to the lake.	
		• Hence, expected impacts to capture fisheries, are as a whole insignificant, temporary (short-term), and site specific	
		• A number fish corrals (baklad) will be directly affected by the project (located along or within the footprint of the proposed road alignment between Alabang and Tunasan)	

	- Accidental oil spill	• Commercially exploited fishes and invertebrates may be harmed as a result of toxicity and smothering due to oil spill.	• Oil spill could be reduced by controlling movement of oil spill by containment and/or dispersion. Therefore, Oil Spill Contingency Plans should be prepared and made readily available.
		• Fishes may become contaminated or may become tainted and smothered by oil from the water or sediments in which they live (via absorption through the gills and skin, or through eating contaminated prey species).	
		• Commercial catches may also become externally contaminated from contact with oil-fouled fishing gear. If oil reaches the lake bottom, then species living in fine muddy sediments will be at particular risk of tainting	
		• Greatest impact of oil spill is likely to be found along the shoreline/nearshore area.	
		• Major oil spills may result in loss of fishing opportunities with boats unable or unwilling to fish due to	

		the risk of fouling of boats and fishing gear. Temporary financial loss to fishermen. Local fisherfolks, may also suffer temporary food shortage.	
	Aquaculture -Physical damage to fish pens and & fish cages due to construction activities -Accidental oil spills	• A number of fish pen/fish cage structures installed along or within the footprint of the proposed route of the LLRN project between Lower Bicutan and Tunasan are to be directly affected by the construction of this project. • Oil spills may contaminate fixed aquaculture equipment and facilities and tainting of cultivated fish stocks. • Contact with fouled gear can contaminate the produce and render it unsuitable as food. • Free swimming fish can detect oil and might be in a position to avoid it, but caged fish cannot avoid an affected area and thereby stand a high risk of being contaminated or tainted by soluble or dispersed oil	• A more detailed inventory (actual physical counting) on the presence of the structure along the proposed route of the LLRN project is recommended. Affected fish pen/cage need to be relocated and/or affected owner/operator of the structure must be compensated for the lost of the structure. • This potential impact could be reduced by controlling movement of oil spill. Therefore, Oil Spill Contingency Plans should be prepared and made readily available. • Early notification of oil spills to fish farmers and fishermen, giving them as much opportunity as possible to protect fish cages and other facilities, normally using oil spill booms. Consideration may also be given to harvesting the resource before impact. • Contamination of fish farming equipment

		fractions following a spill.	may be avoided by the use of dispersants; however, the use of dispersants in aquaculture areas increases the risk of tainting of cultivated stocks by dispersed oil droplets.
C. Operation			
Project Operation	Aquatic Ecology • Plankton Communities and Primary productivity	• No impacts are expected to results from the normal operations of the LLRN project on the plankton communities and primary productivity at the project site and surrounding waters.	• No mitigation is required.
	• Benthic Communities	• Impact of LLRN project normal operations on the bottom benthic communities at the project site and of the surrounding waters will be none.	• No mitigation is required.
	• Fishes and Other Aquatic Fauna	• Normal operations of LLRN project are not expected to pose a threat to fish and invertebrate	• No mitigation is required.

		communities. • The embankment and lake viaduct structures which are made up of rock boulders and concrete piles, respectively could, in fact, acts as artificial hard substrates that: (a) could attract colonization for a variety of fishes and other aquatic life; (b) provide shelter to a number of organisms; (c) provide food and protection for numerous and diverse aquatic organisms; and (d) also serve as attachment or substrate for attached forms. Thus, these artificial hard structures will enhance the aquatic habitat in the lake; a positive or beneficial impact upon fish and other aquatic life at the project site because of the creation of artificial hard substrata on the lakebed	
	• Macrophytes	• Normal operations of the LLRN project are not likely to result in	• No mitigation is required

		impacts.	
	• Fisheries - Fish Capture -Aquaculture	• Fishing operations can now be done all throughout the year since the lakeshore fishing ground during the lean months (from November to February), which coincides with rough water conditions making fishing difficult, will now be protected by the embankment and viaduct structures from the big waves brought about by the strong NE monsoon winds (amihan). This is a positive impact	• To reduce the impact to the fishery, fishery basin facilities are planned to be incorporated along the LLRN mainline. Each fishery basin would be sized to fit the local fish boat demand and have adequate navigation clearance to connect between the basin and Laguna Lake.
	Water Quality		• Treatment of road runoff should be proposed to mitigate water quality impacts on all freshwater receptors.
D. Decomissioning/ Abandonment	• Fishes and Other Aquatic Fauna	• Removal of LLRN structures - significant impact on fish/ and other aquatic species populations because of habitat loss (artificial hard substrata) and it cannot be mitigated	

2.3 The Air

2.3.1 Meteorology and Climate

2.3.1.1 Methodology

This section describes the climatology and meteorology characteristics based on records from three different weather stations near the project location (**Table 2.72**). First is the Ninoy Aquino International Airport (NAIA) synoptic station in Pasay City located at the northwestern side with geographic coordinates of 14°38'41.35" north latitude and 121°02'40.45" east longitude, and about 7 km away from the Lower Bicutan station. Second is the Science Garden PAGASA station in the northern side at the coordinates of 14°38'41.35" north latitude and 121°02'40.45" east longitude and approximately 18 km away from Station 0+000 of the proposed project. This station is considered because rainwater and stormwater from Quezon City and neighboring cities drains directly into the Laguna Lake (**Figure 2.153**)[27]. Third is the National Agrometeorological Station (NAS) - University of the Philippines Los Baños (UPLB) station in Laguna located at the southeastern portion with of coordinates of 14°10'20.36"N; 121°13'48.74"E) and nearly 7 km away from the Calamba station. This station represents the influences in the southern portion of the project area covered by the Province of Laguna.

Aside from three (3) stations datasets, the baseline climate conditions of the project area at the provincial scale are taken following the latest Philippine Climate Extreme Report 2020.[28]

Table 2.72 Details of the Weather Stations

Station	Location	Elevation (m asl)	Coordinates	Description
NAIA (MIA), Pasay City	NAIA Pasay City	21	14°30'25.75"N 121°00'15.90"E	About 7 km away from the Lower Bicutan station and located at the northwestern side.
PAGASA Science Garden	PAGASA Science Garden Complex, Agham Road, Diliman Quezon City, Philippines	43	14°38'41.35"N 121°02'40.45"E	More or less 18 km away from Station 0+000 of the proposed project and located at the northern side
UPLB National Agrometeorological Station	University of the Philippines Los Baños, College, Laguna	27.1	14°10'20.36"N 121°13'48.74"E	7 km away from the Calamba station and located at the southeastern portion

[27] Laguna de Bay basin is sub-divided into 24 watersheds from which over 100 rivers and streams drain toward the lake. Twenty-two (22) of these are major river systems including one (1) outlet, the Pasig River through the Napindan Channel. These tributary rivers are the Pagsanjan River, the Sta. Cruz River, the Balanak River, the Marikina River, the Mangangate River, the Tunasan River, the San Pedro River, the Cabuyao River, the San Cristobal River, the San Juan River, the Bay, Calo and Maitem rivers in Bay, the Molawin, Dampalit and Pele Rivers in Los Baños, the Pangil River, the Tanay River, the Morong River, the Siniloan River, and the Sapang Baho River.
[28] DOST-PAGASA, Manila Observatory and Ateneo de Manila University. 2021. Philippine Climate Extremes Report 2020: Observed and Projected Climate Extremes in the Philippines to Support Informed Decisions on Climate Change Adaptation and Risk Management. Philippine Atmospheric, Geophysical and Astronomical Services Administration, Quezon City, Philippines. 145 pp.

Figure 2.153 Location of the Weather Stations Near the Project Location

2.3.1.2 Baseline Environmental Conditions

2.3.1.2.1 Local Climate

Based on the modified Coronas Climate Classification System, the road alignment, and other components of the Laguna Lake Road Network (LLRN) project falls under Type I climate classification as shown in the Climate Map of the Philippines in **Figure 2.154**. Type I Climate is characterized by two pronounced seasons, dry season from November to April and wet season from May to October with a maximum rainy period from June to September. Areas under this type of climate are generally exposed to the southwest monsoon during rainy seasons and receive a fair share of rainfall as brought about by the tropical cyclones occurring during the maximum rainy period.

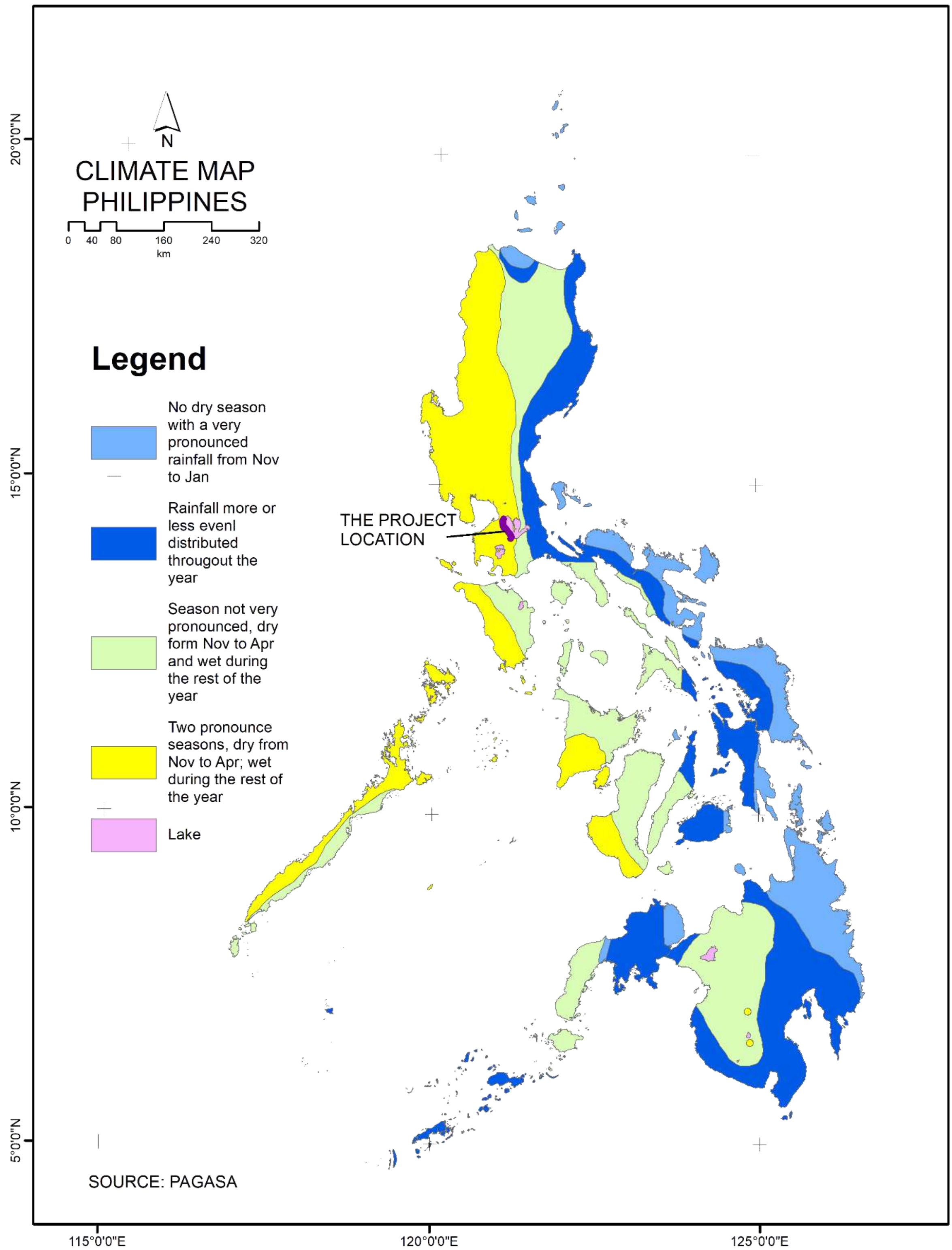


Figure 2.154 The Philippines Climate Map

Rainfall

The monthly rainfall ranged from 12 mm to 586 mm at the three different weather stations near the project areas. A large amount of the rainfall occurs in August with an average of 403 mm and 585 mm at the NAIA station and the Science Garden Station, respectively. The highest rainfalls in the southern portion are recorded in July with an average value of 334 mm. Rainfall amounts with more than 200 mm are noted at the NAIA Station from June to September, and at the Science Garden from May to October. The chance of wet months in the southern portion varies significantly throughout the year. Also, the wetter months occur from June to December.

Table 2.7373 shows the recorded annual rainfall at the NAIA, Science Garden, and NAS-UPLB stations are 1,846 mm, 2,891 mm, and 2,078 mm, respectively. Amounts of rainfall in two (2) stations in Metro Manila are within the range and an average of the observed rainfall (2,260 mm) provided in the Philippine Climate Extreme Report 2020 for the National Capitol Region (NCR). The annual rainfall for Laguna province baseline and the UPLB-NAS station is nearly identical. Other details of the monthly rainfall distribution based on the three (3) stations near the project site are shown in **Table 2.7373**.

Table 2.7373 Comparison between Synoptic Values and the Observed Baseline Rainfall

Location	Rainfall (mm)
Synoptic Stations	
NAIA (MIA), Pasay City	1,846
PAGASA Science Garden	2,891
UPLB National Agrometeorological Station	2,078
Observed Baseline Rainfall	
National Capitol Region, Baseline (Observed)[a]	2,260
Laguna Province, Baseline (Observed)[a]	2,112

[a] Source: Philippine Climate Extremes Report 2020

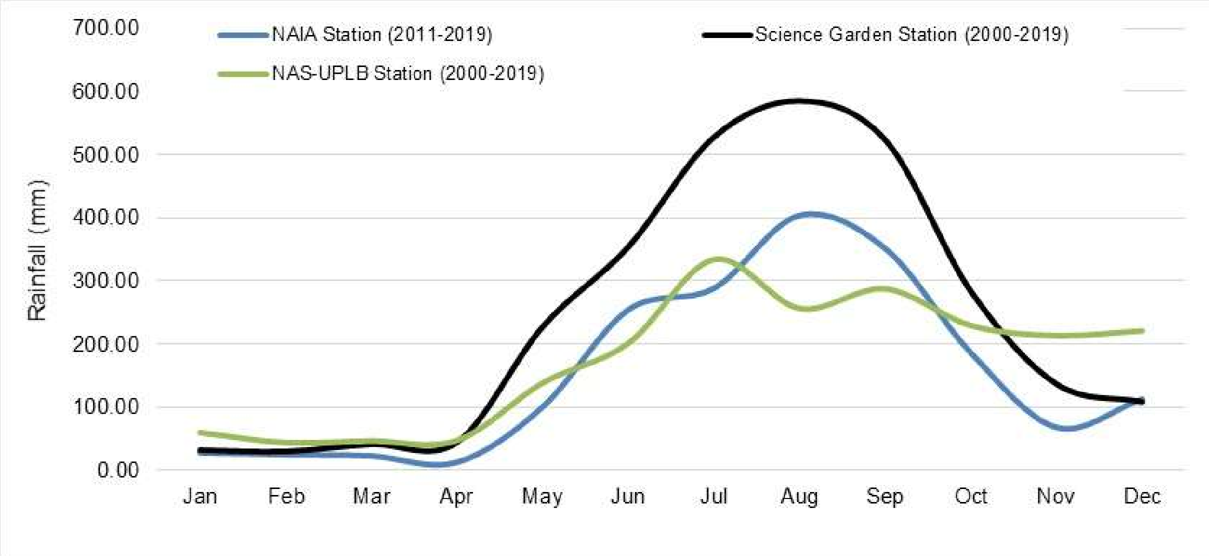


Figure 2- 54. Average monthly rainfall (2000-2019) at the synoptic stations near the project site (data from PAGASA)

Table 6. Seasonal rainfall baselines (1971-2000) at the project site (DOST-PAGASA, 2018)

Province	Baseline seasonal rainfall (mm)			
	DJF	MAM	JJA	SON
Laguna	629.2	368.8	845.0	1,066.5
NCR	107.5	198.5	1,170.2	758.7

Temperature

The annual mean average temperatures from 2000-2019 as recorded at the NAIA, Science Garden and NAS-UPB stations are 28.46 °C, 27.93 °C, and 27.67 °C, respectively. Records show that the mean temperature in the project areas ranged from 25.8 °C to 30.4 °C with January being the coldest month having a mean temperature of 25.8 - 26.1 °C. The month of May is the hottest with a mean temperature of 29.3 – 30.4 °C at the three (3) stations. As shown in **Figure 2-55**, higher temperatures are consistently recorded at the NAIA station compared to the other stations. However, the recorded temperatures do not vary significantly from each station. The mean maximum and minimum temperatures were 34.6 °C and 21.6 °C. Other details are presented in **Table 7.**

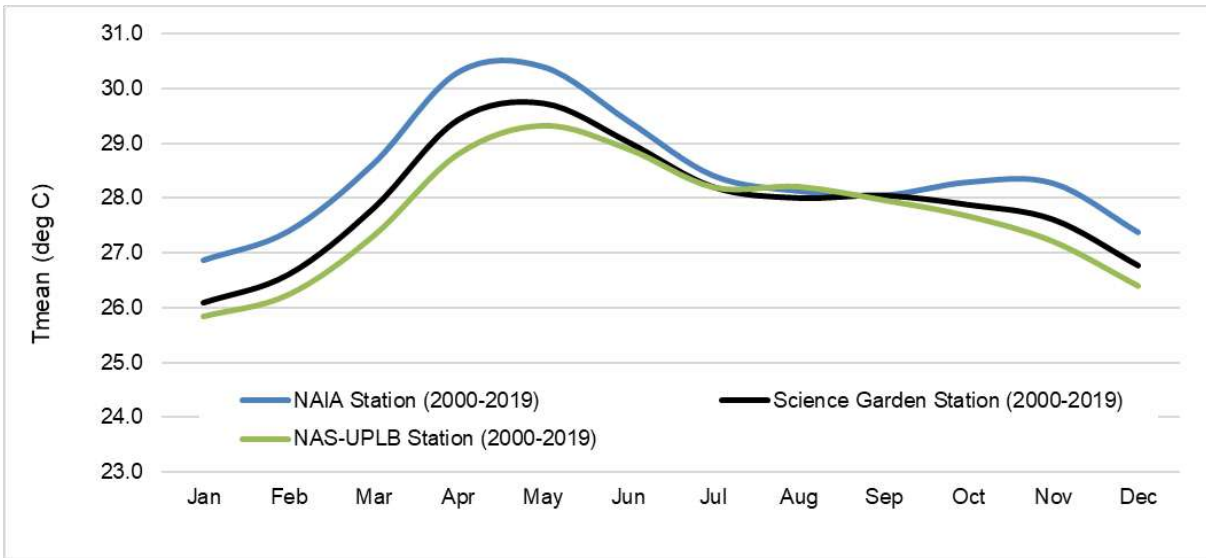


Figure 2- 55. Monthly mean temperature (2000-2019) at the three different stations (data from PAGASA)

In terms of baseline seasonal temperatures at the project site, Table 7 shows that cooling at the project site commences in September, and the months of December to February are the coolest. These are consistent with the observational data at the three stations shown in **Figure 2-55**. From the same table, it can be observed that the seasonal temperatures of NCR are slightly warmer than Laguna by approximately 1°C.

Table 7. Seasonal mean temperature baseline (1971-2000) at the project site (DOST-PAGASA, 2018)

Province	Seasonal mean temperature (°C)			
	DJF	MAM	JJA	SON
Laguna	25.0	27.5	27.5	26.7
NCR	26.1	28.8	28.0	27.4

Wind Regime

Generally, the prevailing wind at the proposed project site is from east-south-east and west-north-west directions which comprise about 58% and 20%, respectively based on the monthly average meteorological data recorded at the NAIA Station (2000-2019) (**Figure 2.158**). The average hourly wind speed is 2.64 m/s occur from all directions. Strongest wind mostly comes from the west and followed by the west-north-west direction.

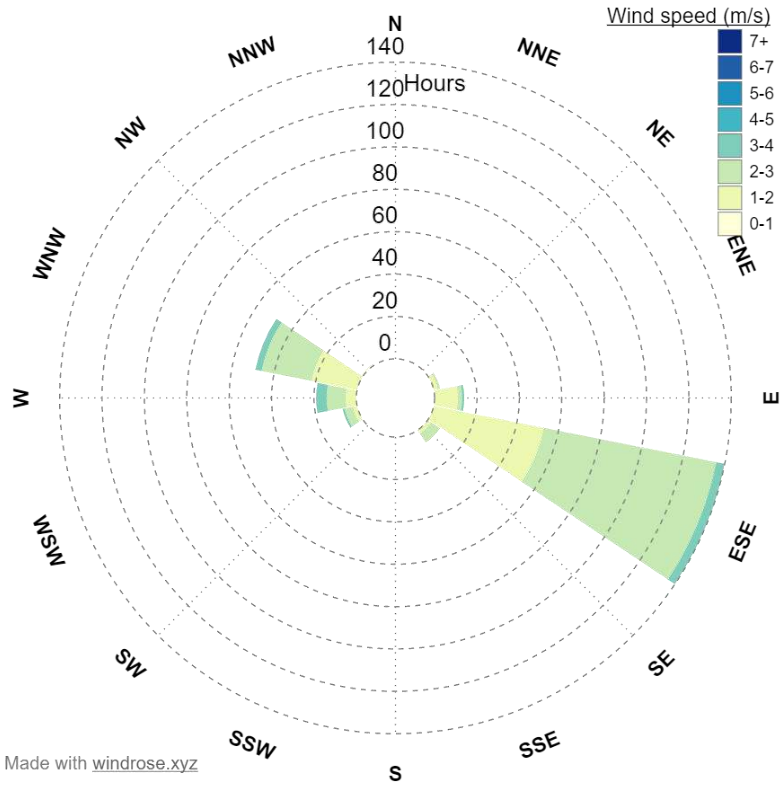


Figure 2- 56. Generated windrose diagram using wind speed and direction at the NAIA station

Relative Humidity

The annual relative humidity recorded at the three different stations are 76% (NAIA Station), 78% (Science Garden) and 79% (NAS-UPLB) as presented in **Figure 2.158.** The period, July to October, is the most humid. A change in humidity can be associated with differences in temperature and atmospheric circulation. Basically, the air is saturated when it contains the maximum amount of water vapor possible at a given temperature. The relative humidity does not vary significantly from each station.

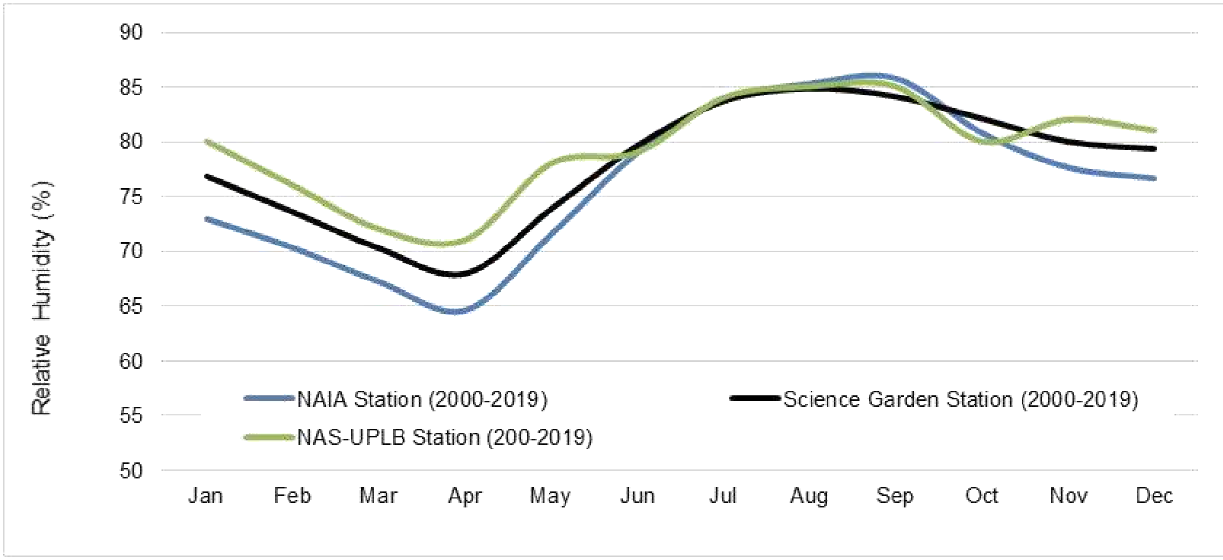


Figure 2.158 Average Monthly Relative Humidity (2000-2019) at Three Different Stations (Source: PAGASA)

Magnitude of Extreme Events

Table 2.76 and **Table 2.77** present the climatological extreme values from the 30-year monthly and annual summaries of temperature, rainfall, and wind speed. In the Science Garden station, the recorded annual extreme high and low temperatures were 38.5 °C on 14 May 1987 and 14.9 °C on 01 March 1963, respectively. The greatest daily rainfall recorded was 455 mm on 26 September 2009 during Typhoon Ondoy. The strongest wind that occurred was 50 m/s on 3 November 1995 prevailing from NNW direction.

Tropical Storm Ondoy (2009) is an extreme event because it was classified as an event with a 100-year return period (i.e., probability of occurrence is 0.1%). It is also an extreme event because the recorded accumulated rainfall over 24 hours on 26 September 2009 (368.8 mm) that exceeded the threshold (e.g., the climatological monthly total rainfall for September in Metro Manila is about 320 mm).

In the NAIA Synoptic station, the recorded annual extreme high and low temperatures were 38.2 °C on 18 May 1969 and 14.6 °C on 01 February 1962, respectively. The greatest daily rainfall recorded was 472 mm on 20 July 1972. The strongest wind was 56 m/s on 19 November 1970 prevailing from west direction.

Comparing the baseline magnitude of rainfall and temperature extremes for NCR, the recorded and observed (baseline) values are not distinct with each other. It must be noted that the baseline datasets only cover the period from 1986 to 2005. Extreme rainfall events from PAGASA Science Garden (455 mm) and NAIA (472.4 mm) stations were recorded in 2009 and 1972, respectively which is beyond the baseline period. The magnitude of extreme temperatures (both low and high) was recorded earlier than baseline period. Other details are presented in **Table 2.78** and **Table 2.79**.

There are no available climatological records found in the NAS-UPLB Synoptic Station.

Table 2.76. Climatological Extreme Recorded (1961 -2019) at the Science Garden Station in Quezon City

Month	Temperature (°c)				Greatest daily rainfall (mm)		Strongest winds (mps)		
	High	Date	Low	Date	Amount	Date	Spd	Dir	Date
Jan	34.7	01-17-1998	15.5	01-27-1987	55.8	01-16-1988	24	ESE	01-17-1972
Feb	35.6	02-24-1967	15.1	02-04-1987	61.7	02-22-2013	22	SSE	02-02-1992
Mar	36.8	03-26-1983	14.9	03-01-1963	65.0	03-31-2012	13	S	03-16-1992
Apr	38.0	04-25-1998	17.2	04-05-1963	64.8	04-21-2015	26	SSE	04-07-1992
May	38.5	05-14-1987	17.8	05-03-1962	166.0	05-20-1966	21	N	05-10-1992
June	38.0	06-02-1993	18.1	06-27-1961	334.5	06-07-1967	37	SW	06-25-1972
July	36.2	07-20-1998	17.7	07-23-1961	246.4	07-07-2002	36	NNW	07-09-1977
Aug	36.1	08-17-2017	17.8	08-23-1964	391.4	08-07-2012	32	N	08-22-2000
Sep	35.6	09-10-2017	20.0	09-08-1964	455.0	09-26-2009	35	NE	09-28-2006
Oct	35.4	10-09-2003	18.6	10-31-1967	209.3	10-18-1975	30	SE	10-11-1989
Nov	35.0	11-01-2001	15.6	11-12-1962	169.9	11-20-1966	50	NNW	11-03-1995
Dec	34.9	12-06-2018	15.1	12-13-1988	135.5	12-15-2015	22	SE	12-22-1997
Annual	**38.5**	**05-14-1987**	**14.9**	**03-01-1963**	**455.0**	**09-26-2009**	**50**	**NNW**	**11-03-1995**

Source: PAGASA

Table 2.77. Climatological Extreme Recorded (1947 – 2019) at the NAIA Synoptic Station in Pasay City

Month	Temperature (^{O}C)				Greatest Daily Rainfall (mm)		Strongest Winds (m/s)		
	High	Date	Low	Date	Amount	Date	Spd	Dir	Date
Jan	35.8	01-07-1989	14.8	01-18-1961	55.3	01-03-1970	20	ENE	01-12-1986
Feb	35.1	02-21-1998	14.6	02-01-1962	20.5	02-18-2017	20	E	02-28-1988
Mar	36.5	03-30-1978	16.0	03-03-1963	36.0	03-07-2011	26	E	03-29-1992
Apr	37.8	04-23-1948	18.7	04-01-1994	63.0	04-04-1992	22	ESE	04-06-1986
May	38.2	05-18-2014	19.1	05-11-1950	229.1	05-27-1960	31	SW	05-22-1976
June	38.0	06-02-1991	20.0	06-22-1954	353.8	06-01-1958	36	S	06-29-1964
July	36.4	07-26-2016	18.3	07-28-1948	472.4	07-20-1972	36	W	07-08-1986
Aug	36.5	08-15-2017	17.4	08-09-1949	401.8	08-10-1947	30	WSW	08-16-1984
Sep	35.6	09-08-2017	19.1	09-15-1950	228.9	09-08-1963	40	NNW	09-28-2006
Oct	36.0	10-24-1976	18.0	10-23-1981	274.5	10-09-1978	27	W	10-18-1985
Nov	35.8	11-17-1972	17.2	11-26-1949	121.7	11-14-1977	56	W	11-19-1970
Dec	34.2	12-29-	16.3	12-18-	125.5	12-15-	25	NW	12-30-

		1978		1955		2015			1950
Annual	**38.2**	**05-18-1969**	**14.6**	**02-01-1962**	**472.4**	**07-20-1972**	**56**	**W**	**11-19-1970**

Source: PAGASA

Table 2.78 Comparison of the Greatest Daily Rainfall between Synoptic Values and the Baseline (Observed) for NCR

Location	Rainfall (mm)	Date
Synoptic Stations		
NAIA (MIA), Pasay City	472.4	02-01-1962
PAGASA Science Garden	455.0	09-26-2009
National Capitol Region, Baseline (Observed)[a]		
Maximum 1-day total	121.4	1986-2005
Total rainfall from very wet days	585.8	1986-2005
Total rainfall from extremely wet days	189.7	1986-2005

[a] Source: Philippine Climate Extremes Report, 2020

Table 2.79 Comparison between the Recorded Temperature Extremes in the Synoptic Stations and the Baseline (Observed) for NCR

Temperature Extremes	Synoptic Stations		Baseline for NCR [a]
	NAIA (MIA), Pasay City	PAGASA Science Garden	
Temperature (low)/ Coldest nighttime temperature (TNn), °C	14.6	14.9	18.0
Temperature (high)/ Warmest day time temperature (TXx), °C	38.2	38.5	36.4

[a] Source: Philippine Climate Extremes Report, 2020

Cyclone Frequency and Magnitude

The Philippines is geographically situated in a "typhoon-belt" area, hence it is often crossed by typhoons. A tropical cyclone is a non-frontal low-pressure system of synoptic scale. It has a maximum mean wind speed of 62 kph (34 knots) or greater and persists for at least six hours. In 2015, PAGASA has started to categorize tropical cyclones into five public storm warning signals (PSWS) based on its strength, intensity, and impact to the community, as itemized below:

- PSWS No. 1 - Tropical depression with maximum sustained winds up to 61 kph
- PSWS No. 2 - Tropical storm with sustained winds 62 to 88 kph
- PSWS No. 3 - Severe tropical storm with maximum wind speed of 89kph to 117 kph
- PSWS No. 4 - Typhoon with maximum sustained winds of 118 to 220 kph
- PSWS No. 5 - Super Typhoon with maximum sustained winds more than 220 kph.

Most number of cyclones occurs from June to November. These tropical cyclones are associated with the occurrence of low-pressure areas normally originating over the North-

Western Pacific Ocean side of the Philippine Area of Responsibility (PAR) and generally moving northwestward. Tropical cyclones also originate in the West Philippines Sea. These cyclones have unusual motions and are quite rare with just 32 occurrences in more than 50 years. PAGASA categorized cyclones as i) tropical depressions (TD) with wind speeds of up to 61 kph or less; ii) tropical storm (TS) with wind speeds of 62 – 88 kph, iii) severe tropical storm (STS) with wind speed of 89 – 117 kph, iv) tropical typhoon (TY) with wind speeds of over 118 - 220 kph, and v) super typhoon with wind speed of more than 220 kph.

Figure 2- 57 shows that the proposed project location is within the areas that are highly exposed to TCs.

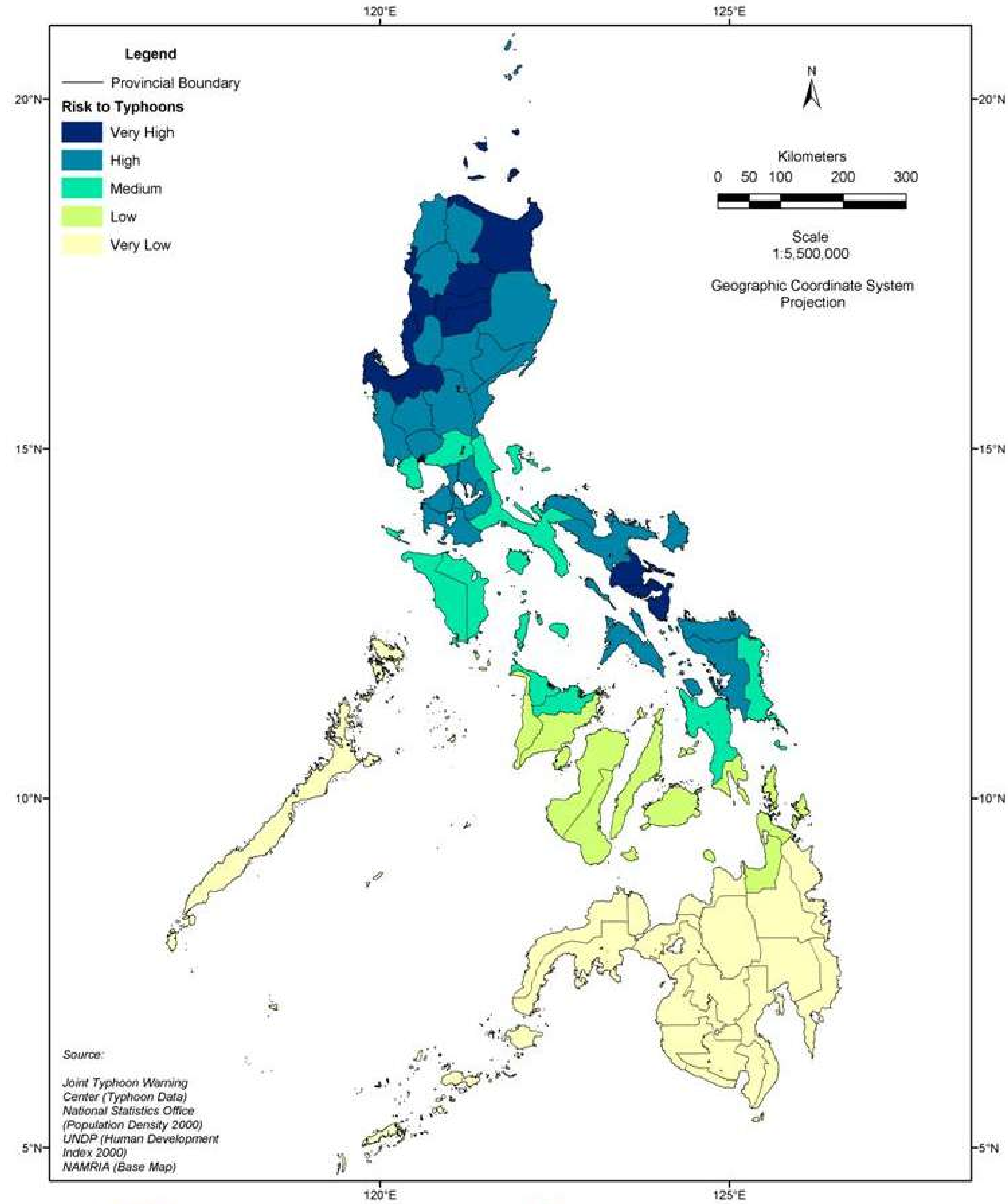


Figure 2- 57. The Philippines' typhoon risk map

From 1948 to 2019 (more than 70 years), PAGASA recorded an annual average of 20 tropical cyclones in the PAR, with 9 of these passing through Philippine landmasses. For instance, PAGASA tracked 18 tropical cyclones that crossed NCR while 32 tropical cyclones crossed the Province of Laguna from 1948 - 2019 as shown in Figure 2- 58 and Figure 2- 59. The months from June to December have the highest number of tropical cyclones at the project site (Figure 2- 60 and Figure 2- 61).

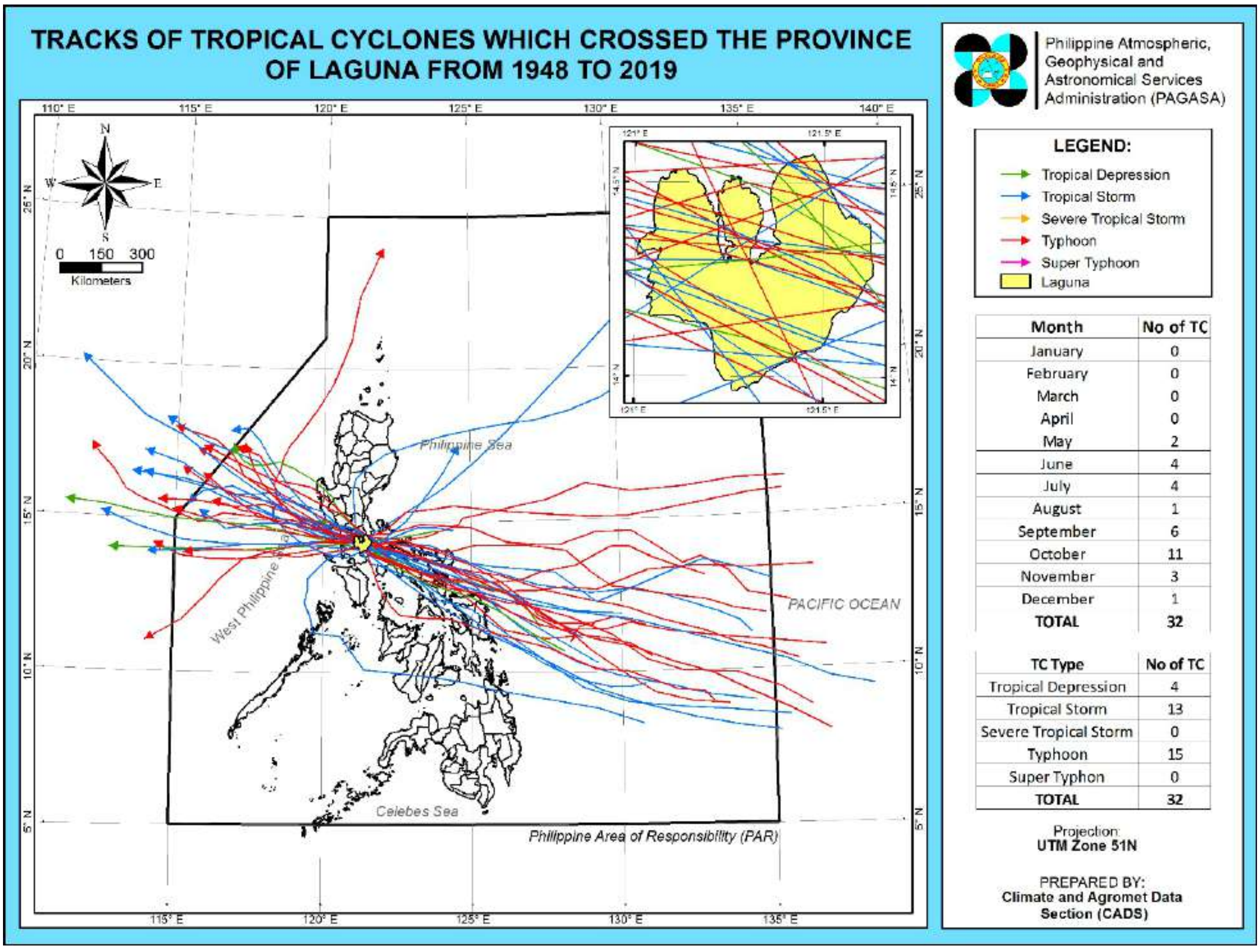


Figure 2- 58. Tropical cyclone tracks in the province of Laguna (1948 to 2019)

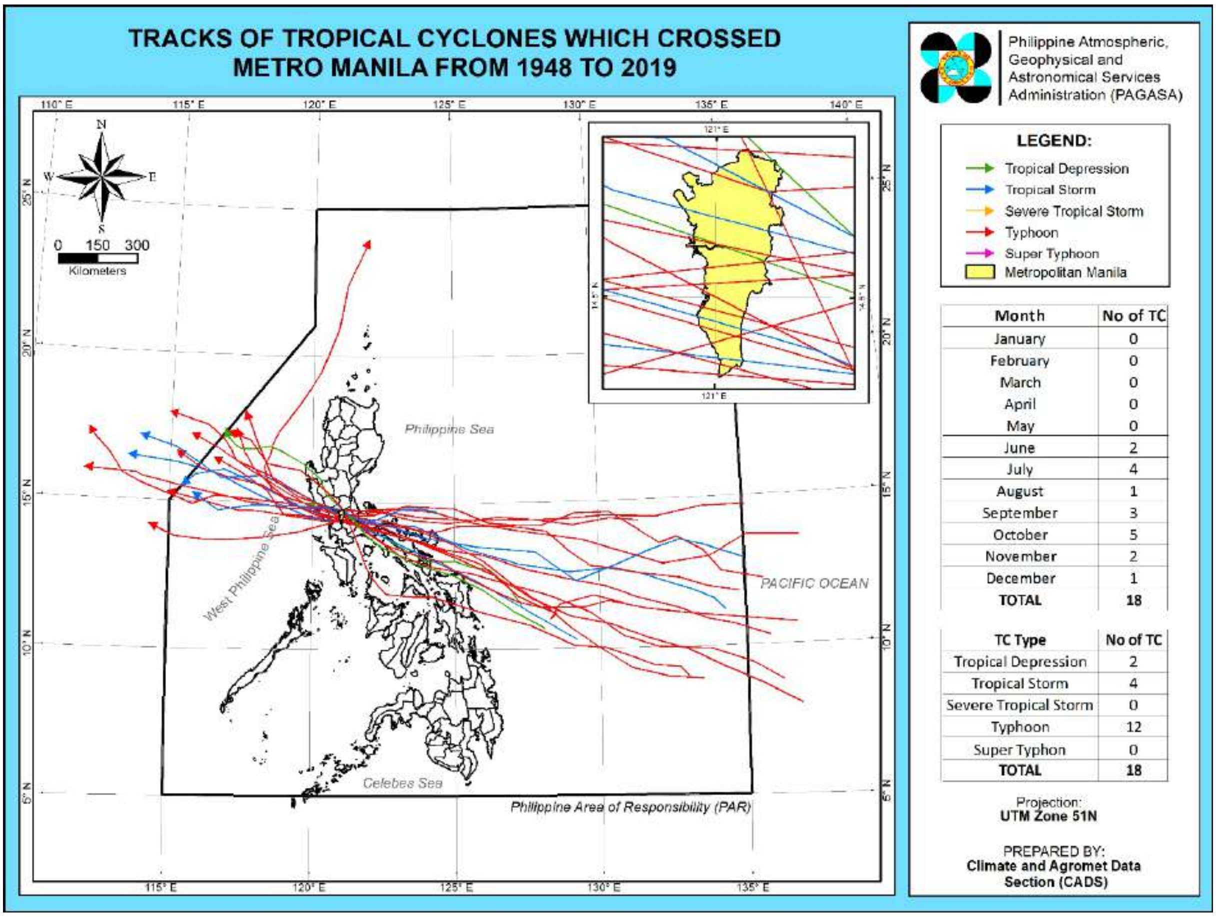


Figure 2- 59. Tropical cyclone tracks in NCR (1948 to 2019)

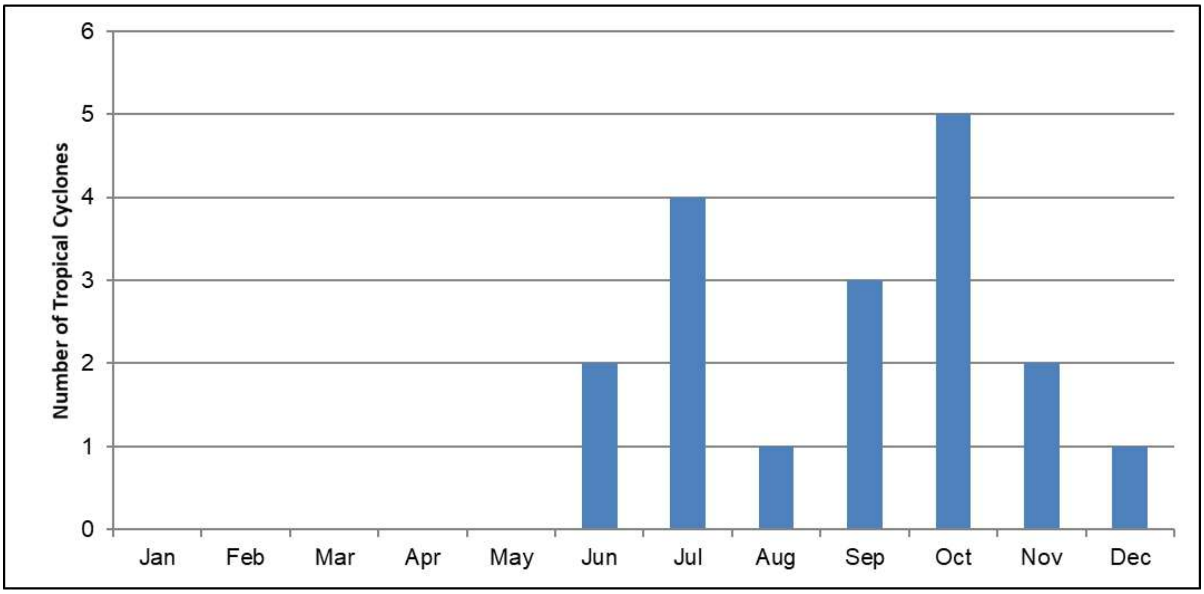


Figure 2- 60. Number of tropical cyclones which crossed NCR from 1948 – 2019

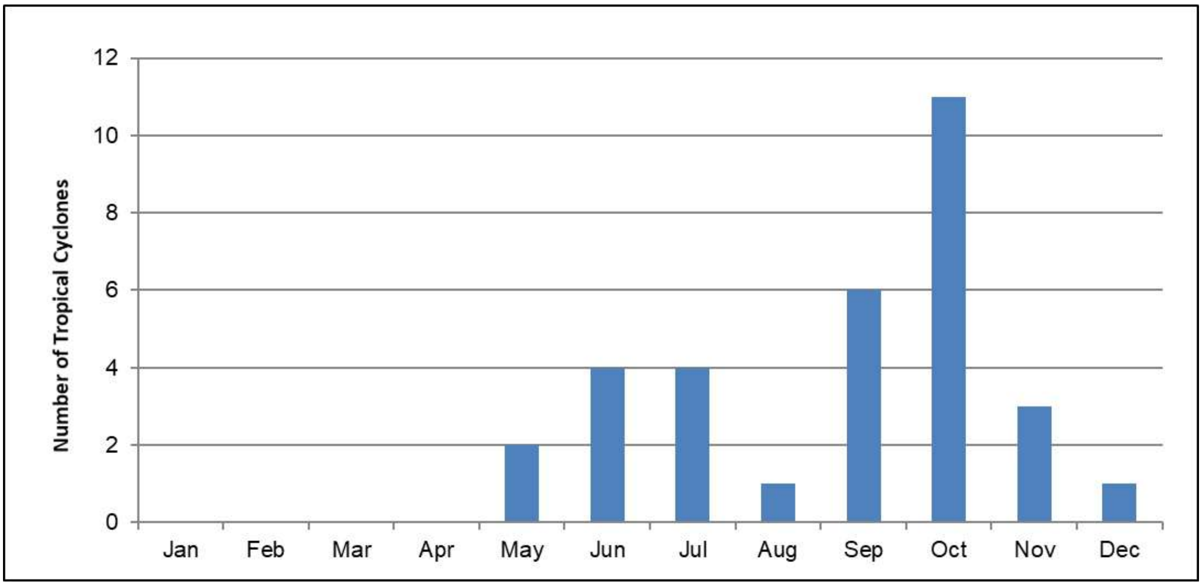


Figure 2- 61. Number of tropical cyclones which crossed Laguna from 1948 – 2019

12 typhoons or about 67% of the tropical cyclones and four (4) tropical storms are recorded that crossed NCR from 1948 to 2019 (Figure 2- 62). Likewise, 15 typhoons or about 47% of the tropical cyclones and 13 tropical storms are recorded that crossed in the province of Laguna from 1948 to 2019 (Figure 2- 63).

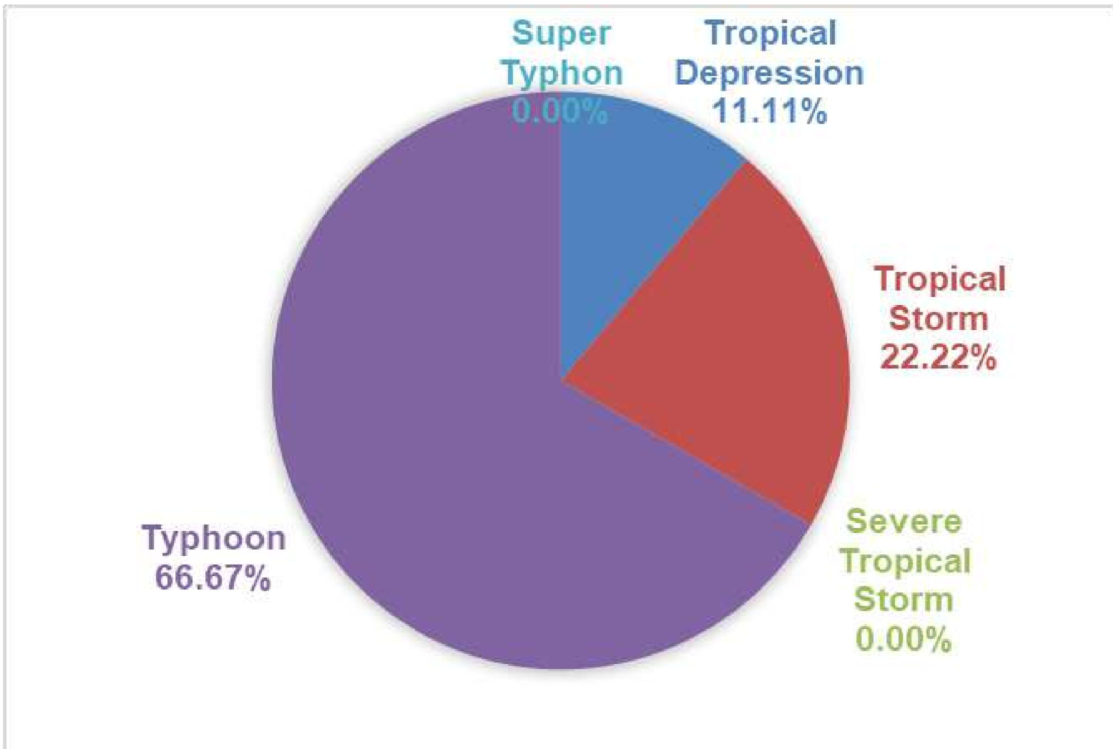


Figure 2- 62. Relative distribution of tropical cyclones which crossed NCR from 1948 to 2019, by intensity

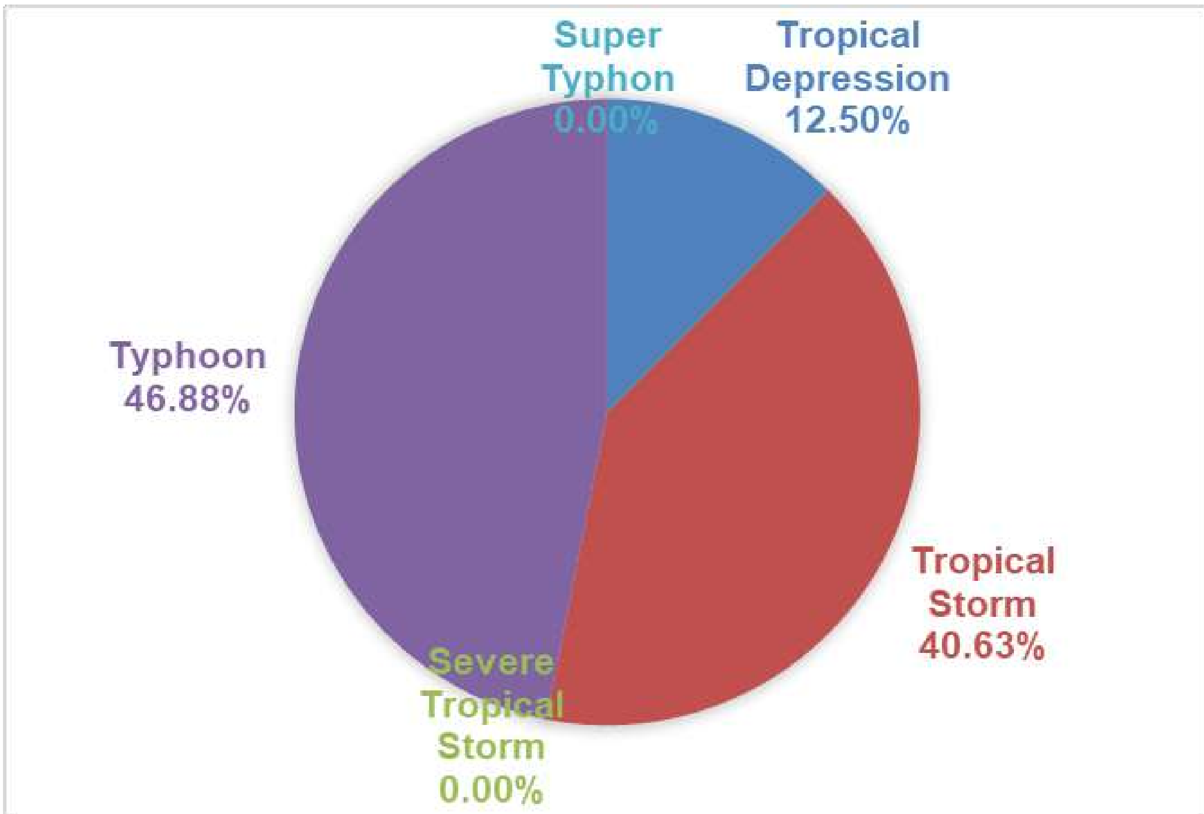


Figure 2- 63. Relative distribution of tropical cyclones which crossed the province of Laguna from 1948 to 2019, by intensity

2.3.1.2.2 Contribution in Terms of Greenhouse Gas Emission

The implementation of the project will generate greenhouse gases (GHGs) primarily from the combustion of fossil fuels during the project's construction and operations. Although there are other non-CO_2 GHGs, this inventory will only focus on CO_2 because it is the most significant source of GHGs in transport.

2.3.1.2.2.1 Methodology

This inventory follows the methods prescribed by the Asian Development Bank (ADB)[29] for transport projects and the Intergovernmental Panel on Climate Change (IPCC) for energy-related emissions[30].

It covers the emissions from the project's activities during construction and operations. In terms of estimation boundaries, Scope 1, which pertains to sources and activities controlled

[29] ADB (2016). Guidelines for estimating greenhouse gas emissions of Asian Development Bank projects additional guidance for transport projects. Mandaluyong, Philippines. Retrieved from: https://www.adb.org/sites/default/files/institutional-document/219791/guidelines-estimating-ghg-emissions-transport.pdf

[30] IPCC (2006). 2006 IPCC Guidelines for greenhouse gas inventories, Volume 2: Energy. Kanagawa, Japan. Retrieved from: https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html

and owned by the proponent, is followed during construction. Due to the nature of transport of infrastructure projects, Scope 3, which covers indirect emissions resulting from the project but are not owned and controlled by the proponent, such as vehicles traversing the roads, is used to estimate the GHGs during operations. In the absence of more granular emission factors, Tier 1 estimation method is used. This approach applies regional default values from the IPCC, ADB, and other published sources.

2.3.1.2.2.2 CO2 emissions during construction

To estimate CO_2 emissions during construction, a top-down approach that is based on total fuel consumption is employed. The use of vehicles and equipment during construction consumes an average of 800,000 liters of diesel per month. It is assumed that this fuel consumption rate remains unchanged throughout the entire construction phase of four years. Equation 1 is used to estimate the resulting GHG emissions. ADB's emission factor for diesel of 2.70 kilograms CO_2 ($kgCO_2$) per liter of diesel is also used[31]. Refer to **Table 8** for a summary of the parameters used to estimate total GHGs from construction.

Equation 1. Formula for estimating CO_2 emissions from diesel consumption

$$GHG_{FC,\,diesel} = FC_{diesel} \times EF_{diesel}$$

where:

$GHG_{FC,\ diesel}$	GHG emissions from diesel fuel consumption
FC_{diesel}	Total diesel consumption
EF_{diesel}	Emission factor of diesel fuel

Table 8. Activity data and emission factors used to estimate CO_2 emissions during construction

Description	Value	Unit
Average monthly fuel consumption	800,000	L/month
Average annual fuel consumption	9,600,000	L/month
Construction period	4	Years
CO_2 emission factor for diesel fuel	2.70	$kgCO_2$/L

Given these, the construction of the project releases 25,920 tons of CO_2 (tCO_2) annually. Based on ADB's threshold of 100,000 tCO_2/year[32], the project's construction is an insignificant source of emissions. Throughout the 4-year construction period, 103,680 tCO_2 can be attributed to the project.

[31] ADB (2016). Guidelines for estimating greenhouse gas emissions of Asian Development Bank projects additional guidance for transport projects. Mandaluyong, Philippines. Retrieved from: https://www.adb.org/sites/default/files/institutional-document/219791/guidelines-estimating-ghg-emissions-transport.pdf

[32] ADB (2017). Guidelines for estimating greenhouse gas emissions of Asian Development Bank Projects: Additional guidance for clean energy projects. Mandaluyong City, Philippines. Retrieved from: https://www.adb.org/sites/default/files/institutional-document/296466/guidelines-estimating-ghg.pdf

2.3.1.2.2.3 CO_2 emissions during operations

A bottom up approach is used to estimate CO_2 emissions during the project's operations. It uses the (activity-structure-intensity-fuel) ASIF framework, shown in Equation 2, to estimate the GHGs from the vehicles traversing the road network.

Equation 2. Formula for estimating emissions from road transport using the bottom-up approach

$$GHG_{Transport} = A \times S \times I \times F$$

where:

GHG transport	total road transport activity
S	structure; pertains to travel shares of each mode of transport
I	fuel intensity of each mode
F	carbon content of fuels

A transport model was used to estimate travel activity per mode in two scenarios: with and without the project. The appraisal period is harmonized with the economic and transport models at 30 years, which starts from 2025 until 2054. Refer to the transport model of the report for more details on the assumptions on travel activity, speed, and modal structure.

Table 9 compares travel activity, measured as vehicle kilometer travelled (vkt), with and without the project. The table shows that travel activity is estimated to be higher across all modes with the project. It likewise shows that the annual growth in vkt is higher with the project for cars, buses, and trucks. In both scenarios, it is assumed that travel activity grows for a decade and stabilizes at 2035 levels until the end of the appraisal period.

Table 9. Travel activity in vehicle kilometer travelled (vkt) by vehicle type

Mode	2025 travel activity		Annual growth for 2025-2035	
	Without project	With project	Without project	With project
Car	15,531,406	15,556,406	640,836,624	649,442,839
Bus	1,019,737,537	1,024,138,745	37,457,341	38,081,001
Truck	2,951,191,195	2,9151,916,688	72,262,592	72,850,158
Motorcycle	11,967,211,246	11,990,592,869	611,838,565	595,452,678
Jeepney	3,577,272,301	3,574,969,488	89,605,094	87,291,617

Table 10 and **Table 11** show the rest of the inputs for estimating the CO_2 emissions during operations. The travel structure was derived from the Department of Transport's (DOTr) National implementation plan (NIP) on environment improvement in the transport sector low pollution-low emission[33]. The fuel efficiency values were taken from Clean Air Asia's study[34] on air pollution and GHG emissions indicators for road transport, except for jeepney,

[33] DOTr (n.d.). Philippines National implementation plan (NIP) on environment improvement in the transport sector low pollution-low emission. Pampanga, Philippines. Retrieved from: https://dotr.gov.ph/images/front/other_matters/nip.pdf

[34] Clean Air Asia (2012). Air Pollution and GHG Emissions Indicators for Road Transport and Electricity Sectors (Guidelines for Development, Measurement, and Use). Pasig City, Philippines. Retrieved from: https://www.gcca.eu/sites/default/files/2019-12/Air%20Pollution%20and%20GHG%20Emissions%20Indicators%20for%20Road%20Transport%20and%20Electricity%20Sectors%20Guidelines%20for%20Development%2C%20Measurement%2C%20and%20Use%2C%202012.pdf

which was taken from Marasigan's article[35] on PUV modernization. The carbon content of fuels followed the values prescribed by ADB[36].

Table 10. Travel structure and average fuel efficiency

Mode	Travel structure (%)		Average fuel efficiency (L/km)
	Gas	Diesel	
Car	90	10	0.08
Bus	20	80	0.28
Truck	10	90	0.30
Motorcycle	100	-	0.02
Jeepney	-	100	0.18

Table 11. Carbon content of gas and diesel

Fuel type	Emission factor ($kgCO_2/L$)
Gas	2.32
Diesel	2.70

A straightforward application of the ASIF framework, hereafter referred to as 'Approach 1', using the data in the previous tables yields higher CO_2 emissions with the project compared to the counterfactual scenario without the project. This is primarily due the relatively higher travel activity resulting from the new road network. **Table 12** shows that in 2025, the project emits 8,393 tCO_2 more than the counterfactual scenario. While being a net emitter, this rate is way below ADB's threshold of 100,000 tCO_2 per year. This means that the project is not a significant GHG emissions source. Throughout the entire appraisal period, the project generates 438,232 tCO_2 more than the scenario without it.

Table 12. CO_2 emissions summary (in tCO_2) with and without the project using the approach 1 estimation methodology

Estimation scenario	Opening year (2025)	Entire appraisal period (2025-2054)
Without project (A)	8,245,217	314,606,458
With project (B)	8,253,609	315,044,690
Net emissions (B-A)	8,393	438,232

Aside from increases in travel activity across different modes of transport, the project also leads to improvements in travel speed. Shown in **Table 13** are the estimated travel speeds with and without the project. The table likewise shows that, except for jeepneys, these travel speeds gradually decline for a decade and stabilize at 2035 levels. To reflect the fuel savings and its associated GHG emission reductions, another estimation was performed. Hereafter referred to as 'Approach 2', it uses the same ASIF framework, modal structure, and fuel

[35] Marasigan, L. (2018). Political will drives PUV modernization. Retrieved from: https://businessmirror.com.ph/2018/05/05/political-will-drives-puv-modernization/

[36] ADB (2016). Guidelines for estimating greenhouse gas emissions of Asian Development Bank projects additional guidance for transport projects. Mandaluyong, Philippines. Retrieved from: https://www.adb.org/sites/default/files/institutional-document/219791/guidelines-estimating-ghg-emissions-transport.pdf

carbon content as the preceding approach but adjusts fuel intensity according to the average travel speeds.

Table 13. Average speed across the entire network (km/h) by mode

Mode	Opening year (2025)		Annual decrement (2025-2035)	
	Without project	With project	Without project	With project
Car	26.363	26.513	0.163	0.137
Bus	19.062	19.346	0.035	0.030
Truck	25.881	25.935	0.116	0.109
Motorcycle	23.854	24.326	0.179	0.156
Jeepney	18.091	18.481	-0.013	-0.005

To derive the speed-adjusted fuel intensities, the average fuel consumption values of vehicles in Metro Manila across different speed classes, shown in Table 14 were used. These values were from Japan International Cooperation Agency's (JICA) Metro Manila urban transportation integration study (MMUTIS) update and enhancement project (MUCEP) database[37].

Table 14. Average fuel consumption (in L/km) for vehicles in Metro Manila, by mode and speed classes

Mode	Speed classes (km/h)		
	12.5	20	32.5
Car	0.0990	0.0790	0.0610
Bus	0.6020	0.5320	0.4550
Truck	0.6450	0.5700	0.4880
Motorcycle	0.0220	0.0180	0.0140
Jeepney	0.2190	0.1750	0.135

Applying the new fuel intensity values to the ASIF equation, Table 15 shows that the project contributes to 33,033 tCO_2 of net emissions reduction in its opening year and 522,715 tCO_2 in 30 years of operations compared to the scenario without the project.

Table 15. CO_2 emissions summary (in tCO_2) with and without the project using the approach 2 estimation methodology that adjusts fuel intensity according to travel speeds

Estimation scenario	Opening year (2025)	Entire appraisal period (2025-2054)
Without project (A)	10,443,466	399,444,149
With project (B)	10,410,433	398,921,433
Net emissions (B-A)	-33,033	-522,715

[37] The MUCEP database is not available online but some of the data are available in Regidor, J. (2019) Current state of transportation data and statistics in the Philippines and opportunities for improvement towards usability. 14th National Convention on Statistics, Quezon City, Philippines. Retrieved from: https://psa.gov.ph/sites/default/files/7.5.1%20Current%20State%20of%20Transportation%20Data%20and%20Statistics%20in%20the%20Philippines%20and%20Opportunities%20for%20Improvement%20Towards%20Usability%20_0.pdf

Table 16 compares the CO_2 emissions that can be attributed to the project during its operations using the two approaches. From the table, it can be observed that the estimates of both approaches are on the same order of magnitude. However, approach 2 shows that the project, compared to the scenario without it, is a net negative emitter. By contrast, approach 1 shows that the project is a net emitter although an insignificant one by ADB's standard. Between the two, approach 2 likely reflects the situation better as it accounts for the benefits of improvements in travel speeds and the resulting fuel savings and GHG emissions reduction. It likewise applies fuel intensities specific to vehicles in Metro Manila instead of regional default values.

Table 16. Summary of CO_2 emissions (in tCO_2) between two estimation approaches

Scenario	Approach 1 (default fuel intensity)		Approach 2 (speed-adjusted fuel intensity)	
	2025	30 years	2025	30 years
Without project (A)	8,245,217	314,606,458	10,443,466	399,444,149
With project (B)	8,253,609	315,044,690	10,410,433	398,921,433
Net emissions (B-A)	8,393	438,232	-33,033	-522,715

Given these, the project is a net negative emitter which will not necessitate mitigation measures. Moreover, even with the conservative estimation approach that shows the project as a net positive emitter, the annual rate of emissions is still below the threshold to be considered a significant emission source. However, while not necessary, the absolute emissions between 300-400$MtCO_2$ in both approaches and scenarios indicate that opportunities exist to reduce GHGs.

2.3.1.2.2.4 Climate Risk/Climate Change

2.3.1.2.2.4.1 Climate Change Policy in the Philippines

In 2009, the Climate Change Act (Republic Act 9729) was enacted creating the Climate Change Commission (CCC) to help mainstream climate change into government policy formulations and establish framework strategies and actions towards adaptation and mitigation. In 2010, the National Framework Strategy on Climate Change (NFSCC) was adopted to serve as a reference point to steer national mitigation and adaptation strategies. In line with the NFSCC, the Philippine Strategy on Climate Change Adaptation (PSCCA) was prepared to guide the country's climate change adaptation actions. In 2011, the National Climate Change Action Plan (NCCAP) outlined the priority areas for adaptation and mitigation. In 2012, the People's Survival Fund (RA 10174) was passed to finance adaptation programs and projects based on the NFSCC.

In 2011, PAGASA released the report, "Climate Change in the Philippines".[38] The main outputs of this report are: a) the observed climate trends using historical data from 1951 to 2010 and climatic normal (1971–2000) as a reference value, and b) the climate projections in 2020 and 2050 in the Philippines using the PRECIS (Providing Regional Climates for Impact Studies) climate model developed by the Hadley Centre of UK Met. Simulation outputs used three Special Report on Emissions Scenarios (SRES) such as A2 (high-range), A1B (mid-range), and B2 (low-range). Further, climate projections for each province in the Philippines were presented in terms of temperature increase and rainfall change by seasons (e.g., DJF or northeast monsoon, MAM or summer season, JJA or southwest monsoon, and SON or transition from southwest to northeast monsoon season).

In 2018, DOST-PAGASA updated its existing set of local climate information using the latest climate models.[39] PAGASA summarized a seasonal climate projection data for each province of the Philippines using Representative Concentration Pathways (RCPs) through DOST-PAGASA's new developed Climate Information Risk Analysis Matrix (CLIRAM), with the following scenarios: i) RCP4.5 – moderate level of GHG emission scenario, and ii) RCP8.5 – high level of GHG emission scenario. The CLIRAM provides the projected changes in climate variables (particularly for rainfall, mean, minimum and maximum temperature) in both the mid-21st century (2036-2065) or the late-21st century (2070-2099) relative to the 1971-2000 baseline period.

Just recently, DOST-PAGASA in partnership with the Manila Observatory and the Ateneo de Manila University published the Philippine Climate Extremes Report 2020 which features the results from the "Multitemporal and extremes analysis of modeled climatology over the Philippines in the SEA-CORDEX domain (CVAR) project which is part of the Analyzing CORDEX-SEA (Coordinated Regional Climate Downscaling Experiment - Southeast Asia) Regional Climate Simulations for Improved Climate Information over the Philippines: SST Influence, Variability and Extremes, Tropical Cyclone Activity" Program.[40] In that report, the downscaled historical and projected daily extremes data were used to calculate the projected changes in 24 climate extremes indices for two Representative Concentration Pathways: RCP4.5 and RCP8.5. Historical simulations for the baseline period (1986-2005) served as the threshold. The multi-model ensemble consisted of 12 models consisting of three regional climate models (RCMs) forced with data from 10 global climate models (GCMs) from the Coupled Model intercomparison Project- Phase 5 (CMIP5) archive. SA-OBS, a daily gridded observational dataset for Southeast Asia based on the Southeast Asian Climate Assessment & Dataset (SACA&D) project was used as the historically observed baseline data.

The Philippine Climate Extremes Report 2020 also presents information on historical and projected annual climate extremes indices of the country and demonstrates their relevance to sector specific climate impacts assessment. The report extends the climate projection information released by DOST-PAGASA in 2018 which used the 10th, 50th and 90th percentile thresholds of temperature and rainfall to describe the average annual and seasonal changes in future climate scenarios. The annual climate extremes indices may be used to identify areas and sectors which are most at risk to climate extremes and thus require rapid

[38] PAGASA (2011). Climate Change in the Philippines. Philippine Atmospheric, Geophysical and Astronomical Services Administration. https://pubfiles.pagasa.dost.gov.ph/climps/climateforum/ClimatechangeinthePhilippines.pdf
[39] PAGASA, 2018: Observed and Projected Climate Change in the Philippines. Philippine Atmospheric, Geophysical and Astronomical Services Administration, Quezon City, Philippines, 36 pp.
[40] DOST-PAGASA, Manila Observatory and Ateneo de Manila University. 2021. Philippine Climate Extremes Report 2020: Observed and Projected Climate Extremes in the Philippines to Support Informed Decisions on Climate Change Adaptation and Risk Management. Philippine Atmospheric, Geophysical and Astronomical Services Administration, Quezon City, Philippines. 145 pp.

disaster risk assessment and climate adaptation planning to minimize current and future impacts. Local government units may use this report in formulating local climate change action plans and mainstreaming of national climate change initiatives.

These trends and scenarios, which are further discussed in the succeeding paragraphs, indicate that the country and the project location will not be spared by the impacts of climate change given its geographical location, archipelagic formation, biophysical characteristics, and population distribution. Additionally, even if GHG emissions are drastically reduced, the magnitude of GHG presence in the atmosphere is irreversible. Stabilizing these GHGs will take time and climate change impacts will continue to be felt for the years to come.

2.3.1.2.2.5 PAGASA Projected Climate Trends

Climate projections are necessary for climate change impact assessment and national planning. In particular, the impacts of climate change on road projects for the coming years are critical. With this, the project utilized the recent Philippine Climate Extremes Report 2020 published by DOST-PAGASA in partnership with Manila Observatory and the Ateneo de Manila University as well as the Observed Climate Trends and Projected Climate Trends in the Philippines 2018 report also by DOST-PAGASA.

In PAGASA 2020 report, the downscaled historical and projected daily extremes data were used to calculate the projected changes in 24 climate extremes indices for two Representative Concentration Pathways: RCP4.5 and RCP8.5. The annual extremes are averaged over the 20-year time periods to come up with the climatological extreme. The observed data is based on the SA-OBS gridded data for 1986-2005; the projected changes are based on the ensemble median of the 12 models. The projections from two scenarios, RCP4.5 and RCP8.5, are provided for three time periods: early-future (2020-2039), mid-future (2046-2065) and late-future (2080-2099). All three time periods were considered for this analysis given the long lifetime of the project.

Based on DOST-PAGASA, climate extreme indices provide additional information that can describe the magnitude, frequency, and duration of extremes, which could help in the assessment of possible adaptation options. Extreme indices are grouped by variable (rainfall and temperature) and by attribute (magnitude, frequency, and duration).

2.3.1.2.2.6 Extreme and seasonal rainfall

Projections under the medium and high GHG emissions scenarios indicate a general drying trend over NCR and Laguna. They also show that extreme rainfall events are expected to intensify, although the timing and magnitude vary across emissions scenarios in the two provinces. In terms of frequency, these extreme rainfall events are expected to largely remain the same relative to the historical baseline across all scenarios and future time slices. The duration of wet and dry spells in the project area are also projected to remain the same or, shorten by as much as three days throughout the century. Refer to the succeeding paragraphs for more details on each of the precipitation indices and to **Table 17** and Table 18 for a summary of these values. In terms of seasonality, wet months are generally projected to have less rainfall, while dry months are expected to have more by mid-century.

Total wet day rainfall (PRCPTOT)

PRCPTOT refers to the total amount of rainfall received during wet days, when at least 1 mm of daily rainfall is recorded within the year. Averaged over a 20-year period, it provides a general pattern indicating how much rainfall each area receives in a typical year.

Baseline observations show that the proposed project area gets an annual rainfall of up to 2,260 mm. Projections under medium and high emissions scenarios show a general drying trend at the project site in the future. For NCR, the total wet day rainfall is projected to progressively decrease between 55-112mm in the future under a medium emissions scenario. The range and magnitude of reduction is larger under high emissions scenario at 4-230mm. Future projections for Laguna reflect similar trends with PRCPTOT decreasing between 50-69mm and 39-83mm under medium and high emissions scenarios, respectively.

Simple Daily Intensity Index (SDII)

SDII is the average daily rainfall intensity and indicates the typical amount of rainfall during wet days. That is, if it rains, the amount of rainfall for the day will most probably be within this value.

Historically, the project areas have similar average amounts of rainfall during rainy days, which ranges from 12-16 mm/day. These values are projected to progressively decrease in the future for both climate scenarios. For NCR, SDII is expected to decrease between 0.1-0.8mm under RCP 4.5 and between 0.1-1.2mm under RCP 8.5, with the higher end of the values projected to manifest in the late century. The reductions in SDII for Laguna are at 0.3-0.6mm under RCP 4.5 and between 0.3-1.0mm under RCP 8.5.

Maximum 1-day rainfall total (Rx1day)

Rx1day describes the maximum amount of rain that can fall in one day. Such extreme rainfall is typically associated with local thunderstorms or large-scale systems such as monsoons or tropical cyclones and may induce flash floods or landslides.

Historically, the maximum 1-day rainfall in NCR is 121.4mm. With medium GHG emissions in the future, this is projected to increase to 126.9, 132.3, 124.7mm by early, mid, and late century, respectively. The magnitude of increase is slightly larger with high GHG emissions at 135.7, 131.3, and 128.2mm by early, mid, and late century, respectively. The baseline maximum 1-day rainfall for Laguna is slightly lower at 109.2mm but future increases follow the same trend as that of NCR. The Rx1day is projected to increase to between 113-177mm this century under RCP 4.5, whereas the increase is higher for RCP 8.5 at 117- 132.4mm.

Maximum 5-day rainfall total (Rx5day)

As with Rx1day, Rx5day describes the maximum amount of rainfall that falls over a period of five consecutive days. These typically occur during the wet season and are closely related with large-scale systems such as tropical cyclones, monsoons, and the Intertropical Convergence Zone (ITCZ). Increased 5-day consecutive rainfall may lead to widespread flooding and swelling of waterways.

Historically, Rx5day for NCR is 261.9mm. Under RCP 4.5, it is projected to increase by 289.3 and 290.5mm by early and mid-century before declining to 261.9mm in the late century. The increase is slightly lesser for similar time slices under RCP 8.5 at 277.6, 289.0, and 279.0mm. The values from these projections also indicate that for both climate scenarios, largest increases will be observed in the early to the middle of the century. For Laguna, its historical Rx5day is slightly less intense than NCR at 217.6smm. Under RCP 4.5 it is projected to increase to 225.3, 232.2, and 223.1mm by early, mid, and late century. The equivalent increases under RCP 8.5 are 218.6, 224.2, and 236.8mm. In terms of timing, RCP 4.5 is like that of NCR with the largest increases occurring in the early and mid-century. By contrast, under RCP 8.5, the largest change is expected to manifest in the late century.

Total rainfall from very wet days (R95p)

R95p indicates the total amount of rain that falls on 'very wet days', or when daily rainfall exceeds the 95th percentile threshold of the base period.

Historically the amount of rain that falls in NCR on 'very wet days' is 585.8mm. Future projections for NCR vary temporally under the two GHG emissions scenarios. Under RCP 4.5, it is projected to increase to 632.0mm in the middle of the century while decline to 562.4 and 552.4.mm by early and late century, respectively. By contrast, under RCP 8.5, it is expected to slightly increase in the early century to 590.6mm and progressively decline from mid to late century to 579.6 and 543.2mm, respectively. The projections for Laguna also reflect the same temporal variability and overall decreasing trend. Its baseline R95p is 543.3mm and in RCP 4.5, it will slightly decrease to 528.2 in the early century but slightly increase to 550.4 in the middle of the century. In the same scenario, it is projected to substantially decrease to 495.1mm in the late century. For RCP 8.5, the climate signal is straightforward, with R95p progressively decreasing to 528.3, 525.3, 481.9mm in early, mid, and late century.

Total rainfall extremely wet days (R99p)

R99p describes the total amount of rain that falls on 'extremely wet' days when rainfall exceeds the 99th percentile. Like R95p, it is related to the rainfall events that occur during the wet season as well as during tropical cyclone events.

The baseline amount of rain in NCR on 'extremely wet' days is 189.7mm. It is projected to generally increase in the future. Under RCP 4.5, while it will slightly decrease to 175.9mm in the early century, it will increase to 216.2 and 198.6mm in the mid and late century, respectively. The magnitude of change under RCP 8.5 is similar with increases of up to 26mm. This increasing trend is also expected for Laguna. With a baseline of 173.0mm, it is projected to increase between 2-37mm in this century in RCP 4.5. The magnitude of increase in RCP 8.5 is slightly lower at 2-19mm.

Rainfall on extremely wet days (P99) and very wet days (P95)

P95 is the threshold for 'very wet' days. It is defined as the 95th percentile of the baseline daily rainfall during wet days. That is, 5% of wet days during the year are expected to be 'very wet'. Because the amount of rainfall varies spatially, this threshold is expected to have different values over the Philippines. Similarly, P99 indicates the amount of rainfall "extremely wet" days, defined as those exceeding 99th percentile threshold.

For NCR, its P95 and P99 are 52.4 and 101.1mm, respectively. The magnitudes of change in its P95 and P99 are marginal, especially in the context of impacts to infrastructure, across different emissions scenarios and future time slices at 1-4mm and 1-5mm, respectively. However, it must be noted that for P95, the values solely refer to increases whereas for P99, they indicate changes in both directions. For Laguna. Its P95 and P99 are relatively lower at 42.5 and 83.8mm, respectively. Their corresponding magnitudes of change are also marginal at 0.6-5mm and 0.5-3.8mm, respectively. These values indicate slight decreases relative to the baseline for P95, whereas they indicate changes in both directions in RCP 4.5 and decline in RCP 8.5 for P99.

Table 17. Baseline and projected rainfall extremes in the project site

Extreme Index			Location	Baseline Value	Moderate Emission (RCP 4.5)			High Emission (RCP 8.5)		
Code	**Description**	**Unit**			**Early (2020-2039)**	**Mid (2046-2065)**	**Late (2080-2099)**	**Early (2020-2039)**	**Mid (2046-2065)**	**Late (2080-2099)**
Magnitude										
PRCPTOT	Total wet-day rainfall	mm	NCR	2,259.8	2,204.6 (-55.2)	2,214.8 (-45.0)	2,147.0 (-112.8)	2,255.6 (-4.2)	2,198.9 (-60.9)	2,029.1 (-230.7)
			Laguna	2,112.0	2062.2 (-49.8)	2047.8 (-64.2)	2042.9 (-69.1)	2069.0 (-43.0)	2073.5 (-38.5)	1929.4 (-182.6)
SDII	Average daily rainfall intensity	mm/day	NCR	15.4	15.3 (-0.1)	15.1 (-0.3)	14.6 (-0.8)	15.3 (-0.1)	14.9 (-0.5)	14.2 (-1.2)
			Laguna	12.8	12.5 (-0.3)	12.5 (-0.3)	12.2 (-0.6)	12.5 (-0.3)	12.3 (-0.5)	11.8 (-1.0)
Rx1day	Maximum 1-day rainfall total	mm	NCR	121.4	126.9 (5.5)	132.3 (10.9)	124.7 (3.3)	135.7 (14.3)	131.3 (9.9)	128.2 (6.8)
			Laguna	109.2	113.3 (4.1)	116.5 (7.3)	112.5 (3.3)	117.0 (7.8)	117.3 (8.1)	132.4 (23.2)
Rx5day	Maximum 5-day rainfall total	mm	NCR	268.8	289.3 (20.5)	290.5 (21.7)	261.9 (-6.9)	277.6 (8.8)	289.0 (20.2)	279.0 (10.2)
			Laguna	217.6	225.3 (7.7)	232.2 (14.6)	223.1 (5.5)	218.6 (1.0)	224.2 (6.6)	236.8 (19.2)
P95	Rainfall on very wet days	mm	NCR	52.4	50.6 (-1.8)	51.3 (-1.1)	48.5 (-3.9)	51.1 (-1.3)	50.4 (-2.0)	48.4 (-4.0)
			Laguna	42.5	41.9 (-0.6)	41.4 (-1.1)	39.7 (-2.8)	41.7 (-0.8)	40.1 (-2.4)	37.5 (-5.0)
P99	Rainfall on extremely wet days	mm	NCR	101.0	100.0 (-1.0)	106.1 (5.1)	98.8 (-2.2)	98.9 (-2.1)	103.5 (2.5)	103.3 (2.3)
			Laguna	83.8	83.0 (-0.8)	87.6 (3.8)	80.4 (-3.4)	81.9 (-1.9)	83.3 (-0.5)	80.5 (-3.3)
R95p	Total rainfall from very wet days	mm	NCR	585.8	564.2 (-21.6)	632.0 (46.2)	552.4 (-33.4)	590.6 (4.8)	579.6 (-6.2)	543.2 (-42.6)
			Laguna	543.3	528.2 (-15.1)	550.4 (7.1)	495.1 (-48.2)	528.3 (-15.0)	525.3 (-18.0)	481.9 (-61.4)
R99p	Total rainfall from extremely wet days	mm	NCR	189.7	175.9 (-13.8)	216.2 (26.5)	198.6 (8.9)	200.3 (10.6)	215.4 (25.7)	198.3 (8.6)
			Laguna	173.0	178.8 (5.8)	210.2 (37.2)	175.1 (2.1)	176.1 (3.1)	175.4 (2.4)	191.8 (18.8)
Frequency										
P95d	Number of very wet days	days	NCR	7.2	6.7 (-0.5)	7.1 (--0.1)	6.4 (-0.8)	6.9 (-0.3)	6.8 (-0.4)	6.3 (-0.9)
			Laguna	8.1	8.0 (-0.1)	7.8 (-0.3)	7.2 (-0.9)	7.7 (-0.4)	7.4 (-0.7)	6.7 (-1.4)
P99d	Number of extremely wet days	days	NCR	1.5	1.5 (0.0)	1.7 (0.2)	1.5 (0.0)	1.5 (0.0)	1.6 (0.1)	1.5 (0.0)
			Laguna	1.7	1.7 (0.0)	1.9 (0.2)	1.6 (-0.1)	1.6 (-0.1)	1.6 (-0.1)	1.6 (-0.1)
Duration										
CWD	Longest wet spell	days	NCR	17.0	14.4 (-2.6)	17.0 (0.0)	15.7 (-1.3)	15.5 (-1.5)	17.2 (0.2)	15.3 (-1.7)
			Laguna	19.3	17.6 (-1.7)	19.1 (-0.2)	18.4 (-0.9)	17.8 (-1.5)	17.6 (-1.7)	17.8 (-1.5)
CDD	Longest dry spell	days	NCR	39.8	37.4 (-2.4)	37.0 (-2.8)	41.8 (2.0)	37.1 (-2.7)	36.7 (-3.1)	37.2 (-2.6)
			Laguna	37.2	36.9 (-0.3)	34.6 (-2.6)	37.6 (0.4)	37.3 (0.1)	36.2 (-1.0)	38.0 (0.8)

Number of very wet days (P95d)

P95d pertains to the number of 'very wet days' when the daily rainfall is greater than the 95th percentile of the baseline daily rainfall.

The historical number of 'very wet days' in NCR is 7.2 days. Under the moderate and high GHG emissions scenarios, this is projected to slightly decrease across different future time slices to between 6.4-7.1 days and 6.3-6.9 days, respectively. A similar trend is also expected for Laguna. With a baseline P95d of 8.1 days, it is expected to decrease to 7.2-8 days and 7.4-6.7 days under moderate and high future emissions, respectively.

Number of extremely wet days (P99d)

P99d counts the number of days when daily rainfall exceeds P99.

Typically, NCR has 1.5 'extremely wet days.' These are projected to remain the same under both emissions scenarios except at mid-century where it is projected to marginally increase by 1.7 days under RCP 4.5 and 1.6 days under RCP 8.5. For Laguna, the baseline is 1.7 days. The projected changes across different time scales and emissions scenarios are also marginal, with future values ranging from 1.6-1.9 days.

Longest wet spell/Consecutive Wet Days (CWD)

CWD is the number of consecutive wet days when daily rainfall is at least 1 mm. It denotes the longest stretch of wet days within the year. CWD has implications on soil saturation, storage at water reservoirs, and drainage of waterways. Increased CWD indicates not only increased water availability but also increased risk to flooding and landslide hazards. On the other hand, decreased CWD would also point towards less water availability and increased drying and heating.

Historically, the longest wet spells in NCR lasts for 17 days. In NCR, CWD is projected to remain the same, or decline with magnitudes of change ranging from 0-2.6 days in the future under both medium and high emissions scenarios. Decreases, ranging from 0.2-1.7 days, relative to the 19.3-day baseline are also expected for Laguna under different emissions scenarios within this century.

Longest dry spell/Consecutive Dry Days (CDD)

CDD is the number of consecutive dry days, when daily rainfall is less than 1 mm, denoting the longest stretch of dry days within the year. This has implications on the recharge of surface and groundwater resources.

The baseline CDD for NCR is 39.8 days. The projected changes across future climate scenarios and time slices are generally decreasing by up to 2 days relative to the baseline. The only exception is in RCP 4.5 where CDD is expected to last 41.8 days in the late century. For Laguna, the baseline is 37.2 days. While the direction of change varies temporally under each scenario, the absolute change relative to the baseline hovers between 1-3 days.

Projected changes in seasonal rainfall

In NCR, the bulk of the annual precipitation falls from June to August (JJA) and September to October (SON). Under RCP 4.5, these wet cluster of months are projected to be drier by 10% in JJA and 6% in SON. Conversely the rainfall in the drier months of December to February (DJF) and March to May (MAM) are expected to increase by 18% and 7%, respectively. Under RCP 8.5, the rainiest months of JJA are also expected to decrease by 6%. The months of SON, DJF, and MAM are projected to have increased rainfalls by 3.9, 27.8, and 4.8% relative to the baseline. In Laguna, the wet months are JJA, SON, and, to an extent, DJF. Under RCP 4.5, the wet months of JJA and SON are projected to be drier relative to the baseline by 14 and 6%, respectively. By contrast, the rainfall in the months of DJF and MAM are projected to increase by 10 and 13%, respectively. For RCP 8.5, the changes in seasonal rainfall are heterogeneous with drying expected in JJA by 11%, marginal increase in SON by 1.4%, increase in DJF by 13.8%, and marginal decrease in MAM by 0.1%. Refer to Table 18 for more information. Note that these are limited to mid-century projections because these are the only available seasonal projections from PAGASA.

Table 18. Seasonal change in total rainfall (in mm) at the project site by mid-century (DOST-PAGASA, 2018)

Province	Baseline (1971-2000)				Scenario	Projected (2036-2065)*			
	DJF	MAM	JJA	SON		DJF	MAM	JJA	SON
NCR	107.5	198.5	1,170.2	758.7	RCP 4.5	126.5 (17.7)	212.2 (6.9)	1,1051.6 (-10.1)	713.5 (-6.0)
					RCP 8.5	137.4 (27.8)	208.1 (4.8)	1098.6 (-6.1)	788.3 (3.9)
Laguna	629.2	368.8	845.0	1,066.5	RCP 4.5	693.2 (10.2)	435.4 (12.6)	724.0 (-14.3)	1,004 (-5.8)
					RCP 8.5	716.3 (13.8)	386.3 (-0.1)	752.0 (-11.0)	1,081 (1.4)

**values in parenthesis are in %*

2.3.1.2.2.6.1 Extreme and seasonal temperature

Almost all temperature indices (i.e. magnitude, duration, and frequency) in both GHG emissions scenarios indicate progressive warming at the project site from the early century to the late century. The main difference in these scenarios is that more warming is expected with higher GHG emissions.

Refer to the subsequent paragraphs for further details on the temperature indicators. The summaries of the extreme and seasonal temperatures are in Table 19 and Table 20.

Magnitude

NCR is projected to be warmer in the future, with the extent of warming progressively increasing from early to late century. Unlike the heterogeneous response of precipitation to the GHG emissions scenarios, the change in temperature is more straightforward with higher GHG emissions corresponding to higher increases in temperature. Under RCP 4.5, the daytime and nighttime temperatures are projected to increase relative to the baseline by 0.4-1°C, 1.1-1.3°C, and 1.4-1.8°C by early, mid, and late-century, respectively. The magnitude of change is relatively larger under RCP 8.5, with increases in the same time slices of 0.7-1.0 °C, 1.6-1.8 °C, and 2.9 to 3.7 °C, respectively. The only exception from this trend is the daily temperature range (DTR), which pertains to the difference between the annual average daytime and nighttime temperatures. The DTR is projected to remain unchanged throughout the century under RCP 8.5, while it is projected to decrease by 0.1°C by early-century, return to baseline levels by mid-century, and increase by 0.1 °C by late-century under RCP 4.5. These changes in DTR seem to indicate a slight cooling. However, because the magnitude of change is small, PAGASA (2020) recommends further investigation of this phenomenon.

The direction and magnitude of temperature increases in Laguna are comparable to that of NCR. Under RCP 4.5, Laguna's daytime and nighttime temperatures are projected to increase by 0.5-0.9 °C, 1.2-1.3 °C, and 1.3 to 1.7 °C in the early, mid, and late-century, respectively. Higher magnitudes of warming are expected under RCP 8.5 in the same time slices at 0.7-1.1°C, 1.5-1.9°C, and 2.8-3.7°C. Similarly, the only exception to this overall warming is the DTR, which signals a marginal cooling in the future of 0.1°C for both scenarios.

Fraction of cold nights (TN10p)

TN10p refers to the number of cold nights within the year. A night is considered cold when the minimum temperature falls below the 10th percentile threshold of the baseline.

Consistent the overall future warming trend, the number of cold nights in NCR is projected to decline by 8.2-10.1% and 8.8-11% relative to the baseline under medium and high GHG emissions scenarios, respectively. The same trend is expected in Laguna with equivalent future reductions of 7.9-10.0% and 8.6-11%. In terms of timing for TN10p and the rest of the frequency indices in the subsequent paragraphs, the lower ends of the range are expected to manifest in the early century and progressing to the higher percentages by late century.

Fraction of cool days (TX10p)

TX10p keeps track of the number of cool days, when the maximum temperature is below the 10th percentile threshold of the baseline.

In NCR, cool days are projected to decrease by 6.5-9.8% and 7.4-10.6% relative to the historical levels under RCP 4.5 and 8.5, respectively. A similar decline is also expected in Laguna by 6.5-10% in RCP 4.5 and 7.6-10.6% in RCP 8.5. These demonstrate that lesser cool days are expected under a high GHG emissions scenario.

Fraction of warm nights (TN90p)

TN90p indicates the frequency of warm nights, which are when the minimum temperature exceeds the 90th percentile threshold.

In NCR, warm nights in the future are projected to be even more common. Under RCP 4.5, TN90p is expected to increase by 24.5-59.3%. The magnitude of increase is even larger under a high GHG emissions scenario at 31.8-85.1%. Laguna is also expected to experience the same with increases of 26.4-60.9% and 32.5-85.6%, under medium and high GHG emissions scenarios, respectively.

Fraction of hot days (TX90p)

TX90p tracks the number of hot days when the maximum temperature exceeds the 90th percentile threshold.

Like the earlier frequency indices, changes TX90p are consistent with the progressive future warming, with larger changes associated with higher GHG emissions. In NCR, the number of hot days is projected to increase in the future. Relative to baseline values, the number of hot days will increase by 14.7-50.5% and 23.8-79% under RCP 4.5 and 8.5, respectively. In Laguna, equivalent increases in the number of hot days are 15-51.6% and 25.6-90.7%.

Table 19. Baseline and projected temperature indices in the project site

Extreme Index			Location	Baseline Value	Moderate Emission (RCP 4.5)			High Emission (RCP 8.5)		
Code	**Description**	**Unit**			**Early (2020-2039)**	**Mid (2046-2065)**	**Late (2080-2099)**	**Early (2020-2039)**	**Mid (2046-2065)**	**Late (2080-2099)**
Magnitude										
TNn	Coldest night time temperature	°C	NCR	18.0	19.0 (1.0)	19.3 (1.3)	19.6 (1.6)	19.0 (1.0)	19.8 (1.8)	21.5 (3.5)
			Laguna	18.1	19.0 (0.9)	19.3 (1.2)	19.7 (1.6)	19.2 (1.1)	19.9 (1.8)	21.4 (3.3)
TNm	Average night time temperature	°C	NCR	23.1	23.8 (0.7)	24.3 (1.2)	24.6 (1.5)	23.9 (0.8)	24.8 (1.7)	26.3 (3.2)
			Laguna	22.7	23.4 (0.7)	23.9 (1.2)	24.2 (1.5)	23.5 (0.8)	24.4 (1.7)	25.9 (3.2)
TNx	Warmest night time temperature	°C	NCR	26.6	27.3 (0.7)	27.8 (1.2)	28.2 (1.6)	27.4 (0.8)	28.3 (1.7)	29.7 (3.1)
			Laguna	25.8	26.5 (0.7)	27.0 (1.2)	27.4 (1.6)	26.6 (0.8)	27.5 (1.7)	28.9 (3.1)
TXn	Coldest day time temperature	°C	NCR	25.7	26.4 (0.7)	26.8 (1.1)	27.1 (1.4)	26.4 (0.7)	27.3 (1.6)	28.6 (2.9)
			Laguna	25.0	25.7 (0.7)	26.2 (1.2)	26.3 (1.3)	25.7 (0.7)	26.5 (1.5)	27.8 (2.8)
TXm	Average day time temperature	°C	NCR	31.8	32.4 (0.6)	33.0 (1.2)	33.3 (1.5)	32.6 (0.8)	33.4 (1.6)	35.0 (3.2)
			Laguna	30.8	31.5 (0.7)	32.1 (1.3)	32.3 (1.5)	31.7 (0.9)	32.5 (1.7)	34.1 (3.3)
TXx	Warmest day time temperature	°C	NCR	36.4	37.1 (0.7)	37.7 (1.3)	38.2 (1.8)	37.3 (0.9)	38.2 (1.8)	40.1 (3.7)
			Laguna	35.1	35.6 (0.5)	36.4 (1.3)	36.8 (1.7)	36.0 (0.9)	37.0 (1.9)	38.8 (3.7)
DTR	Daily temperature range	°C	NCR	8.7	8.6 (-0.1)	8.7 (0.0)	8.8 (0.1)	8.7 (0.0)	8.7 (0.0)	8.7 (0.0)
			Laguna	8.1	8.1 (0.0)	8.2 (0.1)	8.2 (0.1)	8.2 (0.1)	8.1 (0.0)	8.2 (0.1)
Frequency										
TN10p	Fraction of cold nights	%	NCR	11.4	3.3 (-8.1)	1.7 (-9.7)	1.3 (-10.1)	2.6 (-8.8)	1.0 (-10.4)	0.4 (-11.0)
			Laguna	11.3	3.4 (-7.9)	1.6 (-9.7)	1.2 (-10.1)	2.7 (-8.6)	0.9 (-10.4)	0.2 (-11.1)
TN90p	Fraction of warm nights	%	NCR	11.4	35.9 (24.5)	59.3 (47.9)	70.7 (59.3)	43.2 (31.8)	78.3 (66.9)	96.5 (85.1)
			Laguna	11.2	37.6 (26.4)	61.1 (49.9)	72.1 (60.9)	43.7 (32.5)	78.9 (67.7)	96.8 (85.6)
TX10p	Fraction of cool days	%	NCR	11.5	5.0 (-6.5)	2.4 (-9.1)	1.7 (-9.8)	4.1 (-7.4)	1.6 (-9.9)	0.9 (-10.6)
			Laguna	11.4	4.9 (-6.5)	2.0 (-9.4)	1.4 (-10.0)	3.8 (-7.6)	1.5 (-9.9)	0.8 (-10.6)
TX90p	Fraction of hot days	%	NCR	11.6	26.3 (14.7)	49.7 (38.1)	61.9 (50.3)	35.4 (23.8)	63.2 (51.6)	90.6 (79.0)
			Laguna	11.5	26.5 (15.0)	50.4 (38.9)	63.1 (51.6)	36.1 (24.6)	64.8 (53.3)	90.7 (79.2)
Duration										
WSDI	Warm Spell Duration Index	days	NCR	7.2	73.6 (66.4)	226.2 (219.0)	364.3 (357.1)	129.1 (121.9)	365.0 (357.8)	365.0 (357.8)
			Laguna	4.9	50.9 (46.0)	174.2 (169.3)	264.0 (259.1)	106.4 (101.5)	330.5 (325.6)	365.0 (360.1)

Warm Spell Duration Index (WSDI)

WSDI indicates the number of days contributing to warm periods. A warm spell occurs when the daily maximum temperature for six or more consecutive days exceeds the 90th percentile threshold of the baseline. The WSDI accounts for the total number of days within the year that contribute to these warm spells. Successive occurrences of extremely hot maximum temperatures are detrimental to many sectors of the country, including the integrity of materials and infrastructures.

In NCR, the historical length of consecutive days contributing to warm spells is only about a week. Under RCP 4.5, this is projected to increase to 73.6 days in the early century and to 364.3 days by the late century. The warm periods are even longer under RCP 8.5 at 129.1 days in the early century and becoming a year-round phenomenon by the late century. Similar increases are also expected in Laguna. With a baseline WSDI value of 4.9 days, it is projected to increase to 50.9 and 264 days under RCP 4.5 in early and late century, respectively. The equivalent increases under RCP 8.5 are 106.4 and 365 days.

Projected changes in seasonal mean temperature

The warmest months in both NCR and Laguna are March to May (MAM) while the coldest months are December to February (DJF). Projected increases of seasonal mean temperature by mid-century are relatively uniform throughout the year in both provinces. Under RCP 4.5, increases range from 1.1 to 1.3 °C, while under RCP 8.5, the range is relatively higher at 1.5 to 1.6°C. See Table 20 for more details. Note that these projections are only for mid-century as they are the only ones available.

Table 20. Seasonal change in mean temperature (in °C) at the project site by mid-century (DOST-PAGASA, 2018)

Province	Baseline (1971-2000)				Scenario	Projected (2036-2065) *			
	DJF	MAM	JJA	SON		DJF	MAM	JJA	SON
NCR	26.1	28.8	28.0	27.4	RCP 4.5	27.3 (1.2)	30.0 (1.2)	29.3 (1.3)	28.5 (1.1)
					RCP 8.5	27.7 (1.6)	30.4 (1.6)	29.5 (1.5)	28.9 (1.5)
Laguna	25.0	27.5	27.5	26.7	RCP 4.5	26.2 (1.2)	28.7 (1.2)	28.8 (1.3)	27.8 (1.1)
					RCP 8.5	26.6 (1.6)	29.1 (1.6)	29.0 (1.5)	28.2 (1.5)

**values in parenthesis are in °C*

2.3.1.2.2.6.2 Tropical cyclones

On average, 20 tropical cyclones (TCs) enter the Philippine Area of Responsibility (PAR) annually. Of these, five are very strong TCs with maximum sustained wind speeds exceeding

170 kph. Historical data from 1951 to 2015 show a slight decrease in the number of TCs and a marginal increase in the number of very strong ones. This trend is projected to continue in the future. DOST-PAGASA (2018), however, warns that apart from these long-term trends, high interannual variations in the frequency of occurrence of TCs are also expected. A limited modelling initiative (DOST-PAGASA, 2018), was also conducted to project changes in TCs under RCP 8.5. The simulations show that by mid-century, the frequency of occurrence of TCs will remain the same or decrease. In terms of intensity, the four of the five simulations project increases although only two find these increases significant. Given the absence of more granular climate projections for TCs, these trends are assumed to apply to the project site.

2.3.1.2.2.7 Potential Impacts and Options for Mitigation and Adaptation

2.3.1.2.2.7.1 Impacts of Climate Change to Project

A combination of the project site's topography, increasing impervious surfaces, and siltation of waterways make it already vulnerable to flooding under current climate conditions, especially during the rainy and typhoon seasons41. The extent and incidences of flooding are likely to increase in the future given that climate projections converge on an increase in the intensity of extreme rainfall events from early to late century. Another flood trigger, tropical cyclones, are also projected to slightly increase in the future especially the stronger ones. These tropical cyclones are also expected to continue exhibiting large interannual variability. These would mean more frequent and severe flooding, which can increase erosion, impact road foundations, overwhelm existing drainage capacities, and damage road infrastructure. They can also lead to road closures that not only reduce mobility but also pose safety risks and reduce the project's economic returns. Aside from flooding, strong winds and storm surges associated with the tropical cyclones can also damage road infrastructure and increase their likelihood of failures.

Conversely, climate projections also indicate long-term drying in the future. For instance, annual rainfall in NCR and Laguna are expected to decline by 4-55mm and 39-64mm in the early century, respectively. This reduction in rainfall can affect the availability of water for compaction during the project's construction.

In terms of temperature, both mean and extremes are projected to progressively increase in the future, with more and extreme warming associated with the higher GHG emissions scenario. Sustained air temperatures exceeding 32°C can accelerate the deterioration of the pavement through softening, or traffic-related rutting42. The average daytime temperature is projected to exceed this threshold by mid-century in Laguna while NCR is already near this level at present and will likely breach this threshold within the decade or so. In addition to the deterioration of road infrastructure, heat waves can also reduce the efficiency of construction equipment, increase the risk of heat strokes to workers, and increase the cooling demand of vehicles. Combined with reduction in rainfalls, warming can also increase the corrosion rates

[41] See, for example, reports of flooding incidences at the project site: De Vera-Ruiz, E. (2020). Laguna de Bay rehab project to address flooding; endorsed for NEDA ICC review. Manila Bulletin. Retrieved fom: https://mb.com.ph/2020/11/25/laguna-de-bay-rehab-project-to-address-flooding-endorsed-for-neda-icc-review/ & Cinco, M. (2020). Laguna de Bay shore villages still flooded. Philippine Daily Inquirer. Retrieved from: https://newsinfo.inquirer.net/1363999/laguna-lakeshore-villages-still-underwater

[42] ADB (2011). Guidelines for climate proofing investment in the transport sector: Road infra projects. Mandaluyong, Philippines. Retrieved from: https://www.adb.org/documents/guidelines-climate-proofing-investment-transport-sector-road-infrastructure-projects

of steel reinforcements that can damage or reduce the operational life of roads. Refer to Table 21 for a summary of the nature and extent of climate impacts to the project's infrastructure and operations.

Table 21. Summary of the impacts of climate change to the project

Characteristics	Description			
Impact nature	Negative	Positive	Neutral	
	Climate change will affect the project negatively.			
Impact type	Direct	Indirect	Induced	
	The project will be directly affected by climate change. Flooding due to increases in tropical cyclones and intensification of extreme rainfall events can damage road infrastructure and interrupt road operations. On the other end, drying in terms of annual and seasonal rainfall reduces the availability of water, which are needed for compaction. Sustained temperature increases can also accelerate the deterioration of road infrastructure and pose heat-related health risks to workers during construction. The project will likewise be affected by climate change indirectly. Increases in temperature can increase the cooling demand of vehicles using the road network. This can then increase fuel use and reduce the estimated GHG emissions savings from improvements in travel speeds. Flooding and extreme weather events can also disrupt the operations of the project which have economic and safety implications.			
Impact duration	Temporary	Short-term	Long-term	Permanent
	Flooding triggered by heavy rainfall and tropical cyclones are already affecting the project site. This will likely continue and become even more severe in the future. Since these are rapid-onset events, their duration is short-term but recurring. Warming impacts will be progressive, long-term, and permanent. They will likely manifest in the mid-century as the critical warming threshold for road infrastructure is exceeded.			
Impact extent	Local	Regional	Global	
	The impacts will be local			
Impact frequency	For impacts due to hydrometeorological hazards, the frequency will be the same or slightly higher than current levels. For warming, the impacts will be higher than the baseline.			
Impact magnitude	Negligible	Small	Medium	Large
	In the absence of interventions, impacts to the project will be medium. Impacts due to flooding and general drying will manifest in the near to medium-term while the impacts of warming will be more acute in the medium to long term.			
Sensitivity of	Low	Medium	High	

Characteristics	Description			
receptors	Unlike renewables, the project's performance is not climate sensitive. However, it susceptible to damage from climate-related hazards without adaptation measures.			
Significance	Negligible	Minor	Moderate	Major
	Overall, climate change is of moderate significance to the project in terms of its impacts on the physical infrastructure and operations.			

2.3.1.2.2.7.2 Adaptation and Mitigation Measures

The project is an insignificant source of GHG emissions during construction and operation. It is even a net negative emitter when compared to the 'without project' scenario because emissions savings from improvements in travel speeds offset the emissions from increased travel activity. Mitigation is, thus, not required for the project. Given, however, that absolute emissions are still positive, at approximately 300-400MtCO2 (depending on the estimation method employed) in 30 years of the project's operations, opportunities exist to mitigate GHG emissions.

During construction, optimization of routes and equipment use, regular maintenance and use of fuel-efficient equipment can reduce GHG emissions. During operations, the ASIF framework used in the GHG inventory can inform mitigation strategies. Although beyond the scope of the project, some options that can be pursued include integrating the project with the broader urban and spatial development plans of NCR and Laguna to reduce travel demand, encourage modal shift to high occupancy modes of transport, increase fuel efficiency of vehicles, and switch to low-carbon fuels. Complementary regulatory and economic measures can also be implemented to buttress these mitigation strategies and ensure that the projected improvements in travel speeds are realized, such as congestion charges. If the aim is carbon neutrality, carbon offsetting mechanisms and nature-based interventions that increase carbon sinks can also be pursued.

A combination of engineering and non-engineering measures is incorporated and proposed to adapt to the current and future impacts of climate change to the project. Refer to the Feasibility Study Report for more details especially on the design parameters.

For flooding, the project's design is harmonized with the Parañaque Spillway Project. With the spillway, a 1 in 100-year rainfall event will result to a maximum high-water level of +3. 4mSL.The road level of the embankment and viaduct are well above this level at +5.5mSL and +8.5mSL, respectively. For the road level, 1.5m buffer zone for wave and free board are added for the embankment structure and 0.5m for road surfacing and sub-base to avoid submerge condition. There is also a significant number of openings throughout the onshore embankment to allow surface runoff to effectively drain to the lake without exacerbating the flood risk along the shoreline areas. Surface channels at the toe embankment slope to collect overland flow and discharge box culverts across the embankment to effectively discharge to the lake are also proposed. Surface channels are likewise proposed to be equipped with permeable bottom to prevent accumulation of surface water. Moreover, given the large uncertainties in the future precipitation, a safety factor of 20% was used to estimate peak flow that guided the sizing of channels and culverts for intercepting on-land drainage. This safety factor can be further reviewed and refined at the detailed design stage. The overall design of the drainage system is also compliant with the DPWH Design Guidelines Criteria and Standards (DGCS). The project does not have flood control structures as it is not a flood prevention scheme per se, and the first phase of the project is focused on transport linkage along the western shoreline. However, it can be designed such that flood protection systems, such as flood gate and pumps, can be later provided.

Flooding, along with changes in land use, also cause erosion and siltation. To address these, geofilters and underlayer rock are proposed to be constructed to prevent the erosion of finer embankment core materials through the larger rock armourstone. Geotextile tubes will also be used to facilitate the construction of the embankment. By placing these tubes at the toe of the embankment, they can serve as protection against erosion. The rock armor protection will also be built in layers ahead of each filling. Silt curtains will likewise be used during construction to prevent siltation.

Aside from rainfall, tropical cyclones also threaten the project via strong winds and flooding due to storm surges. The project structures are compliant with design and construction standards and codes to ensure that they will withstand tropical cyclones. A wave overtopping assessment was also conducted and incorporated in the design. Based on this assessment, a dike embankment top level of +16m above LLDA datum with armored seaward slopes of IV:3H is recommended to mitigate risks of overtopping. A full hydraulic modelling and coastal flooding study will also be conducted at the design stage to reassess and validate wind-wave overtopping conditions at the embankment once alignment and structural form are finalized.

The projected drying can affect water availability during construction. This can be addressed by construction planning and scheduling. For instance, construction activities that are water-intensive can be timed to coincide with the rainy season. For warming (both mean and extremes), the materials and design of the pavement and structures can already withstand temperatures exceeding 32°C.

In addition to the hazard-specific engineering measures, the following cross-cutting soft adaptation measures can also be implemented. First, regular, and timely inspection and maintenance can preserve the intended reliability of the structures. Second, having preparedness and response plans in place can also minimize risks to both people and assets. These include developing emergency warning systems, emergency preparedness plans, preparedness trainings and drills, evacuation plans, and deployment of emergency repair teams. Construction activities also need to be suspended during adverse weather conditions.

Another avenue that can be explored are strategies that combine adaptation and mitigation. These can include integrating the project to the area's land use and development plans to minimize the project's hazard exposure and deliver mobility goals while also minimizing the unintended creation of social and environmental vulnerability in the area. Ecosystem restoration and increasing vegetative cover can also deliver environmental benefits, mediate hazard impacts, like flooding, erosion, and temperature increases, while also serving as a carbon sink.

2.3.2 Ambient Air Quality

Ambient air quality is defined by the Republic Act No.8749 or the Philippine Clean Air Act of 1999, which is an act the provides a comprehensive air pollution control policy to protect the people to a balanced and healthful ecology. The responsibility under R.A. 8749 has been further emphasized through its Implementing Rules and Regulations under the DENR Administrative Order 2000-81.

Compliance of the ambient air quality results in this assessment is compared to the limitations provided under R.A. 8749, which includes the National Ambient Air Quality Standards (NAAQS) for Source Specific Air Pollutants from Industrial Sources/ Operations. These standards are maximum concentration used for one-hour averaged ambient air quality results to avoid adverse health effects. To assess the 24-hour ambient air values in an area prior to the implementation of a project, the National Ambient Air Quality Guideline Values (NAAQGV) of DAO 2000-81 provides standards for 24-hour ambient air quality monitoring. For further evaluation, the air quality index (AQI) of the DAO 2000-81 is used to classify the ambient air quality in the environment.

This section discusses the ambient air quality in the vicinity of the project alignment, to set the baseline conditions at the project area, identify and assess the air pollutants and possible impacts, and recommend management

2.3.2.1 Methodology

2.3.2.1.1 Study Area

The sampling points were chosen to represent sensitive receptors, within the project area, that may be affected by the construction and operational phases of the project. Sensitive receptors identified in this study include the schools, residential communities, and other areas that may have individuals with health conditions and may be more vulnerable to the exposure to air quality changes.

2.3.2.1.2 Sources Identification

Air pollution is a complex mixture of various gases, particulates, hydrocarbons and transition metals. This can be natural (i.e. forest fires and volcanic eruptions) and anthropogenic (i.e. combustion of fuel and wastes) sources of various gases, particulate matter, hydrocarbons, and transition metals. Overexposure to these pollutants may cause adverse health effects, specifically affecting the heart and the lungs.

Air pollutants that are associated with the project construction can be attributed to congestion of people, and the use of high-volume equipment, earthmoving vehicles and diesel generator. These parameters such as particulate pollutants (i.e. Total Suspended Particles (TSP) and particulate matter (PM10 and PM2.5)), and gaseous pollutants (i.e. NO_2, and SO_2), may cause adverse effects when exposed in excessive amounts.

Particulate pollutants are characterized based on the particle diameter:

- Total Suspended Particles: <50 – 60 µm

- PM10: < 10 µm
- PM2.5: < 2.5 µm

Depending on the size of the particles, these pollutants can inflict various health effects as PM10 can penetrate the nose, while PM2.5 can penetrate the lungs.

SO_2 is a colorless pungent gas at low concentrations, while NO_2 is odorless but the color of the gas is reddish-brown. These gaseous pollutants have the capacity to chemically react to the air, forming SOx and NOx, compounds posing a threat to human health, including NOx potentially forming O_3 through photolysis.

During the demolition of existing structures and materials, earthworks, grinding operations, and stockpiling of soil, TSP and PM10 are produced as fugitive dust. Diesel-powered transport vehicles and construction equipment emit fine particles, such as PM2.5 or black carbon, from their exhaust. Emissions from excavators, industrial trucks, cranes, and stationary engines, such as generators and pumps, include PM2.5, NO_2, and SO_2.

2.3.2.1.3 Field Surveys and Sampling Areas

Twenty-nine (29) stations were identified for ambient air quality sampling and were strategically positioned to be close to the proposed alignment and sensitive receivers. The coordinates of each sampling site are shown in

Table 2.91 and the sampling map in the figures shown in the table.

Table 2.91 Ambient air and noise monitoring sites

Station ID Location	Coordinates	Description and Observations	Picture
A1	14°29'27" N, 121°02'46 "E	Equipment set on concrete ground Beside TLC park and residential area with vegetation 10-15m away from Laguna Lake Highway Road 5m away from a creek 10-minute rain Observed barbeque stand 10m away Observed burning of wood 10m away Sources of noise were various vehicles, residential activities, and wildlife at nighttime	 **Figure 2- 64** Ambient Air and Noise Monitoring Location A1

Station ID Location	Coordinates	Description and Observations	Picture
A2	14°29'19" N 121°03'44 "E	Equipment set up on concrete ground Located in front of a Barangay Hall 1-3m away from a creek 10-15m away from the main road Sunny to partly cloudy weather Sources of noise were light vehicles, residential activities, and wildlife at nighttime	 **Figure 2- 65** Ambient Air and Noise Monitoring Location A2

Station ID Location	Coordinates	Description and Observations	Picture
A3	14°27'14.447"N (14.454013) 121°3'4.211"E (121.05117)	Equipment set up on rocky and sandy ground Near residential area 10-15m away from the railroad 15-20m away from a residential area Sunny weather condition Sources of noise were regular trains passing by, residential activities, and wildlife at nighttime	 **Figure 2- 66** Ambient Air and Noise Monitoring Location A3

Station ID Location	Coordinates	Description and Observations	Picture
A4	14°27'8.899"N (14.452472) 121°2'56.522"E (121.049034)	Equipment set in concrete ground 2m away from condominium wall 1m away from the main road Rainy weather at night, fair and sunny weather during the day Sources of noise were light vehicles, residential activities, and wildlife at nighttime	 **Figure 2- 67** Ambient Air and Noise Monitoring Location A4

Station ID Location	Coordinates	Description and Observations	Picture
A5	14°25'9.5628"N 121°2'572568"E	Equipment set in an old basketball court and demolished house Surface is flat cement floor surrounded by debris 10-15m away from Montillado Road 5m away from service road 5-10m away from residential by-standers with smoking and using their phones Group of kids playing nearby the court Cloudy weather Sources of noise were various vehicles, residential activities, and wildlife at nighttime	 **Figure 2- 68** Ambient Air and Noise Monitoring Location A5

Station ID Location	Coordinates	Description and Observations	Picture
A6	14°25'8" N 121°3'7"E	Equipment set on dusty concrete Heavy machinery activities 20m away Construction activity 10m away Observed burning of wood 15m away Observed conversation among kids and teenagers residing nearby Sources of noise were light vehicles, residential activities, heavy machinery from construction, and wildlife at nighttime	 **Figure 2- 69** Ambient Air and Noise Monitoring Location A6

Station ID Location	Coordinates	Description and Observations	Picture
A7	14°23'11.166"N 121°3'15.31"E	Located at Espeleta Pantalan Compound Equipment set on concrete ground 15m away from residential houses Sunny with partial cloudy weather condition Sources of noise were light vehicles, residential activities, and wildlife at nighttime	 **Figure 2- 70** Ambient Air and Noise Monitoring Location A7

Station ID Location	Coordinates	Description and Observations	Picture
A8	14°22'19.916"N 121°46'54.56"E	Equipment set on grassy ground 10-15m away from the access road and residential area Cloudy weather condition Sources of noise residential activities, and wildlife at nighttime	 **Figure 2- 71** Ambient Air and Noise Monitoring Location A8

Station ID Location	Coordinates	Description and Observations	Picture
A9	14°21'33.818"N 121°3'48.263"E	Located in a residential area Equipment in a sandy soil ground 10m away from the lakeshore 15m away from a garage Rain occurrence at 1400H Cloudy weather condition Sources of noise were light vehicles, construction, and wildlife at nighttime	 **Figure 2- 72** Ambient Air and Noise Monitoring Location A9

Station ID Location	Coordinates	Description and Observations	Picture
A10	14°21'21.809"N 121°46'28.55"E	Sampling location in a residential area Equipment set on a concrete platform 5-7m away from the lakeshore 5m away from the access road to residential areas Gloomy weather condition Sources of noise were light vehicles, residential activities, construction, and wildlife at nighttime	 **Figure 2- 73** Ambient Air and Noise Monitoring Location A10

Station ID Location	Coordinates	Description and Observations	Picture
A11	14°21'10.141"N 121°4'29.496"E	Equipment set on grassy ground Sampling location is in residential area 20-50m away from the access road 5m away from the wall Cloudy to gloomy weather conditions Sources of noise were various vehicles, residential activities, and wildlife at nighttime	 **Figure 2- 74** Ambient Air and Noise Monitoring Location A11

Station ID Location	Coordinates	Description and Observations	Picture
A12	14°21'0.786"N 121°5'20.898"E	Equipment set on muddy ground Location in a residential area 5m away from the access road Surrounding is wet from rain 20m away from mini stores where groups eat and talk 5-8m away from resident smoking during 1000H, 0800H, 1400H Sunny weather condition Sources of noise were light vehicles, residential activities, and wildlife at nighttime	 **Figure 2- 75** Ambient Air and Noise Monitoring Location A12

Station ID Location	Coordinates	Description and Observations	Picture
A13	14°21'6.744"N 121°5'17.472"E	Equipment set on wet sandy soil ground beside access road Near residential houses and mini stores Light vehicles passing Observed residents nearby Near Artes Compound Gate Gloomy cloudy with light wind weather conditions Sources of noise were light vehicles, residential activities, construction, and wildlife at nighttime Generator set was installed 20m away	 **Figure 2- 76** Ambient Air and Noise Monitoring Location A13

Station ID Location	Coordinates	Description and Observations	Picture
A14	14°19'50.927"N121°6'32.818"E	Equipment set on grassy area Location is in residential area 50m away from access road Light rain with strong winds at 1500H Moderate rain observed during 2400H and 0300H. Light rain continues until 0600H Sources of noise were minimal light vehicles, residential activities, and wildlife at nighttime	 **Figure 2- 77** Ambient Air and Noise Monitoring Location A14

Station ID Location	Coordinates	Description and Observations	Picture
A15	14°19'49.7712"N121°6'34.6896"E	Equipment in sandy soil ground Location is in a parking area/vacant lot 20-50m from the access road 5m away from the wall Cloudy to gloomy weather condition Sources of noise were light vehicles, and wildlife at nighttime	 **Figure 2- 78** Ambient Air and Noise Monitoring Location A15

Station ID Location	Coordinates	Description and Observations	Picture
A16	14°19'8.5728"N 121°7'16.4316"E	Equipment set in concrete ground Location in residential area surrounded by vegetation 500m away from the river 100m away from the main road Observed foul odor from the duck house Moderate to heavy shower weather condition before sampling Sources of noise were wildlife at nighttime	 **Figure 2- 79** Ambient Air and Noise Monitoring Location A16

Station ID Location	Coordinates	Description and Observations	Picture
A17	14°18'16.846"N 121°7'429.634"E	Equipment set on cement ground Location within school premises 15-20m away from the school gate and highway road 5-10m away from sand and gravel pile Observed light rain during 0430H Cloudy, sunny, and light rain weather condition Sources of noise were light vehicles, and wildlife at nighttime	 **Figure 2- 80** Ambient Air and Noise Monitoring Location A17

Station ID Location	Coordinates	Description and Observations	Picture
A18	14°17'24.8244"N121°8'19.2912"E	Equipment set on sandy ground 200-300 away from the main road Cloudy weather condition Sources of noise residential activities, and wildlife at nighttime	 **Figure 2- 81** Ambient Air and Noise Monitoring Location A18

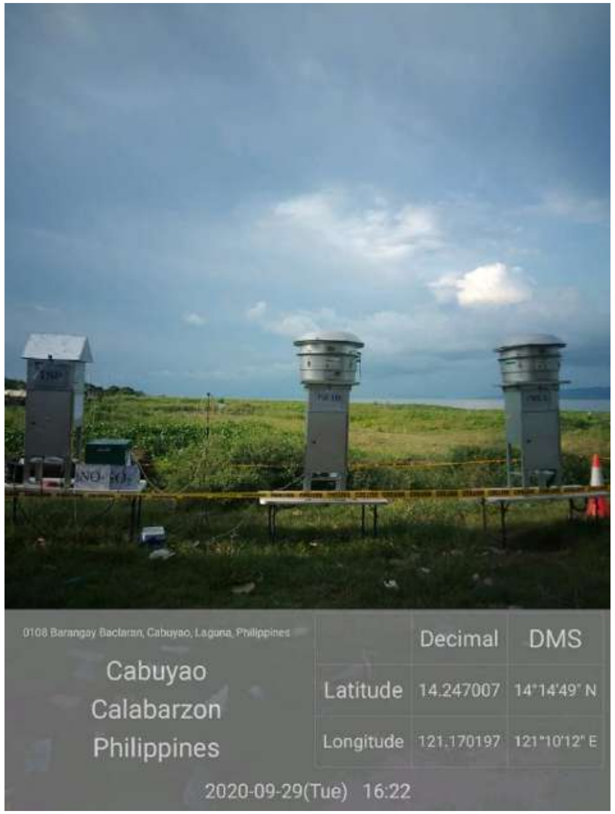
Station ID Location	Coordinates	Description and Observations	Picture
A19	14°16'58.0"N 121°8'41.6"E	Equipment set on sandy soil Location in residential area 500m away along the river 100m away from the main road Observed foul odor from the duck house Observed rain from 1515H to 1710H Sunny and rainy weather condition Sources of noise residential activities, and wildlife at nighttime	 **Figure 2- 82** Ambient Air and Noise Monitoring Location A19

Station ID Location	Coordinates	Description and Observations	Picture
A20	14°16'50.1564"N121°8'43.9656"E	Equipment on a grassland 15m away from the access road Rain with light wind weather condition Sources of noise were light and heavy vehicles, residential activities, and wildlife at nighttime	 **Figure 2- 83** Ambient Air and Noise Monitoring Location A20

Station ID Location	Coordinates	Description and Observations	Picture
A21	14°16'29.6364"N121°9'16.4592"E	Equipment set on grassy ground Located inside Queen Aurora resort near sea wall 30m away from nearest function hall Surrounded by tall trees and plants Observed various birds in the area Sunny with strong wind weather conditions Sources of noise were strong winds and wildlife at nighttime	 **Figure 2- 84** Ambient Air and Noise Monitoring Location A21

Station ID Location	Coordinates	Description and Observations	Picture
A22	14°16'6.204"N 121°9'40.6548"E	Equipment set on grassy ground 100-200m away from laguna lakeshore Surrounded by medium trees Located in backyard of Marasigan Residence Frequent residential interaction Observed cooking activity using wood Heavy rain with strong winds weather condition Sources of noise residential activities, and wildlife at nighttime	 **Figure 2- 85** Ambient Air and Noise Monitoring Location A22

Station ID Location	Coordinates	Description and Observations	Picture
A23	14°15'25.308"N 121°10'3.18"E	Equipment set on concrete ground 200m away from Gulod Brgy Hall Surrounded by trees and residential houses Observed frequent residential interaction Sunny with moderate winds weather condition Sources of noise residential activities, and wildlife at nighttime	 **Figure 2- 86** Ambient Air and Noise Monitoring Location A23

Station ID Location	Coordinates	Description and Observations	Picture
A24	14°14'49.2252"N121°10'12.7092"E	Equipment set on grassy ground Near basketball court 30-40m away from Brgy Hall Observed children playing, vehicles parking, ongoing hammering activity Sunny and partly cloudy with light to moderate winds weather condition Sources of noise were light vehicles, residential activities, construction, and wildlife at nighttime	 **Figure 2- 87** Ambient Air and Noise Monitoring Location A24

Station ID Location	Coordinates	Description and Observations	Picture
A25	14°14'4.362"N 121°10'42.654"E	Equipment set on concrete ground Location beside the access road Surrounded by residential houses Nearby mini garden Observed light vehicles passing through the access road Observed group smoking 15-20m away at 2000H Fair weather condition Sources of noise were light vehicles, residential activities, and wildlife at nighttime	 **Figure 2- 88** Ambient Air and Noise Monitoring Location A25

Station ID Location	Coordinates	Description and Observations	Picture
A26	14°13'41.628"N 121°11'5.7156"E	Equipment set on concrete ground Location beside the access road Observed light vehicles passing by Observed residents passing by Sunny, cloudy to partial rainy with light to moderate winds weather conditions Sources of noise were light vehicles, residential activities, and wildlife at nighttime Generator set was installed 20m away	 **Figure 2- 89** Ambient Air and Noise Monitoring Location A26

Station ID Location	Coordinates	Description and Observations	Picture
A27	14°12'57.1968"N121°11'20.6736"E	Equipment set on sandy soil ground Near lakeshore and 5m away from residential houses Observed karaoke and kids playing in the lakeshore Sunny with light to moderate wind weather conditions Sources of noise were residential activities, engines from boats, and wildlife at nighttime Generator set was installed 20m away	 **Figure 2- 90** Ambient Air and Noise Monitoring Location A27

Station ID Location	Coordinates	Description and Observations	Picture
A28	14°11'59.3772"N121°11'1.6764"E	Equipment set on sandy ground 25m away from lakeshore 20m away from residential houses Observed frequent residential interaction Cloudy to rainy with low to moderate wind and rain showers weather condition Sources of noise were various vehicles, residential activities, and wildlife at nighttime Generator set was installed 20m away	 **Figure 2- 91** Ambient Air and Noise Monitoring Location A28

Station ID Location	Coordinates	Description and Observations	Picture
A30	14°11'21.048"N 121°10'34.68"E	Equipment set on dusty ground Located inside subdivision Near illegal settlers' area East wind direction Sunny with low to moderate wind blowing weather conditions Sources of noise were residential activities, construction, and wildlife at nighttime Generator set was installed 20m away	 **Figure 2- 92** Ambient Air and Noise Monitoring Location A30

Figure 2- 93 Air and Noise Sampling Locations Map

2.3.2.1.4 Sampling Methodology

Ambient air quality sampling was conducted at eleven sampling sites for 24-hour and 1-hour measurements. These were performed in accordance with the protocols and sampling procedures specified in the DAO 2000-81, DAO 2013-13, USEPA and World Health Organization (WHO) Guidelines, which are all summarized in **Table 2.92**.

Table 2.92 Methods of air sampling and analysis

Parameters	Sampling Scheme	Method of Collection	Method of Analysis	Source*
TSP	24-hour and 1-hour	Tisch High Volume Sampler	High Volume Gravimetric Method	USEPA 40 CFR, Part 50, Appendix B
PM10		Tisch High Volume with 10 micron particle-size inlet	High Volume Gravimetric Method	USEPA 40 CFR, Part 50, Appendix J
PM2.5		Tisch High Volume with 2.5 micron particle-size inlet	High Volume Gravimetric Method	USEPA 40 CFR, Part 50, Appendix L
SO_2		RAC3 Gas Analyzer/SKC Pump	Tetra-chloromercurate (TCM) Absorber-Pararosaniline Colorimetric	USEPA 40 CFR, Part 50, Appendix A
NO_2		RAC3 Gas Analyzer/SKC Pump	Impinger Griess-Saltzman Reaction Method	Methods of Air Sampling and Analysis-3rd ed./James O. Lodge, Jr

Source: DAO 2000-81, DAO2013-13

Figure 2.172 Ambient Air Sampling Set-up

2.3.2.2 Data Analysis

Following the Environmental, Health, and Safety Guidelines – General EHS Guidelines: Environmental - Air Emissions and Ambient Air Quality under the International Finance Corporation (IFC) guidelines, emissions should not result in pollutant concentrations that reach or exceed relevant ambient quality guidelines and standards by applying national legislated standards.

In the Philippines, RA 8749 and DAO 2000-81 provide the air quality standards for air pollutants including total suspended particulates (TSP), respirable suspended particulates (RSP/ PM10), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2). DAO 2013-13 provides the provisional NAAQGV for particulate matter 2.5 (PM2.5). **Table 2.93** summarizes the ambient air quality standards and values relevant to this study.

Table 2.93 National Ambient Air Quality Guideline Values and Standards

DAO 2000-81	TSP (µg/Ncm)	PM10, (µg/Ncm)	PM2.5, (µg/Ncm)	NO_2 (µg/Ncm)	SO_2 (µg/Ncm)
24-hour Sampling (NAAQGV)	230	150	50	150	180
1-hour Sampling (NAAQS)	300	200	--	260	340

The project's ambient air quality sampling results are compared to these standards to verify its compliance. The quality of the pollutants is evaluated through the Air Quality Indices (AQI) in **Table 2.94**. The AQI is used to classify the conditions of ambient air quality in the project area.

Table 2.94 Air quality indices

Type/ Classification	TSP, µg/Ncm (24-hour average)	PM_{10}, µg/Ncm (24-hour average)	SO_2, µg/Ncm (24-hour average)*	NO_2, ppm (1-hour average)*
Good	0 to 80	0 to 54	0 to 88.8	--
Fair	81 to 230	55 to 154	91.4 to 376.2	--
Unhealthy for sensitive groups	231 to 349	155 to 254	378.8 to 627.4	--
Very unhealthy	350 to 599	255 to 354	587.8 to 794.2	--
Acutely unhealthy	600 to 899	355 to 424	796.8 to 1577.9	1,220.5 to 2,328.3
Emergency	900 and above	425 to 504	1580.5 to 2100.3	2,347.0 to 3,079.3

*Conversion factor for SO_2: 1 ppm = 2,612.4 µg/Ncm; NO_2: 1 ppm = 1,877.6 µg/Ncm; Annex A of DAO 2000-81.

2.3.2.3 Air Quality Modelling

The California Line Source Dispersion model version 4 (CALINE4) is a roadway dispersion model developed by the California Department of Transportation. This software is commonly adopted in many highway projects in different parts of the world for air quality assessment. It is used to predict the air quality impact from the road traffic emission in this study. The input data of CALINE4 include surface roughness, meteorological data, receiver coordinates, hourly traffic flows, and vehicular emission factors.

2.3.2.3.1 Assessment Area

The assessment area covers 500 m radius from the project boundary. The main road alignment and the corresponding slip roads are shown in **Figure 2.173**, **Figure 2.174** to **Figure 2.180**.

The road types (at-grade or elevated) are summarized in **Table 2.95**. Further to the proposed main roads of LLRN (Roads 1 – 14), some connecting slip roads (A, B, Z, C, D, and E) are also proposed, and hence, they are also included in the air modelling.

Table 2.95 Summary of Road IDs

Road ID	Description/Road Name	Road Type
1	Main road from Lower Bicutan to Sucat	Elevated
2	Main road from Sucat to Alabang	
3	Main road from Alabang to Putatan	
4	Main road from Putatan to San Pedro	
5	Main road from San Pedro to Sta Rosa	
6	Main road from Sta. Rosa to Cabuyao	
7	Main road from Cabuyao to Calamba	
8	Main road from Sucat to Lower Bicutan	
9	Main road from Alabang to Sucat	
10	Main road from Putatan to Alabang	
11	Main road from San Pedro to Putatan	
12	Main road from Sta Rosa to San Pedro	
13	Main road from Cabuyao to Sta Rosa	
14	Main road from Calamba to Cabuyao	
A1	Slip road from Road 9 to Sucat	
A2	Slip road from Sucat to Road 2	
A3	Slip road from Road 1 to Sucat	
A4	Slip road from Sucat to Road 8	
B	Slip road connecting to Alabang	At grade

Z	Slip road connecting to Tunasan	
C	Slip road connecting to San Pedro	
D	Slip road connecting to Sta. Rosa	
E	Slip road connecting to Cabuyao	

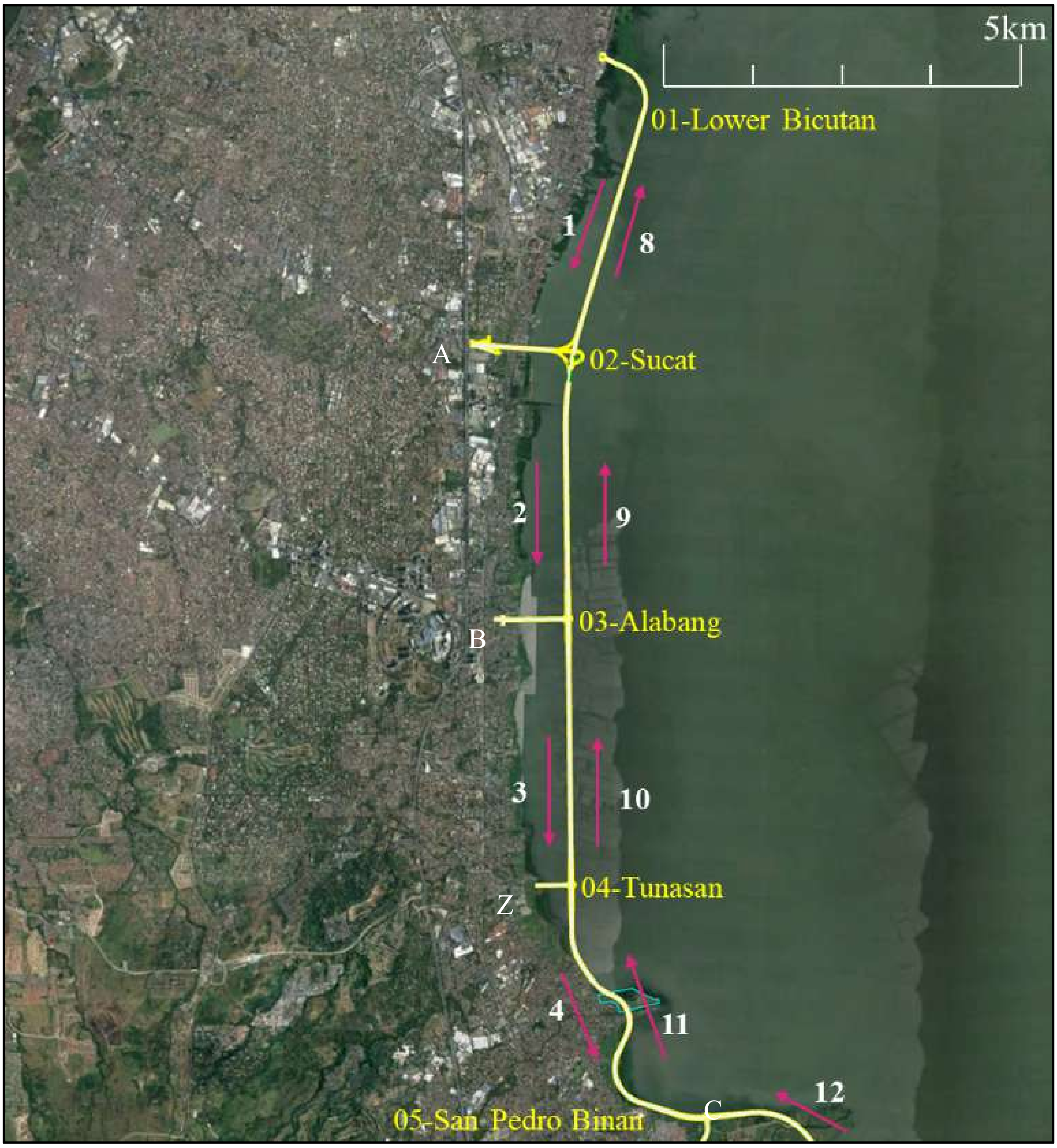


Figure 2.173 Road ID (Northern Portion)

Figure 2.174 Road ID (Southern Portion)

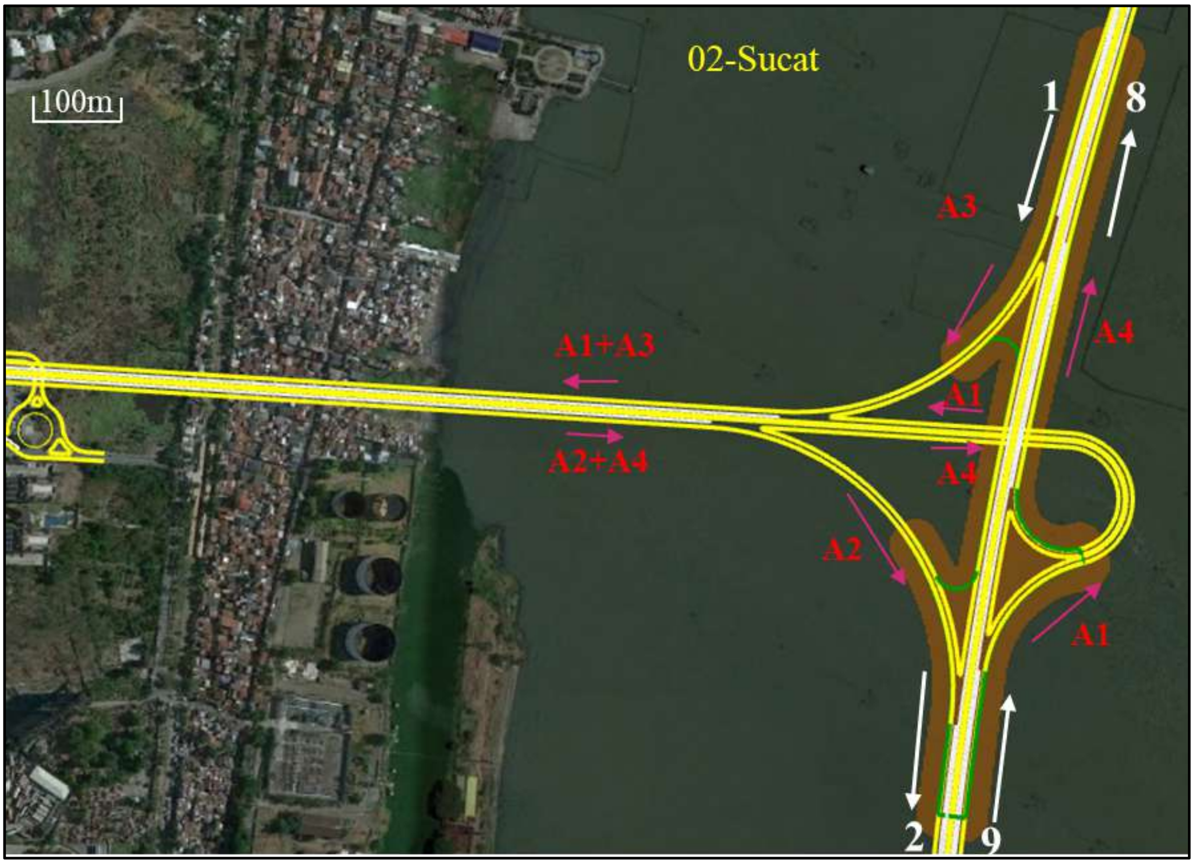


Figure 2.175 Road ID (Slip Roads)

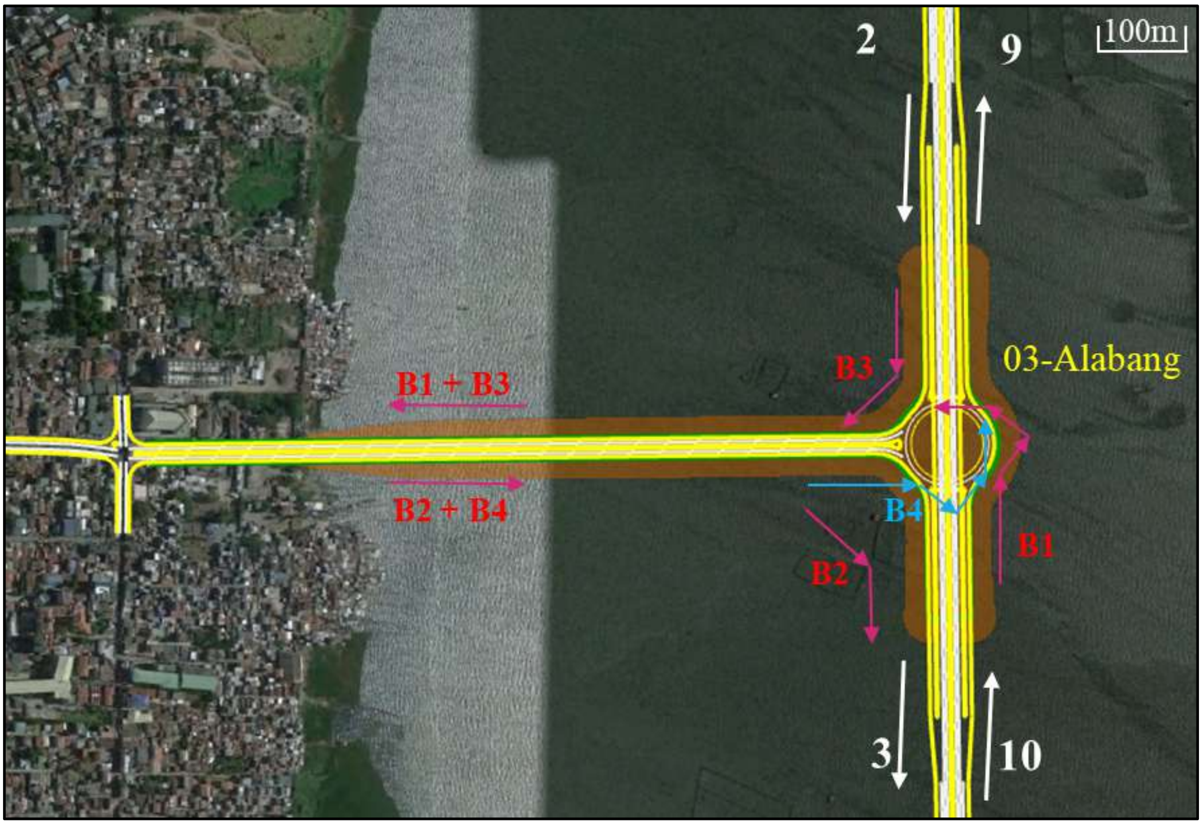


Figure 2.176 Road ID in LLRN (slip roads)

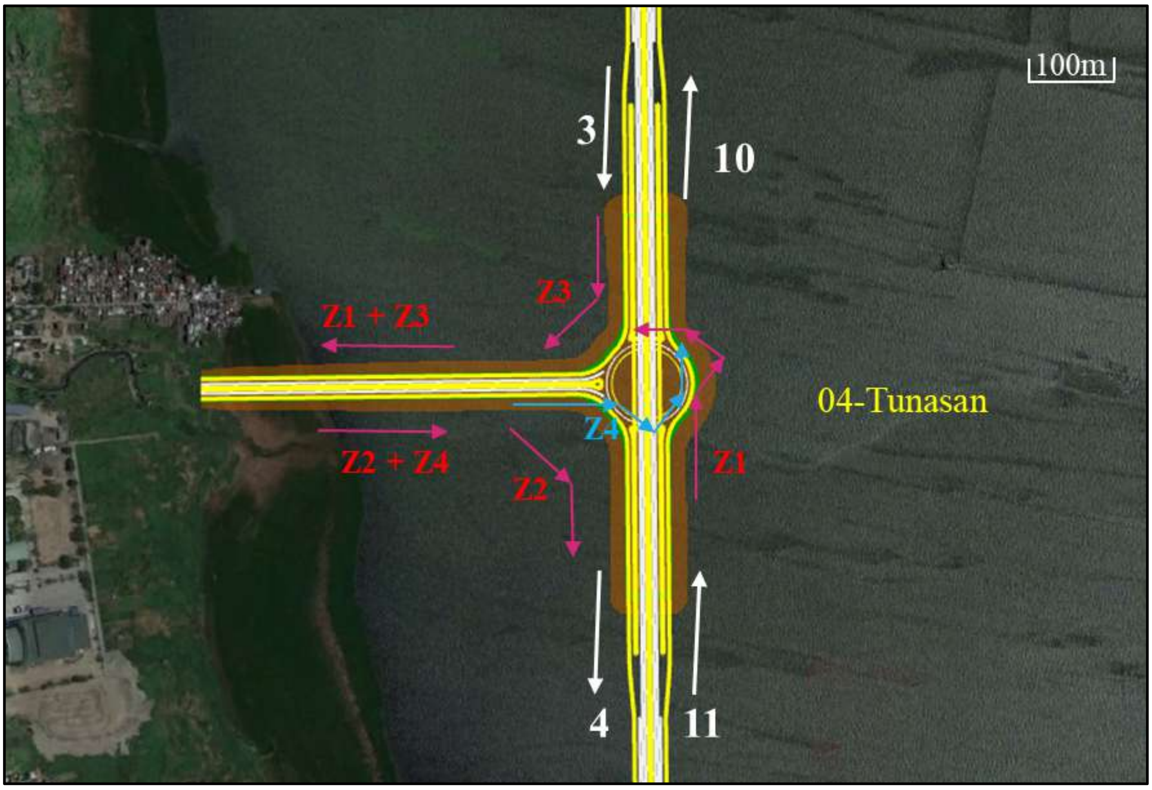


Figure 2.177 Road ID in LLRN (slip roads)

Figure 2.178 Road ID in LLRN (slip roads)

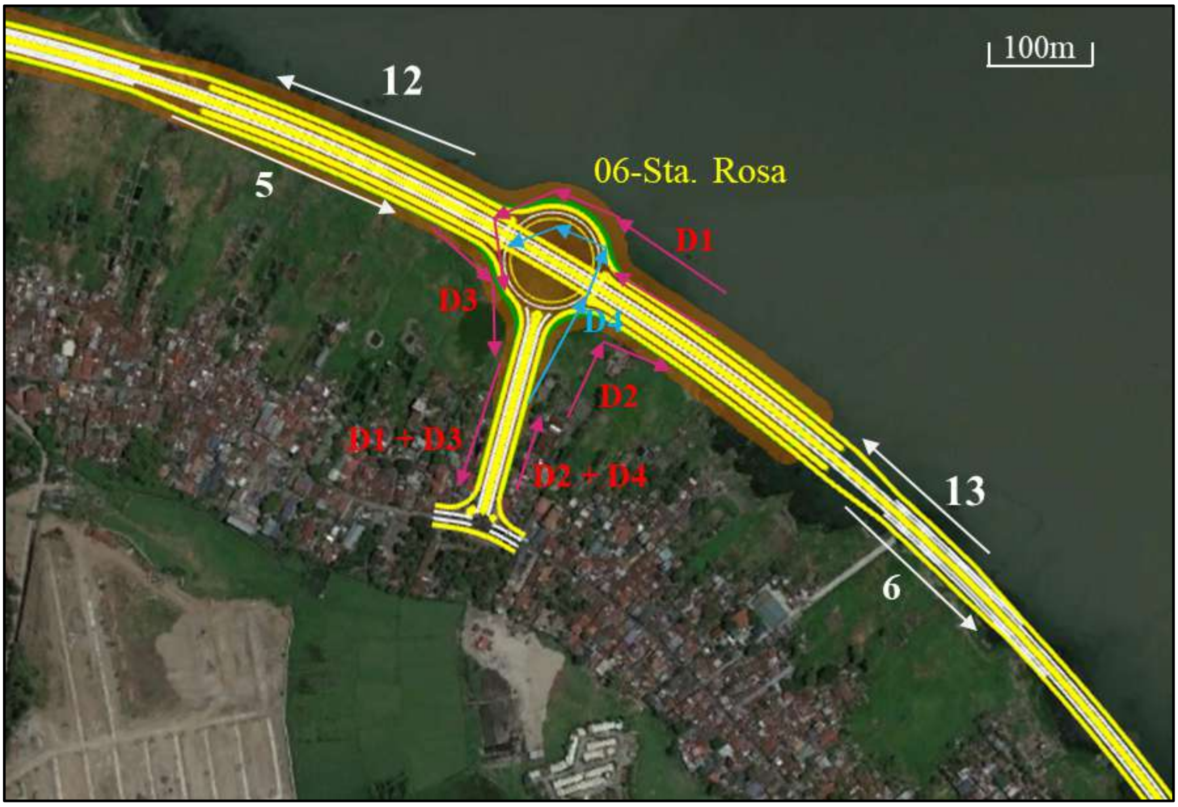


Figure 2.179 Road ID in LLRN (slip roads)

Figure 2.180 Road ID in LLRN (slip roads)

Along the proposed LLRN from Northern to Southern, the areas between 01-Lower Bicutan and 04-Tunasan (northern region) are highly urbanized and characterized by shoreline development. Areas in the vicinity of 05-San Pedro, Binan (central region) are urbanized clusters with intermittent waterfront access, while the areas in 06-Sta. Rosa and 07-Cabuyao (southern region) have low urbanization, with agricultural lands and undeveloped shorelines. Among the various regions, the existing land uses of the study areas are mainly composed of low-rise buildings (with 1 or 2 storey/s).

The vehicular emission impacts are modelled for Air Sensitive Receptors (ASRs) at 1.5 m and 5 m above the ground. A 100 × 100 m-grid is used to generate the pollution contours to present the pollution dispersion model.

2.3.2.3.2 Surface Roughness

CALINE4 Manual43 reflects that the surface roughness is set at 15% of the typical average canopy height. Since the existing buildings are 1 to 2 storey high and it is anticipated that there would be more developments in the future, a surface roughness of 45cm (i.e. 15% × 3m) is adopted in the CALINE4 modelling for both assessment areas to represent the existing rural area.

2.3.2.3.3 Meteorological Data

The meteorological data for CALINE4 input include wind angle, wind speed, Pasquill-Gifford (P-G) stability class, mixing height, wind direction standard deviation, and ambient temperature. A literature review has been conducted to identify any weather stations that would best represent the assessment areas. Review results reveal that the nearest weather station is located at the Ninoy Aquino International Airport (NAIA) Manila International Airport Authority (MIAA) in Pasay City, which is about 5 km away from the northern portion of the proposed LLRN.

As the hourly meteorological data of the nearby weather station is not available, worst-case meteorological condition is adopted to predict the maximum hourly concentration.

In order to predict the maximum hourly concentration, the worst wind angle search (i.e. run type 3 in CALINE4) is adopted. Other input data is shown in **Table 2.96**. It can be seen that atmospheric stability classes have been varied from Pasquill-Gifford stability class 1 to 6, associated with the reasonable wind speeds (1 – 6 m/s) and typical ambient air temperatures (i.e., annual average temperature 27.8ºC in NAIA (MIA), Pasay City from 1980-2017).

Table 2.96 Meteorological Input Data

ID [1]	Wind Speed (m/s) [2]	P-G Stability Class	Wind Direction Standard Deviation (º) [3]
1	1	1	28.0
2	2	1	28.0
3	3	1	28.0
4	1	2	28.0

43 Benson, P., 1984. CALINE4 - a dispersion model for predicting air pollutant concentrations near roadways. FHWA/CA/TL-84/15, California Department of Transportation, Sacramento, CA.

ID [1]	Wind Speed (m/s) [2]	P-G Stability Class	Wind Direction Standard Deviation (°) [3]
5	2	2	28.0
6	3	2	28.0
7	4	2	28.0
8	5	2	28.0
9	1	3	21.8
10	2	3	21.8
11	3	3	21.8
12	4	3	21.8
13	5	3	21.8
14	6	3	21.8
15	1	4	15.6
16	2	4	15.6
17	3	4	15.6
18	4	4	15.6
19	5	4	15.6
20	6	4	15.6
21	2	5	9.3
22	3	5	9.3
23	4	5	9.3
24	5	5	9.3
25	1	6	4.7
26	2	6	4.7
27	3	6	4.7

Note:

[1] Weather condition index.

[2] Refer to the Table 4-2 of PCRAMMET User's Guide by USEPA, varied wind speed (1 - 6 m/s) is adopted for the various P-G stability class.

[3] Wind direction standard deviation is calculated from surface roughness and P-G stability class refer to Section 6.4 in "Meteorological Monitoring Guidance for Regular Modeling Applications" by USEPA 2000.

[4] The CALINE4 modelled results are less sensitive to the ambient temperature, and hence the past 10 years average temperature is adopted as a typical temperature in the modelling.

For the estimation of mixing height in the above table, due to the lack of measured mixing height around the assessment area, the mixing height has been calculated via the following equation[44]:

$$MIXH = \frac{0.185\ \mathrm{U\ K}}{\ln\left(\frac{\mathrm{Z}}{\mathrm{Z0}}\right)\mathrm{f}} = 559\ m$$

Where,
U =Wind speed (m/s),
Z =Height U measured at (m)
$\mathbf{Z_0}$ = Surface roughness (m)
K= von Karman constant (0.35)
F = Coriolis parameter
= 1.45×10^{-4} cosϴ (radian/Sec)
ϴ = 90 – site latitude

2.3.2.3.4 Traffic Forecast

The year with the highest emission strength from the Project within the next 15 years upon commencement shall be typically considered as the assessment year. Generally, the traffic flow is anticipated to grow progressively while the emission factor per vehicle would gradually decrease due to the phasing out of vehicles with older emission standards. As the vehicular emission factor for a particular year is not available, as a conservative approach, it is proposed to adopt the highest traffic flow (in the 15th year after the road operating) and the highest emission factor (in the 1st year) as the worst-case scenario. Since the proposed LLRN is planned to commence in Year 2025. The traffic forecast in 2040 is therefore adopted for this CALINE4 modelling. The traffic forecast for different road segment of peak hour in 2040 are listed in **Table 2.97**.

Table 2.97 Peak Hour Traffic Forecast in 2040 (Vehicle/hour)

Road ID	Car	Jeepney	Truck	Bus	MC	Total
1+8	2931	495	26	18	2547	**6016**
2+9	5193	43	93	116	2935	**8379**
3+10	5260	273	93	70	3302	**8997**
4+11	5260	273	93	70	3302	**8997**
5+12	3874	2	121	77	3580	**7655**
6+13	2731	28	89	70	3503	**6420**
7+14	2102	34	71	20	1696	**3923**
A1	1128	28	40	33	165	**1394**
A2	1133	15	27	64	223	**1462**
A3	0	269	0	0	0	**269**

[44] Table 6 of CALINE4 Manual

A4	0	225	0	0	0	**225**
B	67	315	0	46	367	**795**
C	1587	275	36	8	1062	**2967**
D	1169	30	37	8	414	**1657**
E	628	62	18	53	1952	**2713**

2.3.2.3.5 Emission Factors for each Vehicle Type

DENR had tightened the pollution emission standard of vehicle from EURO II to EURO IV since 1st January 2016 and only EURO IV vehicles are allowed to be registered since 1st January 2018. It is anticipated that more vehicles with higher emission standards will be registered. However, there are no published information /statistics on the replacement programme for existing vehicles. Hence, in order to be conservative, the vehicular emission factors for EURO II vehicles are adopted in this assessment.

The emission factors are derived from the “Air Pollution and GHG Emissions Indicators for Road Transport and Electricity Sectors. Guidelines for Development, Measurement, and Use. Pasay City, Philippines” and “Emission Factors 2009: Report 3 – exhaust emission factors for road vehicles in the United Kingdom” Version 6. The calculations of emission factors are detailed in Appendix E. The emission factors used in this study are listed in **Table 2.98**.

Table 2.98 Emission Factors

Pollutants	Emission Factor (g/mile/vehicle)				
	Car	Jeepney	Truck	Bus	MC
PM	0.010	0.107	0.589	0.241	0.048
NOX	0.149	0.917	10.378	10.040	0.547
SO_2	0.010	0.011	0.040	0.037	0.004
PM10	0.012	0.133	0.373	0.231	0.059

Notes:
[1] Refer to **Annex D** for further details.

2.3.2.3.6 Emission Factors for Combined Vehicle Types

Considering the traffic forecast for 2040 and EURO II emission factor, the emission rates for each road segment are summarized in **Table 2.99**.

Table 2.99 Combined Emission Rate for Each Road Segment

Road ID	Pollutant Emission Rate (g/mile/vehicle)			
	PM	NO_X	SO_2	PM10
1+8	0.0373	0.4541	0.0077	0.0440
2+9	0.0335	0.5426	0.0085	0.0360

Road ID	Pollutant Emission Rate (g/mile/vehicle)			
	PM	NO_X	SO_2	PM10
3+10	0.0347	0.5006	0.0083	0.0383
4+11	0.0347	0.5006	0.0083	0.0383
5+12	0.0393	0.5967	0.0079	0.0419
6+13	0.0418	0.6181	0.0075	0.0455
7+14	0.0390	0.5639	0.0080	0.0410
A1	0.0386	0.7402	0.0106	0.0354
A2	0.0376	0.8419	0.0107	0.0365
A3	0.1074	0.9172	0.0112	0.1327
A4	0.1074	0.9172	0.0112	0.1327
B	0.0797	1.2121	0.0094	0.0943
C	0.0402	0.5118	0.0083	0.0449
D	0.0354	0.5384	0.0092	0.0349
E	0.0480	0.7128	0.0065	0.0553

The ratio of NOx to NO_2 is dependent on the ambient Ozone concentration. According to "A new Approach to Deriving NO_2 from NOx got Air Quality Assessment of Roads", the NO_2 to NOx ratio ranges from 20% to 37.5%. Therefore, the daily average NO_2 contour maps use 37.5% of NOx to NO_2 as an illustration.

2.3.2.3.7 Averaging Time Conversion

As discussed previously, a total of 24 modelling scenarios have been considered using CALINE4 to predict the worst-case scenario covering 1-hour pollutant concentrations.

To estimate the 8-hour average, 24-hour averages, and annual averages, the conversion factors recommended in the "Guidelines for Air Dispersion Modelling" have been adopted. **Table 2.100** presents those conversion factors. The 1-hour concentrations, 8-hour concentrations, 24-hour concentration and the annual concentration of those estimated values are then compared with the NAAQG criteria to identify any potential adverse impacts of the proposed Project.

Table 2.100 Averaging Time Conversion Factors

Convert to Convert from	10 min	1/2hour	1 hour	8 hour	24 hour	Annual
10 min	1	1/1.36		-	-	-
1/2hour	1.36	1	1/12	0.5	1/3	1/15
1 hour	1.65	1.2	1	0.6	0.4	1/12.5
8 hour		1/0.5	1/0.6	1		

Convert to Convert from	10 min	1/2hour	1 hour	8 hour	24 hour	Annual
24 hour		3	2.5		1	0.2
Annual		15	12.5		5	1

Note:

[1] Referred to Table B1 in Appendix B of "Guidelines for Air Dispersion Modelling" by Department of Environmental and Natural Resources of Philippines and reviewed with Table 4-1 in Air Dispersion Modelling Guidelines for Ontario Version 3.0 by Ministry of the Environment 2017.

2.3.2.4 Baseline Environmental Conditions

2.3.2.4.1 Baseline Sampling

Ambient air quality monitoring has been conducted from Laguna to Taguig on 21 September – 30 November 2020. There are 29 background monitoring locations as shown in **Table 2.993**. Monitoring locations A1 and A2 are in Taguig, A3 – A7 are in Muntinlupa, A8 – A11 in San Pedro, A12 – A13 in Binan, A14 – A17 in Sta Rosa, A18 – A24 in Cabuyao, and A25 – A30 in Calamba. The results of the baseline conditions for 24-hr and 1-hr sampling air pollutants are summarized in **Table 2.994** and **Table 2.995**.

Table 2.993 24-hr ambient air monitoring results

ID Stations	Date	Time	Pollutants (µg/Ncm)				
			TSP	PM10	PM2.5	NO_2	SO_2
A1	20-21 November 2020	2030H-2030H	35.2	28.5	23.5	<3.02*	<10.4*
A2	21-22 November 2020	2200H-2200H	96.2	71.0	40.7	<3.01*	<10.3*
A3	14-15 November 2020	1245H-1245H	36.4	21.4	11.7	3.14	<10.3*
A4	29-30 November 2020	2150H-2150H	117	40.6	19.6	<3.03*	<10.4*
A5	13-14 November 2020	1025H-1025H	105	52.5	37.6	4.10	<10.4*
A6	28-29 October 2020	1550H-1550H	52.3	19.2	19.4	<3.03*	<10.4*
A7	27-28 October 2020	1220H-1220H	27.9	8.60	2.04	<3.04*	<10.4*

ID Stations	Date	Time	Pollutants (µg/Ncm)				
			TSP	PM10	PM2.5	NO_2	SO_2
A8	10-11 November 2020	1015H-1015H	22.2	17.0	20.6	3.12	<10.3*
A9	3-4 November 2020	1245H-1245H	31.1	16.9	7.78	4.38	<10.3*
A10	4-5 November 2020	1610H-1610H	23.2	14.5	6.94	<2.99*	<10.3*
A11	5-6 November 2020	2015H-2015H	46.4	28.8	17.5	4.18	<10.4*
A12	22-23 October 2020	1600H-1600H	39.6	30.4	19.7	<3.04*	<10.4*
A13	23-24 October 2020	1815H-1815H	56.3	44.0	42.2	<3.02*	<10.4*
A14	7-8 November 2020	0800H-0800H	25.5	16.9	4.17	3.44	<10.3*
A15	8-9 November 2020	1050H-1050H	26.3	19.9	13.4	4.43	<10.4*
A16	21-22 October 2020	1040H-1040H	28.9	27.2	19.3	<3.03*	<10.4*
A17	12-13 October 2020	1200H-1200H	27.4	24.2	14.0	<3.00*	<10.3*
A18	9-10 October 2020	0600H-0600H	16.4	17.0	11.9	<3.02*	<10.3*
A20	12-13 October 2020	1200H-1200H	21.9	6.27	6.84	<3.01*	<10.3*
A21	6-7 October 2020	1100H-1100H	8.17	7.13	4.42	<3.03*	<10.4*
A22	7-8 October 2020	1500H-1500H	23.5	15.9	10.4	<3.00*	<10.3*
A23	30 September – 1 October	2030H-2030H	33.2	29.9	18.3	<3.04*	<10.4*

ID Stations	Date	Time	Pollutants (µg/Ncm) TSP	PM10	PM2.5	NO_2	SO_2
	2020						
A24	29-30 September 2020	1620H-1620H	43.1	37.7	28.0	<3.03*	<10.4*
A25	26-27 September 2020	1100H-1100H	34.1	25.5	17.8	<3.03*	<10.4*
A26	25-26 September 2020	0800H-0800H	46.4	37.3	25.1	<3.01*	<10.3*
A27	28-29 September 2020	1140H-1140H	66.7	25.4	13.2	<3.03*	<10.4*
A28	23-24 September 2020	2000H-2000H	21.9	17.1	8.57	<3.02*	<10.3*
A29	22-23 September 2020	1430H-1430H	48.5	33.7	28.1	<3.02*	<10.3*
A30	21-22 September 2020	1045H-1045H	15.1	13.1	8.75	<3.03*	<10.4*
DAO 2001-81			**230**	**150**	**50**	**180**	**150**

** - Values below the laboratory's Method Detection Limit or pollutant minute enough to be 0 or have a slight mechanical error.*

Table 2.994 1-hr ambient air monitoring results

ID Stations	Date	Time	Pollutants (µg/Ncm)				
			TSP	PM10	PM2.5	NO_2	SO_2
A1	21 November 2020	2010H-2110H	32.4	<28.2*	<28.2*	<7.16*	<24.6*
A2	22 November 2020	2210H-2310H	52.5	37.2	<28.4*	<7.14*	<24.6*
A3	15 November 2020	1210H-1310H	36.9	36.2	<28.7*	9.94	<25.3*
A4	30 November 2020	2200H-2300H	180	80.1	44.7	<7.23*	<24.9*
A5	14 November 2020	1040H-1140H	107	107	103	13.4	<25.4*
A6	29 October 2020	1610H-1710H	421	158	87.9	<7.37*	<25.4*
A7	28 October 2020	1230H-1330H	59.7	46.2	<28.6*	<7.43*	<25.6*
A8	11 November 2020	1025H-1125H	65.4	60.2	34.5	12.6	<25.0*
A9	4 November 2020	1258H-1358H	26.0	<28.4*	<28.0*	22.8	36.1
A10	5 November 2020	1620H-1720H	47.5	<28.1*	<28.2*	14.0	<24.7*
A11	6 November 2020	2045H-2145H	47.1	38.1	41.1	<7.13*	<24.5*
A12	23 October 2020	1615H-1715H	<22.7*	65.2	94.7	12.0	<25.2*
A13	24 October 2020	1825H-1925H	33.8	96.1	123	8.41	<24.8*
A14	8 November 2020	0810H-0910H	24.6	<28.2*	<28.3*	7.77	26.8
A15	9 November 2020	1100H-1200H	28.8	<28.8*	<28.9*	10.7	<25.2*
A16	22 October 2020	1050H-1150H	<22.9*	77.3	73.1	<7.39*	<25.4*
A17	13 October 2020	1515H-1615H	39.8	<28.8*	51.3	7.71	<25.2*
A18	10 October 2020	0615H-0715H	32.6	57.5	76.6	<7.18*	31.4
A20	13 October 2020	1215H-1315H	23.6	<29.1*	<29.2*	<7.35*	<25.3*
A21	7 October	1115H-	25.9	39.1	46.6	<7.27*	<25.0*

ID Stations	Date	Time	Pollutants (µg/Ncm)				
			TSP	PM10	PM2.5	NO_2	SO_2
	2020	1215H					
A22	8 October 2020	1530H-1630H	43.4	176	50.8	<7.17*	<24.7*
A23	1 October 2020	2045H-2145H	24.3	64.8	65.1	<7.21*	<24.8*
A24	30 September 2020	1630H-1730H	172	163	149	<7.31*	<25.2*
A25	26 September 2020	1000H-1100H	37.1	46.7	73.3	<7.18*	36.7
A26	26 September 2020	0825H-0925H	<22.6*	107	69.9	<7.19*	24.9
A27	29 September 2020	1150H-1250H	<22.9*	48.2	32.3	<7.35*	26.3
A28	24 September 2020	2015H-2115H	25.5	101	65.6	<7.16*	37.7
A29	23 September 2020	1445H-1545H	147	98.9	90.5	<7.38*	<25.4*
A30	22 September 2020	1100H-1200H	<23.5*	83.7	117	<7.49*	<25.8*
DAO 2001-81			**230**	**150**	**50**	**180**	**150**

**- Values below the laboratory's Method Detection Limit or pollutant minute enough to be 0 or have a slight mechanical error.*

TSP

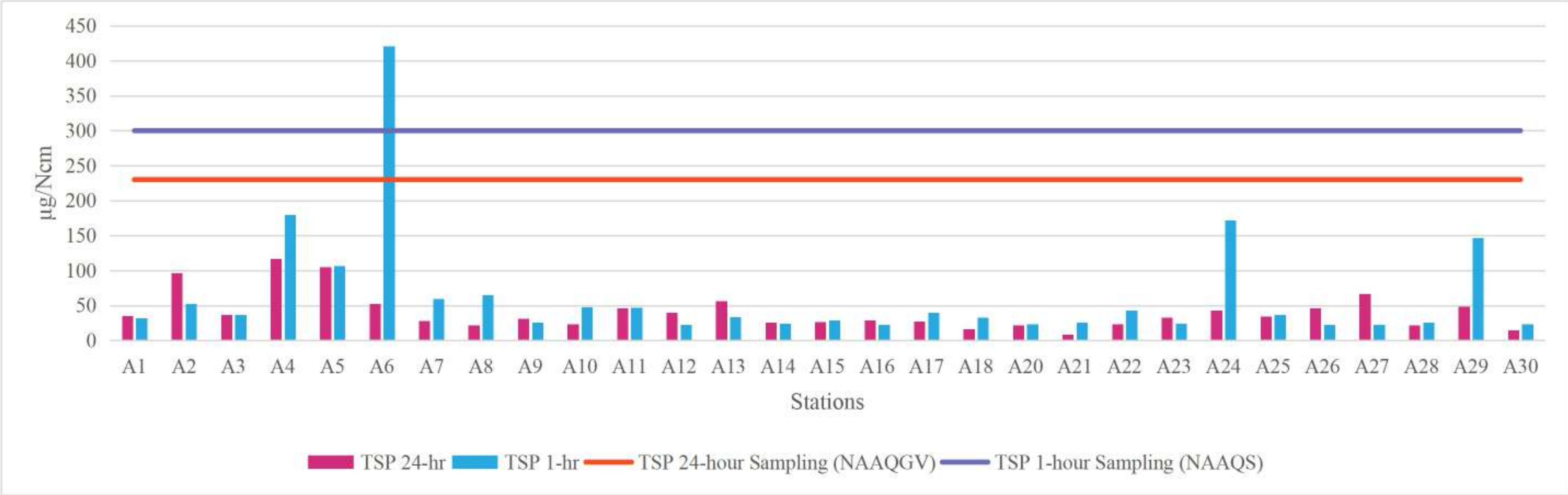


Figure 2.181 Ambient TSP Levels

The results for TSP for 24-hr and 1-hr monitoring conform to the guideline values and standards of DAO 2000-81 except for 1-hr monitoring of station A6 located in Alabang, Muntinlupa. This is due to the dusty ground, and the observed construction activity, with heavy machinery, approximately 20m away from the sampling point. Despite this, all stations in the 24-hr sampling all comply with the standards. The air quality index of the stations falls under "good", aside from stations A2, A4, and A5 at "fair".

PM10

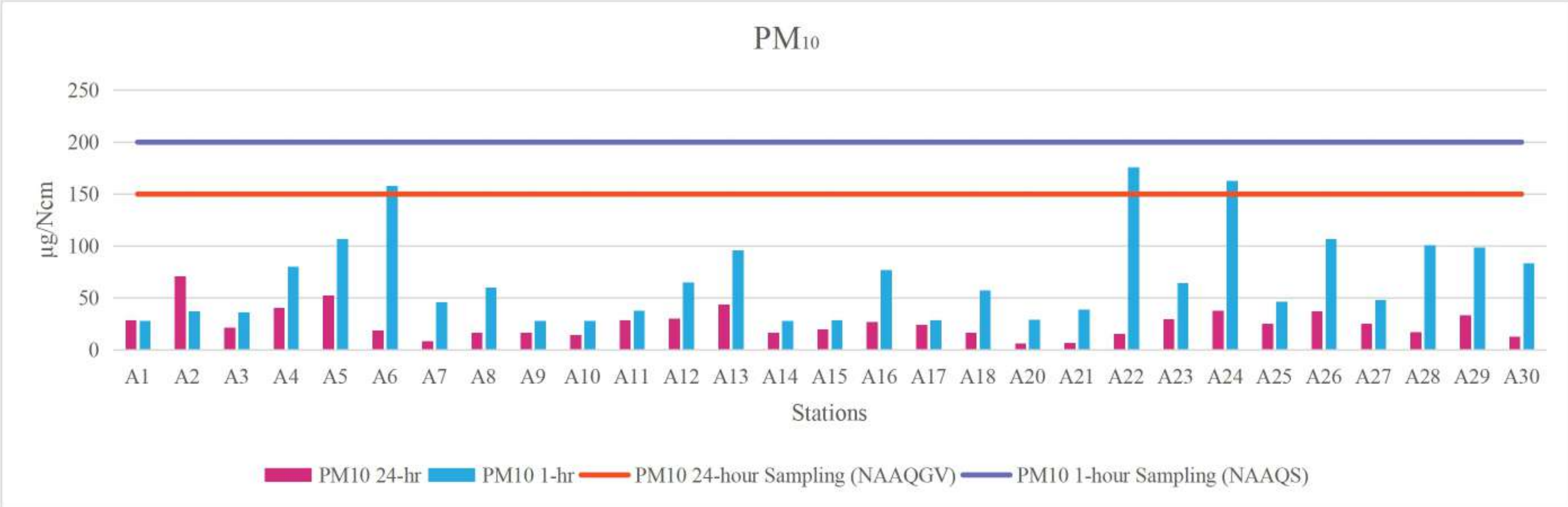


Figure 2.182 Ambient PM_{10} Levels

The results of PM_{10} shows that all of the sampling stations all fall within their respective limits and standards. Stations that exceeded the 1-hr limit are located in A22 with 176 μg/Ncm, due to the near residential usage of firewood in cooking, A6 at Alabang, Muntinlupa due to near construction, and A24 at Cubayao due to the equipment set in a parking lot in a residential area . The AQI in area A2 falls under "fair" while the other areas are classified as "good".

PM2.5

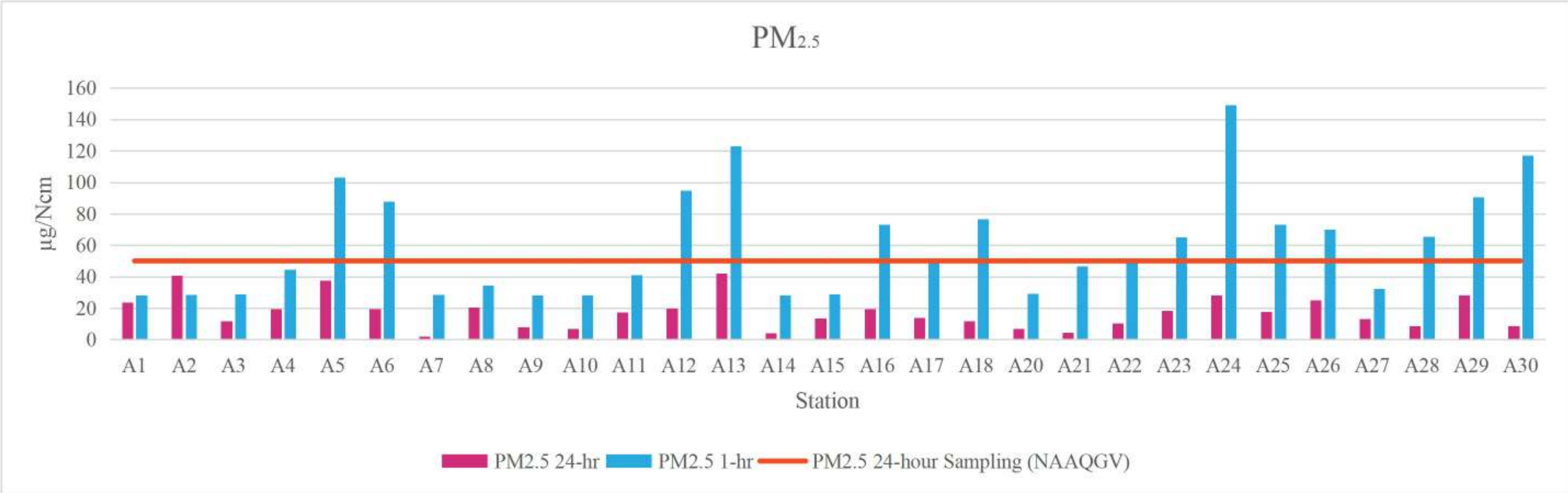


Figure 2.183 Ambient $PM_{2.5}$ Levels

The results for particulate pollutants for 24-hr conform to the guideline values and standards of DAO 2000-81. The highest particulate pollutants for 24-hr and 1-hr sampling, were observed in A13 and A24, respectively. The sampling point of A13 was set beside the access road, thus road dust and emissions are observed. An ongoing hammering activity was observed nearby station A24. Stations A5, A6, A12, A13, A16, A18, A23, A26, A28 had high values due to anthropogenic activities, such as smoking, cooking and burning, and release of settled dust from residential interaction, and stations A5, A13, A16, A18, A25, A26, A28, A29 A30 observed higher values due to cars passing by or near access roads.

Gaseous Pollutants

NO_2

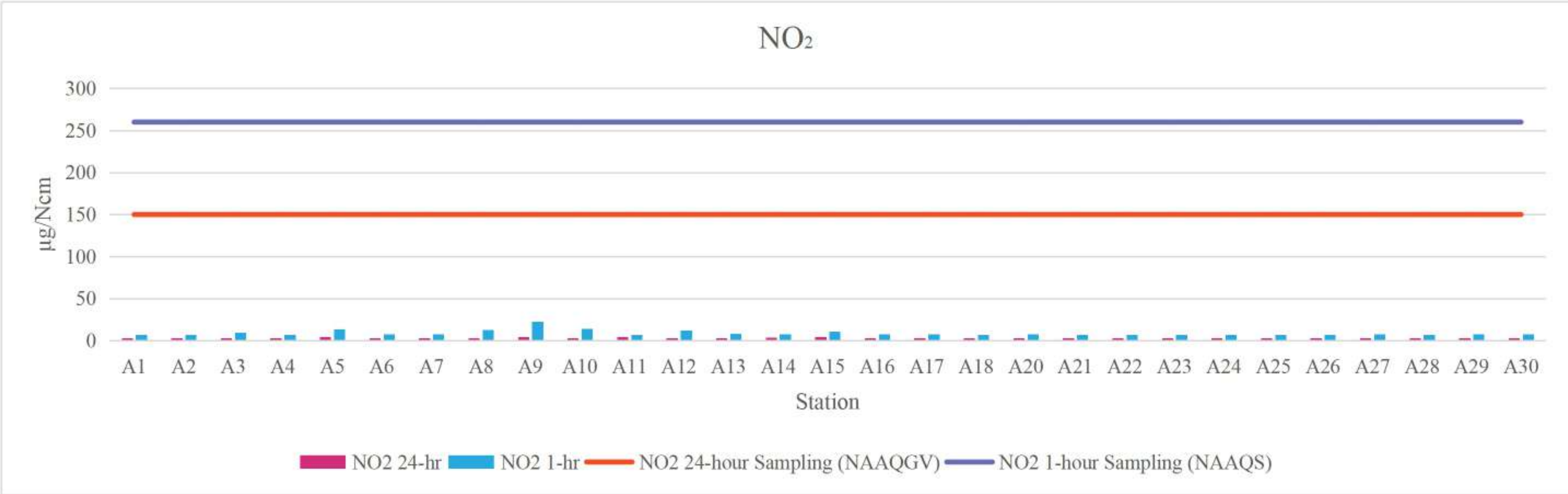


Figure 2.184 Ambient NO_2 Levels

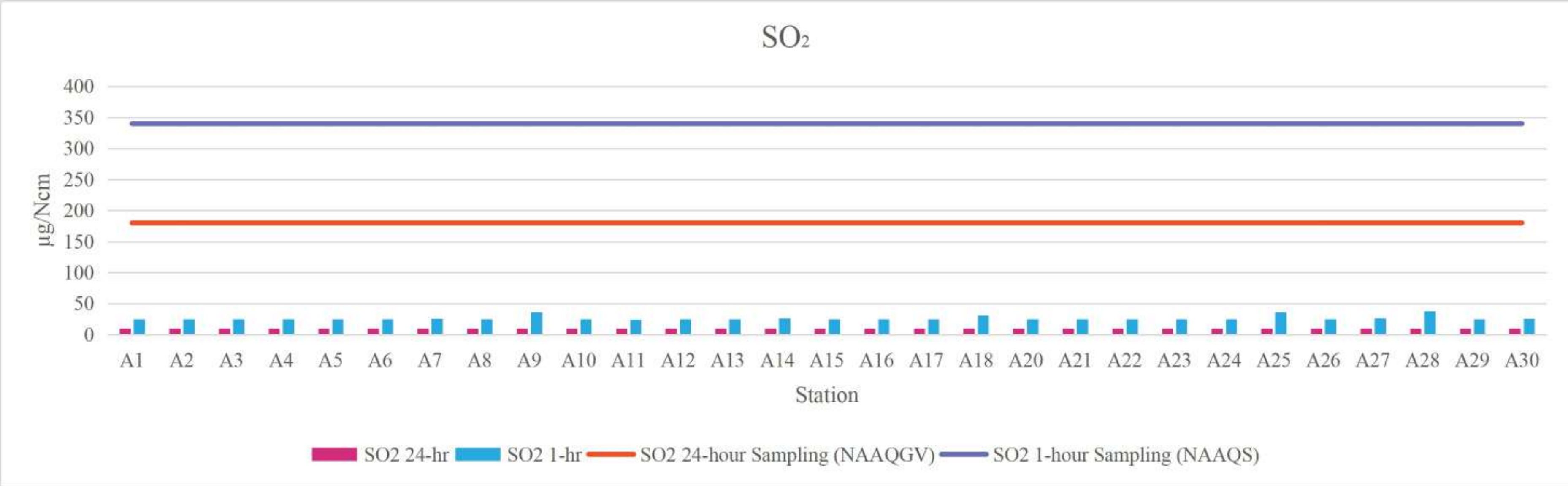


Figure 2.185 Ambient SO_2 Levels

The gaseous pollutant concentrations in the monitoring stations generally comply with the standards for both 1-hr and 24-hr monitoring. All results for NO_2 and SO_2 are below the detection limit (**Figure 2.184** and **Figure 2.185**).

The highest gaseous pollutants for 24-hr NO_2 sampling results were observed in A15, and 1hr sampling results in A9. Similarly, the highest monitoring results for SO_2 among the stations for 1-hr sampling is in stations A28, while all 24-hr sampling monitoring resulted to levels below the detection limit.

Vehicular traffic, aside from congestion of people, is the most common source of particulate and gaseous pollutants in the area. These particulates are found minimal and do not cause adverse health risks. Moreover, these particulates should frequently be monitored based on the DENR standards to prevent exceedances, which may cause toxicity in the environment and human health.

2.3.2.4.2 Cumulative Air Quality Impact

According to the EMB's "Guidelines for Air Dispersion Modelling", the estimation of the cumulative air quality impact can be provided by incorporating the background air quality data, which may be obtained by on-site measurements, with the model results.

Air quality monitoring has been conducted at 29 background locations from 22 September 2020 to 30 November 2020. The monitoring results of the 24-hour average concentrations are summarized in **Table 2.101**.

The 24-hour average concentrations of all pollutants at the 30 monitoring stations complied with the NAAQG criteria. The maximum 24-hour concentrations are aggregated to the modelled results from CALINE4 to generate both the daily average and annual average (adopted the conversion factor 1/5 from 24-hour to annual in **Table 2.97** for the estimation of the cumulative pollutant concentrations. Contour maps are prepared to illustrate the cumulative air quality impact to the surrounding ASRs at 1.5 m and 5 m above local ground (**see Appendix F**).

The predicted cumulative 24-hour average TSP concentrations range from 118 to 122 μg/m³ which are below the NAAQG threshold of 230 μg/m³. As for the predicted annual average, the concentrations range from 23.8 to 24.2 μg/m³ which meet the NAAQG criterion of 90 μg/m³. They are mainly attributed to the background concentration.

For RSP, the predicted 24-hour concentrations range from 73 to 76 μg/m³ which are less than half of the NAAQG criterion of 150 μg/m³. The annual average RSP concentrations are in the range of 14.6 to 16.2 and are lower than the NAAQG maximum level of 60 μg/m³.

For SO_2, daily average concentrations range from 10.8 to 11.4 μg/m³ which are much lower than the NAAQG criterion of 180 μg/m³. Similarly, the predicted annual average SO_2 concentrations are less than 3 μg/m³, and thus are compliant with the NAAQG annual criterion of 80 μg/m³.

The predicted daily average concentrations of NO_2 range from 10 to 35 μg/m³. The potential major NO_2 emission sources include the traffic emissions that can be generated during the operation phase of the proposed LLRN. The daily average NO_2 contour maps used 37.5% of NOx to NO_2 as an illustration. However, the predicted cumulative NO_2 concentrations are well below the NAAQG daily criterion of 150 μg/m³.

Generally, the pollutant concentrations are very near to each other for the 1.5 m and 5 m scale above ground. The background concentration is the major contributor to the cumulative concentrations recorded for TSP, RSP and SO_2. The predicted cumulative concentrations at the level 1.5m and 5m above ground for daily average and annual average of TSP, RSP and SO_2, as well as daily average of NO_2, are below their respective NAAQG criteria.

2.3.2.5 Potential Impacts and Options for Prevention, Mitigation or Enhancement

2.3.2.5.1 Fugitive Dusts

Fugitive dusts are fine air particles, ranging from 2 µm to 10 µm that can escape into the air because of its size. Wind is the main cause of the spreading of this pollutant as its lightweight allows it to float easily and spread to its surroundings. Industrial processes that break down and crush material emit these fugitive dusts into the environment. During the construction phase, the concentration of pollutants in the air will increase. This is due to land clearing, loading and unloading of materials, and the use of construction and transportation vehicles.

Depending on the size, composition, and length of exposure to the particles, fugitive dust can be detrimental to workers and nearby communities. Exposure to this pollutant can cause eye and even skin irritation upon repeated contact. Individuals who experience asthma will have can have more frequent asthma attacks as these particles are small enough to enter your nose and lungs. Long-term effects from over-exposure to fugitive dust can be illnesses to the lungs and to the heart.

Listed below are ways to control and mitigate fugitive dusts, pollutants caused by combustion of fuels and other particulate matter:

- Water spraying to apply dust suppression, especially during transportation of materials.
- Cement paths and roads humans and vehicles use.
- Provide washing areas for construction vehicles to remove mud and dirt from tires before leaving the project site.
- Add rumble grids in the entrances and exits to remove dust stuck on the wheel.
- Control speed in which the transport vehicle is driving at to prevent chunks of material to break on the pavement and become dust.
- Cover vehicles when not in use to keep dust and particulates from sticking to its walls when it leaves the site.
- Regularly conduct maintenance for construction vehicles and machines.
- Constantly monitor air quality in the area and strictly follow set mitigation plans. Prioritize sensitive receivers, strictly implementing buffer zones.
- Publicize the information of the project and activities to communities nearby.
- If possible, immediately plant trees in-between the roads and the residential areas in order to have a buffer for air pollutants and to prevent erosion and dust dispersion. This will help lower the air pollution experienced by the local communities.
- Add wind breakers in areas upwind to prevent wind from disturbing the dust.
- Conduct training, which includes:
    - Proper and efficient use of fuel-powered equipment for air pollution reduction.

- Safety briefings, giving importance to personal and environmental implications. Ensure the proper use of personal protective equipment (PPE) based on Occupational Safety and Health Association (OSHA) guidelines.
- Guidelines to manage traffic.

2.3.2.5.2 Emissions due to the combustion of fossil fuels

Vehicle and equipment emissions are one of the primary sources of air pollution as these create particulate matter, such as smoke and dust, and other and other gaseous pollutants. Gaseous pollutants such as NO_2 and SO_2, are emitted from the combustion of fossil fuels by vehicles and equipment. Along with these emissions, fine particulates are produced from the exhaust of vehicles. Combustion of fossil fuels result in the emission of TSP, PM10, and PM2.5, specifically black carbon. As previously mentioned, the particles have diameters so small that it can bypass human defense systems, such as nasal hair and filia in the lungs. This can produce adverse health effects as the particles are able to enter the lungs, causing respiratory diseases like asthma, or cardiovascular disease during long-term over-exposure.

NO_2 and SO_2 are released during fossil fuel combustion. The gaseous pollutants mix and react with water, making it more acidic. In addition to this, this pollutant can react to rain and result in acid rain. This can pollute bodies of water and nearby soil, changing their chemical properties. This has an ecological effect as many organisms, especially plants and aquatic creatures, have a narrow pH limit, dying once basicity or acidity exceeds these limits.

Another by-product released by the combustion of fossil is carbon dioxide (CO_2). CO_2 is considered a greenhouse gas (GHG) and these are the main cause of climate change and global warming. CO_2 can react with O_3, otherwise known as ozone, which is of the gases responsible for the degradation of the ozone layer in the stratosphere. The result of this is global warming and climate change, causing habitat loss, species extinction, and resource depletion. On a local level, over-exposure to CO_2 can lead to carbon dioxide poisoning. This kind of intoxication can lead to loss of oxygen, or anoxia, or an elevated level of CO_2 in the blood and tissue and may lead to death. Nearby communities may experience nuisances by the odor of the combustion of fossil fuels.

The release of pollutants into the atmosphere during the operation phase will rise as the public will be permitted to utilize the highway. The resulting increase of vehicles passing through the highway, and the roads connecting to it, will increase the emission of air pollutants, imposing health hazards to the area, especially on the locals situated in the immediate surroundings of the roads.

Mitigation approaches and ways to control the emissions of particulate matter and gaseous pollutants from combustion of fossil fuels are:

- Conduct regular inspection and maintenance for construction and transport vehicles, and machine in order to avoid incomplete combustion of fuels.
- Use cleaner fuel such as biofuel or diesel if possible.
- Use renewable energy to power equipment or appliances found on site.
- Construction plans for temporary buildings and rest areas should consider cooling effects by different roofs, such as green roofs and energy star roofs, and interior

design to lessen the use of cooling systems such as air conditioners and heavy-duty electric fans. In addition to these methods, locations of such areas should be properly planned to be put up in cooler places on site.

- Plant trees in between project site and local communities to reduce their exposure to these emissions as the vegetation act as a buffer.
- Conduct training to inform the workers proper and efficient use of construction equipment and vehicles transport
    - Proper and efficient use of fuel-powered equipment for air pollution reduction.
    - Safety briefings, giving importance to personal and environmental implications. Ensure the proper use of personal protective equipment (PPE) based on Occupational Safety and Health Association (OSHA) guidelines.
    - Guidelines to manage traffic.
    - Turn off the engine of idling vehicles to prevent wasting fuel.

2.3.2.5.3 Enhancement of climate change impacts

LLRN may increase the ground level concentration of air pollutants during construction and operation phases. Particulate pollutant emission can have significant impacts on climate. The direct effects come from particles' ability to absorb and scatter light. These particles absorb heat from the sunlight preventing the dispersion of heat thus, cause an increase in temperature in the atmosphere. Other causes of climate change include the change in reflectivity of the scattered particles, which influence cloud lifetime and precipitation. Changes may also increase influence in altering air pollutant dispersal and formation of inversion layers.

Gaseous pollutants such as emission of NO_X from the combustion of fossil fuels, from use equipment and vehicle use, may contribute to the formation of ozone, which is a significant contributor to climate warming. SO_2, when combined with water, formed harmful compounds, such as sulfuric acid, sulfurous acid and sulfate particles. This may be dispersed in air and forms acid rain that may damage plants and crops and may even affect human health.

In addition to minimizing any negative impacts on the community, good sustainable development practices should be implemented to have environmental sustainability targets. The project implementation may generate significant amounts of air pollution. The changes in seasonal rainfall and temperature that are projected to occur in a changing climate may harm species, habitat and ecosystem. Measures to minimize the Projects' contribution to the effects of climate change are the same as the above.

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2.3.3 Ambient Noise Level

Noise impact assessment aims to protect people from the adverse effects of noise in human health and the environment. The study aims to identify the baseline condition at the project vicinity, conduct the ambient noise impact assessment and propose mitigation measures.

Ambient noise results are compared to the Philippine Noise Standards (1978 National Pollution Control Commission (NPCC)) Memorandum Circular No. 002 Series of 1980, Section 78 – Ambient Noise Quality and Emission Standards for Noise. Noise standards were developed with the aim of protecting the people from the adverse effects of noise. These were set according to the category of the area and time range of sampling.

The assessment is also compared to the Environmental, Health, and Safety Guidelines on Noise Management set by the International Finance Corporation (IFC) to ensure that noise will always comply with its acceptable limit.

2.3.3.1 Methodology

2.3.3.1.1 Study Area

The twenty-nine (29) noise sampling sites were selected to represent the sensitive receptors in the vicinity of the project area and were located coincident with the ambient air sampling stations. The most common category in the study is category A for the purpose of obtaining the most accurate representational data experienced by the residents. One location, A21, is classified as B.

2.3.3.1.2 Sources Identification

Decibel (dB) is a unit used to measure the intensity of sound. Various components may affect the sound level produced such as power, sound pressure, distance, voltage, and many more. Measuring dB is important as over-exposure to this pollutant may lead to sleeping disorders, and irritation, while exposure to high levels can cause hearing loss.

Sources of noise pollution can be found throughout the site. From heavy transport trucks to construction machinery, many of the necessary equipment produce loud and unsettling noises.

During the construction phase, the two main sources of noise pollution are from construction and from transport. The sound from construction mainly occurs from heavy machinery. Excavators, bulldozers, track loaders, and cranes are a few of the common equipment that can produce large amounts of noise because of their purpose to move earth, soil, and rock. Because high numbers of rock and soil require large amounts of energy to be displaced, engines and its parts need to be bigger and stronger to do enough work. This increases the noise the machine makes as larger parts are at work and grinding against each other.

Vehicles going to the area also emits a significant amount of noise. Construction workers are brought to the site and this constant transport to and from the area may result in loud noises depending on the shift of the workers. Trucks carrying material to the construction site are not necessarily as common as transport vehicles, but their sizable engines cause louder noises. Conversations from construction workers near the edge of the site may also be loud enough to bother nearby communities.

The main source of noise pollution during the operational phase of the projects is the transport vehicles that will utilize the roads. As locations are more accessible, travel to and from these areas will be simpler, increasing the number of cars, motorcycles, trucks, and others. Neighboring communities may be affected by the loud noises these vehicles produce.

2.3.3.1.3 Sampling Methodology

Noise monitoring was conducted on 21 September – 30 November 2020. Sampling was stationed at twenty-nine (29) noise level sampling stations, consistent with the ambient air sampling stations, using the Lutron Sound Level Meter. The meter used for noise level monitoring was an A-weighted, dB (A), frequency filter to approximate the sounds humans hear. This digital sound level meter was calibrated using Extech 407766 Sound Level Calibrator. Sampling was obtained for 24 hrs with an interval of a second.

2.3.3.2 Data Analysis

Noise level standard used at sampling sites varies depending on the category of each locations. The noise sampling station category is shown in **Table 2.9951**.

Table 2.9951 Noise Sampling Station Category

Category	Description
AA	A section of contagious area, which require quietness such as area within 100m from school sites, nursery schools, hospitals and special home for the aged.
A	A section or contagious area primarily used as residential purposes.
B	A section or contagious area primarily used as commercial purposes.
C	A section primarily reserved as light industrial area.
D	A section primarily reserved as heavy industrial area.

Source: Rules & Regulations of the National Pollution Control Commission (1978), Section 78, Table 1. Environmental Quality Standards for Noise in General Areas (maximum allowable noise levels in general areas)

The sampling sites used in this assessment belong to Category A and B, which requires quietness and Category A, which is located in residential areas.

To prevent possible complaints from nearby communities and institutions, noise levels during construction and operation stages should be monitored. As part of the baseline sampling, a continuous 24-hr measurement divided into four time periods was the method used to note any predominant noise sources. These four time periods with standards corresponding to the sensitivity in receiving noise levels are summarized in **Table 2.9952**.

Table 2.9952 The Philippine Noise Standards

Category	Noise levels (dBA)			
	Morning 5:00am- 9:00am	Daytime 9:00am-6:00pm	Evening 6:00pm-10:00pm	Nighttime 10:00pm-5:00am
AA	45 dB	50 dB	45 dB	40 dB
A	50 dB	55 dB	50 dB	45 dB
B	60 dB	65 dB	60 dB	55 dB
C	65 dB	70 dB	65 dB	60 dB
D	70 dB	75 dB	70 dB	65 dB

In accordance with Environmental, Health, and Safety Guidelines – General EHS Guidelines: Environmental – Noise Management under IFC guidelines, noise impacts should not exceed the levels presented in **Table 2.9953**, or result in a maximum increase in the background level of 3dB at nearest receptor location off-site.

Table 2.9953 IFC Noise Level Guidelines

Receptor	One Hour L_{Aeq} (dBA)	
	Daytime (07:00-22:00)	**Nighttime (22:00-07:00)**
Residential; institutional; educational	55	45
Industrial; commercial	70	70

2.3.3.3 Road Traffic Noise Modelling

2.3.3.3.1 Assessment Area

The assessment area should cover at least 300m from the project boundary. As the northern portion of the proposed LLRN is on top of the Laguna Lake and maintain a certain distance (more than 600m) from the residential region as shown in **Figure 2.186.**

The main road alignment and the corresponding connecting slip roads are also shown in **Figure 2.186 to Figure 2.188** and **Figure 2.189 to Figure 2.190** respectively. The road types are summarized in **Table 2.9954**. Further to the proposed main roads of LLRN (Roads 1 – 14), some connecting slip roads (A1 – A4, B1 – B4, Z1 – Z4, C1 – C4, D1 – D4, E1 – E4) are also proposed and hence they are also included the noise modelling:

- Main roads: Roads 1 – 14; and

- Slip road: Roads A1 – A4, B1 – B4, Z1 – Z4, C1 – C4, D1 – D4, E1 – E4 and corresponding at-grade roundabouts are proposed to connect the LLRN.

Table 2.9954 Summary of Road IDs

Road ID	Description/Road Name	Direction	Designed Speed Limit (km/hr)	Road Type
1	Main road from Lower Bicutan to Sucat	Southbound	80	Viaduct
2	Main road from Sucat to Alabang			
3	Main road from Alabang to Putatan			
4	Main road from Putatan to San Pedro			
5	Main road from San Pedro to Sta Rosa			
6	Main road from Sta Rosa to Cabuyao			
7	Main road from Cabuyao to Calamba			
8	Main road from Sucat to Lower Bicutan	Northbound		
9	Main road from Alabang to Sucat			
10	Main road from Putatan to Alabang			
11	Main road from San Pedro to Putatan			
12	Main road from Sta Rosa to San Pedro			
13	Main road from Cabuyao to Sta Rosa			
14	Main road from Calamba to Cabuyao			
A1	Slip road from Road 9 to Sucat	-	60	Flyover
A2	Slip road from Sucat to Road 2			
A3	Slip road from Road 1 to Sucat			
A4	Slip road from Sucat to Road 8			
B1	Slip road from Road 10 to Alaban			At grade
B2	Slip road from Alaban to Road 3			
B3	Slip road from Road 2 to Alaban			
B4	Slip road from Alaban to Road 9			
Z1	Slip road from Road 11 to Tunasan			
Z2	Slip road from Tunasan to Road 4			
Z3	Slip road from Road 3 to Tunasan			
Z4	Slip road from Tunasan to Road 10			
C1	Slip road from San Pedro to Road 5			
C2	Slip road from Road 12 to San Pedro			
C3	Slip road from Road 4 to San Pedro			
C4	Slip road from San Pedro to Road 11			
D1	Slip road from Sta Rosa to Road 6			
D2	Slip road from Road 13 to Sta Rosa			
D3	Slip road from Road 5 to Sta Rosa			
D4	Slip road from Sta Rosa to Road 12			
E1	Slip road from Cabuyao to Road 7			
E2	Slip road from Road 14 to Cabuyao			
E3	Slip road from Road 6 to Cabuyao			
E4	Slip road from Cabuyao to Road 13			

2.3.3.3.2 Existing Land Uses

Along the proposed LLRN from Northern to Southern, the area between 01-Lower Bicutan and 04-Tunasan (northern region) are highly urbanized and shoreline development. The area in the vicinity of 05-San Pedro Binan (central region) are urbanized clusters with intermittent waterfront access, and the area in the vicinity of 06-Sta. Rosa and 07-Cabuyao (southern region) are low urbanization, agricultural lands and undeveloped shorelines. Among the various regions, mainly low-rise buildings (with 1 or 2 storeys) are found in the study area and some of them will be removed due to the construction and operation of the LLRN. The main roads of the proposed LLRN are designed as viaduct above the lake (northern region) or lakeshore (central and southern region).

2.3.3.3.3 Noise Sensitive Receivers

As there are no confirmed information on the details of any future urban planning near to the proposed LLRN, the first layer of those existing NSRs along the proposed LLRN alignment have therefore been selected as representative NSRs for this road traffic noise impact assessment. These NSRs are currently residential houses or hotels of 1 to 2 storeys. The assessment points are set at 1.5m above the first floor and second floor accordingly. Representative NSRs are shown in **Figure 2.186 to Figure 2.190** respectively.

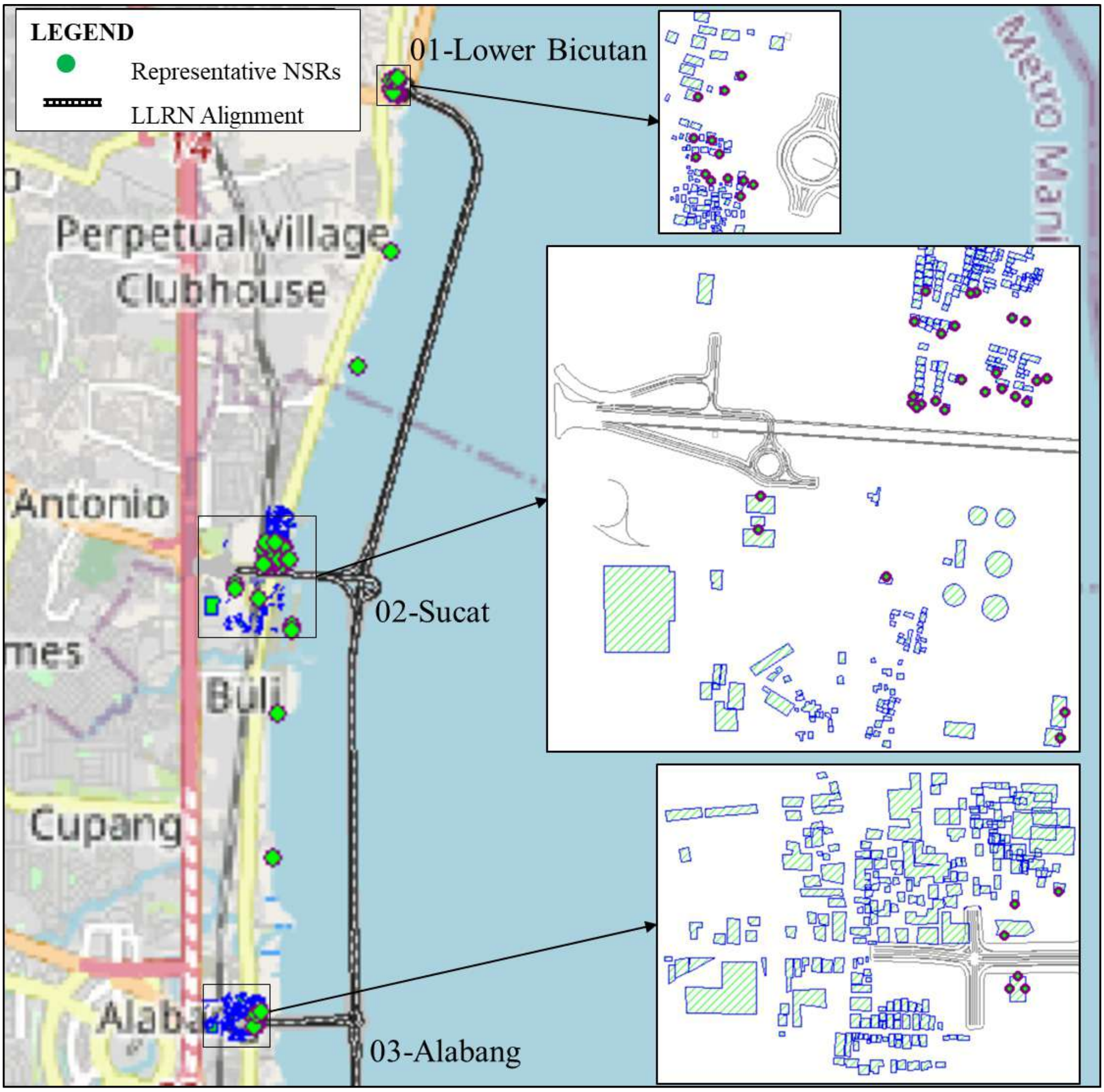

Figure 2.186 Location of Representative NSRs

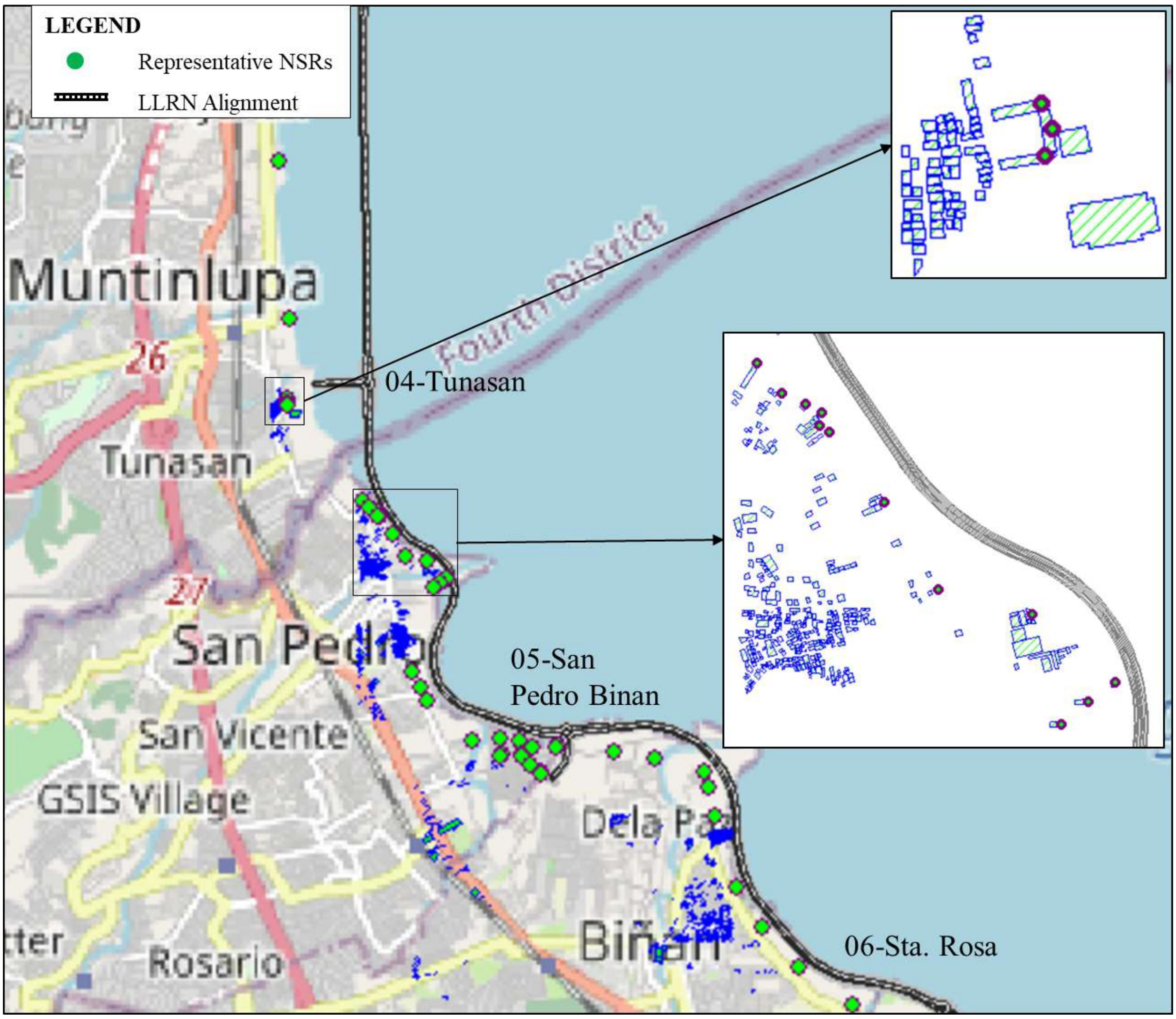

Figure 2.187 Location of Representative NSRs

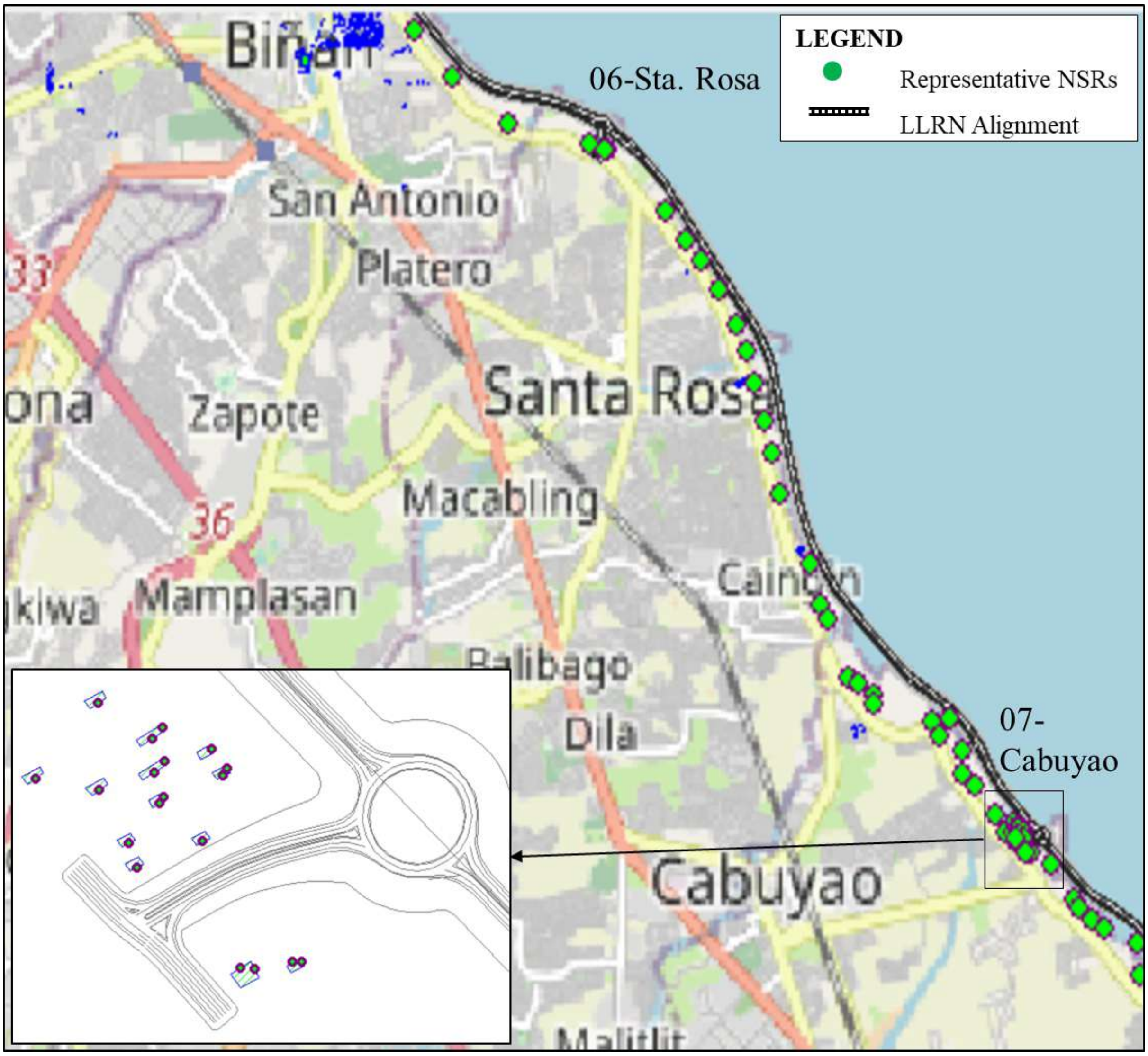

Figure 2.188 Location of Representative NSRs

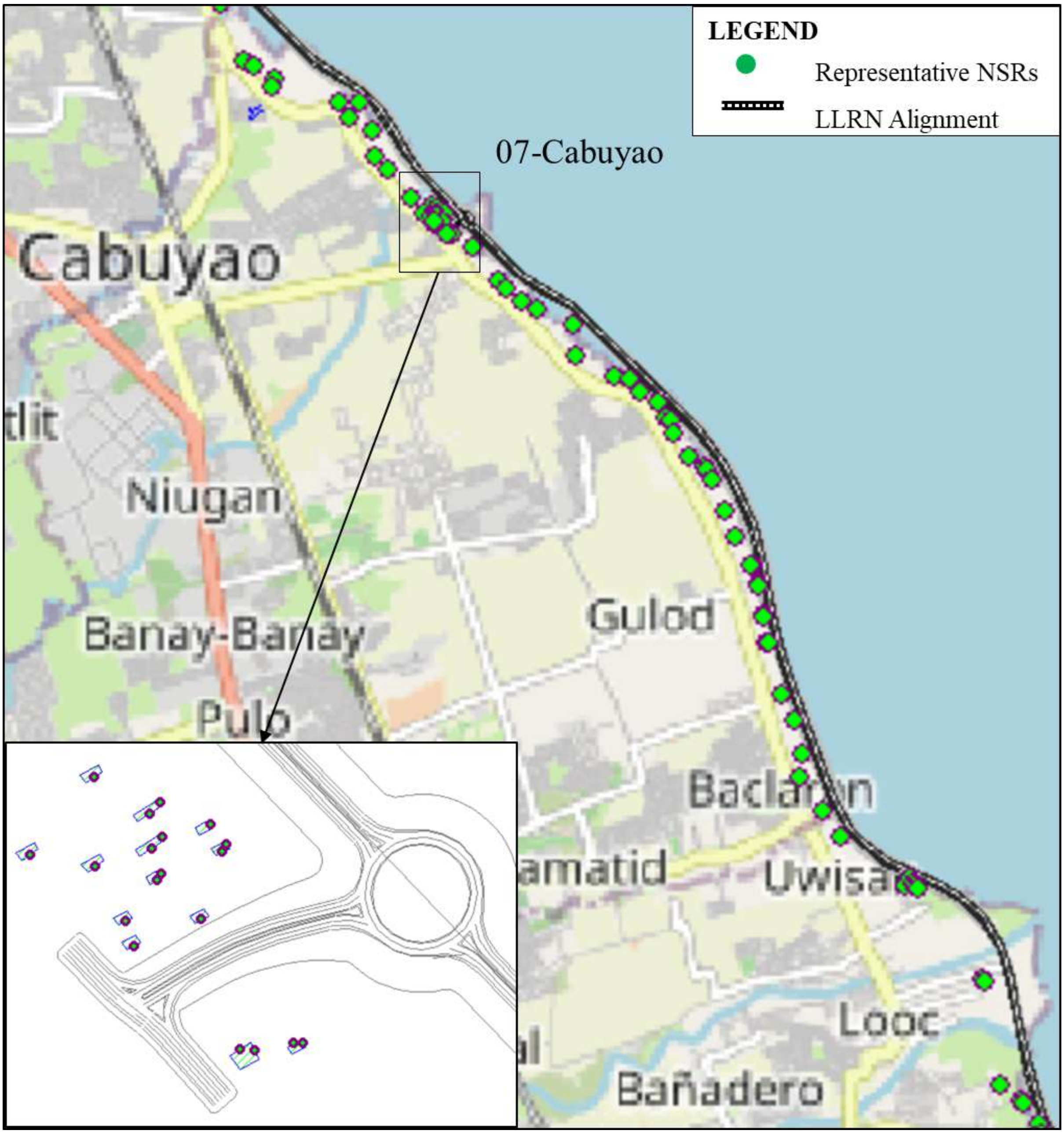

Figure 2.189 Location of Representative NSRs

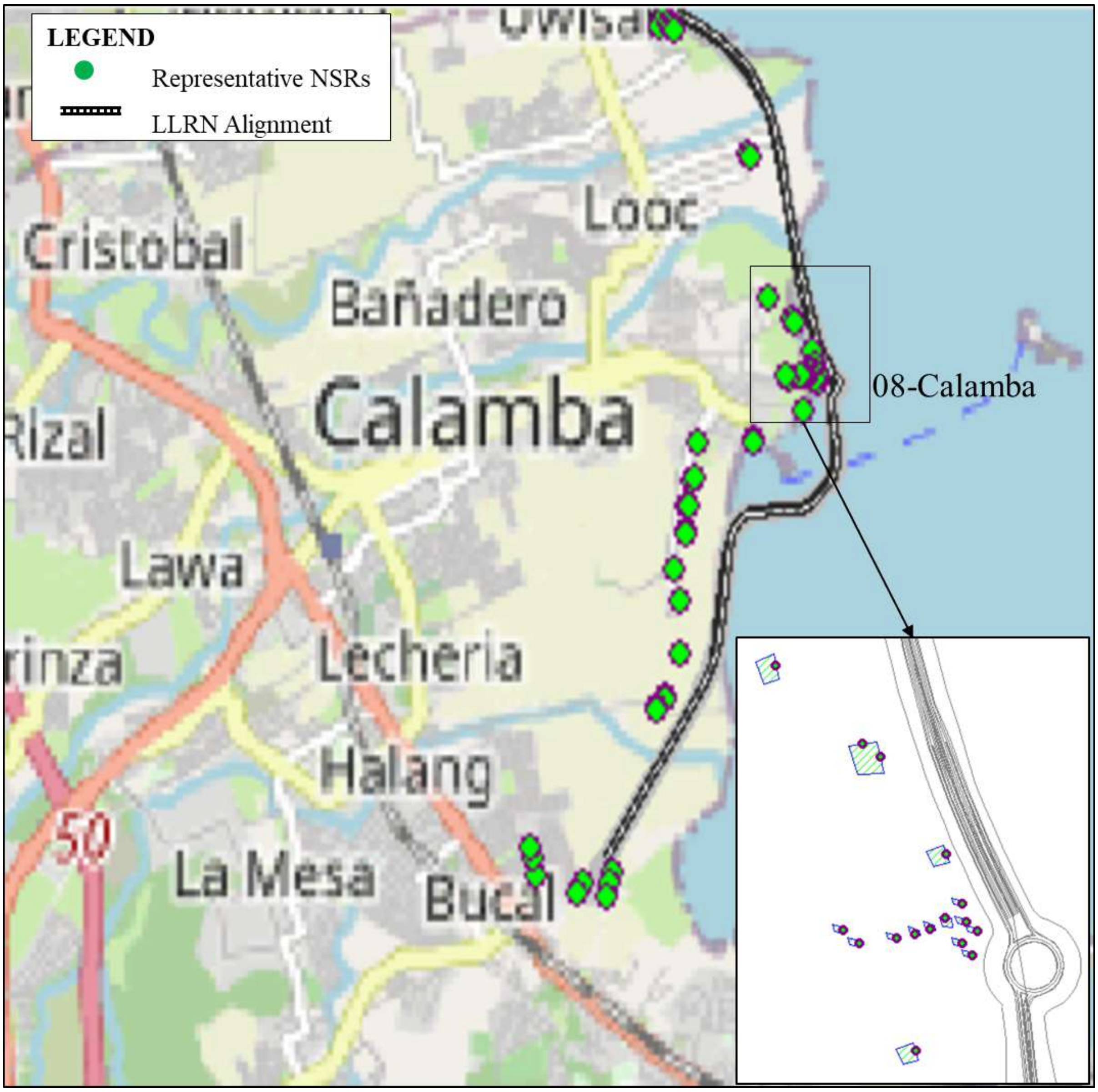

Figure 2.190 Location of Representative NSRs

2.3.3.3.4 Geographic Data

Apart from the topography, the surrounding environment has been modelled. The land section of the proposed LLRN is located in the vicinity of some buildings, including residential, industrial or commercial institution which are mainly 1 – 2 storeys. The structures of these buildings are included in the model, which provide screening effect along the propagation paths of road traffic noise.

2.3.3.3.5 Traffic Forecast

The year with the highest traffic flow from the project within the next 15 years upon commencement shall be typically considered as the assessment year. Since the proposed LLRN is planned to be in operation in Year 2025, the traffic forecast in 2040 is therefore adopted for this road traffic noise assessment.

For the purpose of comparing with the hourly noise criteria for daytime (07:00 – 22:00) and night time (22:00 – 07:00), the average hourly traffic for daytime and night time are adopted for the road traffic noise assessment, listed in **Table 2.9955** and **Table 2.9956**.

Table 2.9955 Daytime Average Hourly Traffic Forecast in 2040 (Vehicle/hour)

Road ID	Automobiles	Medium trucks	Heavy trucks	Buses	Motorcycles	Total
1	798	0	4	36	681	1,519
2	1,510	0	77	95	806	2,488
3	1,669	0	78	73	846	2,666
4	1,669	0	78	73	846	2,666
5	463	0	11	80	451	1,005
6	365	0	9	73	436	883
7	249	0	7	53	165	474
8	907	0	10	11	611	1,540
9	1,602	0	32	46	701	2,381
10	1,759	0	32	26	734	2,551
11	1,759	0	32	26	734	2,551
12	742	0	34	30	609	1,415
13	631	0	33	26	608	1,298
14	524	0	32	13	547	1,116
A1	769	0	22	34	91	916
A2	790	0	73	59	125	1,046
A3	79	0	0	0	0	79
A4	74	0	0	0	0	74
B1	192	0	0	0	32	224
B2	168	0	1	0	40	209
B3	9	0	0	22	0	31
B4	35	0	0	20	0	54
C1	37	0	5	4	89	135
C2	30	0	2	6	93	131
C3	1,236	0	68	0	488	1,792
C4	1,054	0	3	0	213	1,271
D1	16	0	0	0	20	36
D2	18	0	1	0	14	33
D3	118	0	3	6	29	155
D4	127	0	2	4	21	153
E1	13	0	0	7	5	25
E2	20	0	0	10	7	37
E3	136	0	2	32	277	448
E4	121	0	1	20	66	208
Z1	16	0	0	0	20	36
Z2	18	0	1	0	14	33
Z3	118	0	3	6	29	155
Z4	127	0	2	4	21	153

Table 2.9956 Night-time Average Hourly Traffic Forecast in 2040 (Vehicle/hour)

Road ID	Automobiles	Medium trucks	Heavy trucks	Buses	Motorcycles	Total
1	369	0	4	30	347	750
2	687	0	78	78	411	1,254
3	770	0	79	60	432	1,340
4	770	0	79	60	432	1,340
5	211	0	11	65	230	518
6	167	0	9	60	222	459
7	115	0	8	43	84	249
8	418	0	10	9	312	749
9	731	0	33	37	358	1,158
10	811	0	33	21	374	1,239
11	811	0	33	21	374	1,239
12	338	0	35	24	311	708
13	288	0	33	21	310	653
14	239	0	32	11	279	561
A1	352	0	22	28	46	449
A2	360	0	74	48	64	546
A3	42	0	0	0	0	42
A4	39	0	0	0	0	39
B1	98	0	0	0	16	115
B2	88	0	1	0	21	109
B3	5	0	0	18	0	23
B4	18	0	0	16	0	35
C1	17	0	5	3	45	71
C2	14	0	2	5	47	69
C3	573	0	69	0	249	891
C4	491	0	3	0	109	602
D1	8	0	0	0	10	19
D2	10	0	1	0	7	17
D3	54	0	3	5	15	77
D4	58	0	2	3	11	74
E1	7	0	0	5	3	16
E2	11	0	0	8	3	23
E3	63	0	2	26	141	233
E4	56	0	1	17	34	108
Z1	8	0	0	0	10	19
Z2	10	0	1	0	7	17
Z3	54	0	3	5	15	77
Z4	58	0	2	3	11	74

Notes:
Automobiles: All vehicles with two axles and four tires -- primarily designed to carry nine or fewer people (passenger cars, vans) or cargo (vans, light trucks) -- generally with gross vehicle weight less than 4,500 kg (9,900 lb)
Medium trucks: All cargo vehicles with two axles and six tires -- generally with gross vehicle weight between 4,500 kg (9,900 lb) and 12,000 kg (26,400 lb)

Heavy trucks: All cargo vehicles with three or more axles -- generally with gross vehicle weight more than 12,000 kg (26,400 lb)
Buses: All vehicles designed to carry more than nine passengers
Motorcycles: All vehicles with two or three tires and an open-air driver/passenger compartment

Except for the design speed of the main roads (i.e. Roads 1 - 14) of 80km/hr, other slip roads connecting between the main roads and the nearby districts in LLRN are designed at 60km/hr.

2.3.3.3.6 Road Surface

The noise emission levels for vehicles database of TNM includes the following pavement types:

- Dense-graded asphaltic concrete (DGAC)
- Portland cement concrete (PCC)
- Open-graded asphaltic concrete (OGAC)
- An "Average" composite pavement type consisting of data for DGAC and PCC combined.

As the design of the pavement is yet to be finalized at the early stage of the study, an "Average" composite pavement type consisting of data for DGAC and PCC combined is assumed.

2.3.3.3.7 Structure Feature of Viaduct

All viaduct of proposed LLRN will be installed with 1 m height of pedestrian barriers. The structure features would provide noise screening to the traffic noise propagation and both of them are taken into the noise modelling.

2.3.3.4 Baseline Environmental Conditions

2.3.3.4.1 Baseline Sampling

The results of the four-time period for NPCC and two-time period for IFC noise monitoring are presented in **Table 2.110**. Most of results from all stations exceeded the NPCC and IFC standards in all time periods.

Table 2.110 Results of Noise Level Measurements

ID Stations	Date	NPCC Standards					IFC Noise Level Guidelines	
		Class/ Category	Morning	Day time	Evening	Night-time	Day time	Night-time
A1	1630H 20/11/2020-21/11/2020	A	69.1	73.0	69.9	69.3	66.9	67.4
A2	2200H 21/11/2020-22/11/2020	A	65.4	62.5	61.2	66.5	62.4	66.6

ID Stations	Date	NPCC Standards					IFC Noise Level Guidelines	
		Class/ Category	Morning	Day time	Evening	Night-time	Day time	Night-time
A3	1300H 15/11/2020-16/11/2020	A	64.3	63.7	60.2	60.8	60.5	59.8
A4	2130H 29/11/2020-30/11/2020	A	71.8	69.8	71.6	72.0	71.6	71.7
A5	1030H 13/11/2020-14/11/2020	A	63.2	67.0	66.9	66.6	66.6	66.5
A6	1540H 28/10/2020-29/10/2020	A	66.1	65.7	70.4	69.7	68.4	68.3
A7	1215H 27/11/2020-28/11/2020	A	77.8	70.4	69.9	72.5	72.8	76.0
A8	1025H 10/11/2020-11/11/2020	A	58.4	60.5	59.5	51.9	59.5	52.2
A9	1300H 3/11/2020-4/11/2020	A	61.0	60.4	50.1	53.5	57.8	50.3
A10	1620H 4/11/2020-5/11/2020	A	57.9	67.5	60.0	56.9	58.1	56.6
A11	2029H 5/11/2020-6/11/2020	A	58.5	60.4	53.8	51.8	56.8	50.4
A12	2040H 22/10/2020-23/10/2020	A	61.9	65.2	49.0	51.3	55.0	52.8
A13	1825H 23/10/2020-24/10/2020	A	64.6	67.9	65.6	53.9	64.2	54.3
A14	0815H 7/11/2020-8/11/2020	A	55.8	58.1	58.1	55.3	58.4	56.5
A15	1050H 8/11/2020-9/11/2020	A	58.0	58.5	58.6	58.3	58.4	58.1
A16	1030H 21/10/2020-22/10/2020	A	55.8	56.1	53.5	52.9	55.3	50.7
A17	1630H 13/10/2020-	A	64.0	60.5	63.8	62.7	61.8	57.9

ID Stations	Date	NPCC Standards					IFC Noise Level Guidelines	
		Class/ Category	Morning	Day time	Evening	Night-time	Day time	Night-time
	14/10/2020							
A18	0615H 9/10/2020-10/10/2020	A	58.4	59.6	58.5	58.4	59.7	59.2
A20	1200H 12/10/2020-13/10/2020	A	57.8	62.3	59.6	57.7	60.3	58.0
A21	1100H 6/10/2020-7/10/2020	B	44.8	42.9	41.7	44.3	44.6	45.2
A22	1515H 7/10/2020-8/10/2020	A	69.3	65.5	59.8	69.2	63.8	59.8
A23	2040H 30/09/2020-1/10/2020	A	56.1	55.2	49.0	51.3	55.0	52.8
A24	1602H 29/09/2020-30/09/2020	A	52.8	51.8	51.8	50.8	49.7	46.6
A25	1115H 26/09/2020-27/09/2020	A	61.0	58.6	56.8	58.3	58.4	56.1
A26	0810H 25/09/2020-26/09/2020	A	60.2	60.4	60.5	60.9	60.7	62.0
A27	1150H 28/09/2020-29/09/2020	A	61.0	58.5	59.4	60.1	58.7	58.3
A28	2008H 23/09/2020-24/09/2020	A	57.9	58.2	58.2	58.6	57.8	56.7
A29	1430H 22/09/2020-23/09/2020	A	59.0	59.2	59.9	59.4	60.5	59.0
A30	1140H 21/09/2020-22/09/2020	A	54.8	54.7	47.7	51.0	53.9	42.5

Note: Noise readings in red exceeded the NPCC and IFC Standards.

The 24-hour noise monitoring at location A1-A11, A13-A20, A22, A25-A27, and A29 had median values that exceeded the NPCC standards for all time zones. Station A21 had values below NPCC standards for all time stations, while all other locations exceeded standards for the majority of the time periods, apart from A30 with daytime and evening complying to standards.

For the IFC Standards, locations A12, A21, A23-A24, A28, and A30, or six (6) out of twenty-nine (29) locations had values lower than the daytime standard. The night-time standard, however, complied with standards only in stations A21 and A30.

The common contributors of noise in these monitoring stations are vehicles, mainly tricycles, motorcycles, and some heavy trucks, residential noise, weather occurrences, and animal noises, from cows, chicken, dogs, birds, and crickets and insects at night. Construction activity with hammering and heavy equipment was observed in certain stations.

It should be noted, however that a power generator for the sampling machines was set up for stations A13, A26, A27, A28, and A30. All generators were placed 20m away from the sampling point.

2.3.3.4.2 Background Noise Levels and Noise Criteria

According to "Environmental, Health, and Safety Guidelines – General EHS Guidelines: Environmental – Noise Management", noise monitoring may be carried out for the purposes of establishing the existing ambient noise levels in the area of the proposed facility. Noise monitoring has been conducted in 30 background monitoring locations from 22nd September 2020 to 30th November 2020. The noise monitoring stations A1-A6, A7-13, A14-A23, A23-30 are presented in **Figure 2.191 to Figure 2.193** and **Figure 2.194 to Figure 2.197** respectively.

The noise monitoring station A1, A2 and A3 are located at Zone 1 (from Lower Bicutan to Sucat) and close to the existing General Santos Ave Road and Dir. A. Bunye Road. As shown in Table 4, the night-time noise level (i.e., 78dB(A)) of Station A2 is larger than the daytime noise level (67dB(A)) by more than 10dB(A), which is not considered as a normal noise condition. In addition, the daytime noise level of Station A3 is 93dB(A), as station A3 is set up next to the railway track and the measured noise are contributed from the train passing nearby during daytime. Therefore, only Station A1 is adopted to be representative for the NSRs in Zone 1.

Station A4 and A5 are located at Zone 2 (from Sucat to Alabang). The night-time noise level (i.e. 72dB(A)) of Station A5 is larger than the daytime noise level (70dB(A)) by 2dB(A), which is not considered as a normal noise condition. Only Station A4 would be considered representative for the NSRs in Zone 2.

The noise monitoring station A6 and A7 are located at Zone 3 (from Alabang to Tunasan) and close to the existing Ilaya Road and Umali Street respectively. The daytime and night-time noise level of Station A7 are 77dB(A) and 80dB(A), which may be affected by residential activities such as karaoke, amplifier used, kids playing and others are shouting/talking, according to the measurement record. Therefore, only Station A6 would be considered representative for the NSRs in Zone 3.

The noise monitoring station A8, A9 and A10 are located at Zone 4 (from Tunasan to San Pedro Biñan) and close to the existing Cuyab Road and Cataquiz Ave. The daytime noise level of Station A10 is 75dB(A), which is much higher than the noise levels at Station A8 to A9. Therefore, only Station A8 and A9 would be considered representative for the NSRs in Zone 4.

For the area in Zone 5 (i.e., from San Pedro Binan to Sta. Rosa), noise monitoring station A11, A12, A13 and A14 are located close to the existing road such as South Fairway Drive, Llaya and Brgy Sinalhan. They are considered as the representative background noise level for the NSRs in Zone 5 (from San Pedro Binan to Sta. Rosa).

The noise monitoring stations A15 to A19 are located close to existing Brgy Sinalhan roads. They are considered as the representative background noise level for the NSRs in Zone 6 (from Sta. Rosa to Cabuyao). However, the night-time noise level of Station A19 is higher than their daytime noise level 4 dB(A), and which night-time noise level is much higher compared to A 15-A18. Station A19 may be affected by the accidental events and not representative, only Station A15-A18 would be considered representative for the NSRs in Zone 6.

The noise monitoring stations A20 to A30 are located between Cabuyao, Calamba and Bucal. They are considered as the representative background noise level for the NSRs in Zone 7 (from Cabuyao to Calamba and Bucal). However, the night-time noise level (i.e., 90dB(A)) of Station A29 seems to be unnormal comparing to their daytime noise level (i.e. 70dB(A)) by 20dB(A). Therefore, only Station A20-A28 and A30 would be considered representative for the NSRs in Zone 7.

As the background noise measurement levels at Station A1-30 are higher than the noise criteria of IFC for both daytime and night-time, the background noise measurement levels at Station A1-30 with +3dB(A) are adopted as the noise criteria. The noise criteria are presented in **Table 2.111** below.

Table 2.111 Noise Criteria for Representative NSRs

Location of the Representative NSRs	Zone Name	Corresponding Noise Monitoring Station	Noise Criteria, dB(A)*	
			Daytime	Nighttime
Zone 1	from Lower Bicutan to Sucat	A1	74	73
Zone 2	from Sucat to Alabang	A4	78	76
Zone 3	from Alabang to Tunasan	A6	75	72
Zone 4	from Tunasan to San Pedro Binan	A8-A9	69	66
Zone 5	from San	A11-A13	70	66

	Pedro Binan to Sta. Rosa			
Zone 6	from Sta. Rosa to Cabuyao	A14-A18	67	64
Zone 7	from Cabuyao to Calamba and Bucal	A20-A28, A30	69	65

*Note: *The noise criteria are the background noise measured + 3 dB(A).*

Noise criteria of zone with more than 1 representative station will be averaged logarithmically

The TNM model has been set up to represent two-time intervals, including the day time (07:00-22:00) and night time (22:00-07:00). The predicted road traffic noise levels are summarized in Table 6. The detail results are presented in **Appendix G** and **Figure 2.191 to Figure 2.197**.

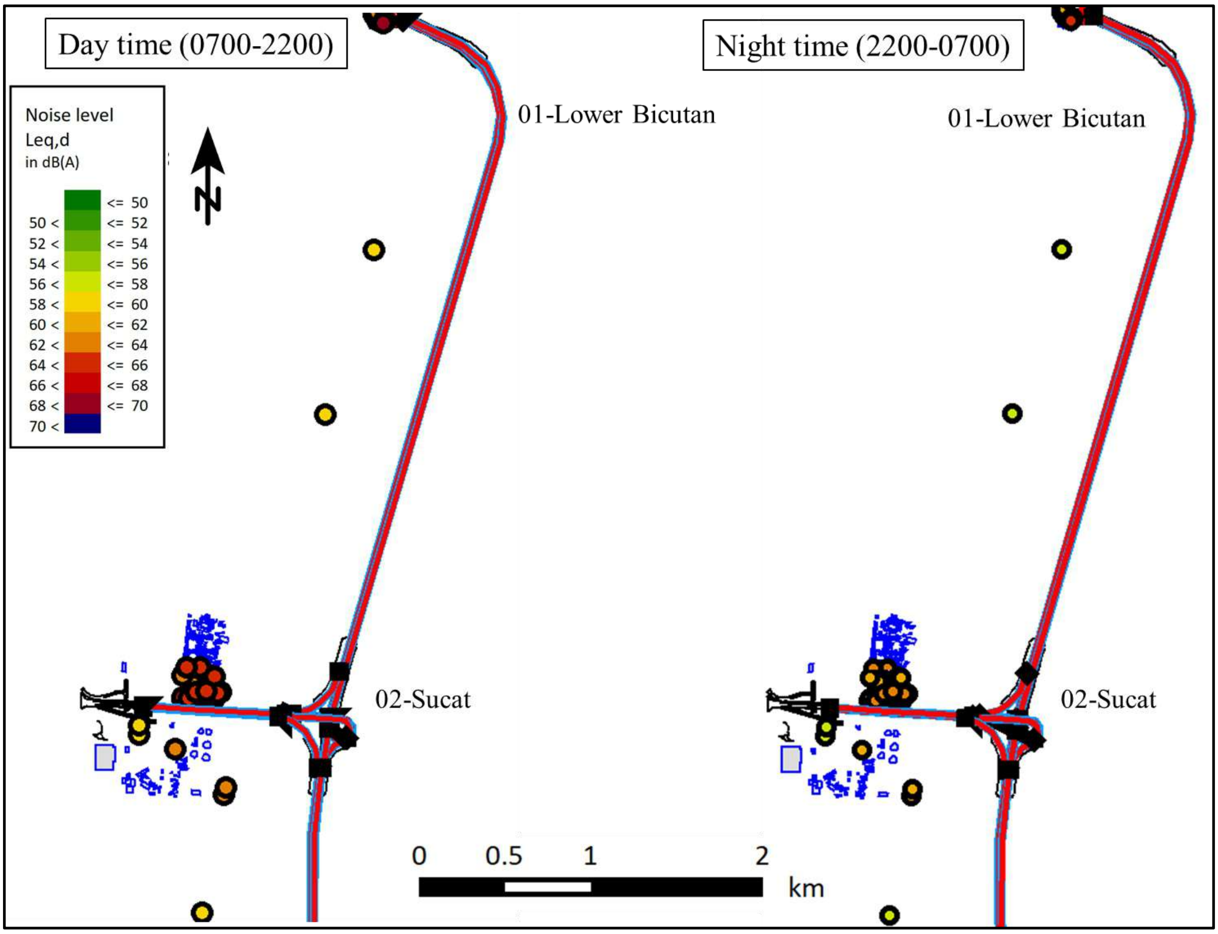

Figure 2.191 Predicted Noise Level (Unmitigated) at the NSRs near Lower Bicutan & Sucat

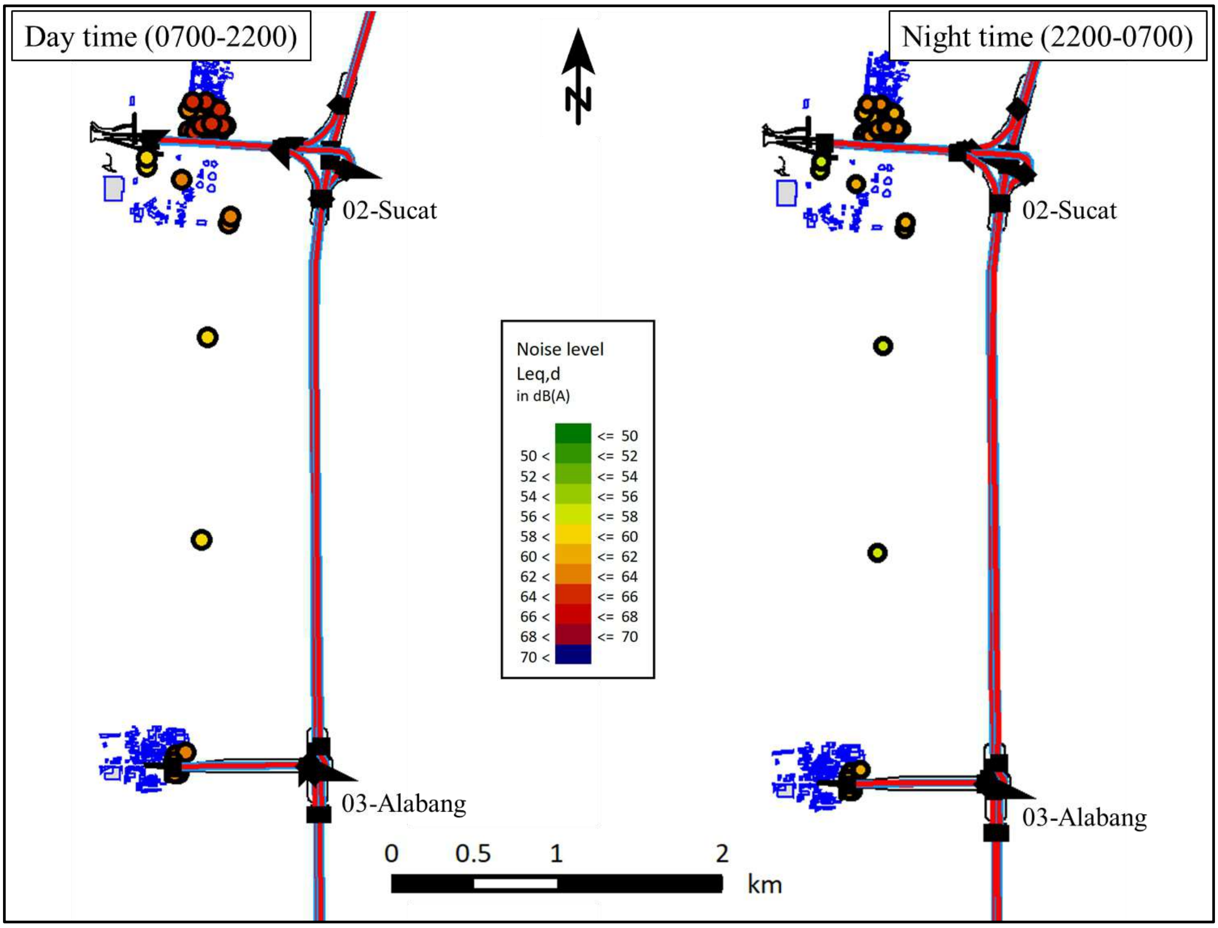

Figure 2.192 Predicted Noise Level (Unmitigated) at NSRs near Sucat & Alabang

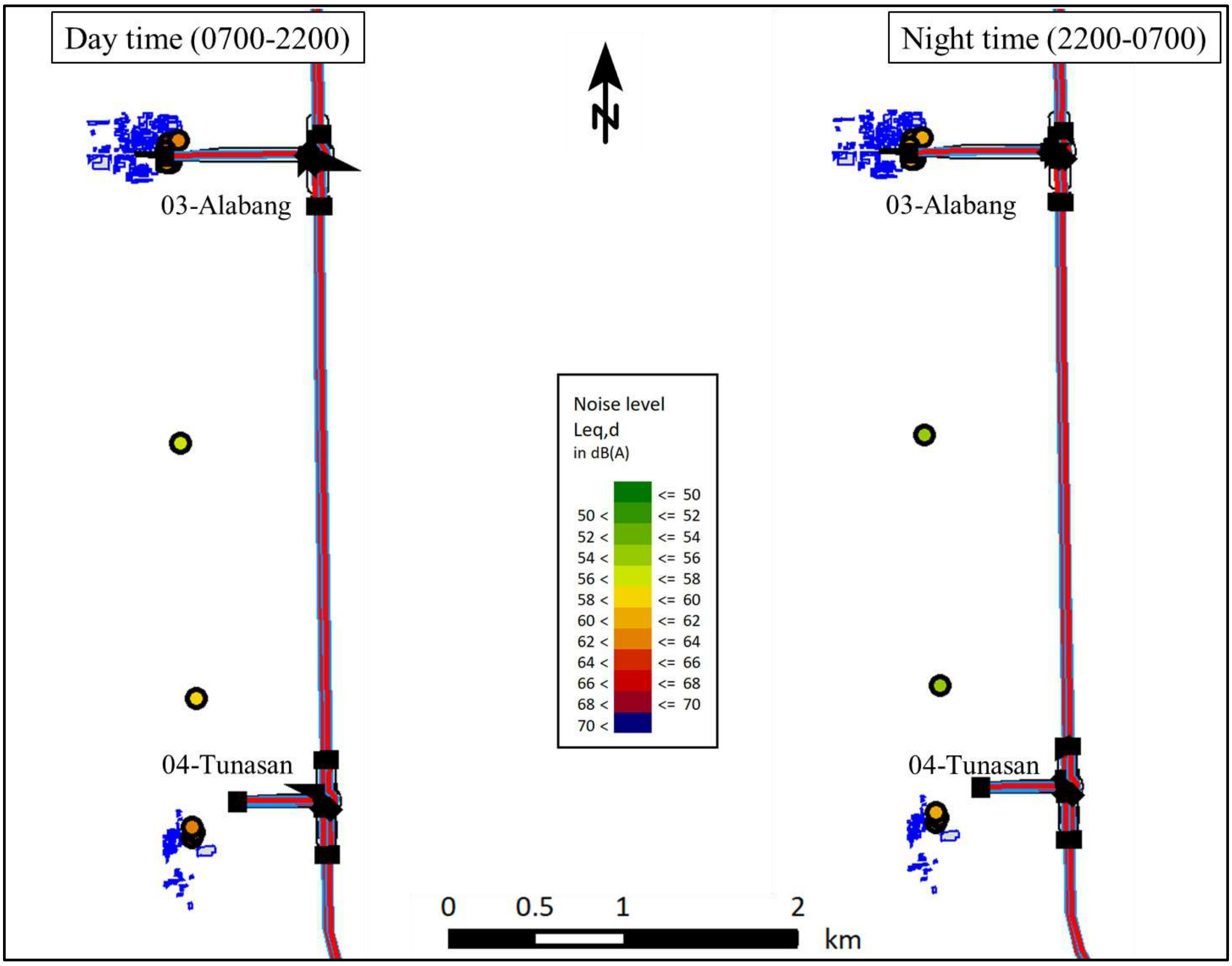

Figure 2.193 Predicted Noise Level (Unmitigated) at NSRs near Alabang & Tunasan

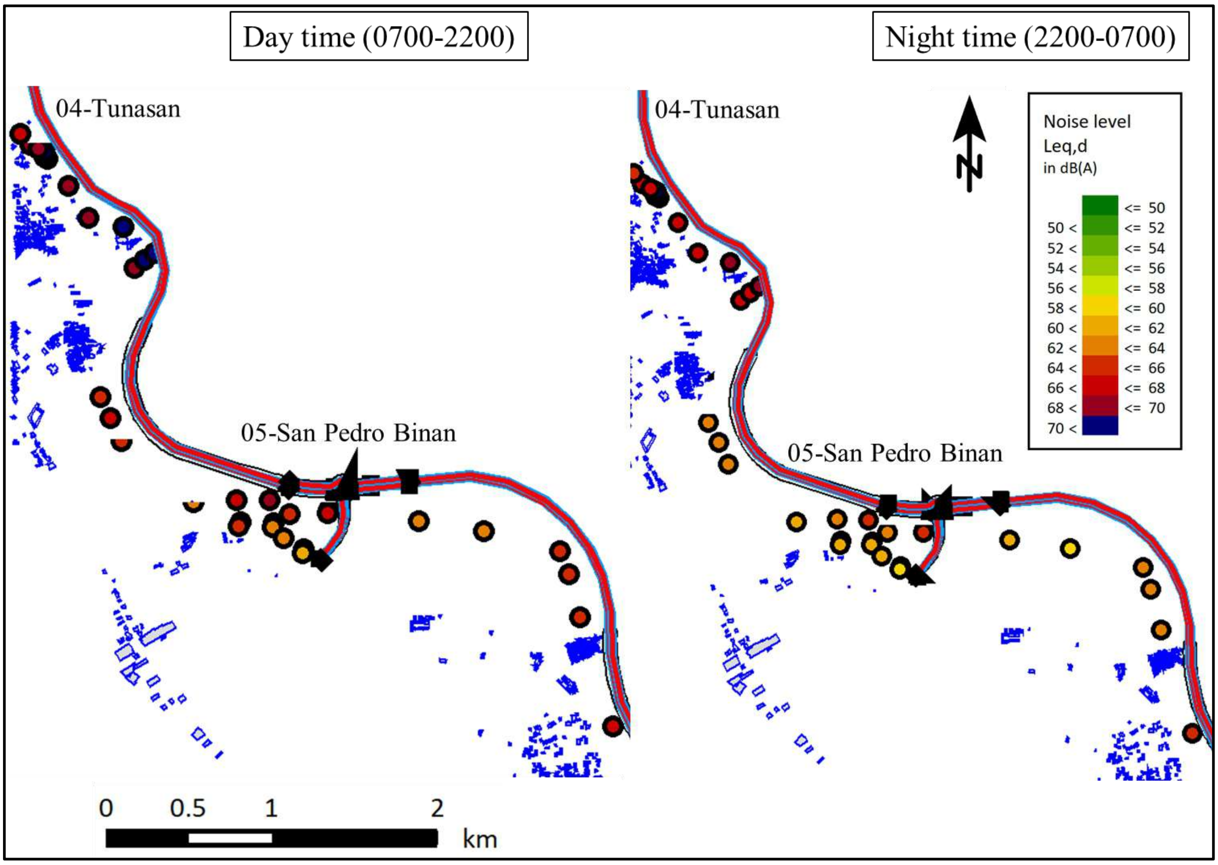

Figure 2.194 Predicted Noise Level (Unmitigated) at the NSRs near Tunasan & San Pedro Binan

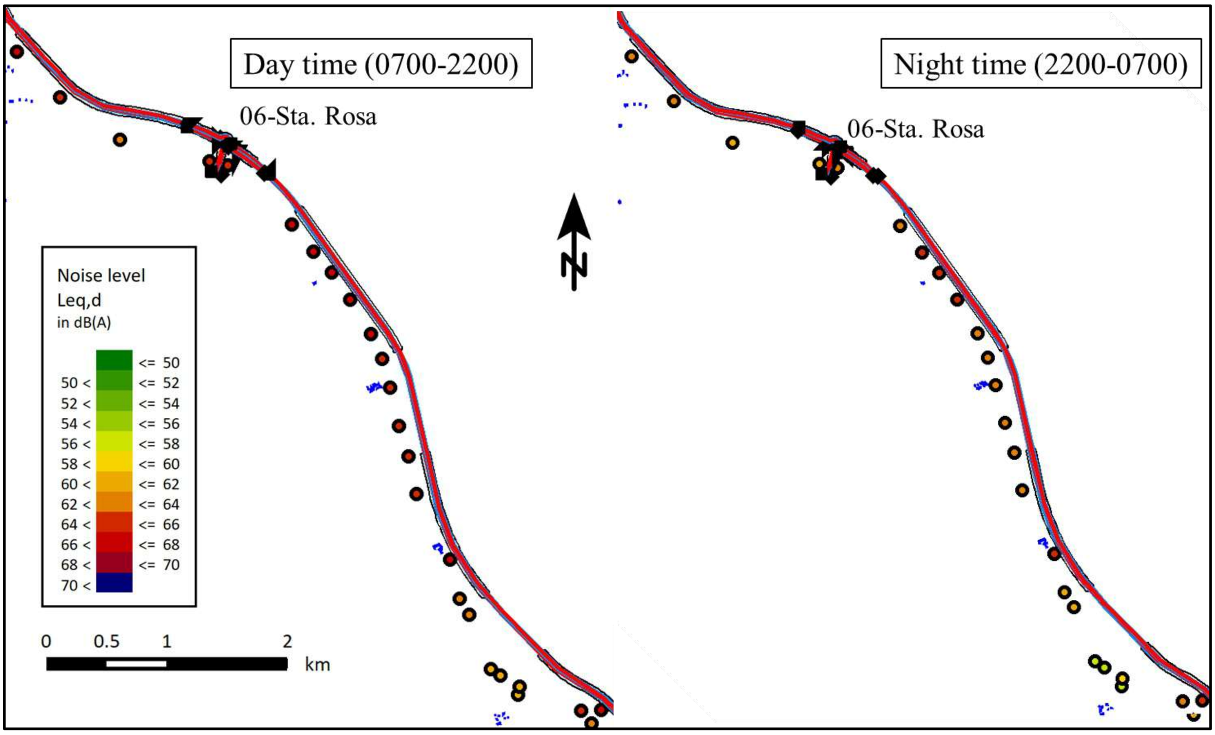

Figure 2.196 Predicted Noise Level (Unmitigated) at NSRs near Sta. Rosa

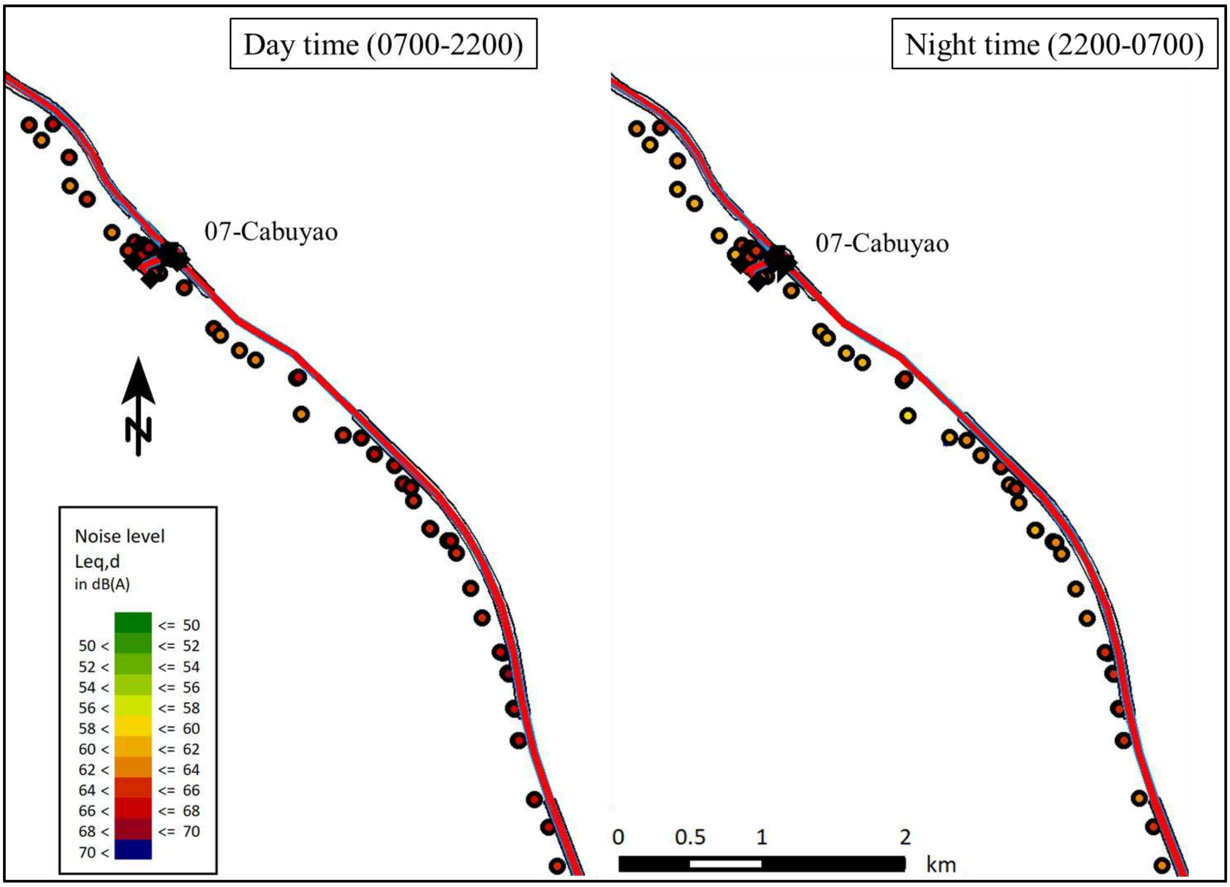

Figure 2.195 Predicted Noise Level (Unmitigated) at NSRs near Cabuyao

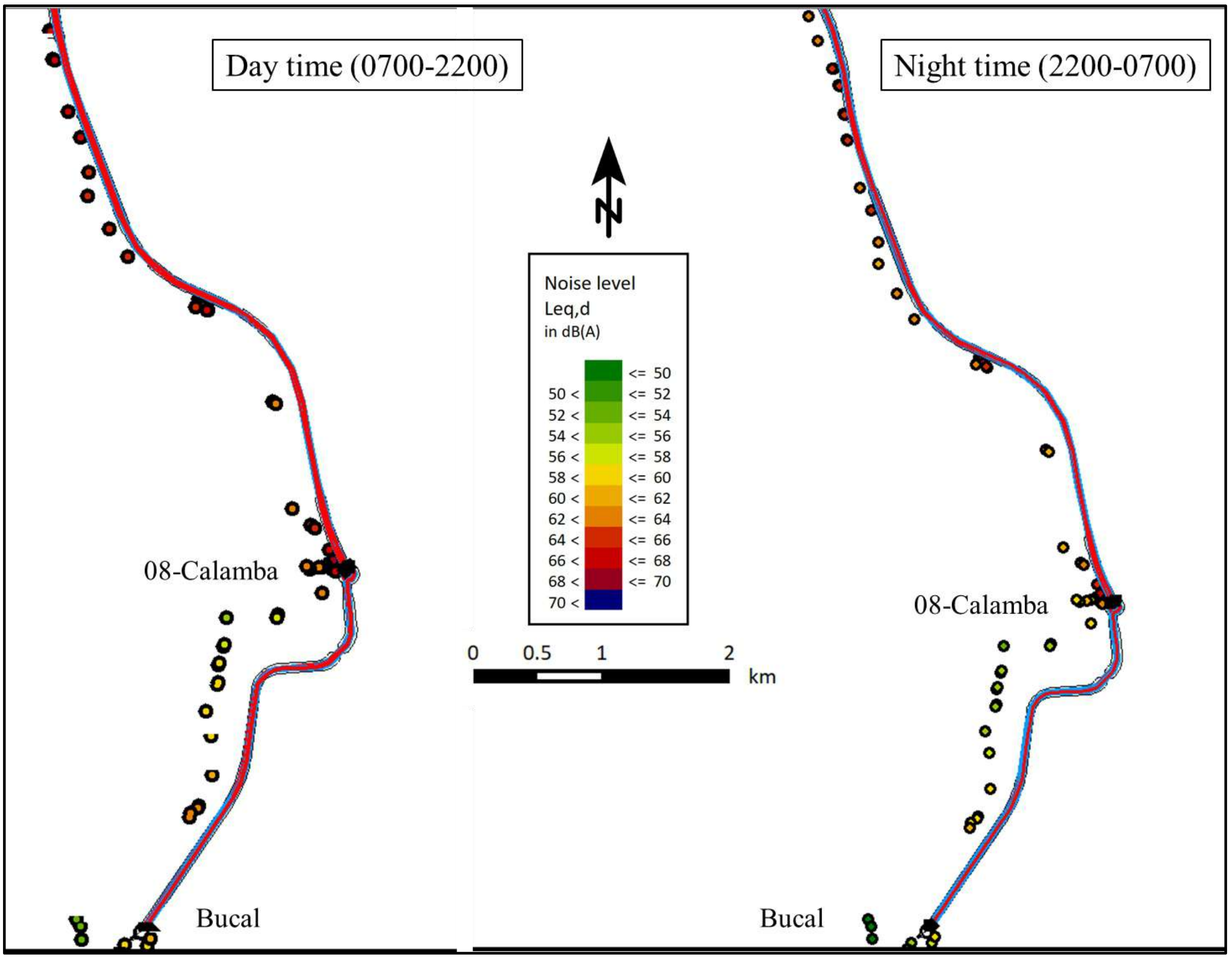

Figure 2.197 Predicted Noise Level (Unmitigated) at NSRs near Calamba & Bucal

Table 2.112 Predicted road traffic noise levels under unmitigated scenario

Zone ID	Zone Name	Result		Noise Criteria, dB(A)		Compliance of Noise Criteria	
		Day Time	Night Time	Day Time	Night Time	Day Time	Night Time
1	from Lower Bicutan to Sucat	59 - 69	56 - 66	74	73	Yes	Yes
2	from Sucat to Alabang	59 - 65	56 - 62	78	76	Yes	Yes
3	from Alabang to Tunasan	58 - 63	55 - 60	75	72	Yes	Yes
4	from Tunasan to San Pedro Binan	62 - 73	59 - 70	69	66	No	No

Zone ID	Zone Name	Result		Noise Criteria, dB(A)		Compliance of Noise Criteria	
		Day Time	Night Time	Day Time	Night Time	Day Time	Night Time
5	from San Pedro Binan to Sta. Rosa	62 - 67	60 - 64	70	66	Yes	Yes
6	from Sta. Rosa to Cabuyao	60 - 68	57 - 66	67	64	No	No
7	from Cabuyao to Calamba and Bucal	50 - 68	48 - 66	69	65	Yes	No
% of noise exceedance						6%	8%

As shown in **Table 2.112**, for the base case (without noise mitigation measure) the range of predicted traffic noise level during the day time (07:00 – 22:00) is 50 to 73 dB(A) while the range of night time (22:00 – 07:00) is 48 to 70 dB(A). In general, the predicted noise level in daytime is higher than the night-time about 2-3 dB(A). The highest noise level is obtained in the Zone 4 (from San Pedro Binan to Sta. Rosa). The predicted noise levels of the representative NSRs at Zone 4, Zone 6, Zone 7 are exceeding the corresponding noise criteria. Under the unmitigated scenario, it is predicted that about 6% and 8% of noise sensitive receiver will be exposed to traffic noise impact during daytime and night-time respectively. Direct mitigation measures such as Noise Barrier and Low Noise Road Surfacing were recommended for Zone 4, Zone 6 and Zone 7.

2.3.3.4.3 Recommended Mitigation Measures for Road Traffic Noise Impact

Noise mitigation measures such as noise barrier and low noise road surfacing are recommended for the NSRs at Zone 4, Zone 6 and Zone 7. It is demonstrated that the traffic noise impact can be reduced by the adoption of a 3m high noise barrier (Length of noise barrier are ranged from 350m to 1360m) along the traffic road in Zone 4, Zone 6 and Zone 7 as shown in Figures 8a-d. The predicted noise level with the adoption of the 3m high noise barrier is presented in **Table 2.113**. The detail results under mitigated scenario are presented in **Appendix H**.

Table 2.113 Predicted Road Traffic Noise Levels under Mitigated Scenario

Zone ID	Zone Name	Result (Mitigated with)		Noise Criteria, dB(A)		Compliance of Noise Criteria	
		Day Time	Night Time	Day Time	Night Time	Day Time	Night Time
4	from Tunasan to	62-70	59 - 67	69	66	No	No

	San Pedro Binan						
6	from Sta. Rosa to Cabuyao	59-66	56 - 64	67	64	Yes	Yes
7	from Cabuyao to Calamba and Bucal	50-68	48 - 65	69	65	Yes	Yes
% of noise exceedance						0.4%	0.4%

As shown in **Table 2.113**, 0.4% NSRs with noise exceedances of 1 dB(A) were still found in Zone 4 after the adoption of the 3m high noise barrier. In view of this, low noise road surfacing would also be recommended at Zone 4 to attenuate the residual traffic noise impact. The provision of low noise road surfacing can provide additional 1dB(A) noise reduction. It is estimated that the daytime and night-time maximum noise level of NSRs in Zone 4 can be reduced from 70dB(A) to 69dB(A) and 67dB(A) to 66dB(A) respectively. Location of the low noise road surfacing is illustrated in **Figure 9**. It is anticipated that the noise level of all representative NSRs would comply with their corresponding noise criteria after the implementation of the 3m noise barrier at Zone 4, Zone 6 and Zone 7 and low noise road surfacing at Zone 4.

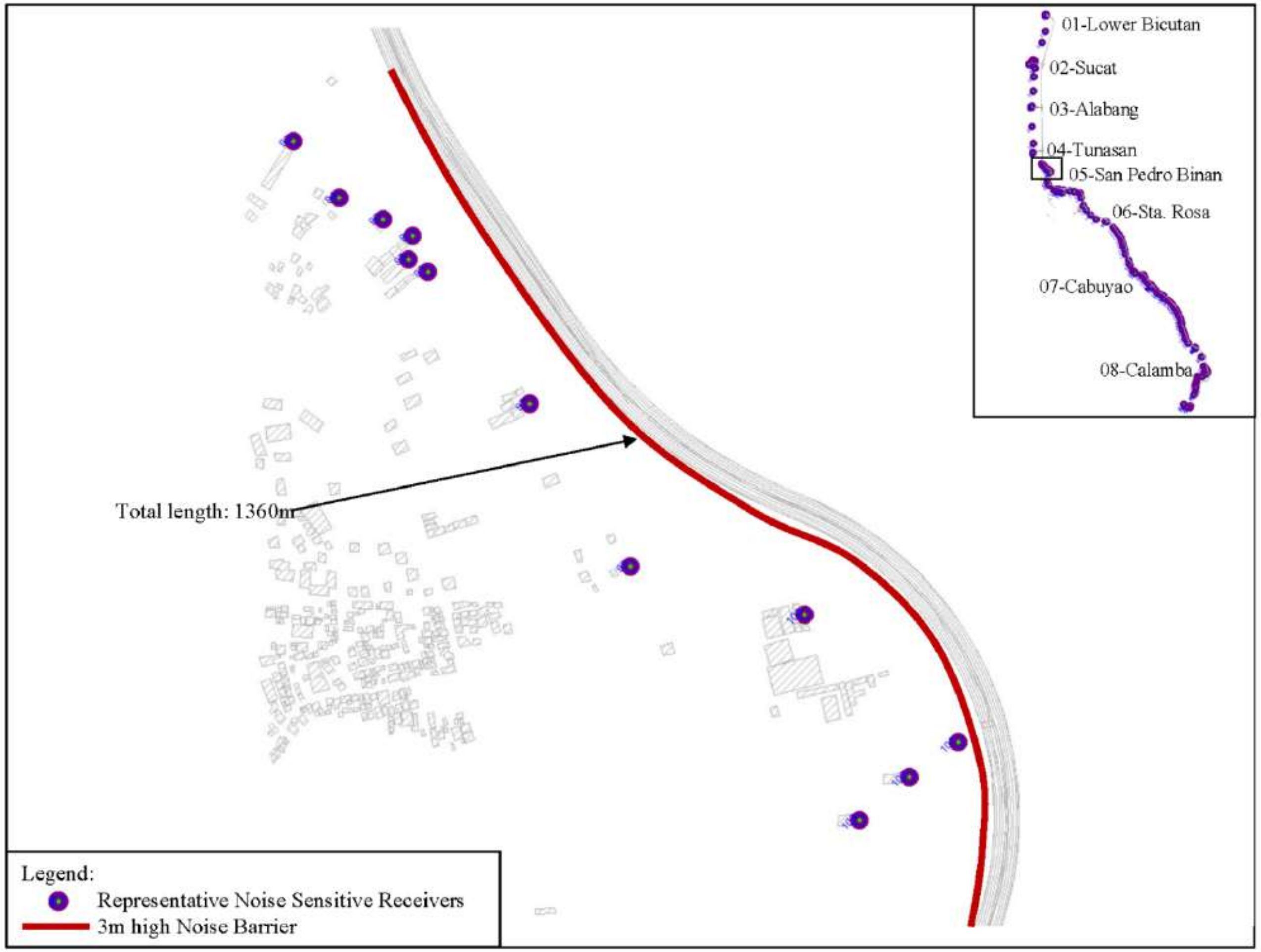

Figure 2.198 Location of Noise Barrier (Zone 4-5)

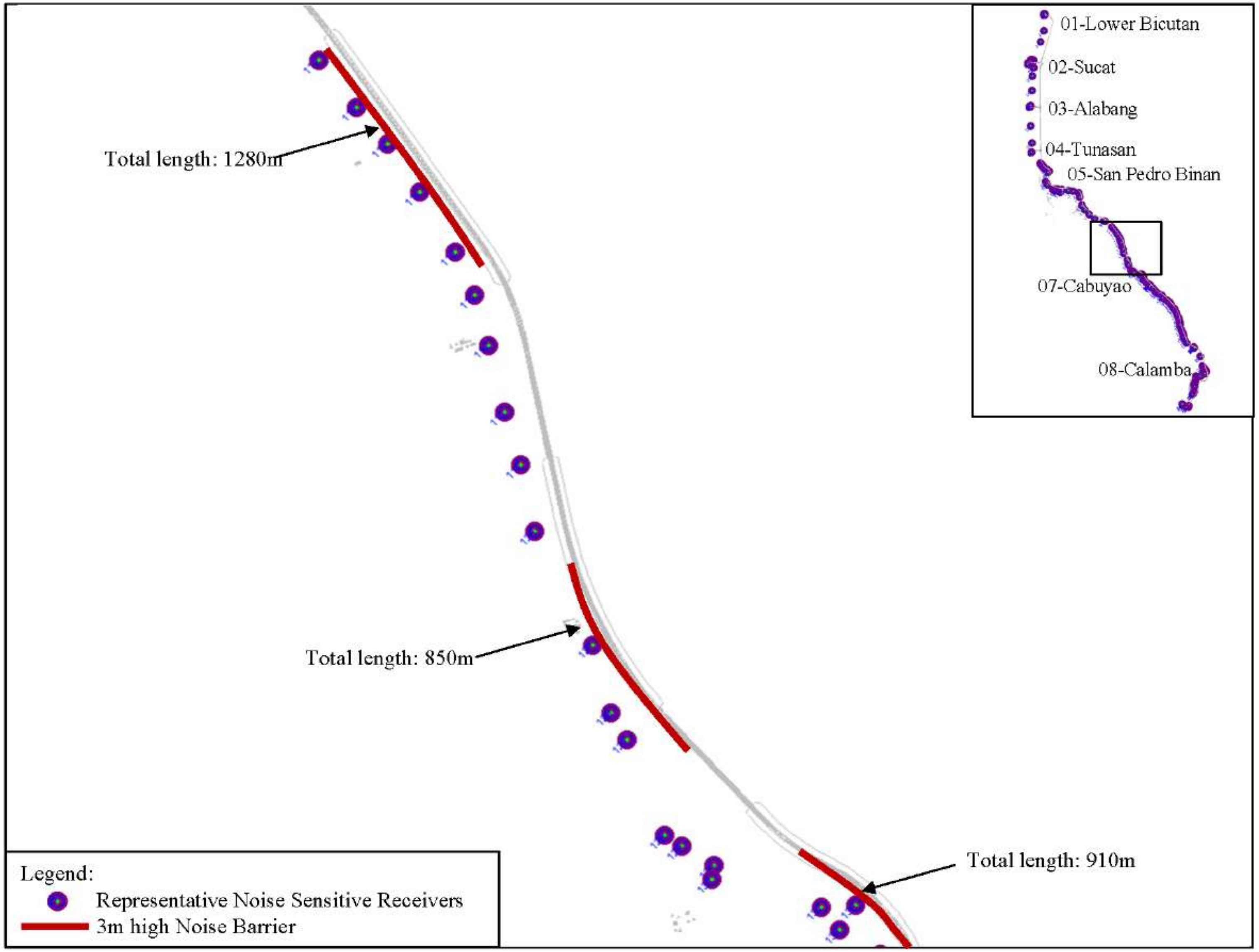

Figure 2.199 Location of Noise Barrier (Zone 6)

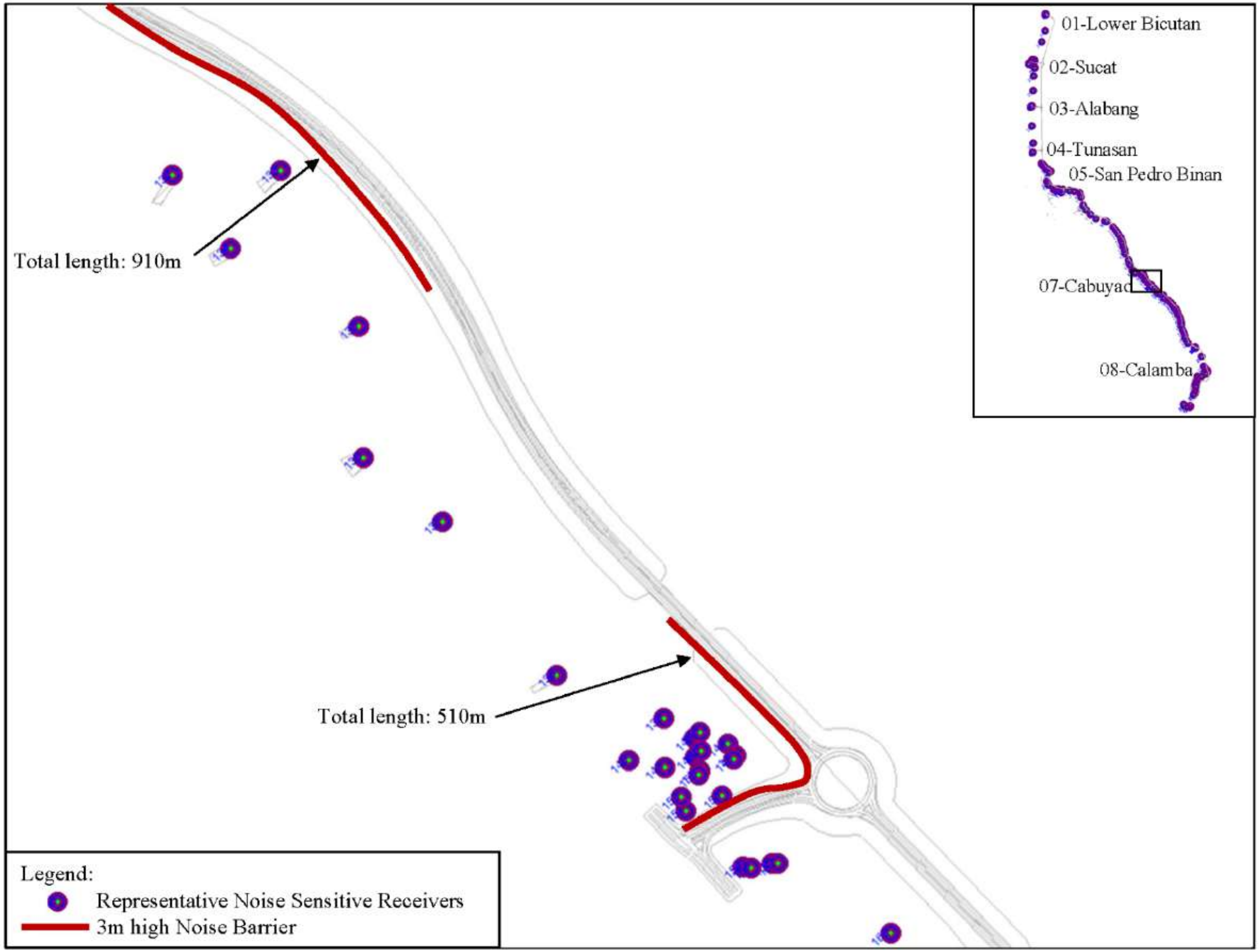

Figure 2.200 Location of Noise Barrier (Zone 7)

Figure 2.201 Location of Noise Barrier (Zone 8)

Figure 2.202 Location of Low Noise Road Surfacing (Zone 4)

2.3.3.5 Potential Impacts and Options for Prevention, Mitigation or Enhancement

The noise sensitive receivers along the project site have been predicted. Result indicate that the proposed project road would induce additional traffic noise impact to NSRs and 6% and 8% of noise exceedances were found under unmitigated scenario. No noise level exceedance at all NSRs are anticipated with mitigation measure of 3m high noise barrier along Zone 4, Zone 6 and Zone 7 in total 5260m length and low noise road surfacing at Zone 4 in total 420m length.

Nevertheless, it should be noted that the noise assessments are based on a number of assumptions including the following:

- The traffic forecast adopted in the assessment is based on the forecast for 2040 (ie 15 years after the commissioning of the Project). For a large highway infrastructure as the LLRN, there would be lot of planning initiatives / developments (eg now town planning, infrastructure etc). Any such initiatives / developments that may be further studied or materialised would have significant bearing on the traffic forecast and hence the noise impacts as well.
- As discussed previously, the noise criteria are dependent on the ambient noise levels. With the definitely stimulate economic growth, there would inevitably be regeneration in the surrounding assessment area. As in other cities, such a process would reshape the cities and hence change background noise levels.
- The current study has only considered the ROW that is anticipated at this stage. During the actual construction phase, any need for further temporary construction works areas would be further identified. In case there are residential buildings within these temporary works areas, they would need to be cleared for land resumption. This would also change the land uses immediately next to the alignment after the completion of the project.

In view of the above, the Project Proponent is recommended to consider conducting regular reviews on the need of mitigation after the commissioning of the Project. The reviews shall take into account all the latest available information at that time and recommend the next strategy for noise abatement.

2.3.3.5.1 Increase in ambient noise level

Heavy machinery, construction equipment, and transport vehicles are possible sources of noise during the construction phase. Transportation vehicles are the main source of noise during operation phase as cars and trucks will begin their passage through the area. Added noise during the operation will come from heavy machinery when maintenance is needed. The overexposure to the noise may result in nuisances, sleep deprivation, stress, and other physical, physiological, and psychological effects, experienced by nearby residents.

Listed below are some of the anticipated sources of noise during implementation of the project:

- Earth moving and land clearing activities.

- Ingress and egress of vehicles, heavy equipment, and transportation and placement of material.
- Engines from different kinds of vehicles, since the road will be open for public use.

During the construction period, adequate orientation is recommended to discourage construction workers to generate unnecessary noise i.e. shouting or making disturbing noise especially in places near residential areas and schools. In cases of activities and situations where the generation of noise cannot be avoided, noise barriers, fences and warning signs should temporarily be installed at the representative NSRs that would fall within their respective noise criteria.

Regular reviews should be conducted by the proponent on the need and extent of the proposed noise barriers after the commissioning of the Project. The reviews shall take into account all the latest available information at that time and recommend the next strategy for noise abatement.

Workers should be prescribed to wear appropriate personal protective equipment (PPE) to conform to OSH guidelines, if necessary. Since traffic is one of the major sources of noise, the implementation of an efficient Traffic Management Plan within the project area should be established and implemented. This has the objective of ensuring a smooth flow of traffic because this generates less sound compared to stop-and-start flow.

Summary of the prevention and mitigation plans for noise impacts are listed below:

- Proper scheduling and limiting loud activities during construction and maintenance of the road.
- Conduct orientation during construction phase and maintenance to include:
- Rules regarding noise level to prevent disturbing local communities, giving more importance to areas near sensitive receivers.
- Conduct training during construction phase and maintenance, which includes:
- Proper and efficient use of equipment during construction and maintenance, minimize the noise.
- Safety briefing for personal and environmental implications, which includes proper use of personal protective equipment (PPE) for workers based on Occupational Safety and Health Association (OSHA) guidelines.
- Traffic management guidelines.

- Place fences and warning signs to remind workers of noise guidelines and act as noise barriers.
- Plant trees in-between the roads and the residential areas in order to have a buffer to lessen the noise experienced by the locals.
- Ensure that all machinery used are regularly maintained and properly used in order to avoid noisier sounds from unmaintained machines.
- Regularly monitor the noise during construction and maintenance.
- Strictly implement vehicle speed limits.

Install mufflers in construction vehicles and heavy equipment.

2.3.3.5.2 Potential impact of noise in sensitive rece*ivers*

Sensitive receivers are typically defined as schools, hospitals, residential care facilities, or day-care centers, or other facilities that may house individuals with health conditions that would be adversely impacted by changes in the environment. This may include individuals who are disabled, elderly, children, etc. These people experience greater impacts when exposed to the same pollution as compared to the average person. Because of their sensitivity towards pollution, the impacts such as sleep deprivation, stress, and nuisances are still possible, but will most likely be experienced and lower levels of exposure. Over-exposure to noise may lead to a lack of rest, hindering their natural healing systems. This may worsen their conditions and even lead to fatalities of the people in hospitals who are in critical status.

In controlling noise at the receiver's end, several action plans may be taken into account. This includes the scheduling and limiting of loud activities at nearby settlements and institutions. It can also be recommended that insulating noise, use of noise screens, and the control of noise be implemented near the receiver's end.

Continuous monitoring is required to check and plan how to minimize the effect of noise pollution. Increase levels of noise may be due to traffic since it is used as a major thoroughfare in the area.

Mitigation efforts to avoid effects on sensitive receivers must be done properly as impacts are greater during the exposure of these individuals. The following are mitigation efforts specifically for sensitive receivers:

- Install fences and noise barriers near sensitive areas.
- Schedule use of roads passing through these areas, finding alternate routes when the time is too late in the evening or too early in the morning.
- Install larger numbers and more noticeable "No blowing of horn" signs.
- Provide buffer area that will enforce noise mitigating procedures.
- Maintain vehicles and equipment regularly.
- Conduct regular noise monitoring at sensitive receptor areas to prevent effects on human health.
- Prevent workers from loitering in these areas by conducting orientations.

2.5 People

2.5.1 Methodology

Primary Data

Household survey was conducted in the primary impact areas to gather baseline information and stakeholders' perception of the proposed project.

Secondary Data

Secondary data were gathered from the following sources:

- Comprehensive Land Use Plan of Taguig City
- Comprehensive Land Use Plan of Muntinlupa City
- Comprehensive Land Use Plan of San Pedro, Laguna
- Comprehensive Land Use Plan of Binan, Laguna
- Comprehensive Land Use Plan of Santa Rosa, Laguna
- Comprehensive Land Use Plan of Cabuyao, Laguna
- Comprehensive Land Use Plan of Calamba, Laguna
- 2015 Census of Population from the Philippine Statistics Authority

2.5.2 Baseline Data

Demographic Data

Population and household size

The National Capital Region (NCR) accounted for about 12.8 percent of the 2015 population of the Philippines. Of the four cities in NCR that will be traversed by the proposed SEMME, Taguig City registered the largest total population in 2015 at 804,915 and was recorded as the fastest growing highly urbanized city (HUC) with an average annual population growth rate of 4.32 percent during the period 2010 to 2015.

Table 2.9961 Shows the population trend in the two cities in NCR that will be traversed by the LLRN.

Table 2.9961 Population trend in direct impact cities in NCR

City	Population (in thousands)		
	2000	2010	2015
Taguig	467	644	805
Muntinlupa	379	460	505

Source: https://psa.gov.ph/content/population-national-capital-region-based-2015-census-population-0

Based on the 2015 Census of Population conducted by the Philippine Statistics Authority (PSA), Laguna was recorded as the third most populous province in the country (3.04 million total population). San Pedro City was also tagged as the most densely populated component city in the country in 2015 with 13,829 persons per square kilometer.[45]

Table 2.9962 shows the population trend in the five cities in Laguna that will be traversed by the LLRN.

Table 2.9962: Population trend in direct impact cities in Laguna

City	Population		
	2000	2010	2015
Biñan	201,186	283,396	333,028
Cabuyao	106,630	248,436	308,745
Calamba	281,146	389,377	454,486
San Pedro	231,403	294,310	325,809
Santa Rosa	185,633	284,670	353,767

Source: 2015 Census of Population and Housing, PSA.

The proposed project will traverse three barangays in Taguig City. Of the three, Lower Bicutan recorded the highest total population in 2015.

Table 2.9963 shows the population in the three barangays in Taguig City that will be traversed by the LLRN.

Table 2.9963 Population of Taguig City and its three direct impact barangays, 2015

TAGUIG CITY	804,915
Bagumbayan	40,685
Lower Bicutan	56,754
Upper Bicutan	41,216

Source: 2015 Census of Population, PSA.

Taguig City's household population is 3,772 less than its total population in 2015. Its working age population[46] comprised majority (68.7%) of its household population, while dependents[47] made up 31.3%. Senior citizens, or the elderly[48], made up 2.7%. Females comprised more than half (50.3%) of Taguig's working-age population.

Table 2.9964 shows Taguig City's household population by age group and sex in 2015.

[45] Adapted from PSA's official report: https://psa.gov.ph/content/philippine-population-density-based-2015-census-population
[46] The Philippine Statistics Authority (PSA) defines the working age population as those 15-64 years old at a specified time.
[47] The Philippine Statistics Authority (PSA) defines dependents as those below 15 years and above 64 years old.
[48] Republic Act No. 7432 (An Act to Maximize the Contribution of Senior Citizens to Nation Building, Grant Benefits and Special Privileges and for Other Purposes) defines senior citizens, or the elderly, as those at least 60 years old.

Table 2.9964 Taguig City's household population by age group and sex, 2015

Age group and sex	Both sexes	Male	Female
All Ages	801,143	400,542	400,601
Under 1	16,521	8,570	7,951
1 - 4	64,178	33,344	30,834
5 - 9	76,968	39,569	37,399
10 - 14	71,022	36,475	34,547
15 - 19	76,321	38,003	38,318
20 - 24	85,092	41,956	43,136
25 - 29	85,760	43,015	42,745
30 - 34	73,700	37,379	36,321
35 - 39	63,392	32,247	31,145
40 - 44	48,993	24,698	24,295
45 - 49	40,798	20,352	20,446
50 - 54	32,771	15,734	17,037
55 - 59	25,721	12,065	13,656
60 - 64	17,948	8,413	9,535
65 - 69	10,637	4,614	6,023
70 - 74	5,349	2,170	3,179
75 - 79	3,378	1,205	2,173
80 years and over	2,594	733	1,861

Source: 2015 Census of Population, PSA.

The average household size[49] in Taguig City was 4.0. For female-headed households, the average household size was 3.6, compared to the 4.2 average size for male-headed households. More than a fourth (23.6%) of Taguig City's household heads were female, with the highest proportion (22.9%) belonging to the 30-39 age range.

Table 2.9965 _ shows the number of households in Taguig City by age group, sex of household head, and household size.

[49] According to the PSA, household size refers to the number of usual members in a private household.

Table 2.9965 Number of households in Taguig City by age group, sex of household head, and household size, 2015

Sex and age group of the household head	Total number of households	Household size								Average household size
		1	2	3	4	5	6	7	8 and over	
Both Sexes	198,256	17,731	28,496	39,004	40,956	31,083	19,081	10,774	11,131	4.0
Below 20	1,479	395	417	474	130	29	21	7	6	2.4
20 - 29	37,645	6,051	8,658	10,700	7,091	3,153	1,208	481	303	3.0
30 - 39	58,606	5,028	8,070	11,791	14,112	9,887	5,296	2,539	1,883	3.9
40 - 49	45,883	2,584	4,049	6,909	9,895	9,165	6,217	3,546	3,518	4.6
50 - 59	31,921	1,669	3,405	5,033	6,095	5,656	4,050	2,705	3,308	4.7
60 - 69	16,656	1,261	2,634	3,056	2,727	2,427	1,743	1,174	1,634	4.4
70 - 79	4,852	544	999	814	735	622	462	275	401	4.0
80 years and over	1,214	199	264	227	171	144	84	47	78	3.6
Male Household Head	151,445	10,874	19,448	29,671	33,125	25,391	15,596	8,626	8,714	4.2
Below 20	924	235	245	326	84	17	12	3	2	2.4
20 - 29	28,839	3,895	6,220	8,715	5,932	2,581	933	345	218	3.1
30 - 39	47,891	3,382	6,020	9,612	12,155	8,518	4,523	2,137	1,544	4.0
40 - 49	36,569	1,711	2,706	5,123	8,054	7,774	5,305	2,980	2,916	4.7
50 - 59	23,231	881	1,996	3,401	4,533	4,375	3,260	2,170	2,615	4.9
60 - 69	10,899	518	1,585	1,965	1,911	1,707	1,250	819	1,144	4.6
70 - 79	2,619	189	575	444	392	357	270	149	243	4.2
80 years and over	473	63	101	85	64	62	43	23	32	3.8
Female Household Head	46,811	6,857	9,048	9,333	7,831	5,692	3,485	2,148	2,417	3.6
Below 20	555	160	172	148	46	12	9	4	4	2.4
20 - 29	8,806	2,156	2,438	1,985	1,159	572	275	136	85	2.7
30 - 39	10,715	1,646	2,050	2,179	1,957	1,369	773	402	339	3.5
40 - 49	9,314	873	1,343	1,786	1,841	1,391	912	566	602	4.1
50 - 59	8,690	788	1,409	1,632	1,562	1,281	790	535	693	4.2

Sex and age	Total	Household size								Average
60 - 69	5,757	743	1,049	1,091	816	720	493	355	490	4.0
70 - 79	2,233	355	424	370	343	265	192	126	158	3.8
80 years and over	741	136	163	142	107	82	41	24	46	3.4

Source: 2015 Census of Population, PSA.

In Muntinlupa City, the proposed project will traverse eight barangays. Among the eight direct impact barangays, Poblacion recorded the highest total population in 2015.

Table 2.9966 shows the population in the three barangays in Muntinlupa City that will be traversed by the LLRN.

Table 2.9966 Population of Taguig City and its three direct impact barangays, 2015

CITY OF MUNTINLUPA	504,509
Alabang	63,793
Bayanan	36,673
Buli	9,292
Cupang	58,331
Poblacion	115,387
Putatan	89,022
Sucat	57,504
Tunasan	53,078

Source: 2015 Census of Population, PSA.

The City of Muntinlupa registered a household population of 481,762 in 2015, which is 22,747 less than its recorded total population of 504,509 for the same year. Its working age population comprised majority (69.3%) of its household population while dependents made up 30.7%. Senior citizens, or the elderly, made up 4%. Females comprised more than half (53.4%) of the City's working-age population. **Table 2.9967** shows Muntinlupa City's household population by age group and sex in 2015.

Table 2.9967 Muntinlupa City's household population by age group and sex, 2015

Age group and sex	Both sexes	Male	Female
All Ages	481,762	237,300	244,462
Under 1	9,014	4,638	4,376
1 – 4	35,590	18,499	17,091
5 – 9	43,003	22,170	20,833
10 – 14	41,659	21,471	20,188
15 – 19	45,408	22,869	22,539
20 – 24	49,580	24,389	25,191
25 – 29	49,032	24,218	24,814
30 – 34	41,952	20,786	21,166
35 – 39	36,816	18,031	18,785
40 – 44	31,010	15,159	15,851
45 – 49	26,649	12,693	13,956
50 - 54	21,800	10,204	11,596
55 - 59	17,928	8,214	9,714
60 - 64	13,554	6,112	7,442
65 - 69	8,729	3,868	4,861

Age group and sex	Both sexes	Male	Female
70 - 74	4,522	1,948	2,574
75 – 79	3,037	1,207	1,830
80 years and over	2,479	824	1,655

Source: 2015 Census of Population, PSA.

The average household size recorded in Muntinlupa City in 2015 was 3.9. For female-headed households, the average household size was 3.4, compared to the 4.1 average size for male-headed households. Female-headed households comprised 24% of Muntinlupa City's households, with the highest proportion (19.3%) belonging to the 30-39 age range.

Table 2.9968 shows the number of households in the City of Muntinlupa by age group, sex of household head, and household size.

Table 2.9968 Number of households in Muntinlupa City by age group, sex of household head, and household size, 2015

Sex and age group of the household head	Total number of household	Household size								Average household size
		1	2	3	4	5	6	7	8 and over	
Both Sexes	122,286	13,383	18,743	23,471	23,147	18,416	11,952	6,679	6,495	3.9
Below 20	1,042	318	346	262	80	18	11	7	-	2.2
20 – 29	21,659	4,764	4,591	6,072	3,608	1,586	672	233	133	2.8
30 – 39	31,640	3,179	4,553	6,295	7,197	5,211	2,867	1,398	940	3.8
40 – 49	27,924	1,879	3,124	4,189	5,494	5,404	3,703	2,086	2,045	4.5
50 – 59	21,152	1,416	2,647	3,382	3,786	3,659	2,697	1,723	1,842	4.5
60 – 69	13,040	1,100	2,282	2,289	2,129	1,824	1,450	904	1,062	4.2
70 – 79	4,560	558	947	745	682	572	406	271	379	4.0
80 years and over	1,269	169	253	237	171	142	146	57	94	3.9
Male Household Head	92,974	7,575	12,930	17,787	18,792	15,228	9,898	5,519	5,245	4.1
Below 20	697	180	240	192	61	12	7	5	-	2.3
20 – 29	16,393	2,754	3,305	5,081	3,093	1,323	557	180	100	3.0
30 – 39	25,979	2,044	3,368	5,124	6,236	4,640	2,537	1,222	808	4.0
40 – 49	22,349	1,192	2,153	3,103	4,538	4,603	3,187	1,816	1,757	4.6
50 – 59	15,598	729	1,714	2,247	2,892	2,885	2,218	1,413	1,500	4.7
60 – 69	8,724	417	1,470	1,477	1,486	1,321	1,070	689	794	4.4
70 – 79	2,632	201	551	464	400	361	250	170	235	4.2
80 years and over	602	58	129	99	86	83	72	24	51	4.1
Female Household Head	29,312	5,808	5,813	5,684	4,355	3,188	2,054	1,160	1,250	3.4
Below 20	345	138	106	70	19	6	4	2	-	2.0
20 – 29	5,266	2,010	1,286	991	515	263	115	53	33	2.3
30 – 39	5,661	1,135	1,185	1,171	961	571	330	176	132	3.2
40 – 49	5,575	687	971	1,086	956	801	516	270	288	3.8
50 – 59	5,554	687	933	1,135	894	774	479	310	342	3.9
60 – 69	4,316	683	812	812	643	503	380	215	268	3.7

Sex and age	Total	Household size								Average
70 – 79	1,928	357	396	281	282	211	156	101	144	3.7
80 years and over	667	111	124	138	85	59	74	33	43	3.7

Source: 2015 Census of Population, PSA.

Based on the 2015 Census of Population conducted by the Philippine Statistics Authority (PSA), Laguna was recorded as the third most populous province in the country (3.04 million total population). San Pedro City was also tagged as the most densely populated component city in the country in 2015 with 13,829 persons per square kilometer.[50]

Of San Pedro City's 27 barangays, three (3) will be traversed by the proposed project. Of the three barangays, Landayan recorded the biggest population.

Table 2.9969 shows the population of San Pedro City and its three (3) barangays that will be traversed by the proposed project.

Table 2.9969 Population of San Pedro City and its eight direct impact barangays, 2015

CITY OF SAN PEDRO	325,809
Cuyab	21,731
San Roque	7,011
Landayan	31,407

Source: 2015 Census of Population, PSA.

The City of San Pedro registered a household population of 325,252 in 2015, which is 557 less than its recorded total population of 325,809 for the same year. Its working age population comprised 68% of its household population while dependents made up 32.1%. Senior citizens, or the elderly, made up 4.5%. Females comprised 50.8% of the City's working-age population.

Table 2.9970 shows San Pedro City's household population by age group and sex in 2015.

Table 2.9970 San Pedro City's household population by age group and sex, 2015

Age group and sex	Both sexes	Male	Female
All Ages	325,252	161,269	163,983
Under 1	6,043	3,218	2,825
1 – 4	23,680	12,383	11,297
5 – 9	30,011	15,547	14,464
10 – 14	29,957	15,557	14,400
15 – 19	31,633	16,081	15,552
20 – 24	31,443	15,701	15,742
25 – 29	28,691	14,195	14,496
30 – 34	27,408	13,551	13,857
35 - 39	24,944	12,361	12,583
40 - 44	20,884	10,317	10,567
45 - 49	18,202	8,859	9,343
50 - 54	14,920	7,180	7,740
55 - 59	12,574	5,887	6,687

[50] Adapted from PSA's official report: https://psa.gov.ph/content/philippine-population-density-based-2015-census-population

Age group and sex	Both sexes	Male	Female
60 - 64	10,273	4,629	5,644
65 - 69	6,839	2,954	3,885
70 - 74	3,539	1,468	2,071
75 - 79	2,285	821	1,464
80 years and over	1,926	560	1,366

Source: 2015 Census of Population, PSA.

The average household size recorded in San Pedro City in 2015 was 4.5. For female-headed households, the average household size was 4.1, compared to the 4.6 average size for male-headed households. Female-headed households comprised 23.3% of San Pedro City's households, with the highest proportion (22.1%) belonging to the 50-59 age range.

Table 2.9971shows the number of households in the City of San Pedro by age group, sex of household head, and household size.

Table 2.9971 Number of households in San Pedro City by age group, sex of household head, and household size, 2015

Sex and age group of the household head	Total number of household	Household size								Average household size
		1	2	3	4	5	6	7	8 and over	
Both Sexes	73,030	4,437	8,633	12,973	15,144	12,443	8,109	4,929	6,362	4.5
Below 20	355	87	104	92	38	19	7	5	3	2.6
20 – 29	8,096	737	1,469	2,394	1,839	914	423	168	152	3.4
30 – 39	17,850	950	1,928	3,315	4,397	3,429	1,983	994	854	4.3
40 – 49	18,007	886	1,488	2,563	3,886	3,565	2,409	1,470	1,740	4.7
50 – 59	14,641	793	1,470	2,128	2,702	2,576	1,792	1,269	1,911	4.9
60 – 69	9,725	596	1,376	1,716	1,638	1,376	1,055	739	1,229	4.6
70 – 79	3,404	294	609	574	526	451	347	220	383	4.4
80 years and over	952	94	189	191	118	113	93	64	90	4.1
Male Household Head	56,001	2,749	5,737	9,651	12,218	10,164	6,585	3,971	4,926	4.6
Below 20	247	58	72	73	23	14	3	2	2	2.6
20 – 29	6,615	527	1,085	2,033	1,579	782	365	124	120	3.5
30 – 39	15,015	683	1,430	2,694	3,872	3,024	1,721	877	714	4.3
40 – 49	14,525	618	987	1,919	3,227	3,034	2,057	1,242	1,441	4.9
50 – 59	10,871	479	908	1,432	2,040	2,075	1,425	1,018	1,494	5.0
60 – 69	6,494	269	839	1,094	1,149	955	753	541	894	4.8
70 – 79	1,827	101	329	321	279	225	215	135	222	4.6
80 years and over	407	14	87	85	49	55	46	32	39	4.3
Female Household Head	17,029	1,688	2,896	3,322	2,926	2,279	1,524	958	1,436	4.1
Below 20	108	29	32	19	15	5	4	3	1	2.7
20 – 29	1,481	210	384	361	260	132	58	44	32	3.2
30 – 39	2,835	267	498	621	525	405	262	117	140	3.9
40 – 49	3,482	268	501	644	659	531	352	228	299	4.3
50 – 59	3,770	314	562	696	662	501	367	251	417	4.4
60 – 69	3,231	327	537	622	489	421	302	198	335	4.2

Sex and age	Total	Household size								Average
70 – 79	1,577	193	280	253	247	226	132	85	161	4.2
80 years and over	545	80	102	106	69	58	47	32	51	4.0

Source: 2015 Census of Population, PSA.

Four barangays in Biñan City will be traversed by the proposed project. Of these, San Antonio recorded the biggest population. Casile, one of the affected barangays, has a population that is only 12% of San Antonio's.

Table 2.9972 shows the population of Biñan City and its four (4) barangays that will be traversed by the proposed project.

Table 2.9972 Population of Biñan City and its four direct impact barangays, 2015

BIÑAN CITY	333,028
Dela Paz	31,374
Malaban	26,513
Casile	4,148
San Antonio	35,811

Source: 2015 Census of Population, PSA.

Biñan City registered a household population of 332,170 in 2015, which is 858 less than its recorded total population of 333,028 for the same year. Its working age population comprised 69% of its household population, while dependents made up 31%. Senior citizens, or the elderly, made up 3%. Females comprised 50.5% of the City's working-age population.

Table 2.9973 Biñan City's household population by age group and sex, 2015

Age group and sex	Both sexes	Male	Female
All Ages	332,170	165,392	166,778
Under 1	6,448	3,240	3,208
1 – 4	26,556	13,504	13,052
5 – 9	30,559	15,846	14,713
10 – 14	29,245	15,096	14,149
15 – 19	31,961	16,150	15,811
20 – 24	37,094	18,238	18,856
25 – 29	34,104	16,798	17,306
30 – 34	28,946	14,557	14,389
35 – 39	25,851	12,894	12,957
40 – 44	19,910	10,048	9,862
45 – 49	17,483	8,766	8,717
50 – 54	14,290	6,852	7,438
55 – 59	11,306	5,420	5,886
60 – 64	8,321	3,864	4,457
65 – 69	4,799	2,109	2,690
70 – 74	2,490	1,038	1,452
75 – 79	1,586	620	966
80 years and over	1,221	352	869

Source: 2015 Census of Population, PSA.

The average household size recorded in Biñan City in 2015 was 3.8. For female-headed households, the average household size was 3.3, compared to the 4.0 average size for male-headed households. Female-headed households comprised 23.7% of Biñan City's households, with the highest proportion (22%) belonging to the 20-29 age range.

Table 2.9974 shows the number of households in the Biñan City by age group, sex of household head, and household size.

Table 2.9974 Number of households in Biñan City by age group, sex of household head, and household size, 2015

Sex and age group of the household head	Total number of household	Household size 1	2	3	4	5	6	7	8 and over	Average household size
Both Sexes	86,752	9,758	13,204	17,052	18,146	13,199	7,640	4,077	3,676	3.8
Below 20	1,138	516	306	205	76	21	7	4	3	2.0
20 – 29	17,455	3,921	3,968	4,579	3,003	1,246	463	171	104	2.8
30 – 39	23,578	2,203	3,097	4,811	5,847	3,947	2,065	944	664	3.8
40 – 49	19,359	1,228	1,861	2,891	4,374	3,910	2,503	1,342	1,250	4.4
50 – 59	14,317	874	1,771	2,409	2,932	2,595	1,672	1,042	1,022	4.4
60 – 69	7,846	637	1,462	1,533	1,446	1,151	702	429	486	4.0
70 – 79	2,431	285	566	514	368	270	184	129	115	3.6
80 years and over	628	94	173	110	100	59	44	16	32	3.4
Male Household Head	66,155	5,794	8,820	12,893	14,841	10,987	6,392	3,382	3,046	4.0
Below 20	652	245	203	140	44	13	4	2	1	2.1
20 – 29	12,914	2,251	2,791	3,709	2,538	1,039	377	125	84	3.0
30 – 39	19,483	1,466	2,218	3,935	5,105	3,513	1,840	831	575	4.0
40 – 49	15,642	864	1,223	2,127	3,639	3,357	2,172	1,164	1,096	4.6
50 – 59	10,623	542	1,080	1,642	2,258	2,046	1,349	858	848	4.6
60 – 69	5,257	283	911	1,027	995	843	531	312	355	4.2
70 – 79	1,333	113	326	268	222	150	100	81	73	3.8
80 years and over	251	30	68	45	40	26	19	9	14	3.5
Female Household Head	20,597	3,964	4,384	4,159	3,305	2,212	1,248	695	630	3.3
Below 20	486	271	103	65	32	8	3	2	2	1.8
20 – 29	4,541	1,670	1,177	870	465	207	86	46	20	2.3
30 – 39	4,095	737	879	876	742	434	225	113	89	3.2
40 – 49	3,717	364	638	764	735	553	331	178	154	3.8
50 – 59	3,694	332	691	767	674	549	323	184	174	3.8
60 – 69	2,589	354	551	506	451	308	171	117	131	3.6

Sex and age	Total	Household size								Average
70 – 79	1,098	172	240	246	146	120	84	48	42	3.5
80 years and over	377	64	105	65	60	33	25	7	18	3.3

Source: 2015 Census of Population, PSA.

Three (3) barangays in the City of Santa Rosa will be traversed by the proposed project. Of these, Sinalhan recorded the biggest population, closely followed by Caingin.

Table 2.9975 shows the population of the City of Santa Rosa and its three (3) barangays that will be traversed by the proposed project.

Table 2.9975 Population of Santa Rosa City and its three direct impact barangays, 2015

CITY OF SANTA ROSA	353,767
Aplaya	15,519
Caingin	21,597
Sinalhan	21,797

Source: 2015 Census of Population, PSA.

The City of Santa Rosa registered a household population of 353,592 in 2015, which is 175 less than its recorded total population of 353,767 for the same year. Its working age population comprised 71% of its household population, while dependents made up 29%. Senior citizens, or the elderly, made up 3%. Females comprised 51.3% of the City's working-age population.

Table 2.9976 shows the Santa Rosa City's household population by age group and sex in 2015.

Table 2.9976 Santa Rosa City's household population by age group and sex, 2015

Age group and sex	Both sexes	Male	Female
All Ages	353,592	173,775	179,817
Under 1	6,012	3,037	2,975
1 – 4	25,476	12,990	12,486
5 – 9	30,708	15,932	14,776
10 – 14	29,479	15,173	14,306
15 – 19	31,987	16,034	15,953
20 – 24	39,772	18,973	20,799
25 – 29	41,154	19,811	21,343
30 – 34	33,310	16,209	17,101
35 – 39	29,482	14,534	14,948
40 – 44	21,922	11,108	10,814
45 – 49	19,042	9,318	9,724
50 – 54	15,114	7,297	7,817
55 – 59	11,325	5,379	5,946
60 - 64	8,276	3,751	4,525

Age group and sex	Both sexes	Male	Female
65 - 69	4,987	2,166	2,821
70 - 74	2,601	1,055	1,546
75 - 79	1,666	620	1,046
80 years and over	1,279	388	891

Source: 2015 Census of Population, PSA.

The average household size recorded in Santa Rosa City in 2015 was 3.5. For female-headed households, the average household size was 2.9, compared to the 3.7 average size for male-headed households. Female-headed households comprised 26.5% of
Santa Rosa City's households, with the highest proportion (30.3%) belonging to the 20-29 age range.

Table 2.9977 shows the number of households in the Santa Rosa City by age group, sex of household head, and household size.

Table 2.9977 Number of households in Santa Rosa City by age group, sex of household head, and household size, 2015

Sex and age group of the household head	Total number of household	Household size 1	2	3	4	5	6	7	8 and over	Average household size
Both Sexes	101,385	16,734	16,796	20,830	19,612	13,535	7,317	3,604	2,957	3.5
Below 20	1,214	751	234	153	40	14	16	3	3	1.7
20 - 29	24,144	8,740	5,375	5,229	2,885	1,197	469	149	100	2.4
30 - 39	28,506	3,447	4,376	6,488	6,619	4,127	2,040	883	526	3.6
40 - 49	21,609	1,618	2,292	3,834	5,069	4,198	2,355	1,234	1,009	4.2
50 - 59	15,044	1,047	2,028	2,937	3,226	2,612	1,535	871	788	4.1
60 - 69	7,710	683	1,672	1,585	1,306	1,042	673	342	407	3.8
70 - 79	2,466	338	636	466	365	290	179	94	98	3.5
80 years and over	692	110	183	138	102	55	50	28	26	3.3
Male Household Head	74,528	9,261	10,947	15,673	15,954	11,301	6,075	2,947	2,370	3.7
Below 20	732	418	148	120	25	7	8	3	3	1.8
20 - 29	15,995	4,472	3,594	4,070	2,364	952	366	106	71	2.6
30 - 39	22,677	2,208	3,099	5,152	5,629	3,624	1,751	758	456	3.7
40 - 49	17,283	1,090	1,413	2,883	4,247	3,661	2,071	1,053	865	4.3
50 - 59	11,117	607	1,236	2,077	2,505	2,125	1,247	696	624	4.3
60 - 69	5,079	311	1,032	1,043	914	735	503	257	284	4.0
70 - 79	1,363	125	346	263	225	177	106	63	58	3.7
80 years and over	282	30	79	65	45	20	23	11	9	3.4
Female Household Head	26,857	7,473	5,849	5,157	3,658	2,234	1,242	657	587	2.9
Below 20	482	333	86	33	15	7	8	-	-	1.5
20 - 29	8,149	4,268	1,781	1,159	521	245	103	43	29	1.9
30 - 39	5,829	1,239	1,277	1,336	990	503	289	125	70	3.0
40 - 49	4,326	528	879	951	822	537	284	181	144	3.6
50 - 59	3,927	440	792	860	721	487	288	175	164	3.6
60 - 69	2,631	372	640	542	392	307	170	85	123	3.5

Sex and age	Total	Household size								Average
70 - 79	1,103	213	290	203	140	113	73	31	40	3.2
80 years and over	410	80	104	73	57	35	27	17	17	3.3

Source: 2015 Census of Population, PSA.

Five (5) barangays in Cabuyao City will be traversed by the proposed project. Of these, Marinig recorded a population that is about four times as big as the other covered barangays.

Table 2.9978 shows the population of Cabuyao City and its five (5) barangays that will be traversed by the proposed project.

Table 2.9978 Population of Cabuyao City and its five direct impact barangays, 2015

CABUYAO CITY	308,745
Baclaran	13,626
Bigaa	10,967
Butong	13,442
Gulod	14,611
Marinig	43,315

Source: 2015 Census of Population, PSA.

Cabuyao City registered a household population of 307,998 in 2015, which is 747 less than its recorded total population of 308,745 for the same year. Its working age population comprised 67.6% of its household population, while dependents made up 32.4%. Senior citizens, or the elderly, made up 9%. Females comprised 51% of the City's working-age population.

Table 2.9979 shows Cabuyao City's household population by age group and sex in 2015.

Table 2.9979 Cabuyao City's household population by age group and sex, 2015

Age group and sex	Both sexes	Male	Female
All Ages	307,998	153,201	154,797
Under 1	5,862	2,970	2,892
1 – 4	24,960	12,729	12,231
5 – 9	30,776	16,032	14,744
10 – 14	29,355	15,220	14,135
15 – 19	27,838	14,180	13,658
20 – 24	27,881	13,649	14,232
25 – 29	29,023	14,123	14,900
30 – 34	29,348	14,247	15,101
35 – 39	29,017	14,189	14,828
40 – 44	22,074	11,318	10,756
45 – 49	15,831	8,136	7,695
50 – 54	11,556	5,632	5,924
55 – 59	8,960	4,309	4,651
60 – 64	6,782	3,013	3,769
65 – 69	4,118	1,790	2,328
70 – 74	2,221	863	1,358
75 – 79	1,384	479	905
80 years and over	1,012	322	690

Source: 2015 Census of Population, PSA.

The average household size recorded in Cabuyao City in 2015 was 3.8. For female-headed households, the average household size was 3.1, compared to the 3.9 average size for male-headed households. Female-headed households comprised 19.8% of Cabuyao City's households, with the highest proportion (25.2%) belonging to the 30-39 age range.

Table 2.9980 shows the number of households in the Cabuyao City by age group, sex of household head, and household size.

Table 2.9980 Number of households in Cabuyao City by age group, sex of household head, and household size, 2015

Sex and age group of the household head	Total number of household	Household size								Average household size
		1	2	3	4	5	6	7	8 and over	
Both Sexes	81,573	8,241	13,022	16,577	17,957	12,768	6,939	3,423	2,646	3.8
Below 20	595	186	202	134	44	18	8	1	2	2.2
20 – 29	13,723	2,416	3,533	3,725	2,478	995	367	142	67	2.9
30 – 39	26,737	2,626	3,875	5,552	6,716	4,383	2,165	866	554	3.7
40 – 49	20,442	1,349	1,935	3,301	4,904	4,316	2,471	1,213	953	4.3
50 – 59	11,604	759	1,558	2,114	2,454	1,983	1,267	787	682	4.2
60 – 69	6,048	555	1,283	1,254	1,027	810	508	309	302	3.8
70 – 79	1,941	268	510	402	274	216	116	85	70	3.4
80 years and over	483	82	126	95	60	47	37	20	16	3.3
Male Household Head	65,461	5,025	9,189	13,240	15,499	11,223	6,033	2,979	2,273	3.9
Below 20	400	102	142	107	32	11	5	-	1	2.3
20 – 29	10,656	1,478	2,545	3,141	2,145	859	309	124	55	3.0
30 – 39	22,677	1,715	2,950	4,736	6,069	4,003	1,949	775	480	3.8
40 – 49	17,357	937	1,376	2,614	4,327	3,916	2,230	1,097	860	4.4
50 – 59	8,980	410	1,023	1,536	2,011	1,677	1,060	684	579	4.4
60 – 69	4,117	249	827	835	740	599	390	236	241	4.0
70 – 79	1,052	105	269	229	147	131	71	52	48	3.6
80 years and over	222	29	57	42	28	27	19	11	9	3.5
Female Household Head	16,112	3,216	3,833	3,337	2,458	1,545	906	444	373	3.1
Below 20	195	84	60	27	12	7	3	1	1	2.1
20 – 29	3,067	938	988	584	333	136	58	18	12	2.4
30 – 39	4,060	911	925	816	647	380	216	91	74	3.0
40 – 49	3,085	412	559	687	577	400	241	116	93	3.6
50 – 59	2,624	349	535	578	443	306	207	103	103	3.5
60 – 69	1,931	306	456	419	287	211	118	73	61	3.3

Sex and age	Total	Household size								Average
70 – 79	889	163	241	173	127	85	45	33	22	3.2
80 years and over	261	53	69	53	32	20	18	9	7	3.1

Source: 2015 Census of Population, PSA.

Eight (8) barangays in Calamba City will be traversed by the proposed project. Of these, Marinig recorded a population that is about four times as big as the other covered barangays.

Table 2.9981shows the population of Calamba City and its eight (8) barangays that will be traversed by the proposed project.

Table 2.9981 Population of Calamba City and its eight direct impact barangays, 2015

CALAMBA CITY	454,486
Bucal	12,818
Halang	7,169
Lecheria	9,108
Lingga	6,056
Looc	21,754
Palingon	5,685
Sampuiruhan	9,410
Uwisan	2,519

Source: 2015 Census of Population, PSA.

Calamba City registered a household population of 449,908 in 2015, which is 4,578 less than its recorded total population of 453,486 for the same year. Its working age population comprised 68% of its household population, while dependents made up 32%. Senior citizens, or the elderly, made up 10.2% of the dependents. Females comprised 50.8% of the City's working-age population.

Table 2.9982 shows Calamba City's household population by age group and sex in 2015.

Table 2.9982 Calamba City's household population by age group and sex, 2015

Age group and sex	Both sexes	Male	Female
All Ages	449,908	223,043	226,865
Under 1	9,448	4,812	4,636
1 - 4	37,396	19,342	18,054
5 - 9	42,901	22,250	20,651
10 - 14	39,547	20,462	19,085
15 - 19	41,680	20,933	20,747
20 - 24	48,106	23,319	24,787
25 - 29	45,693	22,331	23,362
30 - 34	40,516	19,943	20,573
35 - 39	35,660	17,840	17,820
40 - 44	26,466	13,474	12,992
45 - 49	22,757	11,301	11,456
50 - 54	18,620	8,949	9,671
55 - 59	15,374	7,248	8,126
60 – 64	11,048	5,096	5,952
65 – 69	6,671	2,870	3,801

Age group and sex	Both sexes	Male	Female
70 – 74	3,621	1,402	2,219
75 – 79	2,440	871	1,569
80 years and over	1,964	600	1,364

Source: 2015 Census of Population, PSA.

The average household size recorded in Calamba City in 2015 was 3.7. For female-headed households, the average household size was 2.8, compared to the 3.9 average size for male-headed households. Female-headed households comprised 22.9% of Calamba City's households, with the highest proportion (25.6%) belonging to the 20-29 age range.

Table 2.9983 shows the number of households in the Calamba City by age group, sex of household head, and household size.

Table 2.9983 Number of households in Calamba City by age group, sex of household head, and household size, 2015

Sex and age group of the household head	Total number of household	Household size								Average household size
		1	2	3	4	5	6	7	8 and over	
Both Sexes	123,071	20,510	18,614	22,647	23,365	17,047	10,143	5,437	5,308	3.7
Below 20	1,971	1,288	361	218	65	22	12	3	2	1.6
20 – 29	26,307	9,190	5,167	5,781	3,766	1,549	556	197	101	2.5
30 – 39	34,042	4,647	4,635	6,527	7,771	5,311	2,935	1,327	889	3.7
40 – 49	25,810	1,952	2,587	3,934	5,494	4,992	3,176	1,807	1,868	4.4
50 – 59	19,394	1,489	2,519	3,281	3,856	3,265	2,144	1,334	1,506	4.3
60 – 69	10,770	1,157	2,160	2,026	1,787	1,392	967	567	714	3.9
70 – 79	3,706	557	918	683	508	415	276	167	182	3.5
80 years and over	1,071	230	267	197	118	101	77	35	46	3.2
Male Household Head	94,877	11,392	12,739	17,947	20,038	14,738	8,778	4,755	4,490	3.9
Below 20	1,124	667	218	171	48	11	7	-	2	1.7
20 – 29	19,087	4,885	3,665	4,998	3,397	1,399	490	179	74	2.8
30 – 39	28,689	2,920	3,419	5,555	7,132	4,923	2,710	1,239	791	3.9
40 – 49	21,651	1,333	1,781	3,062	4,776	4,470	2,872	1,667	1,690	4.6
50 – 59	14,784	820	1,606	2,385	3,069	2,713	1,785	1,131	1,275	4.5
60 – 69	7,159	537	1,366	1,322	1,284	972	713	421	544	4.1
70 – 79	1,932	166	555	373	277	204	166	98	93	3.7
80 years and over	451	64	129	81	55	46	35	20	21	3.5
Female Household Head	28,194	9,118	5,875	4,700	3,327	2,309	1,365	682	818	2.8
Below 20	847	621	143	47	17	11	5	3	-	1.4
20 – 29	7,220	4,305	1,502	783	369	150	66	18	27	1.8
30 – 39	5,353	1,727	1,216	972	639	388	225	88	98	2.7
40 – 49	4,159	619	806	872	718	522	304	140	178	3.5
50 - 59	4,610	669	913	896	787	552	359	203	231	3.6
60 - 69	3,611	620	794	704	503	420	254	146	170	3.5
70 - 79	1,774	391	363	310	231	211	110	69	89	3.4
80 years and over	620	166	138	116	63	55	42	15	25	3.1

Source: 2015 Census of Population, PSA.

Literacy

Literacy rate among the cities that will be traversed by the proposed LLRN Project is high. The top three with highest literacy rate are Muntinlupa City at 99.86%, followed by Santa Rosa City at 99.85% and Cabuyao City at 99.83%.

Table 2.9984 presents the literacy rate by gender in the seven cities.

Table 2.9984 Literacy rate in the seven affected cities of the LLRN Project.

City	Literacy Rate		
	Both sexes	Male	Female
Taguig City	99.79%	99.80%	99.78%
Muntinlupa City	99.86%	99.85%	99.87%
San Pedro City	99.71%	99.67%	99.75%
Biñan City	99.68%	99.67%	99.70%
Santa Rosa City	99.85%	99.84%	99.85%
Cabuyao City	99.83%	99.83%	99.83%
Calamba City	99.70%	99.69%	99.72%

Source: 2015 Census of Population, PSA.

Informal settlers

The proliferation of informal settlers along the shore of Laguna Lake has been noted by the Study Team during various ocular inspections and site visits. Various studies have noted their presence as one of the challenges besetting the Lake. For the purposes of this project, however, a total of 505 settlers (including households and other establishments) have been documented, 85.9% of which are non-landowners.

Table 2.9985 below shows the classification of settlers recorded along the project alignment.

Table 2.9985 Classification of settlers recorded along the LLRN

City	Landowner	Non-Landowner	No response	Total
Taguig City	N/A	N/A	N/A	N/A
Muntinlupa City	26	326	4	356
Biñan City	1	10	0	11
Santa Rosa City	13	67	0	80
Cabuyao City	26	17	0	43
Calamba City	1	14	0	15
Total	67	434	4	505

Poverty and Food Poverty Indices

NCR and CALABARZON remained as the regions with the lowest poverty incidence among families in the first semester of 2015 and 2018.

Poverty incidence among families in NCR was estimated at 4.9 percent in the first semester of 2018. This translates to around five out of 100 families that did not have sufficient income to meet their basic food and non-food needs in the first half of 2018. Poverty incidence in the same period in 2015 was recorded at 4.6 percent.

Poverty incidence among families in Laguna was estimated at 5.0 percent in the first semester of 2018. This translates to five out of 100 families that did not have sufficient income to meet their basic food and non-food needs in the first half of 2018. Poverty incidence in the same period in 2015 was recorded at 5.6 percent.

2.5.3 Potential Impacts and Options for Preventions and Mitigation and/or Enhancement

Potential Impacts

Among the project's potential impacts on demographics include the physical and economic displacement of some families and individuals. Influx of workers and other individuals seeking to benefit from the potential economic gains from the project are also expected. Number of informal settler households may increase.

There are no groups of indigenous peoples (IPs) present within the project site based on review of secondary data and conduct of survey.

On cultural and lifestyle change, social tension may arise within communities because of income and wealth disparity between those who will benefit economically from the project and those who will not. It is also possible that project workers and other in-migrants will introduce different lifestyles and patterns of behaviour that may cause social tensions.

The project will have no impact on physical cultural resources based on the assessment of environmentally critical areas (ECA) along the project alignment.

Options for Prevention and Mitigation

Locals will be prioritized in hiring for the project.

Concerned LGUs may also check their respective policies when it comes to business registration to ensure that businesses and establishments are compliant with relevant national and local policies. These include regulations on sanitation, structure (building), and employees.

Barangays should keep tab of the number of informal settlers within their area of jurisdiction. With support from their respective city government, they should be able to strictly enforce zoning.

Regular conduct of IEC with affected communities/barangays should be undertaken to ensure that project updates are continuously provided to stakeholder and that their concerns are documented and decisively addressed. The proponent should also ensure that employees, contractors, and subcontractors are properly oriented on local culture and how they should interact with the local community.

Basic Services / Public Resources

Baseline Information

Power, Water, and Communication

Both the Manila Water Company and Maynilad supply water in the cities of Taguig and, Muntinlupa.

Laguna Water, a joint venture between the Provincial Government of Laguna and Manila Water Philippine Ventures (MWPV), a wholly-owned subsidiary of the Ayala-led water industry leader, Manila Water Company, operates in the cities of Biñan, Santa Rosa, and Cabuyao. Calamba City has its water district but Laguna Water also has presence in the City. The San Pedro Water District supplies water to residents of San Pedro City.

The Manila Electric Company (MERALCO) supplies power to the cities of Taguig, Muntinlupa, San Pedro, Calamba, Biñan, Cabuyao, and Santa Rosa.

The Philippine Long Distance Telephone (PLDT) and Globe Telecom serve as major providers of land-based telephone services, while Smart Communications, Globe Telecom, and Sun Cellular remain the major mobile phone service providers operating in said localities.

All of the covered cities in Laguna can be reached by radio and television broadcasts from Metro Manila, as well as print materials that are distributed in Metro Manila.

Transportation

The cities of Taguig and Muntinlupa, along with all the covered cities in Laguna, are accessible by bus, jeepney, metered taxi, UV Express, rail, and private hire car services. Tricycles are also prominent in these cities, especially in inner minor roads.

The DOTr is also set to implement the North-South Commuter Railway Project, a 147-kilometer elevated railway that will run from New Clark City in Capas, Tarlac, to Calamba, Laguna, with a total of 36 stations.

Peace and Order

Peace and order in Muntinlupa City is maintained by the Philippine National Police (PNP). As of 2018, the local PNP has a total of 583 personnel, 62 of which are women, with most (45) holding the lowest rank of PO1. Aside from the headquarters found in Brgy. Tunasan, there are also six (6) community precincts, one (1) station traffic investigation unit, and one (1) Special Reaction Unit. The City also has one national government fire station located in Susana Heights and two local government-run fire stations. There are also two volunteer fire sub-stations in Ayala and Filinvest and a government fire sub-station in Sucat.

In Muntinlupa City, Barangays Poblacion, Putatan, and Alabang reportedly have the highest number of reported crime cases, while Buli has the least for the past three years.[51]

Taguig City PNP has a total of 697 personnel composed of 28 police commissioned officers, 656 police non-commissioned officers, and 16 non-uniformed personnel. The City has 16 police community offices, eight of which are under the jurisdiction of the barangays.

Based on records, index crimes increased between the years 2015 to 2017. Moreover, there is a steady increase in the number of recorded traffic incidents, which started from 2,667 incidents recorded in

[51] As lifted from Muntinlupa City-2018 Ecological Profile.

2015 to 6,173 traffic incidents recorded by the police in 2017. There are two detention facilities in the city, namely, the (1) Headquarters Detention Cell, and the (2) extension cell at Camp Bagong Diwa with a total population of 1,832 inmates.

In San Pedro City, the Philippine National Police (PNP) is complemented by the City Public Order and Information Office (POSO) and the City Traffic Management Unit (TMU). Recorded crimes against person in San Pedro City during 2014 and 2015 were mostly on physical injuries, followed by homicide, murder, and rape. Crimes against property recorded during the same period were mostly theft, robbery, motor napping, and carnapping.

The Santa Rosa City PNP has a total strength of 162 police personnel as of 2014: 139 policemen and 23 policewomen. The police-to-population ratio based on the National Statistics Office 2014 estimate of the Santa Rosa City population is 1:2,013. The main station is located on Rizal Blvd. in Brgy. Tagapo. Only 10 of the force is stationed in the headquarters, while the remaining 90 are in the field. Four police assistance centers and 10 police outposts are maintained by the PNP-Santa Rosa.

Cabuyao City's police personnel increased to 124 in 2015. Of this, only 4%, or five personnel, are commissioned officers, while non-commissioned officers comprise the largest share at 96%, or 119 personnel of the total police personnel. Unfortunately, the police-population ratio in 2015 (1:3058) was below the national standard of 1:1,000. The City has one police station and four police substations located in Mabuhay City, Brgy. Mamatid, Southville Marinig, Brgy. Banlic, and LISPP 1 in Brgy. Diezmo.

In Biñan City, protective services are rendered by the PNP, BFP, and BJMP, with augmentation from the tanods of the 24 barangays as force multiplier. The Central Police Headquarter is located in the new City Hall Compound, while police outposts are scattered in the 24 barangays and the fire station and city jail are temporarily housed at the old City Hall in Poblacion.

Potential Impacts

Competition for basic utilities and services is to be expected as the local population increases due to the influx of workers and other individuals seeking to benefit from the expected expansion of the local economy.

The water and power needs of the project may also impact on the local supply of the host LGUs.

Options for Prevention and Mitigation

Aside from prioritizing locals in hiring for the project, the contractor can also set up facilities that would look after some of the basic needs of its employees, such as a clinic and housing for migrant employees.

The contractor should also look into the project requirements and activities and ensure that local supply will be sufficient and that project activities will not cause unnecessary disruptions to local services.

Health and Safety

Baseline Information

Public Health and Safety

Muntinlupa City has 15 public health centers, and three (3) public and six (6) private hospitals as of 2018. Major hospitals, such as the city-operated Ospital ng Muntinlupa (OSMun) and Asian Hospital and Medical Center, are located in Barangay Alabang. In terms of health personnel, Table _ below shows the health personnel to population ratio using the Department of Health (DOH) population value, which is lower than the projected 2017 population of Muntinlupa City based based on the 2015 Philippine Statistics Authority (PSA) Census.

Table 2.9985 shows the number of health personnel against the DOH prescribed ratio in Muntinlupa City.

Table 2.9985 Number of health personnel against the DOH prescribed ratio in Muntinlupa City

Health Personnel	Number	DOH population	Ratio
Barangay health workers	437	506,144	1,158
Barangay Nutrition Scholars	15	506,144	33,743
Medical doctors	1,765	506,144	288
Nurses	1,215	506,144	417
Midwives	278	506,144	1,821
Sanitary Inspector	28	506,144	18,077
Medical Technologist	111	506,144	4,560
Dentist	35	506,144	14,461
Nutritionist	8	506,144	63,268

Source: Muntinlupa City-2018 Ecological Profile

Taguig City has 31 health centers and 5 super health centers. Super health centers function like a regular hospital in terms of personnel and facilities. It operates with a medical doctor, a nurse, a midwife 24/7, and equipped with mini ambulance. Aside from health and super health centers, there are also major health facilities available in the city that are run by the private sector. Currently, the LGU is managing one major health facility located in District 2.

Table 2.9986 shows the number of health personnel in public and private hospitals in the City of Taguig.

Table 2.9986 Number of health personnel in public and private hospitals in Taguig City

Specialization	Number	Ratio	Standard Ratio
Physician	44	1:18,294	1:20,000
Nurse	39	1:20,638	1:20,000
Midwife	78	1:10,319	1:5,000
Dentist	45	1:17,887	1:50,000
Medical Technologist	21	1:38,329	1:50,000
Nutritionist	43	1:18,719	1:50,000
Sanitary Inspectors	28	1:28,747	1:50,000

Source: Taguig City Comprehensive Land Use & Zoning Plan

In Cabuyao City, there are only two (2) main health centers, 21 barangay health units distributed in 18 barangays, and three hospitals. In 2015, there were about 346 persons rendering medical health services to the City of Cabuyao, 98 out of 346 persons rendering medical health services are in public sector. Of the total number of medical/health personnel, 36 are doctors, 44 are nurses, 20 are midwives, 14 are dentists, two (2) are nutritionists, one (1) is a sanitary inspector, and the remaining 26 are other personnel handling menial jobs.

Calamba City has two (2) Rural Health Units, two (2) Birthing Facilities, and (1) District Hospital managed by the Provincial Government (JP Rizal Memorial Hospital) and 60 Barangay Health Stations (BHS) in Calamba's 54 barangays. There are also six (6) private hospitals, 15 private clinics, six (6) diagnostic centers, two (2) drug testing centers, and 18 lying-in clinics, which supplement the City's health services.

In Santa Rosa City, each of the 18 barangays has a health center that is conveniently located for accessibility to residents. There are two health offices that supervise the different health centers. There are 37 small and private city clinics spread over the city.

In San Pedro City, there are three government hospitals, two (2) RHUs, 26 BHS, five (5) private hospitals, and 53 private clinics.

Biñan City has two Rural Health Units (RHUs), one covering 10 barangays. The RHU in San Antonio covers the other 14 barangays. There are also Barangay Health Stations housed within barangay multi-purpose halls. Perpetual Health Hospital, Unihealth-Southwoods Hospital and Medical Center, and Biñan Doctor's Hospital are the City's three big hospitals. There are 25 private medical clinics offering primary, secondary and tertiary level health services. Several dental clinics, eye clinics, skin clinics and lying-in clinics are also present in the City.

Public Services

The standard public services provided by local government units in the country are present in the project areas. Social welfare services are available for vulnerable sectors, there are public schools for elementary and high school, and health services are provided through municipal and barangay health centers.

Environmental Health and Sanitation

Taguig City currently disposes its sorted collected household and market waste at the Montalban Sanitary Landfill, hauled by its contractor, Leonel Waste Management Inc., which is supervised by the SWMO and also operates the Leonel Transfer Station. The Metropolitan Manila Development Authority (MMDA) subsidized half of the City's garbage tipping fee at the Montalban SLF as it does to all LGUs using the said disposal facility and all other accredited disposal facilities. Hazardous wastes of hospitals, government and private, have their own private treater contractor. St. Luke's Hospital employs the services of Integrated Waste Management and Taguig City Hospital is catered to by Chevalier for their hazardous hospital wastes.

Waste reduction at source mainly by the household is the focus of the City's SWM campaign since households contribute 92.7% of Taguig City's waste generation as per WACS study. Biogas Digesting, Drum Tumbler Composting and Urban Container Gardening will be pushed at the household level. A reward system may be conceived to motivate the household in managing their garbage. The barangay level approach will focus mainly on enforcement and establishment of Barangay MRF. Recovery and diversion of recyclables will be the main activity plus livelihood generation out of recovered wastes. The barangay MRF can also do composting and be the model in Urban Container Gardening for their community. Creation of Barangay Environmental Police will also be enjoined to enforce discipline among the people. The city government must employ a monitoring and incentive system for the barangay with the highest diversion achieved every year. The City level approach will engage in cost-effective technologies that can compost biodegradables at high capacity. A Central MRF needs to be established to cater mainly to biodegradable processing. More than 50% of waste generated is biodegradable, so, if this can be processed, then we can easily reach or even exceed the target diversion rate. A model Eco-Farm naturally goes alongside composting.

San Pedro City lacks a citywide wastewater and septage treatment facilities, except for septic tanks that discharge wastes directly on surface waters like rivers, creeks, and drainage canals. This contributes to the unfavorable Class C status of Laguna Lake, and leads to fish kills, water pollution, and foul odor. Used oil and grease are also not properly disposed by industrial and commercial establishments and households in the City.

When it comes to solid waste, about 165 tons of waste are generated on a daily basis based on the computation using the projected population resulting in water, air, and soil contamination. Most solid wastes, especially non-hazardous domestic wastes, are collected daily by the garbage contractor (Pilotage Trading) and directly disposed in the sanitary landfill area at Barangay San Antonio, which has a capacity of 200 metric tons daily.

There is an operational material recovery facility providing income to waste pickers. A methane gas extraction sourced from the landfill area is being operated by Bacavalley Energy producing four megawatts of electricity fed to the Transcon Grid.

A centralized material recovery facility is not yet operational in the City although households practice waste segregation. Biodegradable wastes are used for composting and recycled materials are sold in junkshops.

In Santa Rosa City, it is estimated that about 64,775 households (93 of total) have private sanitary toilets and complete sanitation facilities. With the exception of industrial estates, however, the City has no sewerage system.

Santa Rosa has adopted a 10-year Solid Waste Management Plan, which requires the City Government, through the supervision of the City ENRO, to provide daily garbage collection in its 18 barangays, including almost all private subdivisions. Industries, shopping malls, restaurants, and high-end residential subdivisions have their own private hauler to collect and dispose their waste, including special wastes.

The 10-year Solid Waste Management Plan also includes the operation of the Eco-Waste Center located at the Barangay Market Area. It is where biodegradable wastes from the Santa Rosa Public Market are converted into organic fertilizer through the process of composting. An estimated of 50 kilos of wastes per day are being collected from the public market.

Other wastes collected in the City of Santa Rosa are hauled directly to the sanitary landfill of the Pilotage Trading and Construction (PTAC) in Brgy. San Antonio in nearby San Pedro City. The sanitary landfill has an area of 12 ha and can accommodate not more than 200 metric tons of waste per day. An estimated of 600 cubic meters of wastes are being collected per day from the 18 urban barangays of Santa Rosa. All raw and assorted garbage are disposed to the landfill area wherein the recyclables are being collected by waste pickers who are legally recognized by PTAC. These waste pickers are educated and trained in proper waste management system. They are provided uniforms and safety personal protective equipment (PPE), such as gloves, masks, and boots.

Biñan City's Ten-Year Solid Waste Management Plan was approved in 2015 by the National Solid Waste Management Commission of the Department of Environment and Natural Resources (DENR).

The City Government of Cabuyao reconstituted the City Solid Waste Management Board (CSWMB) through Executive Order No. 18, Series of 2011. The CSWMB convenes monthly to discuss issues, problems and concerns on solid waste management. In addition, a multi-sectoral Barangay Solid Waste Management Committee was created in each of the 18 barangays. The City Environment and Natural Resources Office (City ENRO) is designated as the CSWMB secretariat. The city's solid waste management scheme is detailed in a 10-year City Solid Waste Management Plan (2016-2025). It envisions Cabuyao to have a proactive community-based solid waste management system that is conducive to the challenges of sustainable, socio-economic and environmental development.

Potential Impacts

Among the identified project impacts on public health and safety include accumulation of solid waste, generation of hazardous materials, degradation of water quality, noise generation, dust accumulation, and workplace and road accidents.

The capacity of host LGUs to accommodate the increased demand for services may also be affected.

Options for Prevention and Mitigation

The proponent should make sure that the contractor observes the strict implementation of the EMP. There should be prior and sustained coordination between the proponent and contractor and host LGUs on project activities, its requirements, and possible impacts to enable LGUs to plan ahead and be prepared.

Income and Employment

Baseline Information

Main Sources of Income and Livelihood

Taguig is a financial district bustling with growth and development. It is currently home to top corporations, embassies and government offices. New hotels, educational institutions and shopping malls have also sprung up in recent years within the fast-growing business districts of Bonifacio Global City (BGC) and ARCA South. A large number of registered businesses in Taguig are linked to commercial and industrial establishments. At present, there are 7,776 registered commercial and industrial establishments which are able to employ thousands of people. Establishments include banks and other lending institutions, manufacturing firms, restaurants, shopping malls, cottage industries, manufacturing firms, batching plant, public and flea markets and memorial parks.

The local government's commitment to develop and revitalize its business sector resulted in the influx of businesses and investors in Taguig City, which significantly contributed to its progress. Taguig City is host to 16 universal and commercial banks; 10 rural banks; 1,126 manufacturing firms; 243 restaurants; 13 registered batching plant; two shopping malls; 24 cottage industries; and 7,776 registered commercial and industrial establishments. It is also home to 53 subdivisions, two public markets, 19 flea markets, six public memorial parks, and five private memorial parks.

For 2018, the City of Muntinlupa reported a total of 15,409 business registrations with a total declared employment of 146,299 individuals. It also reports a robust MSME sector, accounting for more than 99% of all businesses in Muntinlupa.

Table 2.9987 shows the number and percentage share of MSMEs and large enterprises.

Table 2.9987 Number and share of MSMEs and large enterprises in Muntinlupa City

Type	Capitalization		Number of businesses	Percentage share
Micro	Less than	3,000,000.00	13,189	85.61
Small	3,000,001.00	15,000,000.00	1,643	10.66
Medium	15,000,001.00	100,000,000.00	451	2.93
Large	100,000,001.00	above	126	0.80
TOTAL			15,409	100

Source: Muntinlupa City – 2018 Ecological Profile.

San Pedro City is considered an emerging growth center in CALABARZON, which is largely supported by its close proximity to Metro Manila as well as its excellent road and transport facilities. Its main economic activity is derived from its service sector, followed by the manufacturing industry and by the rapidly vanishing agricultural sector, which include the cultivation of sampaguita flower and livestock and fishing industries. There are no more rice producing agricultural areas in its lowland as well as in its upland barangays.

No specific land has been allocated for the so-called Strategic Agriculture and Fisheries Development Zone (SAFDZ) except for the large-scale fish pens operated commercially by businessmen, for which San Pedro shares income from the LLDA fees and charges.

Its underground economy is flourishing, providing jobs and livelihood to the low-income population, particularly the informal sector families. MSME products and services are labor intensive and with downstream supply chain linkages to the big manufacturing industries in the neighboring economic zones operating in Biñan, Santa Rosa, Cabuyao, and Calamba. However, MSMEs in the City are not so visible, especially the home-based cottage industry in some barangays that needs shared technological modernization and capitalization infusion.

Commercial activity is concentrated in San Pedro's Poblacion area, while industrial establishments are located mostly in Barangay San Antonio.

Santa Rosa's Services sector serve as the biggest employer of the City's working population, followed by the industry sector, composed of the manufacturing industry of food and beverage, automotive assembly, and electronics and related areas. Its agricultural sector is seen to shrink further in terms of employment in view of the City's decreasing hectares of land devoted to farming, livestock, and fishing, as well as the seemingly lack of interest of farmers to cultivate the land. The Strategic Agricultural and Fisheries Zone Areas (SAFDZ) of Santa Rosa, situated along the lakeside area, are not fully utilized by the farmers-fishermen for food production purposes, especially the cultivation of high value crops and raising of livestock.

The share of Cabuyao's employment to Laguna increased in all sectors. It may be noted the increase in the city's share of employment in the manufacturing sector coincided with the uptrend in the sector. Although the employment in industries located in Cabuyao increased in the past years, it must be noted that most of the workers employed are non-residents of the city. This is mainly due to the lack of skills required by the industries located in the town.

Biñan is a first-class city, which means it is basically urban wherein non-agricultural industry and services sectors are the dominant drivers of business growth. It includes the secondary sector of manufacturing, construction, electricity, gas and water supply. The tertiary sector are wholesale and retail trade, transportation and communication, finance, insurance, real estate, personal services and tourism. The primary sector of small agricultural crops, livestock and fish harvest in Laguna Lake are contributing a very small portion to the City's local economy and employment.

Property valuations have been increasing due to robust business in property acquisitions and development by the private sector. Laguna Lake has huge potential for mixed use development. Considering the accessibility of the City of Biñan from nearby cities including Metro Manila and provinces down southern Luzon, a food processing and distribution terminal dubbed "Bagsakan" connected to the PNR train station in Barangay San Vicente and Public Market can make Biñan as the regional trading center of CALABARZON. With this, so much potential is seen for the City as a premier hub south of Metro Manila.

Employment profile

The nationwide lockdown and subsequent quarantines imposed due to the Covid-19 disease became most felt as the unemployment[52] rate rose to 17.7%, which accounted to 7.3 million unemployed Filipinos in the labor force in April 2020, according to a report posted by the PSA.[53]

The report further states the following:

- The labor force participation rate among Filipinos 15 years and older is estimated at 55.6% in April 2020, the lowest in the history of the Philippine labor market.

- The employment rate in April 2020 fell to 82.3% from 94.7% in January 2020. In April 2019, it is posted at 94.9 percent. This translates to 33.8 million employed persons in April 2020 from 41.8 million in April 2019.

- The average number of hours worked per week also fell to 35.0 in April 2020, a drop from 41.8 hours per week in April 2019.

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[52] According to the PSA, the unemployed include all persons who are 15 years and over as of their last birthday and are reported as: (1) without work and currently available for work and looking for work; or (2) without work and currently available for work but not looking for work due to the following reasons: 1) tired/believed no work available; 2) awaiting results of previous job application; 3) temporary illness/disability; 4) bad weather; and 5) waiting for rehire/job recall.
[53] From https://psa.gov.ph/content/employment-situation-april-2020

- Employed persons with jobs but not at work are reported at 38.4%, or 13.0 million of the total employed.

Pre-pandemic[54], 24.6% of gainful workers 15 years and over in Taguig City were employed as Service and Sales Workers. For both sexes, the greatest number of gainful workers belonged to said category (22.5% of the total for male gainful workers and 27.9% of the total for female gainful workers).

Similarly, 22.2% of gainful workers 15 years and over in Muntinlupa City were employed as Service and Sales Workers, followed by those in Elementary Occupations at 14.5%. For both sexes, the greatest number of gainful workers are employed as Service and Sales Workers (19.6% of the total for male gainful workers and 25.9% of the total for female gainful workers).

Total family income and employment of the workforce in San Pedro City comes from wholesale / retail trade, manufacturing, transport, banking and finance, real estate, electricity, gas and water, construction, hotels, education, health and working as overseas workers. There is no income from large-scale agricultural production, except in small fishing and commercial fish pens by big operators. There is also no forestry, mining, and quarrying activities in the City. It also has no industrial estates, unlike in Biñan, Santa Rosa, Cabuyao and Calamba.

Local Benefits of the Project

From the pre-construction up to the construction stages, the project is expected to result to an increase in business and other income-generating opportunities. It may lead to more investors coming to the host LGUs. The increase in demand for supplies and services may also lead entrepreneurial individuals and groups to maximize this opportunity. The expansion of the local economy will open doors for people's greater participation and inclusion in entrepreneurial and other income-generating activities. More micro and small entrepreneurs may be able to take part in the local economic activities that the project may present.

During the construction stage, the project may also provide temporary employment to locals. It also presents an additional income source for the host LGUs for the taxes and other permits that the project will require.

2.5.4 Public Participation

DENR Administrative Order (DAO) No. 2017-15 provides the guidelines on public participation under the Philippine EIS system. In line with this guidelines, initial stakeholder identification and IEC meetings were done.

Stakeholder Identification

Stakeholders, as defined by DAO 2017-15, are people (natural or juridical) who affect or are affected by the project or undertaking, such as, but not limited to members of the local community, industry, local government units (LGUs), national government agencies (NGAs) and non-government organizations (NGOs) and people's organizations (POs).

[54] Based on results of the 2015 Census of Population conducted by the PSA.

A preliminary stakeholder identification and analysis was done to come up with a list of stakeholder groups that have interest in or stand to be affected by the project given its potential impacts. Note that stakeholder mapping is an iterative process that is informed by the conduct of site visits, observations, and validations by the study team.

The following are the identified stakeholders of the project based on site visits, interviews, coordination, IEC meetings, and desk research done:

- Local government units
- Owners and operators of commercial sea vessels
- National government bodies
- Transport sector
- Business sector
- Fisherfolk
- Senior citizens/elderly
- Youth
- Women
- Residents/Homeowners

Initial IEC Meetings

Taguig City

An online IEC meeting was held with the City Government of Taguig in 22 September 2020 at 2 PM. There were 20 participants in said meeting, including key officials and representatives from the City Administrator's Office, City Planning and Development Office, City Environment and Natural Resource Office, City Assessor's Office, City Agriculturist's Office, City Engineer's Office, and City Housing Office.

Among the issues and concerns raised during said meeting were the following:

- Final copy of the alignment
- Viaduct elevation and basis for it
- Viaduct design and its capacity to accommodate bigger sea-borne vehicles
- Recycling of excavated materials and its possible re-use in the embankments
- Traffic congestion and traffic management during construction
- Clear demarcation of LLDA boundary
- Aligning the LLRN project with other national government projects
- Identification of affected barangays
- Compensation for project affected people, especially fish cage operators who stand to be displaced by the project
- Health and safety protocols of the project

Figure 2.203 show the screenshots of the online IEC meeting with the City Government of Taguig.

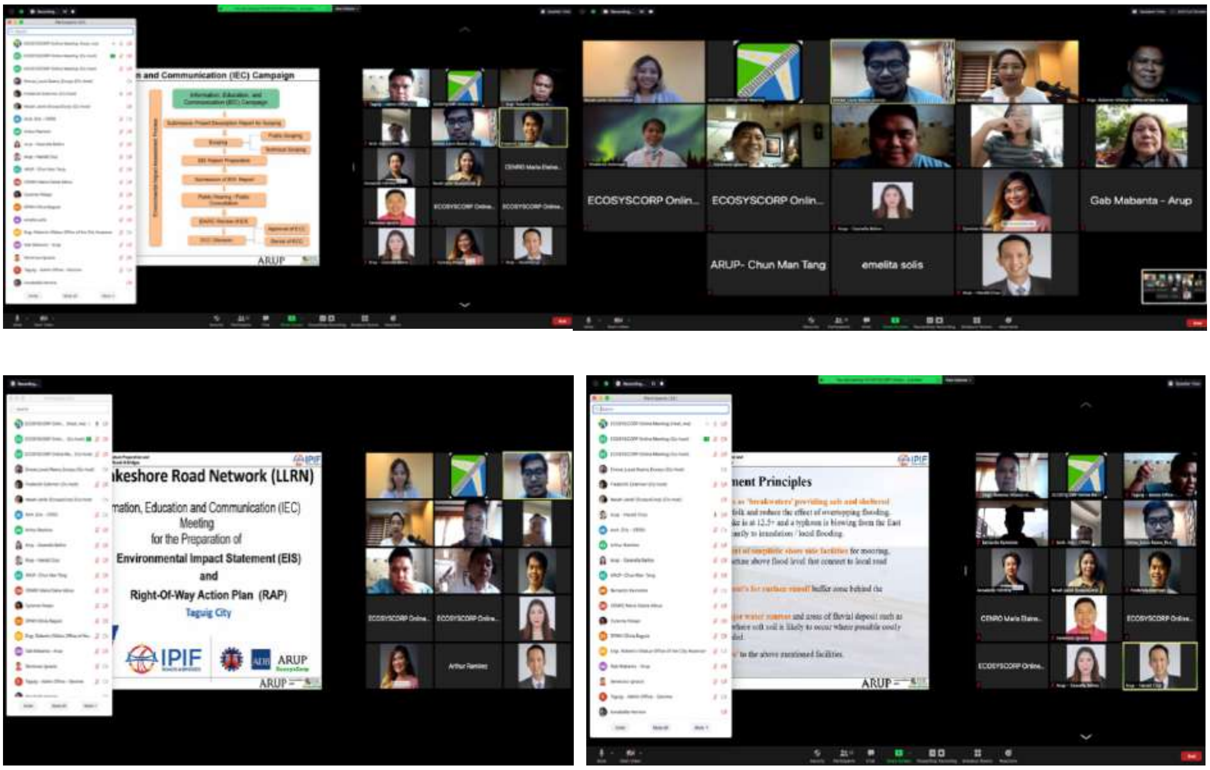


Figure 2.203 Screenshots of online meeting with the City Government of Taguig

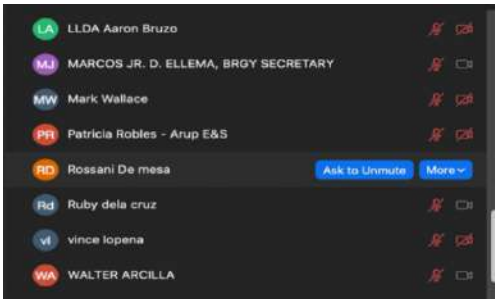
Muntinlupa City

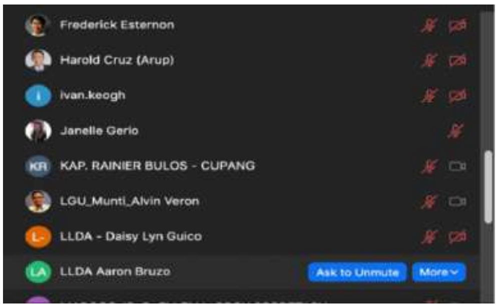
An online IEC meeting was held with the City Government of Muntinlupa in 28 July 2020 at 10 AM. There were 31 participants in said meeting, including key officials and representatives from the City Administrator's Office, City Planning and Development Office, City Environment and Natural Resource Office, City Assessor's Office, City Engineer's Office, Fisheries and Aquatic Resources Management Council, Department of Agriculture, and Lake Management Office. Representatives from the affected barangays of Tunasan, Cupang, Sucat, Poblacion, Putatan, and Bayanan were also present. There were also representatives from the Laguna Lake Development Authority (LLDA) who joined the meeting.

Among the issues and concerns raised during said meeting were the following:

- Placement of the alignment interchange in Susana Heights
- LLRN alignment with other projects, including the Paranaque Spillway Project
- Inclusion of DRRM and climate change in the EIA
- Provision of PPEs to participants to on-site activities

Figure 2.204 show the screenshots of the online IEC meeting with the City Government of Muntinlupa.





San Pedro City

An online IEC meeting was held with the City Government of San Pedro in 11 August 2020 at 10 AM. There were 22 participants in said meeting, including key officials and representatives from the City Administrator's Office, City Planning and Development Office, City Environment and Natural Resource Office, City Agriculturist's Office, and Urban Development and Housing Office. Representatives from the affected barangays of Cuyab and San Roque were also present.

Among the issues and concerns raised during said meeting were the following:

- Access to the lake as it affects the livelihood of residents
- Technical details of the viaduct and embankments, especially as it relates to reducing adverse impacts to people
- Notifying residents who stand to be displaced by the project
- NEDA acceptance and approval of the project
- Adherence to ADB safeguard policies
- Conduct of IEC at the barangay level

Figure 2.205 show the screenshots of the online IEC meeting with the City Government of San Pedro.

Figure 2.205 Screenshots of online meeting with the City Government of San Pedro.

Binan City

An online IEC meeting was held with the City Government of Binan in 30 June 2020 at 8 AM. There were 21 participants in said meeting, including key officials and representatives from the City Planning and Development Office, City Assessor's Office, and Liga ng mga Barangay. Representatives from the affected barangays of Dela Paz, Malaban, Casile, and San Antonio were also present. A representative from the Laguna Lake Development Authority (LLDA) also joined the meeting.

Among the issues and concerns raised during said meeting were the following:

- Displacement of residents who rely on the lake for their livelihood
- Possible adverse impacts of excavation activities in the lake and corresponding mitigating measures
- Sourcing and hauling of construction materials
- Technical details of the viaduct and embankments, especially as it relates to reducing adverse impacts to people
- Placement of entry and exit points in every city
- Placement of interchanges on San Pedro/Binan
- Structures to be affected
- Accuracy of maps shown
- Provision of assistance/compensation to PAPs
- Possible routes of heavy equipment and its impact on the barangay, especially on the integrity of barangay roads
- Maintaining the cleanliness of shorelines
- Grievance redress
- Coordination with affected barangays

Figure 206 show the screenshots of the online IEC meeting with the City Government of Binan

Figure 2.206 Screenshots of online meeting with the City Government of Binan

Sta Rosa City

An online IEC meeting was held with the City Government of Santa Rosa in 23 July 2020 at 10 AM. There were 25 participants in said meeting, including the City Mayor and key officials and representatives from the City Planning and Development Office, City Environment and Natural Resource Office, City Agriculturist's Office, City Assessor's Office, and Urban Development and Housing Office. Representatives from the affected barangays of Aplaya, Caingin, and Sinalhan were also present. A representative from the Laguna Lake Development Authority (LLDA) also joined the meeting.

Among the issues and concerns raised during said meeting were the following:

- Displacement of residents along the shoreline
- Updating of the City's Local Shelter Plan
- Coordination of site activities
- Health and safety protocols before the conduct of on-site activities
- Clarification on the flood mitigation component of LLRN

Figure 2.207 show the screenshots of the online IEC meeting with the City Government of Santa Rosa.

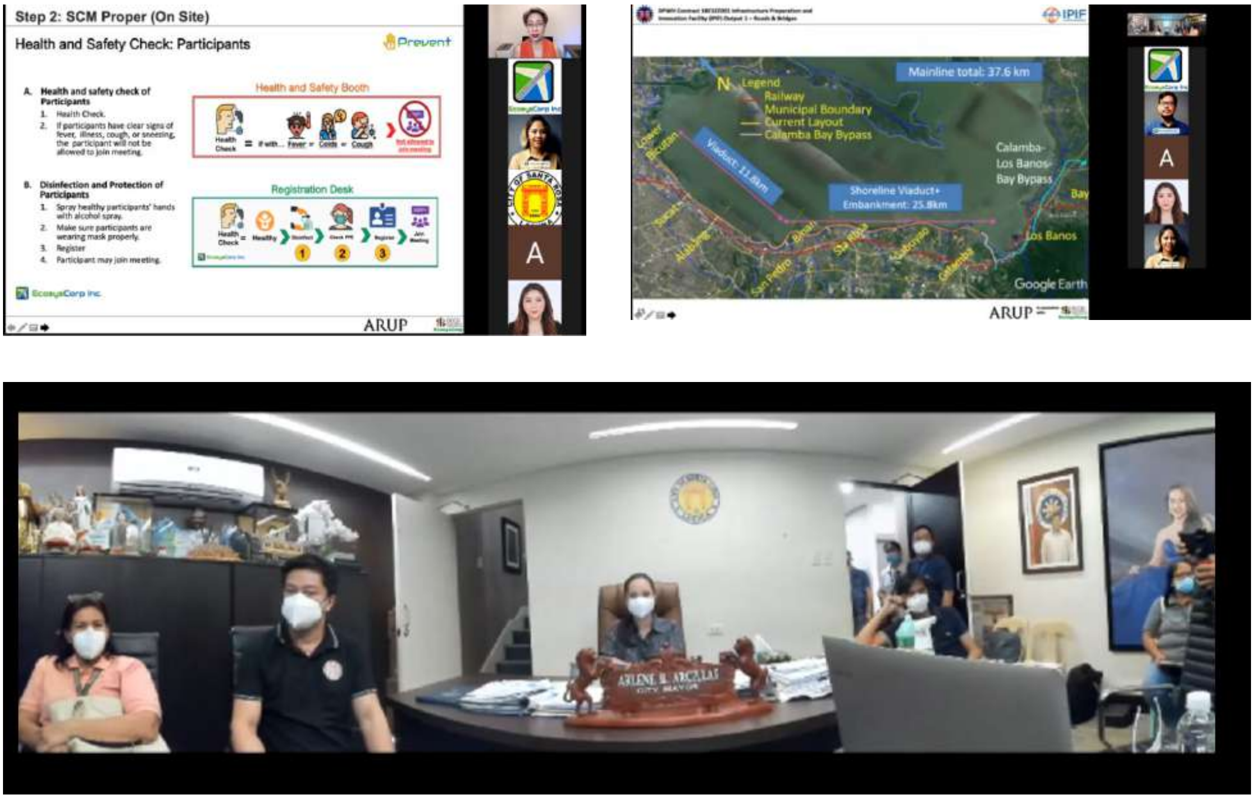


Figure 2.207 Screenshots of online meeting with the City Government of Santa Rosa

Cabuyao City

An online IEC meeting was held with the City Government of Cabuyao in 01 July 2020 at 10 AM. There were 20 participants in said meeting, including key officials and representative from the City Planning and Development Office, City Assessor's Office, and City Engineer's Office. Representatives from the affected barangays of Butong, Marinig, and Bigaa were also present.

Among the issues and concerns raised during said meeting were the following:

- Survey of PAPs
- Participants to on-site activities
- Distance of the project to the lakeshore
- Project impact on flooding in the area
- Placement of interchange in Cabuyao
- Access of fisherfolks
- Design of the structure
- Timing of conduct of meetings with barangays

Figure 2.208 show the screenshots of the online IEC meeting with the City Government of Cabuyao.

Figure **2.208** Screenshots of online meeting with the City Government of Cabuyao

Calamba City

An online IEC meeting was held with the City Government of Calamba in 24 July 2020 at 2 PM. There were 25 participants in said meeting, including key officials and representatives from the City Engineer's Office, Calamba Housing Office, City Agriculturist's Office, and City Assessor's Office. Representatives from the affected barangays of Uwisan, Sampiruhan, Lingga, and Lecheria were also present. A representative from the Laguna Lake Development Authority (LLDA) also joined the meeting.

Among the issues and concerns raised during said meeting were the following:

- Project design as it affects residents' source of livelihood and their access to it
- Height of vertical clearance
- Health and safety protocols before the conduct of on-site activities

Figure 2.209 show the screenshots of the online IEC meeting with the City Government of Calamba.

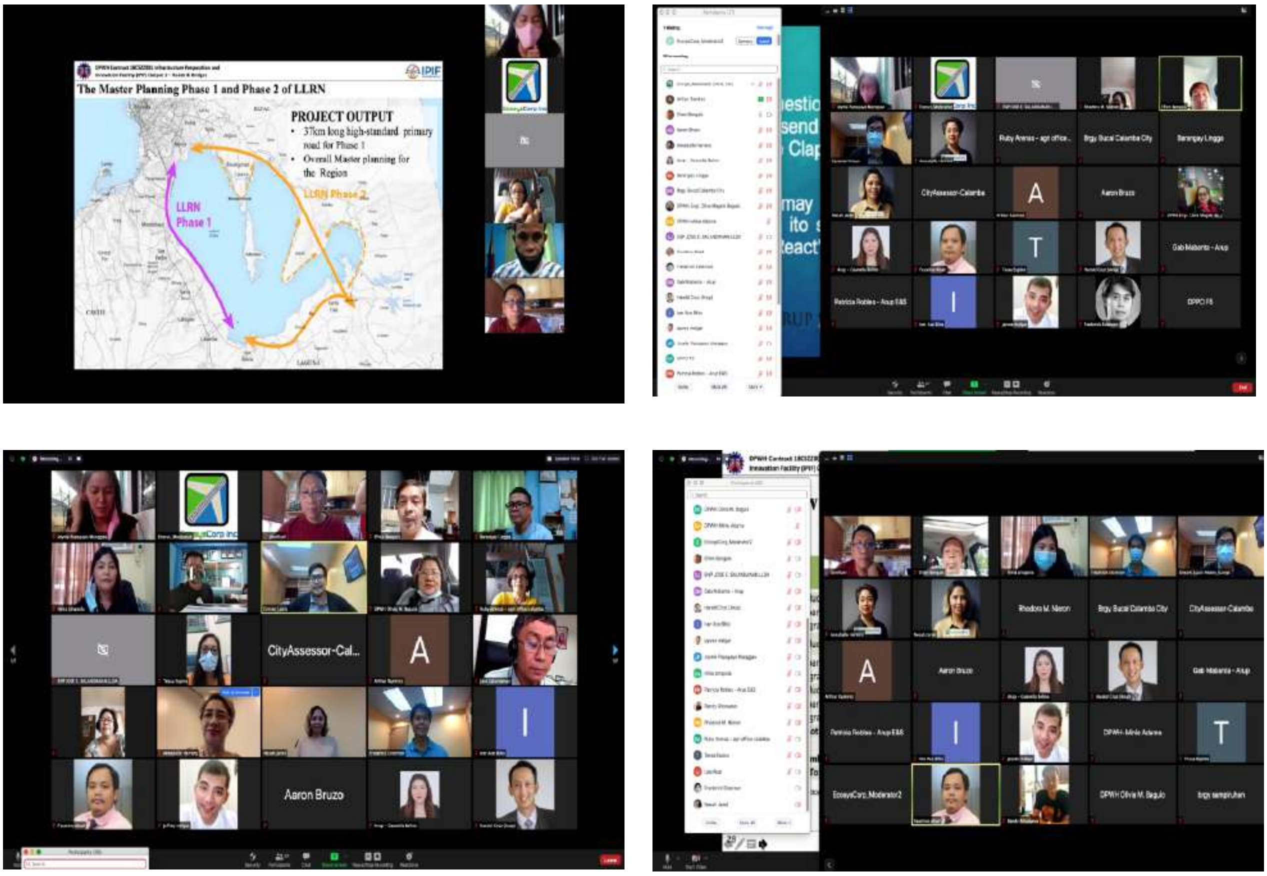


Figure 2.209 Screenshots of online meeting with the City Government of Calamba

Result of the socio-economic and perception survey

Profile of respondents

A total of 100 respondents took part in the household perception survey that was implemented from September 2020 to December 2020. Of this, 29% were female.

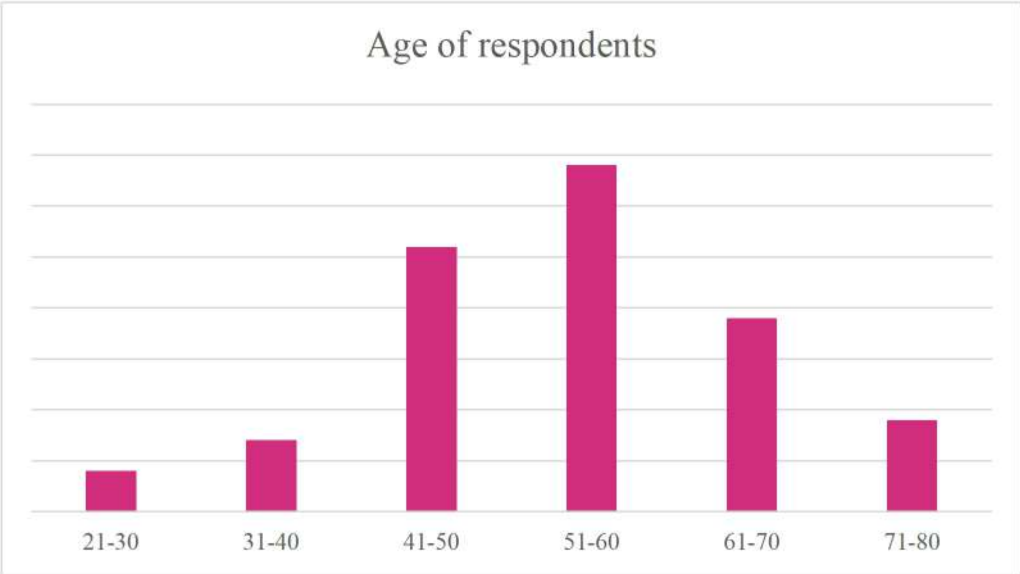


Figure 2.210 Age of survey respondents

The biggest proportion (34%) of the respondents were between the ages 51 to 60 years old followed by those between 41 to 50 years old at 26%.

Residents of Muntinlupa City comprised 39% of the respondents, while only 7% came from Sta. Rosa City in Laguna. Barangay Alabang in Muntinlupa City registered the highest number of respondents at 21%, followed by Barangay San Roque in San Pedro City, Laguna, at 17%. Majority (66%) of the respondents were married, while 10% said they were solo parents. Farmers/Fisherfolk was the most represented sector at 39%.

Source of income

More than a third (37%) of the respondents said they were self-employed, while four percent said they belong to the informal sector. Ten percent said their combined family income is between Php 5,001 to 10,000, while 11% said theirs is between PHP 500 to 5,000. More than half (54%) of the respondents did not give an answer.

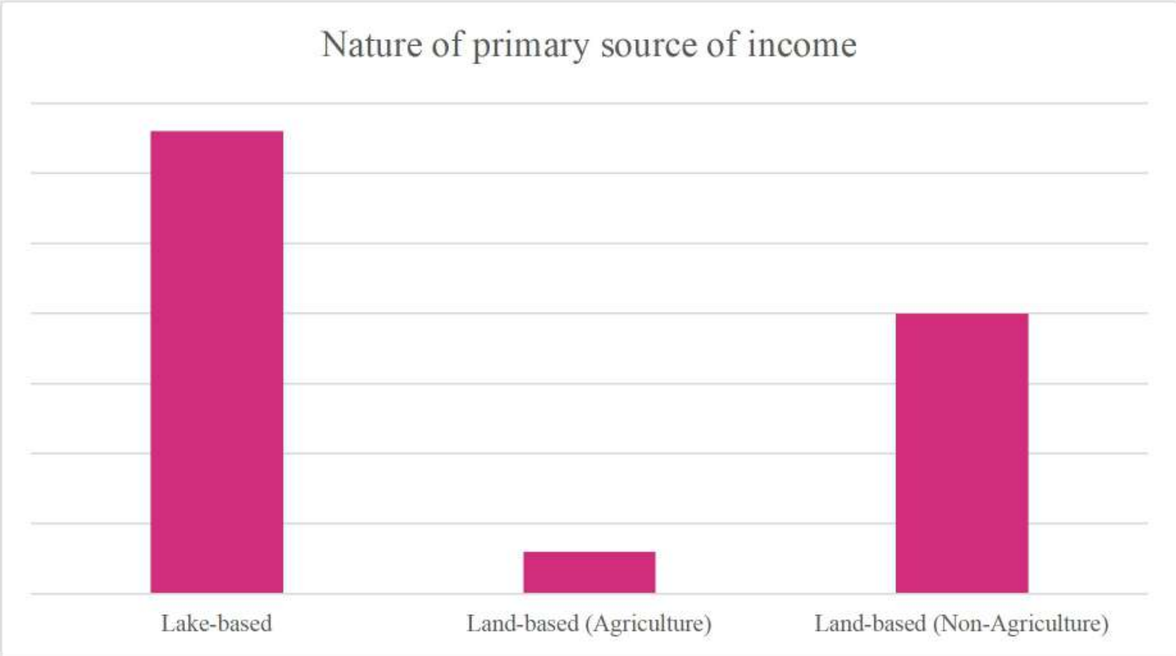


Figure 2. 211 Nature of respondents' primary source of income

More than a third (33%) said that their primary source of income is lake-based, compared to 20% non-agriculture land-based. Almost half (44%) did not give any answer.

Awareness of the project

Most (70%) of the respondents said they are aware of the LLRN Project. Majority (67%) recognize its positive impact in terms of reduced traffic. More than a third (39%), however, said that their fish cage/pen stand to be affected by the project, while 15% said they will lose their source of income. Another 12% said that their fishing/lake-based livelihood activity will be affected/stopped during the construction phase of the project. Despite these, however, 68% said that they support the project, with 36% recommending financial assistance to help addressed the issues and concerns that they articulated related to the project.

Figure 2.212 Awareness of the project

Public Scoping

Scoping is that stage in the EIA process where project information and impact assessment requirements are established to provide the proponent and stakeholders the scope of work and terms of reference for the EIS. And in adherence to the principle of public participation upheld by DENR Administrative Order 2017-15 (Guidelines on Public Participation under the Philippine Environmental Impact Statement (PEIS) System), the conduct of public scoping involves identified project stakeholders.

The public scoping activities for the Laguna Lakeshore Road Network (LLRN) Project were conducted in November 10, 11, 26, 2020 and January 13, 2021. The public scoping set up was a combination of online and onsite activities. This is in compliance with the minimum Public Health Standards for COVID-19 Mitigation Risk set by the Department of Health thru DOH Administrative Orders 2020-15 and 2020-16, and in consonance with EMB Memorandum Circular No. 2020-30, the alternative method for ensuring public participation selected is via the blended video conferencing and small group meetings, as well as focus group discussions with important stakeholders.

A second set of scoping meeting was led and initiated by DENR-EMB Central Office in June 17, 2021, this time through Zoom. A list of invitees was accomplished based on the identified stakeholders and participants to the initial public scoping held. A date was set by the EMB and invitations were sent. The scoping meeting was divided into two in consideration of the project coverage and number of stakeholders---one was held in the morning and another one was held in the afternoon.

Participants to the public scoping activities done for LLRN consisted of fishermen, boat operators, fish cage owners, farmers (kangkong or water spinach), ambulant vendors, business owners, transport drivers/operators, local government officials, women, and senior citizens.

Issues and concerns that were raised mostly refer to the project's potential adverse impacts to those depending on Laguna Lake for their livelihood. The fishing community surrounding the lake expressed concern on the possible impacts of the project activities to the water and its resources. They pointed out how such impacts can, in turn, affect their livelihoods. Refer to **Annex A** for the summarized issues, concerns and recommendations gathered from the series of stakeholder consultation meetings done.

There were also concerns expressed by groups whose sources of livelihood are not necessarily lake-based but also stand to be adversely affected should fisherfolks encounter challenges in their business. They acknowledged the heavy reliance of some households to resources found on the lake and how these interconnects with the whole local economy. There were also business owners who expressed concern over the structures that will be built in their communities and how these may not only affect the cityscape (aesthetics) but may also affect the flow of customers.

There were also concerns on the limitations to mobility that the project may pose to some pedestrians. This concern was most prominently raised by the elderly.

Below is the list of issues and concerns that were raised during the series of public scoping activities done for LLRN:

- Toxicity in the water and fish may increase if the lake is dredged during construction.
- Fish breeding may get affected if the fish sanctuary is not restored or maintained.
- Possible accumulation of water lilies due to the structure that will be built.
- Water turbidity may increase which may negatively affect fishing activities.
  Dredging activities will make the lake floor deeper thus fisherfolk would require more materials to restore their fish pens and fish cages.
- Water from Laguna Lake may deteriorate due to construction activities which may negatively affect kangkong farming.

- If the construction is near the fish sanctuary, fish breeding activity will be disrupted, affecting the fish populations of Laguna Lake.
- The structure may cause stagnation of the water, which would negatively affect kangkong farmers.
- Fish growth in fish pens may be severely affected due to construction noise resulting to smaller sickly fish.
- Noise and vibration from the construction and operation phases may scare away the fish.
- Noise and vibrations may reach up to 500 meters. Fisherfolk may need to travel 1000 meters in order to fish.
- Limited access to the lake.
- Possible displacement among fisherfolk.
- Local hiring.
  Possible income-generating activities for women.
- Conduct of skills assessment and livelihood training programs for the affected fisherfolk.
- Communal fish cage project after the LLRN construction.
- A dedicated access route in the lake.
- Provision of financial assistance to fisherfolk who will be affected and displaced by the project.
- There will be less parking space because of the project hence, less customers.
- Possible adverse effect of the viaduct on the cityscape.
- Customer access after the project construction.
- Reduced traffic after the project.
- Proper information dissemination about the project.
- As an ambulant vendor, the project will disrupt my daily means of livelihood as I will lose
- If structures are close to the shoreline, the total number of fish in the lake might diminish because fish lay their eggs near the shoreline.
- Rehabilitation of the environment if it is altered after the project construction.
- Planting kamachile and yangkaw to aid in the rehabilitation of the environment.

Details of Public Scoping Activities

The public scoping activities, through online and onsite Barangay Level Stakeholder Consultation Meeting (i.e., IEC and FGD) for the LLRN project were done while observing strict health protocols.

Figure 2.213 Photo documentation of the series of focus group discussions held in project-affected barangays.

FGD with stakeholders in Binan City.

FGD with stakeholders in Muntinlupa City.

FGD with stakeholders in Cabuyao City.

FGD with stakeholders in Calamba City.

FGD with stakeholders in San Pedro City.

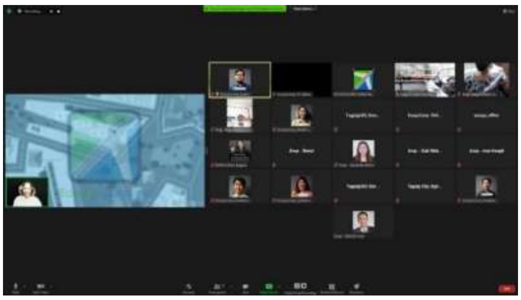
FGD with stakeholders in Muntinlupa City.

FGD with stakeholders in Calamba City.

FGD with stakeholders in Muntinlupa City.

FGD with stakeholders in San Pedro City.

FGD with stakeholders in Santa Rosa City.



Onsite and online attendees to the Stakeholders' Online Stakeholders Consultation

Meeting Consultation Meeting in Sucat, Muntinlupa City. **Table 2.9988** presents the issues and concerns raised per locality during the stakeholder engagement.

Table 2.9988 Issues and concerns per locality

CITY/MUNICIPALITY	ISSUES AND CONCERNS
Taguig City **Barangays Lower Bicutan, Upper Bicutan, Bagumbayan**	Access of fisherfolk to the lake Clearing of water hyacinth on the lake Identification of PAPs Coordination between the DPWH and LLDA Alternative livelihood for those who will be displaced
Muntinlupa City (Sept. 16) **Barangays Buli, Cupang, Poblacion, Alabang, Bayanan, Putatan, Tunasan**	Target date for construction Manner of identifying PAPs Area for the relocation site Extent of land to be acquired from private properties Height of the viaduct Distance of the LLRN from the shoreline Inland areas in the City where structures will be built Access of fisherfolk, especially during construction Ensuring access of fisherfolk by putting it in writing Project impact to fish cages Impact of noise and vibration to fish catch Project impact to kangkong (water hyacinth) farmers Manner of identifying project-affected fisherfolk Construction of posts on water that might affect fish catch Compensation for PAPs Accumulation of water lilies Site for relocation Design of the interchanges
Muntinlupa City **Barangay Sucat**	Identification of PAPs for compensation Coordination between LIACs for LLRN and NSCRP Relocation for PAPs in Sucat Reclamation sites to be turned into relocation site for displaced residents of Sucat Compensation options for PAPs Dissemination of information about the project, especially relocation. Dissemination of information about the project Rights of and compensation of PAPs, especially renters.
Biñan City **Barangays Dela Paz, Malaban, Casile, San Antonio**	Possible re-alignment to avoid some properties Access roads will be affected by the project Compensation for PAPs Dissemination of information about the Project
Cabuyao City **Barangays Bigaa, Gulod**	Compensation for renters Compensation for multiple occupants of structures/properties Treatment for PAPs with tax declaration only or with land titles that are not named after them Dissemination of information about project activities Extent of project impact Manner and execution of compensation and relocation for PAPs
Cabuyao City **Barangays Marinig, Baclaran, Mamatid, Butong**	Amenities/facilities on the relocation site Measurement of the alternative road project of the government Relocation site PAPs with land titles that are named after their deceased parent Project impact on livelihoods Local hiring Lake water will become murky during the construction phase Areas to be traversed by the alignment

CITY/MUNICIPALITY	ISSUES AND CONCERNS
	Flood prevention
Sta. Rosa City **Barangays Sinalhan and Aplaya**	Site for relocation Identification of PAPs and structures that will be affected Compensation for PAPs Properties that will be traversed by the alignment Identification of PAPs Compensation for PAPs Project's environmental impacts to livelihood Livelihood assistance to fisherfolk Properties to be traversed by the alignment LLRN distance from the shoreline
Calamba City **Barangays Lecheria, Halang, Bucal**	Barangays to be traversed by the project Presence of fish sanctuary in Lecheria, Bucal, and Pansol Assurance of compensation for affected fisherfolk River of Bucal that will be affected Fisherfolk access to the Lake Project impact on nearby farm lots Compensation for PAPs
San Pedro City **Barangays San Roque, Cuyab**	Distance f LLRN from the shoreline Areas to be traversed by LLRN Residential structures to be affected Project might worsen flooding in San Roque and Cuyab Explanation on the catchment drain and how it will affect flooding in the barangay Compensation for PAPs, including affected livelihoods Rehabilitation of access roads to be affected Location of interchange exits Design of the LLRM, if road-dike structure Project consideration for the fish sanctuary in San Pedro City

A second set of scoping meeting was led and initiated by DENR-EMB Central Office in June 17, 2021, this time through Zoom. A list of invitees was accomplished based on the identified stakeholders and participants to the initial public scoping held. A date was set by the EMB and invitations were sent. The scoping meeting was divided into two in consideration of the project coverage and number of stakeholders---one was held in the morning and another one was held in the afternoon.

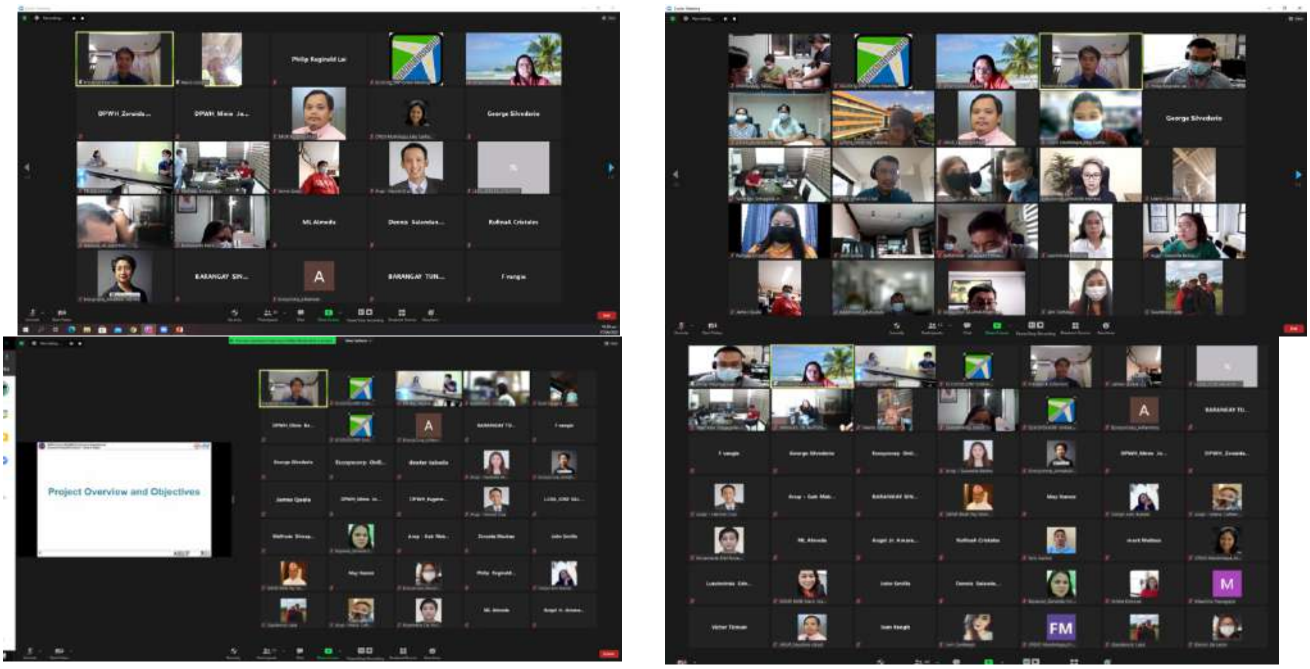
Most of the concerns raised by stakeholders this time mostly centered on the convergence of different projects that are being communicated to local government units and stakeholders, as well as the sufficient dissemination and level of project details shared to stakeholders. There was obvious confusion among stakeholders, especially LGUs, given the numerous infrastructure projects that are being shared to them. Stakeholders also expressed uncertainties, which was more prominent among fisherfolks who felt powerless and without a voice in the process. The Study Team, for their part, as led by the DPWH, assuaged these concerns and uncertainties by explaining the processes that proposed projects go through. It was clarified that the government and its concerned agencies are not remiss in ensuring the convergence of proposed projects and that appropriate steps are being undertaken to ensure that these projects are well planned, with the proper and sufficient involvement of stakeholders.

The following lists down the issues raised in said scoping meetings:

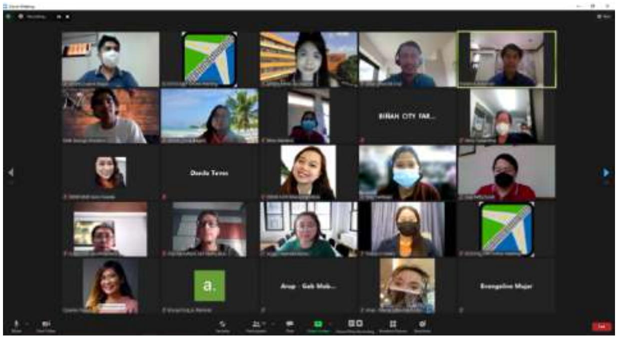
- Synchronization of local plans with those of the national government, including proposed projects.
- Project deign consideration of local situation, i.e., the provision of fishery basin or docking port for fisherfolks.
- Resettlement and compensation of those who will be displaced, especially the small fisherfolk who live by the lake.
- Inclusion of the rehabilitation of fish cages in the resettlement of those who will be displaced by the project.
- Possible adverse effects of the project, including flooding and impediment to access of small fisherfolks to their source of livelihood.
- Land acquisition.
- Upgrading/maintenance of local roads.
- Convergence of different national projects.
- Inclusion of bike lanes in the project design.
- Conduct of information dissemination for the project.
- Establishment of toll system.

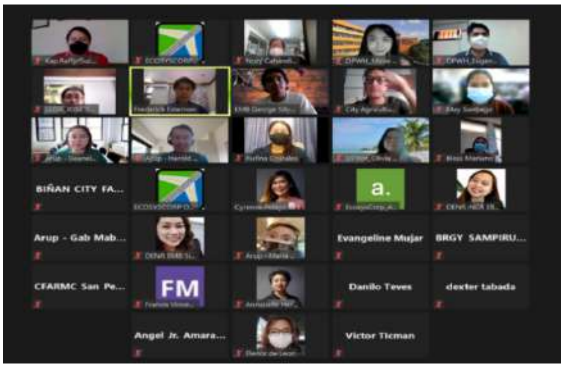
The following are the screenshots of the morning and afternoon virtual scoping meetings organized by the EMB:

Figure 2.214 Screenshots of the virtual public scoping meetings initiated by the EMB.



Screenshots of the morning session.






Screenshots of the afternoon session.

Table 2.9989 presents the issues and concerns raised per sector during the second set of public scoping meetings.

Table 2.9989 Issues and concerns per sector

SECTOR	ISSUES AND CONCERNS
LGUs/BLGUs	• Project conflict with LGU Santa Rosa's plan to construct a People's Park in the project site in the city. • Mayor Arcilla's preference not to have an exit point at Sinalhan to avoid displacement and further congestion in said area. • LLRN Project's contribution in resolving the issue on a complained road by Brgy, Lawa in Calamba City. • Possible flooding that the project will cause and its adverse impact on small fishermen and residents along the shores of the lake. • Inclusion of bike lane in the project design. • Establishment of toll system. • Convergence of different national projects.
LLDA	• Project design to accommodate planned ferry vessels passing under the viaducts of the LLRN.
Fisherfolks, BFARMC, residents by the lake	• Flooding of their community • Displacement of and commensurate compensation for small fisherfolks who will be directly affected. • Impediments to access of fisherfolks to their sources of livelihood. • Sufficient sharing of project details to fisherfolks and residents who will be directly affected by the project. • Land acquisition.

2.5.5 Traffic

2.5.5.1 Methodology

A transport model has been developed by Japan International Cooperation Agency (JICA) using the STRADA software. In principle, the transport model adopts the conventional 4-stage modelling approach including Trip Generation, Trip Distribution, Modal Split and Trip Assignment. However, only the Trip Assignment Model has been converted to the CUBE (a commercial modelling software) platform and provided to DOTr. The CUBE transport network covers the greater Manila area and is illustrated in **Figure 2-94**. The CUBE model has been provided by DOTr for use in this Study.

The CUBE model has been established for Existing Year 2014 and projected to Design years 2020, 2025 and 2035.

Given the strategic network coverage of this CUBE model and it is recognised by the authority, the CUBE model is considered applicable in this Study to fast-track the overall forecasting process with some modifications. The model modification has been discussed as follows.

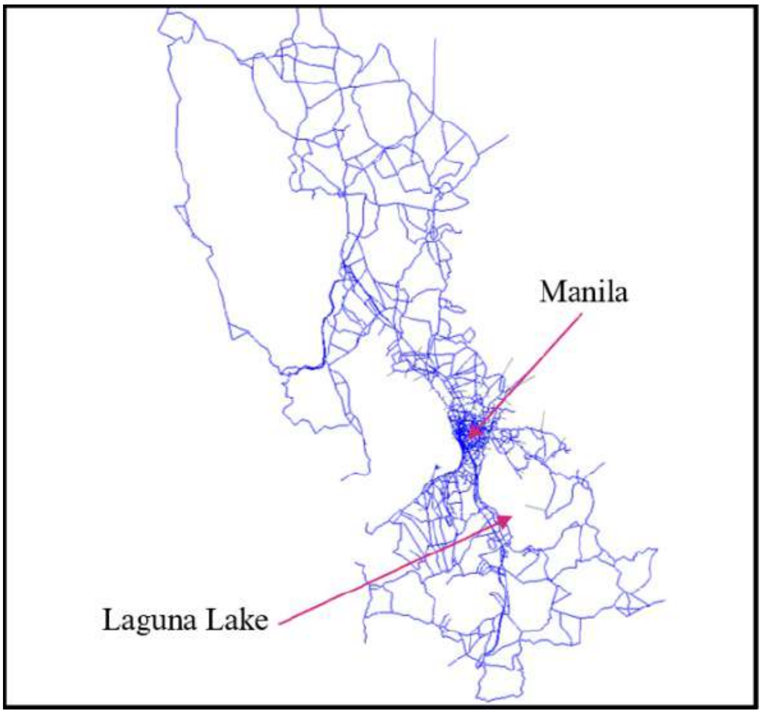


Figure 2-94 CUBE Transport Network

The CUBE model elements received are summarised in **Table 2.22**.

Table 2.22 Model Elements of the Trip Assignment CUBE Model

Element \ Year	2014	2020	2025	2035
Bare network	√		√	√
Loaded network	√	√[5]		
Daily Demand Matrices		√	√	√
Daily Assignment Matrices	√	√		

Note:

1. Bare network means the pure model network without traffic assignment result

2. Loaded network means the model network with traffic assignment result
3. Daily demand matrices are person trip matrices by modes of walk, private, public, truck and others. These are not the matrices for transport model assignment
4. Daily assignment matrices are person trip matrices by modes of motorcycle, private car, jeepney, bus and truck and they are the matrices for transport model assignment
5. The loaded network of 2020 is based on the assignment of the 2020 daily assignment matrices onto the 2025 bare network. There is no bare network for year 2020.

Model limitations and input assumptions adopted into the transport model are discussed in detail in **Appendix O . B2 Traffic Study, and Highway Alignment and Design** Report. In general, the model was adjusted to account for:

- City/municipality population changes at night-time and day-time
- Planned road infrastructure projects determined by the model, updated to include missing information: (i) NLEX-SLEX Connector Road; (ii) NLEX Harbour Link (Segment 8.2); (iii) Cavite-Tagaytay-Batangas Expressway; (iv) Tarlac-Pangasinan-La Union Expressway; (v) Molino Link; and (vi) Calamba-Los Banos-Bay Bypass Road
- Toll assumptions
- Value of time (VOT) used in the Economic Analysis is JICA, MMUTIS Update and Enhancement Project (MUCEP) and VOT used in Traffic Model is JICA, MMUTIS Update and Enhancement Project (MUCEP)

Table 2.23 Value of Time based on JICA study (PhP/min/person in 2014 price)

Source	JICA's Model		
Vehicle Type\ Year	2025	2026	2035
Motorcycle	11.0	11.5	15.5
Private Car	11.0	11.5	15.5
Jeepney	11.0	11.5	15.5
Bus	7.9	8.2	11.1
Truck	7.9	8.2	11.1

- Passenger Car Unit and Occupancy

Table 2.24 PCU Factor and Occupancy

Type	PCU Factor in the CUBE model	PCU Factor adopted in this Study[A]	Occupancy[B]
Motorcycle	0.3	0.75	1.20
Private Car	1.0	1.0	1.58
Jeepney	1.5	1.5	8.8
Bus	2.5	2.0	34.19
Truck	2.5	2.5	2.17

[A] Based on DPWH typical classifications, except for motorcycles, which are adjusted referencing international practice, such as Hong Kong's Transport Planning and Design Manual
[B] Based on JICA's traffic count and occupancy survey

- Design Speed and Capacity

Table 2.25 Design Speed and Capacity by Road Type

Road Type	Road Category	Carriageway Type	Capacity1-way pcu/day/lane	Maximum Speed (km/h)
Inside EDSA	Local road	Single	2,200	30
	Secondary	Single	4,400	40
	Primary	Single	6,600	45
Outside EDSA Inside Metro Manila	Secondary	Single	7,700	50
	Primary	Single	8,250	60
	Secondary	Divided	14,000	70
	Primary	Divided	16,500	80
Outside Metro Manila	Local road	Single	8,000	30
	Secondary	Single	11,000	55
	Primary	Single	15,400	60
Urban / Intercity	Access/ egress	Single	15,000	80
	Expressway	Single	17,000	80
	Expressway	Divided	20,000	100

- Speed Flow Relationship

Travel speed is evaluated based on the typical speed-flow function as shown in **Figure 2- 95**.

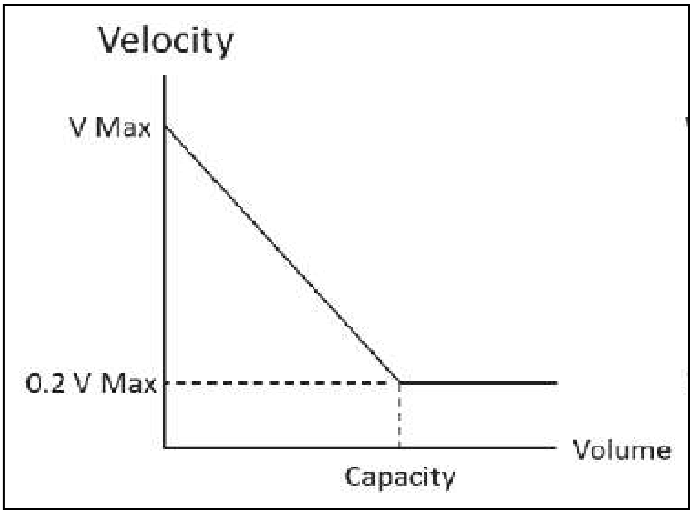


Figure 2- 95 Adopted Speed-Flow Relationship in the CUBE Model

The model was validated based on the 2014 traffic count by JICA and further revalidated based on latest traffic count survey data conducted under this project.

A 24-hour vehicle classified count survey along key roads and junctions in Bataan and Cavite was conducted by the Transport and Traffic Planners Inc (TTPI). Survey locations are provided in **Table 2.26**. Other traffic survey details are provided in **Appendix O . B2 Traffic Study, and Highway Alignment and Design** Report.

Table 2.26 Description of Survey Sites

Screenlines/ Key Roads	Site ID	Location
Screenline A-A	A1	Governor's Drive, Naic
	A2	Naic-Indang Road
	A3	Trece Martires – Indang Road
	A4	Crisanto M. de los Reyes Avenue
	A5	Emilio Aguinaldo Highway
	A6	Santa Rosa – Tagaytay Road
	A7	Pan-Philippine Highway
	A8	South Luzon Expressway
	A9	South Manila Road
Screenline B-B	B1	Dr. Arcadio Santos Avenue
	B2	Alabang – Zapote Road
	B3	Filinvest Avenue
	B4	Muntinlupa – Cavite Expressway
	B5	Susanna Avenue
	B6	Magsaysay Road
	B7	San Francisco Road
	B8	Governor's Drive, Carmona
	B9	LIIP Avenue
	B10	Santa Rosa – Tagaytay Road
	B11	Greenfield Parkway
	B12	Pulo – Diezmo Road
	B13	Silangan Industrial Park Road
	B14	Mayapa Road
	B15	CPIP Main Road
	B16	Pan-Philippine Highway
	B17	Talisay – Tanauan Road
Screenline C-C	C1	Radial Road 1
	C2	Daang Radyal Blg 2
	C3	Dr. Arcadio Santos Avenue
	C4	Carlos P. Garcia Ext
	C5	Pres. E. Aguinaldo
	C6	South Luzon Expressway
	C7	Dir. A. Bunye
Screenline D-D	D1	Marcos Highway
	D2	Sumulong Highway
	D3	Ortigas Avenue
	D4	Bonifacio Avenue
	D5	East Bank Road
	D6	West Bank Road
	D7	Ejercito Avenue
Screenline E-E	E1	Quirino Highway, SM City, SJDM
	E2	North Luzon Expressway, Marilao
	E3	McArthur Highway
	E4	Paco, Obando, Bulacan
Key Roads	K1	C-6
	K2	M.L. Quezon Street
	K3	General Santos Avenue
	K4	Meralco Road
	K5	Manila South Road
	K6	Manila South Road
	K7	South Luzon Expressway
	K8	Governor's Drive
	K9	Balibago Road
	K10	South Luzon Expressway

Screenlines/ Key Roads	Site ID	Location
	K11	Manila South Road
	K12	Real Road
	K13	Manila South Road
	K14	National Highway, Calauan, Calabarzon
	K15	MRT Avenue
	K16	Montillano Street
	K17	A. Mabini Street
	K18	Brgy Sinalhan
	K19	JP Rizal Street
	K20	San Juan Road
	K21	Sto Domingo
	K101	AH26, Pagsanjan
	K102	Paete-Pakil-Famy Diversion Road
	K103	Famy-Real-Infanta Road, Famy
	K104	Mabitac
	K105	J Rizal Street
	K106	Manila East Road
	K107	Pililla-Jaol-Jala-Pakil Road
	K108	Sampaloc Road
	K109	R-5, Baras
	K110	J.P. Rizal Street, Baras

2.5.5.2 Traffic Model Trip Assignment Matrix

The trip matrix is the key component of the traffic forecast on the road network as it presents the number of trips between one zone to another zone, which would find the most suitable path (route) from the origin zone to the destination zone in the trip assignment process. The assignment of trips of every origin-destination zone pair would then form the total traffic on each major corridor in the road network. The sector definition is illustrated in **Figure** 2- 96.

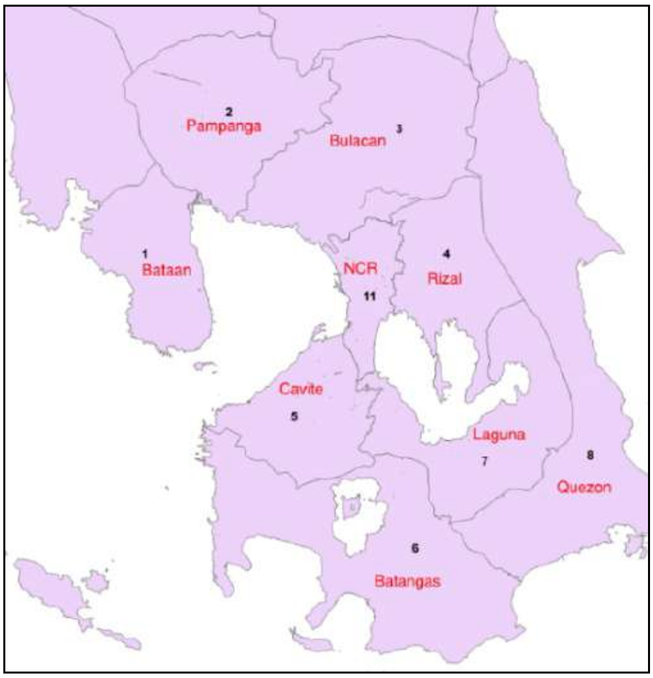


Figure 2- 96 Sector Definition of Trip Matrix

The CUBE Trip Assignment Model provides the daily demand matrices for year 2020, 2025 and 2035 and the daily assignment matrices for years 2014 and 2020. Conversion factors were derived from the 2020 demand and assignment matrices, and applied to the demand matrices of 2025 and 2035. The trips are estimated based on the PSA population data, adopting similar trip rate and distribution pattern of adjacent provinces, and fed into the assignment matrix for design years 2020, 2025 and 2035.

After the trip matrix development and update, the total trip demand of the daily assignment matrices for design year 2020, 2025 and 2035 are shown in **Table 2.27** to **Table 2.29**.

Table 2.27 Updated Total Daily Sector-Sector Person Trips (‘000) for 2020 Assignment Matrix

Sector	1	2	3	4	5	6	7	8	11	Total
1: Bataan	596	66	35	9	4	0	0	0	14	**723**
2: Pampanga	66	2,014	133	44	15	0	0	0	57	**2,330**
3: Bulacan	35	128	2,677	11	7	0	9	73	363	**3,302**
4: Rizal	9	44	11	1,835	7	37	58	64	425	**2,490**
5: Cavite	4	15	4	5	2,682	145	62	0	346	**3,264**
6: Batangas	0	0	0	37	145	2,084	192	43	38	**2,539**
7: Laguna	0	0	9	58	65	177	3,004	134	165	**3,612**
8: Quezon	0	0	73	64	0	43	131	1,740	21	**2,072**
11: NCR	13	56	337	411	365	56	151	29	12,588	**14,005**
Total	**723**	**2,323**	**3,279**	**2,474**	**3,290**	**2,543**	**3,606**	**2,083**	**14,015**	**34,338**

Note:

1. Sector-sector trip number zero in orange box is absolute zero, while for sector-sector trip number zero in white box, it is a number rounded to zero
2. The figures are presented in thousands. The figures in red represent the self-containment trips.

Table 2.28 Developed Total Daily Sector-Sector Person Trips (‘000) for 2025 Assignment Matrix

Sector	1	2	3	4	5	6	7	8	11	Total
1: Bataan	612	79	42	10	5	0	0	0	16	**764**
2: Pampanga	79	2,063	155	53	18	0	0	0	65	**2,431**
3: Bulacan	42	149	2,842	13	10	0	11	88	445	**3,599**
4: Rizal	10	53	14	1,979	9	44	99	77	464	**2,750**
5: Cavite	5	18	6	7	2,927	175	85	0	419	**3,641**
6: Batangas	0	0	0	44	174	2,157	237	52	40	**2,704**
7: Laguna	0	0	11	100	89	221	3,920	192	178	**4,710**
8: Quezon	0	0	88	77	0	52	189	1,806	24	**2,235**
11: NCR	16	64	412	463	446	60	161	32	11,820	**13,473**
Total	**764**	**2,425**	**3,569**	**2,745**	**3,678**	**2,709**	**4,700**	**2,247**	**13,471**	**36,308**

Note:

1. Sector-sector trip numbered zero in orange box is absolute zero, while for sector-sector trip numbered zero in white box, it is a number rounded to zero
2. The figures are presented in thousands. The figures in red represent the self-containment trips.

Table 2.29 Developed Total Daily Sector-Sector Person Trips (‘000) for 2035 Assignment Matrix

Sector	1	2	3	4	5	6	7	8	11	Total
1: Bataan	659	103	54	14	7	0	0	0	21	**857**
2: Pampanga	103	2,232	200	69	23	0	0	0	83	**2,710**
3: Bulacan	54	193	3,259	17	16	1	13	117	607	**4,277**
4: Rizal	14	69	18	2,260	13	58	114	103	595	**3,244**
5: Cavite	7	23	8	9	3,437	236	106	1	609	**4,436**
6: Batangas	0	0	1	58	236	2,359	293	69	46	**3,062**
7: Laguna	0	0	13	115	113	277	4,380	238	206	**5,343**
8: Quezon	0	0	117	102	0	69	235	1,986	31	**2,541**
11: NCR	21	82	557	605	654	66	187	40	12,306	**14,518**

Sector	1	2	3	4	5	6	7	8	11	Total
Total	**857**	**2,701**	**4,230**	**3,250**	**4,499**	**3,067**	**5,328**	**2,554**	**14,502**	**40,988**

Note:

1. Sector-sector trip numbered zero in orange box is absolute zero, while for sector-sector trip numbered zero in white box, it is a number rounded to zero
2. The figures are presented in thousands. The figures in red represent the self-containment trips.

Assumptions, detailed methodology, and resulting developed CUBE 2025 and 2035 initial trip assignment matrices are provided in **Appendix O . B2 Traffic Study, and Highway Alignment and Design** Report.

As the transport model is only an Assignment Model, the model revalidation is mainly to adjust the trip matrices to match with the traffic survey count data. The adjustment made to the 2020 initial assignment trip matrices was then carried forward to 2025 and 2035 matrices and these matrices were fine-tuned based on the latest observed traffic pattern.

Table 2.30 Total Daily Sector-Sector Person Trips ('000) for 2025 Assignment Matrix (without LLRN)

Sector	1	2	3	4	5	6	7	8	11	Total
1: Bataan	601	23	13	2	1	0	0	0	8	648
2: Pampanga	22	2,034	75	14	4	0	1	0	22	2,171
3: Bulacan	12	73	2,807	10	7	0	4	17	408	3,339
4: Rizal	2	14	12	1,960	7	8	39	20	556	2,619
5: Cavite	1	5	7	3	2,902	55	162	0	520	3,655
6: Batangas	0	0	0	8	57	2,128	176	14	17	2,400
7: Laguna	0	0	3	38	181	171	3,302	60	148	3,902
8: Quezon	0	0	17	20	0	13	62	1,781	4	1,897
11: NCR	8	23	385	567	527	31	162	4	12,407	14,115
Total	646	2,172	3,319	2,622	3,686	2,407	3,909	1,896	14,090	34,746

Note:

1. For sector-sector trip numbered zero, it is a number rounded to zero
2. The figures are presented in thousands. The figures in red represent the self-containment trips.

Table 2.31 Total Daily Sector-Sector Person Trips ('000) for 2035 Assignment Matrix (without LLRN)

Sector	1	2	3	4	5	6	7	8	11	Total
1: Bataan	652	47	26	5	2	0	0	0	13	746
2: Pampanga	46	2,214	121	30	9	0	1	0	40	2,461
3: Bulacan	25	118	3,246	15	14	0	7	46	569	4,039
4: Rizal	6	30	17	2,272	11	22	55	46	687	3,145
5: Cavite	3	10	10	5	3,427	116	191	0	708	4,470
6: Batangas	0	0	0	22	118	2,343	237	30	23	2,773
7: Laguna	0	0	5	53	213	231	3,920	104	182	4,709
8: Quezon	0	0	45	45	0	30	107	1,971	10	2,209
11: NCR	13	41	533	713	738	38	196	12	13,009	15,292
Total	744	2,460	4,004	3,161	4,531	2,780	4,713	2,209	15,241	39,844

Note:

1. For sector-sector trip numbered zero, it is a number rounded to zero
2. The figures are presented in thousands. The figures in red represent the self-containment trips.

To tie in with the implementation programme of LLRN, it is assumed that LLRN will be in place by year 2026. The trip matrices of year 2025 has been projected to 2026 by adopting the annual growth rate of total trip demand between years 2025 and 2035 trip matrices. The annual growth rate is derived by vehicle types. For truck matrix, the annual growth of 6% has been adopted. The projected 2026 daily person trip assignment matrix is presented in **Table 2.32**.

Table 2.32 Total Daily Sector-Sector Person Trips ('000) for 2026 Assignment Matrix (without LLRN)

Sector	1	2	3	4	5	6	7	8	11	Total
1: Bataan	614	23	13	2	1	0	0	0	8	662
2: Pampanga	22	2,076	76	14	4	0	1	0	22	2,216
3: Bulacan	12	75	2,866	10	7	0	5	17	417	3,410
4: Rizal	2	14	12	2,003	7	8	40	21	568	2,675
5: Cavite	1	5	8	3	2,962	56	166	0	531	3,732
6: Batangas	0	0	0	8	58	2,172	180	14	17	2,449
7: Laguna	0	0	3	38	185	174	3,370	61	151	3,983
8: Quezon	0	0	17	20	0	13	64	1,818	4	1,936
11: NCR	8	24	393	580	539	32	166	4	12,664	14,410
Total	660	2,217	3,389	2,678	3,764	2,456	3,991	1,935	14,383	35,473

Note:

1. For sector-sector trip numbered zero, it is a number rounded to zero
2. The figures are presented in thousands. The figures in red represent the self-containment trips.

In application, with LLRN incorporated into the CUBE transport network, the travel cost for some origin-destination pairs, especially Laguna and Manila sectors, would change and lead to change in trip redistribution. The change in distribution pattern was estimated based on the derived trip distribution curves and the changes were applied to the updated trip assignment matrices (without LLRN), as presented in **Table 2.30** and **Table 2.31**, through a matrix balancing process.

The 2026 and 2035 assignment matrices were revised for the scenario with LLRN in place, by exercising trip redistribution especially for the trips between Laguna and Manila. The 2026 and 2035 daily person trip assignment matrices are presented in **Table 2.33** and **Table 2.34** It is anticipated that the change of trip distribution with LLRN in place would be insignificant. The trip matrix (with LLRN) would be very similar to the trip matrix (without LLRN).

Table 2.33 Total Daily Sector-Sector Trips ('000) for 2026 Assignment Matrix (with LLRN)

Sector	1	2	3	4	5	6	7	8	11	Total
1: Bataan	614	23	13	2	1	0	0	0	8	662
2: Pampanga	22	2,076	76	14	4	0	1	0	22	2,216
3: Bulacan	12	75	2,866	10	7	0	5	17	416	3,409
4: Rizal	2	14	12	2,003	7	8	40	21	567	2,674
5: Cavite	1	5	8	3	2,962	57	164	0	531	3,732
6: Batangas	0	0	0	8	59	2,172	179	14	17	2,449
7: Laguna	0	0	3	38	182	174	3,370	61	154	3,983
8: Quezon	0	0	17	20	0	13	64	1,818	4	1,936
11: NCR	8	24	393	579	540	31	169	4	12,664	14,413
Total	660	2,217	3,389	2,678	3,764	2,456	3,991	1,935	14,385	35,474

Note:

1. For sector-sector trip numbered zero, it is a number rounded to zero
2. The figures are presented in thousands. The figures in red represent the self-containment trips.

Table 2.34 Total Daily Sector-Sector Trips ('000) for 2035 Assignment Matrix (with LLRN)

Sector	1	2	3	4	5	6	7	8	11	Total

Sector	1	2	3	4	5	6	7	8	11	Total
1: Bataan	652	47	26	5	2	0	0	0	13	746
2: Pampanga	46	2,214	121	30	9	0	1	0	39	2,461
3: Bulacan	25	118	3,246	15	14	0	7	46	568	4,038
4: Rizal	6	30	17	2,272	11	22	55	46	686	3,144
5: Cavite	3	10	10	5	3,427	120	193	0	702	4,469
6: Batangas	0	0	0	22	123	2,343	228	30	27	2,773
7: Laguna	0	0	5	53	215	222	3,920	104	189	4,709
8: Quezon	0	0	45	45	0	30	107	1,971	10	2,209
11: NCR	12	41	532	713	730	44	203	12	13,009	15,296
Total	744	2,460	4,003	3,161	4,531	2,780	4,713	2,209	15,243	39,845

Note:

1. For sector-sector trip numbered zero, it is a number rounded to zero
2. The figures are presented in thousands. The figures in red represent the self-containment trips.

2.5.5.3 Traffic Forecast and Impact Assessments

Person trips were converted into vehicle trips expressed in PCUs, referenced in **Table 2.24**. Volume-to-capacity (V/C) ratios, indicating the proportion of road capacity used by peak hour traffic volume (in PCU) were further determined to assess the current performance of the road network and to determine the level of improvements needed to accommodate future travel. Road capacity is defined by road type, road width, and roadside friction, referenced from **Table 2.25**. Any road performance at or above 1.2 V/C is considered unacceptable. The peak hour traffic flow and V/C ratio under Base Case is provided in the table below.

Table 2.35 Peak Hour Performance LLRN

Direction	Section	No. of Lanes	Capacity (PCU/hr)	Year 2026		Year 2035	
				AM	PM	AM	PM
Southbound	Lower Bicutan - Sucat	2	4,000	0.3	0.2	0.4	0.3
	Sucat - Alabang	3	6,000	0.2	0.1	0.5	0.3
	Alabang - San Pedro	3	6,000	0.2	0.1	0.5	0.4
	San Pedro - Santa Rosa	3	6,000	0.2	0.2	0.4	0.4
	Santa Rosa - Cabuyao	2	4,000	0.3	0.3	0.4	0.5
	Cabuyao - Calamba	2	4,000	0.1	0.2	0.1	0.4
Northbound	Lower Bicutan - Sucat	2	4,000	0.3	0.2	0.4	0.3
	Sucat - Alabang	3	6,000	0.2	0.2	0.5	0.4
	Alabang - San Pedro	3	6,000	0.2	0.2	0.5	0.4
	San Pedro - Santa Rosa	3	6,000	0.2	0.2	0.4	0.4
	Santa Rosa - Cabuyao	2	4,000	0.2	0.3	0.5	0.5
	Cabuyao - Calamba	2	4,000	0.2	0.2	0.4	0.4

LLRN will operate satisfactorily within its capacity in 2025 and 2035. The most critical V/C ratio will be about 0.5 in 2035 AM peak hour.

Daily and peak hour traffic comparisons of "without project" and "with project" scenarios at screenline level for 2025 and 2035, are respectively provided in **Table 2.36**and **Table 2.37**.

Table 2.36 Screenline Traffic Change between "without project" and "with project" scenarios in 2026

Screenline	Direction	Without project	With project	Design/ Base
Daily				
A-A	Southbound	159,300	160,700	1.0
	Northbound	163,000	165,100	1.0
B-B	Southbound	306,100	303,700	1.0
	Northbound	293,200	291,100	1.0
C-C	Southbound	352,200	356,400	1.0
	Northbound	346,700	349,700	1.0
D-D	Southbound	223,100	225,500	1.0
	Northbound	227,600	229,700	1.0
E-E	Southbound	160,100	160,800	1.0
	Northbound	153,000	152,300	1.0
AM Peak				
A-A	Southbound	11,520	11,670	1.0
	Northbound	11,550	11,680	1.0
B-B	Southbound	20,370	19,640	1.0
	Northbound	21,460	20,860	1.0
C-C	Southbound	20,780	21,220	1.0
	Northbound	23,450	23,980	1.0
D-D	Southbound	18,550	19,000	1.0
	Northbound	16,890	17,180	1.0
E-E	Southbound	10,330	10,090	1.0
	Northbound	8,470	8,500	1.0
PM Peak				
A-A	Southbound	10,020	9,880	1.0
	Northbound	10,820	10,900	1.0
B-B	Southbound	20,510	20,030	1.0
	Northbound	18,240	17,630	1.0
C-C	Southbound	20,550	21,160	1.0
	Northbound	15,670	15,970	1.0
D-D	Southbound	13,130	13,270	1.0
	Northbound	16,650	16,890	1.0
E-E	Southbound	9,180	9,040	1.0
	Northbound	8,930	8,960	1.0

Note:

1. The daily traffic flow is rounded to nearest hundred for presentation.
2. The peak hour traffic flow is rounded to nearest ten for presentation.

Table 2.37 Screenline Traffic Change between "without project" and "with project" scenarios in 2035

Screenline	Direction	Without project	With project	Design/ Base
Daily				
A-A	Southbound	218,500	215,500	1.0
	Northbound	225,900	222,700	1.0
B-B	Southbound	372,200	362,100	1.0
	Northbound	349,600	337,600	1.0
C-C	Southbound	424,800	434,600	1.0
	Northbound	412,200	418,500	1.0
D-D	Southbound	285,200	287,700	1.0
	Northbound	290,700	291,600	1.0
E-E	Southbound	211,800	211,200	1.0
	Northbound	204,900	206,300	1.0
AM Peak				
A-A	Southbound	17,470	17,030	1.0
	Northbound	17,930	17,520	1.0
B-B	Southbound	27,200	26,130	1.0
	Northbound	27,320	26,240	1.0
C-C	Southbound	29,310	29,920	1.0
	Northbound	31,110	31,430	1.0
D-D	Southbound	24,360	24,600	1.0
	Northbound	24,790	24,900	1.0
E-E	Southbound	15,340	15,280	1.0
	Northbound	13,810	14,050	1.0
PM Peak				
A-A	Southbound	14,120	13,370	1.0
	Northbound	15,390	14,680	1.0
B-B	Southbound	25,720	24,300	1.0
	Northbound	22,870	21,440	1.0
C-C	Southbound	26,240	26,690	1.0
	Northbound	21,210	21,780	1.0
D-D	Southbound	17,580	17,910	1.0
	Northbound	20,140	20,310	1.0
E-E	Southbound	12,890	12,790	1.0
	Northbound	12,740	12,710	1.0

Note:

1. The daily traffic flow is rounded to nearest hundred for presentation.
2. The peak hour traffic flow is rounded to nearest ten for presentation.

Generally, the screenlines traffic are very similar for "without project" and "with project" case. It indicates that LLRN will not have significant change of traffic pattern in Laguna area.

Regarding the traffic impact to the road network, the change of traffic in the road network between "without project" scenario and "with project" case in 2026 and 2035 AM peak hour is analysed and illustrated in **Figure 2-97** and **Figure 2-98** respectively. The road network shown as Red is represented the forecast traffic "without" project is greater than "With" Project, while Blue is represented the forecast traffic "with" project is greater than "Without" Project and illustrated in **Figure 2-97** and **Figure 2-98** respectively

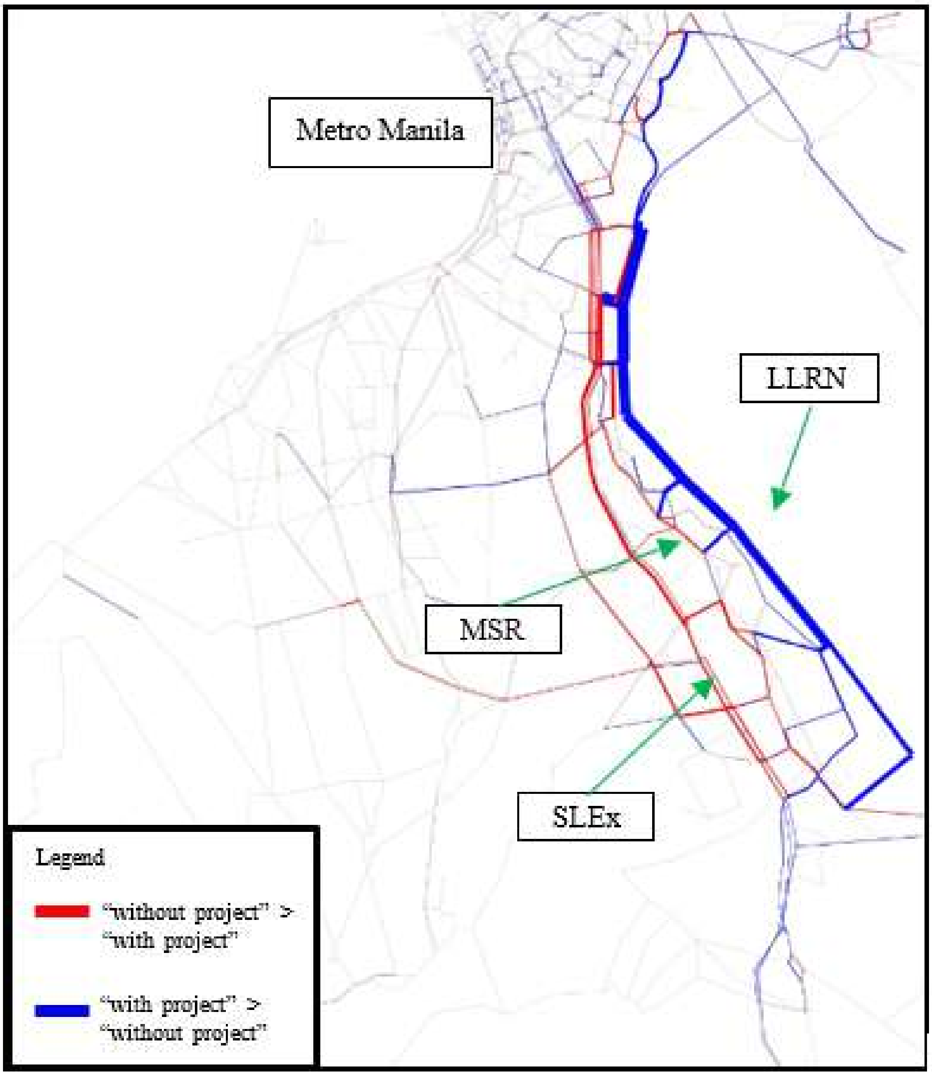


Figure 2-97 Network Traffic Comparison (With project – Without project) for 2026 AM

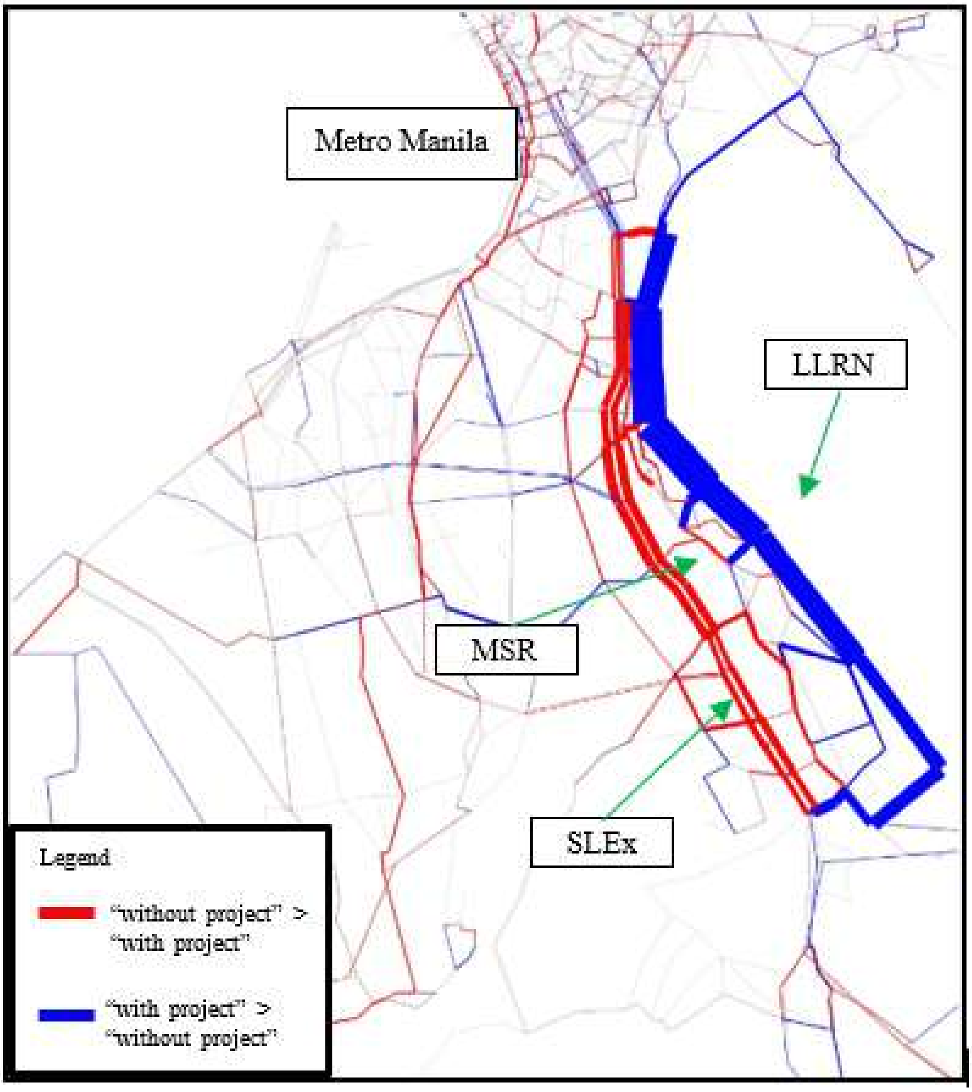


Figure 2- 98 Network Traffic Comparison (With project – Without project) for 2036 AM

The network comparison indicates that a considerable proportion of South Luzon Expressway and Manila South Road traffic will be diverted to LLRN when it is in place. The diversion is more apparent for South Luzon Expressway. This pattern is similar in both 2026 and 2035 AM peak hour.

The road performance of separate figures for "without project" and "with project" case in terms of volume/ capacity ratio is 2026 and 2035 AM peak is assessed and the result is illustrated in **Figure 2- 99** to **Figure 2- 102**.

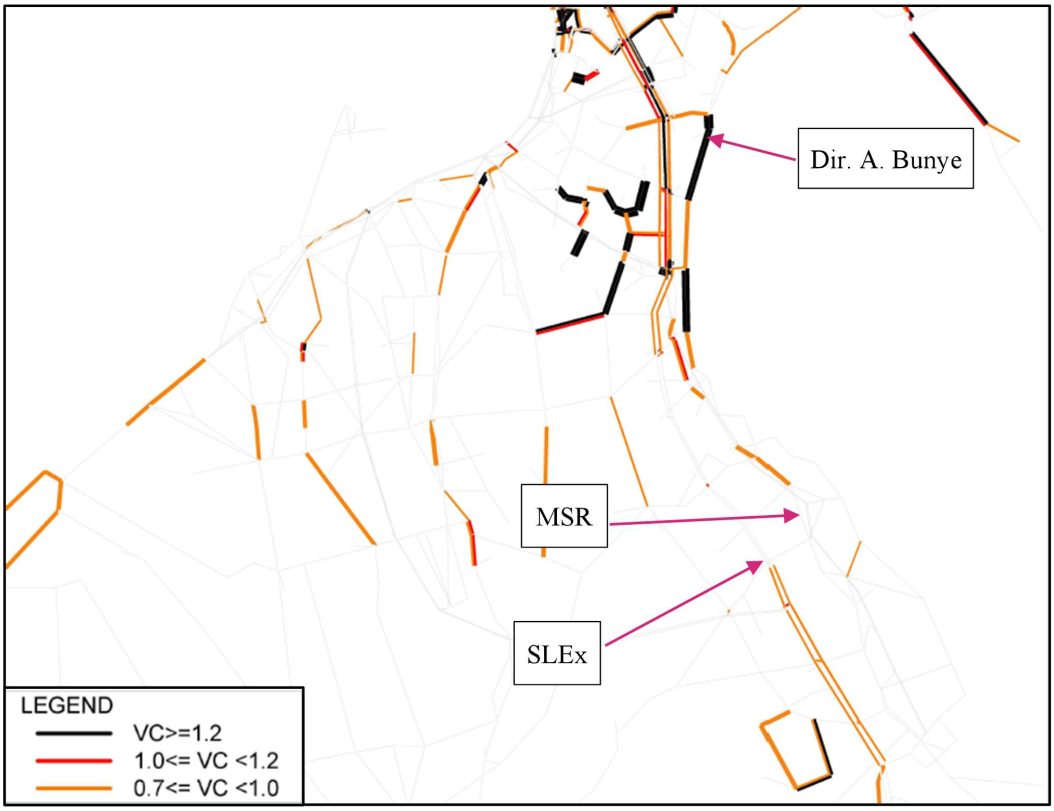


Figure 2- 99 Network Performance in V/C ratio for 2025 AM “without project” case

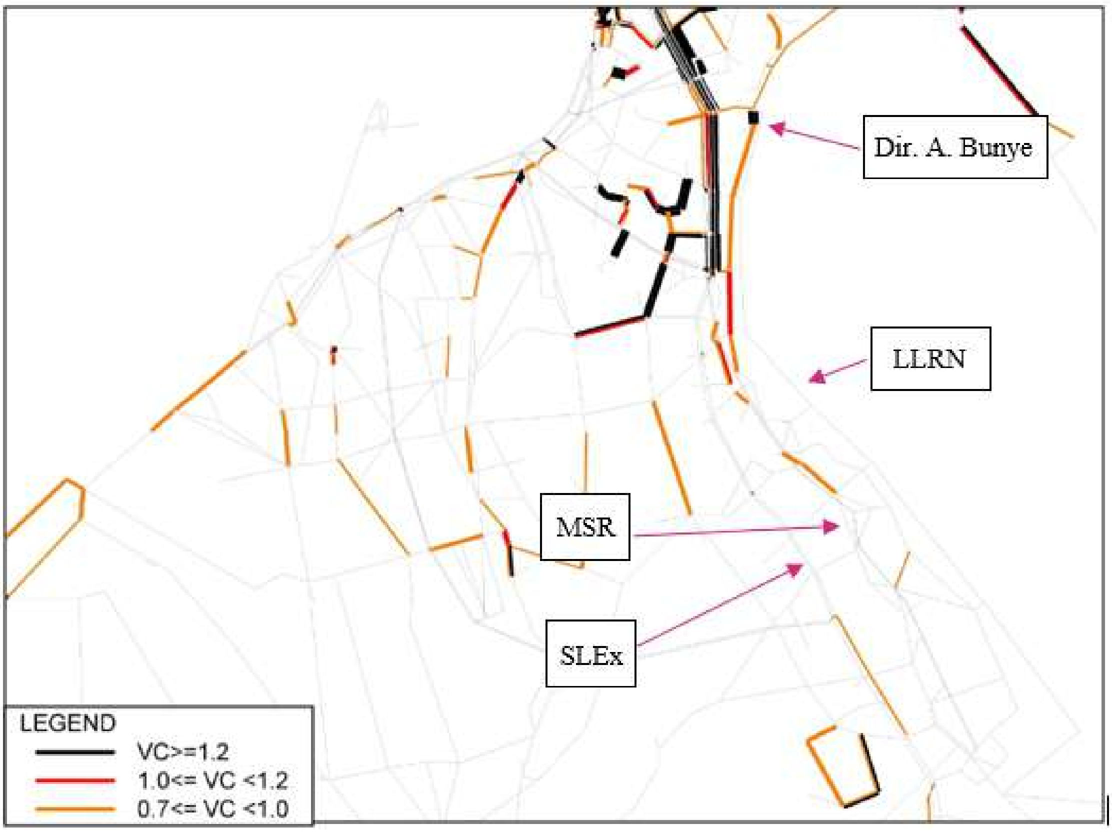


Figure 2- 100 Network Performance in V/C ratio for 2025 AM “with project” case

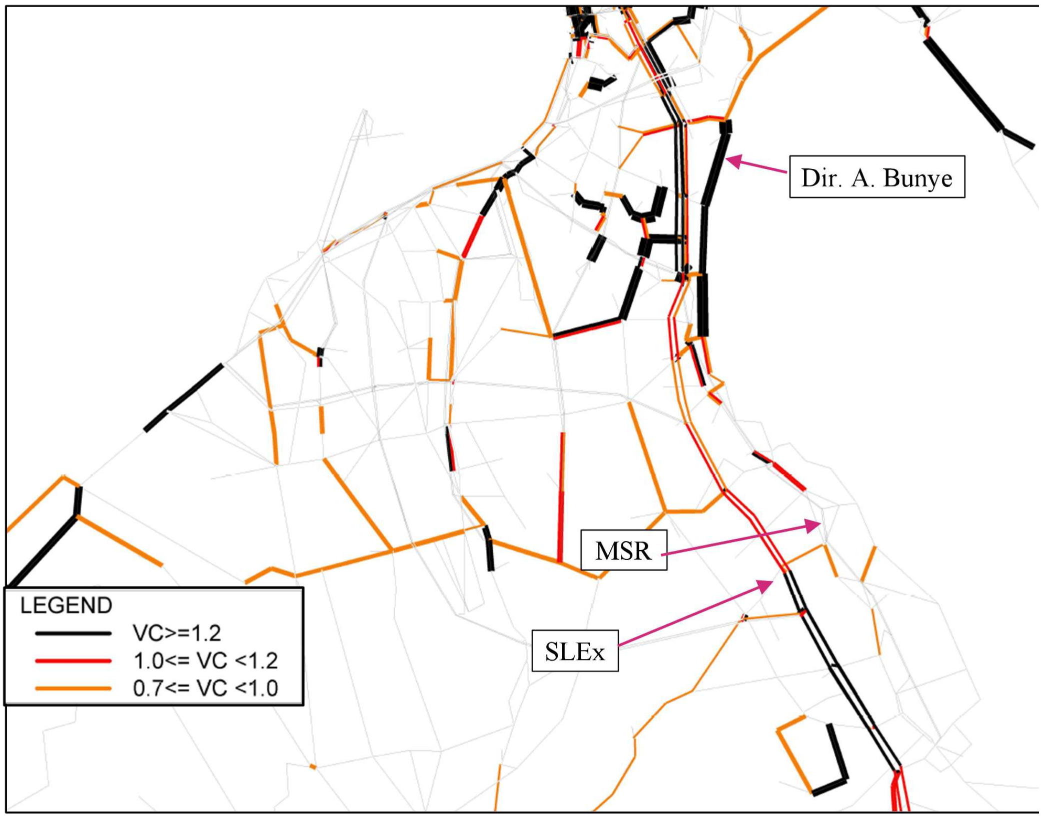


Figure 2- 101 Network Performance in V/C ratio for 2035 AM "without project" case

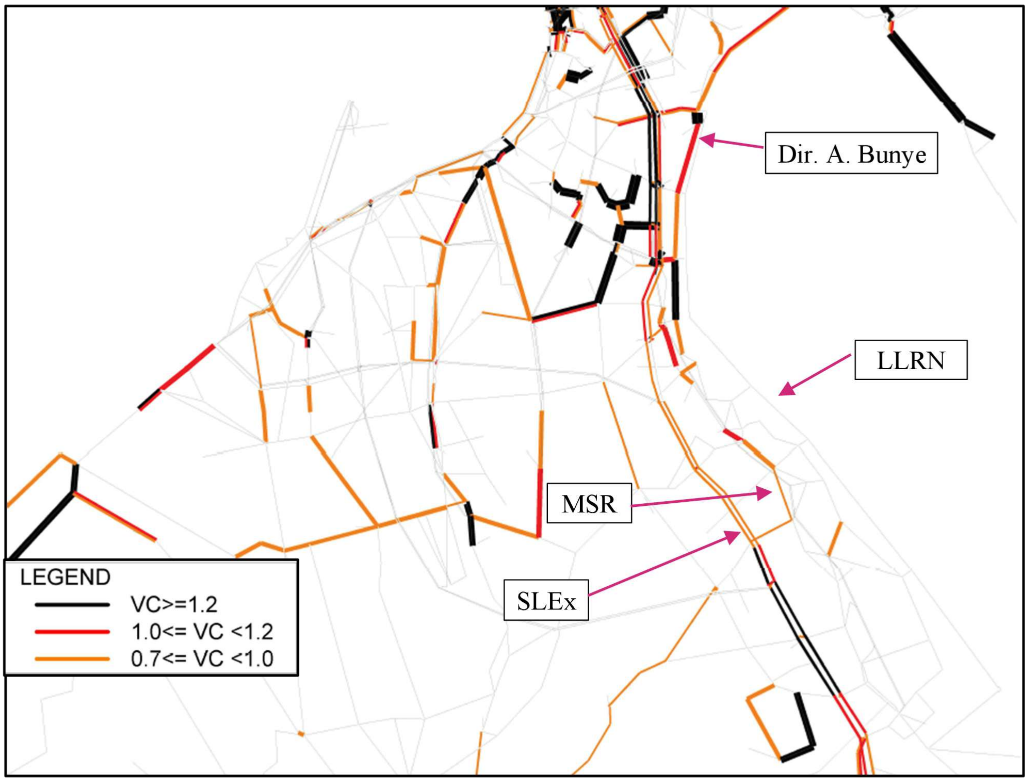


Figure 2- 102 Network Performance in V/C ratio for 2035 AM "with project" case

Under the "without project" case, V/C ratio will be in general within 1.0 for the major corridors but some localized sections near Metro Manila will be over 1.2 in both 2026 and

2035. In 2035 AM peak hour, South Luzon Expressway will have heavy usage in Cabuyao area, V/C ratio of these sections is anticipated to exceed 1.2.

The V/C ratio assessment of "with project" case indicates that the road performance for major corridors will be improved, in particular at northern section of the local road (Dir. A Bunve) and tolled South Luzon Expressway near Cabuyao area. However, the V/C ratio of these roads will still be over 1.0 even LLRN in place.

For the parallel Manila South Road (MSR), the V/C ratio of the section between Santa Rosa and Calamba are general within 1.0 under both "without project" and "with project" cases. However, the MSR section near Metro Manila will be over 1.0 in both cases.

The V/C ratio for the roads in Cavite side are similar between "without project" case and "with project". It indicates that there is no significant traffic impact by the implementation of LLRN.

2.5.5.4 Travel Time Savings

It is anticipated that the provision of LLRN will reduce the travel time along the corridor of the project. **Table 2.38** presents the comparison of travel time in 2026 AM and 2035 AM between the "with project" case and "without project" case.

Table 2.38 Travel Time Saving for 2026 and 2035 AM (with project - without project) (minutes)

	(Minutes)	
Locations	**2026**	**2035**
between Manila sector and Laguna sector[1]	-2	-13
between Alabang and Bicutan	-10	-10
between Biñan and Bicutan	-50	-60
between Santa Rosa and Bicutan	-20	-30
between Calamba and Bicutan	-10	-50

Note:

1. The sector location is shown in Figure 2- 96.

From the above table, the average time saving between Manila and Laguna sectors during AM peak hour will be about 2 minutes and 13 minutes in 2026 and 2035 respectively, with the introduction of LLRN in the network. For cities closer to the interchange location of LLRN, the time saving will be more prominent. For traffic between Biñan, Santa Rosa, Calamba and Bicutan, the time saving shall achieve about 20-50 minute in 2026 and about 30-60 min in 2035.

3 Environmental Management Plan

The summary of potential environmental impacts and proposed mitigation measures with details on duration, institutional responsibilities, cost estimates, and financial arrangements during the project's pre-construction, construction, operation, and demobilization phases are presented in **Table 3.1** below.

Table 3.1 Environmental Management Plan for LLRN

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
Pre-Construction Phase						
Site preparation activity - utility relocation	Utilities	Temporary disruption and relocation of utility services *(telephone lines, electric poles and wires, and water lines)* existing within LLRN ROW	• Preparation of utilities relocation plan and inventory of the affected utilities will be done during the DED stage of the project to consider the final LLRN ROW; • Close coordination with the affected LGUs and concerned utility companies and service providers with regards to project timeline, project plans and utility relocation schedule / activities.	DPWH LGUs	Part of development cost	Pre-operational expenses
Land Acquisition and resettlement along the alignment	Land	Displacement of settlers, Disturbance of properties and Loss of livelihood of project affected persons	• Preparation of FS and DED Resettlement Action Plan. The RP will be based on the final detailed design of the project to avoid involuntary resettlement; • Implementation of the approved Resettlement Action Plan (RAP) of the Project in accordance with the applicable government process and directives; • Provide relocation / compensation to affected landowners, households, and owners of other establishments based on the Entitlement Matrix (EM) prepared for the project • An agreement should be settled between DPWH and the landowner. • Ensure that all losses and entitlements of the project affected persons will be compensated accordingly and in a timely manner;	DPWH DHSUD LGUs	Approximately PhP 3,314,954,242.56 (estimated resettlement cost based on the RAP for LLRN)	Resettlement Plan budget MOA with LLDA and Key Shelter Agencies (KSAs)

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			• Continuous consultations with the project affected persons to inform them about the status and resettlement plan schedule of LLRN; • Coordination with DHSUD and the LGUs for the proper preparation and implementation of Right-of-Way Acquisition and Resettlement Action Plan (ROWARAP) • Regularly monitor of presence/absence of complaints from PAPs. • Immediate action on the stakeholder complaints through the implementation of Grievance Redress Mechanism (GRM)			
Site preparation, clearing and/or tree cutting along the alignment	Land	Removal of trees and other vegetation present in the project area are anticipated to be affected by civil works. Loss of vegetation is the result of land clearing during the pre-construction and construction phase. Agricultural lands in some identified areas that will be traversed by the mainline will potentially be affected.	• Inventory of trees and application for tree cutting/balling permit should be done, if necessary. • To compensate for the loss in vegetation, there should be a replacement for the number of trees lost during land clearing operation and plant these trees in the areas designated by the DENR. • The acquisition cost of affected lots and structures including these agricultural lands and crops that will be affected were assessed. An economic analysis is conducted and will be further studied to carefully plan out appropriate actions to manage impacts.	DPWH DENR-EMB	Part of development cost	ECC Condition Compliance to Tree Cutting Permit
Site preparation, clearing along the	Water/People	Removal/Relocation of fish cages along the mainline as the proposed scheme of the	• All barangays along the shoreline are suggested to have minimum 1 fishery	DPWH DENR-	Approximately PhP 3,314,954,242.56	Resettlement Plan budget MOA with

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
alignment		project consist of viaduct and embankment	basin, and more depending on demand. It will be useable all year around to avoid excessive relocation to existing fisherfolks. However, it is unavoidable that there might still be some fisherfolks and fish pens that need to be relocated; • Some segments of the highway will be in the form of long viaduct and short bridges to elevate LLRN across the existing rivers or fishery basin; • Economic valuation and assessment of possible affected fish cages; • Coordination with the relevant government offices and cities accordingly; • Fish cage/pen owners and operators, whose livelihood will be severely affected, they will be eligible to participate in the Livelihood Restoration and Improvement Program (LRIP) and provided compensation for loss of income	EMB LLDA LGUs (i.e. BFARMC)	(estimated resettlement cost based on the RAP for LLRN)	LLDA
	Religious practices	Disturbance to church activities in the nearby chapel	• Proper scheduling of construction activities to minimize impact			
Procurement and planning	Economy	Increase in business opportunities and support to local suppliers through purchase of construction materials, equipment, machineries, etc.	• Sourcing of materials from nearby provinces and purchase from local suppliers, whenever possible • Secure services of local communities and residents, whenever possible	DWPH	Part of development cost	Incorporated as part of the project
Project	People	Public resistance on the	• Undertake consultation meetings with	DWPH	Part of	ECC Condition

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
information dissemination to affected communities		proposed development project	stakeholders including IEC, FGD and other consultation meetings • Conduct FGD and consultation meetings with LGU, directly affected people, and key stakeholders	LGUs	development cost	
Construction Phase						
Dredging and soil Excavation activities	Water Quality	Increased suspended and dissolved solids, color, and turbidity in streams and Laguna Lake	• Proper management of stockpiles and the drainage system should be undertaken. To avoid contamination by rain washing, stockpiles should be distant from the waterways and covered. • Apply proper siltation control measures • Excavated materials, such as soil debris, will be hauled out from the site • Regular monitoring of the adjacent water bodies	DPWH LLDA LGUs DENR-EMB	Part of development cost	Incorporated as part of the project ECC Condition
Use of construction vehicles, machine, and equipment	Water Quality	Excessive oil and grease, and other particulate material due to run off or spillages on site may degrade water quality	• Project will have oil-water separators to remove oil from effluents prior to discharge • Organized waste storage with an impermeable area will be implemented for bulk waste oils and lubricants • Implement a proper waste management in accordance with RA 9003 • Waste oils and other hazardous wastes will be collected by a DENR-EMB accredited third-party hauler and treater • Emergency and contingency plan will be made in case of spills • Maintenance and proper use of	DPWH DENR-EMB	Part of development cost	Incorporated as part of the project ECC Condition Compliance with R.A. 9003

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			construction materials and heavy machinery			
Mobilization of equipment and supplies to project site; construction of shoreline viaduct and embankment	Water Quality	Increase organic contaminants (BOD, ammonia, phosphorus) if domestic wastewater is not properly managed	• LLRN road network is designed with intercepting channels and box culverts to be provided in regular intervals to allow the catchment area along the shoreline embankment be drained to prevent runoff of waste materials into the lake • Strict implementation of waste management rules and regulation shall be made.	DPWH DENR-EMB LGUs (in support to the implementation of waste management)	Part of development cost	Incorporated as part of the project ECC Condition Compliance with R.A. 9003
Land Clearing and excavation activities such as bored piling and/or pile cap construction	Siltation and Erosion	Siltation and sedimentation Runoff of solids on land towards water bodies	• Implement appropriate erosion control measures (additional pavements, concrete seawalls, sediment traps, and barriers during heavy rain periods) • Stockpiles will be placed away from water sources and protected against natural elements • Identify dumping/storage areas for material which is either suitable or unsuitable for re-use • Excavated materials, waste soils, and other debris will be hauled out from the site at the designated area such as landfill site; dumping site should ideally be close to the project location as possible to reduce the cost of transportation • Regular monitoring of adjacent water bodies • Set up silt traps and settling ponds to minimize downstream siltation and regularly remove debris and other	DPWH DENR-EMB LLDA	Part of development cost	Incorporated as part of the project ECC Condition
Land Clearing and excavation activities such as bored piling and/or pile cap construction	Siltation and Erosion	Disturbance and resuspension of bottom sediments in water bodies due to excavation activities such as bore piling and/or pile cap construction for both land and viaducts and embankment base layer				

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			materials that may obstruct water flow • Proper construction methodology should be followed strictly • Conduct immediate re-vegetation of the cleared land if feasible			
Dredging for barge access; construction of embankment and viaduct	Stream Contamination	Debris, contaminants and sediments from construction may runoff to water streams including liquids such as gasoline and oil	• Low level culverts are to be provided for river stream connecting to the lake; intercepting channels and box culvert are also proposed along the western side of shoreline embankments to provide drainage capacity to the lake and shoreline area • Implement an organized waste storage with bulk waste oils and lubricants placed in impermeable area with appropriate secondary containment • Implement proper waste management and housekeeping measures • Waste oils and other hazardous wastes will be collected by an accredited third-party hauler and treater • A health and safety management plan will be prepared and implemented to establish protocols and procedures in addressing potential health and safety emergencies (i.e., oil spills)	DPWH DENR-EMB LLDA	Part of development cost	Incorporated as part of the project ECC Condition
Road Network Construction	Stream Contamination	Soil compaction from construction on land may increase risk of surface runoff				
Use of temporary facilities for workers and field office, storage sheds, and workshops	Effluent Discharge	Domestic waste generated by the workforce may be carried to nearby water bodies due to poor waste management	• Require contractors to implement proper solid waste management throughout the development stages of the project to ensure pollution control management • Conduct trainings and seminars to disclose plans and improve awareness on proper solid waste management practices • Stockpiles will be placed away from	DPWH DENR-EMB LGUs	Part of development cost	Incorporated as part of the project ECC Condition Compliance with R.A. 9003

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			water sources and protected against natural elements • Sewage waste discharges will be directed to a local septic tank • Temporary sanitary facilities should be employed on-site • Construction materials, substances, chemicals, etc. shall be properly stored and managed in a secured designated storage area with provision of secondary containment			
Dredging for barge access; installation of pile foundation; construction of viaduct and embankment	Groundwater	Change in quality of groundwater sources due to construction activities	• Proper planning of construction activities to avoid tapping and contaminating groundwater sources • Re-vegetation practices, proper planning of slopes, drainage pipes, and canals, and the application of silt and waste barriers to avoid excessive percolation	DPWH DENR-EMB	Part of development cost	Incorporated as part of the project ECC Condition
Excavation; dredging for barge access; installation of pile foundation; construction of viaduct and embankment	Groundwater	Untreated waste materials may penetrate the soil and contaminate ground water sources				
Land clearing activities; mobilization of vehicles, equipment and machines at the project site	Air Quality	Increased fugitive dust due to land clearing activities and vehicles usage	• Regular water spraying especially during transportation of materials • Cement paths and roads • Provide washing areas for vehicles for mud and dirt removal • Add rumble grids in the entrances and exits • Control speed of vehicles • Provide washing areas for	DPWH DENR-EMB	Part of development cost	Incorporated as part of the project ECC Condition

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			construction vehicles to remove mud and dirt from tires before leaving the project site.			
Mobilization of vehicles, equipment and machines at the project site	Air Quality	Emission from combustion of fossil fuels increases	• Conduct regular inspection and maintenance for construction and transport vehicles • Heavy equipment and other vehicles to be used on site should have passed the emission testing; • Use cleaner fuel such as biofuel and diesel • Use renewable energy to power equipment on site • Construction plans for temporary buildings to include cooling effects and set up in cooler areas • Conduct training to inform workers of proper and efficient use of equipment and management of traffic • Turn engines off while idled	DPWH DENR-EMB	Part of development cost	Incorporated as part of the project
Mobilization of vehicles, equipment and machines at the project site	Climate Change	Generation of greenhouse gases (GHG) through the consumption of fossil fuels; changes in temperature and rainfall extremes over project areas have an effect on road, bridges and steel infrastructure; potential overflowing of tributaries and mainstreams around the lake; Removal of vegetative covers, including trees along various stations within its alignment will slightly affect the local	• Construct drainage basins to facilitate drainage and stormwater channels • Set up silt traps and settling ponds to minimize downstream siltation and regularly remove debris and other materials that may obstruct water flow • Road pavements must be designed and constructed about 8 meters from the surface water level • Only remove trees in the affected areas within its alignment • Tree cutting permits shall be secured following DENR guidelines (i.e., Forest Management Bureau Technical Bulletin No. 3) with consideration to	DPWH DENR-EMB	Part of development cost	Incorporated as part of the project ECC Condition

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
		temperature, moisture, wind speed, and evapotranspiration rate	DPWH Department Order 116, series of 2018 on the tree cutting and earth-balling permit application.			
Mobilization of vehicles, equipment and machines at the project site	Noise Level	Increased noise from heavy machinery, construction equipment, and transport vehicles	• Scheduling and limiting loud activities at nearby settlements • If possible, install noise barriers/screens • Continuous monitoring is required to check and plan minimization efforts • Schedule the use of the roadway or alternative routes if the time is too late in the evening or early in the morning • Maintain vehicles regularly • Prevent workers from loitering in residential areas by conducting orientations • Install large numbers of “No blowing of horn” signs near residential areas	DPWH DENR-EMB	Part of development cost	Incorporated as part of the project
Land clearing activities	Vegetation and Agricultural Lands and Crops	Loss of crops and trees. Agricultural lands in some identified areas that will be traversed by the LLRN mainline will potentially be affected.	• To compensate for the loss in vegetation, there should be a replacement for the number of trees lost during land clearing operation and plant these trees in the areas designated by the DENR. • The acquisition cost of affected lots and structures including these agricultural lands and crops that will be affected will be assessed and included in the RAP prepared by the project. An economic analysis is conducted and will be further studied to carefully plan out appropriate actions to manage impacts.	DPWH LGUs (i.e. City Agriculture Office)	Part of development cost	Incorporated as part of the project
Excavation and Dredging	Soil and Terrestrial Disturbance	Removal/ loss of topsoils due to removal of vegetative	• Proper phasing and/or scheduling of earthmoving activities and proper	DPWH LGUs	Part of development cost	Incorporated as part of the

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
Activities		cover as a result of excavation activities. Erosion and siltation may occur due to occasional rain Dredging activities may lead to accumulation of contaminated sediments.	stockpiling of soil waste. Installation of barrier nets, silt traps in strategic places. • Prepare and implement a materials handling program or a site protection and rehabilitation program • Proper disposal will present an opportunity to prevent pollutants from going into the lake • Compaction of all-weather roads to prevent erosion			project ECC Condition
Construction of viaduct and embankment	Existing Infrastructure and facilities	Construction may cause disruption of telephone, electric and water services and damage to existing infrastructures.	• These should be identified in the earlier stage and planned ahead to prevent disruption. • These should be included in the Emergency Response Procedures to manage any possible events.	DPWH	Part of development cost	Pre-operational expenses
Excavation and Dredging Activities	Aesthetics conditions	There will be temporary unacceptable aesthetic conditions in the area during the construction phase	• DPWH and consultant should ensure that the contractor will be in full compliance to ensure that the site is clean as far as practicable and visually acceptable during construction phase. • Construction of temporary facilities and staging areas for equipment and materials shall be placed in non-vegetated areas with adequate sanitary facilities. • All areas used during construction shall be restored for the post-construction and operational stages to improve aesthetic values and even enhance the micro-climate conditions • The LLRN design should harmonise the project with the existing surroundings as much as practicable.	DPWH	Part of development cost	Incorporated as part of the project

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
General Construction Activities	Accessibility	Heavy traffic is anticipated during rush hours due to construction. Some existing roads may temporarily be inaccessible due to improvement plans.	• Implement the Traffic Management Plan to aid in avoiding traffic congestion; • Contractors to provide traffic enforcers in areas where construction is on-going; • There should be alternative routes recommended during the construction phase • Post road signals and traffic wardens are also recommended. • To avoid contribution to traffic, sources of materials to be used for the construction from nearby provinces shall be considered.	DPWH LGUs	Part of development cost	Incorporated as part of the project
General Construction Activities	Economic/People	Regular economic and leisure activities by the fishermen, tourists, commercial boats, and the Coast Guards in Laguna Lake may temporarily be affected during the construction phase.	• The construction methodology for dredging for barge access will be conducted as this method will have minimum interruption to the navigations on the lake as no obstacles would be formed at location of proposed viaduct • Coordination with LGUs and affected stakeholders/groups on timing and schedule of construction activities shall be conducted • Fishery basins shall be incorporated along the LLRN mainline. Each fishery basin would be sized to fit the local fish boat demand and have adequate navigation clearance connect between the basin and Laguna lake • The design shall consider the navigation of vessels within the lake with 4m vertical clearance from the design water level (+2.022mSL) to the	DPWH LLDA LGUs	Part of development cost	Incorporated as part of the project

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			soffit level • Bridges shall be provided along the embankment at various locations to allow boats navigation form/to the lake from the fishery basin and outlet opening for the rivers and streams			
General Construction Activities	Occupational Health and Safety	Impacts are anticipated to the workers during construction phase in terms of health and safety as both onshore and offshore construction works are expected.	• Occupational health and safety plans are necessary to be imposed towards the completion of the project • Workers should be provided with suitable trainings and workshops to engage awareness for the possibilities of risks and accidents during and after work hours. • To eliminate and minimise risks and accidents, PPEs are required upon entering the construction sites. • There should also be awareness on possible traffic and hazard driving conditions along the area. • Along with the traffic management, temporary alternative routes to avoid heavy traffic and risks should be recommended.	DPWH LGUs	Part of development cost	Incorporated as part of the project ECC Condition
General Construction Activities	Community health and safety	Traffic accident risks may increase during the construction of the Project.	• Traffic management should be provided to avoid / minimise possible accident risks during construction of the Project.	DPWH LGUs	Part of development cost	Incorporated as part of the project
General Construction Activities	Impacts on fisherfolks; fisheries	Impacts on livelihood of fisherfolks-The embankment and viaduct scheme will affect the fisheries and the fishing activities of fisherfolks.	• Incorporation of fishery basins in the LLRN alignment design to fit the local fish boat demand and have adequate navigation clearance connect between the basin and Laguna lake. • All barangays along the shoreline are suggested to have minimum 1 fishery	DPWH LLDA LGUs (i.e. BFARMC)	Part of development cost	Incorporated as part of the project MOA with LLDA

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			basin, and more depending on demand. It will be useable all year around to avoid excessive relocation to existing fisherfolks. However, it is unavoidable that there might still be some fisherfolks and fish pens that need to be relocated. • Some segments of the highway will be in the form of long viaduct and short bridges to elevate LLRN across the existing rivers or fishery basin. • The affected economic valuation of possible affected fish cages was assessed and will be coordinated with the relevant government offices and cities accordingly. • Implementation of the RAP for fisherfolks that will be affected during construction phase.			
General Construction Activities	Hazardous driving conditions and accident risks	Traffic hazards and vehicular accidents / risks to road users	• Temporary alternative routes to avoid heavy traffic and risks should be recommended. • Traffic management should be provided to avoid / minimise possible accident risks during construction of the Project. • The Project will connect to different barangays and cities' thoroughfares. There should be awareness on possible traffic and hazard driving conditions along the area.	DPWH LGUs (i.e. Traffic Unit)	Part of development cost	Incorporated as part of the project
General Construction Activities	Possible transmission of communicable diseases	Poor sanitation, solid waste disposal, and possible transmission of communicable diseases	• The Waste Management Plan for work sites and construction camp shall include procedures for management of domestic wastes, hazardous wastes, and sewage.	DPWH DENR-SWMD LGUs	Part of development cost	Incorporated as part of the project ECC Condition

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			• Workers should be informed on solid waste management for proper disposal and educated on hygiene and sanitation for possible communicable diseases. • Proper waste disposal, hygiene, and drainage plans must be imposed to minimise diseases transmitted by mosquitoes and rodents.			Compliance with R.A. 9003
Erection of temporary facilities for workers and field office, storage sheds, and workshops	Community health and safety	Increased risks to community due to increase in vehicular movement Noise disturbance to nearby residents	• Coordination with the LGUs on proper scheduling of construction activities to minimize impacts to vehicular movement and community activities • Conduct IECs with affected communities and LGUs • Posting of safety signage to warn motorists of the ongoing construction works • Regular coordination with the LGUs and barangays with regards to project plans and concerns of the residents • Regularly monitoring of presence/absence of complaints from PAPs • Immediate action on the stakeholder complaints through the implementation of GRM	DPWH LGUs	Part of development cost	Incorporated as part of the project ECC Condition
		Possible spread of diseases due to workers' unsanitary practices	• There should be health and safety protocols in place to prevent spread of diseases in the construction areas • Coordination with the LGUs' Health Management Units for possible integration of health and safety protocols • Observe proper sanitation practices in the construction area and workers'	DPWH LGUs (i.e. health unit)	Part of development cost	Incorporated as part of the project

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			barracks to avoid generation and spread of diseases • Regular conduct of health and safety awareness to all construction employees			
	Solid waste	Generation of solid waste from construction activities	• Coordinate with the solid waste management office of local government units for proper waste management implementation and collection • Implement the solid waste management plan prepared for the project • Proper waste management and housekeeping measures; assigned pollution control officer (PCO) for the project shall monitor the activities • Waste will be collected daily by an accredited 3rd party contractor to ensure cleanliness in the workplace; and • Trainings will be provided to site workers to improve the awareness on proper solid waste management practices.	DPWH LGUs (i.e. Waste Management Office)	Part of development cost	Incorporated as part of the project ECC Condition Compliance with R.A. 9003
General Construction Activities	Impacts on the poor, women and children, Indigenous Peoples	The poor, women, children, and other vulnerable sectors of society in the area are perceived to be affected by the Project.	• Ensure that there will be continuous monitoring and security to ensure safety during construction phase including women, elderly, youth. A gender assessment shall be conducted and the Gender Action Plan (GAP) will be prepared as part of the social safeguards study	DPWH	Part of development cost	Incorporated as part of the project
Operations Phase						
Operation of the	Water Quality	Increased suspended and	• Proper management of stockpiles and	DPWH	Part of	Incorporated as

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
LLRN road network		dissolved solids, color, and turbidity in streams and Laguna Lake	the drainage system should be undertaken. To avoid contamination by rain washing, stockpiles should be distant from the waterways and covered.		development cost	part of the project ECC Condition
Operation of the LLRN road network	Air Quality	Increased fossil fuel emissions from the vehicles that utilize the highway	• Plant trees in between project site and local communities to reduce their exposure to these emissions as the vegetation act as a buffer. • Proper and efficient use of fuel-powered equipment for air pollution reduction. • Safety briefings, giving importance to personal and environmental implications. Ensure the proper use of personal protective equipment (PPE) based on Occupational Safety and Health Association (OSHA) guidelines. • Turn off the engine of idling vehicles to prevent wasting fuel.	DPWH	Part of development cost	Incorporated as part of the project ECC Condition
Operation of the LLRN road network	Noise Levels	Frequent passage of transportation vehicles in the project	• Installation of 3m high noise barrier and low noise road surfacing are recommended for the noise-sensitive receivers • Install larger numbers and more noticeable “No blowing of horn” signs • Provide buffer area that will enforce noise mitigating procedures • Conduct regular noise monitoring at sensitive receptor areas to prevent effects on human health	DPWH	Part of development cost	Incorporated as part of the project ECC Condition
Operation of the LLRN road network	Community Health and Safety	Increased probability of road accidents due to increased traffic and higher	• Post appropriate signage along the alignment to warn both residents and motorists	DPWH LGUs	Part of development cost	Incorporated as part of the project

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
		speed limit on the bridge/viaduct	• Widely disseminate information on allowed vehicles on the bridge and speed limit • Provide a crew to monitor traffic on the bridge/viaduct • Continuous coordination with the LGUs and affected barangays			
Operation of the LLRN road network	Occupational Health and Safety	Accidents may befall workers as they maintain the bridge	• Conduct regularly site safety drills • Require use of prescribed PPEs • Practice standard occupational health and safety pursuant to BWC-DOLE Occupational Safety and Health Standard	DPWH	Part of development cost	Incorporated as part of the project
Operation of the LLRN road network	Local economy	Improved mobility is foreseen and contribution to the access of economic opportunities for the growing population in the region.	• Positive impact	-	-	-
Decommissioning/Abandonment Phase						
Disintegration of the demobilized structure	Water Quality/ Contamination	Impacts on existing water quality of Laguna Lake	• Implementation of approved decommissioning plan by the EMB	DPWH	Part of development cost	ECC Condition

4 Environmental Risk Assessment (ERA) & Emergency Response Policy and Guidelines

Emergencies are unforeseen events or episodes that may be caused by natural forces or human actions or inactions which may result to negative effects to people, property, and the surrounding environment. As a preliminary step in developing an effective emergency response policy, it is important to identify the potential emergency scenarios that would most likely occur.

Table 4.1 below presents the emergency scenarios for the project with details on possible causes and potential effects.

With the different emergency scenarios identified for the project, **Table 4.2** then presents the corresponding emergency response procedures that can be followed. **Table 4.3** presents the roles and responsibilities of personnel concerned in the emergency plan.

Table 4.1 Emergency scenarios for the LLRN Project

Type of Emergency Situation	Possible Causes	Potential Effects
Fire	• Electrical short-circuits, overloading of equipment. • Accidental ignition of combustible materials (e.g., diesel/fuel for machineries and oil for maintenance)	• Partial or total loss of equipment and property • Injuries and fatalities to personnel and commuter
Earthquakes	• Movement/rupture of nearby fault lines • Volcanic eruption	• Failure of gantry • Injuries and fatalities to personnel and commuter • Damage to bridge
Occupational safety accidents	• Improper training and supervision of personnel • Equipment and facility failure • Possible collapse of steel structures during gantry installation	• Injuries and fatalities to personnel • Partial and total loss of equipment
Flooding	• Location of the Philippines as a typhoon prone area • Complex weather systems • Topography of the area	• Minimal impact is expected to facility structures
Vehicular accidents	• Human error • Faulty machines (vehicles) • Road obstructions	• Injuries and fatalities to personnel and commuter • Damage to bridge
Physical Risks (Failure of Structure)	• Design errors, deficiency in construction, material defects • Collapse/ malfunction of construction equipment and structures (e.g., construction cranes) • Collision/ mechanical impact on bridge structure from marine vessels, trucks, large debris • Extreme climate events (increased frequency and intensity of typhoons, storm surge, torrential and prolonged rains during rainy seasons, floods) • Erosion of stream bed or bank materials from bridge foundations (scouring)	• Injuries and fatalities to personnel and commuter • Damage to structure that could lead to structure failure/collapse • Damage to properties • Work stoppage and interruptions • Delays to the project • Damage to construction equipment and installed facilities • Additional cost for remedial • Unsafe transport route (slippery, high winds, etc) that may predispose to transport accidents

Type of Emergency Situation	Possible Causes	Potential Effects
	• Environmental degradation of bridge structures (e.g. corrosion of steel components by airborne chloride, metal fatigue) • Overloading of bridge (bridge design load capacity is exceeded) • Terroristic attacks and/or sabotage of bridge	

Table 4.2 Emergency response procedures for different scenarios

Preparation	Response	Recovery
<u>**A. Fire**</u> • **Orientation and training of personnel on fire safety** • **Conduct regular fire drills** • **Installation and regular testing of fire-fighting devices (i.e. fire hoses, fire extinguishers)** • **Regular inspection of electrical equipment and lines, and replacement as necessary, for any defects or malfunctions** • **Proper storage of all flammable items in secured and proper containers and storage facilities** • **Implementation of a 'no-smoking' policy when on duty** • **Placement of emergency numbers and communication equipment in conspicuous areas for easier notification** • **Emergency exits and evacuation procedures shall be put in place, and kept free from any obstructions** • **Regular maintenance of electrical equipment**	• Personnel are advised not to panic to prevent further injuries. • Personnel are advised to follow emergency evacuation procedures. • Immediately report any presence of smoke, sparks, or open flame to authorized personnel. • If the fire can still be contained, use fire extinguishers immediately. • Disconnect electrical or fuel connections, and shut-down all affected equipment. • If possible, remove all flammable materials from the fire scene to avoid further contact. • For responders, wear the proper fire protection attire (i.e. fire suit, boots, breathing apparatus). • Avoid using or pouring water over fuel or alcohol fires, and electrical fires.	• Avoid returning to the fire scene, as long as necessary, unless declared for safe entry. • Check personnel and find out if there are injuries or trapped/injured persons that may need assistance. • Report any important incidents that require immediate attention. • Secure important items and equipment from unauthorized access from outsiders, after the premises have been declared safe for re-entry. • If the fire damage is minimal, or facility is recoverable, make necessary corrective measures to prevent the accident from re-occurring.
<u>**B. Earthquakes**</u> • **Make necessary preparations, which includes equipment and facility checks to prevent injuries in an event of an earthquake** • **All loose items must be secured to prevent falling** • **Placement of heavy materials near the ground** • **Storage of flammable items in designated safe areas** • **Personnel/tenants are**	• Personnel are advised not to panic to prevent further injuries. • Personnel are advised to protect themselves by getting under sturdy structures. • Personnel are advised to stay away from sharp, flammable, or heavy items. • Personnel are advised to prepare immediate evacuation of the facility if necessary • All gas and electric equipment are shut down	• If there are no threats of aftershocks, check other personnel that may be trapped, injured, or needs further assistance. • Avoid returning to the facility if it is deemed structurally unstable, or declared unsafe. • Conduct thorough inspection of the facility's premises for any possible damage to the bridge and other electrical equipment. • Check for possible fires and

Preparation	Response	Recovery
familiarized to safe locations, emergency response equipment and evacuation routes		advice authorities for appropriate response. ● Secure important items and equipment from unauthorized access from outsiders, after the premises have been declared safe for re-entry. ● Inspect the facility for any major structural defects, cracks, unstable items, and other potential hazards. ● If the earthquake damage is minimal, or facility is recoverable, make corrective measures to prevent the further hazards from affecting personnel and property.
<u>C. Release of Toxic Substances</u> ● **Regular visual inspection for potential leaks and corrosion** ● **Inspection of facilities, containers, and equipment for any signs of leaks or spills**	● Report immediately to supervisor. ● Stop operations in the area affected by spillage and stop appropriate source. ● Stop engines of vehicles in the affected area. ● Follow strictly instructions of supervisor in charge of cleaning operations. ● Do not resume operations or any movements until the supervisor has given clearance.	● All spills should be cleaned up immediately using proper conditions, which include stopping and containing the spill or leak. ● Arrest the spill and take steps to prevent repeat.
<u>D. Occupational Hazards</u> ● **Formation of emergency response teams for each department** ● **Provision of first-aid kits and emergency equipment on critical workstations** ● **Training of personnel on proper equipment handling and other safety practices** ● **Posting of safety reminders on workstations** ● **Provision of safety features such safety signage**	● Report immediately any accidents, especially those considered life-threatening ● Immediate application of first aid ● Removal of the affected personnel from the accident site. ● Bring the affected personnel to the nearest first aid station or hospital, if necessary.	● Perform corrective measures on equipment and procedures. ● Provision of additional safety procedures, equipment, and training.
<u>F. Flooding</u> ● **Prior to the incoming storm, secure all loose items** (i.e., **lamp post, roofs, loose planks, and other light materials) by adding extra guy wires or reinforcing materials.** ● **Remove obstructions to the drainage system.** ● **If there is a storm warning from PAGASA, monitor any possible developments, especially for the expected path and intensity of the**	● Personnel are advised to follow evacuation procedures. ● Personnel are advised to stay away from items that may be blown away by strong winds and electrical mains. ● Continuous monitoring of the weather conditions. ● All gas and electric equipment will be shut down.	● Inspect the facility for any major structural defects, cracks, unstable items, and other potential hazards. ● If necessary, repair broken power lines, fuel lines, and other utilities. ● Secure important items and equipment from unauthorized access from outsiders, after the premises have been declared safe for re-entry.

Preparation	Response	Recovery
storm, and other important weather parameters.		
<u>G. Vehicular Accidents</u> ● **Strictly impose speed limits.** ● **Strictly impose limit to types of vehicles allowed on the bridge.**	● Report immediately any accidents, especially those considered life-threatening. ● Immediate application of first-aid. ● Removal of the vehicle and victims from the accident site. ● Bring the affected personnel to the nearest first aid station or hospital, if necessary.	● Perform corrective measures on procedures. ● Provision of additional safety procedures, equipment, and training. ● Inspect the premises for any damage and potential hazards.
<u>H. Physical Risks (Failure of Structure)</u> • **Appropriate infrastructure design of the bridge that takes into consideration resilience to earthquakes, tsunamis, floods, storm surge, high winds, and traffic and other load projections, among other factors (design for adequate drainage, water diversion in flood prone areas)** • **Compliance with local, national and international design standards and building codes for bridges and highways (construction and operation)** • **Quality control of construction materials and close supervision and monitoring of construction processes** • **Implement weight (tonnage) restrictions for vehicles passing the bridge. Install signage on tonnage at the approach of the bridge** • **Regulate traffic volume on the bridge in accordance with the bridge's load capacity** • **Training and drills on emergency preparedness** • **Use of appropriate and well-maintained equipment** • **Provision and use of appropriate PPEs** • **Safety barriers and signages** • **Coordinate with and orient officers of safety vessels of ongoing bridge construction** • **Coordination with the Coast Guard to ensure safety of marine bridge piers and foundations** • **Install visibility signal lights and other signages to alert approaching marine vessels or vehicles of ongoing construction** • **Stop construction activities during adverse or extreme**	● Report immediately to supervisor and stop construction or operations in the area if necessary. ● Do not resume construction or operations until given clearance by the design engineer or supervisor. ● Personnel are advised not to panic to prevent further injuries. ● Personnel are advised to follow emergency evacuation procedures and evacuate the facility if necessary ● Removal of the vehicle/vessel and victims from the accident site. ● Bring the affected personnel to the nearest first aid station or hospital, if necessary. ● All gas and electric equipment are shut down ● Restrict access to impact areas ● Notify the security team, police and fire station of any bomb or terrorist threat and immediately close the structure to all vehicular, human traffic, supervise the evacuation of personnel and the public from the vicinity, and patrol and/or apprehend suspicious persons	● Check other personnel that may be trapped, injured, or needs further assistance. ● Avoid returning to the facility if it is deemed structurally unstable, or declared unsafe. ● Conduct thorough review of the design and inspection of the facility's premises for any possible damage to the structure and other electrical equipment. ● Check for possible fires and advice authorities for appropriate response. ● Secure important items and equipment from unauthorized access from outsiders, after the premises have been declared safe for re-entry. ● Inspect the facility for any major structural defects, cracks, unstable items, and other potential hazards. ● If the damage is minimal, or facility is recoverable, make corrective measures to prevent the further hazards from affecting personnel and property.

Preparation	Response	Recovery
climate events • **Regular and timely inspection and maintenance of the infrastructures, equipment and facilities (signs of corrosion, cracks, drainage water diversion systems, bridge piers and foundation for scouring) and implement rehabilitation as needed** • **Installation and proper maintenance of safety systems** (e.g., **Emergency warning systems etc.)** • **Formulate and disseminate Emergency Preparedness Plan, Evacuation Plan and SOPs to all workers and personnel** • **Conduct of regular emergency preparedness training and drills, which includes earthquake events, for all workers and personnel** • **Mandatory damage assessment of the bridge structures after strong typhoon, flooding, storm surge events** • **Stop vehicles from passing through the structure during extreme weather events** • **Formulate and implement appropriate contingency and evacuation plans** • **Deploy security personnel to monitor and secure the bridge perimeters, as necessary** • **Follow security announcement/advice from government's (national and local) security agency**		

Table 4.3 Roles and responsibilities in the Emergency Plan

Emergency Response Personnel	Roles and Responsibilities
Incident Commander	• Overall in-charge of operations during an event of an emergency • Gives direction and orders to the response teams in managing the emergency
Safety Officer	• Supervises the daily safety performance of operations and maintenance procedures, including emergency response procedures
Liaison Officer	• Secures the necessary permits and training certification for the personnel
Public Information Officer	• Performs communication duties in behalf of the provider to the media, government officials, and the local population • Issues relevant warnings and advisories to concerned authorities

Emergency Response Personnel	Roles and Responsibilities
Operations Team	● Performs the actual response, rescue, and retrieval of personnel and equipment during an event of an emergency
Planning/Intelligence Team	● Devices programs and policies for proper response procedures ● Informs the operations team regarding the nature and type of response procedure for the Operations Team ● Identifies potential hazards and performs recommendations to authorities
Logistics Team	● Provides the necessary supplies and equipment for the Operations Team ● Provides additional support/assistance to the Operations Team
Finance and Administration Team	● Provides the assessment of expenses and allocates the necessary financial resources for the other Teams ● Performs the disbursement of claims and compensation for affected personnel, property and the community

5 Social Development Program (SDP) and Information and Education Campaign (IEC) Framework

5.1 Social Development Program (SDP)

The Social Development Program (SDP) Framework for the LLRN Project is developed based on the issues and concerns that have been identified in the conduct of impact assessment, including the conduct of IEC and consultation activities in the affected communities.

Table 5.1 presents the proposed social development programs for the project benefitting the host barangays with consideration of vulnerable groups, such as senior citizens, women, and children.

Table 5.1 Social Development Framework for the LLRN Project

Concern	Target Beneficiary	Responsible Entity	Possible Programs	Indicative Timeline	Source of Fund
Displacement	Project-affected families	M/CPDO M/CSWDO Local housing offices/ agencies PESO DOTr	Skills inventory and job matching Creation of livelihood programs that is anchored on a clear understanding of supply and demand and value chain	Pre-construction	LGU, NHA, DPWH
Transparency and community involvement	Project affected people in affected areas	BLGUs M/CLGU DOTr	Bi-monthly conduct of barangay consultations Development of audience-specific IEC materials Establishment of grievance redress mechanism	Pre-construction Construction Operation	BLGUs M/CLGU DPWH
Gender responsive livelihood/ Employment and credit facilities	Qualified project affected men, women, youth, and elderly	M/CPDO M/CSWDO GFPS (GAD Focal Point System) PESO (Public	Conduct of gender analysis Mainstreaming of gender in livelihood programs	Pre-construction Construction Operation	LGU, DPWH

Concern	Target Beneficiary	Responsible Entity	Possible Programs	Indicative Timeline	Source of Fund
		Service Employment Office) M/CCDO (Credit Development Office)	Skills inventory and job matching Creation of livelihood programs that is anchored on a clear understanding of supply and demand and value chain		
Health and safety	Project affected families	M/CHO M/CDRRMO BDRRMO	Dissemination of traffic advisories Road safety orientation among schoolchildren	Pre-construction Construction Operation	LGU, DPWH
Environment and sanitation	Project affected families	M/CENRO M/CHO	Conduct of monthly medical missions in affected barangays Strengthening of TB-DOTS programs at the barangay level Strengthening of reproductive health and family planning programs and activities in barangays and workplaces	Pre-construction Construction Operation	LGU, DPWH
Peace and order	Project affected families	LGU PNP PCG	Registration of non-residents who conduct business in the barangay Capacity building for barangay tanods on peace keeping	Pre-construction Construction Operation	LGU, DPWH

5.2 Information and Education Campaign (IEC)

The conduct of Information, Education and Communication (IEC) campaign serves as a venue for the exchange of feedback between the project proponent and the community. The contents of the IEC campaign should contain information about the project based on the proponent's understanding of the community's right to know.

The IEC campaign should have a supporting strategic communication plan that clearly identifies target audience, their interest, and the corresponding message (information disclosure) and approach or medium to be used. Broadly, the communication plan for this Project can cover the following concerns:

- The need for the project;
- The potential benefits of the project;
- The project phases and possible impacts; and
- The social development plan of the proponent and corresponding LGUs.

Table 5.2 presents the proposed IEC Framework for the LLRN Project.

Table 5.2 IEC Framework of the LLRN Project

Stakeholder	Interest	Method	Indicative Timeline and Frequency
Residents of affected barangays	Potential impacts and proposed mitigation measures during construction and operation. Priority hiring for workers and employees.	Briefing sessions Group consultations Barangay bulletins	At least two months prior to start of construction Semi-annually during construction Annually during operation
Fisherfolks	Potential impacts and proposed mitigation measures during construction and operation. Compensation/Livelihood restoration. Access and safety in fishing	Group consultations Posting of bulletins in strategic areas for important announcements	At least two months prior to start of construction Semi-annually during construction Annually during operation
Parents and schoolchildren	Potential impacts and proposed mitigation measures during construction and operation. Access and road safety	Group consultations School bulletins	At least two months prior to start of construction Semi-annually

Stakeholder	Interest	Method	Indicative Timeline and Frequency
			during construction Annually during operation
Local government units	Preparation for construction. Convergence of various government projects in their respective areas. Preparation for construction and operation.	Leadership briefings Provision of briefing notes	At least two months prior to start of construction, Semi-annually during construction Annually during operation
Transport sector	Avoid disturbances, like traffic congestion and inconvenient re- routings, as much as possible that may lead to lesser earning/income. Access and road safety.	Group consultations Posting of bulletins in strategic areas for important announcements	At least two months prior to start of construction, Semi-annually during construction Annually during operation
Business owners within and along the alignment	Avoid disturbances (air pollution, traffic noise, flooding, waste accumulation) as much as possible. Access to their shops from the road/highway. Better and safer roads. Fair compensation. Same or better livelihood condition.	Group consultations Posting of bulletins in strategic areas for important announcements	At least two months prior to start of construction, Semi-annually during construction (notices only, unless necessary) Annually during operation
Municipal/City/Barangay Fisheries and Aquatic Resources Management Councils (FARMCs)	Enforcement of fishery laws, rules, and regulations in municipal waters.	Executive briefings Provision of briefing notes	At least two months prior to start of construction, Semi-annually during

Stakeholder	Interest	Method	Indicative Timeline and Frequency
			construction Annually during operation

6 Environmental Compliance and Monitoring

This Environmental Compliance Monitoring and Management Plan (EMMP) has been prepared to ensure that the proposed project by the government through the Department of Public Works and Highways (DPWH) will be undertaken in a manner that minimizes the environmental effects of the site preparation and construction works.

As a framework to minimize the environmental effects of the pre-construction, construction and up to operation works, all activities that need to be undertaken will have to meet the conditions laid down in the Outline Plan, Land Designations, Resource Consents and relevant By-laws, Acts and Regulations.

This EMMP will be a 'live' document and will be reviewed and updated throughout the life of the project to make sure that environmental protection is achieved at all times.

6.1 Objectives

The objectives of the project, in regard to environmental management and protection are:

(a) To take the necessary steps to prevent or mitigate any adverse environmental effects caused by the pre-construction, construction and up to operation works, or by related activities;

(b) To take the necessary steps to prevent or mitigate any nuisance to adjacent properties during the conduct of various activities.

(c) To maintain to a reasonable standard any land taken or held for the works until the physical works commence.

(d) To ensure that, at all times, reasonable and useable access is maintained to private properties, particularly those directly affected by the pre-construction, construction and up to operation works or related activities;

(e) To provide protective fencing to sites of ecological sensitivity that are identified before construction works and any that are discovered during construction.

(f) To ensure that the requirements of the EMMP are complied with throughout the duration of the project including but not limited to contract works by all parties involved with the construction works, including subcontractors.

6.2 Designation and Resource Consents

A designation approval and several resource consents have been granted for the project. These documents have been reviewed and the EMMP has been prepared to address the conditions and requirements detailed within these documents.

6.3 Environmental Legislation

There are various Government Acts and Regulations including environmental specific acts that are applicable to the worksite, these include but are not limited to:

PD 856 – Code of Sanitation

PD 1067 – Water Code of the Philippines

PD 1586 – The Philippine Environmental Impact Statement System

RA 8749 – The Philippine Clean Air Act of 1999

RA 6969 – Toxic Substances, Hazardous and Nuclear Waste Act

RA 9275 – The Philippine Clean Water Act of 2004

RA 9003 – Ecological Solid Waste Management Act

Compliance to these and any other regulations, by-laws, etc., will be achieved proper implementation of appropriate site and environmental monitoring and management plan presented herein.

6.4 Environmental Management Contacts

The potential environmental effects as a result of the construction of this project are to be minimized through careful planning, adherence with the requirements of this Environmental Monitoring and Management Plan (EMMP). This EMMP utilizes the existing DPWH Procedures as a basis for environmental management on site. These procedures have been modified, as maybe required, to address the specific issues on site. The procedure also specifies the responsibilities of the various staff in the implementation, which is summarized below:

Project Manager

The Project Manager is responsible for ensuring that environmental risk management processes are implemented throughout the duration of the project. The Project Manager is to nominate key personnel to carry out risk assessments on all potential environmental aspects and develop specific risk control measures to eliminate or minimize risks to an acceptable level. The Project Manager is also responsible for ensuring that changes to personnel or the work environment that may impact on the effectiveness of risk control methods are identified.

The risk management process is to involve relevant personnel directly involved with the work. Risk control measures are to be regularly monitored and reviewed to ensure continuing effectiveness.

Project Health, Safety, and Environmental (HSE) Manager

The HSE Manager is responsible for providing the support necessary for the successful implementation of this procedure.

Safety Supervisor, Engineers, and Officer

All Safety Officers are responsible for the maintenance of safety in their respective units by ensuring the implementation of risk management processes and associated risk control methods.

Project Environmental Officer

The Project Environmental Officer (EO) is responsible for ensuring that this procedure is known and implemented by all relevant supervisory personnel. The responsibility of the Environmental Officer also includes the inspection of the Site for any possible issues, monitoring of the area and implementation of the EMMP and the corresponding mitigation measures. The Environmental Officer also acts as the Pollution Control Officer (PCO).

Supervisors/Foremen

Supervisors and Foremen have key responsibility in the planning and coordinating of work activities and assessing potential environmental aspects on the job and instructing employees in risk control methods to accomplish the work without harming the environment.

Contractor's Responsibility and Environmental Programs

This section discusses the responsibility of employees and subcontractor's employees in health, safety, and environmental issues related to the project.

Employees and Subcontractors

Throughout this procedure "employee" shall refer to both **DPWH** direct employees and subcontractor employees. Employees are responsible for complying with environmental controls on the project. Employees are required to be active in awareness on the job by reporting inadequate conditions or practices to supervision. Relevant employees are to be consulted during the risk management process.

Environmental Chain of Responsibility

The first point of contact for any safety and environmental issues on site is the Health, Safety and Environmental (HSE) Manager and the Environmental Officer (EO)**.** In the event that the HSE and EO are unavailable, all issues are referred to the Project Manager. He will then designate who among the remaining Safety Officers will take charge of the issues. Should there be environmental issues outside the control of the **DPWH** or in the event that the response or performance of **DPWH** is not considered appropriate, **the Construction Management** is to be contacted. Below is the sample contact list of key personnel responsible for ensuring that all healthy, safety, and environmental issues related to the project.

Table 6.1 Sample Contact List of Key Personnel

Name	Position	Company	Contact Number	Email
	Project Manager	**DPWH**		
	HSE/ Environmental Manager	**DPWH**		
	Safety Supervisor	**DPWH**		
	Safety Engineer	**DPWH**		
	Safety Engineer	**DPWH**		

Name	Position	Company	Contact Number	Email
	Safety Officer	**DPWH**		
	Environmental Officer	**DPWH and Construction Management Rep**		
	Safety Officer	**Construction Management.**		
	Safety Officer	**Construction Management**		

6.5 Monitoring

The regular monitoring, excluding the specific monitoring, will be undertaken in accordance with the Safety & Environmental Inspections & Monitoring Procedure (Environment) of DPWH. The results of this regular monitoring will be utilized to prepare the required environmental compliance reports. In addition to the internal environmental monitoring, it is expected that there will be a degree of regular external monitoring from **the Proponent (DPWH), Construction Management and the Environmental Management Bureau (EMB)**.

Self-Monitoring Plan

As per Annex 2-20 of the Revised Procedural Manual (RPM) from DAO 2003-30, the self-monitoring plan is summarized in Table 6.3 in the next page. On the other hand, the description of the EQPL is provided in the table below.

Table 6.2 EQPL Definition

EQPL Level	Description
Alert or Red Flag	Early warning
Action Level	Point where management measures must be employees so as not to reach the regulated threshold or limit level, or to reduce deterioration of affected environmental component to pre-impact or optimum environmental quality.
Limit Level	Regulated threshold of pollutant (standard that must not be exceeded); point where emergency response measures must be employed to reduce pollutants to lower than the standard limit.

It is worth noting that the EQPL component of the EMoP is filled out only if they are willing to be committed by the proponent at the pre-ECC stage. Otherwise, the proponent may opt to have EQPLs established post-ECC, which are then mutually agreed upon by the Proponent, EMB and other MMT members. Otherwise, only the Limit Level shall be the reference for regulatory compliance. This means that formulated environmental measures are not to exceed this regulated threshold.

In the case of the LLRN Project, the EQPL component will be established post-ECC.

Table 6.3 Summary of Monitoring Plan (EMoP) with Environmental Quality Performance Levels (EQPLs)

Project Activity	Impact	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost (Php)	EQPL Management Scheme					
			Method	Frequency	Location			Environmental Quality Performance Level			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
CONSTRUCTION PHASE													
General													
Hiring of local workers	Opportunity for employment and livelihood; Competition with local and migrant workers; Reduction of poverty and food poverty.	Number of locals hired	Employment records	Monthly	Project site	Project Contractor Proponent	Part of project cost	40% of on-site employees are migrant workers			Freeze hiring of migrant workers		
	Health and Safety of construction workers	Accident-free man hours	Timesheets and incident reports	Daily	Project site	Health and Safety Officer	1,500,000.00	One near miss accident	One recorded accident	Two recorded accidents	Assess the source of accident	Investigate the root cause of injuries	Temporary stoppage of work until incident properly assess and mitigated
General Construction works	Potential threat to health and safety of people / communities	Number and nature of incidents	Records from Clinics Safety Records	Monthly	At construction site	Project Manager Proponent	Part of construction cost	One recorded injury with no lost time injury (LTI)	>1 recorded injury with no lost time injury (LTI)	One lost time injury (LTI)	Assess the source of accident	Investigate the root cause of injuries	Provide EHS monthly report and plans
Preparation and Construction of Temporary Facilities													
Site preparation, clearing, and/ or tree cutting activities	Displacement and loss of livelihood of residents and business owners during ROW land acquisition.	Resettlement Action Plan	Technical Review	Once	Project Management Office (PMO)	DPWH, Design Contractor;	Part of construction cost	Not applicable					
		Affected residents and land owners and corresponding compensation packages	Inventory and Survey	Quarterly	Direct and Indirect Impact Areas	DPWH, LGU	Part of construction cost	Not applicable					
	Generation of local job opportunities	Employment records	Number of locals hired	Monthly	At construction site	Social Safeguard Specialist, PMO-DPWH	Part of construction cost	40% of on-site employees are migrant workers			Freeze hiring of migrant workers		
	Temporary disruption of public services, such as water and electric supply	Affected communities and businesses	Ocular inspection	Daily during preparation and construction	Direct Impact Areas	Project Contractor Proponent	Not Applicable	Formal complaint					
	Loss of topsoil due to vegetation clearing may trigger soil erosion and may induce landslides in some areas.	Soil and bedrock components	Geologic Investigation	After every major earthquake and during pile driving	At construction site	Project Engineer	Part of contract cost	Presence of cracks, vertical displacement and mass movement					
	Loss of vegetation during clearing operation (i.e. fruit bearing trees, and forest trees);	Terrestrial habitat and trees removed and planted making sure loss has been compensated; survival rate of introduced species	Ocular inspection; Tree count	Monthly	At construction site	PCO of the Contractor, DPWH-PMO, Biodiversity Management Bureau	Part of Contract Cost	Degradation/reduction of vegetative cover relative to the project site					
	Disturbance or loss of habitat and will affect existing wildlife	Inventory of lost habitats and affected population of certain fauna species	Fauna inventory and habitat logging	Quarterly	At construction Site	PCO of the Contractor, DPWH-PMO, BMB	Part of Contract Cost	Degradation/reduction of native species cover relative to the project site					
	Accumulation of solid wastes	Volume and type of solid wastes generated	Segregation and weighing; disposal thru a DENR-accredited service provide	Daily	At construction site	Environment Officer	200,000.00	50% maximum storage capacity	80% maximum storage capacity	Maximum storage capacity	Ensure proper storage and segregation of wastes	Monitoring of trash bins	Proper disposal of solid waste

Project Activity	Impact	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost (Php)	EQPL Management Scheme					
			Method	Frequency	Location			Environmental Quality Performance Level			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
	May trigger siltation	Volume of sediments stored or disposed	Volume estimation	Weekly	At construction site	Proponent	Part of contract cost	Degradation on its physical aesthetics due to accumulation of suspended sediments.					
	Alteration of air quality from vehicles, fugitive dust and from equipment use	PM2.5	Air quality sampling: Refer to DAO 2000-81 Analysis Methods	Quarterly	Project site	Environment Officer	700,000.00	25 ug/Ncm	30 ug/Ncm	50 ug/Ncm	Check of APCD	Conduct maintenance and operation works on APCD	Inspect condition of engines; Repair damages/ defects, repeat analysis
		PM10						120 ug/Ncm	130 ug/Ncm	150 ug/Ncm			
		TSP						180 ug/Ncm	200 ug/Ncm	230 ug/Ncm			
		SO2						120 ug/Ncm	150 ug/Ncm	180 ug/Ncm			
		NO2						65 ug/Ncm	70 ug/Ncm	150 ug/Ncm			
	Noise Generation Disturbs people and areas	Noise levels	Noise monitoring	Daily during onshore construction	Project site	Environment Officer	450,000.00	50 dB(A)	60 dB(A)	65 dB(A)	Investigation of noise generating equipment	Provide maintenance and operation works on equipment	Inspect condition of engines; Repair damages/ defects
Construction and installation of site facilities – Temporary Facilities (field offices and barracks)	Accumulation of solid wastes	Volume and type of solid wastes generated	Segregation and weighing; disposal thru a DENR-accredited service provide	Daily	At construction site	Environment Officer	200,000.00	50% maximum storage capacity	80% maximum storage capacity	Maximum storage capacity	Ensure proper storage and segregation of wastes	Monitoring of trash bins	Proper disposal of solid waste
	Generation of hazardous materials in land (i.e. disposal of busted lamps, batteries, empty chemical containers, used oil etc. (from casting yard and storage areas); generated from the operation of construction machinery and office facility	Proper management and disposal of wastes; Volume and type of hazardous materials generated	Checking compliance to RA 9003 and RA 6969; Segregation and weighing	Weekly	At construction site	Environment Officer	200,000.00	50% maximum storage capacity	80% maximum storage capacity	Maximum storage capacity	Ensure proper storage and segregation of wastes	Monitoring of trash bins	Proper transport and disposal of solid waste
	Soil contamination from leaks of lubricants, reagents and used oil	Presence of lubricants, reagents and oil	Visual inspection	Daily	Project site	Environment Officer	100,000.00	Not applicable					
	Degradation of water quality: Impacts on groundwater and freshwater quality	pH	DENR- EMB Water Quality Monitoring Manual	Monthly	Project site	Environment Officer	10,000.00 per parameter	6.5-8.0	8.0-8.5	6.5-8.5	Investigate and identify non-point sources	Investigate and identify non-point sources	Investigate and identify non-point sources, repeat analysis
		DO						5 mg/L	5.1-5.5 mg/L	8 mg/L			
	Degradation of water quality: Impacts on fresh water quality	Oil and grease	DENR- EMB Water Quality Monitoring Manual	Monthly	Project site	Environment Officer	500,000.00	1.8 mg/L	2.4 mg/L	3 mg/L	Investigate and identify non-point sources	Investigate and identify non-point sources	Investigate and identify non-point sources, repeat analysis
		TSS						62 mg/L	71 mg/L	80 mg/L			
		Fecal coliform						200 MPN/100mL	1000 MPN/100mL	9,200 MPN/100mL		Provision and repair of proper sanitary facility	
		Total coliform						-	-	10,000 MPN/100mL			
	Alteration of air quality from vehicles, fugitive	PM2.5	Air quality sampling: Refer to	Quartlerly	Project site	Environment Officer	840,000.00	25 ug/Ncm	30 ug/Ncm	50 ug/Ncm	Check of APCD	Conduct maintenance	Inspect condition of engines; Repair

Project Activity	Impact	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost (Php)	EQPL Management Scheme					
			Method	Frequency	Location			Environmental Quality Performance Level			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
	dust and from equipment use	PM10	DAO 2000-81 Analysis Methods					120 ug/Ncm	130 ug/Ncm	150 ug/Ncm		and operation works on APCD	damages/ defects, repeat analysis
		TSP						180 ug/Ncm	200 ug/Ncm	230 ug/Ncm			
		SO2						120 ug/Ncm	150 ug/Ncm	180 ug/Ncm			
		NO2						65 ug/Ncm	70 ug/Ncm	150 ug/Ncm			
	Noise Generation; Disturbs people and areas	Noise levels	Noise monitoring	Daily during onshore construction	Project site	Environment Officer	400,000.00	50 dB(A)	60 dB(A)	65 dB(A)	Investigation of noise generating equipment	Provide maintenance and operation works on equipment	Inspect condition of engines; Repair damages/ defects
Construction, bore piling and installation of piers and columns on land and marine – Permanent Structure													
Dredging and excavation on land and water; **Earthmoving through use of heavy equipment; Operation of vessels** **Installation of columns/ foundations and construction of interchanges and bridge structure.**	May trigger soil erosion and induce landslides in some areas (including impacts on Earthquakes, Ground settlement and lateral spread, Mass movements)	Detailed Engineering Design	Technical Review	Once	Project site	DPWH and Design Contractor	Part of contract cost	Not applicable					
	Geohazards	Measurement of displacement caused by geohazards in an area Size of flooded areas and flood heights	Geohazard survey	Quarterly	Project site	DENR-MGB/ DPWH Environment Officer	300,000.00	Not applicable					
	Liquefaction	Ground vertical displacement	Geologic Investigation	After every major earthquake and during pile driving	Project site	Project Manager	300,000.00	Not applicable					
	Ground subsidence	Dissolution cracks and volume of solution cavities	Geologic Investigation	Quarterly	Project site	Project Manager	300,000.00	Not applicable					
	Change in sub-surface geology and underground conditions due to the project, inducement of subsidence, karst subsidence, liquefaction and mass movements Damage or collapse due to strong ground shaking	Detailed Engineering Design	Technical Review	Once	Project Management Office	DPWH and Design Contractor	Incorporated as part of the design cost	Not applicable					
	Soil contamination from leaks of lubricants, reagents and used oil	Presence of lubricants, reagents and oil	Visual inspection	Daily	Project site	Environment Officer	100,000.00	Not applicable					
	Accumulation of solid wastes	Volume and type of solid wastes generated	Segregation and weighing; disposal thru a	Daily	At construction site	Environment Officer	200,000.00	50% maximum storage	80% maximum storage	Maximum storage capacity	Ensure proper storage and segregation of	Monitoring of trash bins	Proper disposal of solid waste

Project Activity	Impact	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost (Php)	EQPL Management Scheme					
			Method	Frequency	Location			Environmental Quality Performance Level			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
			DENR-accredited service provide					capacity	capacity		wastes		
	Generation of hazardous materials in land (i.e. disposal of busted lamps, batteries, empty chemical containers, used oil etc. (from casting yard and storage areas); generated from the operation of construction machinery and office facility	Proper management and disposal of wastes; Volume and type of hazardous materials generated	Checking compliance to RA 9003 and RA 6969; Segregation and weighing	Weekly	At construction site	Environment Officer	200,000.00	50% maximum storage capacity	80% maximum storage capacity	Maximum storage capacity	Ensure proper storage and segregation of wastes	Monitoring of trash bins	Proper transport and disposal of solid waste
	Impairment of visual aesthetics	Final Project Design	Technical Review	Once	At construction site	DPWH and Design Contractor	Part of contract cost	Not applicable					
	Increase in flooding susceptibility	Detailed Engineering Design	Technical Review	Once	At construction site	DPWH and Design Contractor	Part of contract cost	Not applicable					
		Size of flooded areas and flood heights	Geohazard survey	After every flooding event	At construction site	Proponent	Part of contract cost	Exceeded the carrying capacity of flood mitigating measures applied					
	May trigger siltation; Degradation of water quality due to oil, fuel or other lubricant agents leaks; Water Quality	pH	DENR- EMB Water Quality Monitoring Manual	Monthly	Project site	Environment Officer	10,000.00 per parameter	6.5-8.0	8.0-8.5	6.5-8.5	Investigate and identify non-point sources	Investigate and identify non-point sources	Investigate and identify non-point sources, repeat analysis
		DO						5 mg/L	5.1-5.5 mg/L	8 mg/L			
		Oil and grease	DENR- EMB Water Quality Monitoring Manual	Monthly	Project site	Environment Officer	500,000.00	1.8 mg/L	2.4 mg/L	3 mg/L	Investigate and identify non-point sources	Investigate and identify non-point sources	Investigate and identify non-point sources, repeat analysis
		TSS						62 mg/L	71 mg/L	80 mg/L			
		Fecal coliform						200 MPN/100mL	1000 MPN/100mL	9,200 MPN/100mL		Provision and repair of proper sanitary facility	
		Total coliform						-	-	10,000 MPN/100mL			
	Traffic congestion	Traffic Management Plan	Monitoring and evaluation of TMP implementation	Daily during onshore construction	Project site	Project Contractor Proponent	Not Applicable	Formal complaint			Coordinate with LGUs on Traffic Management Reassess Traffic Management Plan		
	Alteration of air quality from vehicles, fugitive dust and from equipment use	PM2.5	Air quality sampling: Refer to DAO 2000-81 Analysis Methods	Quarterly	Project site	Environment Officer	840,000.00	25 ug/Ncm	30 ug/Ncm	50 ug/Ncm	Check of APCD	Conduct maintenance and operation works on APCD	Inspect condition of engines; Repair damages/ defects, repeat analysis
		PM10						120 ug/Ncm	130 ug/Ncm	150 ug/Ncm			
		TSP						180 ug/Ncm	200 ug/Ncm	230 ug/Ncm			
		SO2						120 ug/Ncm	150 ug/Ncm	180 ug/Ncm			
		NO2						65 ug/Ncm	70 ug/Ncm	150 ug/Ncm			
	Noise Generation; Disturbs people and areas	Noise levels	Noise monitoring	Daily during onshore construction	Project site	Environment Officer	400,000.00	50 dB(A)	60 dB(A)	65 dB(A)	Investigation of noise generating equipment	Provide maintenance and operation works on equipment	Inspect condition of engines; Repair damages/ defects

Project Activity	Impact	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost (Php)	EQPL Management Scheme					
			Method	Frequency	Location			Environmental Quality Performance Level			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
Dredging and excavation on water; **Operation of Vessels;** **Installation of columns/ foundations and construction of bridge structure**	Local loss and disturbance of natural sedimentary habitats due to introduction of hard substrates and increase in sediment loads from construction materials; Deterioration, destruction and disruption of fish habitats	Monitoring and evaluation of benthic habitats to capture changes; Should there be any affected corals and freshwater grasses mitigation / translocation of any benthic species should be undertaken by a suitably qualified freshwater/marine ecologist.	Ecological inventory	Semi-annual	Project Site	PCO of the Contractor, DPWH-PMO, BMB	Part of Contract Cost	Degradation/reduction of native species cover relative to the project site					
	Changes in channel beds and impacts on fish and aquatic life	Monitoring and evaluation of benthic habitats to capture changes based on Biodiversity Protection Plan	Ecological inventory	Semi-annual	Project Site	PCO of the Contractor, DPWH-PMO, BMB	Part of Contract Cost	Degradation/reduction of native species cover relative to the project site					
OPERATION PHASE													
Hiring of local workers	Opportunity for employment and livelihood; Competition with local and migrant workers; Reduction of poverty and food poverty.	Number of locals hired	Employment records	Monthly	Project site	Project Contractor Proponent	Part of project cost	40% of on-site employees are migrant workers			Freeze hiring of migrant workers		
Hiring of local workers	Health and Safety of construction workers	Accident-free man hours	Timesheets and incident reports	Daily	Project site	Health and Safety Officer	2,000,000.00	One near miss accident	One recorded accident	Health and Safety of construction workers	Accident-free man hours	Timesheets and incident reports	Daily
Operation of the bridge	Potential threat to health and safety of people / communities	Number and nature of incidents	Records from Clinics Safety Records	Monthly	At construction site	Project Manager Proponent	Part of construction cost	One recorded injury with no lost time injury (LTI)	>1 recorded injury with no lost time injury (LTI)	1 lost time injury	Assess the source of accident	Investigate the root cause of injuries	Provide EHS monthly report and plans
Movement of passengers	Increase in solid waste generation from passengers and operational works	Proper management and disposal of wastes	Checking compliance to RA 9003 and RA 6969	Weekly	Project site	PMO	Part of the operation cost	50% maximum storage capacity	80% maximum storage capacity	Maximum storage capacity	Ensure proper storage and segregation of wastes	Monitoring of trash bins	Proper disposal of solid waste
Movement of vehicles along the bridge	Noise from vehicles may exceed national standards for noise in general areas	Noise levels	Noise monitoring	Daily	Project site	Environment Officer	400,000.00	50 dB(A)	60 dB(A)	65 dB(A)	Investigation of noise generating equipment	Provide maintenance and operation works on equipment	Inspect condition of engines; Repair damages/ defects

6.6 Environmental Guarantee and Monitoring Fund Commitments

DPWH shall initiate a Memorandum of Agreement (MOA) in coordination with the concerned EMB Office on the formation of a Multipartite Monitoring Team (MMT), as well as the establishment of an Environmental Monitoring Fund (EMF) and Environmental Guarantee Fund (EGF). The establishment of the EMF and EGF shall be in accordance with the prescribed guidelines and procedures of the Revised Procedural Manual for DENR Administrative Order No. 2003-30. These funds are allocated for the expenses and services of the MMT and for the following purposes:

- Conduct necessary environmental monitoring for LLRN
- Expenses that will be used to compensate communities that will be negatively impacted by the project
- Proper preparation measures (i.e. damage preventive programs, capacity building) to reduce vulnerability to hazards, and
- Repairing deteriorated environmental areas that were damaged from the project's construction and operation phases

6.6.1 Environmental Monitoring Fund

In support of the activities of the MMT for compliance monitoring, an Environmental Monitoring Fund (EMF) shall be allotted by the proponent. The EMF will be established as agreed upon and specified in the MOA between DENR-EMB and the Proponent, with conformity of the MMT members. An EMF is required for all MMTs of EIS based projects.

However, the final proposed amount for the EMF will be based on the costs of monitoring activities and environmental programs stated in the Environmental Management Plan that shall be carried out by the MMT. Further, the Administration and Management Guidelines for EMF is provided in Annex 3-5 of RPM for DAO 2003-30.

6.6.2 Environmental Guarantee Fund

An Environmental Guarantee Fund (EGF) is required to be established for all co-located or single projects that have been determined by DENR to pose a significant public risk or where the project requires rehabilitation or restoration. The EGF shall be established and used exclusively for the following purposes:

The immediate rehabilitation of areas affected by damages to the environment and the resulting deterioration of environmental quality as a direct consequence of project construction, operation and abandonment

- The just compensation of parties and communities affected by the negative impacts of the project

- The conduct of scientific or research studies related to the project that will aid in the prevention or rehabilitation of accidents and/or environmental damages, and

- For contingency clean-up activities, environmental enhancement measures, damage prevention programs and social equity measures (e.g. livelihood, social development programs) including the necessary IEC and capability building activities related to the project.

Additionally, the Administration and Management Guidelines for EGF is provided in Annex 3-6 of RPM for DAO 2003-30.

6.6.2.1 Establishment of Environmental Guarantee Fund

EGF Trust Fund

DPWH will require the contractor to post a Contractor's All Risk Insurance (CARI) equivalent to the total contract cost valid for the whole duration of the contract. Beyond the coverage of CARI, DPWH will establish a Trust Fund in the amount of Two Million Million Pesos (PhP2,000,000.00) charged against the Provisional Sum of the contract. The Trust Fund shall be replenished to its original amount annually or whenever the amount goes below the mutually agreed amount of One Million Pesos (PhP 1,000,000.00).

The Trust Fund will be used to compensate aggrieved parties for any damages to life or property, undertake community-based environmental programs, conduct environmental research aimed at strengthening measures to prevent environmental damage and to finance restoration and rehabilitation of environmental quality of the project-affected area.

7 Decommissioning/ Abandonment/ Rehabilitation Policy

The abandonment plan is not applicable for LLRN project. This abandonment plan would mean abandonment or decommissioning of the construction team and all construction related facilities during the end of construction period.

Once the Environmental Compliance Certificate (ECC) is issued, among the conditions will be the abandonment plan. This shall be prepared ninety (90) days prior to abandonment of the area and will be submitted to DENR-EMB Central Office. Activities will include the following:

1. On-site inspection of the project site,
2. Pull out construction equipment and remaining supplies and materials,
3. Dismantling and pull out of temporary construction facilities,
4. Disposal of waste generated during construction.
5. Clean-up, remediate (if any) contaminated areas (soil or water) cause by the project during construction; and
6. Revegetation or rehabilitation of environment disturbed by the construction support facilities.

The proponent will hire a consultant to prepare a separate comprehensive decommissioning plan and/or rehabilitation management plan (RMP) to address specific issues with regards to the abandonment of the project. This shall be prepared and submitted to DENR for review and approval prior to actual project decommissioning.

8 Institutional Plan for EMP Implementation

The Institutional Plan is the establishment of a body that will implement the proposed Environmental Management Plan (EMP) whose main thrust is to ensure that environmental, socio-economic, political and public health issues are properly address in a timely manner. It provides necessary mechanism that will strengthen the organizational relationship of the proponent with the host community, concern government agencies and other stakeholders.

8.1 Environmental Unit

One on the major requirement of EMB is the creation of the Environmental Unit (EU) to monitor the environmental compliance of the project. During the construction of the LLRN project the proponent must initiate the creation of the project's Environmental Unit (EU) which will be primarily composed of the proponent's Environmental Officer (EO) or Pollution Control Officer (PCO), contractors PCO or Environmental Health and Safety Officers (EHSO), subcontractors' representatives, and project engineers. The proponents' designated EO/PCO will lead the EU and coordinate with DENR-EMB CO.

The project engineers and EHSOs shall be responsible in the monitoring of the project in coordination with the DPWH - Environmental and Social Safeguards Division (ESSD), under the Planning Service. Enough resources/budget shall be appropriated to support the different environmental programs.

The created EU shall implement the Construction Environmental Management Plan (CEMP) and monitor the project's compliance with the ECC conditions of the project. The proponent's EO/PCO should be given enough authority and competence on decision-making with reference to environmental management.

The Managers, PCOs, Safety Officers, and Security Officer should have appropriate educational background and/or experience and training on environmental, community organization and development, health and safety and security risk regulations and practices.

8.2 ECC Compliance Monitoring and Reporting

The Proponent will commit to comply with the environmental laws, particularly on the conditions stated in the project's ECC.

During the pre-construction phase of the project, the DED contractor shall be required, thru their contract agreement, to incorporate in the project's design all the gathered data from the environmental baseline study, listed environmental impacts and formulated mitigation plans, and issues and concerns.

The same will be done during the construction phase of the project. The Contractor's Agreement will include the implementation of the applicable conditions of the ECC and implementation of the EMP and EMoP. The Contractor's environmental compliance will be monitored by the hired Project Management Consultants (PMC) and by the corporate PCO.
The created Environmental Unit will ensure that regular reporting of compliance to DENR standards and other regulatory agencies will be undertaken. The Self-Monitoring Reports (SMR) and Compliance Monitoring Reports (CMR) detailing status of compliance with ECC

and other environmental regulations shall be submitted to DENR – EMB CO on quarterly and semi-annually, respectively.

8.3 Multi-Partite Monitoring Team (MMT)

The proponent shall initiate the creation of the Multi-partite Monitoring Team (MMT) for LLRN Project. The MMT shall be responsible for the conduct of quarterly environmental monitoring of the project, as well as drafting of the Compliance Monitoring and Verification Report (CMVR) to be submitted to DENR-EMB CO on a semi-annual basis. MMT members will be based DAO 2017-15 and DAO 2018-18.

Budget to implement the Environmental Management Plan (EMP) and for the Environmental Monitoring Fund (EMF) will be prepared during the Detailed Engineering Design (DED) and will be included in the Civil Works Contract. The budget will cover the following items:

a. All mitigation cost which includes dust suppression, installation of movable noise barriers, cutting of trees, waste management, etc.
b. Monitoring cost which includes air, water, noise, soil quality, etc.

In lieu of the Environmental Guarantee Fund (EGF), the Contractors' All Risks (CAR) Insurance will be used to compensate aggrieved parties for any damages to life or property.

8.4 Organizational Structure for Implementation

Figure 8- 1 to **8.2** shows the proposed organizational structure with respective roles for the environmental monitoring and reporting.

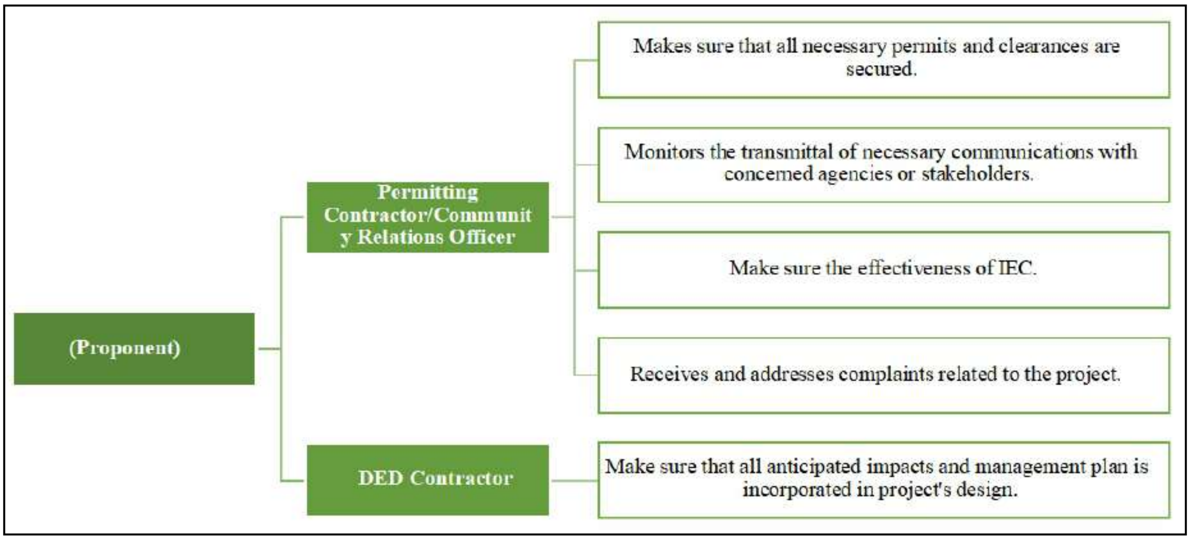


Figure 8- 1 Organizational Structure for EMP Implementation during the Pre-Construction Phase

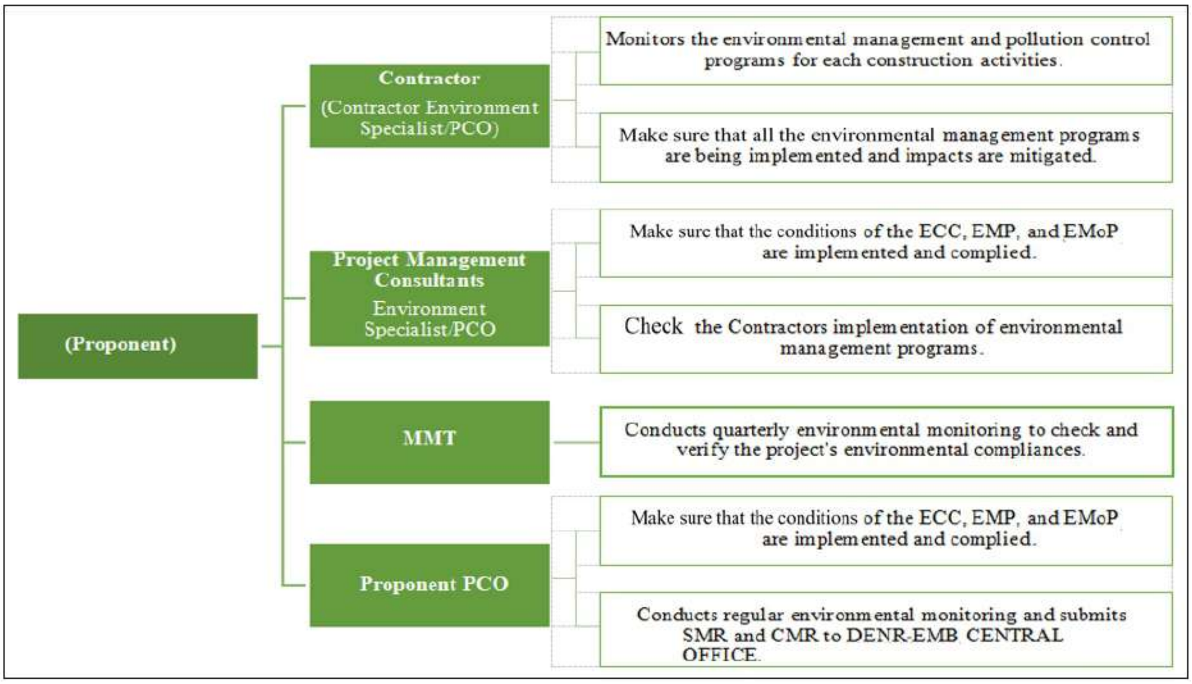
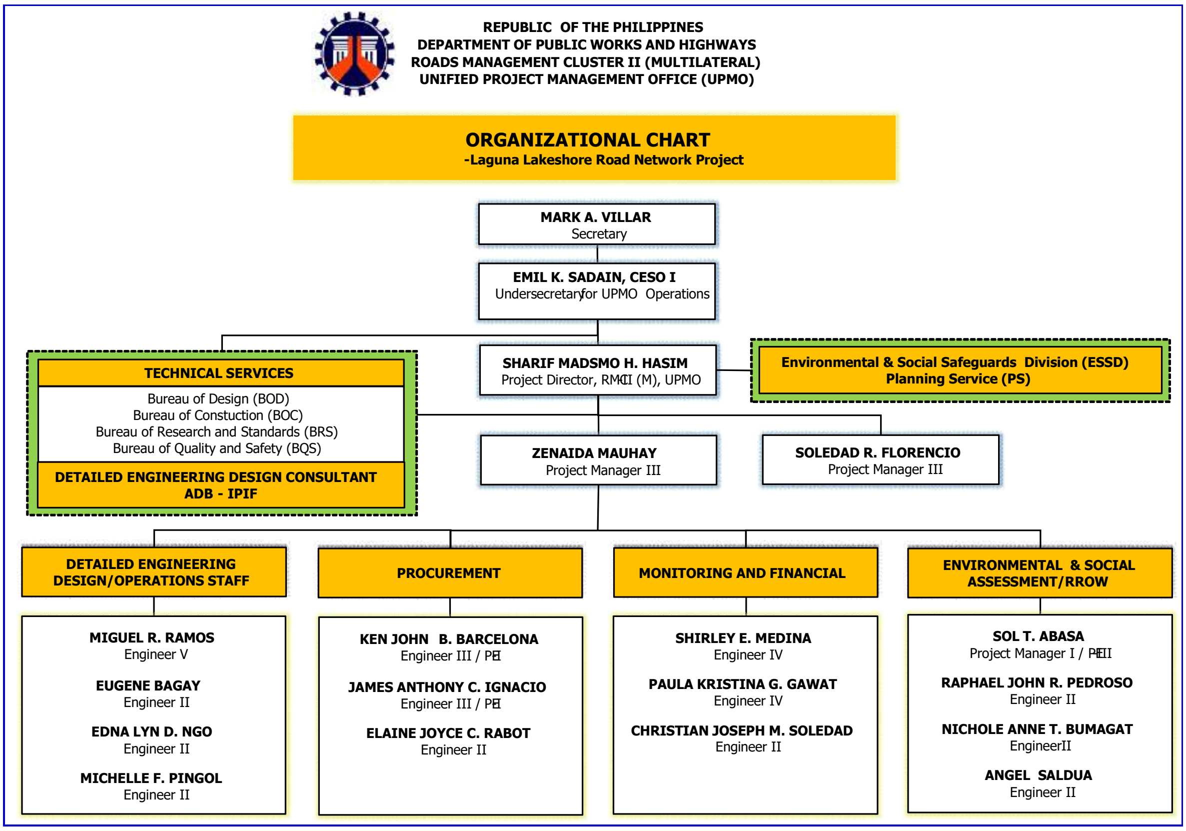


Figure 8- 2 Organizational Structure for EMP Implementation during the Construction Phase

Figure 8- 3 The Initial Organization Chart



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Delmendo (1967): Yearly catch of fish averaged 80,000 to 82,000 MT and about 240,000 MT of shrimps, clams and snails. The bulk of this produce from the lake was used for animal feeds mainly in the duck-raising industry along the lakeshore.

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WHO/LLDA (1978): In 1968, the fish catch was estimated at 39,000 MT.

Mercene (1983): Only 15% of the lake catch was used for human consumption.

Mercene (1986): Fish production declined from 82,881 MT in 1963 to 20,398 MT in 1980. Snail production decreased from 153,880 MT to 66,132 MT in the same period.

Mercene (1987): Aggregate annual fish production (1978 -1980) yielded 25,678.14 MT caught by four (4) major gears such as gill net, fish corral, motorized push net and long line.

Mercene (1987): Actual survey of all snail (melanid) dredgers in 1982 reported to have an average catch of 364 kg per day.

Mercene and Nasino (1991): The aggregate annual production of goby (*Glossogobius guirus*) and dulong (*Mirogobius lacustris*) in the period 1989-1990 was 1,139,190 MT and 206 MT, respectively.