ENVIRONMENTAL IMPACT STATEMENT

NAVOTAS COASTAL BAY RECLAMATION PROJECT

BARANGAY TANZA, NAVOTAS CITY

2020

TABLE OF CONTENTS

EXECUTIVE SUMMARY

ES 1. PROJECT FACT SHEET

Project Information

Project Name	Navotas Coastal Bay Reclamation Project
Project Type	Reclamation Project
Project Location	Barangay Tanza, Navotas City, Metro Manila
Project Size	576.7 hectares
Project Cost	PhP 57.4 billion

Proponent Profile

Project Proponent	**City Government of Navotas**
Authorized Representative	Tobias Reynald M. Tiangco
Designation	Mayor
Proponent Address	Navotas City Hall, M. Naval St, Navotas
Proponent Contact Details	T (02) 281 8602

Project Components

Table ES-1 Reclamation Equipment

S/N	Equipment	No.	Capacity	Production rate each (m^3 /day)	Total Production rate (m^3 /day)
1	Cutter Suction Dredger (CSD) at Borrow Area	2	3,000 m^3/hr	33,000	66,000
2	Cutter Suction Dredger (CSD) at Reclamation Site	2	3,000 m^3/hr	33,000	66,000
3	Split Hopper Barge (SHB) (4 - 4.5 m draft)	14	1,600 m^3	4,800	66,000
4	Tug Boat	14	-	-	-
5	Backhoe Dredger (for sand key)	2	8 – 11 m^3	4,000	8,000
6	Excavator	4	-	-	-
7	Bulldozer	4	-	-	-
8	Clamshell and Barge (for revetment construction)	2	600 m^3	-	-
9	Wheel Loader	4	-	-	-
10	Vibratory Roller	4	-	-	-

On the other hand, the following facilities will be constructed during reclamation activities:

1. Temporary lodging (with sanitation facilities);
2. Material and equipment storage;
3. Field office;
4. Drainage systems;
5. Warehouse, and
6. Administration office.

ES 2. EIA PROCESS/PROCESS DOCUMENTATION

The City Government of Navotas commissioned RHR Consult Services, Inc. to conduct an Environmental Impact Assessment and prepare an Environmental Impact Statement (EIS) for the proposed Navotas Coastal Bay Reclamation Project. This EIS evaluates the existing environmental and socio-economic conditions of the proposed project site as well as assess the potential impacts of the project.

This EIS will guide the proponent to implement environmental management strategies for all the stressors that will be generated in the operation of Navotas Coastal Bay Reclamation Project. These strategies would determine the kind of development that will be allowed within the project site.

This study follows essentially the revised procedural guidelines of MC 2014-005.

The Navotas Coastal Bay Reclamation Project EIS contains the following:

- Project Description;
- Analysis of Key Environmental Impacts;
- Impacts Management Plan;
- Social Development Plan and IEC Implementation;
- Environmental Compliance Monitoring;
- Emergency Response Policy and Generic Guidelines;
- Environmental Risk Assessment;
- Abandonment/Decommissioning/ Rehabilitation Policies and Generic Guidelines; and
- Institutional Plan for EMP Implementation.

In terms of process, a participative process was adopted thru public consultation and IEC. Implicit in the approach was allowing the proponent and the various project stakeholders to provide their inputs and ideas from which the Impact Management Plan (IMP) was crafted so that appropriate measures can be developed to ensure greater acceptance, commitment and support for the project.

ES 2.1 Limitations of the Study

The scoping process essentially determined the coverage of the study. Sensitive issues as well as other applicable parameters were included in the scoping activity. The study was limited to the primary and secondary data gathered on-site, other related literatures and fieldwork conducted. The provision of precise data determines the effectiveness of the report in supplying all the appropriate conclusion and recommendations. The study team put forth its thoroughness in completing the entire EIS. Details on the scoping checklist were carefully considered to generate a reliable and accurate report.

ES 2.2 The Project Team

The members of the team who professionally conducted the Environmental Impact Assessment (EIA) are depicted on Table ES-2.

Table ES-2 EIA Study Team

Name	Field of Expertise	Registration Number
Mr. Jess Addawe	Team Leader; Land Use and Classification, EIA Process, GIS Mapping	IPCO-056
Mr. Arnel Mendoza	Geology and Geomorphology	---
Engr. Catherine Addawe	Water Quality	IPCO-055
Mr. Michael Edrial	Terrestrial Flora and Fauna	IPCO-101
Engr. Isabelo Abellon	Hydrology	---
Engr. Ronald Pahunang	Hydrodynamic Modelling, Air and Noise	IPCO-173
Mr. Robert Pabiling	Marine Ecology	IPCO-107
Mr. Henry James Botengan	Socio-economic/People Module	IPCO-063

ES 2.3 EIA Study Schedule

The schedule of activities performed as part of the preparation of the EIS is detailed in the table below:

Table ES-3 EIA Study Schedule

Activity	Date
Site visit	22 May 2016
Public scoping	24 May 2016
Submission of Project Description for Scoping (PDS) to EMB	31 May 2016
Technical scoping	12 July 2016
Conduct of field sampling and surveys	April – May 2016
Conduct of perception survey, key informant interviews and focus group discussions	17-20 May 2016
Public consultation	TBA

ES 2.3 EIA Study Area

The EIA study was undertaken within the vicinity of the proposed project footprint and its potential impact areas, particularly in Barangay Tanza, Navotas City. The coverage of the EIA study is based on the agreed scope of the EIA Review Committee (EIARC) during the technical scoping activity conducted on 12 July 2016. The primary and secondary impact zones of the project are delineated and discussed in Section 1.1.3.

ES 2.3 EIA Methodology

The approach and methodology adopted to complete this EIS is in accordance with the prescribed methods of EMB and the procedural manual for DAO 2003-30. The table below provides the methodology used for each module.

Table ES-4 EIA Study Schedule

Module	Methodology	Data sources and references
Land		
Land use and classification	• Review of secondary data • Spatial analysis of reference maps	• Comprehensive Land Use Plan of Navotas City (2016-2025) • NAMRIA
Geology and geomorphology	• Review of secondary data • Spatial analysis of reference maps through GIS • Analysis of historic occurrences of geologic hazards	• MGB • PHIVOLCS • NAMRIA
Pedology	• Review of secondary data • Soil sampling and analysis	• Primary data gathering • NAMRIA
Terrestrial ecology	• Biological survey of existing flora and faunal components including onsite species identification and comparison of identified species with published identification guides • Vegetation analysis through plot sampling (20m x 20m) • Ocular observation of fauna through transect walk • Interview with locals and guides	• Primary data gathering
Water		
Hydrology	• Review of secondary data • Delineation of watersheds of rivers draining the project site using GIS software • Site assessment and investigation of rivers and areas frequented by flooding	• Primary data gathering • PAGASA • MGB • NAMRIA
Oceanography	• Review of secondary data • Oceanographic baseline monitoring (tidal, currents and sedimentation rate sampling) • Hydrodynamic modeling using the Environmental Fluid Dynamics Code (EFDC)	• Primary data gathering • NAMRIA
Water quality	• Characterization of water quality by water sample collection and analysis	• Primary data gathering
Marine ecology	• Manta tow technique for benthic community assessment • Fish visual census for reef associated fish community assessment • Spot dives for seagrass community assessment • Key informant interviews for fisheries • Vertical net sampling and microscopic identification of phytoplankton and zooplankton • Sediment sampling by use of grab sampler, sieving and microscopic identification of soft bottom community	• Primary data gathering
Air		
Climate and meteorology	• Review of secondary data	• PAGASA (Sangley Point and Port Area Station data)

Module	Methodology	Data sources and references
Air quality and noise	• Characterization of ambient air quality and noise levels by sampling • Noise modeling using Sound Propagation Model (SPM9613 Version 2 or PM9613V2)	• Primary data gathering
People		
Socio-economic conditions and perception of stakeholders	• Review of secondary data • Perception survey • Characterization of socio-economic condition • Key informant interviews	• Primary data gathering • Comprehensive Land Use Plan of Navotas City (2016-2025) • Socio-Economic Profile of Navotas City (2015) • City Ecological Profile (2011)

ES 2.4 Public Participation

Stakeholder participation for the project was ensured to determine the current situation of the affected residents, including the issues and concerns they are experiencing in their community. The issues and concerns based on the results of the perception survey and public scoping are summarized below:

Table ES-5 Issues and concerns raised during Public Scoping and Perception Survey

Aspect	Issues and Concerns
Livelihood/Employment	1. Loss of fishery resources/main source of livelihood
	2. Opportunities for tricycle drivers
	3. Alternative livelihood for fishermen
	4. Impacts on shipyard industry
Public/Social Services	1. Inclusion of housing projects on the reclamation area
	2. Alternative plans on the construction of C5 and C6 road networks
	3. Spread of Illness/Diseases
	4. Conflict to other government projects in Barangay Tanza
Environment	1. Water will be affected
	2. Loss/negative impact on mangrove areas
	3. Risks from chemicals found on dredged materials
	4. Accumulation of silt
	5. Source of borrow materials
	6. Heavy siltation due to strong current on the southern part of the proposed reclamation
Disaster Risk Management	1. Erosion
	2. Increased flooding

ES 2.4 Summary of baseline characterization, key environmental impacts and mitigation plan

The summary of baseline characterization and its corresponding environmental impacts and mitigation plan is presented below. Chapter 2 of this EIS provides a more detailed discussion of the baseline conditions, environmental impacts and mitigation measures.

Table ES-6 Summary of the baseline environmental conditions

Module	Summary of Baseline Condition / Key Findings
Land Use	No CARP or CADC/CADT areas were identified within or near the area of

Module	Summary of Baseline Condition / Key Findings
	the project. The proposed project, however, will be situated right beside the mangrove areas of Barangay Tanza which is a locally declared protected area. The proposed project site is also situated at Manila Bay and may be vulnerable or susceptible to natural hazards.
Geology/Geomorphology	In terms of ground shaking, five major earthquake generators, namely, the West Valley Fault, the Philippine Fault Zone, the Lubang Fault, the Casiguran Fault and Manila Trench have been identified as the most likely sources of future earthquakes that could affect the project. Identified liquefaction-prone areas in Metro Manila are essentially within the zone of average to above average zone of ground shaking. Several areas in Navotas and Malabon have high potential to liquefaction. Surface rupturing may also occur from WVF. Damages as a result of this hazard is expected to be substantial for structures directly straddling and located within few meters from the rupture zone. Tsunamis may occur but are not expected to significantly impact the project area. Based on the recorded hazards associated with the eruption of Taal Volcano, the project area being 65 km away from the said volcano could only experience ashfall. Navotas being situated in low grounds is very much prone to flooding. As seen during Typhoon Pedring, Manila Bay coastline is considered highly vulnerable to storm surges and coastal floods.
Terrestrial Ecology	A total of 212 individuals were recorded represented by 2 species from 2 genera of 2 families. *Avicennia marina* (Bungalon) has the highest number of species encountered accounting to 96%. The species also turned out to have the highest relative density and relative dominance. Cutting of mangroves were also observed and used as poles and charcoals by the locals. A total of 23 bird species representing 14 families were counted in the area during the 3-day observation period. All species recorded falls under Least Concern for conservation status. Gull-billed Tern *Gelochelidon nilotica)*- are found to be the most abundant among the species observed.
Hydrology	The proposed project site is drained by four (4) of the major rivers of Bulacan province, one (1) major rivers of Quezon City and small creeks natural depressions and drainage waterways. The areas fronting the proposed project site are fishponds that are part of the flood prone areas.
Water Quality	Based on DENR Memorandum Circular No. 2010-08, Manila Bay is classified as Class SB.
Oceanography	Currents generally move north-northwest in the vicinities of the project site and in coastal areas of Pampanga. In coastal areas in Cavite during February 2015, currents tend to move westward due probably to the effect of flooding and to some extent, effect of wind flows on currents at shallow areas in Cavite area.

Module	Summary of Baseline Condition / Key Findings
	During persistent southwesterly winds in August 2015, currents move eastward offshore Cavite area tends to increase at shallower areas. The increased of river inflows in August 2015 during the wet season, tend to produce higher currents near the mouths of said rivers, specifically in Obando and Pampanga rivers. On the other hand, storm surge of about 0.66 m was observed in Manila area south of proposed project site. Results of simulated cohesive sediment concentration at twelve (12) horizontal locations showed abrupt increased of sediment loads from initial concentration level of 8 mg/l to about 60 mg/l during reclamation works in February. Higher cohesive sediment concentrations are found in the vicinities of Obando river. Sediment concentrations also tend to significantly increase in the vicinities of the project site from the baseline February simulations during reclamation works. During wet season (August), significant higher concentrations of cohesive sediment concentrations than February simulations are noted near the river mouths of Obando river prior to reclamation works. This is highly attributed to the significant increase of river discharges due with corresponding increase of cohesive sediment concentrations due to erosion. With the reclamation works, further increases of sediment loads are expected at almost all areas adjacent the proposed reclamation site, especially near the Obando River. Also noted is the significant increase of sediment loads at areas near the mouths of all rivers in Manila Bay.
Marine Ecology	No live coral and other benthic organisms were recorded across the ten (10) spot dive stations. The associated reef fishes were also absent across the impact area. There was no seagrass species observed in any of the six (6) spot dive stations. Alimasag (blue crabs), hipon (shrimps), talaba (oyster) and tahong (mussel) were the dominant Invertebrates and considered as the major fishery catch. The dominant fish catch were aligasin/kapak (Mugilidae), kanduli (Plotosidae), kitang (Scatophagidae), buga-ong (Terapontidae), bakoko (Haemulidae), bangus (Chanidae) and others aside from blue crab (Portunidae). Trawl was also observed within the impact area. Other fish identified were sap-sap (Slip mouth/*Leiognathus sp.),* Asohos, (Sillago/ *Sillago sp*.), Malakapas (Mojarra/*Gerres sp*.) and Salinas. However, fisherfolk does not fish in the project area anymore because of the shallow area. The fish mostly at the deeper portion of the bay which is outside the project area. A total of 29 phytoplankters were identified belonging to class Bacillariophyceae (diatoms) with thirteen species, Pyrrophyceae (dinoflagellates) with sixteen species, Cyanophyceae (blue-green algae) with one species, silicoflagellate with two species and a single species of marine ciliate. A total of 18 zooplankton groups were observed from samples taken from ten stations combined. Seventeen (17) representatives/taxa were recorded under five (5) Phyla

Module	Summary of Baseline Condition / Key Findings
	and seven (7) Classes respectively. The results from this survey demonstrate that the benthic communities within the Manila Bay Study Area are primarily made up of polychaetes (Phylum Annelida). The most striking feature of the results is the abundance of the representative species Family Nereididae within nearly all of the stations sampled.
Meteorology	The proposed project site belongs to an area zoned as Type 1 climate. High rainfall is expected during the southwest monsoon season that normally occurs in the Philippines from June to September. At PAGASA-Port Area Station, the annual wind rose shows prevailing southwest and east winds with relatively lower frequencies of wind flows from the north, east, and southeast. At PAGASA-Sangley Point, dominant winds are from the southwest, followed by east and southwest and north directions. Wind speeds at both stations (Port Area and Sangley Point) show average of 3 m/s with Sangley Point generally showing consistent monthly average wind speeds through the year.
Ambient Air and Noise	Ambient PM_{10}, SO_2, and NO_2 were within the ambient standards of 200, 340, and 260 µg/Nm^3, respectively. Measured TSP, however, were relatively high at Stations 3 and 4 as compared to the ambient standard of 340 µg/Nm^3. The observed TSP concentrations ranged from 124.1 to 844 µg/Nm^3. Baseline noise levels in the vicinities of the proposed project site were generally higher than noise standards prescribed for residential areas. High noise levels were due generally due to vehicular noise traffic and from community noise during daytime at the time of monitoring.
Socio-Demographic/ Economic Conditions	As of 2015, Navotas City has a total of 249,131 population while Barangay Tanza has 24,917. Fishery production in the city involves mostly marginal fisherfolks where 5,497 fisherfolks are registered for the year 2015. Of the 12 barangays involved in fishery production, Barangays Tangos, Tanza, and San Jose are the top three barangays with the most number of fishing boats. The average family income per year in Navotas City is P60,000.00 and the average family size is 4.65. The labor force of the city stands at 63,072. Issues and concerns raised during Public Scoping are: Opportunities for tricycle drivers, Loss of fishery resources/main source of livelihood, Loss/negative impact on mangrove areas, Conflict to other government projects in Barangay Tanza, Risks from chemicals found on dredged materials, Accumulation of silt, Alternative livelihood for fishermen, Impacts on shipyard industry, Increased flooding, Source of borrow materials, Heavy siltation due to strong current on the southern part of the proposed reclamation, Inclusion of housing projects on the reclamation area, Alternative plans on the construction of C5 and C6 road networks
Awareness of the stakeholders to the project	Eighty-eight (88%) of the respondents stated that they have prior knowledge about the project. Most of them knew about the project from the barangay. The biggest problem faced by the community is flooding (32%). Twenty-five percent (25%) stated that the lack of livelihood is also one of the issues they have encountered. This is followed by Peace and Order (16%), Cleanliness and Sanitation (14%) Health (8%) and education (5%).

Table ES-7 Impact Management Plan

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact (+/-)	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee/ financial arrangement
I. Pre-construction Phase						
Geotechnical investigation	Land Water	*Contamination of soil, groundwater, and surface water.* (-) Drilling fluid may potentially leak into receiving environment if not managed properly	▫ Use appropriate drilling fluid ▫ Implement proper bunding to avoid spillage into receiving environment. ▫ Prepare emergency spill kits in case of potential leaks.	Proponent / Contractor	Php200,000.00	Part of the project cost
Increased movement of heavy equipment on site and delivery of materials	Air	*Generation of dust* (-) Increased particulate matter due to movement of vehicles (-) Health effects due to inhalation of dust by residents living in areas adjacent to project site	▫ Implement dust suppression techniques. ▫ Cover trucks with tarpaulin loaded with spoils/filling materials when in transit. ▫ Pre-wetting of road surface to minimise dust.	Proponent / Contractor	Php50,000.00 / quarter.	Part of the project cost
	People	*Threat to public safety* (-) Possible injury or fatality as a result of heavy equipment and delivery trucks movement in the project site	▫ Implement speed limits and safety devices /signs. ▫ Ensure competency of drivers to drive safely. ▫ Engage local communities and inform them of site activities through IECs, posting construction "off limits" and safety signage	Proponent / Contractor	Php50,000/year on safety signages and Php50,000.00 on trainings/seminars	Part of the project cost
		Traffic congestion (-) Rapid deterioration of existing national/ municipal/ barangay road condition as a result of heavy equipment movement	▫ Coordinate with DPWH and Municipal Engineering Department in road maintenance and necessary improvements to accommodate increased vehicle movement.	Proponent / Contractor		Part of the regular coordination of the Proponent with the LGU
Increased manpower requirements	People	*Opportunities for local employment* (+) Employment opportunities and benefits of employees and potential livelihood/business opportunities	▫ Implement priority local hiring policy for qualified local workers. ▫ Provide skills training for local residents	Proponent / Contractor	No cost will be incurred.	Employment generated together with the origins of workers will be

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact (+/-)	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee/ financial arrangement
		(-) Employing outside workers may antagonize local communities				validated by the MMT.
II. Construction Phase						
Site preparation, ground levelling, and drainage improvements	Land	*Change in geomorphology* (-) The Project site's elevation will be altered. The elevation change will result in subsequent change in the hydrology surrounding the Project site	▫ Implement flood control measures which such as construction of proper and adequate drainage systems.	Proponent / Contractor	Php100,000.00/year – maintenance of the drainage facility	Part of project cost
Site preparation, excavation, and filling	Land	*Inducement of subsidence or collapse* (-) Minor subsidence may occur within the project site when the subsurface is disturbed during excavation activities for preparation of foundation (-) Minor settling may also occur as a result of additional loads from heavy machinery and structures	▫ Implement best engineering practices such as suitable backfilling material, proper slope, grading and contouring to minimise possibility of subsidence or differential settling.	Proponent / Contractor	Php10M – implementation of site preparation adhering to best engineering practices.	Part of project cost
Site preparation, ground levelling and drainage improvements	Land People	*Inducement of higher flood levels* (-) Occurrence, frequency and magnitude of flooding may be affected due to the change in drainage morphology and changes in ground elevation in the project site (-) Flooding may cause damage to property, assets, and may pose threat to public safety	▫ Implement best engineering practices such as suitable backfilling material, proper slope, grading and contouring to minimise possibility of subsidence or differential settling. ▫ Probable modification of drainage systems shall maintain natural outlets or consider similar transport regimes/streamflows as the pre-existing natural drainage ▫ Maximize the capacity of two exit river channels on both sides of the reclamation area through regular desilting and clearing operations	Proponent / Contractor	Php10M – implementation of site preparation adhering to best engineering practices and maintenance	Part of project cost

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact (+/-)	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee/ financial arrangement
Site preparation, excavation, and filling	Land	*Soil erosion from onsite activities* (-) Improper storage of construction materials and indiscriminate disposal of fill materials and excavated soils may affect erosion patterns.	▫ Implement best engineering practices such as suitable backfilling material, proper slope, grading and contouring to minimise possibility of subsidence or differential settling. ▫ Progressive ground preparation and clearing to minimize total area of land that will be disturbed at any one time, where practical.	Proponent / Contractor	Php100,000.00/year –ground stabilization and maintenance	Part of project cost
		Contamination of soil / disposal site (-) Excavated soil materials may contain contaminants that may potentially affect soil and ground and surface water quality	▫ Implement best engineering practices such as proper stockpiling and handling of excavated materials. ▫ Implement proper filling and disposal to avoid contamination of soil, groundwater, and surface water	Proponent / Contractor	Php 2,000,000.00 – Provision of proper waste disposal.	Part of project cost
Reclamation works	Water	(-) Degradation of water quality due to siltation brought about by reclamation activities	▫ Install silt curtains around dredging areas ▫ Early construction of bunds along boundaries of the project site ▫ Implement best environmental management practices such as, but shall not be limited to, removal of debris along the waterways, proper disposal of construction wastes, installation of silt traps at strategic locations, and spoils to be properly contoured to prevent erosion	Proponent / Contractor	Php10M – implementation of site preparation adhering to best engineering practices and maintenance	Part of project cost.
Generation of wastes		(-) Degradation of water quality due to runoff from sanitary sewage, waste water, solid wastes, and other construction materials that can harm aquatic flora/fauna	▫ Removal of debris along the waterways will be conducted, all construction wastes will be properly disposed, silt traps at strategic locations and spoils will be properly contoured to prevent erosion. ▫ Construction of sediment/ settling ponds and related structures to	Proponent / Contractor	Php50,000 / Year – provision for proper solid waste disposal	Part of project cost

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact (+/-)	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee/ financial arrangement
			mitigate siltation or sedimentation of water body ▫ Portalets will be provided for use of the workers and its corresponding wastewater will be properly disposed. ▫ Implementation of Solid waste management program and Hazardous waste management program. ▫ Use of DENR accredited haulers/TSD companies.			
Delivery of construction materials and equipment, construction works	Air People	*Generation of dust* (-) Air pollution from fugitive dust resulting from ground clearing operations, site preparation, structure erection, and vehicle movement. (-) Health effects due to inhalation of dust by residents living in areas adjacent to project site	▫ Implement dust suppression measures in active construction areas. ▫ Pre-wetting of road surface to minimise dust. ▫ Provision of tarpaulin cover on trucks loaded with construction materials ▫ Immediate hauling of spoils ▫ Impose speed restrictions/limits and proper signages	Proponent / Contractor	Php50,000/ year – operational expenses	Part of project cost
	Air	*Generation of air emissions* (-) Air pollution from SO_2 and NO_2 emissions from heavy equipment used in site preparation.	▫ Regular maintenance of heavy equipment, motor vehicles and all emission generating equipment	Proponent / Contractor	Php2,000,000 / year –cost of maintenance of heavy equipment	Part of the construction cost
Construction works	Air (noise)	(-) Generation of noise from construction activities	▫ Regular maintenance of motor vehicle mufflers ▫ Provision of noise cancelling ear protection to workers ▫ Proper scheduling of noisy activities during day time ▫ Reduce number of equipment to be operated at nighttime and inform	Proponent / Contractor	Php100,000.00	Part of project cost

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact (+/-)	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee/ financial arrangement
			barangay officials prior to conducting nighttime works ▫ Establishment of buffer zones along the perimeter of the construction site			
Site preparation activities	People	*Community protests or complaints* (-) Potential adverse community response resulting from access restrictions in working areas.	▫ Conduct of IECs to host and neighboring communities. ▫ Properly implement programs stipulated in the SDP	Proponent	Php150,000.00 / year	Part of project cost
Increased manpower requirements	People	*Opportunities for local employment* (+) Employment opportunities and benefits of employees and its multiplier effect or potential livelihood/business opportunities (-) Bringing in of outside workers may antagonise local communities	▫ Implement priority local hiring policy for qualified local workers. ▫ Provide skills training for local residents ▫ Coordinate with barangay or/and municipal LGU as to relevant ordinance on providing opportunities for local employment.	Proponent / Contractor	Php20,000 / year	Employment generated together with the origins of workers will be validated by the MMT.
Increased manpower requirements	People	*In-migration* (+) Workers will be required during construction (-) In-migrants may compete with locals for employment, project benefits, natural resources (i.e. water competition), local health, welfare services and infrastructure In-migration may also lead to proliferation of informal settlers in the project impact barangay	▫ Livelihood opportunities will be provided to local communities especially to host barangay ▫ Provide skills training for local residents ▫ Conduct consultation with barangay LGUs on requirements and process of hiring to maximize employment of local residents. ▫ Regular IEC and consultations with stakeholders (e.g. barangay LGU, local communities) will be conducted to ensure a sustainable community development plan. ▫ Coordination meetings shall be undertaken regularly with the LGUs to identify threats and vulnerabilities in the society as well as to develop	Proponent / Contractor	Php1M / year – SDP budget will be utilized for the implementation of activities such as, livelihood programs, education assistance, medical assistance, IEC, among others.	Part of project cost

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact (+/-)	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee/ financial arrangement
			programs to prevent foreseen social problems.			
Increased manpower requirements	People	*Cultural and lifestyle change* (-) Potential social tensions due to income and wealth disparity between those who will be benefited economically from the project and those who will not be benefited. (-) Workers and other in-migrants may introduce different lifestyles and patterns of behaviour leading to social tensions.	▫ The proponent will implement a code of conduct for employees, contractors, and subcontractors to prevent potential impacts on lifestyle and behaviour. ▫ IEC activities, open dialogue and communication with the stakeholders will be undertaken regularly by the proponent to address concerns of the people on the proposed project and promote transparency	Proponent / Contractor	Php1M / year – SDP budget that will be utilized for the implementation of activities such as, cultural activities, IEC, among others	Part of project cost
		Threat to delivery of basic services and resource competition (-) Unplanned population increase due to in-migration or increase in informal settlers/structures puts pressure on basic services (education, health and social welfare) and utilities (water, electricity and waste management).	▫ Develop and implement SDP, which shall involve improvement of basic services such as health and welfare, livelihood, infrastructure, education, among others	Proponent / Contractor	Php1M / year – SDP budget that will be utilized for the implementation of activities such as, cultural activities, IEC, among others	Part of project cost
Increased movement of heavy equipment on site and delivery of materials, Increased manpower requirements	People	*Traffic congestion* (-) Possible increase in traffic given the number of workers to be employed and delivery of some construction materials.	▫ Implement speed limits, vehicle load limits, vehicle maintenance requirements, and limiting driving hours. ▫ Signs for ongoing construction activities (i.e. speed limit, safety signages) shall be installed at strategic places to notify and warn the general public as necessary.	Proponent / Contractor	Php100,000/ year – Safety and health program will cover this activities.	Part of project cost
III. Operational Phase						
Project Operations (General)	Land People	*Potential liquefaction or ground subsidence due to earthquakes*	▫ Use appropriate soil compaction and more competent backfill materials to	Proponent	Php20,000 / year – cost incurred for	Part of project cost

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact (+/-)	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee/ financial arrangement
		(-) Liquefaction and ground subsidence may occur due to earthquakes, which may cause damage to property, assets, and may pose threat to public safety	minimize possibility of subsidence or differential settling		regular inspection	
	Land	*Vegetation removal and loss of habitat*	▫ Design and construct appropriate buffer area between mangrove area and reclamation site ▫ Support active enforcement of existing laws and regulation pertaining to protection and rehabilitation of Mangrove Park with regular budget allocation ▫ Enhance vegetation cover and diversity of mangrove forest areas by planting a variety of mangrove and mangrove-associated species suitable to the condition of the area. This will supplement biodiversity value in the area by reintroducing key and important species to hasten the process of natural recovery and improve habitat quality. ▫ Establish mangrove nurseries within the Mangrove Park to provide reliable source of mangrove propagules for replanting and rehabilitation of the project area and even to adjacent areas of Manila Bay ▫ Conduct Information, Education and Communication (IEC) campaign on the importance of mangrove and its habitat especially to local residents of Navotas to increase awareness and support from the locals ▫ Collaborate with other government	Proponent	Part of operation cost	Part of project cost

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact (+/-)	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee/ financial arrangement
			agencies such as DENR, PPA, academe and NGOs on other conservation programs and activities such as ecotourism, bird watching, coastal clean-up, research studies and IEC.			
	Land People	*Potential flooding due to extreme weather events and potential threat to public safety* (-) Flooding brought about by extreme weather events may cause damage to property, assets, and may pose threat to public safety	▫ Design and construct appropriate drainage system that will support the transport regimes/streamflows of the pre-existing natural drainage	Proponent	~Php 5,000,000	Part of the project cost
Increased water demand for project activities	Water	*Possible water use competition* (-) Water use competition / reduction in water availability due to the project's use of water	▫ Comply with the requirements and mandates of the concerned water district as to the usage of water supply	Proponent	Php150,000/ quarter – cost to be incurred during quarterly monitoring of MMT, laboratory analysis, among others	Part of project cost
Generation of wastes	Water	(-) Degradation of ground, surface, or marine water quality due to runoff from sanitary sewage, waste water and solid wastes that can harm aquatic flora/fauna	▫ Proper storage and disposal of wastes and implementation of good housekeeping practices ▫ Use of DENR accredited haulers/TSD companies	Proponent	Php100,000/ year – annual maintenance budget.	Part of project cost
Emission of fugitive particles	Air	*Generation of air emissions* (-) Air pollution from SO_2 and NO_2 emissions from genset and vehicles	▫ Regular maintenance of heavy equipment, motor vehicles and all emission generating equipment	Proponent / Contractor	Php 50,000 / year – cost of maintenance of vehicles/equipment	Part of the project cost
Increased manpower requirements	People	*Opportunities for local employment* (+) Employment opportunities and benefits of employees and its multiplier effect or potential livelihood/business opportunities	▫ Implement priority local hiring policy for qualified local workers. ▫ Coordinate with barangay or/and municipal LGU as to relevant ordinance on providing opportunities for local employment.	Proponent	Insignificant	Monitoring and validation activity of MMT, MRFC, LGU Officials, and other

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact (+/-)	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee/ financial arrangement
		(-) Bringing in of outside workers may antagonise local communities				concerned agencies
Increased manpower requirements	People	*In-migration* (+) Employment opportunities during operation (-) In-migrants may compete with locals for employment, project benefits, natural resources (i.e. water competition), local health, welfare services and infrastructure In-migration may also lead to proliferation of informal settlers in the project impact barangays	▫ Livelihood opportunities and skills training will be provided to local communities specially to host barangay ▫ Conduct consultation with barangay LGUs on requirements and process of hiring to maximize employment of local residents. ▫ Conduct regular IEC and consultations with stakeholders (e.g. barangay LGU, local communities) ▫ Undertake regular coordination meetings with the LGUs to identify threats and vulnerabilities in the society as well as to develop programs to prevent foreseen social problems.	Proponent	Php1M / year – SDP budget that will be utilized for the implementation of activities such as, livelihood programs, cultural activities, IEC, among others.	Part of project cost
Increased manpower requirements	People	*Cultural and lifestyle change* (-) Potential social tensions due to income and wealth disparity between those who will be benefited economically from the project and those who will not be benefited (-) Workers and other in-migrants may introduce different lifestyles and patterns of behaviour leading to social tensions	▫ The proponent will implement a code of conduct for employees, contractors, and subcontractors to prevent potential impacts on lifestyle and behaviour. ▫ IEC activities, open dialogue and communication with the stakeholders will be undertaken regularly to address concerns of the people on the proposed project and promote transparency	Proponent	Php1M / year – SDP budget that will be utilized for the implementation of activities such as, cultural activities, IEC, among others.	Part of project cost
Increased manpower requirements	People	*Threat to delivery of basic services and resource competition* (-) Unplanned population increase, due to in-migration puts pressure on basic services	▫ Implement SDP that shall involve improvement of basic services such as health and welfare, livelihood, infrastructure, education, among others	Proponent	Php1M / year – SDP budget that will be utilized for the implementation of activities such as,	Part of project cost

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact (+/-)	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee/ financial arrangement
		(education, health and social welfare) and utilities (water, electricity and waste management) (-) Population influx may create unmet demands for affordable housing leading to an increase in informal settlers and illegal structures			cultural activities, IEC, among others.	
Increased manpower requirements	People	*Generation of local benefits from the project* (+) Employment opportunities and benefits of employees and its multiplier effect or potential livelihood/business opportunities (i.e. canteen, sari-sari store, boarding house, etc) are perceived as positive impacts of the project. (+) Improvement of basic services (i.e. electricity, water, health and education) and infrastructure (i.e. road, recreation and health facility) is expected as a result of the project (+) Increase in barangay income and IRA will also be a positive impact that may subsequently provide more funding for programs and projects of the barangay.	To further enhance the benefits from the project: ▫ The proponent shall develop and implement the SDP, which shall include improvement of basic services such as health and welfare, livelihood, infrastructure, education, among others	Proponent		Part of project cost
Increased movement of heavy equipment on site and delivery of materials, Increased manpower requirements	People	*Traffic congestion* (-) Possible increase in traffic given the number of workers to be employed and delivery of some construction materials. This has the potential to add traffic congestion and affect sensitive receptors such as schools and community centers that may potentially cause road accidents.	▫ Traffic management plan, in coordination with concerned LGUs and DPWH, will be prepared and implemented ▫ IEC will also be conducted to communicate traffic impact and management plan to the community especially the host and neighboring barangays	Proponent	Php100,000 / year – for the implementation of the Safety programs / policies, IEC campaigns, safety materials, etc.	Part of project cost

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact (+/-)	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee/ financial arrangement
		(-) Heavy loads traversing infrastructure over or near load bearing limits	▫ Proper scheduling of delivery of construction materials to avoid peak hours/ traffic congestion and minimize the occurrence of accidents. ▫ Installation of safety warnings and signages			
IV. Decommissioning Phase						
Clearing and removal of structures	Land Water People	*Ground and water contamination* (-) Clearing and removal of structures and facilities that may result to improper disposal of contaminated materials or release of toxic and hazardous wastes / compounds	▫ Proper implementation of the approved Abandonment/ Decommissioning Plan that details the decommissioning, rehabilitation, and social activities which shall include the methodology, timing, and techniques. ▫ Use of DENR accredited haulers/TSD companies for wastes classified under RA No. 6969.	Proponent / Contractor	Php2M – for the handling, transport, and disposal of all hazardous waste and chemicals.	Part of project cost

Table ES-8 Self-Monitoring Plan

Module	Environmental Sector	Parameters to be monitored	Sampling and Measurement			Lead Person / Office	Annual Estimated Cost	EQPL Management Scheme					
								EQPL Range			Management Measure		
			Methods	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
CONSTRUCTION PHASE													
Land													
Geology and Geomorphology	Geohazards	Liquefaction and ground subsidence monitoring	Periodic monitoring of ground stability	5 years or immediately after a major geologic event has taken place	Project area	Engineering Department	No additional cost; in-house	Noticeable ground subsidence and surface creep	Continuous occurrence of ground subsidence and creep	Significant ground subsidence and surface creep; Formation of cracks in columns, beams, pavement; Misalignment of structures; Impoundment of water due to liquefaction	Increase in monitoring frequency and measurement of magnitude of movement for cracks and surface creep	Check impact of ground subsidence to integrity of infrastructures. Implement necessary engineering measures.	Temporary cessation of construction; Retrofitting of damaged structures; Implement necessary engineering measures. Consider abandonment or relocation if necessary
Water													
Water Quality	Ambient Water Quality (marine water)	▫ pH ▫ Temperature ▫ Total Dissolved Solids ▫ Conductivity ▫ Total Suspended Solids ▫ Biochemical Oxygen Demand (BOD); ▫ Chloride (Cl-); ▫ Color (Apparent); ▫ Dissolve Oxygen (DO); ▫ Fecal Coliform; ▫ Nitrate as Nitrogen	In-situ measurement and laboratory analyses	Monthly sampling, Quarterly Reporting through the SMR	Baseline water quality monitoring stations (may be adjusted accordingly)	PCO	Php 50,000 per sampling station	▫ pH below 6.8 and above 8.3 ▫ Temp: 2.6°C rise in the receiving water body ▫ DO: 7 mg/L ▫ TSS: 40 mg/L ▫ As:0.003 ▫ Cd: 0.001 ▫ Cr+6: 0.03 ▫ Cu:0.009 ▫ Pb:0.008 ▫ Hg:0.001	▫ pH below 6.9 and above 8.4 ▫ Temp: 2.8°C rise in the receiving water body ▫ DO: 7 mg/L ▫ TSS: 45 mg/L ▫ As:0.005 ▫ Cd: 0.002 ▫ Cr+6: 0.04 ▫ Cu: 0.01 ▫ Pb:0.009 ▫ Hg:0.001	▫ pH below 7.0 and above 8.5 ▫ Temp: 3°C rise in the receiving water body ▫ DO: 6 mg/L ▫ TSS: 50 mg/L ▫ As:0.01 ▫ Cd: 0.003 ▫ Cr+6: 0.05 ▫ Cu:0.02 ▫ Pb:0.01 ▫ Hg:0.001	▫ Re-conduct testing to verify ▫ Investigate the source ▫ If the problem is within the construction area, conduct adjustments / appropriate corrective action at identified pollutant source.	▫ Re-conduct testing to verify ▫ Investigate the source ▫ If the problem is within the construction area, conduct adjustments/ appropriate corrective action at identified pollutant source. ▫ If source is not project construction, inform MMT regarding possible	▫ Re-conduct testing to verify ▫ Temporarily stop construction works: investigate source ▫ If the problem is within the construction area, conduct adjustments/ appropriate corrective action at identified pollutant source.

Module	Environmental Sector	Parameters to be monitored	Sampling and Measurement			Lead Person / Office	Annual Estimated Cost	EQPL Management Scheme					
								EQPL Range			Management Measure		
			Methods	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
		(N03--N); ▫ Phosphate as Phosphorous (P043--P); ▫ Ammonia as Nitrogen (NH3-N); ▫ Total Suspended Solids (TSS); ▫ Sulfate (S042-); ▫ Arsenic (As); ▫ Cadmium (Cd); ▫ Hexavalent Chromium (Cr6+); ▫ Lead (Pb); ▫ Mercury (Hg); ▫ Oil and Grease; ▫ Sulfactants (MBAS)										source for the group's investigation and coordination with LGU	▫ If source is not project construction, inform MMT regarding possible source for the group's investigation and coordination with LGU
Air													
Air Quality	Ambient Air Quality	TSP SO2 NO2	TSP Hi-volume/ Gravimetric 1-hour averaging period SO2 and NO2 24-hr gas bubbler	Monthly sampling, Quarterly Reporting through the SMR	Baseline air quality monitoring stations (may be adjusted accordingly)	PCO	Php 50,000 per sampling station	TSP: 161 ug/ncm SO2: 126 ug/ncm NO2: 105 ug/ncm	TSP: 184 ug/ncm SO2: 144 ug/ncm NO2: 120 ug/ncm Complaint lodged by community	TSP: 230 ug/ncm SO2: 180 ug/ncm NO2: 150 ug/ncm Complaint lodged by community	▫ Check weather condition during sampling and if location is downwind of construction site ▫ Check possible source ▫ If source is project construction	▫ Check weather condition during sampling and if location is downwind of construction site ▫ Conduct visit at said sampling station and conduct retesting using a 3rd party DENR	▫ Check weather condition during sampling and if location is downwind of construction site ▫ Conduct visit at said sampling station and conduct retesting using a 3rd

Module	Environmental Sector	Parameters to be monitored	Sampling and Measurement			Lead Person / Office	Annual Estimated Cost	EQPL Management Scheme					
			Methods	Frequency	Location			EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
											, inform contractor for their corrective action (i.e. dust suppression) ▫ If source is not project construction, inform MMT regarding possible source for the group's investigation and coordination with LGU	accredited sampling firm to confirm ▫ If source is project construction, inform contractor for their corrective action, and conduct retesting to confirm results of the mitigation measures ▫ If source is not project construction, inform MMT regarding possible source for the group's investigation and coordination with LGU	party DENR accredited sampling firm to confirm ▫ If source is project construction, immediately stop all works involving soil excavation and movement, increase the frequency of the contractor's dust mitigation, resume work only upon visual clearing of the sampling station, and conduct retesting at the said sampling station ▫ If source is not project construction, inform MMT regarding possible source for the group's investigation and coordination

Module	Environmental Sector	Parameters to be monitored	Sampling and Measurement			Lead Person / Office	Annual Estimated Cost	EQPL Management Scheme					
			Methods	Frequency	Location			EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
													with LGU
Noise	Ambient noise levels	Noise levels	24hr sound measurements using sound meter	Monthly sampling, Quarterly Reporting through the SMR	Baseline noise level monitoring stations (may be adjusted accordingly)	PCO	Php 10,000 per sampling station	71dB (daytime) 66dB (morning/ evening) 61dB (night time)	73dB (daytime) 68dB (morning/ evening) 63dB (night time)	75dB (daytime) 70dB (morning/ evening) 65dB (night time)	Identify possible noise source	▫ Conduct visit at said sampling station and conduct retesting using a 3rd party DENR accredited sampling firm to confirm ▫ If source is project construction, inform contractor for their corrective action, and conduct retesting to confirm results of the mitigation measures ▫ If source is not project construction, inform MMT regarding possible source for the group's investigation and coordination with LGU	▫ Conduct visit at said sampling station and conduct retesting using a 3rd party DENR accredited sampling firm to confirm ▫ If source is project construction, reduce use of noisy equipment or reschedule source of noise, conduct retesting at the said sampling station and resume work only upon clearance of the sampling station, ▫ If source is not project construction, inform MMT regarding possible source for the group's investigation

Module	Environmental Sector	Parameters to be monitored	Sampling and Measurement			Lead Person / Office	Annual Estimated Cost	EQPL Management Scheme					
			Methods	Frequency	Location			EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
													and coordination with LGU
People													
	Workers	Health and safety of workers	Review of health and safety records of company Incident reports	Annual	Project site	PCO	Part of the construction cost	Negative verbal feedback of worker	Formal complaint lodged by worker	Multiple complaints lodged by workers	Proponent to investigate the subject of negative feedback. Coordinate with contractor and MMT.	Investigate cause of complaint, determine and address the root cause. Coordinate with contractor and MMT.	Release official statement for general consumption and employees. Coordinate with contractor and MMT.
	Social Development and Management Plan	Projects initiated by the Proponent under the approved SDP	Community Coordination, social engagements	Quarterly	Host barangay	Community Relations Officer	Part of the SDP Cost	Negative verbal feedback of community	Formal complaint lodged by the community	Multiple complaints by the community	Proponent to investigate the subject of negative feedback. Coordinate with barangay LGU and MMT.	Investigate cause of complaint, determine and address the root cause. Coordinate with barangay LGU and MMT.	Conduct consultation with concerned members of the community. Release official statement. Coordinate with barangay LGU and MMT.
	Information, Education, and Communication	Implementation of IEC activities	Community Coordination, social engagements	Quarterly	Host barangay	Community Relations Officer	Part of the SDP Cost	Negative verbal feed back to the Proponent	Formal complaint lodged by the community	Multiple complaints by the community captured by local media organizations	Proponent to investigate the subject of negative feedback. Coordinate with barangay LGU and MMT.	Investigate cause of complaint, determine and address the root cause. Coordinate with barangay LGU and MMT.	Conduct consultation with concerned members of the community. Release official statement. Coordinate with barangay LGU and MMT.
OPERATIONAL PHASE													
Land													
Geology and Geomorpho-logy	Geohazards	Liquefaction and ground subsidence monitoring	Periodic monitoring of ground stability	5 years or immediately after a major geologic	Project area	Engineering Department	No additional cost; in-house	Noticeable ground subsidence and surface creep	Continuous occurrence of ground subsidence and creep	Significant ground subsidence and surface creep;	Increase in monitoring frequency and measure-	Check impact of ground subsidence to integrity of infrastructures	Temporary cessation of construction; Retrofitting of damaged

Module	Environmental Sector	Parameters to be monitored	Sampling and Measurement			Lead Person / Office	Annual Estimated Cost	EQPL Management Scheme					
			Methods	Frequency	Location			EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
				event has taken place						Formation of cracks in columns, beams, pavement; Misalignment of structures; Impound-ment of water due to liquefaction	ment of magnitude of movement for cracks and surface creep	. Implement necessary engineering measures.	structures; Implement necessary engineering measures. Consider abandon-ment or relocation if necessary
Water													
Water Quality	Ambient Water Quality (marine water)	▫ pH ▫ Temperature ▫ Total Dissolved Solids ▫ Conductivity ▫ Total Suspended Solids ▫ Biochemical Oxygen Demand (BOD); ▫ Chloride (Cl-); ▫ Color (Apparent); ▫ Dissolve Oxygen (DO); ▫ Fecal Coliform; ▫ Nitrate as Nitrogen (N03--N); ▫ Phosphate as Phosphorous (P043--P); ▫ Ammonia as Nitrogen (NH3-N);	In-situ measurement and laboratory analyses	Monthly sampling, Quarterly Reporting through the SMR	Baseline water quality monitoring stations (may be adjusted accordingly)	PCO	Php 50,000 per sampling station	▫ pH below 6.8 and above 8.3 ▫ Temp: 2.6°C rise in the receiving water body ▫ DO: 7 mg/L ▫ TSS: 40 mg/L ▫ As:0.003 ▫ Cd: 0.001 ▫ Cr+6: 0.03 ▫ Cu:0.009 ▫ Pb:0.008 ▫ Hg:0.001	▫ pH below 6.9 and above 8.4 ▫ Temp: 2.8°C rise in the receiving water body ▫ DO: 7 mg/L ▫ TSS: 45 mg/L ▫ As:0.005 ▫ Cd: 0.002 ▫ Cr+6: 0.04 ▫ Cu: 0.01 ▫ Pb:0.009 ▫ Hg:0.001	▫ pH below 7.0 and above 8.5 ▫ Temp: 3°C rise in the receiving water body ▫ DO: 6 mg/L ▫ TSS: 50 mg/L ▫ As:0.01 ▫ Cd: 0.003 ▫ Cr+6: 0.05 ▫ Cu:0.02 ▫ Pb:0.01 ▫ Hg:0.001	▫ Re-conduct testing to verify ▫ Investigate the source ▫ If the problem is within the construction area, conduct adjustments / appropriate corrective action at identified pollutant source.	▫ Re-conduct testing to verify ▫ Investigate the source ▫ If the problem is within the construction area, conduct adjustments/ appropriate corrective action at identified pollutant source. ▫ If source is not project construction, inform MMT regarding possible source for the group's investigation and coordination with LGU	▫ Re-conduct testing to verify ▫ Temporarily stop construction works: investigate source ▫ If the problem is within the construction area, conduct adjustments/ appropriate corrective action at identified pollutant source. ▫ If source is not project construction, inform MMT regarding possible source for

Module	Environmental Sector	Parameters to be monitored	Sampling and Measurement			Lead Person / Office	Annual Estimated Cost	EQPL Management Scheme					
								EQPL Range			Management Measure		
			Methods	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
		▫ Total Suspended Solids (TSS); ▫ Sulfate (S042-); ▫ Arsenic (As); ▫ Cadmium (Cd); ▫ Hexavalent Chromium (Cr6+); ▫ Lead (Pb); ▫ Mercury (Hg); ▫ Oil and Grease; ▫ Sulfactants (MBAS)											the group's investigation and coordination with LGU
Air													
Air Quality	Ambient Air Quality	TSP SO2 NO2	TSP Hi-volume/ Gravimetric 1-hour averaging period SO2 and NO2 24-hr gas bubbler	Monthly sampling, Quarterly Reporting through the SMR	Baseline air quality monitoring stations (may be adjusted accordingly)	PCO	Php 50,000 per sampling station	TSP: 161 ug/ncm SO2: 126 ug/ncm NO2: 105 ug/ncm	TSP: 184 ug/ncm SO2: 144 ug/ncm NO2: 120 ug/ncm Complaint lodged by community	TSP: 230 ug/ncm SO2: 180 ug/ncm NO2: 150 ug/ncm Complaint lodged by community	▫ Check weather condition during sampling and if location is downwind of construc-tion site ▫ Check possible source ▫ If source is project construc-tion, inform contractor for their corrective action (i.e. dust suppres-sion)	▫ Check weather condition during sampling and if location is downwind of construction site ▫ Conduct visit at said sampling station and conduct retesting using a 3rd party DENR accredited sampling firm to confirm ▫ If source is project construction, inform	▫ Check weather condition during sampling and if location is downwind of construction site ▫ Conduct visit at said sampling station and conduct retesting using a 3rd party DENR accredited sampling firm to confirm ▫ If source is project

Module	Environmental Sector	Parameters to be monitored	Sampling and Measurement			Lead Person / Office	Annual Estimated Cost	EQPL Management Scheme					
								EQPL Range			Management Measure		
			Methods	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
											▫ If source is not project construc-tion, inform MMT regarding possible source for the group's investigatio n and coordination with LGU	contractor for their corrective action, and conduct retesting to confirm results of the mitigation measures ▫ If source is not project construction, inform MMT regarding possible source for the group's investigation and coordination with LGU	construction, immediately stop all works involving soil excavation and movement, increase the frequency of the contractor's dust mitigation, resume work only upon visual clearing of the sampling station, and conduct retesting at the said sampling station ▫ If source is not project construction, inform MMT regarding possible source for the group's investigation and coordination with LGU
Noise	Ambient noise levels	Noise levels	24hr sound measurements using sound meter	Monthly sampling, Quarterly Reporting through the	Baseline noise level monitoring stations (may be adjusted	PCO	Php 10,000 per sampling station	71dB (daytime) 66dB (morning/	73dB (daytime) 68dB (morning/	75dB (daytime) 70dB (morning/	Identify possible noise source	▫ Conduct visit at said sampling station and conduct	▫ Conduct visit at said sampling station and conduct

Module	Environmental Sector	Parameters to be monitored	Sampling and Measurement			Lead Person / Office	Annual Estimated Cost	EQPL Management Scheme					
			Methods	Frequency	Location			EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
				SMR	accordingly)			evening) 61dB (night time)	evening) 63dB (night time)	evening) 65dB (night time)		retesting using a 3rd party DENR accredited sampling firm to confirm ▫ If source is project, do corrective action, and conduct retesting to confirm results of the mitigation measures ▫ If source is not project inform MMT regarding possible source for the group's investigation and coordination with LGU	retesting using a 3rd party DENR accredited sampling firm to confirm ▫ If source is project, reduce use of noisy equipment, conduct retesting at the said sampling station and resume operation only upon clearance of the sampling station, ▫ If source is not project, inform MMT regarding possible source for the group's investigation and coordination with LGU
People													
	Workers	Health and safety of workers	Review of health and safety records of company Incident reports	Annual	Project site	PCO	Part of the constructio n cost	Negative verbal feedback of worker	Formal complaint lodged by worker	Multiple complaints lodged by workers	Proponent to investigate the subject of negative feedback. Coordinate with contractor	Investigate cause of complaint, determine and address the root cause. Coordinate	Release official statement for general consumption and employees. Coordinate

Module	Environmental Sector	Parameters to be monitored	Sampling and Measurement			Lead Person / Office	Annual Estimated Cost	EQPL Management Scheme					
								EQPL Range			Management Measure		
			Methods	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
											and MMT.	with contractor and MMT.	with contractor and MMT.
	Social Developmen t and Management Plan	Projects initiated by the Proponent under the approved SDP	Community Coordination, social engagements	Quarterly	Host barangay	Community Relations Officer	Part of the SDP Cost	Negative verbal feedback of community	Formal complaint lodged by the community	Multiple complaints by the community	Proponent to investigate the subject of negative feedback. Coordinate with barangay LGU and MMT.	Investigate cause of complaint, determine and address the root cause. Coordinate with barangay LGU and MMT.	Conduct consultation with concerned members of the community. Release official statement. Coordinate with barangay LGU and MMT.
	Information, Education, and Communication	Implementation of IEC activities	Community Coordination, social engagements	Quarterly	Host barangay	Community Relations Officer	Part of the SDP Cost	Negative verbal feed back to the Proponent	Formal complaint lodged by the community	Multiple complaints by the community captured by local media organizations	Proponent to investigate the subject of negative feedback. Coordinate with barangay LGU and MMT.	Investigate cause of complaint, determine and address the root cause. Coordinate with barangay LGU and MMT.	Conduct consultation with concerned members of the community. Release official statement. Coordinate with barangay LGU and MMT.

Environmental management and monitoring plan

Chapter 6 of this EIS presents the environmental management and monitoring plan (EMP) for the proposed Project. The proposed EMP includes the proposed mitigating measures, information on environmental parameters to be monitored (i.e. EQPL values), frequency and procedure of monitoring, and its estimated costs.

Environmental Monitoring Fund and Environmental Guarantee Fund

An Environmental Monitoring Fund (EMF) and Environmental Guarantee Fund (EGF) for the Project will be established in accordance with the Revised Procedural Manual of DAO 2003-30.

An EMF amounting to Six Hundred Thousand Pesos (Php 600,000) will be established to support the compliance monitoring activities and the annual work and financial plan (AWFP) of the MMT. The AWFP will be proposed by the MMT and concurred by the project proponent for the approval of the EMB Regional Director.

As part of the EGF, a Trust Fund amounting to Five Million Pesos (Php 5,000,000) will be established 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. In addition, an Environmental Guarantee Cash Fund amounting to One Million Pesos (Php 1,000,000) will be reserved for immediate rehabilitation and compensation of affected communities in case of damage or accidents. This may also be utilized for community-based environmental programs and information campaign.

CHAPTER 1 PROJECT DESCRIPTION

The Philippine Reclamation Authority (PRA) and the City of Navotas, as the proponent, entered into a Memorandum of Agreement last November 13, 2015 for the reclamation of approximately 650 hectares along the coast of Manila Bay fronting and within the territorial jurisdiction of Navotas City.

Navotas, dubbed as the "Fishing Capital of Philippines" is part of the informal sub-region of Metro Manila. Recognizing the need to diversify its economy, the City of Navotas decided to reclaim 576.70 hectares (the Project) of land for urban and industrial development. Considering that Navotas is the only city with water access that can provide large-scale port and logistic developments, the Project could have significant and positive industrial impacts on future developments in the region which could become a center and gateway for a future industrial district of the northern region.

Understanding the site's economic potentials on a national level, development strategies with emphasis on building competitive advantages including technology development, industrial clustering, sustainable designs and city branding.

1.1 PROJECT LOCATION AND AREA

1.1.1 Project location

The Project is located in the National Capital Region (NCR) of the Philippines. The 576.70 - hectare development site will be reclaimed in the coast of Navotas City which is a coastal city located in the northwest region of Metro Manila. The city stretches approximately 4.5 km across the shoreline of Manila Bay. It has a large fishing community that is famous for producing fish sauce and shrimp paste.

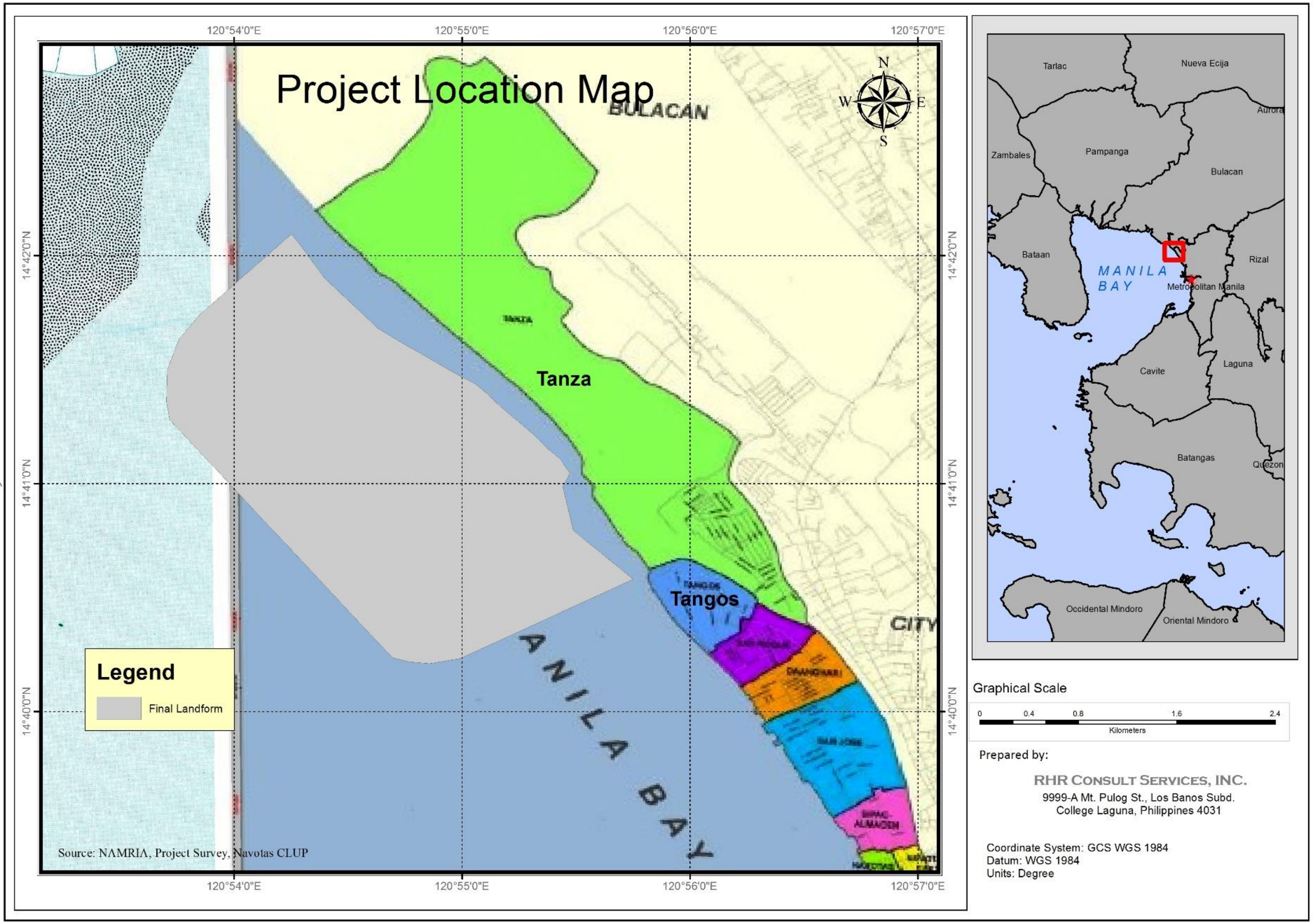


Figure 1-1 Location of the Project Area

Table 1-1 Geographic coordinates of the project area

Corner	Latitude	Longitude
1	14° 40' 30.3750 N	120°55'48.9837 E
2	14°40' 26.5355 N	120°55'40.5772 E
3	14°40'22.3894 N	120°55'31.4995 E
4	14°40'18.2431 N	120°55'22.4219 E
5	14°40'14.0968 N	120°55'13.3445 E
6	14°40'9.5173 N	120°55'3.3190 E
7	14°40'8.1683 N	120°54'55.3187 E
8	14°40'8.6760 N	120°54'49.9179 E
9	14°40'9.6736 N	120°54'45.9667 E
10	14°40'16.0415 N	120°54'40.0013 E
11	14°40'23.2539 N	120°54'33.2447 E
12	14°40'37.6785 N	120°54'19.7310 E
13	14°40'52.1029 N	120°54'6.2168 E
14	14°41'2.0165 N	120°53'56.9283 E
15	14°416.8108 N	120°53'55.9975 E
16	14°41'15.3569 N	120°53'56.2962 E
17	14°41'23.3730 N	120°53'59.3542 E
18	14°41'30.0016 N	120°54'4.8518 E
19	14°41'50.1757 N	120°54'27.7896 E
20	14°41'48.7029 N	120°54'28.8685 E
21	14°41'35.5581 N	120°54'42.8762 E
22	14°41'32.1201 N	120°54'48.5192 E
23	14°41'29.1348 N	120°54'53.7619 E
24	14°41'23.7610 N	120°55'3.1329 E
25	14°41'20.9210 N	120°55'8.5995 E
26	14°4119.1906 N	120°55'10.7245 E
27	14°4116.7973 N	120°55'13.2668 E
28	14°4115.0154 N	120°55'15.1228 E
29	14°41'7.8614 N	120°55'23.6825 E
30	14°41'3.9476 N	120°55'27.5051 E
31	14°40'59.5862 N	120°55'31.9421 E
32	14°40'57.5054 N	120°55'35.1517 E
33	14°40'56.6146 N	120°55'35.7050 E
34	14°40'53.8060 N	120°55'31.6703 E
35	14°40'42.2939 N	120°55'34.4376 E
36	14°40'38.0391 N	120°55'39.3410 E

1.1.2 Site accessibility

Navotas City may be accessed through six (6) identified entry and exit points in the city. These entry and exit points serve as the city's link to the neighboring cities and connected by bridges considering that Navotas is surrounded by water. Barangay Tanza which is separated by water from the rest of the barangays is connected to Malabon City through the Tanza Bridge.

Figure 1-2 presents the location of the project area and road networks in Navotas City.

Table 1-2 Entry points and exit points in Navotas City

Street	Leading to
Estrella Bridge	Malabon City
Circumferential Road 4 (C-4)	Malabon City
Circumferential Road 3 (C-3)	Manila City / Caloocan City
North Bay Boulevard	Manila City
Radial Road 10 (R-10)	Manila City
Tanza Bridge	Malabon City

Regional Transport

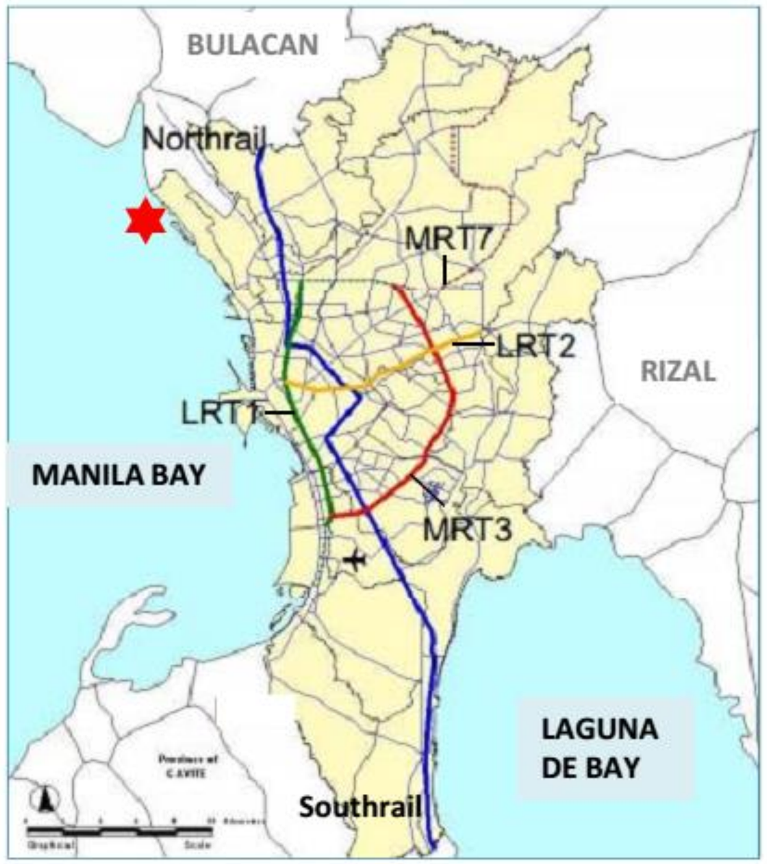
Port of Manila – 3.26million TEU in container traffic (2012)

Ninoy Aquino International Airport – 31million passengers in 2012

Extensive highway network – up to 5092 kilometres long

Railways – LRT Line 1, LRT Line 2, MRT Line 3, PNR Northrail, PNR Southrail

RAIL NETWORK



ROAD NETWORK & URBAN CENTRES

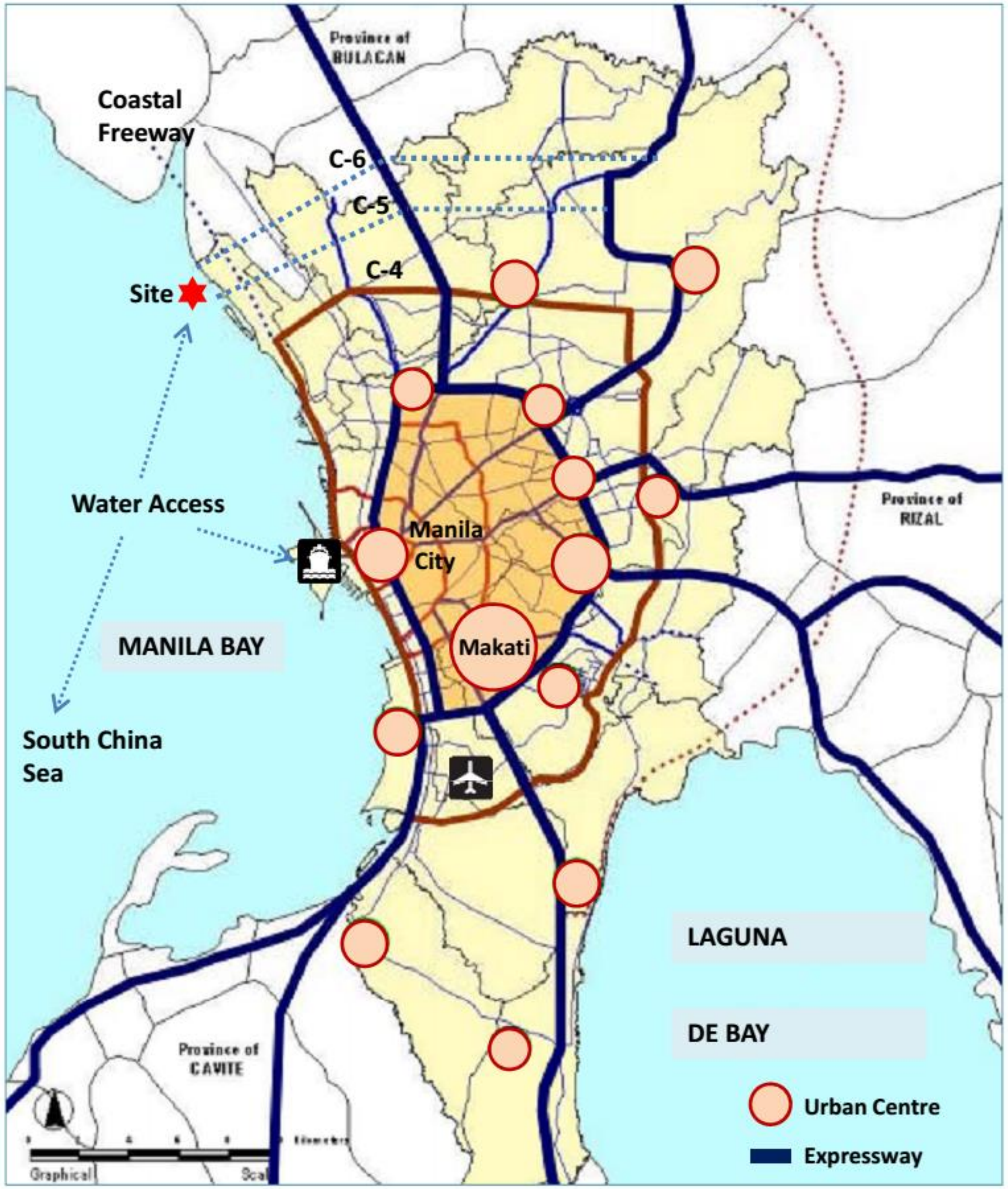


Figure 1-2 Location of the project area and road networks

1.1.3 Delineation of impact zones

As per DENR Administrative Order No. 30 Series of 2003 (DAO 03 -30), the direct impact areas (in terms of the physical environment) are those areas where all project components are proposed to be constructed/situated which is the 576.70-hectare reclamation area.

On the other hand, the whole city of Navotas is considered as the direct social impact area for the Project.

1.2 Project Rationale

The rapid urbanization of the Philippines is marked by the emergence of Metro Manila as a new mega-city. But this urban sprawl is restrained from expanding towards the west and south by the Manila and Laguna de Bay. And as a result, the urbanization is now taking pace towards the north and the City of Navotas is presented with the opportunity to support this spread of the metropolitan area by accommodating urban services as well as to serve as the host locality for extended logistics and other sea trade activities.

By taking advantage of this urbanization trend and carrying out reclamation, Navotas can be transformed to a major seaport city supported by a mix of commercial and industrial development to generate higher paying jobs and higher income generating establishments and to become part of a larger metropolis of Manila in the near future.

1.3 Project Alternatives

1.3.1 Siting

Metro Manila is the center of country's economic, political, social, and cultural activity. It has an area of 638.55 square kilometers that is subdivided into 16 cities and one municipality. Urban settlements first began in Manila, which is now the region's historic center and shipping gateway. Next to Manila along the Pasig River is the Makati CBD, the nation's financial and economic center.

Because of the private sector's involvement in development, some areas of Metro Manila, such as Makati, Manila and Pasig stand out from the rest of the region, shaping a distinctive urban identity.

The Navotas Coastal Bay is located in the far north-western corner of Metro Manila. Navotas, together with Valenzuela and Malabon are emerging industrial cities that are expected to grow into a major industrial district in the future.

Amongst the emerging industrial cities in the northern region, Navotas is the only city with water access that can provide large scaled port and logistic developments. This indicates that the development site of Navotas Coastal Bay could have significant industrial impacts on future developments in the region.

The location the proposed reclamation project in Navotas is adjacent of existing and other proposed reclamation and land development projects in the Manila Bay area. The Bay City, formerly known as Boulevard 2000, is a development that has an area of 1,500 hectares and spans the cities of Pasay and Parañaque. The development of the area consists of seven phases which are;

1) The Cultural Center of the Philippines Complex;
2) Financial Center Area Complex;
3) Central Business Park, Island A;
4) Central Business Park, Islands B & C (ASEANA City)
5) Central Business Park II
6) Asiaworld, and
7) Cyber Bay

The Bay City is host to a number of commercial and institutional establishments that include, among others, the National Theatre, Cultural Center of the Philippines, Folk Arts Theatre, Philippine International Convention Center, Sofitel, Star City, Boom na Boom, DTI-CITEM, GSIS, World Trade Center, Metropolitan Park, and SM Bay City. Future and ongoing developments in Boulevard 2000 include BPO Offices in SM Bay City, Aseana City, Alphaland Bay City, Solaire Manila, PagCor City, Resorts World Bayshore, Manila Bay Resorts, Bagong Nayong Pilipino, Marina Bayhomes, Marina Baytown East, Asia World Development, Mandara Waterfront Residences, Palm Coast Bayside Residences and Marina Baytown South. In general, the Boulevard 2000 will be the prime location for casinos, shopping malls, amusement parks, theaters, hotels, business hubs, residential buildings and resorts.

Future and ongoing developments in Bay City include BPO Offices in SM Bay City, Aseana City, Alphaland Bay City, Solaire Manila, PagCor City, Resorts World Bayshore, Manila Bay Resorts, Bagong Nayong Pilipino, Marina Bayhomes, Marina Baytown East, Asia World Development, Mandara Waterfront Residences, Palm Coast Bayside Residences and Marina Baytown South. In general, the Boulevard 2000 will be the prime location for casinos, shopping malls, amusement parks, theaters, hotels, business hubs, residential buildings and resorts.

The PRA has announced its plan to expand the Boulevard 2000 site to be referred to as the Manila Bay Development Triangle. The expanded reclamation will include new reclamation areas in Ternate Cavite, in the south, extending along the coast parallel to the shorelines of Manila Bay, going up north and passing through the territorial waters of Cavite, Metro Manila, Bulacan and Pampanga up to Balanga in Bataan. The proposed expansion will have complementary land uses of which southern portion will be earmarked for industrial uses given its proximity to the industrial parks in Cavite.

The site of the Navotas reclamation project will complement the existing and planned reclamation project in Manila Bay. It is consistent and supportive of the expanded reclamation plan of the PRA. The strategic location of the Navotas reclamation project will facilitate the relocation of industries from Caloocan and Novaliches (which already have very limited space and are congested) to the Navotas reclamation area. The project has the locational advantage also of being adjacent to the Port of Manila that will provide ease of transport of goods and services into and out of this port.

1.3.2 Technology selection/operation processes

It is relatively easy in most cases to ensure that the seawall cope level and reclamation level are higher than the extreme still water level corresponding to a return period of 100 years, or even 200 years where flooding would cause substantial loss of life and damage to property. However, it is not practical to design a revetment or seawall, even with the addition of a wave wall, to effectively prevent overtopping from waves during extreme events. The water levels will be investigated based on the hydraulic modeling for the post development situation, meteorological events and seasonal water level variation and the most appropriate formation level will be proposed for the reclamation.

A seawall is defined as a shoreline structure whose primary purpose is either to protect against erosion or alleviate flooding or both. The dominant design consideration is wave action. Depending on the formation level, land use adjacent to the coastline and type of marine facilities to be provided, the most appropriate seawall will be proposed. While it is easy at the Inception and Pre-Feasibility stages to determine the likely seawall to be designed, it is envisaged that a combination of various seawalls will be used to achieve the required land use. This is illustrated (Figure 1-3 to Figure 1-5) using examples of seawalls constructed in Singapore.

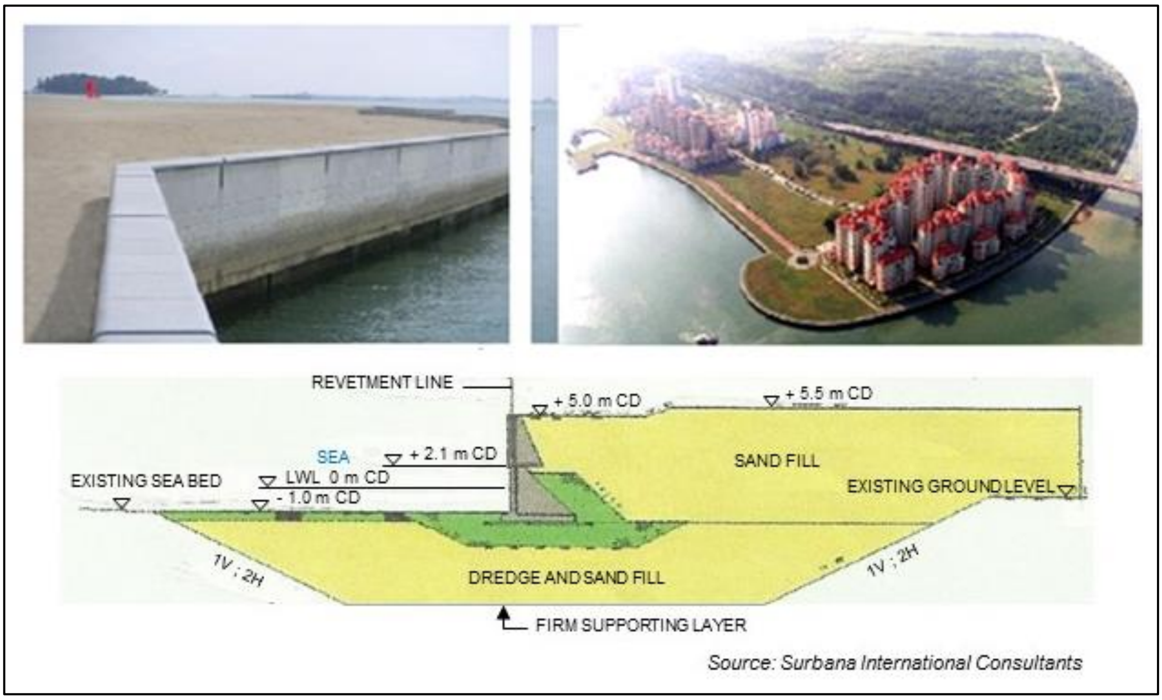


Figure 1-3 Vertical Seawall used in the Tanjong Rhu Reclamation and Southern Island Reclamation in Singapore

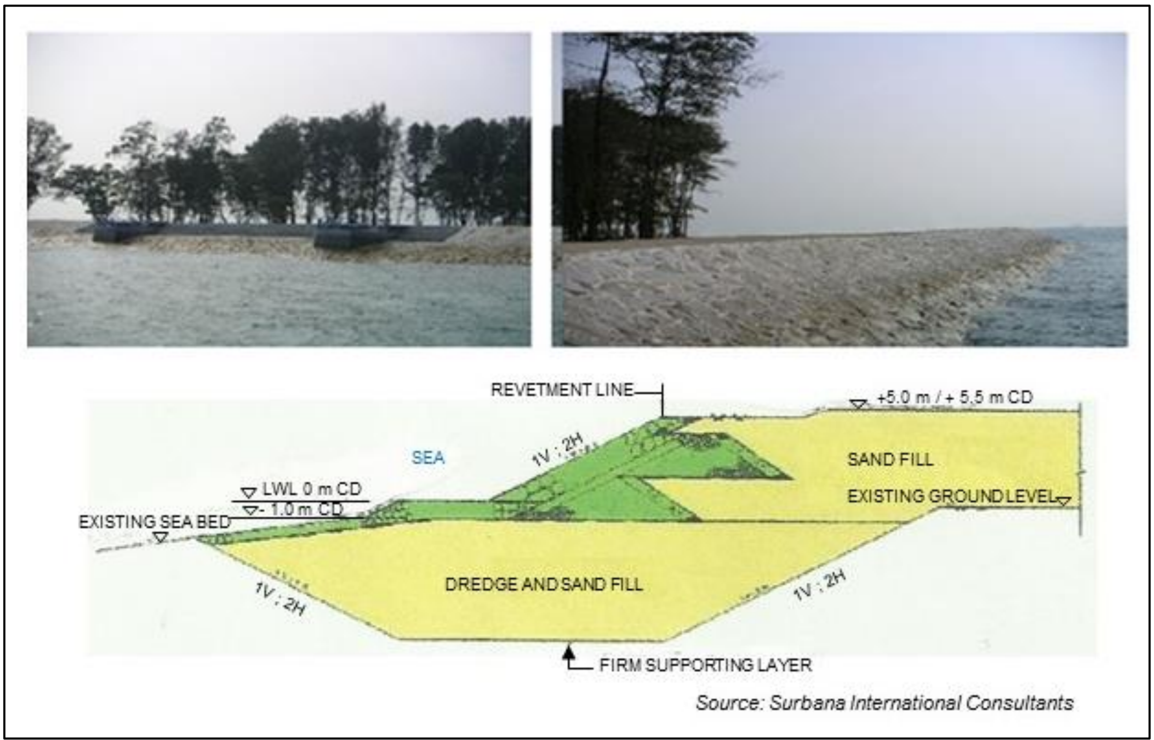


Figure 1-4 Sloping Seawall used in the Southern Island Reclamation in Singapore to provide a natural and tranquil setting

Figure 1-5 Stepped Sloping Seawall used in the Northeastern Coast Reclamation in Singapore

Source: Surbana International Consultants

1.3.3 Resources

Fill for reclamation relies on marine sand and/or crushed rock although dredged and/or land based excavated materials may also be used in some cases. For most reclamation works, the choice of fill is largely dependent on the availability and cost. In order to maximize the benefit of available fill sources, flexibility for combining different types of fill will be considered in the reclamation planning.

The use of marine sand fill can be economically viable for a reclamation project where a marine borrow area is within a reasonable distance from the site and where the size of the project justifies the use of sophisticated dredgers which have high mobilization costs.

There is a need to establish the availability of a sand source and costs as these will be factors to be considered for reclamation planning. At this stage, the reclamation fill material has been identified to come from the Manila Bay particularly the San Nicolas Shoal located within the Municipal waters of Naic and Tanza, Cavite (Figure 1-6), which is the primary source of almost all the reclamation projects in the Manila Bay. Sand from the San Nicolas Shoal is generally medium to coarse in nature and is viable because of the quality and the quantity of sand available for extraction and its proximity to the project site. Alternative sites within a radius of 40 nautical miles from the project site will also be studied.

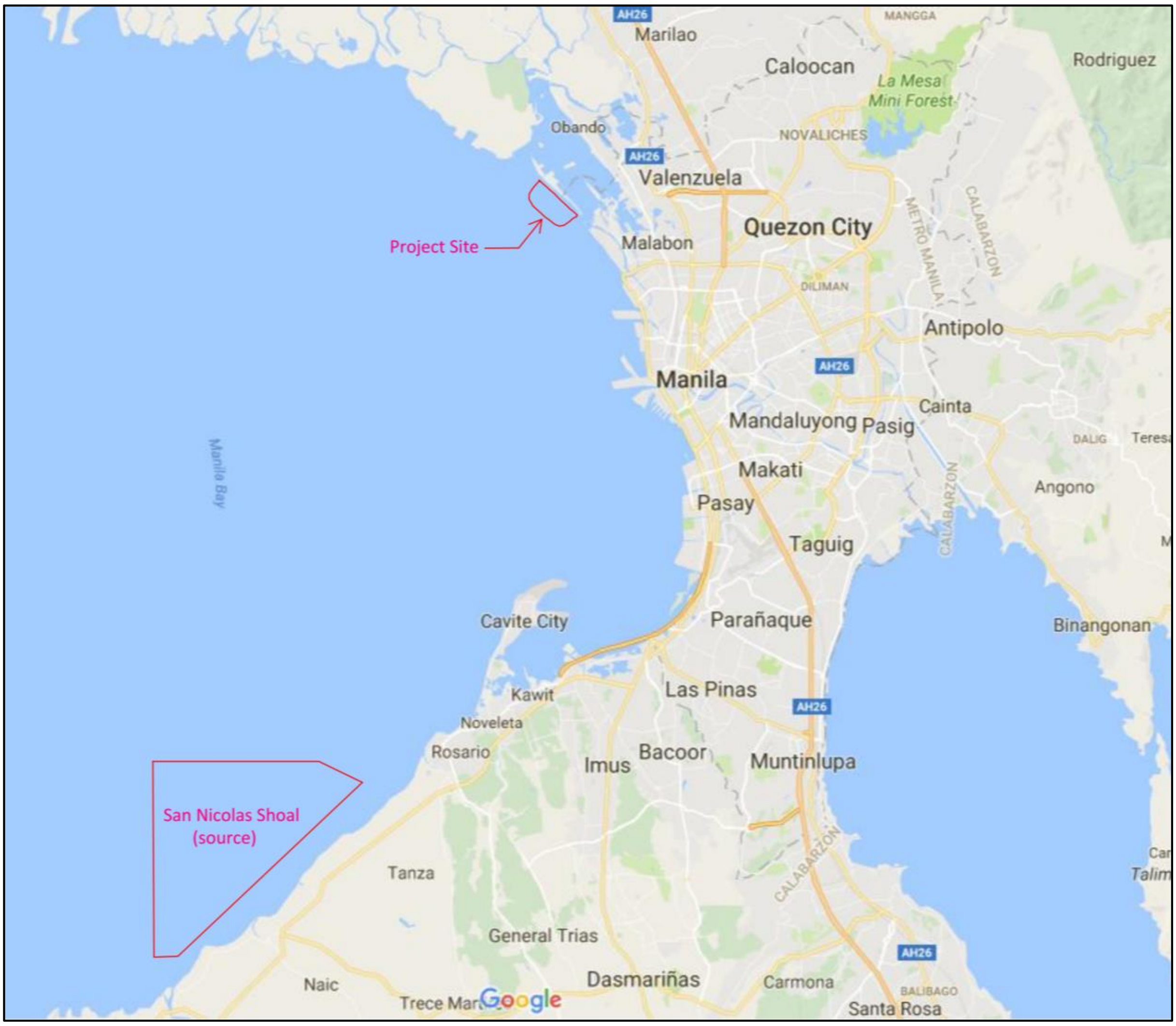


Figure 1-6 Project site and source of materials

1.3.4 No project alternative

The proposed Navotas Reclamation project will offer substantive socio-economic benefits not only for the host local government of Navotas City but also to the regional and national levels as well. Without the project, the urban development expansion to accommodate the urban development requirements needed by the projected increase in population of Navotas City will be constrained primarily due to the very limited land area available for the City. Currently, a large number of the City's urban population lives along the coastal areas with depressed social and environmental conditions. Without the planned reclamation project, these communities will be deprived of opportunities for an improved access to improved and well-planned settlement areas.

The lack of urban spaces also reduces the City's attractiveness as an investment haven for the private business sector. This in turn negatively affects the ability of the City government to generate its own-source revenues thereby consequently reducing its local fiscal performance and financial autonomy. The absence of additional space for business opportunities also will deter the availability of potential employment and downstream livelihood opportunities from an improved business climate resulting from the additional urban space that can be accorded by the proposed reclamation project.

Without the proposed reclamation project, the will not be accorded with a well master planned landscape that will enhance the overall environmental quality of the locality. Without the project, there will be no improvement in the aesthetic quality of the City and also will be deprived of adequate functional open and green spaces that can improve the provision of other urban ecosystem services in terms of air quality, carbon capture, flood mitigation, and recreation, among other things, all of which are seen to contribute to the overall socio-economic well-being of the local communities in Navotas City.

The additional urban space likewise will accord the City new land areas where it can expand its social and institutional infrastructure and facilities to enhance the delivery of basic as well as local administrative services to its constituents.

1.4 Project Components

Overall reclamation will be carried out through a combination of hydraulic dredging from borrow site offshore of the project area and filling with borrow materials. An estimated 65 million cubic meters more or less of borrow materials will be required to reclaim the areas up to 5.0 meters above the Mean Lower Low Water (MLLW). Table 1-3 presents the list of reclamation equipment and their production rates and Figure 1-7 shows the specifications of each equipment.

Table 1-3. Reclamation Equipment

S/N	Equipment	No.	Capacity	Production rate each (m^3 /day)	Total Production rate (m^3 /day)
1	Cutter Suction Dredger (CSD) at Borrow Area	2	3,000 m^3/hr	33,000	66,000
2	Cutter Suction Dredger (CSD) at Reclamation Site	2	3,000 m^3/hr	33,000	66,000
3	Split Hopper Barge (SHB) (4 - 4.5 m draft)	14	1,600 m^3	4,800	66,000
4	Tug Boat	14	-	-	-
5	Backhoe Dredger (for sand key)	2	8 – 11 m^3	4,000	8,000
6	Excavator	4	-	-	-
7	Bulldozer	4	-	-	-
8	Clamshell and Barge (for revetment construction)	2	600 m^3	-	-
9	Wheel Loader	4	-	-	-
10	Vibratory Roller	4	-	-	-

Cutter Suction Dredger (CSD)

1. Tonnage :6250 GRT
2. LOA :131.0 m
3. Mold Depth :6.1 m
4. Max Draft :4.53 m
5. Min Dredge Depth :5.7 m
6. Total Power Installed :12400 kW
7. Cutter Output :1500 kW
8. Delivery Output :6000 kW
9. Ladder Pump Output :1300 kW

Split Hopper Barge (SHB)

1. Tonnage :1284 GRT
2. LOA :58.0 m
3. Mold Depth :5 m
4. Draft :4 m
5. Hold Capacity :1500 m^3

Backhoe Dredger

1. LOA :48.1 m
2. Max Draft :2.15 m
3. Max Dredge Depth :23.7 m
4. Total Power Installed :993 kW
5. Excavator Output :775 kW
6. Bucket Capacity :4.5 m^3

Grab Dredger

1. Tonnage :2140 ton
2. Mold Depth :3.75 m
3. Max Draft :2.2 m
4. Max Dredge Depth :50 m
5. Total Power Installed :2380 kW
6. Crane Capacity :200ton (14m)
7. Grab Capacity :20.0 m^3

Tugboat

1. Light Draft :1.5 m
2. Laden Draft :1.8 m
3. Winches :Electric
4. Horsepower :900 BHP
5. Speed :10 knots

Figure 1-7. Specifications of Reclamation Equipment

Figure 1-8 General Layout of Facilities

On the other hand, the following facilities will be constructed during reclamation activities:

1. Temporary lodging (with sanitation facilities);
2. Material and equipment storage;
3. Field office;
4. Drainage systems (Figure 1-9)
5. Warehouse, and
6. Administration office;

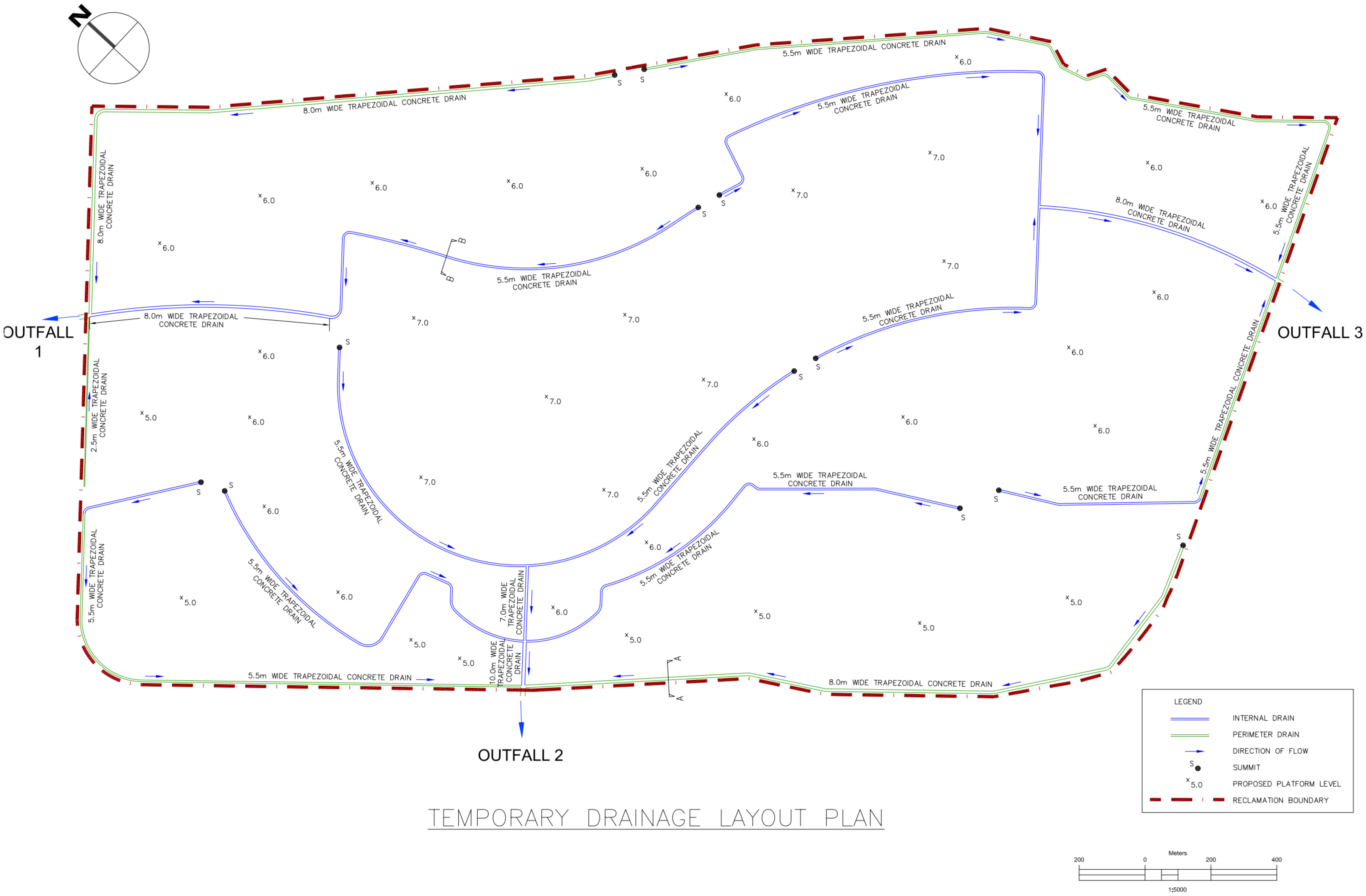


Figure 1-9 Temporary drainage layout plan

1.5 Process/Technology

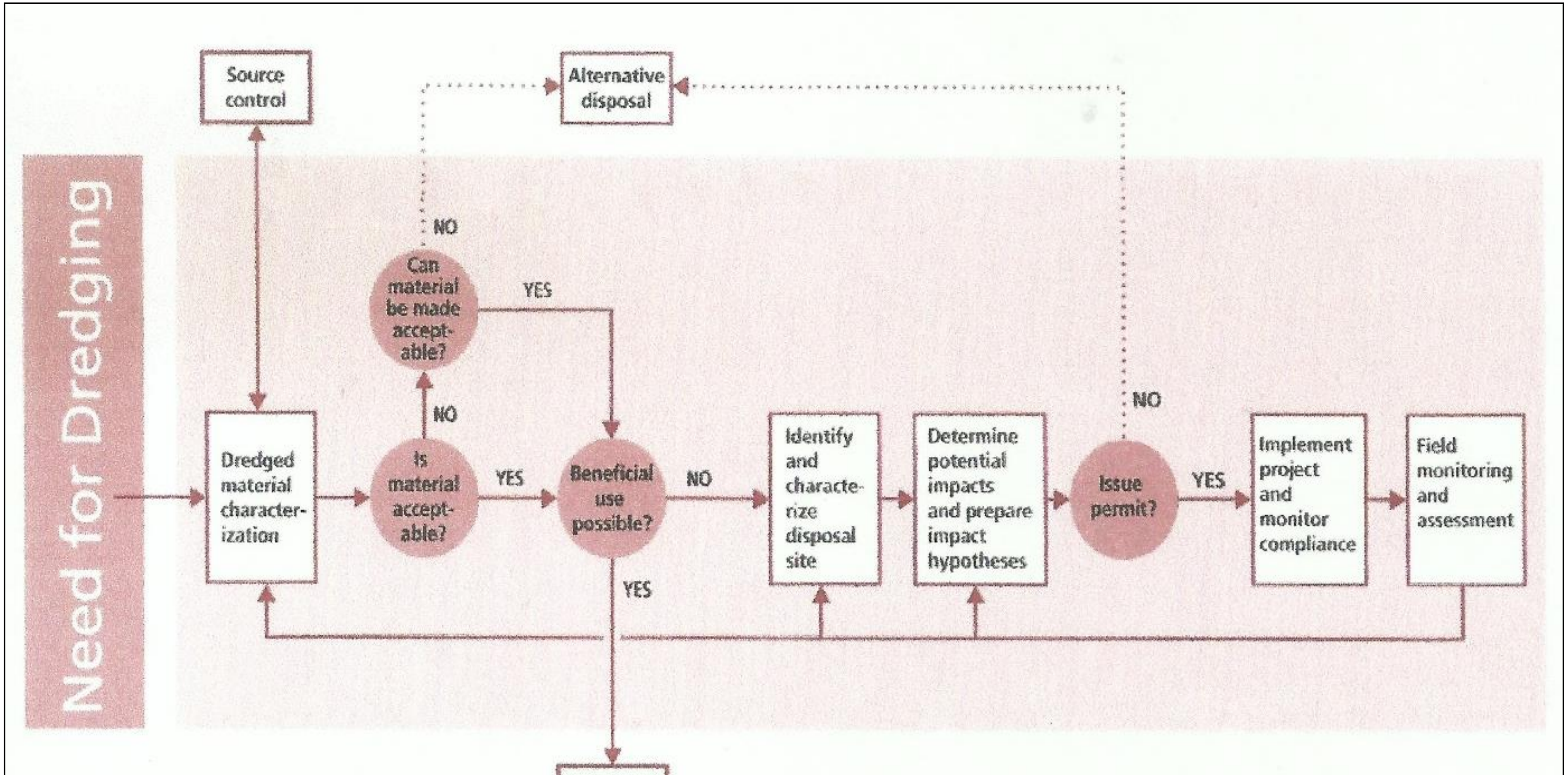
From the coastal geomorphology, preliminary assessment indicates that replacement method would likely to be the most suitable for the construction of the foundation of the seawalls or slope revetment. The soil improvement method would involve the dredging of the soft subsoil layers underneath the seabed to form a trench. The trench is subsequently filled with sand to form a stable sand key foundation. The primary function of this sand key is to ensure stability of the seawall revetment against slip failure and excessive settlement.

However, it is emphasized that the actual detailed design on the method of reclamation can only be carried out after completion of the soil investigations.

The constraint posed by this method is that the planning of the reclamation must ensure that sand is available and that the supply is consistent and continuous during the period of construction. The availability of sand will be evaluated as part of the reclamation planning.

The proposed dredging will also introduce dredged material that would have to be disposed of traditionally. Although this might be seen as a constraint, a range of beneficial engineering uses exist for the disposal of the dredged material and this includes the re-use of the dredged material for land reclamation. The reclamation planning will evaluate the material, taking into account of the environmental regulations or authorities' requirements, and propose innovative use and rehandling the dredged material as reclamation fill with the appropriate treatment. However, the constraint in the re-use of the dredged material is the possible existence of various wastes that are expected to be found on the surface layer of the seabed. Such wastes will have to be removed in order to leave behind the soil that can be re-used.

Figure 1-10 Dredging of the Trench
Source: Surbana International Consultants



*Source: Taylor & Francis Group*Navotas

Figure 1-11 Decision process for the evaluation of the dredging material

In principle, the overall reclamation will be carried out through a combination of hydraulic dredging from borrow site offshore of the project area and filling with borrow materials. An estimated 65 million cubic meters of borrow materials will be required to reclaim the areas up to 5.0 meters above the Mean Lower Low Water (MLLW). This volume is an estimate that does not include the allowance of the subsidence of the original ground.

Soft ground takes a very long time to undergo consolidation and gain sufficient strength. If the reclaimed land is required within a short time, it is necessary to accelerate the consolidation process using ground improvement technique. There are different methods to accelerate ground improvement based upon the different soil conditions. Measures to improve the settlement characteristics of reclamation fill include densification by static methods (such as surcharge preloading and vacuum preloading) or dynamic methods (such as vibratory probe techniques and dynamic compaction). The choice of a particular method is dictated by the degree of improvement required, the depth of fill to be treated, the proximity to existing structures or facilities, and the relative cost benefits. Some common methods used in the industry for treating the reclaimed land are sand surcharge method, prefabricated vertical drains with surcharge and vacuum preloading. The proposed ground improvement methodology to be implemented for the project shall be further studied and would subject to the following conditions:

- The type, dimension and time of construction of any structures to be built on the reclaimed land;
- Cost-benefit and programming considerations; and
- Effect of the densified fill on future piling, excavation and other development activities.

1.6 Project Size

The proposed reclamation project will have an area of 576.7 hectares. The total estimated reclamation volume is 65,000,000 m^3 more or less.

1.7 Development plan, description of project phases and corresponding time frame

The overall project schedule is based on the following key considerations and assumptions:

a. The proposed reclamation of 576.7 hectares of foreshore for the Project (without any vertical and horizontal development works) is expected to take approximately 30 months to complete excluding time required for ground improvement works;

b. At this construction duration of 30 months, the estimated monthly dredging and filling rate is 2.41 million cubic meters, which is a challenging production rate to be achieved;

c. All detailed technical studies, investigations, and survey works are targeted to be completed within 8 months. This will include the whole ECC application and approval process, which will require joint effort from the various relevant authorities such as DENR-EMB including major reduction of time required for the processing of the ECC application.

Based on the above key considerations and assumptions, the Project is expected to complete within approximately 44 months.

1.7.1 Pre-construction phase

The City Government of Navotas has accomplished various pre-construction tasks in support to the proposed Reclamation Project. These tasks are necessary to ensure compliance to government regulations. The following items are included in the pre-construction tasks:

- Sea bottom topography
- Detailed engineering designs, topographic surveys and site investigations
- Philippine Reclamation Authority Memorandum of Agreement
- Selection and awarding of qualified contractors
- Start of procurement of dredgers and equipment

1.7.2 Construction phase

After completing the pre-construction tasks, the City of Navotas will then proceed with the construction and procurement phase of the project. The city of Navotas, through its designated general contractor, shall implement the following construction and procurement activities for the project:

- Establishment of a camp site for construction personnel and equipment, including temporary lodging (with sanitation facilities), material and equipment storage, and field office;
- Upgrading, improvement and construction of necessary access roads and temporary drainage systems;
- Site preparation;
- Construction of the administration office, and
- Procurement and commissioning of reclamation equipment

1.7.3 Operation phase

The reclamation sequence of the NCBRP is as follows:

1. The reclamation site is similar to an irregular shape of trapezium with its longer side adjacent to the Navotas Coast. The proposed borrow area is located within 40 nautical mile radius from the site such as the San Nicholas Shoal (SNS). A stockpile area is proposed within the reclamation area to facilitate unloading of the dredged materials from the borrow area and act as a holding zone to distribute the materials in a planned manner. Due to its shallow topographic nature, this require deepening (by dredging) of the stockpile area to facilitate the movement of barges.

2. The dredged materials from the navigation channel and turning basin will be handled in two ways; pump onto a transport barge for re-handling at the stockpile area before pumping ashore, and/or pump directly onto the reclamation site for direct filling.

3. The construction of the sand bund will be carried out in a progressive manner with the dredging process as well as the revetment construction. The revetment is constructed in multiple stages, starting with the construction of sandkey as follows:

   a. Dredge the existing seabed for sand-key at the boundary location.
   b. Fill the reclamation area with the sandkey dredging material (not more than 2 m thickness).
   c. Replace the existing seabed material with good material from the borrow area.

4. As the sand bund and sandkey construction continues, the revetment construction will follow accordingly. As it progresses, the reclamation area will be filled with the sand dredged from the borrow area up to the proposed reclamation level. Soil improvement works will be carried out thereafter the reclamation filling.

5. All constructions, including the vertical wall, jetty and revetment will move progressively and simultaneously, similarly as stipulated above until the entire area is filled and all the coastal protection structures are constructed. The proposed reclamation cycle is shown in Figure 1-12.

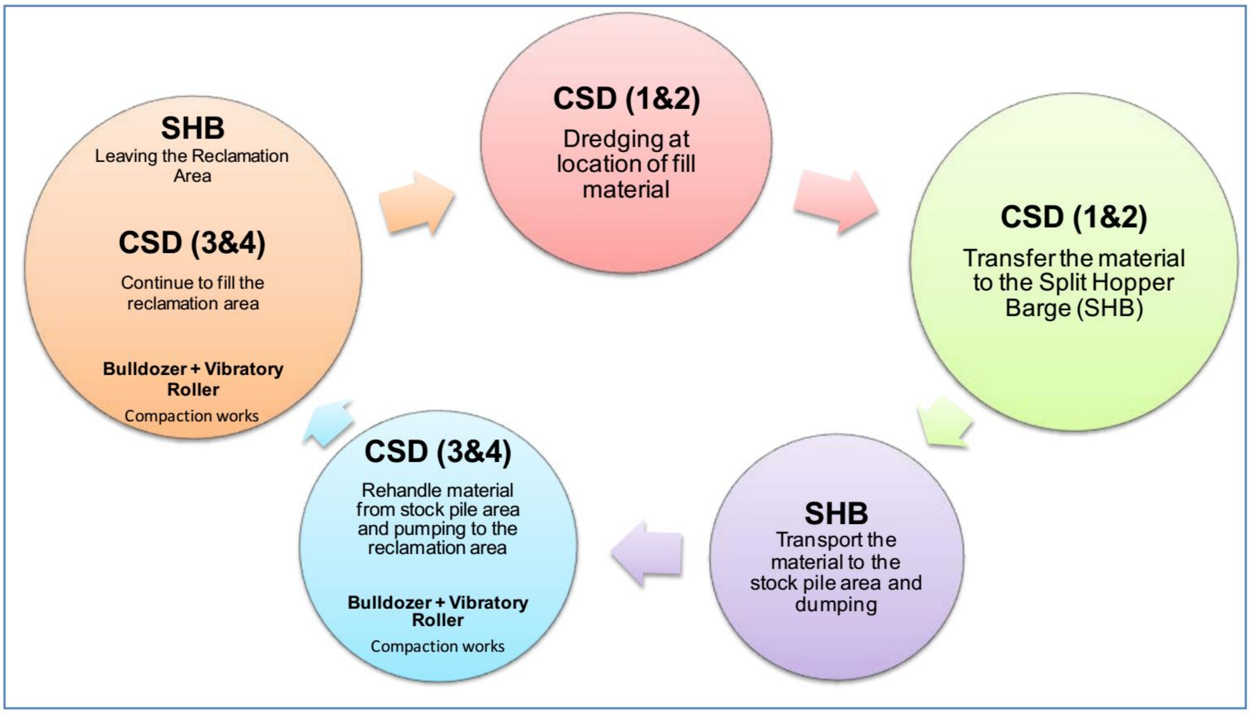


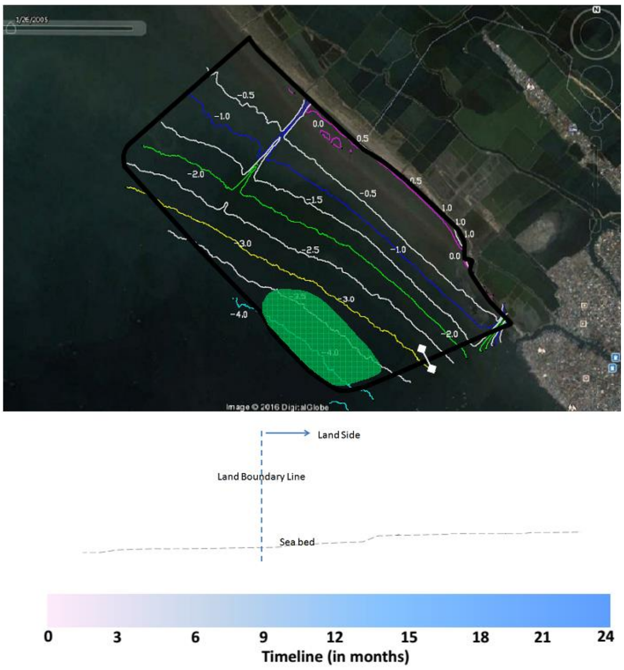
Figure 1-12 Proposed reclamation cycle

The Reclamation Sequence for the proposed project is presented below with illustrations:

Preparation Work

1. Deepening some part of the reclamation area (using CSD), so that the SHB can enter the reclamation area.

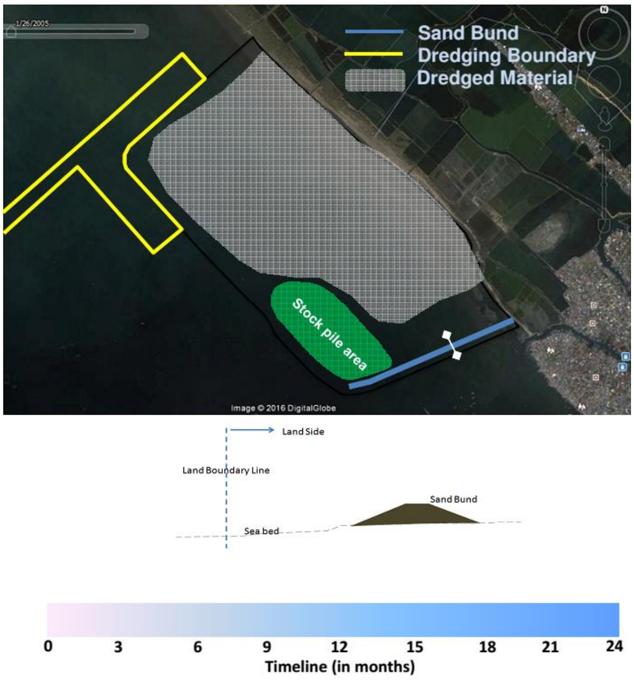
2. This area later will be used as stockpile area.



Equipment	Total	To date
CSD at Dredging Site	2	0
CSD at Reclamation Site	2	2
Split Hopper Barge	14	0
Tug Boat	14	0
Backhoe dredger	2	0
Excavator	4	0
Bulldozer	4	0
Clamshell and barge	2	0
Wheel loader	4	0
Vibratory Roller	4	0

3. Dredging of Navigation Channel and Turning Basin to be done using a mix of CSD pumping dredged material onto SHB for rehandling at the stockpile area before pumping ashore and CSD pumping direct onto reclamation site for direct filling.

4. The construction of sand bund to be done using backhoe dredger.



Equipment	Total	To date
CSD at Dredging Site	2	2
CSD at Reclamation Site	2	2
Split Hopper Barge	14	4
Tug Boat	14	4
Backhoe dredger	2	1
Excavator	4	0
Bulldozer	4	0
Clamshell and barge	2	0
Wheel loader	4	0
Vibratory Roller	4	0

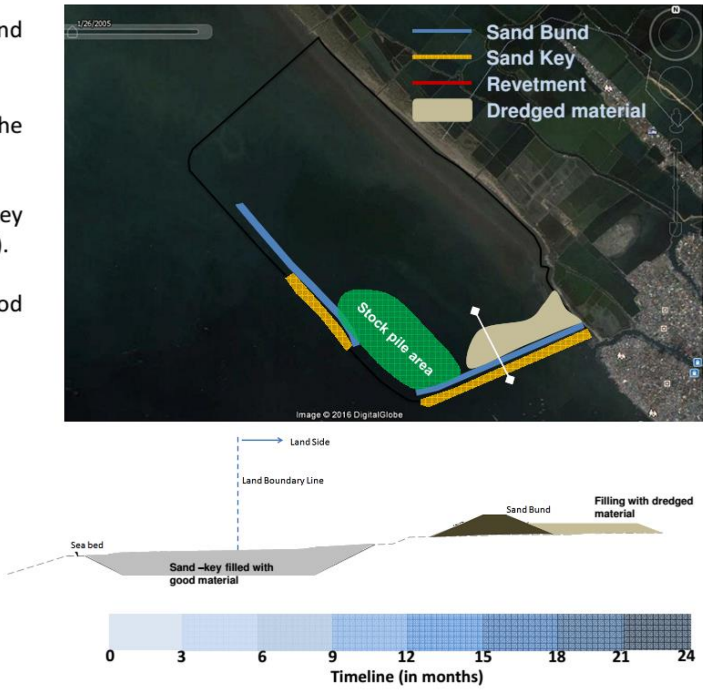
5. Continuing the Construction of Sand Bund and starting the Construction of Sand-Key.

a. Dredging the existing seabed for sand-key at the boundary location using backhoe dredger.

b. Filling the reclamation area with the sand-key dredging material (not more than 2 m thickness).

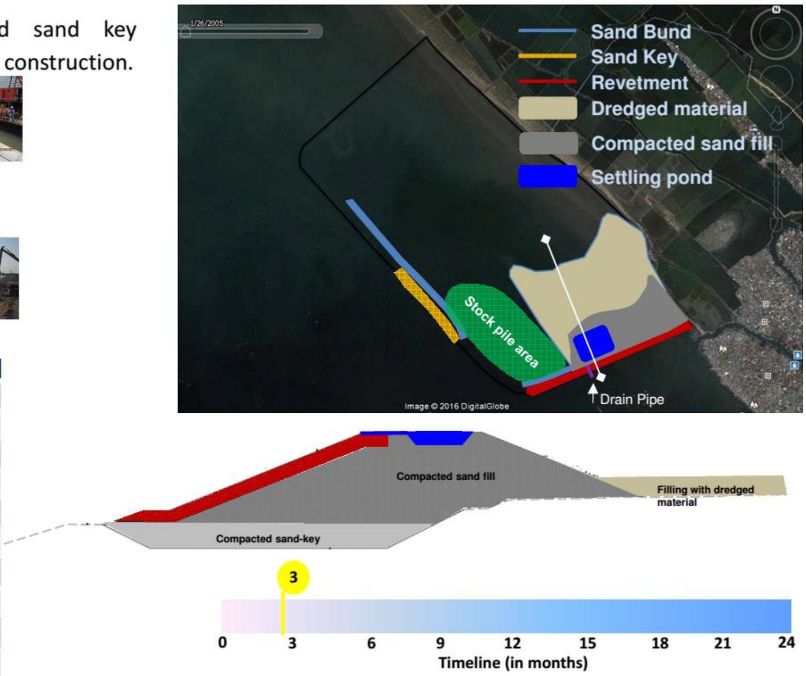
c. Replace the existing seabed material with good material from borrow area.

Equipment	Total	To date
CSD at Dredging Site	2	2
CSD at Reclamation Site	2	2
Split Hopper Barge	14	4
Tug Boat	14	4
Backhoe dredger	2	1
Excavator	4	1
Bulldozer	4	0
Clamshell and barge	2	0
Wheel loader	4	0
Vibratory Roller	4	0

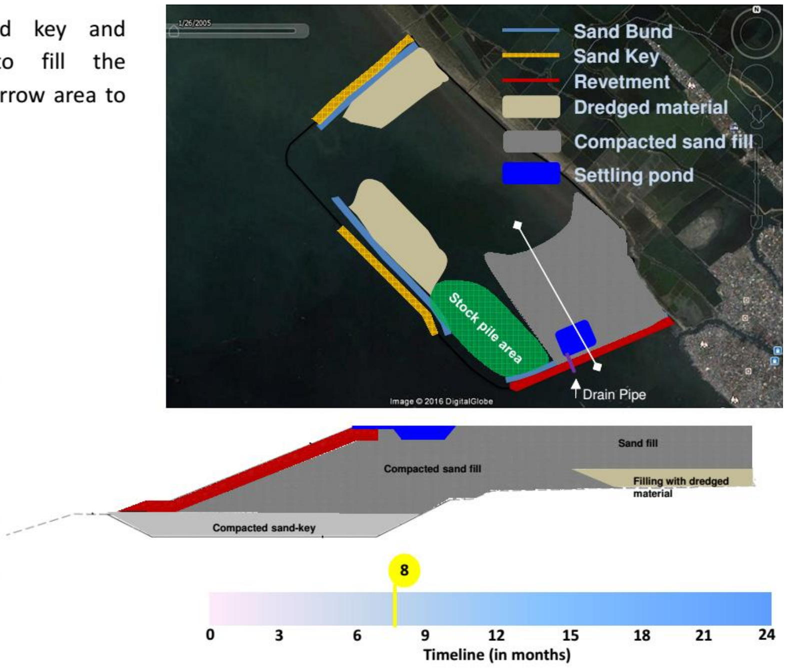


6. Continuing the sand bund and sand key construction, starting the revetment construction.

Equipment	Total	To date
CSD at Dredging Site	2	2
CSD at Reclamation Site	2	2
Split Hopper Barge	14	4
Tug Boat	14	4
Backhoe dredger	2	2
Excavator	4	2
Bulldozer	4	2
Clamshell and barge	2	2
Wheel loader	4	0
Vibratory Roller	4	2



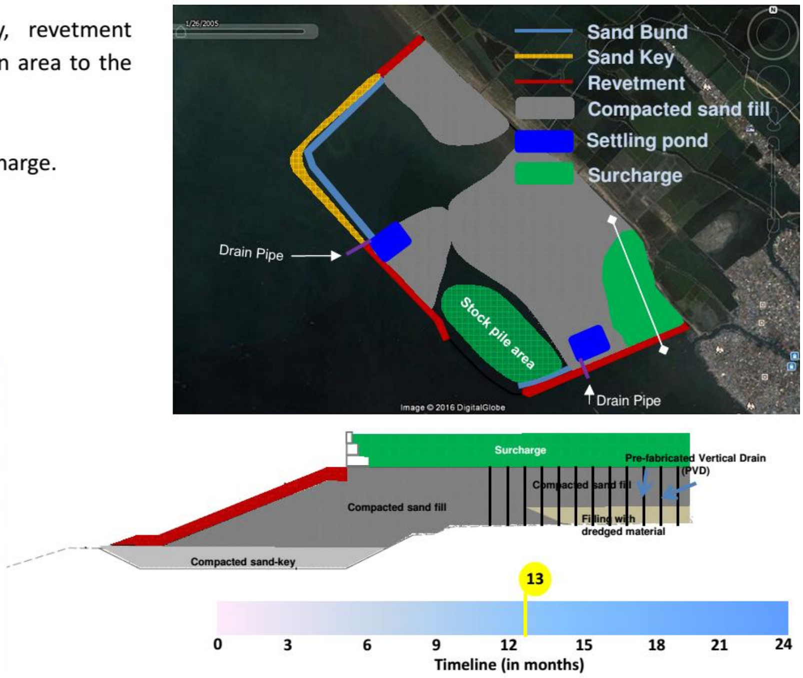
7. Continuing the sand bund, sand key and revetment construction, start to fill the reclamation area with sand from borrow area to the reclamation level +5.00 m CD.



Equipment	Total	To date
CSD at Dredging Site	2	2
CSD at Reclamation Site	2	2
Split Hopper Barge	14	14
Tug Boat	14	14
Backhoe dredger	2	2
Excavator	4	4
Bulldozer	4	4
Clamshell and barge	2	2
Wheel loader	4	0
Vibratory Roller	4	4

8. Continuing the sand bund, sand key, revetment construction, and fill the reclamation area to the reclamation level +5.00 m CD.

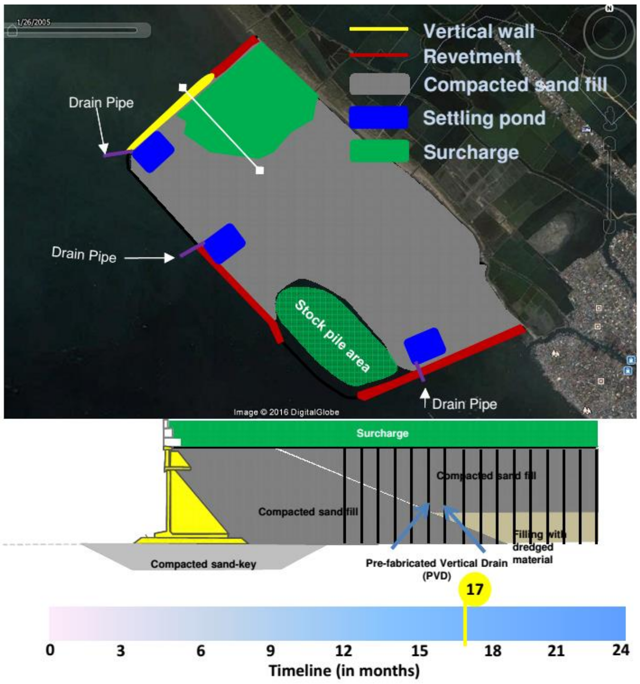
9. Soil improvement with PVD and Surcharge.



Equipment	Total	To date
CSD at Dredging Site	2	2
CSD at Reclamation Site	2	2
Split Hopper Barge	14	14
Tug Boat	14	14
Backhoe dredger	2	2
Excavator	4	4
Bulldozer	4	4
Clamshell and barge	2	2
Wheel loader	4	4
Vibratory Roller	4	4

10. Continuing the previous works and starting to construct vertical wall in the area where port will be developed in the later stage.

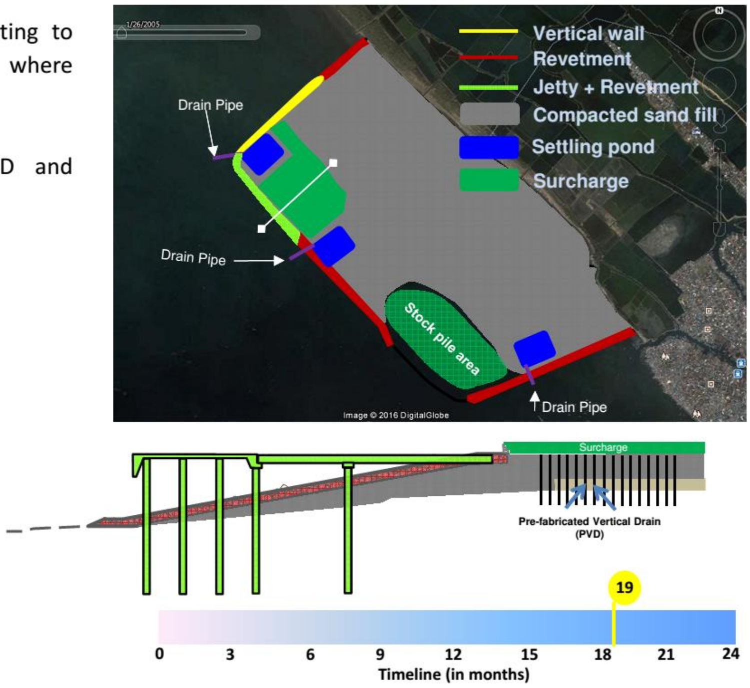
11. Continuing soil improvement with PVD and Surcharge.



Equipment	Total	To date
CSD at Dredging Site	2	2
CSD at Reclamation Site	2	2
Split Hopper Barge	14	14
Tug Boat	14	14
Backhoe dredger	2	2
Excavator	4	4
Bulldozer	4	4
Clamshell and barge	2	2
Wheel loader	4	4
Vibratory Roller	4	4

12. Continuing the previous works and starting to construct jetty + revetment in the area where port will be developed in the later stage.

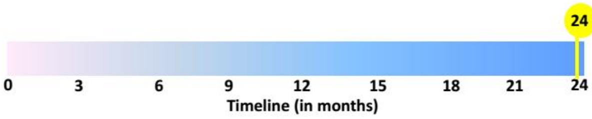
13. Continuing soil improvement with PVD and Surcharge.



Equipment	Total	To date
CSD at Dredging Site	2	2
CSD at Reclamation Site	2	2
Split Hopper Barge	14	14
Tug Boat	14	14
Backhoe dredger	2	2
Excavator	4	4
Bulldozer	4	4
Clamshell and barge	2	2
Wheel loader	4	4
Vibratory Roller	4	4

14. Continuing the previous works until the whole area filled and all the coastal protection constructed.

Equipment	Total	To date
CSD at Dredging Site	2	0
CSD at Reclamation Site	2	0
Split Hopper Barge	14	0
Tug Boat	14	0
Backhoe dredger	2	2
Excavator	4	4
Bulldozer	4	4
Clamshell and barge	2	2
Wheel loader	4	4
Vibratory Roller	4	4

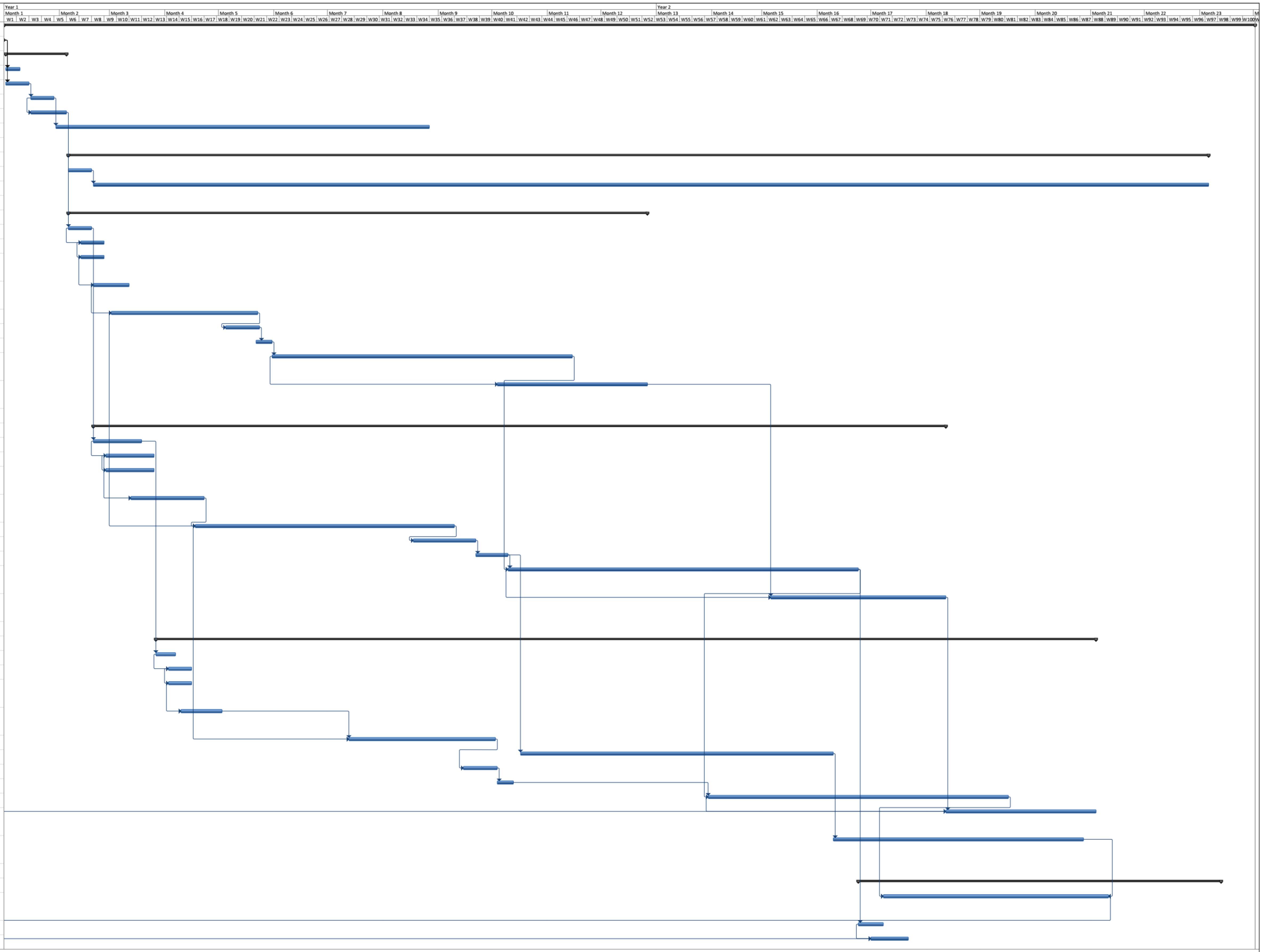


1.7.4 Decommissioning and abandonment phase

The following are possible options that will be considered during the abandonment phase:

- All equipment used during the reclamation activity will be pulled out of the project area
- All existing facilities that are not useful will be removed
- Additional establishment of mangrove plantations
- Engage and hire on contractual basis, personnel from the affected community to undertake the mangrove plantation program.

ID	ID	Task Name	Duration
1	**1**	**Reclamation Construction**	**120 wks**
2	2	Project Commencement	0 days
3	**3**	**Preliminary Stage**	**6 wks**
4	4	Method Statement Review	7 days
5	5	Mobilization and Site Preparation	12 days
6	6	Pre-construction Survey	12 days
7	7	Site Preparation	18 days
8	8	Dredging works of Navigation Channel	180 days
9	9		
10	**10**	**Borrow Area Access & Dredging Works**	**109.4 wks**
11	11	Access Channel at Material Borrow Area	12 days
12	12	Dredging works at Materal Borrow Area	535 days
13	13		
14	**14**	**Stage 1**	**55.6 wks**
15	15	South Bund Filling	12 days
16	16	Dredging Works of South Sand-Key	12 days
17	17	Filling the Reclamation Area with Sand-Key Dredging Material	12 days
18	18	Filling Works for the South Sand-Key with Good Material from Borrow Area	18 days
19	19	The Construction of South Revetment	70 days
20	20	Settling Pond Construction	16 days
21	21	Drainage Pipe Installation	8 days
22	22	Filling works for South Reclamation Area to +5.0 m CD with Filling Material from Borrow Area	144 days
23	23	Soil Improvement with PVD and Surcharge in South Reclamation Area	72 days
24	24		
25	**25**	**Stage 2**	**81.8 wks**
26	26	West Bund Filling	24 days
27	27	Dredging Works of West Sand-Key	24 days
28	28	Filling the Reclamation Area with Sand-Key Dredging Material	24 days
29	29	Filling works for the West Sand-Key with Good Material from Borrow Area	36 days
30	30	The Construction of West Revetment	125 days
31	31	Settling Pond Construction	30 days
32	32	Drainage Pipe Installation	15 days
33	33	Filling works for West Reclamation Area to +5.0 m CD with filling Material from Borrow Area	168 days
34	34	Soil Improvement with PVD and Surcharge in West Reclamation Area	84 days
35	35		
36	**36**	**Stage 3**	**90.2 wks**
37	37	North Bund Filling	10 days
38	38	Dredging Works of North Sand-Keys	12 days
39	39	Filling the Reclamation Area with Sand-Key Dredging Material	12 days
40	40	Filling Works for the North Sand-Key with Good Material from Borrow Area	20 days
41	41	The Construction of North Revetment	70 days
42	42	The Construction of Vertical Wall (Seawall)	150 days
43	43	Settling Pond Construction	16 days
44	44	Drainage Pipe Installation	8 days
45	45	Fillings Works for North Reclamation Area	144 days
46	46	Soil Improvement with PVD and Surcharge in North Reclamation Area	72 days
47	47	The Construction of the Port Deck in the Area where Port will be Developed	120 days
48	48		
49	**49**	**Stage 4**	**34.8 wks**
50	50	Filling works for the rest Reclamation Area to +5.0 m CD with Sand from Borrow Area	108 days
51	51	Bund Filling at Stockpile Area	12 days
52	52	Dredging Works of Sand-Key	18 days



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Date: Tue 04/07/17

Task, Split, Milestone, Summary, Project Summary, External Tasks, External Milestone, Inactive Task, Inactive Milestone, Inactive Summary, Manual Task, Duration-only, Manual Summary Rollup, Manual Summary, Start-only, Finish-only, Deadline, Progress

Page 1

Figure 1-13 Reclamation Schedule

1.8 Manpower requirements

1.8.1 Manpower requirements

The total manpower for the raw land reclamation (construction and operation) is estimated to be about 150 employees. The personnel will be mostly composed of operators of reclamation equipment and construction workers for support facilities and administrative personnel. The manpower requirements for construction will mostly entail male workers because of the physical nature of the work.

1.8.2 Scheme for sourcing locally from host and neighboring LGUs

The proponent shall give priority hiring to locals whose skills and experience match the project's specific needs. A local hiring scheme will be established in close coordination with the concerned barangay Local Government Units (LGUs). In general, the proponent will provide a list of anticipated job requirements with corresponding qualifications to the concerned barangay LGUs. These potential opportunities will be promoted by the barangay LGUs in their respective jurisdictions and potential applicants will be forwarded to the proponent, for further review and evaluation by the Human Resources office.

Consultations shall be made with the LGUs and host communities to finalize a scheme for hiring residents from host communities. Qualified local residents will be given priority in hiring. For technical positions not available in the host communities, the proponent reserves the option to source its manpower requirements elsewhere. Compensation terms and the process of hiring will comply and adhere with existing labor laws, rules, and regulations.

There is no indigenous group/people present in the project area.

1.9 Indicative project cost

The estimated project investment cost is PhP 57.4 billion. Cost is preliminary and will be subjected to revision based on the actual final reclamation planning and design.

CHAPTER 2 ANALYSIS OF KEY ENVIRONMENTAL IMPACTS

2.1 Land

2.1.1 Land use and classification

2.1.1.1 Methodology

The study and investigation of land use and land classification of the project site employed the review of existing documents, maps, plans and reports.

2.1.1.2 Existing land use of Navotas City

Navotas City is part of Luzon, the northernmost major island of the Republic of the Philippines. Navotas City is located on the Extreme Northwest portion of the National Capital Region. The existing land use area of the City of Navotas is 10.69 km^2 representing 1.69% of the total land area of the National Capital Region. Navotas is the second smallest land area in the Metro Manila following the Municipality of Pateros with only 1.76 km^2.

Navotas City is bounded on the North by the Municipality of Obando, Bulacan, on the east by Binuangan River, Daang Cawayan River, Dampalit River, Batasan River, Navotas River, Bangkulasi Channel, Malabon Channel, and the Estero de Maypajo, on the south by the City of Manila, and on the west by the Manila Bay.

Navotas City is classified into various land uses namely: Built-up Area, Production and Protected Areas. Based on the Existing Land Use Map of Navotas City (2015), 34.25% or 366.23 hectares of the land area is classified as fishponds and only 24.57% or 262.72 hectares are classified as residential area. Table 2-1 presents the Land Use Categories in Navotas City while Figure 2-1 shows the Existing Land Use Map of Navotas City.

Table 2-1 Land use allocation of Navotas City

Existing land use (2015)	Area in hectares	Percentage
Residential	262.72	24.57
Socialized Housing	8.40	0.79
Commercial	19.41	1.82
Institutional	17.04	1.59
Industrial	136.33	12.75
Parks and Open Spaces	2.45	0.23
Fishponds	366.23	34.25
Easement	30.20	2.83
Mangroves	29.47	2.76
Utilities	49.56	4.64
Cemeteries	6.50	0.61
Roads	57.96	5.42
Bodies of Water	82.73	7.74
Total	**1,069**	**100.00**

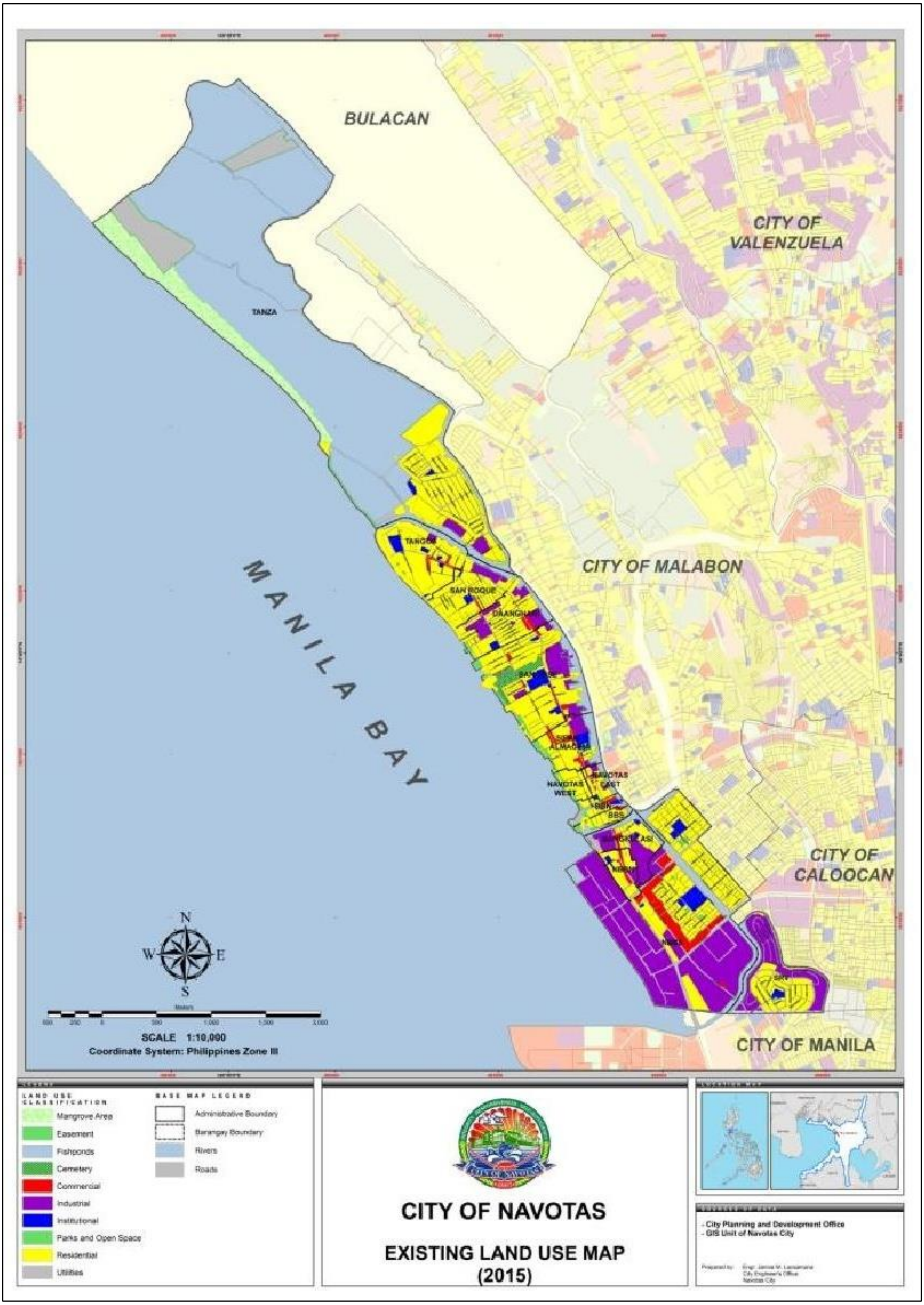


Figure 2-1 Existing land use map of Navotas City

2.1.1.3 Encroachment in Environmental Critical Areas (ECAs)

The project area is situated in the coastal area of Barangay Tanza. As such no CARP or CADC/CADT areas were identified within or near the area of the project. The proposed project, however, will be situated near the mangrove areas of Barangay Tanza. The proposed project site is also situated at Manila Bay and may be vulnerable or susceptible to natural hazards. The proponent should then ensure that the project management plan is compatible with the Manila Bay Management Plan by the Supreme Court Mandamus. In addition to this, proper mitigating measures and wastes disposal plan should be strictly implemented so as not to compromise the water quality and the current multiple use of Manila Bay.

2.1.1.4 Potential impacts and options for prevention, mitigation and enhancement

Change/Inconsistency in the Land Use / Water Use

Land use and water use change and inconsistencies associated with project development will commence during the construction phase and remain permanent during the operation phase.

Water use change is expected in the actual project site where the mass land will be located.

Encroachment in the Environmental Critical Area (ECA)

Under DENR DAO 2003-30, there are 12 categories for environmental critical areas (ECA). Of the 12 categories, only one (1) is present within the project area: Areas frequently visited and or hard-hit by natural calamities, and

Under DAO 2003-30 Environmentally Critical Projects (ECP) whether located within ECA or not are required to prepare an Environmental Impact Statement (EIS). The City Government of Navotas complies with the requirements with the submission of this EIS to the DENR Central Office.

Impairment of Visual Aesthetics

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

1. CSD at Dredging Site – 2 units
2. CSD at Reclamation Site - 2 units
3. Split Hopper Barge – 14 units
4. Tug Boat – 14 units
5. Backhoe dredger - 2 units
6. Excavator - 4 units
7. Bulldozer - 4 units
8. Clamshell and barge - 2 units
9. Wheel loader - 4 units
10. Vibratory Roller - 4 units

During the operation phase, the establishment of the reclaimed land will result in permanent changes to the visual landscape of the area.

2.1.2 Geology/Geomorphology

2.1.2.1 Regional lithological and structural geology

The watershed area of the Manila Bay encompasses the southern half of the Central Plain of Luzon; a 150 km long and 60 km wide north-northwest trending flat terrain bordered along the southwest by the Zambales Range and along the northeast by the southern portion of the Central Cordillera, Caraballo and Sierra Madre mountain ranges.

The bottom topography of Manila Bay is gently sloping from its mouth at about 1 m per km of horizontal distance. The bay is mostly shallow with an average depth is 17 m and about 64 percent of its surface has less than a 10-m depth, mainly at the northern half. The southwestern sector of the Bay is deeper with depths greater than 100 m. Spots of shallow areas, with depth of less than 5 m, are found along the coastline. At its mouth, depth of the Bay is about 50 m, except in the narrow channel north of Corregidor Island, where depth is approximately 90 m.

The seabed bathymetry is shown in Figure 2-3 and Figure 2-4, which clearly indicates that the water along the coastline of Navotas is generally shallow with an average water depth of approximately 5 m. The depth of water in the project area is even less than 5 m. Manila Bay is the catchment for numerous river systems that drain the surrounding land areas. In addition to the Pampanga River and Pasig River, other major rivers discharging directly into Manila Bay are: Meycauayan, Navotas-Malabon-Tullahan-Tenejeros, Talisay (Bataan), Imus (Cavite) and Maragondon (Cavite). Thus, deposition within the Bay is very active.

Depositional features found in the Bay are the sand spit of Cavite and numerous beach and sea bar deposits. A higher level of sedimentation in the northern parts of the Bay is characterized with the deposits of pyroclasic materials extruded by Mt. Pinatubo. Substrate of Navotas and adjoining areas of Malabon and Bulacan is predominantly estuarine deposits and beach/sand bar deposits of Caloocan City and Malabon.

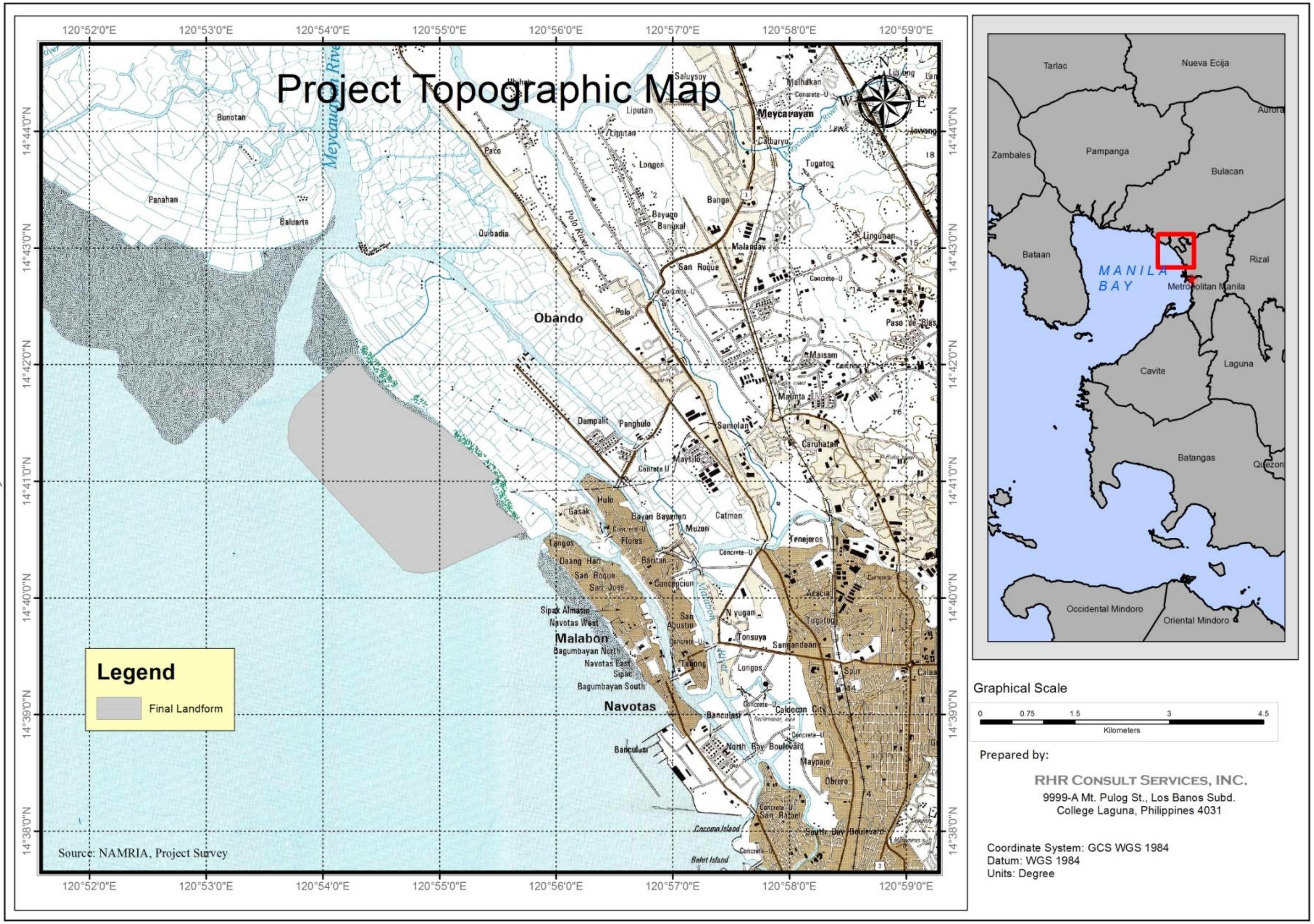
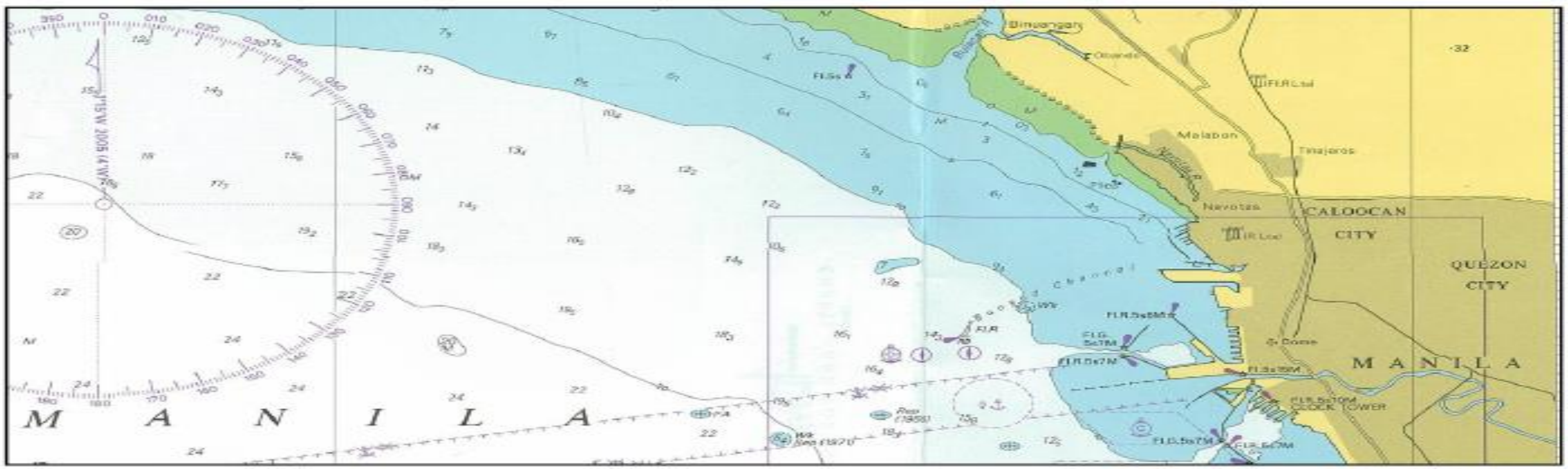


Figure 2-2 General Topography and Different Natural Drainage in Navotas City



Source: Admiralty Chart 4491

Figure 2-3 Seabed Bathymetry along the Coastline of Navotas

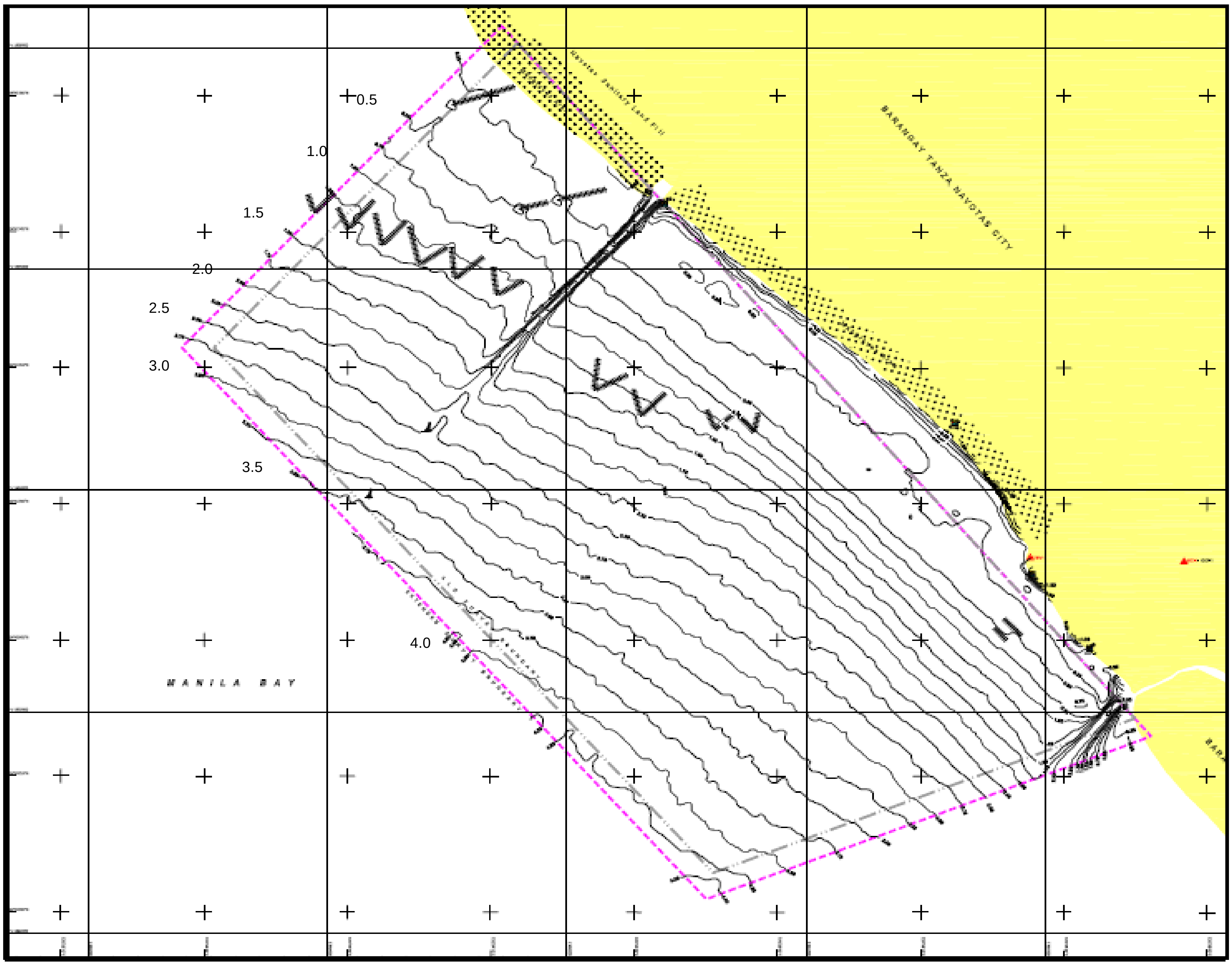


Figure 2-4 Bathymetric Map Produced by EGS Asia, Inc. and MJAS Zenith, 2016

The project area mainly consists of sedimentary deposits of Quaternary era. This formation is a result of erosion and re-deposition of former sediments which generally consists of unsorted fluvial and river deposits. Both the effects of climate processes and tectonic young activities caused a miscellaneous alluvium of different types, thickness and grain sizes to be formed. The subsoil is generally weak (soft or loose) with thick sequence of Quaternary alluvium made up principally of unconsolidated strata of silty and clayey sand and high plasticity clay.

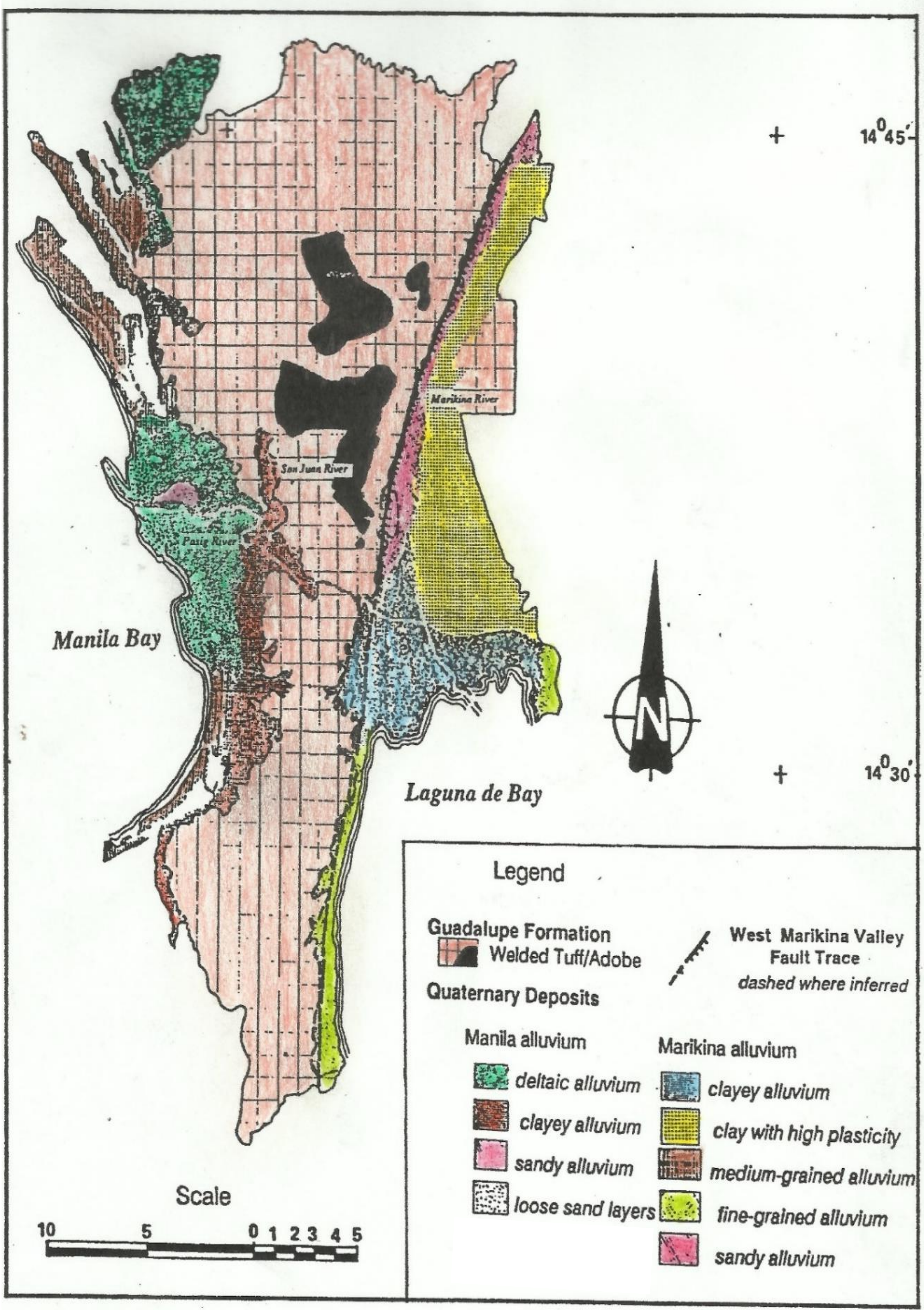
Geology of Metro Manila

The Guadalupe Plateau, East of Manila is underlain by the Guadalupe Formation, composed of interlayered pyroclastic flows, lahar deposit, airfall tephra, fluvio-deltaic sediments and paleosols deposited under terrestrial to partly sub-aqueous conditions.

The volcanics range from agglomerate to fine ash, while the sandstone unit grades from very fine to conglomeratic. The pyroclastic flow units are massive to moderately consolidated while the tephra deposits range from massive to thinly laminated and are well consolidated to porous. The presence of paleosols indicates time gaps in depositional events for formational units.

The flat areas near Manila Bay are underlain by unconsolidated sediments deposited during the Quaternary Period. The lithology belongs to Manila Formation named by Purser and Diomampo (1996) based on the result of subsurface investigation using borehole logs. The Manila Formation is composed of unconsolidated sequence of fluvial, deltaic and marine deposits. To the west, the Manila Formation is overlain by beach sand which blankets the coastline of Manila Bay. Further to the east, the Manila Formation overlay the Proto-Pasig Delta deposit that includes transitional, marine transgression sediments and the Modern Coastal Deposits mainly recent marine sand/silt, recent stream deposits and fill materials.

Figure 2-5 presents the Geologic Map of Metro Manila.



Source: PHIVOLCS, Modified from MMA 1985

Figure 2-5 Geologic Map of Metro Manila

2.1.2.2 Local geology and geomorphology

City of Navotas is generally underlain with recent (Holocene) marine sediments, consisting of sand bars and sand-spits from tidal inundation and delta deposits to form lagoons from the recent river flows. The area and its immediate vicinity used to be a wide estuary that was filled-up with fill materials of varying composition. The tidal surface consists mainly of alternating layers of sand, silt and clay (Holocene age) about 200 years ago.

The geological profile of the City of Navotas consists of reclaimed landfill, Holocene deposits and Pleistocene deposits in order from the ground surface. The half part of this area is reclaimed land or fishponds and the other half is natural sand bar or sandpit area with very thin mantle of clayey sediments.

2.1.2.3 Geologic hazards

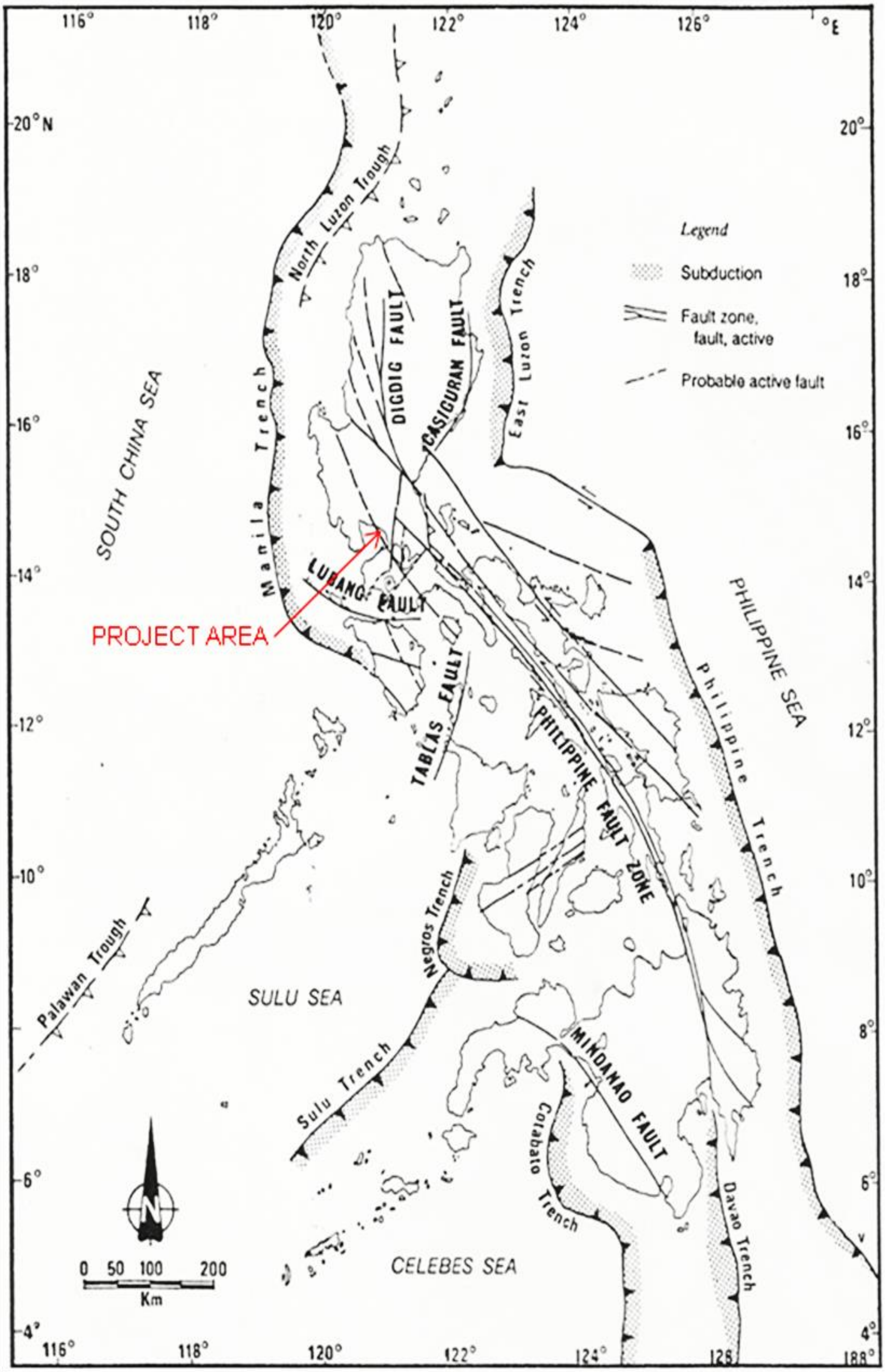
2.1.2.3.1 Seismic Hazards

Major causes of damage during earthquakes include hazards due to 1) ground shaking, 2) liquefaction, 3) surface rupturing, and 4) tsunami. The first two hazards are directly related to actual ground movements while the others are mainly due to the indirect effects of the earthquake shocks.

- ***GROUND SHAKING HAZARD***

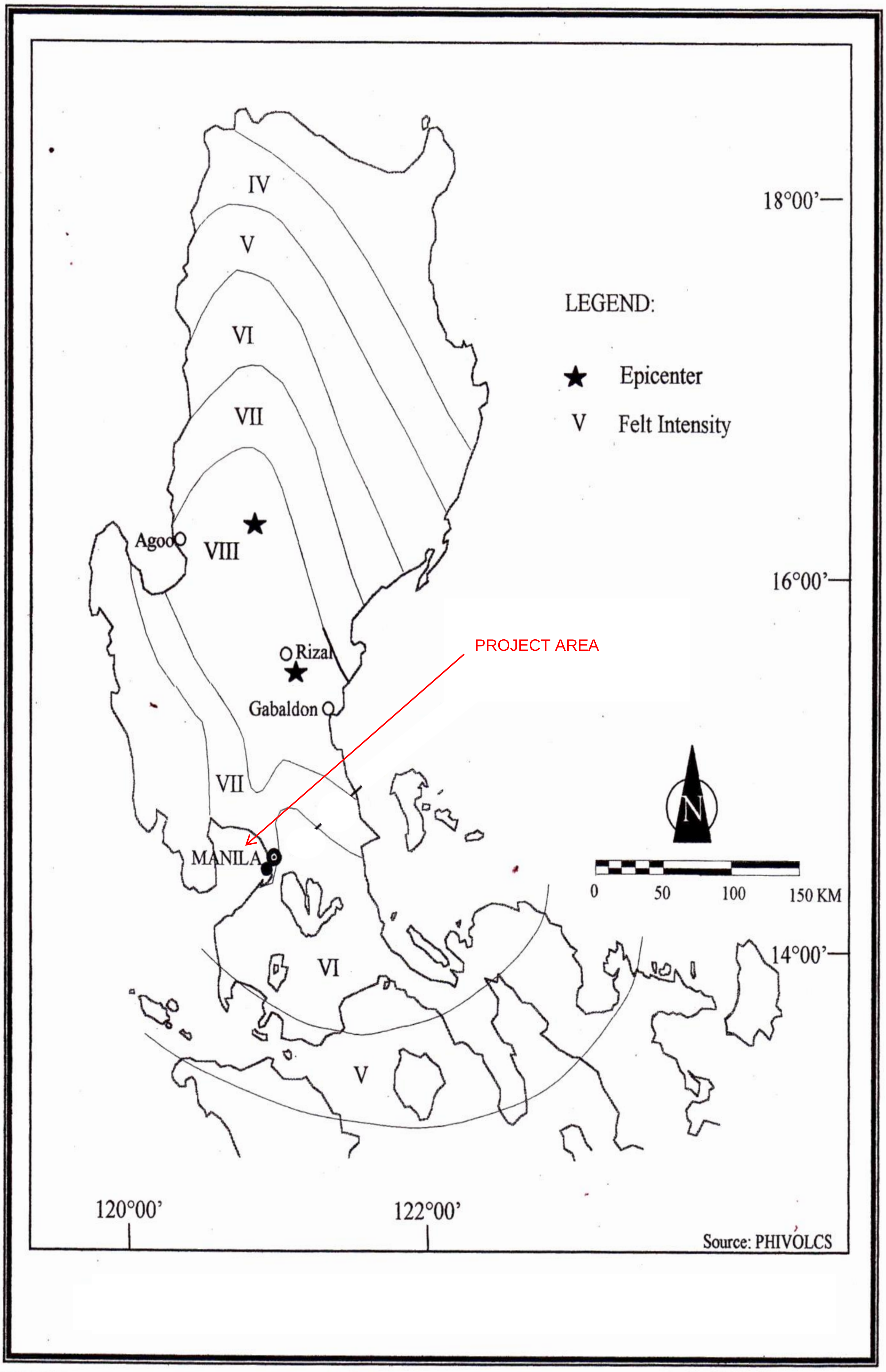
Most of the damages incurred during earthquakes mainly result from strong ground vibrations that are caused by the passage of seismic waves from the earthquake source to the ground surface. The intensity of ground shaking is generally influenced by the magnitude of the earthquake, distance of the site from the earthquake generator, and the modifying effects of subsoil conditions. Observations of effects of large magnitude earthquakes have shown that ground shaking on bedrock is less in intensity than on areas of soft foundation made up of sediments as gravel, sand, silt and/or clay. Figure 2-8 shows the general relationship between near-surface earth material and amplification of shaking during a seismic event.

The project area is prone to ground shaking hazards due to the presence of several earthquake generators (Figure 2-6). The site is considered as high seismic area and has a recorded and experienced intensity of VI during the July 1990 Luzon earthquake (Figure 2-7).



Source: PHIVOLCS

Figure 2-6 Distribution of Earthquake Generators in the Philippines



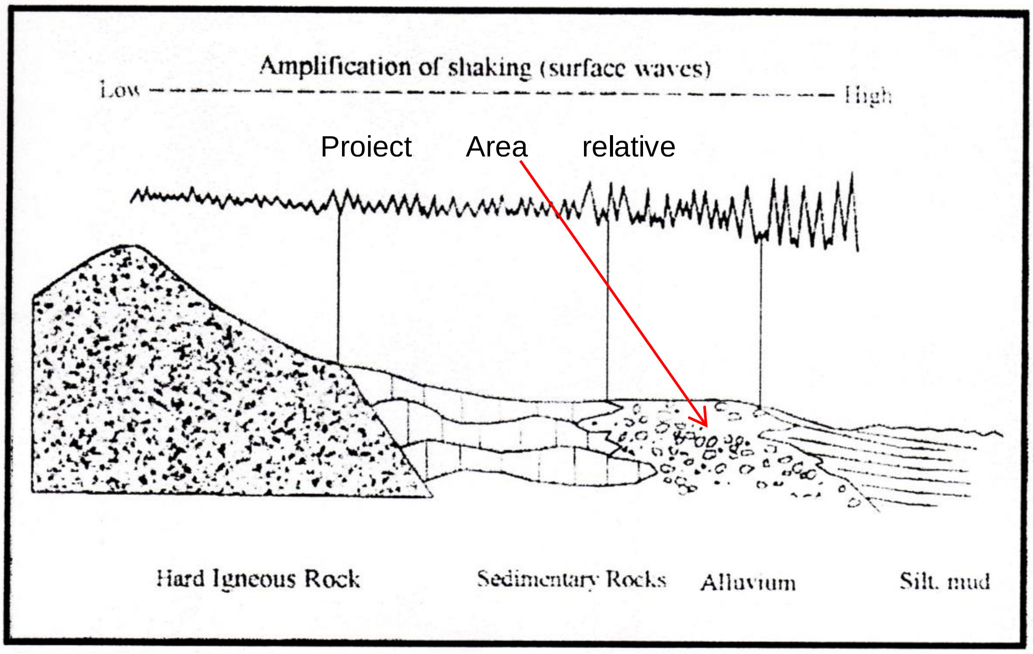
Source: PHIVOLCS

Figure 2-7 Intensity Map of the July 1990 Earthquake

Table 2-2 presents the different areas Metro Manila which are vulnerable to ground shaking and within the identified zones. The zone where ground shaking is expected to be below average is more or less defined by the outline of the tuff deposit of the Guadalupe Formation which corresponds to the bedrock in Metro Manila. The areas underlain by soft and thick sequence of fine sediments will most likely experience average to above average levels of ground shaking depending on the thickness of the soft materials. Areas covered with 10 m or less of these deposits are expected to experience average levels of ground shaking while those underlain by soft materials in excess of 10 m may experience above average shaking.

Table 2-2 Areas Vulnerable to Strong Ground Shaking in Metro Manila

Possible Level of Ground Shaking	Area
Above Average	Manila proper inclusive of the reclaimed areas along Manila bay, the municipalities of western Malabon, Navotas, eastern Pateros, Marikina (valley side) and the eastern section of Pasig
Average	Pasay City, western portion of Makati, northeastern and eastern Quezon City (within the Marikina Valley), the extreme southwestern part of Caloocan City, eastern Malabon, western section of Valenzuela, the coastal and northern portions Paranaque and Las Pinas, and the lakeshore areas of taguig and Muntinlupa
Below Average	Areas within Diliman Plateau



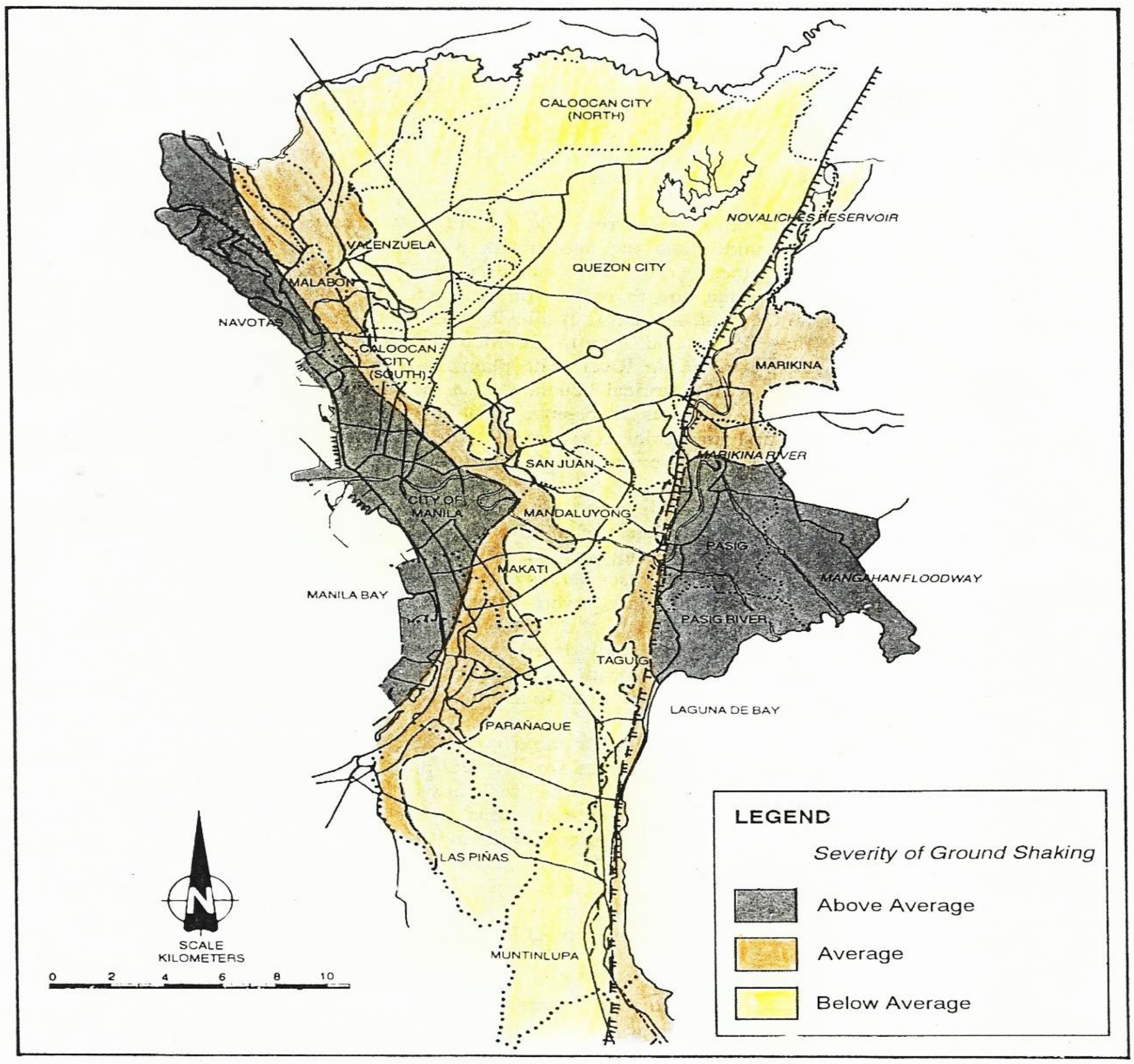
Source: (Keller, E. J., 1996)

Figure 2-8 General Relationship between Near-surface Earth Material and Amplification of Ground Shaking during a Seismic Event

- ***SURFACE RUPTURING***

Surface or ground rupturing is a result of significant movement along faults. It occurs within zones of active fault. Damage can be severe for structures directly straddling and located within a narrow zone of the active fault traces. For the 1990 Luzon earthquake, the deformation zone was within 5 m from the surface rupture. The location, pattern and styleof surface faulting generally appear to occur along pre-existing active fault traces, thus, a precise delineation of these traces is very important in mitigating damages due to surface rupturing.

Figure 2-10 shows the Ground Shaking Hazard Map with the Event Scenario of Magnitude 7.2 Earthquake along the West Valley Fault.



Above Average - Manila proper inclusive of the reclaimed areas along Manila bay, the municipalities of western Malabon, Navotas, eastern Pateros, Marikina (valley side) and the eastern section of Pasig
Average - Pasay City, western portion of Makati, northeastern and eastern Quezon City (within the Marikina Valley), the extreme southwestern part of Caloocan City, eastern Malabon, western section of Valenzuela, the coastal and northern portions Paranaque and Las Pinas, and the lakeshore areas of Taguig and Muntinlupa
Below Average - Areas within Diliman Plateau

Source: Philippine Institute of Volcanology and Seismology, Department of Science and Technology, Disaster Prevention and Mitigation in Metropolitan Manila, UNCHS (Habitat) Project

Figure 2-9 Ground Shaking and Surface Rupture Hazard Map of Metro Manila

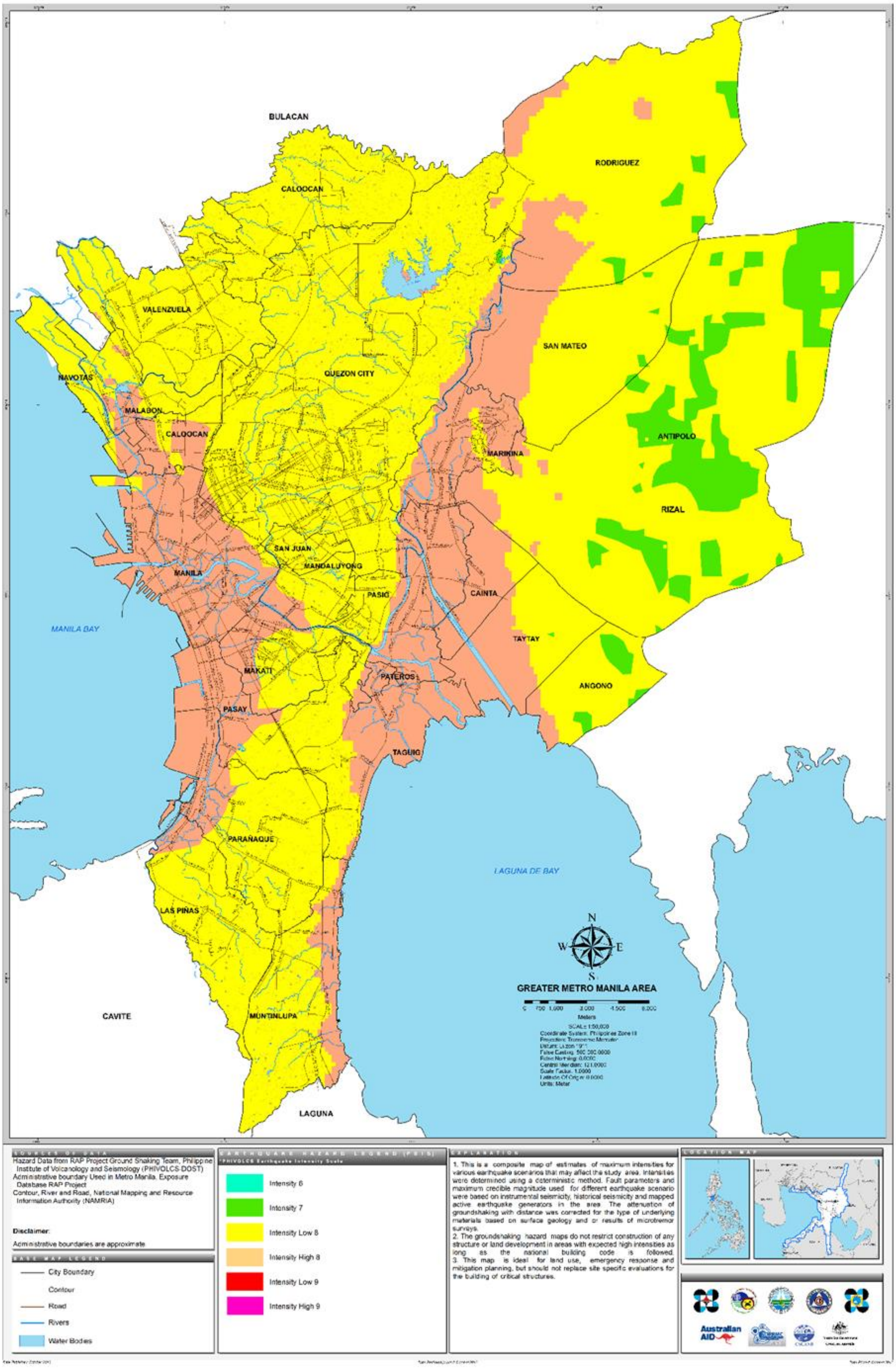


Figure 2-10 Ground Shaking Hazard Map with the Event Scenario of Magnitude 7.2 Earthquake along the West Valley Fault (PHIVOLCS, 2013)

- ***GROUND ACCELERATION***

Since the Philippines is a tectonically active place with noted active faults that are usually the sources of major earthquakes, the Philippine Institute of Volcanology and Seismology (PHIVOLCS) and the United States Geological Survey (USGS) conducted ground motion hazard mapping in terms useful to engineering design using modern probabilistic methodology. In their study, the peak horizontal ground acceleration that have a 10% probability of being exceeded in 50 years have been uniformly estimated for rock, medium soil and soft soil site condition. Results of their study show an estimate on rock ranging from a low of 0.11g in Visayas to a high of 0.30g in the vicinity of Casiguran Fault in Eastern Luzon (Thenhaus, et al, 1994). Estimates for soft soil conditions are considerably higher and range between 0.27g for Visayas and 0.80g along the Casiguran Fault zone.

The estimated horizontal and vertical peak accelerations during an earthquake likely to occur in an area are useful information for designing buildings and other structures to withstand seismic shaking. Maps of Acceleration in Soft Soil, Medium Soil, Hard Soil and Rock are presented in Figure 2-11 to Figure 2-14.

Though underlain by clay, silt and sand but because the undesirable soft or loose materials are to be dredged/removed and replaced by good, compacted fill materials, it is assumed that the ground of acceleration 0.40g and 0.50g for medium and hard soil are more applicable in the area.

In order to determine the ground acceleration that a site can experience in case of a major earthquake, the attenuation model of Fukushima and Tanaka is applied (Thenhaus et al, 1994). A design earthquake is assumed to occur at a point along the causative fault that is nearest to the site. Correction factors are then applied depending on the type of foundation material.

The attenuation model of Fukushima and Tanaka (In Thenhaus, 1994) is written as:

$$\log_{10} A = 0.41M - \log_{10}(R + 0.032 \times 10^{0.4M}) - 0.0034R + 1.30$$

where:

A = mean peak acceleration (cm/sec^2)

R = shortest distance between the site and the fault rupture (km)

M = surface-wave magnitude.

Correction factors are applied depending on the type of foundation material: rock, 0.6; hard soil, 0.87; medium soil, 1.07; and soft soil, 1.39.

The most logical causative fault is the Philippine Fault. It may be considered as a near-source earthquake generator. The Philippine Fault is probably the most active of earthquake generators in the country. Though presently inactive, both the West Valley Fault, the Lubang Fault and Casiguran Fault can also be considered as potential earthquake generators.

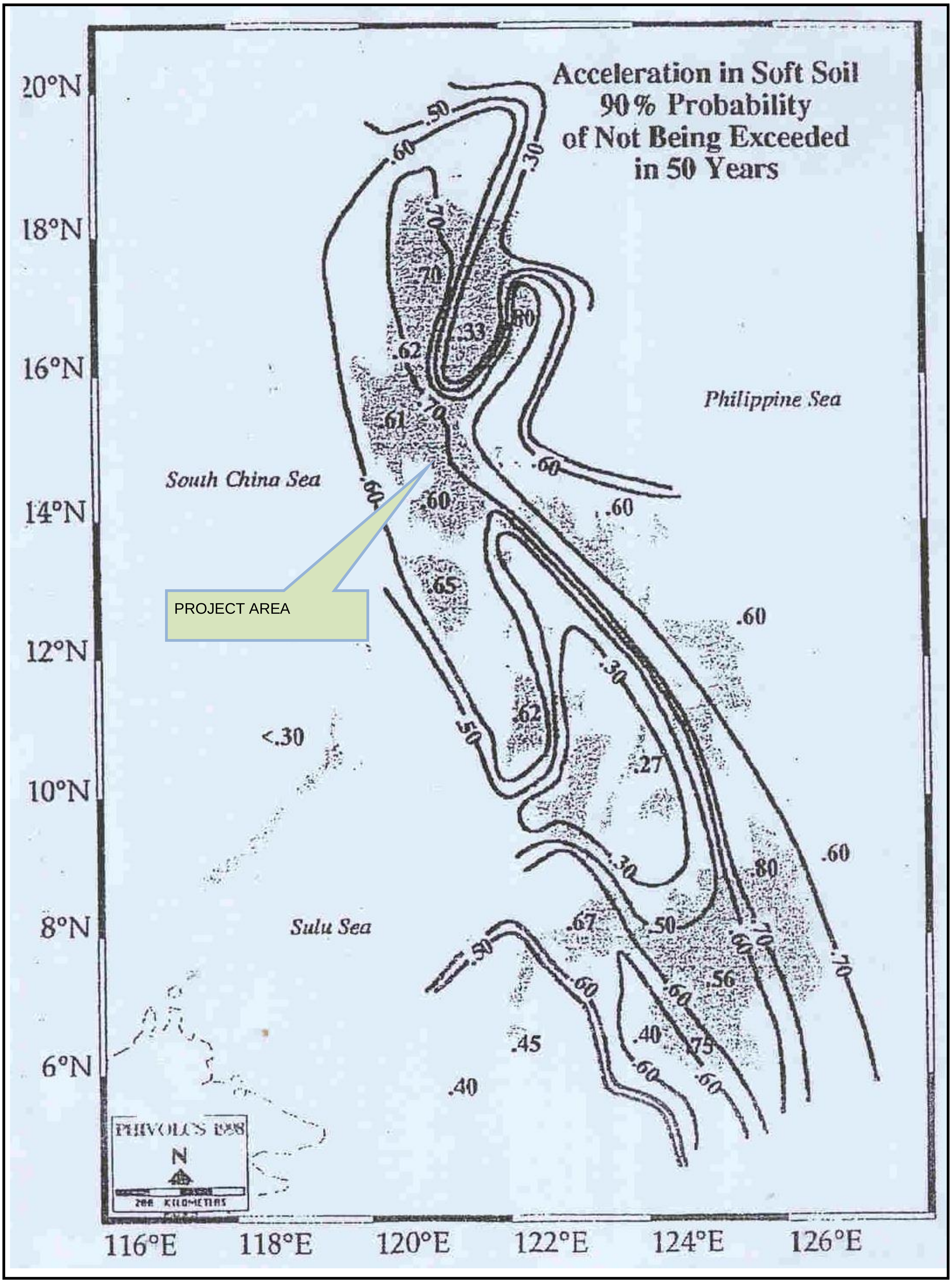


Figure 2-11 Ground Acceleration in Soft Soil

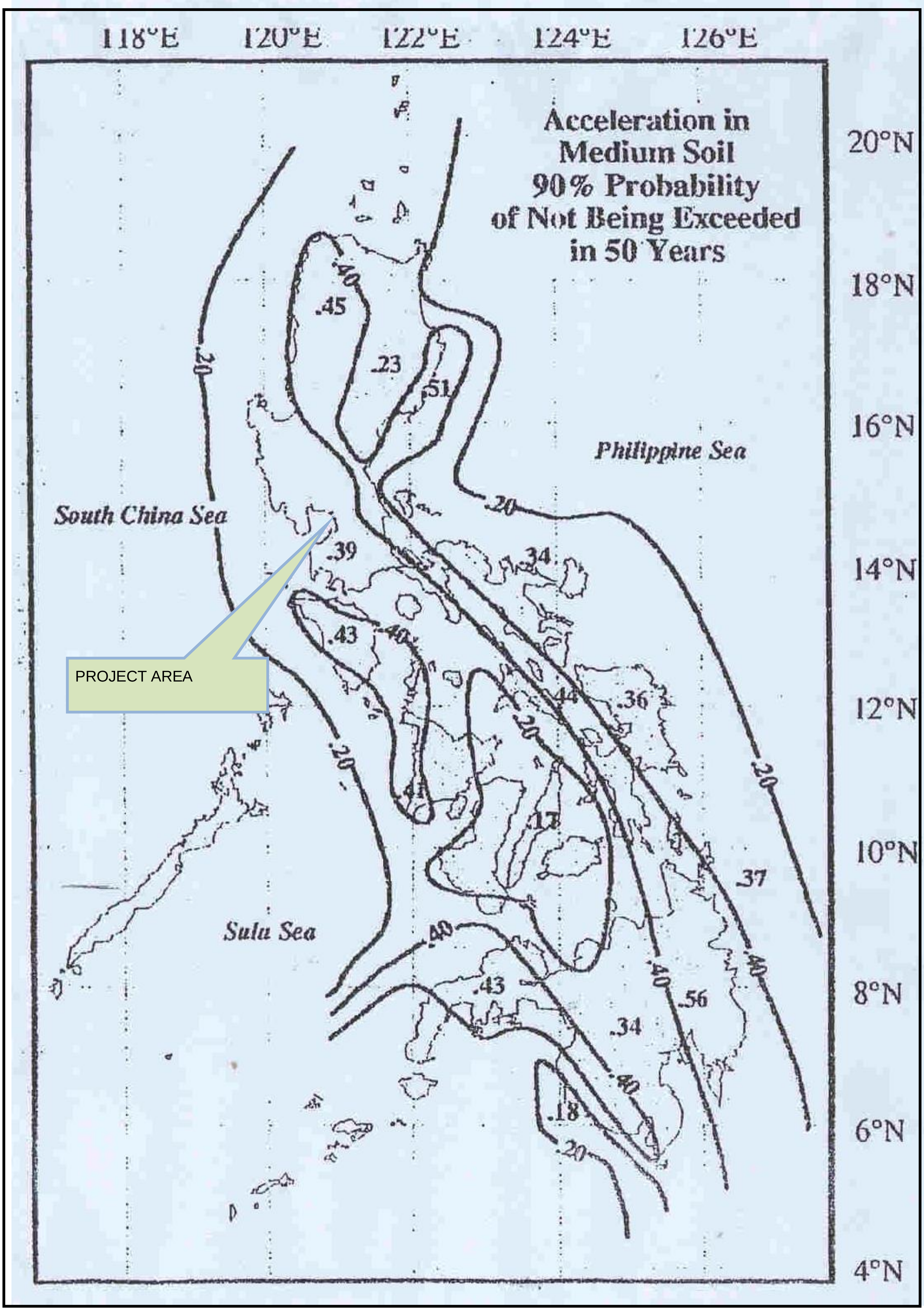


Figure 2-12 Ground Acceleration in Medium Soil

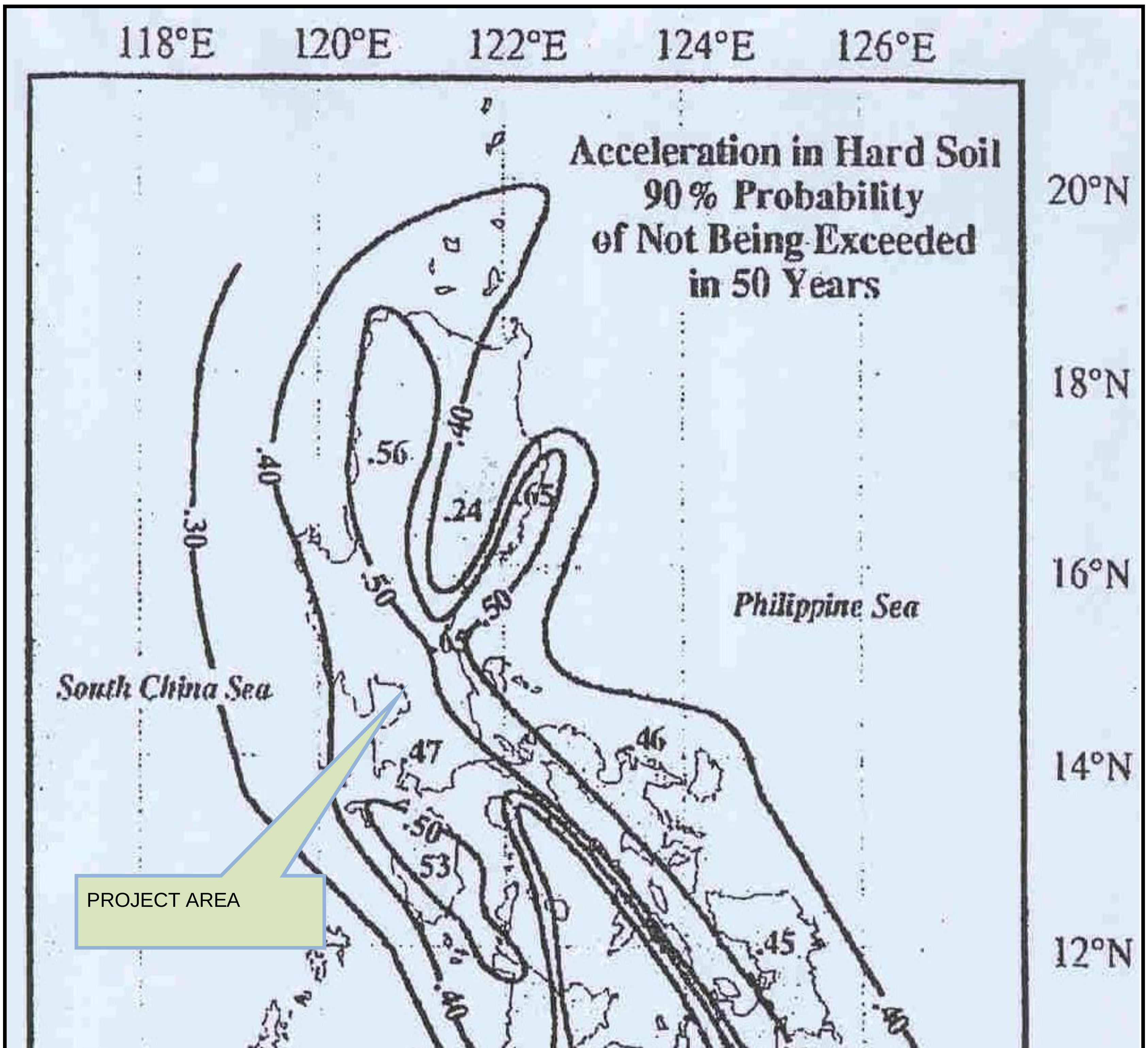


Figure 2-13 Ground Acceleration in Hard Soil

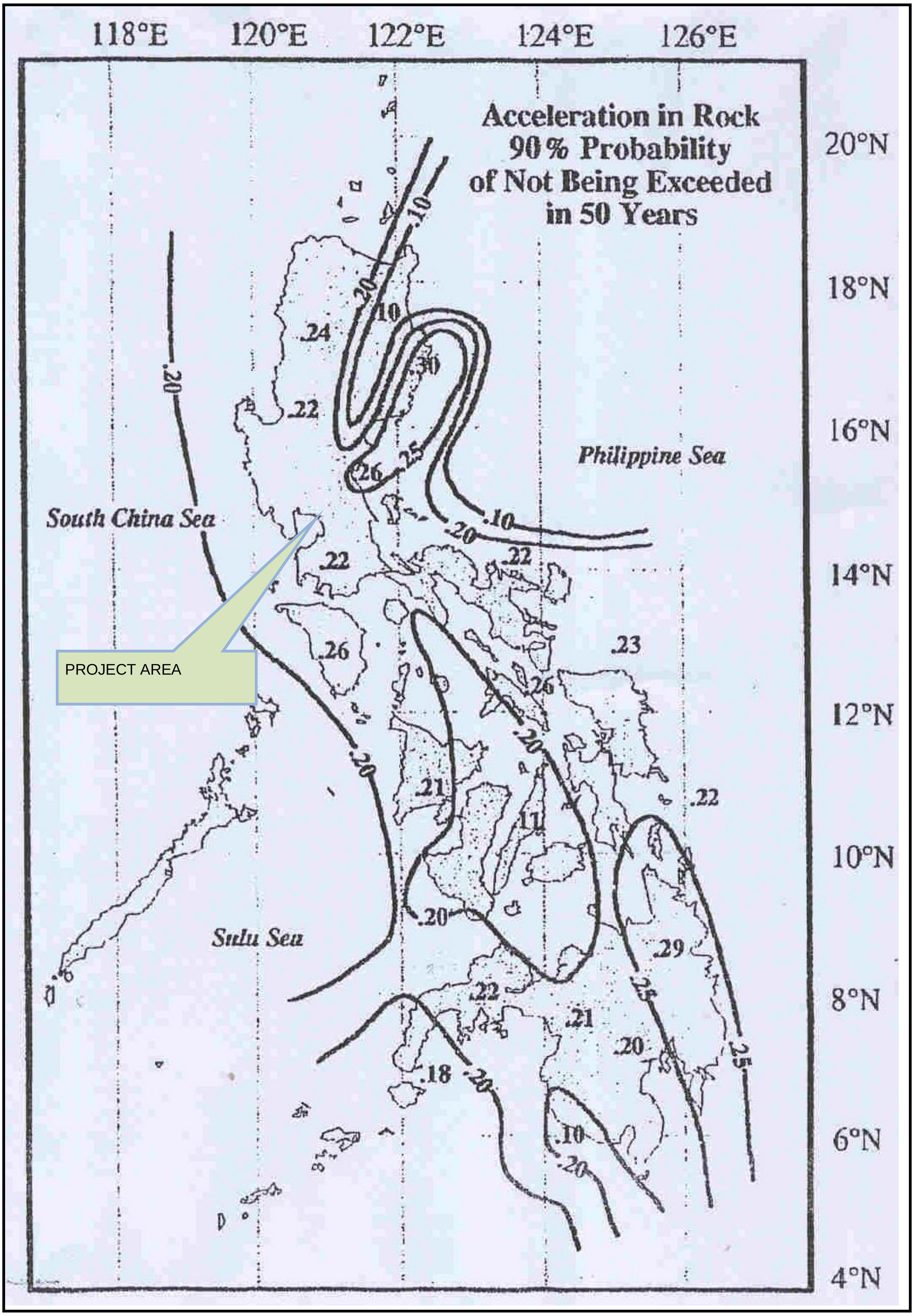


Figure 2-14 Ground Acceleration in Rock

Design Earthquake. The Philippine Fault is such a major fault that it is capable of generating a rare magnitude 8.0 earthquake. Magnitude 7.5 or 7.8 earthquakes might be more reasonable as design earthquake.

Peak Ground Acceleration. Assuming a distance of 75 km from the project area to the Philippine Fault, peak ground accelerations are estimated for different design earthquakes (magnitudes 7.6, 7.8, 8.0) and foundation conditions (rock, hard soil, medium soil, soft soil). Ground accelerations from earthquakes that can be generated from the West Valley Fault, Lubang Fault, Casiguran Fault and Manila Trench were also estimated. Excessively high acceleration values can be expected particularly from those earthquake generators which are relatively close to the project area.

Table 2-3 Peak Ground Accelerations

Earthquake Generator	R	M	PGA	Rock	Hard Soil	Medium Soil	Soft Soil
West Valley Fault	20 km	8.0	0.409	0.246	0.356	0.438	0.569
West Valley Fault	20 km	7.8	0.389	0.234	0.339	0.417	0.541
West Valley Fault	20 km	7.5	0.356	0.214	0.310	0.381	0.495
Philippine Fault	75 km	8.0	0.158	0.095	0.138	0.170	0.220
Philippine Fault	75 km	7.8	0.142	0.085	0.124	0.152	0.198
Philippine Fault	75 km	7.5	0.119	0.071	0.103	0.127	0.165
Lubang Fault	100 km	8.0	0.110	0.066	0.096	0.118	0.153
Lubang Fault	100 km	7.8	0.097	0.058	0.085	0.104	0.136
Lubang Fault	100 km	7.5	0.080	0.048	0.070	0.085	0.111
Casiguran Fault	125 km	8.0	0.078	0.047	0.068	0.084	0.109
Casiguran Fault	125 km	7.8	0.069	0.041	0.060	0.074	0.096
Casiguran Fault	125 km	7.6	0.056	0.033	0.048	0.060	0.077
Manila Trench	150 km	8.0	0.057	0.034	0.049	0.061	0.079
Manila Trench	150 km	7.8	0.049	0.030	0.043	0.052	0.069
Manila Trench	150 km	7.5	0.040	0.024	0.035	0.042	0.055

Source: PHIVOLCS

Figure 2-15 Relative Position of the Project Area relative to the West Valley Fault System

- ***LIQUEFACTION***

Areas underlain by loosely compacted, water-saturated fine sediments such as sand and silt, strong ground vibrations could also cause the underlying foundation to temporarily assume a semi-liquid behavior. Such process is called liquefaction. The July 16, 1990 earthquake has opened opportunities to better understand the liquefaction phenomenon. The studies conducted by Torres and others in 1990 had identified and characterized at least three sedimentary environments that are favorable to liquefaction to take place, namely, 1) deltaic (e.g. Dagupan City and Aringay, La Union), alluvial plain (e.g. Tarlac), and sandpit environment (e.g. Agoo, La Union). Typically, these environments are characterized by the presence of thick accumulation of fine sediments that are water-saturated.

Metro Manila has suffered liquefaction in certain areas of the city in many of earthquakes that have affected it. An occurrence of liquefaction within a certain area in Navotas was recorded in 1863.

The identified liquefaction-prone areas have characteristically shallow water table (3 m or less) with thick (10m or more) piles of water-saturated fine sediments (sand to clayey sand). These areas are those on the shore areas of Manila including the newly-reclaimed areas, the Pasig River delta plain, the Marikina alluvial plains and those lying on the floodplain deposits and abandoned meanders of the Pasig and Marikina rivers. Various points within these areas have been subjected to liquefaction in the past and are therefore likely to be affected again in the future.

Liquefaction is generally accompanied by differential settlement as a result of withdrawal of materials beneath the ground surface. Buildings, houses and other structures built with no special engineering designs against this hazard tend to settle or sink as the underlying foundation losses strength. These structures normally remain intact though some may tilt.

Sand fountaining, lateral spreading, and ground undulation which may also cause damage to roads, bridges and other infrastructures are some of the effects associated to liquefaction. Figure 2-16 shows the sites of historical liquefaction in Metro Manila and Figure 2-17 presents the liquefaction Map of Metro Manila.

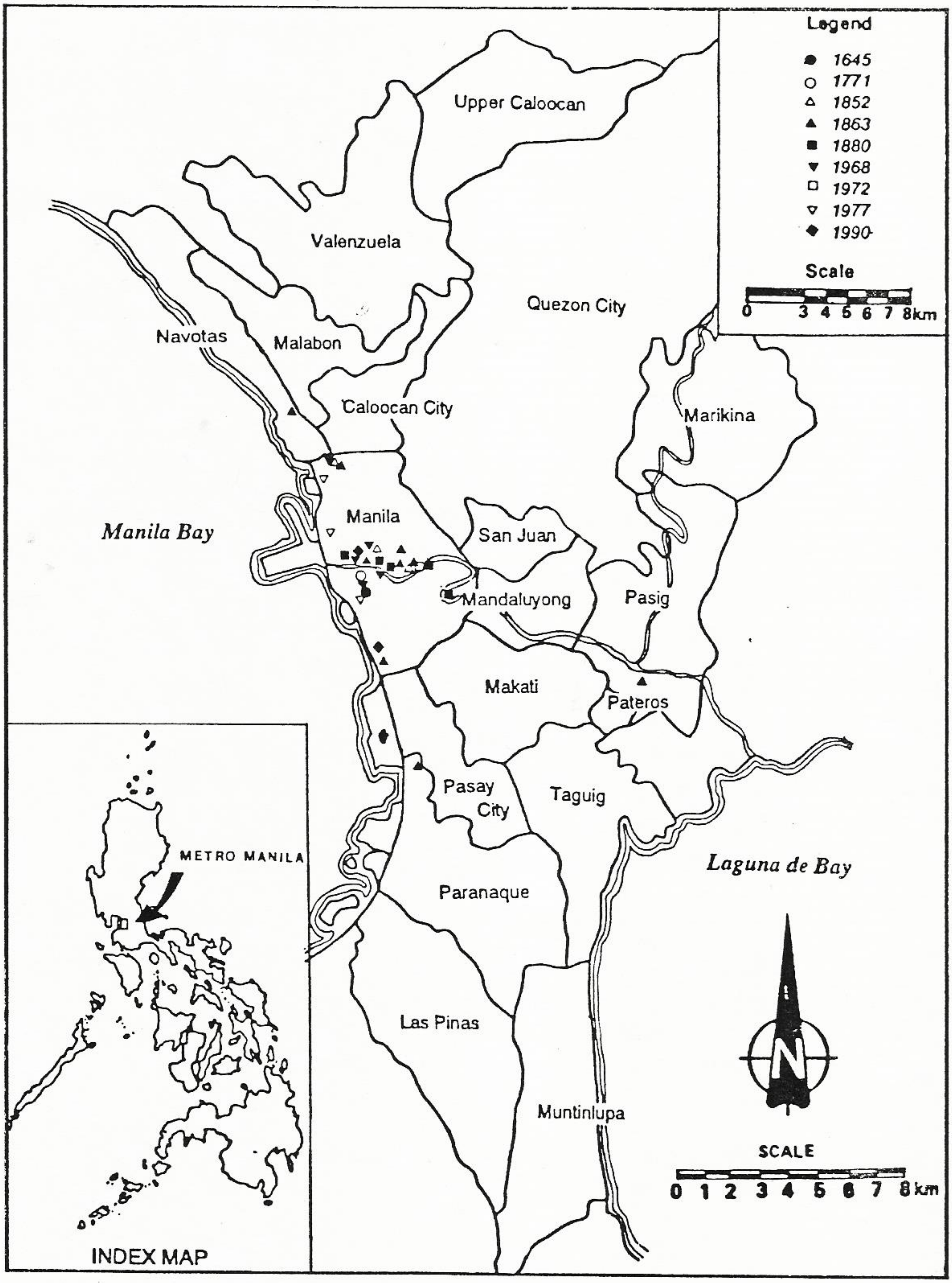


Figure 2-16 Sites of Historical Liquefaction in Metro Manila

Source: Philippine Institute of Volcanology and Seismology, Department of Science and Technology, Disaster Prevention and Mitigation in Metropolitan Manila, UNCHS (Habitat) Project INT/90/701, March 1993

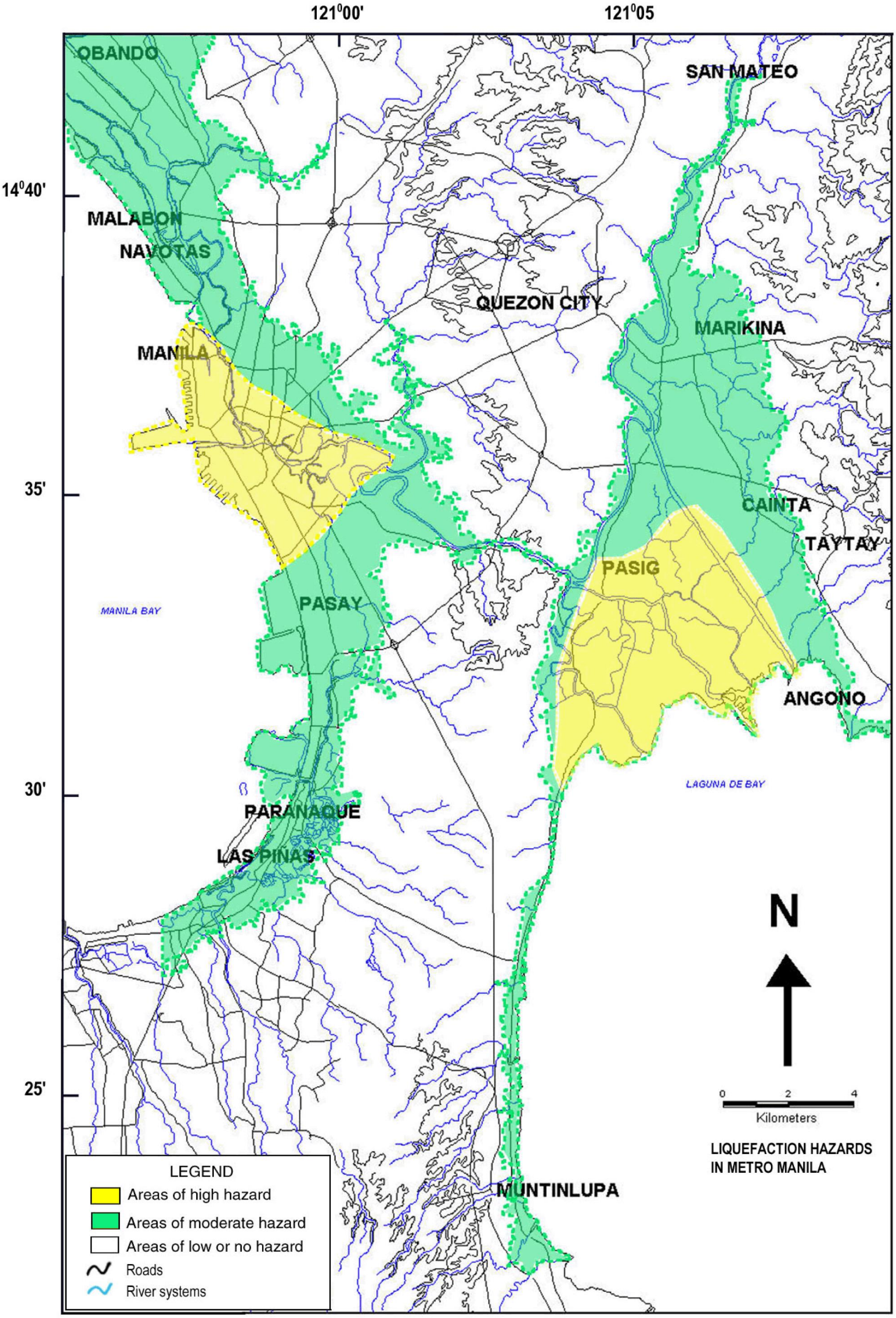


Figure 2-17 Liquefaction Hazard Map of Metro Manila

Source: PHIVOLCS

- **TSUNAMI**

Tsunami or giant sea waves are produced as a result of faulting under submarine conditions at shallow depths. Tsunami can also be triggered by submarine landslides, volcanic eruptions and movements along subduction zones. Areas vulnerable to this hazard are the coastal zones fronting an open sea. The edge of the cities fronting Manila Bay may be exposed to potential tsunami.

Tsunami and earthquakes can happen anytime around the Pacific Ring of Fire - from California up and around Alaska down through Japan, Taiwan, the Philippines and Indonesia. The Philippines is no stranger to earthquakes - the Philippine archipelago was largely created by the tectonic squabble between the Eurasian and Pacific plates, forming the Philippine Plate as a distinct entity.

Tsunamis in the Philippines are extremely rare. On August 16, 1976, a devastating earthquake on the Cotabato Trench caused destruction on the island of Mindanao. The destructive tsunami that was generated in the Gulf of Moro and in the Celeces Sea killed about 8,000 people in the coastal communities in North and South Zamboanga, North and South Lanao, North Cotabato, Maguindanao and Sultan Kudarat and in the neighboring Sulu Islands. This was the worst earthquake and tsunami disaster in the history of the Philippines.

The last significant tsunami in the Philippines occurred in the Verde Island Passage (between Batangas & Mindoro Island and affecting Puerto Galera) in 1994. The **1994 Mindoro earthquake** occurred on November 15 at 03:15 local time near Mindoro, the Philippines. It had a moment magnitude of 7.1. It is associated with a 35-kilometer-long ground rupture, called the Aglubang River fault. Seventy-eight people were reported dead, and 7,566 houses were damaged. The earthquake generated a tsunami and landslides on the Verde Island.The tsunami wave only 2-3 meters when it reached land.

Because tsunami in the Philippines are so rare, those who were drowned were actually opportunist beachcombers who were interested to extract goodies from the suddenly exposed deep coral pools, not realizing that the tsunami wave would follow the rapidly receding water.

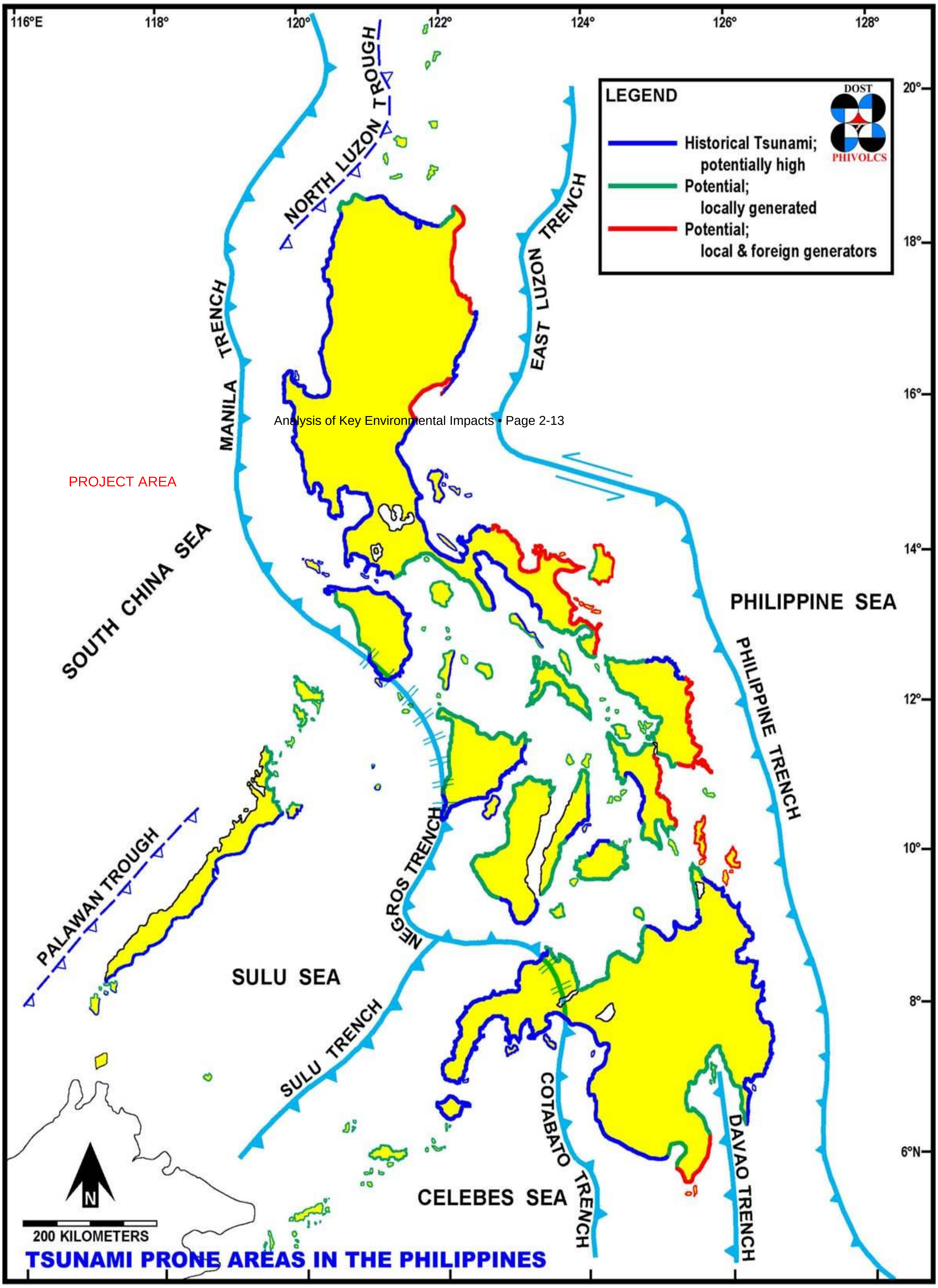
Remarkable historical tsunamis that have affected Manila were those generated by the 1677 and 1863 earthquakes, possibly from the Manila Trench. During the 1677 event, Repetti (1946) reports of boats at sea almost submerged by waves. For the 1863 earthquake, a large wave coming from Manila Bay was reported by the same writer. Other accounts of the latter event describe a retreat of the sea and a subsequent rise in the height of incoming waves. In both cases there were no reports of any damage along the coastal areas of Manila.

The apparent low vulnerability of Metro Manila in terms of this hazard is attributed to the following factors.

1. The narrow configuration of the mouth of Manila Bay has an over-all abating effect to the incoming tsunami wave thus lessening any tsunami impact on the project area. However, coastal areas along the adjoining provinces of Cavite and Bataan near the mouth of Manila Bay are more likely to be highly-prone to this hazard.

2. The presence of the Island of Corregidor near the mouth of Manila Bay likewise tends to deflect and abate the effects of incoming tsunami waves.
3. For any moderate to strong tsunami to significantly affect Metro Manila, the earthquake source or hypocenter should be within the Manila Bay itself. Even considering a modest dip of 45^{o} for the subducting layer of the manila trench, such a situation is highly unlikely as the descending tectonic slab would be too deep as an earthquake source and consequently, too weak to generate a sizable tsunami.

The hazard posed by tsunami is probably only comparable to, or less than that from storm surges. Figure 2-18 shows the tsunami prone areas in the Philippines while Figure 2-19 shows the tsunami prone areas in Navotas.



Source: PHIVOLCS

Figure 2-18 Tsunami Prone Areas in the Philippines

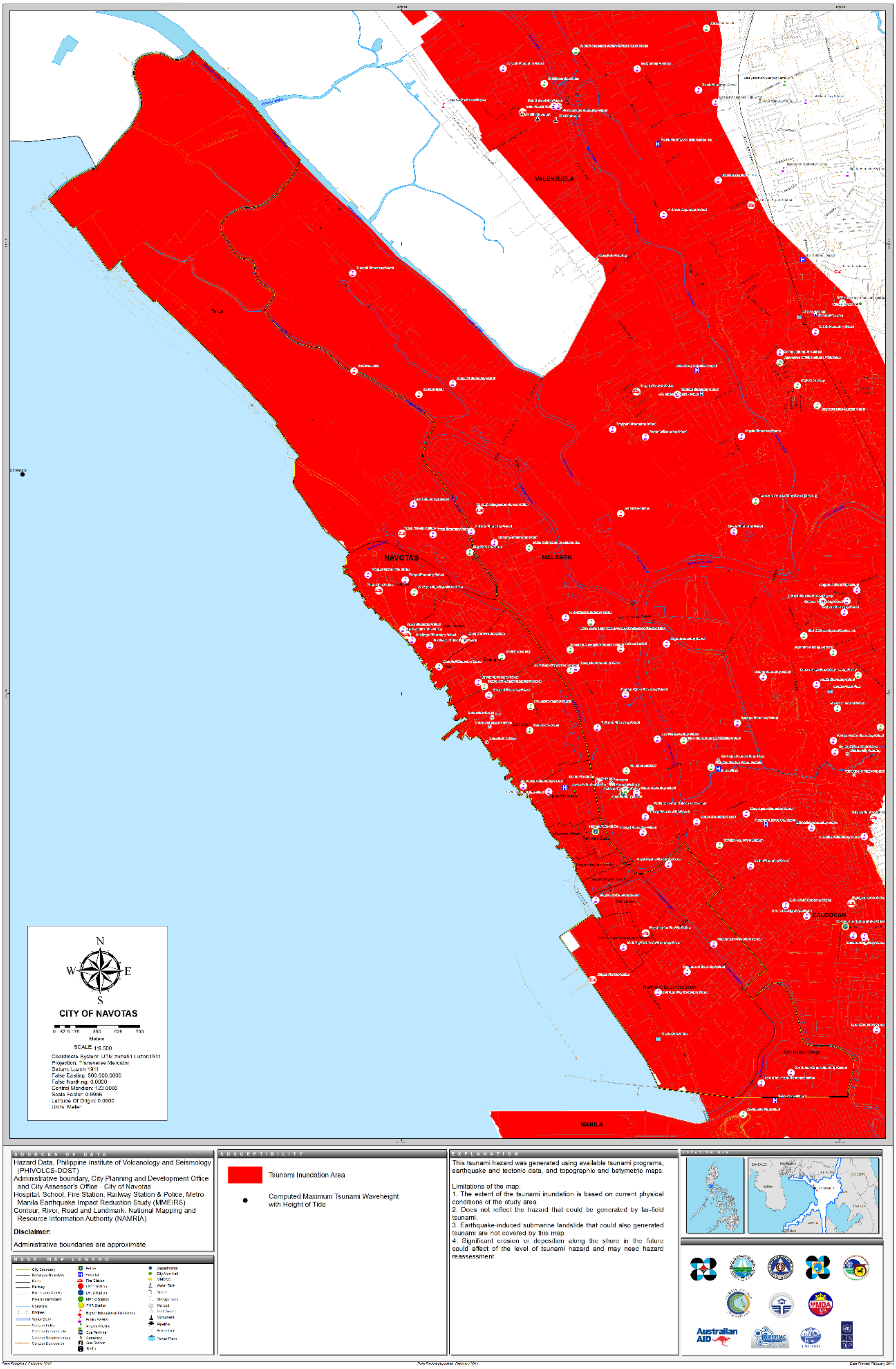


Figure 2-19 Tsunami-prone areas in Navotas City
Source: PHIVOLCS, 2013

2.1.2.3.2 Volcanic Hazards

Most of the hazards associated with the eruptions of Mount Pinatubo and Taal Volcano with the exception of ashfall, are very much localized and are generally confined within the immediate vicinities of these three volcanoes.

A violent eruption of Mount Pinatubo and/or Taal Volcano which may result into a base surge or a rapid expanding cloud at the base will definitely has severe effect at the areas close to them.

Only a minor quantity of ash has affected Metro Manila based on the review of the extent of impacted areas from the largest eruptions of Mount Pinatubo. It is thus conceivable that should Mt. Pinatubo will erupt with the same magnitude in the future, the same level of ashfall impact is expected to likely affect the island.

The 1911 eruption of Taal Volcano killed about 1,300 and wounded 800 people. The solid ejecta produced by the 1911 eruption which was estimated to be around 80,000,000 million cubic meters spread over an area of 230 km2 while ashes spewed from the volcano reached as far as Manila and nearby provinces.

The 1965 eruption killed 180 people and displaced some 55,000 evacuees from the Volcano Island and nearby settlements surrounding Taal Lake. Eruption clouds rose 15 – 20 km high, depositing fine ash on downwind areas up to 80 km away. The eruption blanketed an area of about 60 km^2 with 25 cm of ash.

Based on the recorded hazards associated with the eruption of Taal Volcano, the project area being 75 km away from the said volcano could only experience minor ashfall (Figure 2-20).

Figure 2-20 Relative Position of the Project Area from Mount Pinatubo and Taal Volcano
Source: Published 1:1,000,000 Road Map of the Philippines, published and exclusively distributed by the National Bookstore, Inc.

2.1.2.3.3 *Hydrologic Hazards*

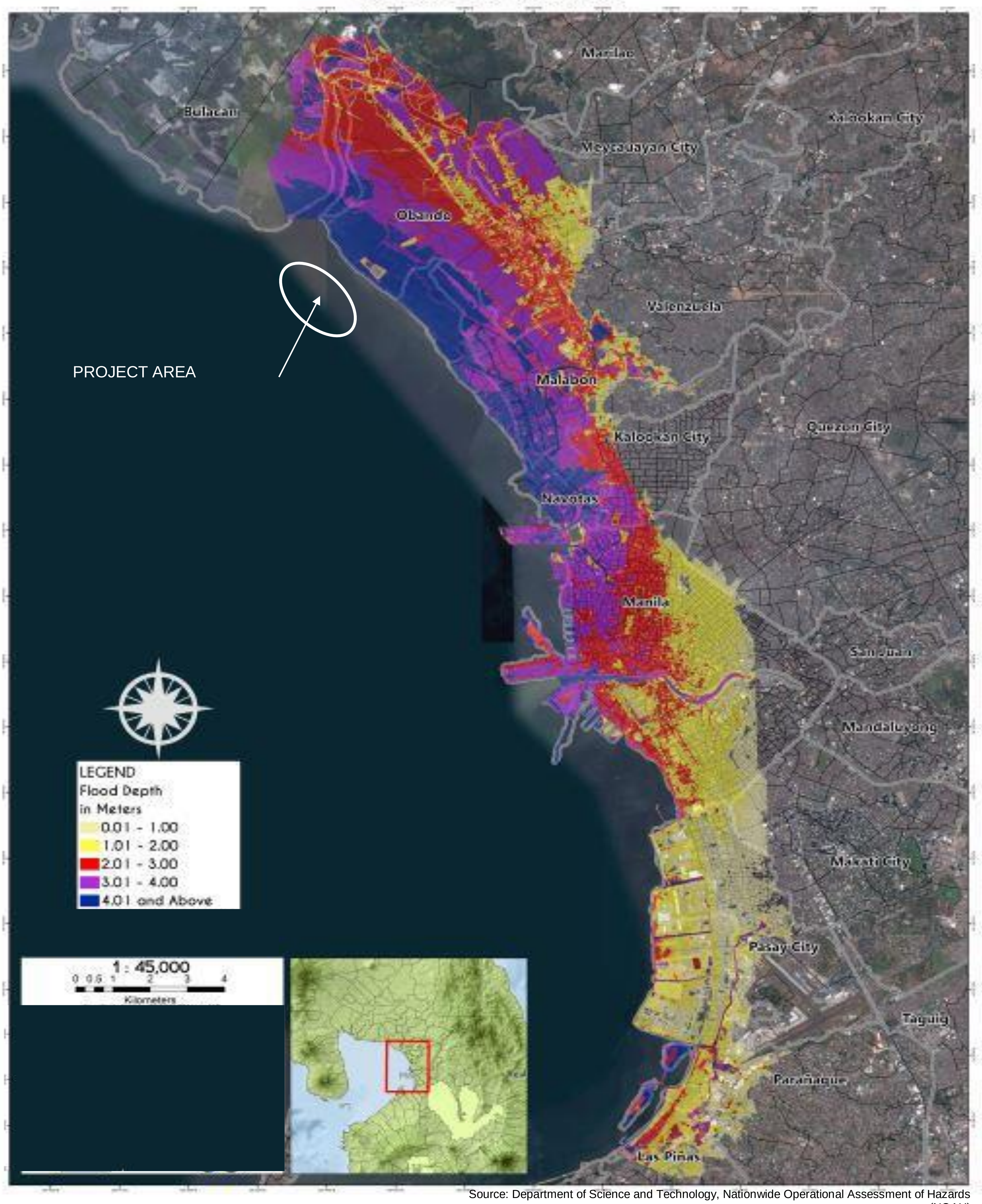
- **FLOODING**

Flooding is usually caused by heavy rains accompanying typhoons or the southwest monsoons. Flooding is a chronic problem, afflicting large areas in Metro Manila, especially the low lying areas like the City of Navotas. Because of the local climate condition, the city is experiencing an average of 18 – 20 flood events yearly, although only a few of these cause severe damage.

In Metro Manila, floodwater is usually due to excessive rainfall particularly during the months of May to November when the southwest monsoon coincides with the typhoon season.

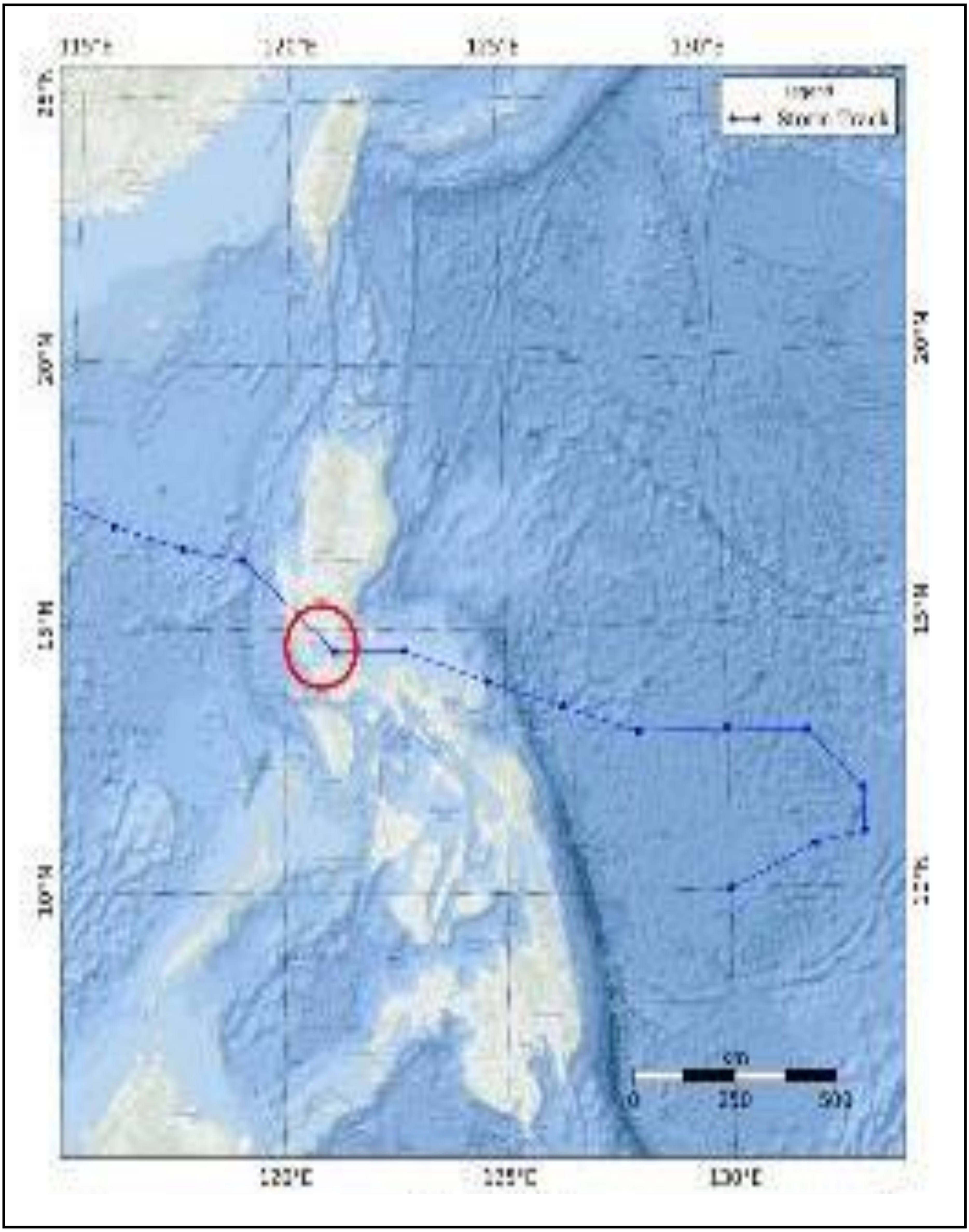
The flooding problems in Metro Manila are aggravated by rapid urbanization, inadequate or non-existent of drainage system, improper waste disposal, low river capacity and lack of maintenance, tidal transgression, reclamation activities and storm surges, squatter settlements, and constraints in the implementation of proper flood control facilities and countermeasures.

The Mines and Geosciences Bureau's published Flood Hazard Map of Metro Manila is presented in Figure 2-23.



Source: Department of Science and Technology, Nationwide Operational Assessment of Hazards (NOAH)

Figure 2-21 Metro Manila Inundation (Flooding) Map



Source: PHIVOLCS

Figure 2-22 Track of typhoon Georgia

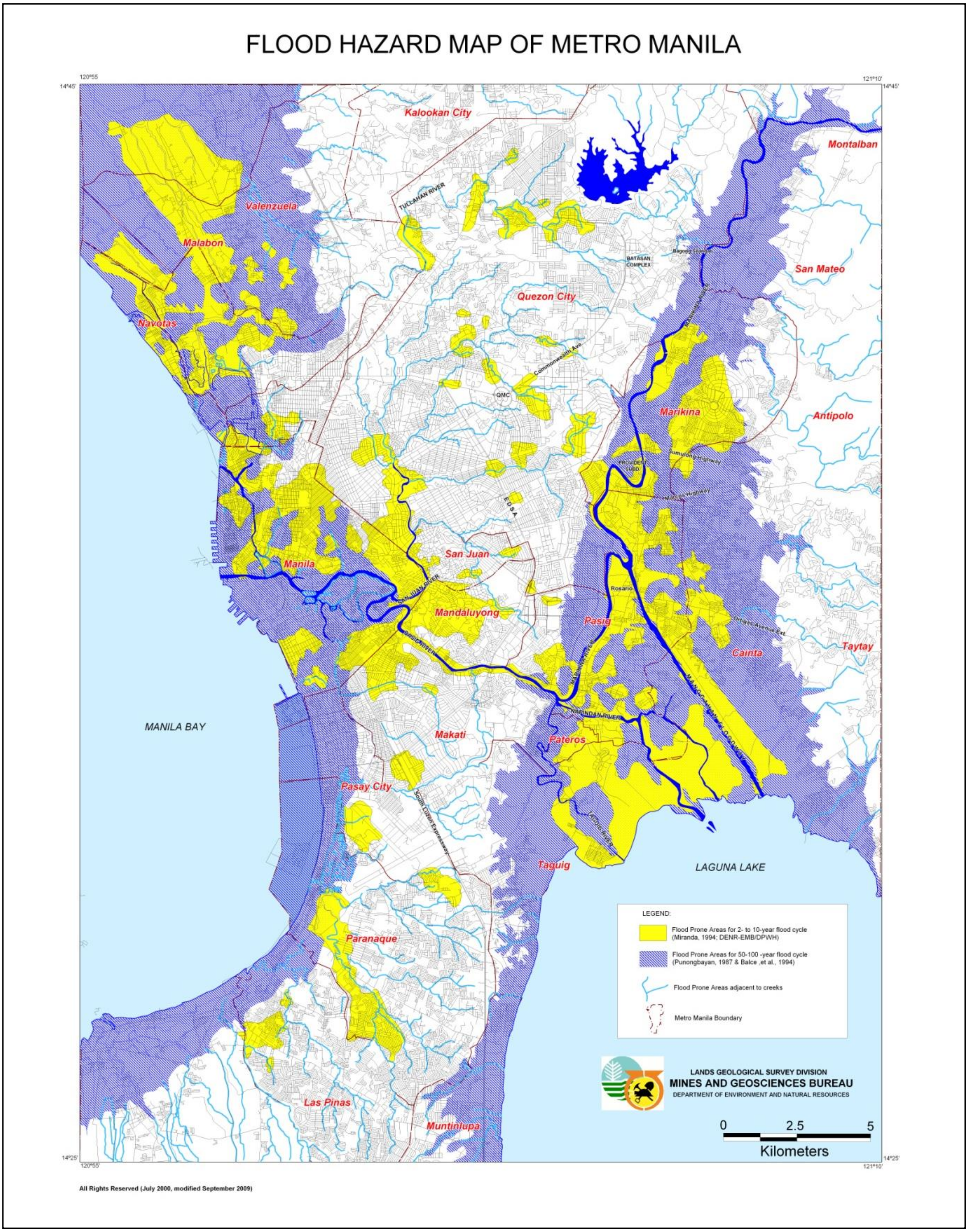


Figure 2-23 Flood Hazard Map of Metro Manila
(Source: Mines and Geosciences Bureau, 2009)

- **STORM SURGE**

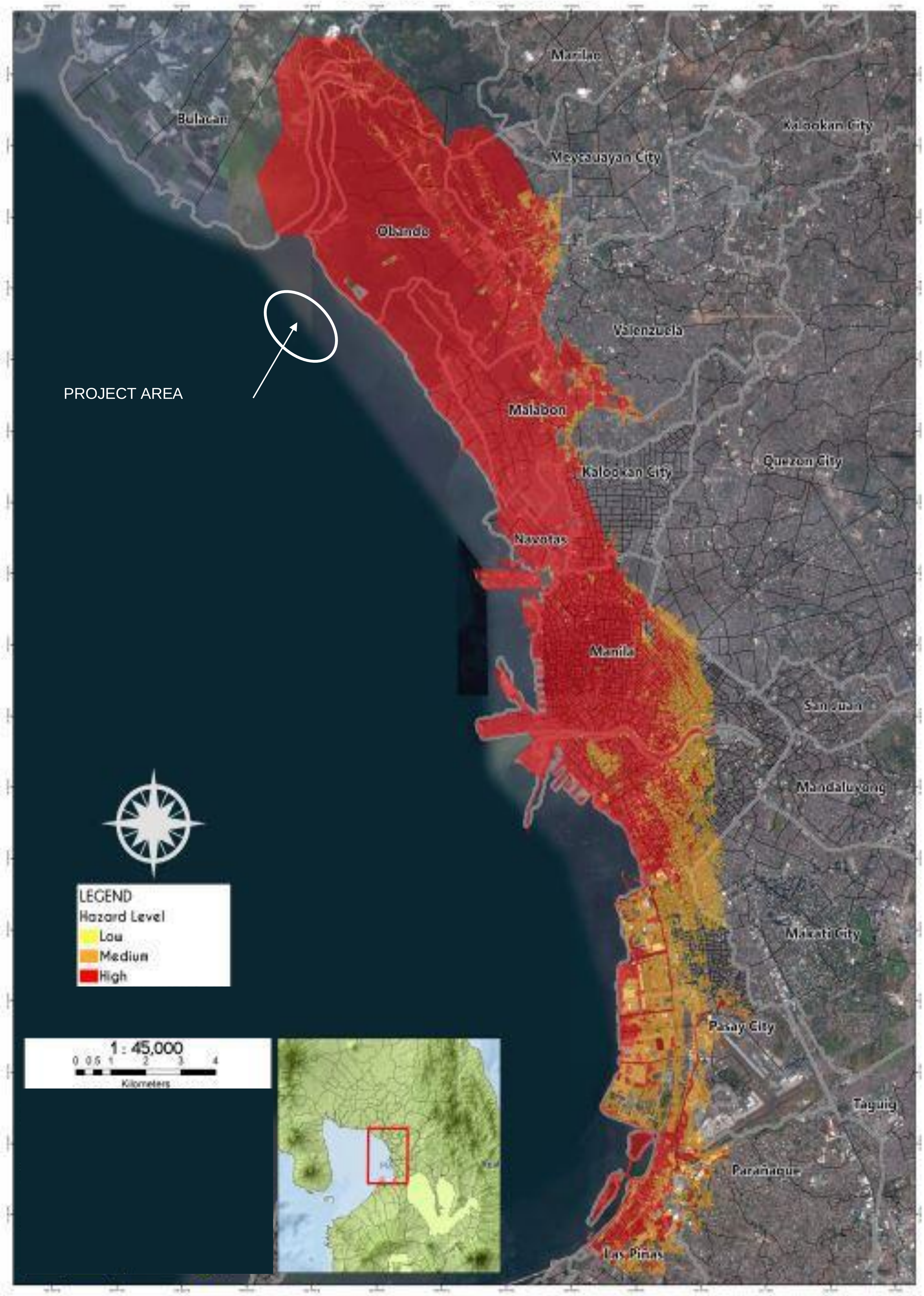
Storm surge refers to the temporary increase at a particular locality in the height of the sea due to extreme meteorological conditions: low atmospheric pressure and/or strong winds. It is caused primarily by strong winds pushing on the ocean's surface causing the water to pile up higher than the ordinary sea level. The rise in water level due to the combined force of storm surge and normal tides could cause severe flooding in coastal areas.

Due to the combination of coastal configuration and seasonal wind regime, waves generated during the rainy southwest monsoon also raise tide levels by as much as 80% at the northern end of Manila Bay (Siringan and Ringor, 1998). Waves three meters high can be generated even along the limited western fetch. Southerly wind speeds at Manila can exceed 220 kph and waves 3.7 meters high have been recorded at Manila's port. PAGASA unpublished records shows storm surges occurred seven times between 1960 and 1972 (Rodolfo and Siringan, 2003).

Recent storms demonstrated wind induced waves breaking at the seawall of the reclamation area and Roxas Boulevard covering the strip with garbage. Portions of the seawall along Roxas Boulevard suffered damage due to consistent pounding of the waves.

As seen during Typhoon Pedring, Manila Bay coastline is considered highly vulnerable to storm surges and coastal floods.

Typhoon Haiyan (Yolanda) with Track of Typhoon Georgia



Source: Department of Science and Technology, Nationwide Operational Assessment of Hazards (NOAH)

Figure 2-24 Metro Manila Storm Surge Hazard Map

MODELING STORM SURGE IN MANILA BAY USING THE ROMS[1]

Carl Drews (of NCAR/UCAR) and Weiqing Han prepared the Modeling Storm Surge in Manila Bay using the ROMS in 2009 for Physical Oceanography Review Symposium. Their study is presented below:

The Philippine Archipelago includes some extreme topography in the form of volcanic peaks, deep ocean trenches, convoluted coastlines, shallow estuaries, and high coastal cliffs. This topography poses a modeling challenge. The areas of greatest risk for storm surge are the long extents of shallow water in Laguna de Bay and the northern portion of Manila Bay. Manila Bay represents both an interesting case for numerical modeling, and a humanitarian opportunity to save lives and property.

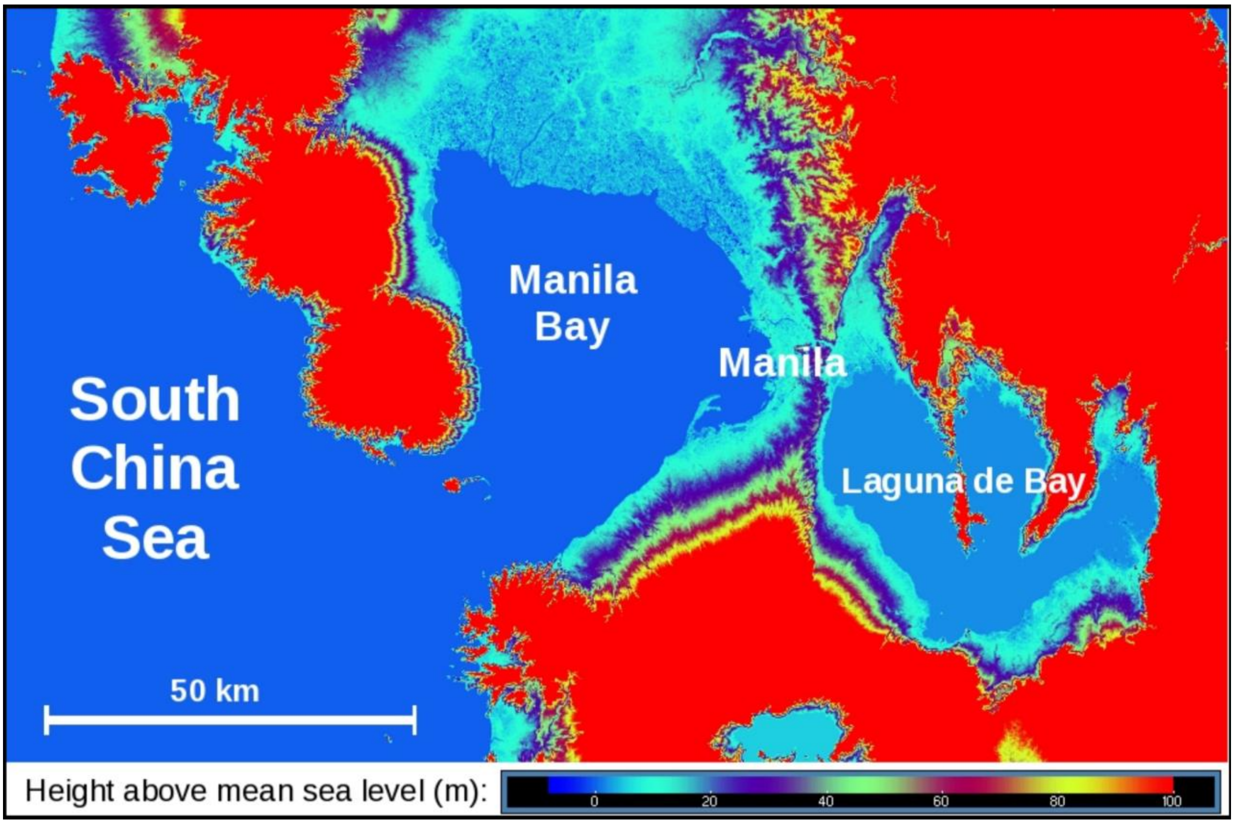


Figure 2-25 Topography of Manila

Figure 2-25 presents the topography of Manila and the surrounding bodies of water. Laguna de Bay is the large shallow lake to the east of Manila. This lake drains into Manila Bay through the Pasig River, a tidal channel passing through Manila. There are low-lying coastal areas along the north shore of Manila Bay. Cavite City is the forked peninsula extending from the south shore of the bay.

[1] Physical Oceanography Review Symposium, C. Drews, and W. Han, 2009: Modeling storm surge in Manila Bay using the ROMS [poster]. *Physical Oceanography Review Symposium*, U.S. Office of Naval Research, Chicago, IL, US.

Methods

The authors model Manila Bay using the Regional Ocean Modeling System (ROMS). The Manila domain uses a 900-meter grid derived from SRTM30 topography combined with Smith & Sandwell bathymetry.

Part 1. The authors apply a uniform wind forcing field from 8 points of the compass to evaluate the directional aspect of storm surge. The wind is comparable to a Category 3 typhoon making landfall.

Part 2. The authors Hurricane Katrina from the Gulf of Mexico to the Western Pacific Ocean, and pass it directly over Manila on a track similar to Typhoon Angela (Rosing) in 1995. This is because there are no data available for Typhoon Angela.

Table 2-4 ROMS configuration for the Manila case study

Parameter	Value
Time step	1.0 seconds
X domain length	215 kilometers
X grid cells	240
X grid length	897 meters
Y domain length	323 kilometers
Y grid cells	360
Y grid length	897 meters
Vertical mode	Barotropic

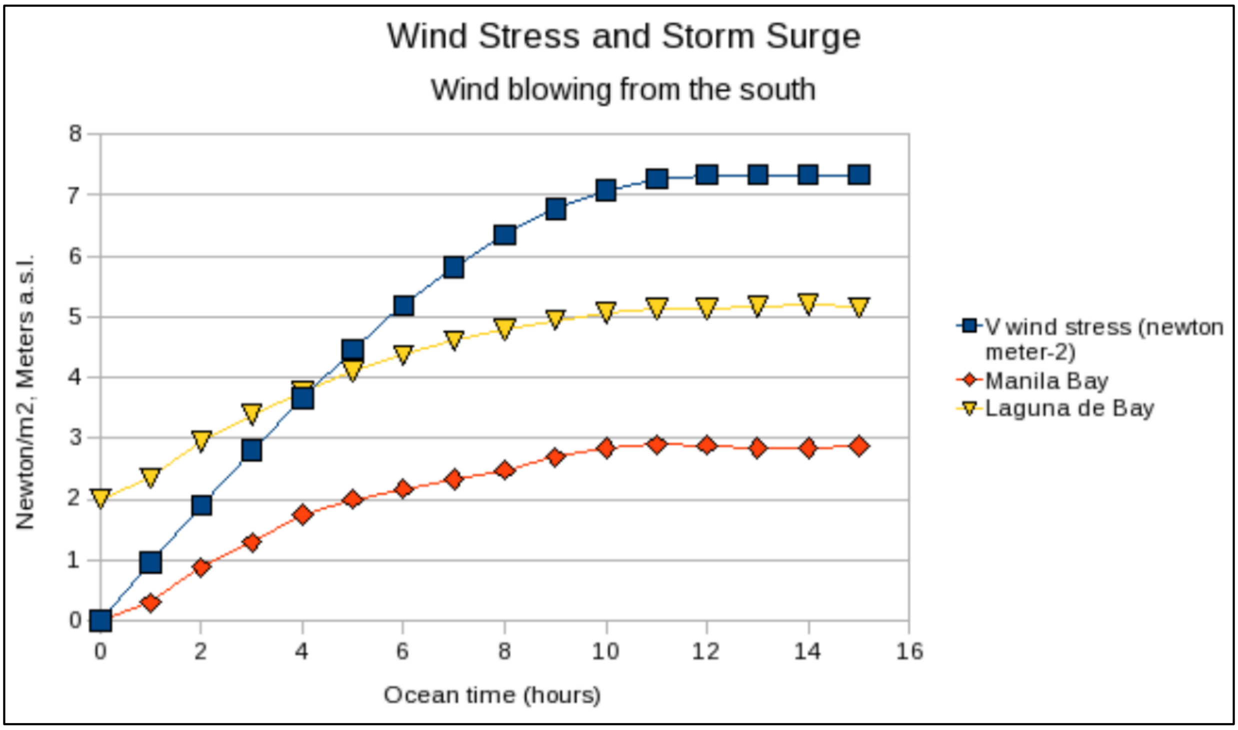


Figure 2-26 Idealized hurricane wind and associated storm surge

These points (shown in Figure 2-26) are at the extreme northwest of Manila Bay and Laguna de Bay, where the storm surge is the highest. The wind is from the south, increasing to Category 3 strength at 12 hours.

Results

Part 1: The forcing wind blows from 8 different directions, and we plot the resulting areas of wetting (storm surge) and drying (wind setdown).

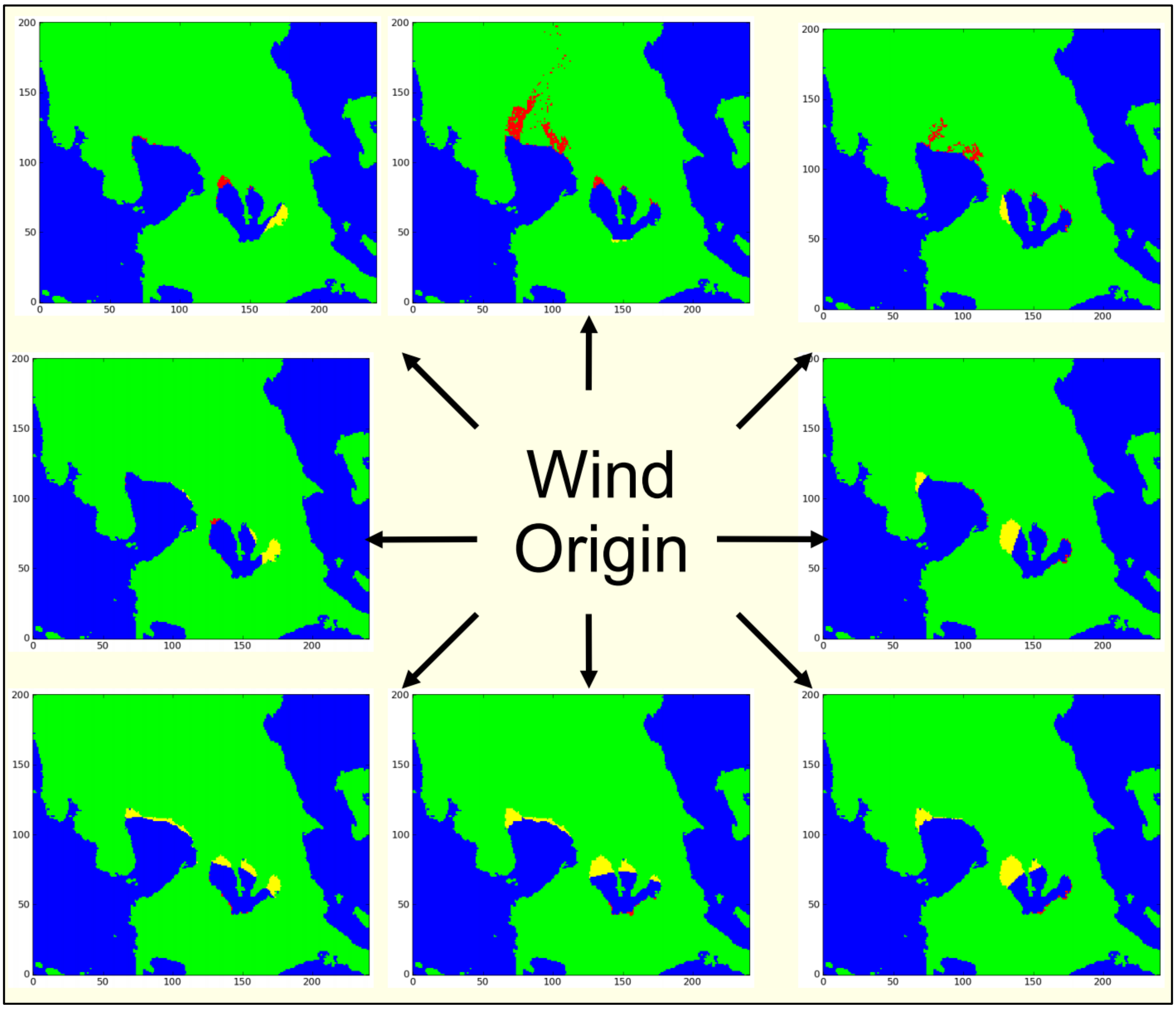


Figure 2-27 Surge and setdown by wind direction

Blue = water; green = land; red = wetting; yellow = drying.

The wind blows from the center of the figure outward (Figure 2-27). The axes are grid points (900 meters). The areas subject to surge and setdown are determined by wind direction and coastal topography.

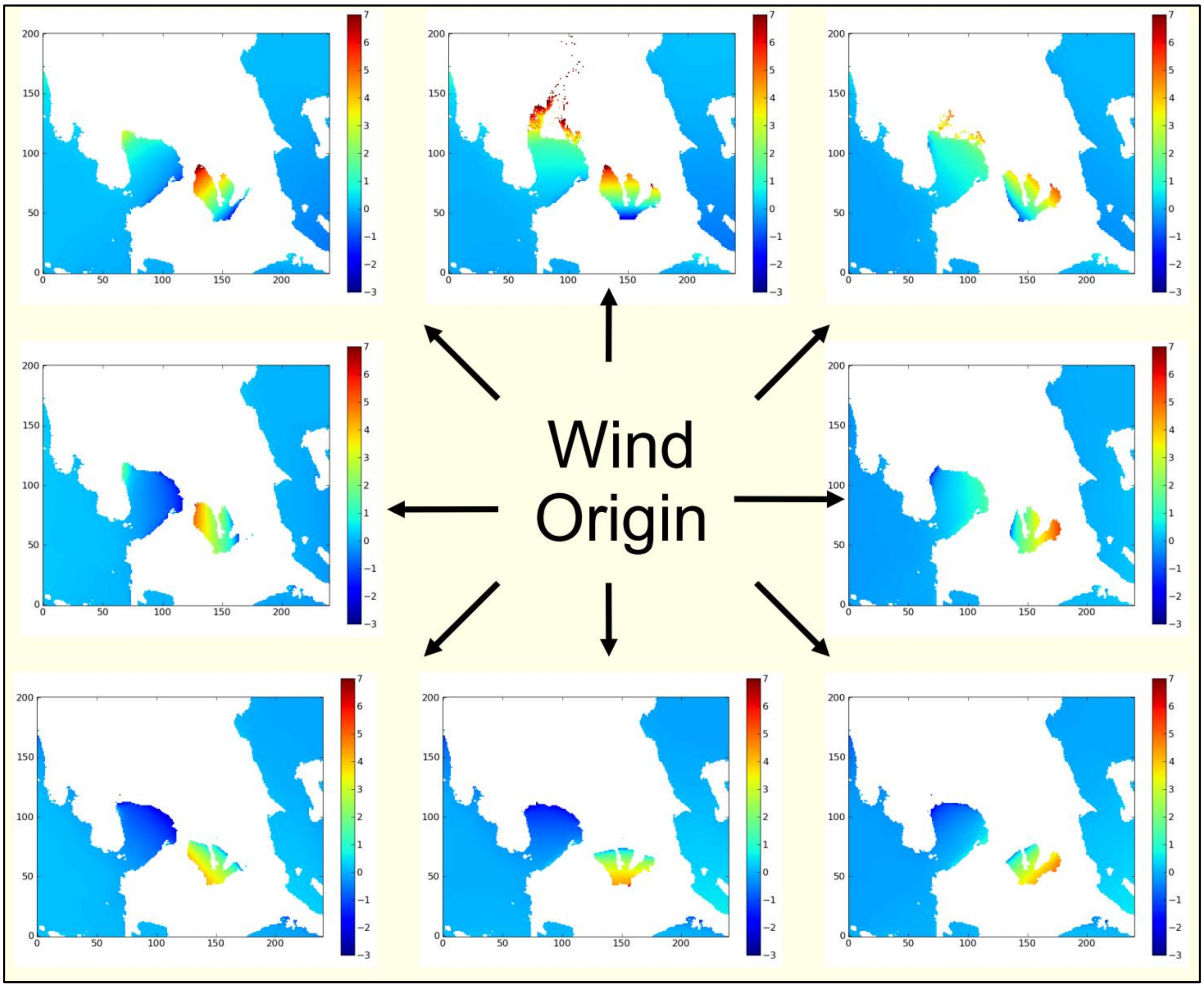


Figure 2-28 Free-surface height (meters) by wind direction.

White represents dry land surface (Figure 2-28). The wind blows from the center of the figure outward. Note that Laguna de Bay is usually at an elevation of 2 meters above sea level. The axes are grid points (900 meters).

Part 2: The wind and barometric forcing are taken from Weather Research and Forecasting (WRF), a mesoscale atmospheric model. The WRF output is from a 12-kilometer simulation of Hurricane Katrina (2005). Typhoon Katrina passes directly over Manila.

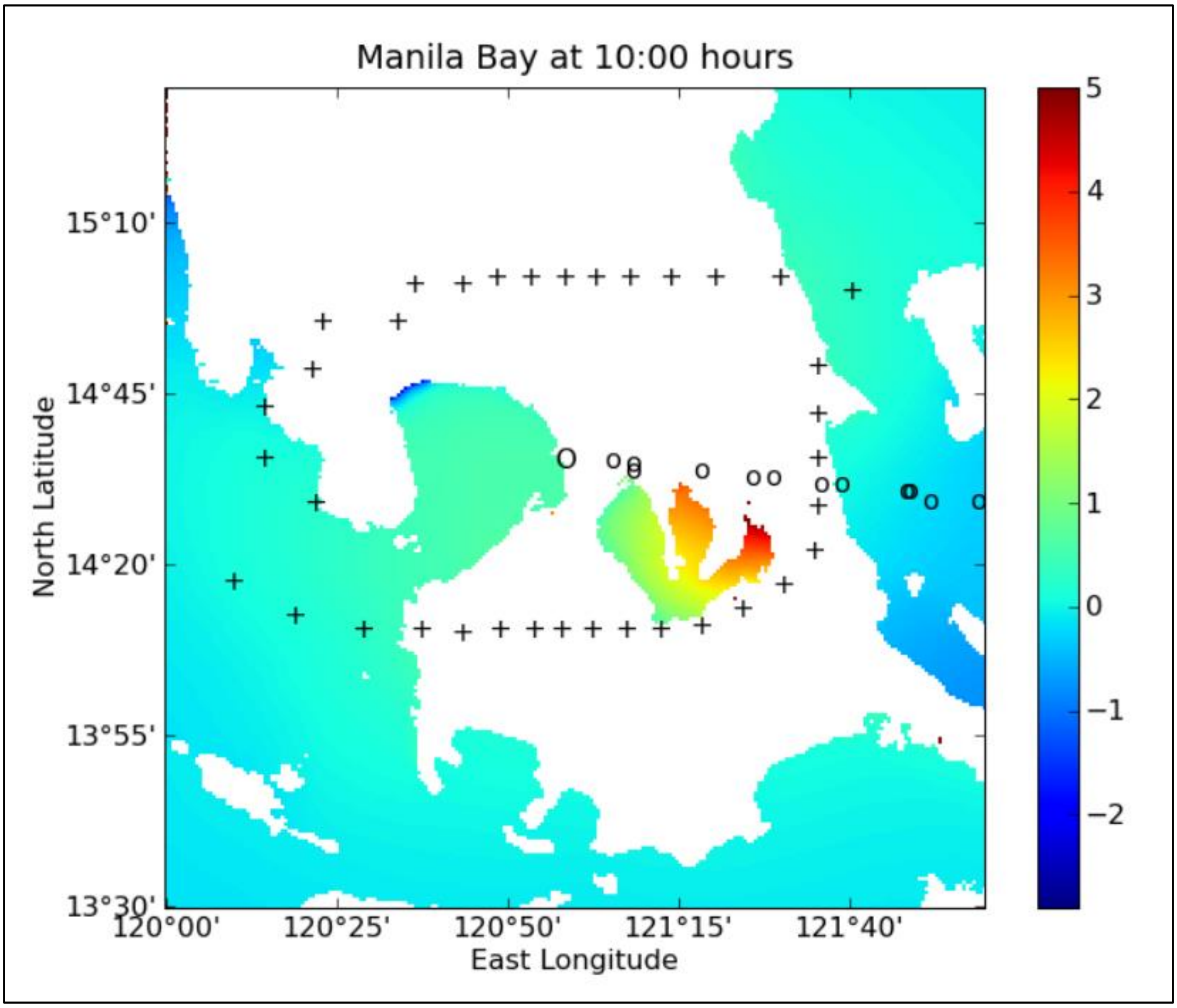


Figure 2-29 Sea surface height after 10 hours of model integration

Sea surface height after 10 hours of model integration (Figure 2-29), when Hurricane Katrina is directly over Manila, moving along the historical typhoon track of Angela in 1995 (smaller circles).

White represents dry land surface. Colored areas represent the height of the sea surface, given in meters above average sea level by the color scale on the right. The large circle represents the eye of the hurricane, and the smaller circles indicate the typhoon track.

The crosses display the radius of maximum wind speed. Note that Laguna de Bay is usually at 2 meters above sea level.

Discussion

The directional analysis provides an efficient way to evaluate the potential for storm surge without having to run all possible typhoon tracks. Since a tropical cyclone's winds blow in a circle, wind stress can come from any direction. These directional charts may be consulted in the absence of an accurate forecast.

The typhoon results from Part 2 agree with the directional analysis in Part 1, although the directional analysis gives higher surge heights due to the winds being sustained longer in a single direction. Those coastal regions susceptible to storm surge and wind setdown are the same in both analyses. This comparison suggests that in the lack of an accurate WRF forecast containing wind fields, storm surge vulnerability may be estimated using the projected typhoon track and cyclone radius alone. Note that here we did not consider tide effects when we discuss storm surge. In the Philippine Archipelago region, tidal effects can be significant.

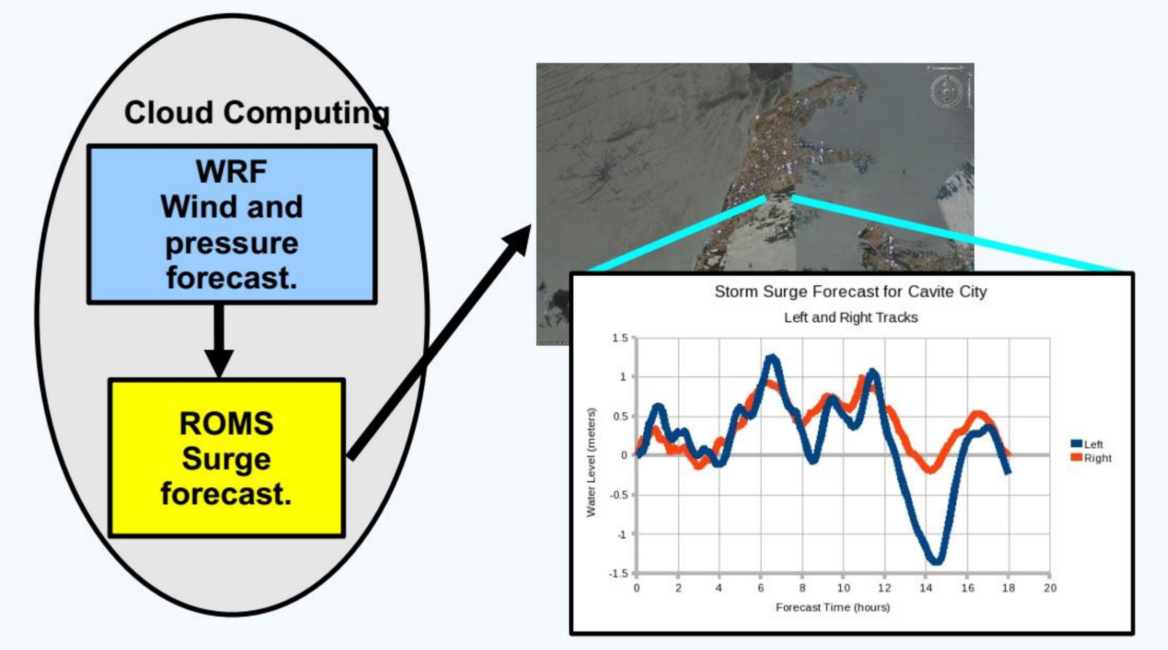


Figure 2-30 Vision for Storm Surge Forecasting

The authors have demonstrated the capability for WRF wind and pressure fields to force the ROMS ocean model. It is now possible to construct a system to provide real time forecasts of storm surge, on a 1-kilometer horizontal grid, with Internet access, for any coastal region of the world.

Conclusions

If a Category 3 typhoon passes over Manila on a track similar to Typhoon Angela in 1995, Manila city will experience about 1 meter of storm surge from Manila Bay. Other localities close to the city will not be so lucky. The northwest lobe of Laguna de Bay will experience rapid drying, then storm surge heights up to 2.5 meters above the normal lake level. The northwest corner of Manila Bay will also experience rapid drying, followed quickly by storm surge heights up to 3 meters that could reach 5 km inland.

2.1.2.4 Potential impacts and options for prevention, mitigation and enhancement

Key Findings

- The project area may experience ground shaking of Intensity VI as felt during the July 1990 Luzon Earthquake. The seismic hazards to which the project will be exposed to are ground shaking, liquefaction and surface rupturing. In terms of ground shaking, five major earthquake generators, namely, the West Valley Fault, the Philippine Fault Zone, the Lubang Fault, the Casiguran Fault and manila Trench have been identified as the most likely sources of future earthquakes that could affect the project. Of these sources, the WVF and the PFZ are most likely to generate the strongest levels of ground shaking. The worst-case scenario is a large magnitude event on the WVF.

- Three zones of average, below and above average levels of ground shaking have been identified in Metro Manila. Areas within the above average are those underlain by thick piles of water-saturated sediments. These include Navotas, Malabon, eastern Pateros, the valley side of Marikina, eastern section of Pasig and the reclaimed areas in Manila.
- Identified liquefaction-prone areas in Metro Manila are essentially within the zone of average to above average zone of ground shaking. Several areas in Navotas and Malabon are highly potential to liquefaction.
- In addition to ground-shaking related hazards, surface rupturing may also occur from WVF. The surface rupture is expected to essentially follow the pre-existing fault trace and restricted to a narrow zone. For a magnitude 7.5 earthquake, the empirical data suggest an associated 70 km long surface rupture and maximum displacement of 2 to 3 meters along the fault trace. Damages as a result of this hazard is expected to be substantial for structures directly straddling and located within few meters from the rupture zone.
- On the other hand, tsunamis may occur but are not expected to significantly impact the project area.
- The project area is 75 km away from Taal Volcano and 80 km from Mount Pinatubo and therefore not susceptible to volcanic hazard even if violent eruption will happen. Based on the recorded hazards associated with the eruption of Taal Volcano, the project area being 65 km away from the said volcano could only experience ashfall.
- Only a minor quantity of ash has affected Metro Manila based on the review of the extent of impacted areas from the largest eruptions of Mount Pinatubo, it is thus conceivable that should Mt. Pinatubo will erupt with the same magnitude in the future, the same level of ashfall impact is expected to likely affect the project area.
- Navotas, being situated in low grounds, is prone to flooding.
- As seen during Typhoon Pedring, Manila Bay coastline is considered highly vulnerable to storm surges and coastal floods.

Options for prevention, mitigation and enhancement

- Review or study of likely hazard impacts on the proposed project and formulate long term plan incorporating measures for risk reduction.
- Proper planning of dredging, filling and compaction of the fill materials have to be carried out by the Contractor/s. Prepare master plan for disaster mitigation – infrastructures.
- The reclaimed area should be at least two meters above the highest recorded flood level and/or storm surge level.
- Flood control infrastructures should be given priorities.
- Engineers have to assess the structural resistance of the different infrastructures to be constructed within the reclaimed area.
- The structural designs of all the structures to be constructed by the proponent must conform to the National Structural Code of the Philippines. These structures should withstand an earthquake with magnitude of at least intensity VI on the Rossi-Forel Intensity Scale

2.1.3 Terrestrial Ecology

2.1.3.1 Flora

2.1.3.1.1 Methodology

The proposed project is primarily located in Manila Bay along the coast of Navotas city. It is adjacent to a mangrove forest which is both natural stand and reforestation in nature. Manila Bay is a large, enclosed sea bay covering a wetland of 4600 hectares (BFAR 1995). It is bordered by coastal cities and municipalities of the National Capital Region and the coastal provinces of Bataan, Pampanga, Bulacan, and Cavite. Wetlands in Manila Bay include mudflats, sand flats, swamps, beaches, mangroves and rocky shores. Large numbers of migratory shorebirds, including several threatened species, use the intertidal mudflats, fishponds and salt pans in Manila Bay in winter and during the migration seasons.

Portion of the mangrove forest adjacent to the proposed reclamation project is the Sitio Pulo Marine Tree Park, is designated as reforestation and conservation area of Navotas City. The mangrove stretch is one of the remaining mangroves in Metro Manila. A sanitary landfill or dumpsite also beside the Tree Park and used as dumping grounds of solid waste or garbage from Metro Manila via barge.

Mangroves

Globally, there are around 50-60 species of mangroves belonging to 16 families, of these 35 species are found in the Philippines alone (Primavera et al., 2012). The species commonly found in this area are *Rhizophora apiculata* (bakauan lalaki), *Rhizophora mucronata* (b. babae), *Rhizophora stylosa* (b. bato), *Avicennia marina* (bungalon), *Avicennia alba* (piapi), *Avicennia officinalis* (miyapi), *Sonneratia alba* (pagatpat) and *Sonneratia caseolaris* (pedada) to name a few.

The study was carried out on mangrove area of Navotas city in Isla Pulo within the boundary of Malabon and Obando, Bulacan. Four plots measuring 20m x 20m were laid randomly throughput the area (Table 2-5 and Figure 2-31). Plants inside the sampling plot were measured and identified. Tree height and crown width were also noted and density, dominance, frequency and importance value were computed.

Table 2-5 Coordinate location of mangrove sampling stations

Plot	Latitude	Longitude
1	14 42’ 12”	120 54’ 15”
2	14 41’ 40”	120 54’ 50”
3	14 41’ 23”	120 55’ 11”
4	14 40’ 59”	120 55’ 33”

Figure 2-31 Location of mangrove sampling stations

2.1.3.1.2 Baseline

Species composition and richness

During the sampling, a total of 212 individuals were recorded represented by 2 species from 2 genera of 2 families. *Avicennia marina* (Bungalon) has the highest number of species encountered accounting to 96% or with 203 individuals noted while *Acacia farnesiana* (Aroma) is the least number of species with 9 individuals representing 4% (Figure 2-32). The mangrove stands were heavily damaged by the garbage deposits and are slowly dying due to lack of salt water inundation. *Avicennia* are generally considered pioneers of mangrove forests. They occupy a diversity of habitats within the tidal range and across salinity extremes of tropical and subtropical sheltered areas. Absence of regenerates was observed due the thick compilation of garbage within the substrate throughout the mangrove island (Figure 2-33) which possibly affects absence of other mangrove associated species in selected plots. Cutting of mangroves were also observed and used as poles and charcoals by the locals.

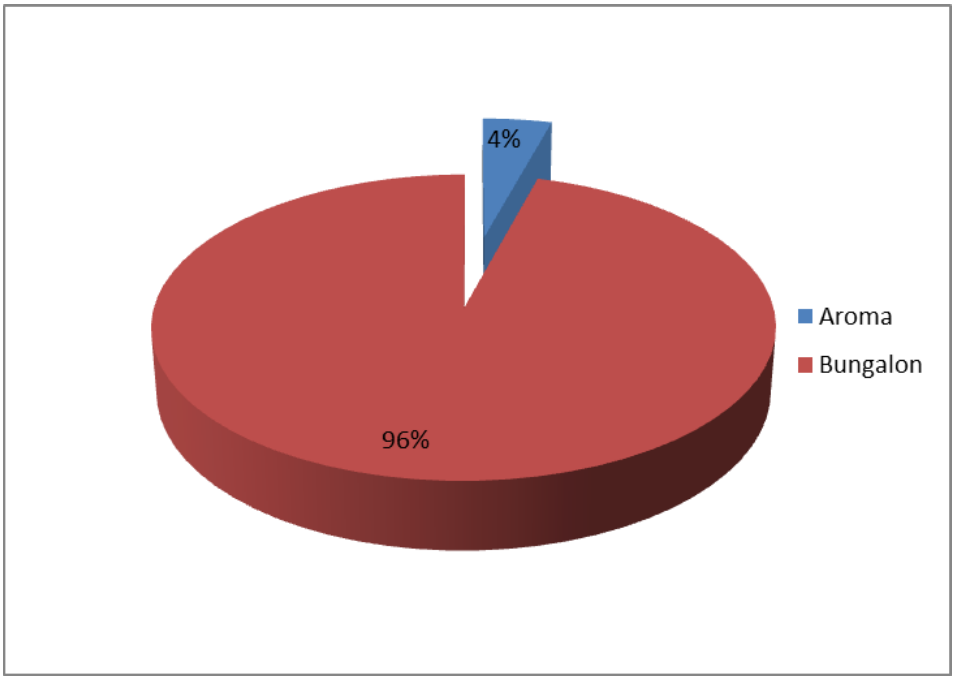


Figure 2-32 Composition of Species recorded inside the 20m x 20m sampling plots.

Figure 2-33 Pile of garbage found throughout the mangrove stand within Brgy. Tanza

Relative Density, Relative Dominance, Relative Frequency and Importance Value

Of the two (2) species encountered in the sampling plots, A. marina turned out to have the highest relative density and relative dominance with 95.75 and 22.80 respectively therefore getting the highest importance value of 198.55. This is followed by Aroma having a relative density of 4.25, relative dominance of 77.20, relative frequency of 20 and with an importance value of 101.45.

Table 2-6 Relative Density, Relative Dominance, Relative Frequency and Importance Value of Encountered Species in the Sampling Sites

Species		Relative Density (Rde)	Relative Dominance (Rdo)	Relative Frequency (RF)	Importance Value (IV)	Rank
Scientific Name	Common Name					
Acacia farnesiana	Aroma	4.25	77.20	20.00	101.45	2
Avicennia marina	Bungalon	95.75	22.80	80.00	198.55	1
		100.00	100.00	100.00	300.00	

Other species observed within the site includes mangrove reforestation and beach forest species among which include Cocos nucifera (Coconut), Terminalia catappa (Talisay), Rhizophora apiculata (Bakawan lalaki), Rhizophora mucronata (Bakawan babae), Avicennia alba (piapi) and Sonneratia alba (pagatpat). Brgy Tanza in collaboration with other concerned stakeholders of Metro Manila regularly conducts tree planting and beach clean-up activities in the area as part of environmental programs of Navotas city.

Figure 2-34 Stand of A. marina and aroma recorded within Brgy. Tanza

2.1.3.2 Terrestrial fauna

2.1.3.2.1 Methodology

Since the project site is primarily located on the sea of Manila Bay, the assessment of wildlife is widely focused on water bird species in most selected sites particularly along the bay and coastline (Table 2-7 and Figure 2-35). Other non-water bird species recorded within the indirect area such as mangrove and fishponds were also recorded. Water birds have been defined as “species of bird that are ecologically dependent on wetlands”, the definition used by the Ramsar Convention on Wetlands. Wetland includes the sea, shorelines, mangroves and fishpond as observed in the proposed project site.

Secondary data gathering of previous and related faunal studies were conducted to determine the extent and status of faunal species present in the area. Ocular observation through transect walk along the mangrove and species listing using boat along the bird were primarily used for bird survey. Interview with the locals and guides with an aid of field materials were also conducted for non-bird species.

Table 2-7 Coordinate location of bird sampling stations

Station	Latitude	Longitude	Station	Latitude	Longitude
1	14 42' 12"	120 54' 15"	6	14° 41' 12.3"	120° 54' 3.8"
2	14 41' 40"	120 54' 50"	7	14° 40' 34.2"	120° 54' 43.6"
3	14 40' 59"	120 55' 33"	8	14° 40' 0.7"	120° 55' 24.4"
4	14° 42' 44.8"	120° 53' 44.8"	9	14° 39' 47.9"	120° 54' 35.5"
5	14° 41' 56"	120° 53' 40.2"	10	14° 40' 59"	120° 53' 1.7"

Figure 2-35 Location of bird sampling stations

2.1.3.2.2 Baseline

Species composition and abundance

Characterization of associated fauna was limited to the avifaunal form. A total of 23 bird species representing 14 families were counted in the area during the 3-day observation period last 11, 14 and 16 May 2016. Two species consists of 300 individuals were recorded exclusively within the sea while16 species with 78 individuals were observed in the mangrove area adjacent to the proposed project. A pair of Oriental house rat and rat-snake was observed near site 3. Domesticated dogs and cats were also recorded in the area.

Figure 2-36 Terns and egrets resting on abandoned fish cage near the project area

Species distribution and conservation status

Distribution range of species is dominated by migrant and non-endemic resident breeders with 13 (57%) and 9 (39%) species respectively. Migrants are migratory species that regularly travel to temperate regions to feed during winter season of their breeding grounds or region of origin. In the Philippines, the peak months for birds migrating to the South are usually from September to November, while those traveling North often occur between February and April. Although the survey was done outside the migration season, 13 species were recorded. These species were probably just late in returning to its region of origin. Meanwhile, resident species are native species that breed or are suspected of breeding in the Philippines and in other countries or region and naturally live within the country throughout the year. Figure 2-37 shows a chart representation of the range distribution of the recorded bird species in the study area and Figure 2-38 for sample photos.

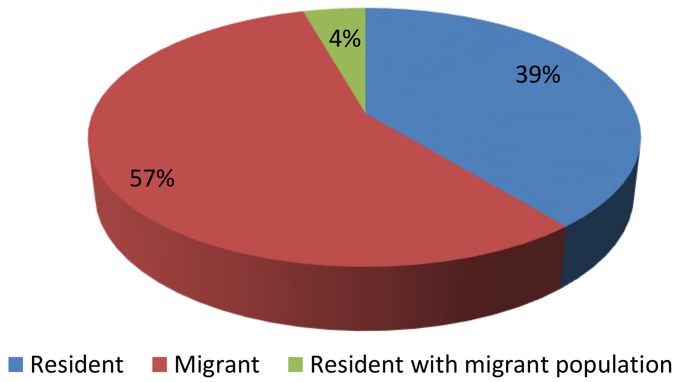


Figure 2-37 Representation of bird species distribution recorded within the study area

All species recorded falls under Least Concern for conservation status. The 23 recoded bird species are distributed within 14 families (Table 2-8). The most represented is Family Ardeidae (egrets and herons) with six species, followed by Family Sternidae (Gulls and Terns), Alcenidae (Kingfishers), Hirundinidae (Swallows) and Phylloscopidae (Warblers) with two individuals each. The rest of the species is represented by one family.

Family Ardeidae consists of long-legged, long-necked, wading birds that have spear-like bills/beaks and long toes. They take a variety of animal food, especially fish. They are also dependent on mangrove for food and refuge.

A. *Gelochelidon nilotica (*Gull-billed Tern), B. *Chlidonias hybridus* (Whiskered Tern)
C. *Butorides striata* (Little Heron), D. *Nycticorax nycticorax* (Black-crowned Night Heron)

Figure 2-38 Migrant species recorded within the vicinity of the project area

Table 2-8 Summary of bird species species recorded

Family	Species Common Name	Species Scientific Name	Conservation Status	Distribution Status
Ardeidae	Great Egret	*Ardea alba*	Least concern	Migrant

Family	Species Common Name	Species Scientific Name	Conservation Status	Distribution Status
Ardeidae	Intermediate Egret	*Egretta intermedia*	Least concern	Migrant
Ardeidae	Little Egret	*Egretta garzetta*	Least concern	Migrant
Ardeidae	Little Heron/Striated Heron	*Butorides striata*	Least concern	Resident with Migrant population
Ardeidae	Black-crowned Night Heron	*Nycticorax nycticorax*	Least concern	Migrant
Ardeidae	Yellow Bittern	*Ixobrychus sinensis*	Least concern	Migrant
Charadriidae	Kentish Plover	*Charadrius alexandrinus*	Least concern	Migrant
Scolopacidae	Common Sandpiper	*Actitis hypoleucos*	Least concern	Migrant
Sternidae	Gull-billed Tern	*Gelochelidon nilotica*	Least concern	Migrant
Sternidae	Whiskered Tern	*Chlidonias hybridus*	Least concern	Migrant
Columbidae	Zebra Dove	*Geopelia striata*	Least concern	Resident
Alcedinidae	Common Kingfisher	*Alcedo atthis*	Least concern	Migrant
Alcedinidae	White-collared Kingfisher	*Todirhamphus chloris*	Least concern	Resident
Hirundinidae	Barn Swallow	*Hirundo rustica*	Least concern	Migrant
Hirundinidae	Pacific Swallow	*Hirundo tahitica*	Least concern	Resident
Campephagidae	Pied Triller	*Lalage nigra*	Least concern	Resident
Pycnonotidae	Yellow-vented Bulbul	*Pycnonotus goiavier*	Least concern	Resident
Acanthizidae	Golden-bellied Flyeater	*Gerygone sulphurea*	Least concern	Resident
Phylloscopidae	Arctic Warbler	*Phylloscopus borealis*	Least concern	Migrant
Phylloscopidae	Clamorous Reed-Warbler	*Acrocephalus stentoreus*	Least concern	Resident
Rhipiduridae	Pied Fantail	*Rhipidura javanica*	Least concern	Resident
Laniidae	Brown Shrike	*Lanius cristatus*	Least concern	Migrant
Passeridae	Eurasian Tree Sparrow	*Passer montanus*	Least concern	Resident

Species diversity

Among the species observed, Gull-billed Tern *Gelochelidon nilotica)*- are found to be the most abundant with 515 individuals, closely followed by Whiskered Tern (*Chlidonias hybridus*) with 149 individuals. Great Egret (*Ardea alba)* is the least with only one individual recorded. The computed Species Diversity Index (H') is very low at H'=1.797. Consistent to the site condition observed, data shows that a low to very low bird diversity exists within the project vicinity (Table 2-9). This can be attributed to the poor habitat quality observed being located in a severely polluted environment with pile of garbage everywhere as well as various human activities observed (e.g. charcoal making, tree cutting, waste disposal).

Table 2-9 Abundance of bird species recorded

Species	No. of Individuals	Relative Abundance	Frequency	Relative Frequency
Ardea alba	1	0.002469136	10.00	1.724137931
Egretta intermedia	2	0.004938272	20.00	3.448275862
Egretta garzetta	15	0.037037037	50.00	8.620689655
Butorides striata	5	0.012345679	30.00	5.172413793
Nycticorax nycticorax	4	0.009876543	30.00	5.172413793
Ixobrychus sinensis	2	0.004938272	20.00	3.448275862
Charadrius alexandrinus	4	0.009876543	20.00	3.448275862
Actitis hypoleucos	3	0.007407407	10.00	1.724137931
Gelochelidon nilotica	151	0.372839506	70.00	12.06896552
Chlidonias hybridus	149	0.367901235	70.00	12.06896552
Geopelia striata	2	0.004938272	10.00	1.724137931
Alcedo atthis	3	0.007407407	20.00	3.448275862
Todirhamphus chloris	2	0.004938272	20.00	3.448275862
Hirundo rustica	7	0.017283951	20.00	3.448275862
Hirundo tahitica	8	0.019753086	20.00	3.448275862
Lalage nigra	3	0.007407407	20.00	3.448275862
Pycnonotus goiavier	12	0.02962963	30.00	5.172413793
Gerygone sulphurea	3	0.007407407	20.00	3.448275862

Species	No. of Individuals	Relative Abundance	Frequency	Relative Frequency
Phylloscopus borealis	2	0.004938272	20.00	3.448275862
Acrocephalus stentoreus	2	0.004938272	20.00	3.448275862
Rhipidura javanica	7	0.017283951	30.00	5.172413793
Lanius cristatus	2	0.004938272	10.00	1.724137931
Passer montanus	16	0.039506173	10.00	1.724137931
	405	1	580.00	100
Species diversity Index H'=	1.797			

The mangrove area near the project area provides food for many species of birds. Most of the species found within the mangrove area are generalist or species that occur in a wide variety of habitats that make do with whatever the habitat provides. Their adaptability in choice of habitat enables them to survive under diverse conditions. Being highly adaptable and successful in colonizing new habitats, they are often most abundant near human habitation.

2.1.3.3 Potential impacts and options for prevention, mitigation and enhancement

Impact of the proposed project to the site is considered high to the mangrove forest primarily due to removal of vegetation and dredging activity.

Vegetation Removal and Loss of Habitat

Removal of mangrove stand or forest is permanent physical loss of vegetation in the area and may disrupt natural essential ecological functions such as natural barrier against waves and strong waves, animal refuge and food source.

An inventory with the identity and number of all tree species should be conducted if stands of mangrove will be removed during construction of project and associated project components (e.g. canal, roads). Proper documentation and clearance or permit from DENR should be accomplished for the trees that will be cut and removed in the affected mangrove areas. The project should ensure that those mature and sources of planting stock and wildlings be replaced or earth-balled to adjacent unaffected site or to other suitable areas. Creation and/or maintenance of stretch of flora or corridors that will still provide habitats for dependent fauna should be ensured. To compensate further loss of vegetation during clearing, measures such as re-vegetation of temporarily affected areas and offset planting for permanently affected areas are recommended. The proponent in coordination with local stakeholders should establish a mangrove nursery to support coastal mitigation and re-greening program of the company and community.

Based on the modeling simulations, change after reclamation will affect the health and growth of mangrove trees in the area. A cascade of effects on the mangrove forest ecosystem resulting from the scenario as a result of the proposed 20m buffer area between the reclaimed and the existing mangrove forest is expected. The change in direction of prevailing currents could possibly lead to decrease on the spread of freshwater discharges thus resulting to higher sedimentation rate and formation of sediment beds. As a result, there could be consequences on the ecology and physiology of mangroves and its associated communities. Specifically, there would be changes in the height and density of plant, species dominance and spatial patterning; nutrient absorption capacity with regard to changes in salinity; asphyxiation of shoots and pneumatophores leading to mortality.

Proponents are encouraged to re-design and establish wider a buffer area >40m between the structure and the mangrove forest to ensure that these impacts to mangrove health is addressed. Deeper and wider buffer will ensure efficient water circulation thereby decreasing sedimentation rates and formation of sediment beds. It will also prevent interference to the littoral sediment transport which may potentially harm the mangroves. Moreover, the wider buffer area between natural environment and man-made structure would provide ideal habitat and pathways for birds, fishes, benthic and marine animals promoting balanced conservation and development.

The LGU of Navotas as proponent of the project shall undertake protection and conservation programs for the remaining mangrove in the area. Specifically:

- support active enforcement of existing laws and regulation pertaining to protection and rehabilitation of Mangrove Park with regular budget allocation
- establish buffer zones bordering the seaward and landward margins to provide a transition between human settlements/activities and to serve as barrier from garbage pollution and indiscriminate cutting of mangroves by local residents
- address the solid waste management issues from the existing sanitary landfill within the mangrove area to prevent further solid waste – related problems
- enhance vegetation cover and diversity of mangrove forest areas by planting a variety of mangrove and mangrove-associated species suitable to the condition of the area. This will supplement biodiversity value in the area by reintroducing key and important species to hasten the process of natural recovery and improve habitat quality.
- establish mangrove nurseries within the Mangrove Park to provide reliable source of mangrove propagules for replanting and rehabilitation of the project area and even to adjacent areas of Manila Bay
- conduct Information, Education and Communication (IEC) campaign on the importance of mangrove and its habitat especially to local residents of Navotas to increase awareness and support from the locals
- collaborate with other government agencies such as DENR, PPA, academe and NGOs on other conservation programs and activities such as ecotourism, bird watching, coastal clean-up, research studies and IEC.

Threat to frequency, abundance and distribution of species

Impacts on the population of wildlife will be permanent and long-term in nature. Wildlife species such as birds in the area are already adapted to such type of disturbance brought by the existing activities such as the garbage disposal and other resource extracting activities (e.g. charcoal making, fishing).

Noise generated during dredging and clearing of mangroves may also disturb wildlife. Noise may temporarily drive away wildlife to quiet areas to take refuge and the loss of natural habitat could cause the wildlife not to return to the area. Increase in sound levels during construction and operation is another source of wildlife disturbance as this threatens the ability of native birds to reproduce, hence affecting their abundance, frequency, and distribution. Construction, if possible, should be limited during the day to minimize noise pollution to species as well as humans.

Hindrance to wildlife access

Species such as migratory birds feeding on the seas of Navotas might be displaced during reclamation activities thereby limiting species' movements and food source. Though the affected avian species will possibly transfer to adjacent area with vegetation cover such as in Bulacan and Bataan, sensitive shorebird species utilizing the vicinity of the mangrove site for food and temporary shelter is the most vulnerable.

To mitigate the impacts, the proponent and its contractors must limit dredging and clearing activities to designated area. They must establish and maintain corridor or buffer zones within the project area. Control siltation using silt curtains, settling ponds and other appropriate and environmentally sound techniques and engineering mechanisms must be considered. At the same time, the proponent must support conservation of habitat and in adjacent areas through reforestation, restoration or species monitoring and conservation as these would most probably serve as refuge to the displaced wildlife in the proposed project site. These areas may be located in Bulacan, Bataan or anywhere within the Manila Bay.

2.2 Water

2.2.1 Hydrology

The Local government of Navotas is planning to reclaim portion of the sea fronting Navotas City particularly in Brgy. Tanza. The area to be developed is about 650 hectares (ha). The proposed project site is drained by four (4) of the major rivers of Bulacan province, one (1) major rivers of Quezon City and small creeks natural depressions and drainage waterways.

The four (4) major rivers of Bulacan merge into a single channel when traversing the municipality of Obando before it finally empties its water to Navotas Bay. The watersheds of the four rivers were delineated reckoned from the boundary of the stretch of the channel where water is not flowing due to level river gradient. Portion of rivers downstream of the delineated areas have level river bed slope where flow is stagnant. The whole basin fronting the proposed project is approximately 682 sq. km. About 30 percent (%) of the areas within the basin that have level to nearly level topography is susceptible to flooding. Roughly, majority of the areas susceptible to flooding are located in Malabon, Navotas and Obando while the remaining areas are found in Marilao, Bucaue, Balagtas and Meycauayan City. The areas fronting the proposed project site are fishponds that are part of the flood prone areas.

The flood prone areas are the recipient of all the flows originating from the five (5) river systems in Bulacan and Quezon City which includes Guiguinto River, Balagtas River, Sta. Maria River Marilao River, all in Bulacan Province and Tullahan River in Quezon City. The combined watershed area of the five (5) river systems is about 472 sq. km. As mentioned earlier, areas located in level to nearly level terrain are prone to flooding. The prolonged occurrence of heavy rainfall in the basin inundates the identified flood prone areas for several hours depending on the duration and intensity of rainfall. Flooding is normally aggravated during high tide particularly during inclement weather condition.

The foregoing flood scenario is without the proposed project fronting the fishponds where the area is open and no structures built to alter the natural behavior of sea water particularly during inclement weather condition. With the project, there could be some positive and negative impacts as far as flood situation is concerned. Mitigating measures have to be formulated to address the negative environmental impacts as a result of the project.

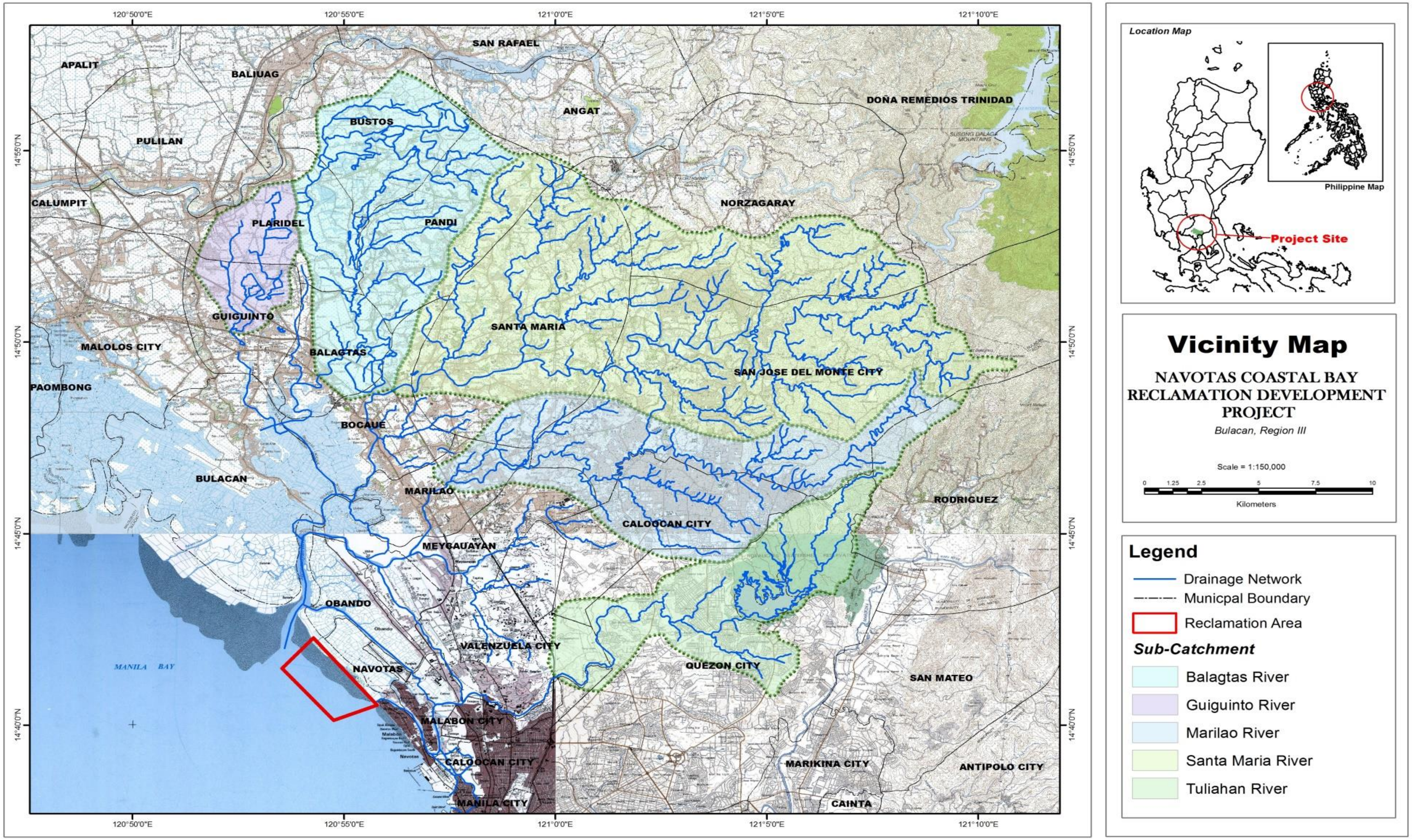


Figure 2-39 Watershed Map

2.2.1.1 Methodology

The following outline of major work elements was used for the conduct of the said undertaking. The outline is intended to establish the general scope and content of the activities to determine the extent of flooding and inundation of the flood areas fronting the proposed reclamation area and the effects of the project on the flood prone areas of Navotas, Malabon, Obando and Meycauayan, Bulacan.

Collection/collation of available secondary information

The activities may include but not limited to: collection of available rainfall data near the project site (Quezon City, Navotas and Caloocan, etc.), geohazard maps (flood susceptibility maps including depth of inundation, etc.), topographic maps (maps (scale 1:50.000) of Meycauayan, Navotas, Obando, Sta. Maria, Caloocan, and Novaliches, Quezon City), historical daily, monthly and peak flow data of gaged rivers near the proposed project.

Delineation of sub-watersheds of major rivers draining to the project area

The identified major river systems that drain to the proposed project are Guigunito River, Balagtas River, Sta. Maria River and Marilao River of Bulacan province, and Tullahan River of Quezon City. These river systems were delineated using GIS software as a requisite in the flood frequency analysis and other hydrological analysis.

Actual site assessment/investigation of rivers and areas frequently flooded

This activity includes: a) assessment of type and hydrological behavioral flow of fluvial systems and other natural drainage waterways near the project site; b) Identification of remnants of flood level on the site left by previous flood/s; and c) Interviews with local people residing near and within the vicinity of rivers particularly those who actually witnessed the occurrence of large flood events like typhoon Ondoy and other major typhoons that visited the country. Information to be obtained includes; approximate depth, extent and duration of inundation, areas covered by flood waters, etc.

Figure 2-40 presents pictorials taken on the areas visited during the assessment.

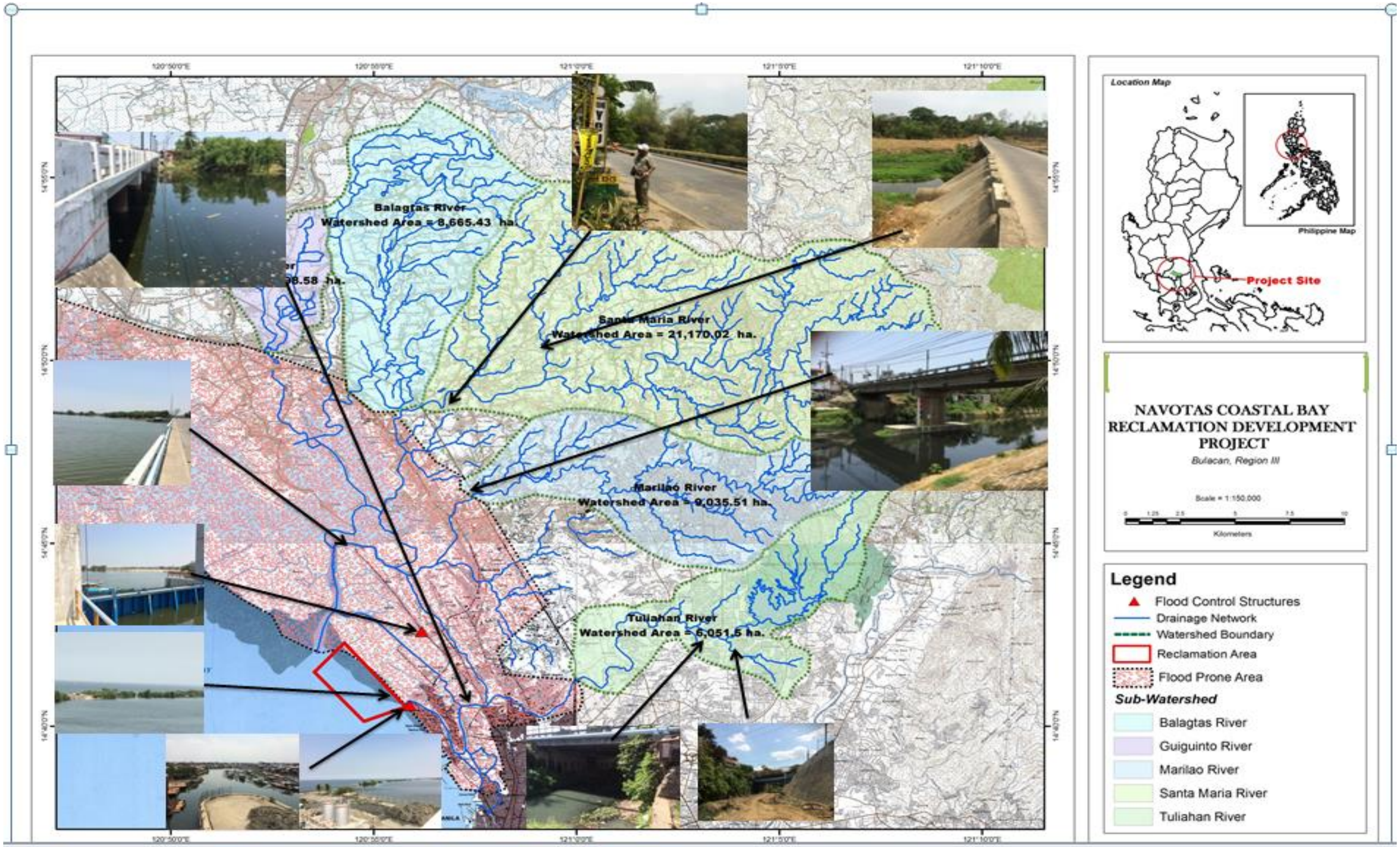


Figure 2-40 Field Assessment

Flood analysis

The procedures adopted are the following:

a. Using the NAMRIA topographic maps with the scale of 1;50,000 and geo-hazard maps prepared by MGB-DENR and information obtained during site investigations delineate areas prone to flooding;
b. Determine other possible factors that contribute to flooding and inundation such obstruction of the flood flows (natural or man-made), emergency release of flood waters from reservoirs, rise of sea level or high tide;
c. Conduct Point/Regional flood frequency analysis to determine flood peaks with different return periods (5, 10, 25, 50, 100,.200, 500 and 1000-year) of five (5) major rivers draining to the project;
d. Estimate the flood value resulting from typhoon Ondoy by converting the hourly rainfall data of Quezon City Science Garden using the empirically developed method of approximation; and
e. Estimate the depth and possible elevation of inundation for 100 and 200-year return period flood on areas prone to flooding and delineate this on the NAMRIA map with a scale of 1;50,000.

2.2.1.2 Hydrological analysis of flooding

2.2.1.2.1 Climate and frequency of tropical cyclone

The project site falls within Type 1 climate (Figure 2-41) characterized by two pronounced season, dry from November to April and wet during the rest of the year, Maximum rain period is from June to September. The frequency of tropical cyclone passing the area is relatively high at 16 percent.

2.2.1.2.2 Rainfall pattern

Rainfall data that are near or within the watershed of the five rivers were collected. Rainfall data obtained in Navotas and Caloocan are Agromet stations while rainfall station located Science Garden, Quezon City is synoptic. All stations are operated by PAGASA. The Navotas and Caloocan rainfall stations started to operate in 1972 and 1975, respectively. Both stations ceased to operate in 1980. On the other hand, the Science Garden rainfall station started its operation 1961 up to the present. The mean monthly and the maximum monthly rainfall of the three (3) stations are shown in the Table 2-10, Table 2-11 and Table 2-12. The mean and the maximum rainfall values of each station were plotted against month to depict the pattern of the stations. The result is shown in Figure 2-42, Figure 2-43 and Figure 2-44.

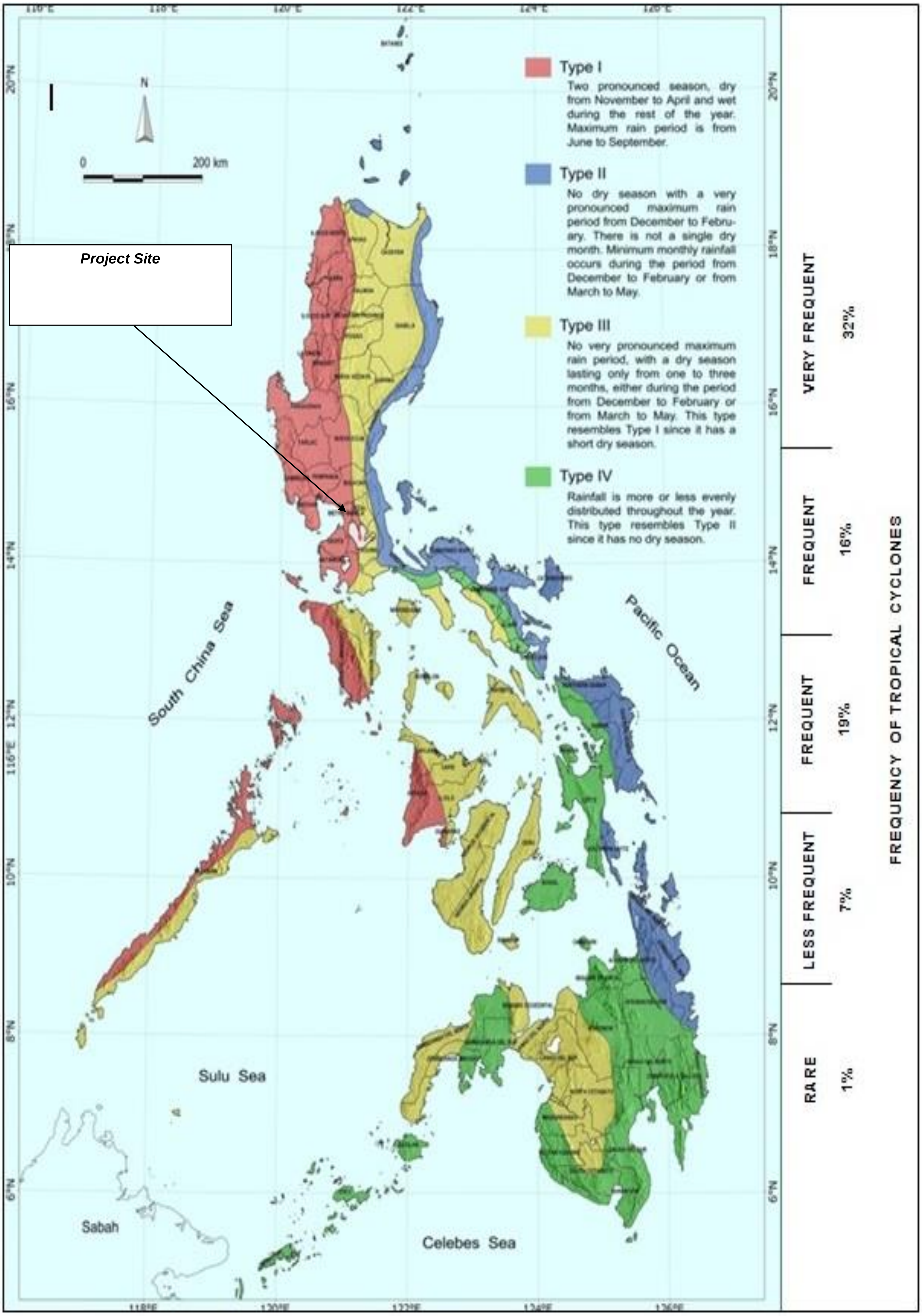


Figure 2-41 Climate Map of the Philippines

Table 2-10 Mean monthly rainfall Navotas rainfall station (1972-1980)

MONTH	Rainfall. mm	
	Mean	Maximum
January	16.1	65
February	5.9	10.2
March	28.1	116.2
April	15.6	55
May	126.4	362.3
June	288.6	538.3
July	592.3	1656.9
August	594.8	831.6
September	355.3	568.9
October	265	643.3
November	142	321.9
December	17.9	28.4
ANNUAL	2449	

Table 2-11 Mean monthly rainfall Caloocan rainfall station (1975-1980)

MONTH	Rainfall. mm	
	Mean	Maximum
January	19.4	64.8
February	6.1	13.7
March	25.6	95.3
April	37.7	120.7
May	345.5	1124.9
June	235	354.2
July	389.4	618.8
August	530.3	846.1
September	440.7	709.2
October	276.1	771
November	122.4	256
December	65.1	238
ANNUAL	2493	

Table 2-12 Mean monthly rainfall Science Garden rainfall station (1984-2013)

MONTH	Rainfall. mm	
	Mean	Maximum
January	41.6	155.3
February	33.2	128.6
March	61.2	195.5
April	40.3	358
May	217.8	327.7
June	392.8	724.7
July	442.5	886.4
August	645.9	1387.2
September	565.2	1123.5
October	292	534.4
November	153.9	284.6
December	87.3	219.9
ANNUAL	**2973.3**	

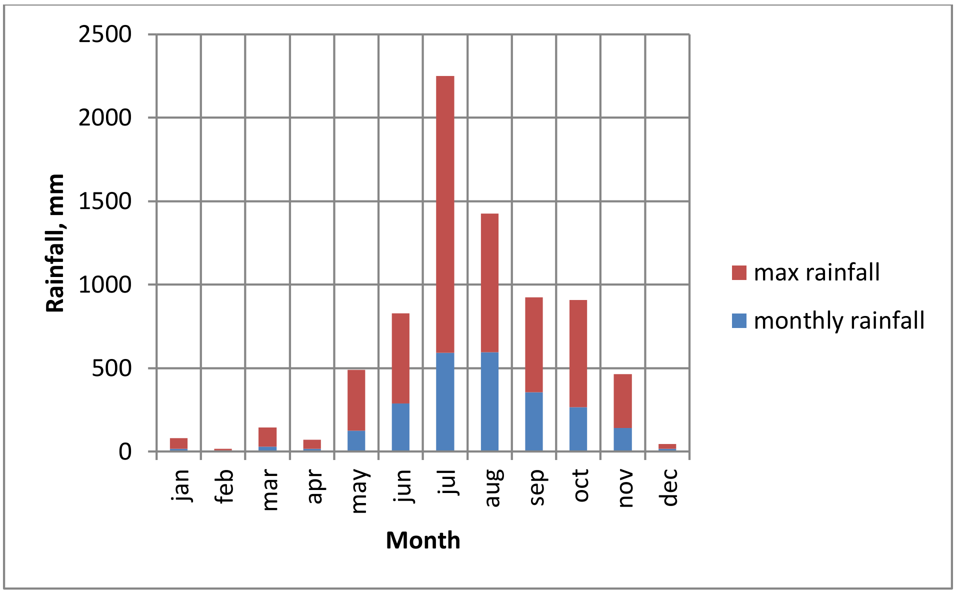


Figure 2-42 Rainfall pattern in Navotas, Metro Manila

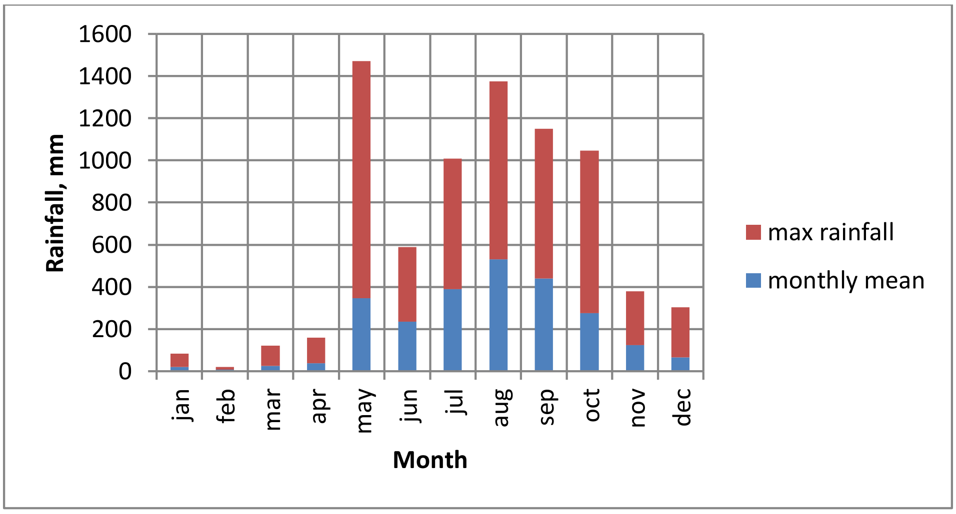


Figure 2-43 Rainfall pattern in Caloocan City, Metro Manila

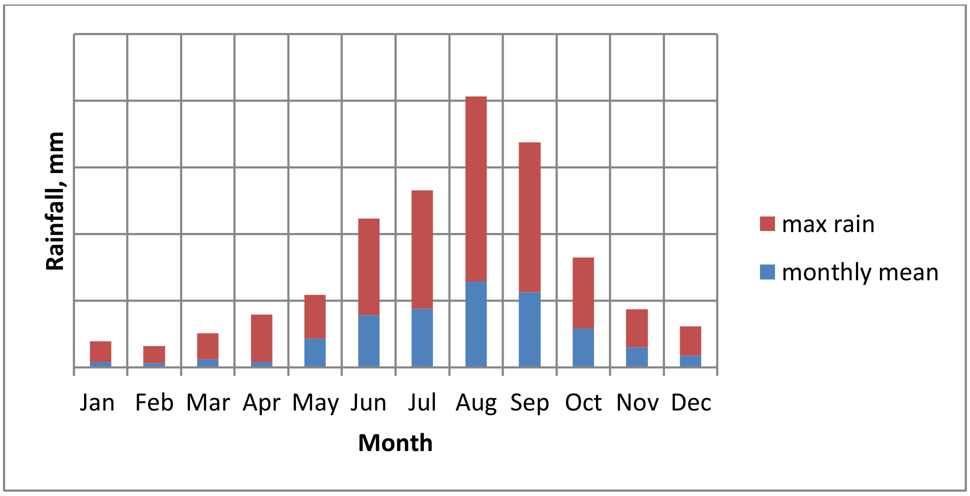


Figure 2-44 Rainfall pattern in Science Garden, Quezon City, Metro Manila

Typhoons or tropical cyclone crossed the Philippine Area of Responsibility (PAR) on the average of 19.8 typhoons per year. Most of the typhoons that visited the country brings heavy rains that resulted to large floods that damaged agricultural crops, damaged to life and properties costing several millions or billions of pesos

The most recent catastrophic flood occurred in Metro Manila is brought by Typhoon “Ondoy” which hit the country on September 26, 2009. Based on the rainfall data obtained from the Science Garden PAGASA rainfall station, rainfall started at around 12 midnight and intensified on the succeeding hours and at around 4:00 am; after 4 hours of continuous heavy rains, it accumulated a total rainfall depth of **229.50 mm**. This amount of rainfall generated a flood with a magnitude of **5,328 cms** over the 499 square kilometer (sq.km.) Marikina River watershed area. This extra-ordinary flood corresponds to about 150 to 200 years return period or recurrence interval. At around 8 am, 8 hours after, it registered a total amount of **406.50 mm**. The amount of rainfall generated a flood flow of **5,300 cms** equivalent also to 150 - 200- year flood. The extreme flood event inundated, damaged and devastated structures, properties and claimed thousands of lives, particularly of those residing within the flood plain areas of Marikina valley which are prone to flooding. Table 2-13 shows the rainfall depth at Science Garden, Quezon City generated by typhoon “Ondoy” on September 26, 2009.

Table 2-13 Rainfall amount in mm during Typhoon Ondoy on September 26, 2009

Time	Rainfall, millimeter (mm)
0000 – 0100	6.0
0101- 0200	49.5
0201 – 0300	82.0
0301 – 0400	92.0 (**229.50**)*
0401 – 0500	55.0
0501 – 0600	63.0
0601 – 0700	40.0
0701 – 0800	19.0 (**406.50**)**
0801 – 0900	6.5
0901 -1000	11.0
1001- 1100	12.5
1101- 1200	12.0 (**448.5**)***
1201- 1300	0.0
1301- 1400	2.0
1401- 1500	4.0
1501- 1600	0.0
1601- 1700	0.5
1701- 1800	0.0
1801- 1900	0.0
1901- 2000	0.0
2001- 2100	0.0
2101- 2200	0.0
2201- 2300	0.0
2301-2400	0.00
TOTAL	**455.0 mm**

Source: PAGASA Forecasting Center

Legend: * total rainfall after 4 hours
** total rainfall after 8 hours
*** total rainfall after 12 hours

The catastrophic effects of Typhoon “Ondoy” that generate heavy rains and large floods was felt by the residence who are residing within the watersheds of five rivers between 12:00 –

1:00 pm, September 26, 2009. Based on the account of the local people residing near the river during interviews, water level rises to over 3 meters and subsided 6 hours later. Generally, the same information we received on people residing near the river and within the flood prone areas. The rainfall depth accumulated for a duration of 4 hours (**229.50 mm**) and 8 hours (**406.5 mm**) were transposed to the five watersheds and estimated the rate of flow or volume per unit time or discharge using the Empirical equation shown below.

$$Qi = \frac{0.011574\ (DA)\ (R_f)\ (R_c) + B_f}{N_{dm}}$$

Where:
- Qi = discharge in cubic meters per second (cms)
- DA = drainage area of the river of interest, sq. km.
- R_f = rainfall in a given given day within or near the project area in mm
- R_c = runoff coefficient (50%-70 %.)
- B_f = base flow (varies from month to month)
- N_{dm} = no. of hours/days

The rate of flow or discharge was converted into depth of water spread uniformly over the entire watershed (Table 2-14). Further, a Regional Flood Frequency analysis for the five rivers was performed to determine the flood flows at different return period. The resulting peak flow calues were multiplied by 6 percent (6%) to account for climate change. The result of the analysis is depicted in Table 2-15.

Table 2-14 Accumulated rainfall depth in mm generated by Typhoon Ondoy

Return period, yr	Accumulated depth of rainfall (mm)/duration	Balagtas River, DA =87 Km^2	Sta. Maria River, DA= 212 km^2	Marilao River, DA=90 km^2	Tullahan River.DA= 61 km^2	Total Depth (m)
200	229.5 mm (4-hour duration), peak Q	1,689 cms	961 cms	750 cms	942 cms	3.61 m
200	229.5 mm (4-hour duration, depth (m)	0.92 m	0.67 m	0.91 m	1.06 m	
200	406.5 mm (8-hour duration, peak Q	920 cms	1,615 cms	952 cms	749 cms	3.57 m
200	406.5 mm (8-hour duration), depth (m)	0.94 m	0.66 m	0.91m	1.06 m	

Table 2-15 Flood peak in cms values of five rivers estimated by Regional Flood Analysis

	Guiguinto River, DA=22 km^2			Balagtas River, DA =87 Km^2	Sta. Maria River, DA= 212 km^2	Marilao River, DA=90 km^2	Tullahan River.DA= 61 km^2	
Return period, yr		Q peak. cms						
MAF	Cv1	83	Cv2	194	336	198	156	
5	1.39	115	1.39	270	467	275	217	
10	2.13	177	1.91	371	642	378	298	
25	3.22	267	2.8	543	941	554	437	
50	3.85	320	3.22	625	1082	638	502	
100	4.95	411	3.88	753	1304	768	605	
200	6.4	531	4.75	922	1596	941	741	
500	8.54	709	5.79	1123	1945	1146	903	

	Guiguinto River, DA=22 km^2			Balagtas River, DA =87 Km^2	Sta. Maria River, DA= 212 km^2	Marilao River, DA=90 km^2	Tullahan River.DA= 61 km^2	
1000	11.00	913	6.4	1242	2150	1267	998	
Runoff depth (meter)								Total depth (m)
100		1.6 m		0.75 m	0.53 m	0.7 m	0.86 m	2.82
200		2.05 m		0.9 m	0.65 m	0.90 m	.90 m	3.45

The five major rivers significantly contribute to the flooding problems on low-lying areas of the Bucaue, Guiguinto, Marilao and Meycauyan of Bulacan province,and Obando,Malabon and Navotas of Metro Manila. The Guiguinto River and Balagtas River upon reaching the level areas of the municipality of Guiguinto during flood events overtaps river banks due to shallow river sections and gentle and flat river gradient. The excess water laterally spreads ad inundate level areas for several hours. The Sta, Maria River and Marilao River floods and inundate part of the level lands of Marilao and Meycauayan. Its contribution to flooding is significant due to its large watershed area. The four rivers merge at Obando before discharging to Manila Bay. Due to level to nearly level terrain intermittent stream will form creating a network of streams that connects major rivers. If no obstruction on the mouth and its vicinity water will spread to the sea like a fan. Simultaneously, deposition of fine sediments is also unimpeded and also spread like a fan. Without obstruction at the mouth of the river and the sea flood waters may recede faster length of the rivers to lower flood level On the other hand Tullahan River is the lone river that discharges to Navotas and Malabon. The head water of the river originates at the La Mesa dam and reservoir. The outlet of the reservoir is the Tullahan River, and whenever the reservoir releases water during inclement weather condition, people residing on the flood plains of the river and at the downstream flat lower portion of the watershed will be affected by flood waters. Just like Obando River if the flow of the river is unobstructed at the mouth and at the sea, floods waters will spread freely like a fan in the sea. The same situation of the sediments that the flood waters carry, it will settle at the sea bed forming like a fan.

The result of the regionalized approach for the 100 and 200-year return period flood (excluding Guiguinto River) indicates that the total depth of flood waters is over 2 and 3 meters, respectively. These are the depth of water that will inundate the flood prone areas having a total area of about 200 square kilometers (sq. km.)

In the Typhoon “ONDOY” scenario the accumulated rainfall depth when estimated to occur over the four rivers using the empirical approach yielded a flood peak value of a 200-year return period flood (Table 2-14). The rate of flow when converted to runoff depth (over 3 meters) is almost the same value obtained from the regionalized approach (Table 2-15).

The flood hazard map prepared by MGB indicates depth of flood waters for 100-year return period over the flood prone areas (Figure 2-23). The basis for the map is the morphology of the rivers and its environs. The result of the flood study for the proposed project is almost the same as shown in (Figure 2-45).

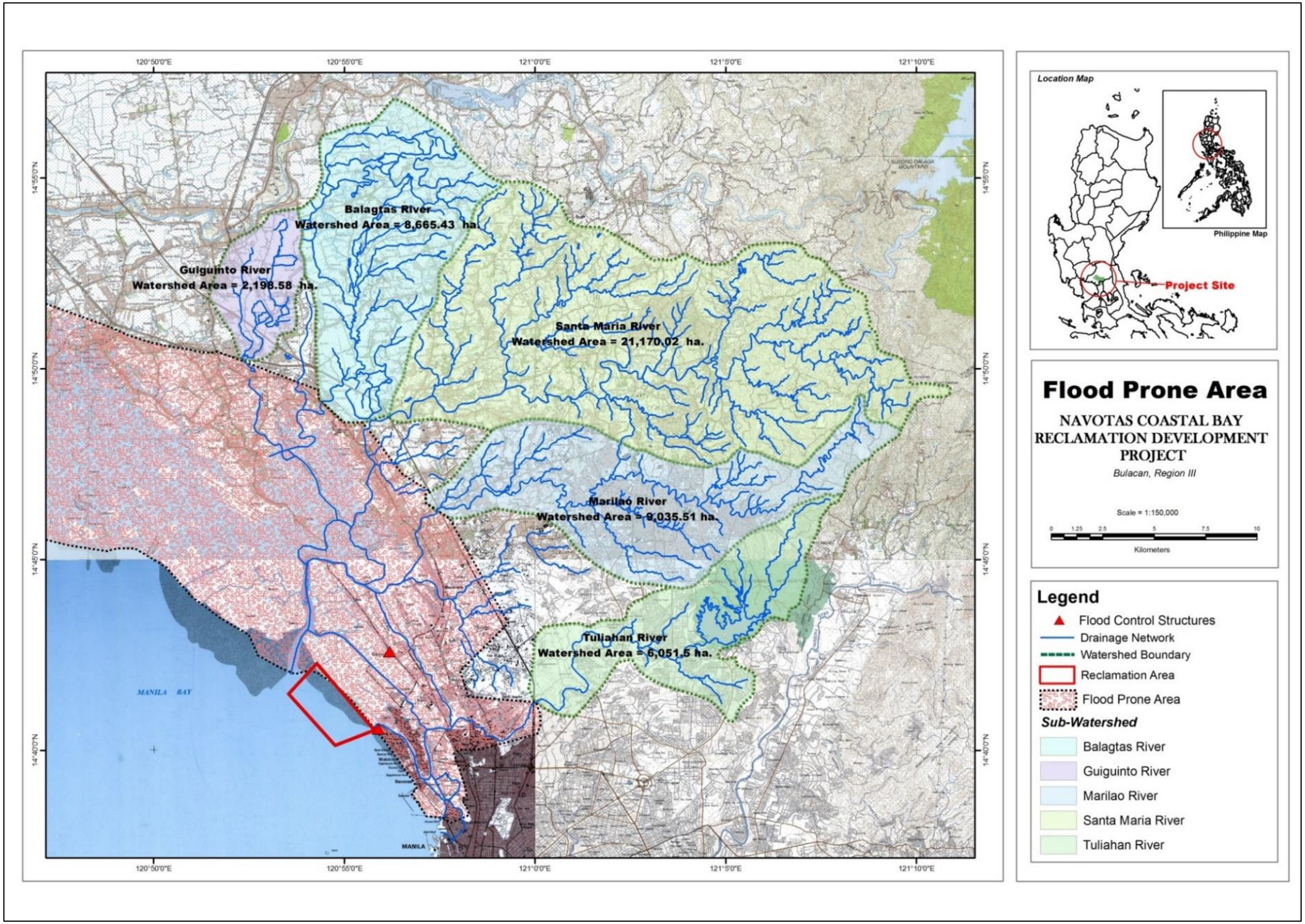


Figure 2-45 Flood Prone Area Map

2.2.1.3 Potential impacts and options for prevention, mitigation and enhancement

2.2.1.3.1 Flood and Backwater Studies

Methodology

The MIKE11 hydraulic model is used to assess the efficiency of the hydraulic design of the drainage system. Synthetic time varying discharge (upstream) and tidal water levels (downstream) are applied as forcing to the model based on relevant design scenarios. The MIKE 11 hydrodynamic module (HD) uses an implicit, finite difference scheme for the computation of unsteady flows in rivers and estuaries. The module can describe sub-critical as well as super critical flow conditions through a numerical scheme which adapts according to the local flow conditions (in time and space).

Advanced computational modules are included for description of flow over hydraulic structures, including possibilities to describe structure operation. The computational scheme is applicable for vertically homogeneous flow conditions extending from steep river flows to tidal influenced estuaries. The system has been used in numerous engineering studies around the world and is very much suitable for the scope implemented under the present study.

The flooding and backwater studies have for objective to quantify changes in the existing channels that might be associated with the development. The analysis will be performed for:

- The major channels directly connected to the Kailugan River (i.e. Muzon-Dampalit and Navotas Rivers) and within the model domain
- Comparison of water levels before and after development along the channel profile using 1 dimensional model simulations
- A number of hypothetical scenarios where each scenario is defined as a combination of river discharge from Navotas, operating rules of the flood gates and pumps, sea level and project design.

River Model Setup Using MIKE 11

With the data provided, a river network is setup as shown in Figure 2-46. In this approach, the study area is schematized in MIKE 11 based on the cross sections extracted. Upon digitizing the network in MIKE 11, the network is calibrated before the scenario setup and execution. It is to be noted that for calibration the full set of datasets, namely, observed water levels and discharges, tide levels, gate operations, for each rainfall events have to be available. In addition, the areal rainfall for the model should ideally be derived from a network of rain gauges within the catchment or from ground-truth rainfall radar measurements. Since the data requirements for calibration could not be met fully, an alternative approach is used to calibrate the network to match the peak discharges based on a designed rainfall event with 10 year return period as given in Figure 2-47.

It is this approach that is employed for the present study. The river model includes the discharge input from South Pinagkabalian and Spine. Also, a water level boundary in Batasan River was assigned to reflect the river draining out from the river model towards Meycauayan River. A tidal water level will be assigned due to the point’s proximity to Manila Bay.

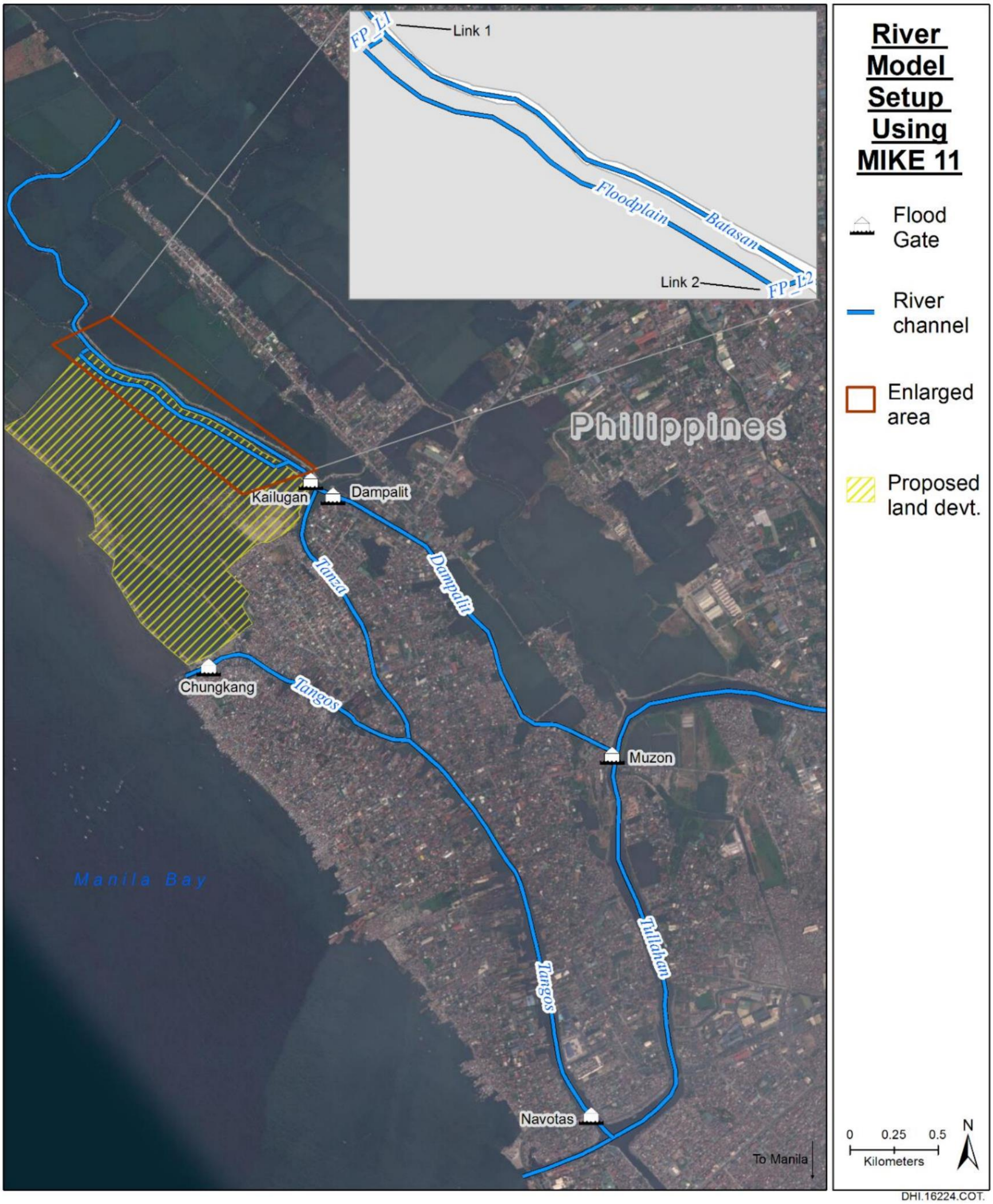


Figure 2-46 River network setup used in MIKE 11 Model

Design Drainage Discharge of 10-year Return Period

	Drainage Area	Peak Discharge (m^3/s)
(1)	Maypajo	45.8
(2)	Spine	40.2
(3)	Bangkulasi	13.9
(4)	Longos	25
(5)	Catmon	52.0
(6)	Navotas	154.4
(7)	Muzon	33.5
(8)	South Pinagkabalian	45.2
(9)	Maysilo (Panghulo)	22.2
(10)	Kailugan	N/A
(11)	Chungkang	37.8
(12)	Pinagkabalian	18.6
(13)	Dampalit	34.5

Figure 2-47 Peak design discharge of 10-year return period

In view of the objective of this study, the above approach is acceptable since the focus is on the changes to the water level in the river when the platform of the study area has been raised due to the intended land development.

Figure 2-48 shows the (10-year return period) rainfall input and the corresponding runoff generated from the rainfall-runoff model. Similar shape of hydrographs is generated using 25-year return period and 50-year + 21.3% climate change increase, of which their corresponding peaks are summarized in Table 2-16. The peak of runoff at L2 coincides with the peak water level (10-year surge plus tide), as shown in Figure 2-49.

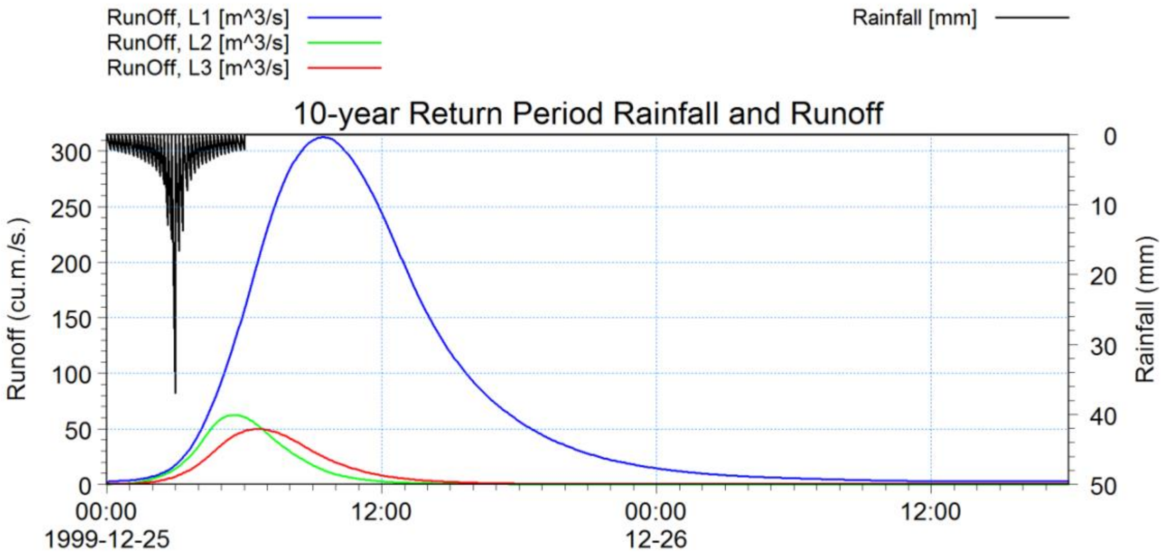


Figure 2-48 10-year return period (RP) of rainfall and corresponding runoff of three catchments from the rainfall-runoff model

Table 2-16 Summary of peak rainfall and runoff of three catchments

Design Rainfall	Peak Rainfall (mm)	Peak Runoff L1 (cmps)	Peak Runoff, L2 (cmps)	Peak Runoff, L3 (cmps)
10-yr RP	36.97	312.48	62.60	49.84
25-yr RP	44.00	419.31	80.52	65.40
50-yr RP + 21.3%	59.70	581.24	111.02	90.42

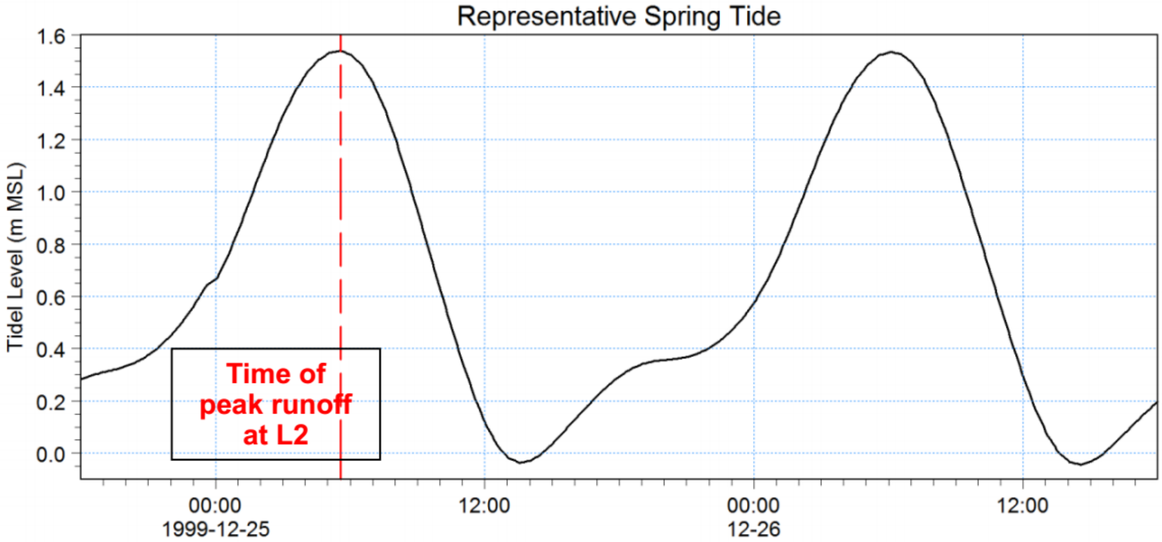


Figure 2-49 10-year return period (RP) of tide input coinciding with peak runoff

Model Verification

Figure 2-47 was verified by DHI to ensure that the modelling work involving extreme events were based on parameters which could be utilized with the upmost confidence.

Figure 2-50 shows the four sub-catchments, delineated from DEM data, which are draining in the river network. However, M1 was removed from the model since it is assumed to drain at the adjacent bigger Meycauayan River system. The runoff from the sub-catchments will be calculated using MIKE 11 Rainfall-Runoff (RR) module. The module uses Unit-Hydrograph Method (UHM) by SCS method, with parameters defined in Table 2-17.

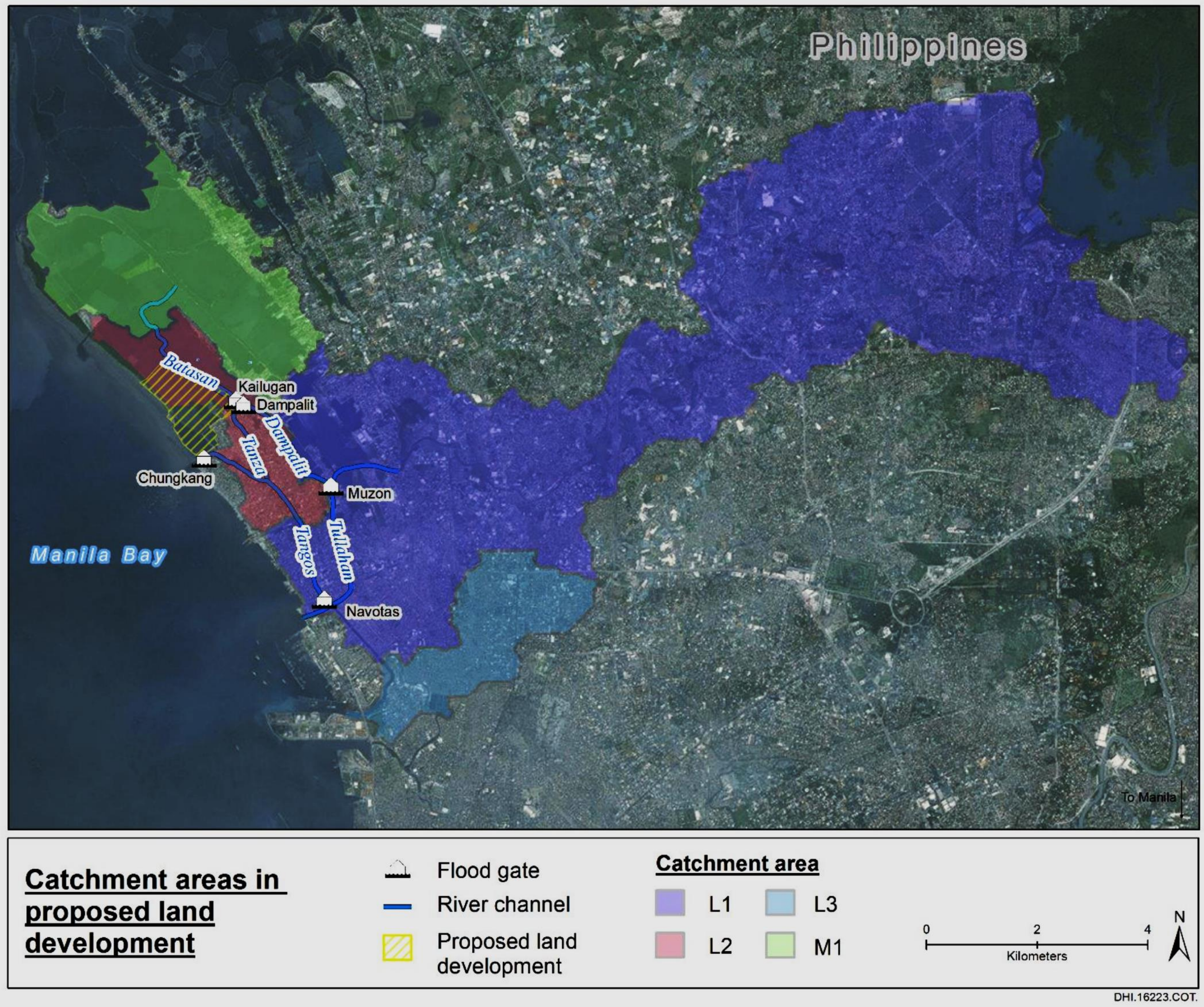


Figure 2-50 Delineated catchment maps draining to the river network

Table 2-17 Rainfall-runoff model parameters

Name	Baseflow (cmps)	Runoff Coefficient [-]	Hydraulic Length (m)	Slope (%)	Curve Number [-]
L1	2.95	0.81	28	3.29	81
L2	0.27	0.9	6	0.94	90
L3	0.3	0.8	7.11	1.28	80

Baseflow is estimated to be 0.05 cmps for every km^2 of catchment area, given in Manual on Flood Control Planning [p. 45, DPWH & JICA, 2003]. Runoff coefficient is based on weighted average between fish ponds (runoff coefficient = 1) and high urban areas values (0.8; p. 26 Manual on Flood Control Planning). The hydraulic lengths and slopes are calculated during basin delineation, while the SCS curve numbers are 10 times the runoff coefficient.

Calibration Results and Analysis

The calibration process mainly involves the adjustment of Manning's coefficient, n, of some parts of the river branches. The ranges of n commonly used in hydrodynamic modelling are given in Table 2-18. From the Table, the model area is set to n=0.05, reflective of natural streams with some debris. The downstream end of Tullahan has high n to account for urban debris in the estuary area; and the whole stretch of Dampalit has slightly higher n to account for more sluggish flow in the area.

Table 2-18 Manning's n for channels (Chow, 1959)

Type of Channel and Description	Minimum	Normal	Maximum
Natural streams – minor streams (top width at floodstage <100 ft)			
Main Channels			
a. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. Same as "d" with more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150

The catchment run off outputs from the Rainfall-Runoff model are shown in Figure 2-51. From the given peak values generated using 10-year rainfall event, the discharge at South Pinagkabalian is estimated to be 14% of the runoff from L1, and Spine is estimated to contribute 80% of L3 to Tullahan. Figure 2-52 shows the discharge hydrographs at the remaining three calibration points (Navotas, Muzon and Dampalit) in comparison with the target 10-year peak discharge.

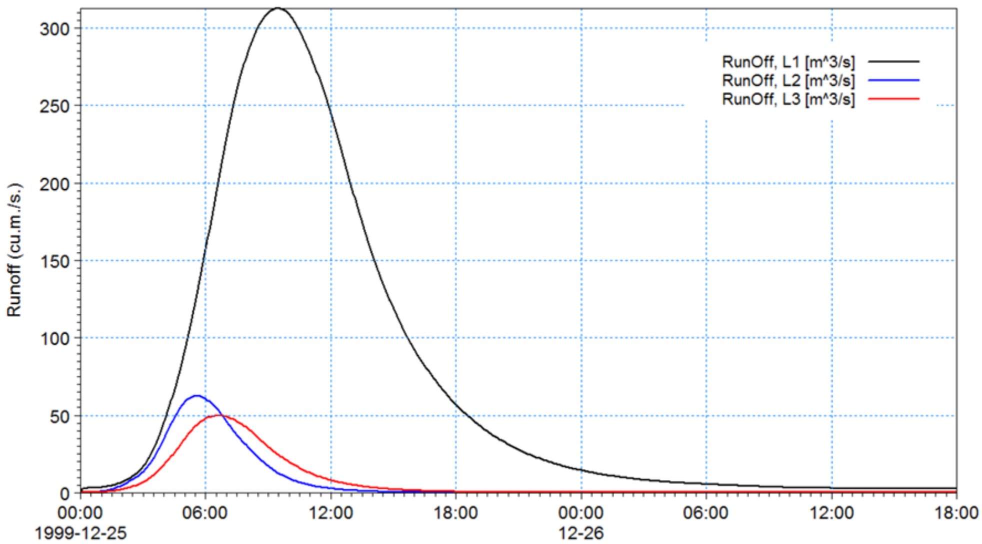


Figure 2-51 Runoff from 3 sub-catchments in the study area generated from MIKE11 RR module

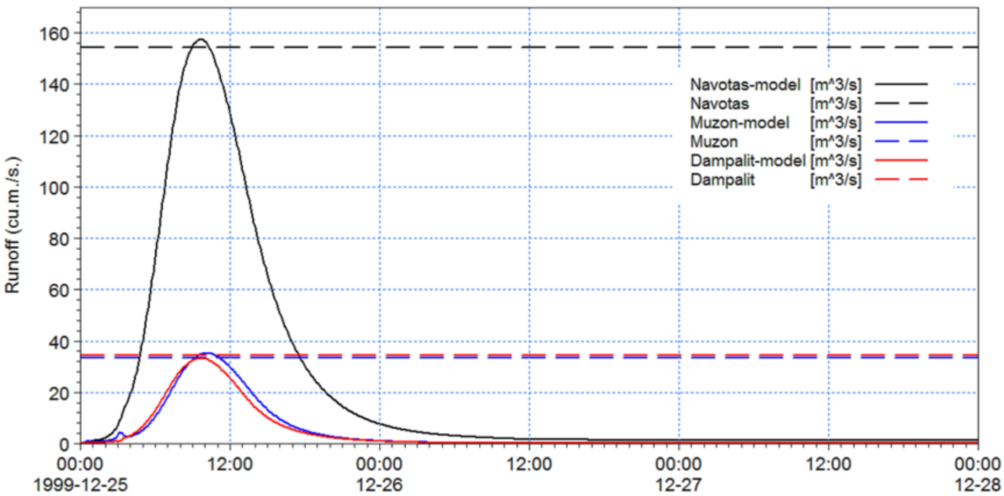


Figure 2-52 Discharge at three points in the MIKE11 river model coinciding with calibration points. Target peak values are indicated by red dashed lines.

The model results at the various discharge points compared to the peak discharges provided in the DPWH study are summarized in the table below.

Table 2-19 Summary of runoff results

S/N	Calibration points	Discharge Values from DPWH (cmps)	Discharge Values from Model (cmps)	Difference
1	South Pinagkabalian	45.2	43.7	-3.30%
2	Spine	40.2	39.9	-0.70%
3	Navotas	154.4	157.5	2.00%
4	Muzon	33.5	33.3	-0.70%
5	Dampalit	34.5	35.2	2.10%

Modelling Scenarios

Table 2-20 summarizes the scenarios that are conducted for evaluating the impact of the future reclamation project on the capacity of the existing river network, including additional two scenarios using constant mean sea level (MSL) as water level boundary. Succeeding scenarios use mean high-high-water-spring (MHHWS) with 10-yr return period surge levels estimated from previous models. The last scenarios are designed to simulate worse-case scenarios that includes 21.3% increase of rainfall value reflecting climate change projections in Metro Manila for year 2050 (PAGASA, 2011) and with gates fully, partially or not operational.

Table 2-20 Designation for twelve scenarios

Design Rainfall	Design Tide Level	Gate operation	Baseline	Post Development
10-yr RP	0-constant MSL	All gates operational	SC01	SC02
10-yr RP	MHHWS + 10-yr RP Surge	All gates operational	SC03	SC04
25-yr RP	MHHWS + 10-yr RP Surge	All gates operational	SC05	SC06
50-yr RP + 21.3%	MHHWS + 10-yr RP Surge	All gates operational	SC07	SC08
50-yr RP + 21.3%	MHHWS + 10-yr RP Surge	All flood gates open (operation failure)	SC09	SC10
50-yr RP + 21.3%	MHHWS + 10-yr RP Surge	Kailugan, Dampalit and Muzon gates open (operation failure)	SC11	SC12

Results and Analysis

The backwater effects of the land development project are evaluated by water level comparisons at the nearby Navotas urban area. Water level time series at specific result points (Figure 2-59) are presented in the following pages. At Batasan River and the floodplain (Figure 2-53 and Figure 2-54), water levels are influenced mostly by the tides because the operating gates prevent much of the runoff to the area. In fact, there is no water flowing to the floodplain when there is no tide input. Only when all or some of the gates are opened does rainfall raise the water levels in Batasan. Comparison between scenarios show that, except for the worst-case scenarios, the raising of the floodplain does not have significant impact on the water levels in the area.

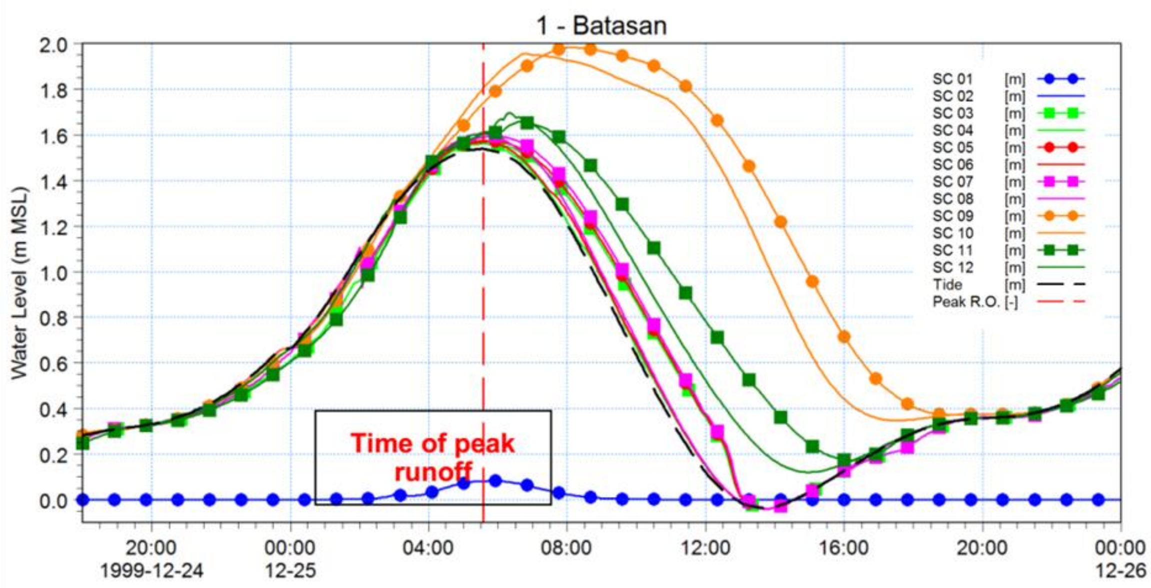


Figure 2-53 Time series of water levels at Batasan

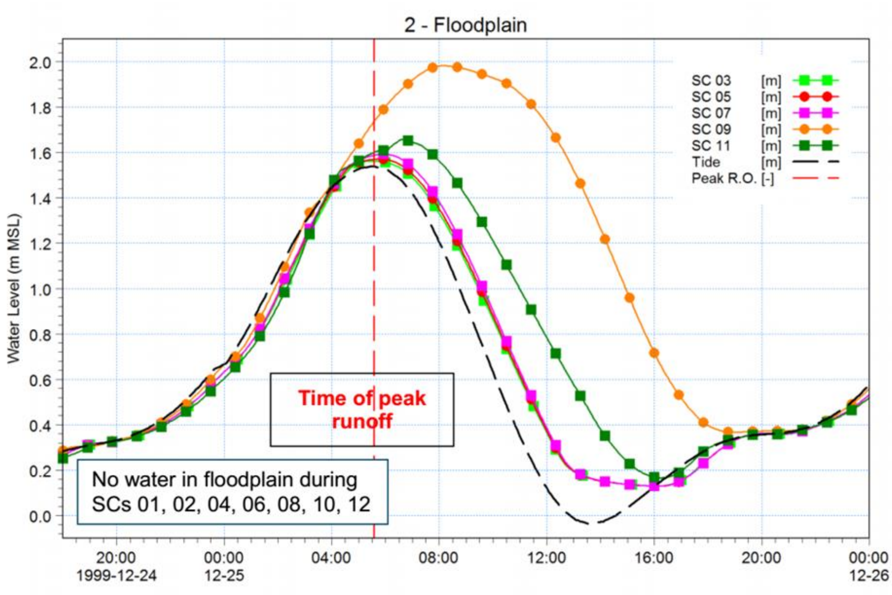


Figure 2-54 Time series of water levels at the development flood plain area

In Dampalit (

Figure 2-55), Kailugan and Dampalit flood gates blocks much of the tide from infiltrating upstream, so the raising of the floodplains have minimal effect in the area. Except when all or some of the gates are opened, the runoff from the bigger Tullahan River are also blocked. Slightly different results are observed in Tanza (Figure 2-56), where there is a slight increase of water levels when the floodplains are taken out and the gates are partially or non-operational. This is also observed in Tangos/Navotas River (Figure 2-57) but to a smaller degree. Tullahan River (Figure 2-58) is mostly unaffected by the changes in the floodplain at Batasan.

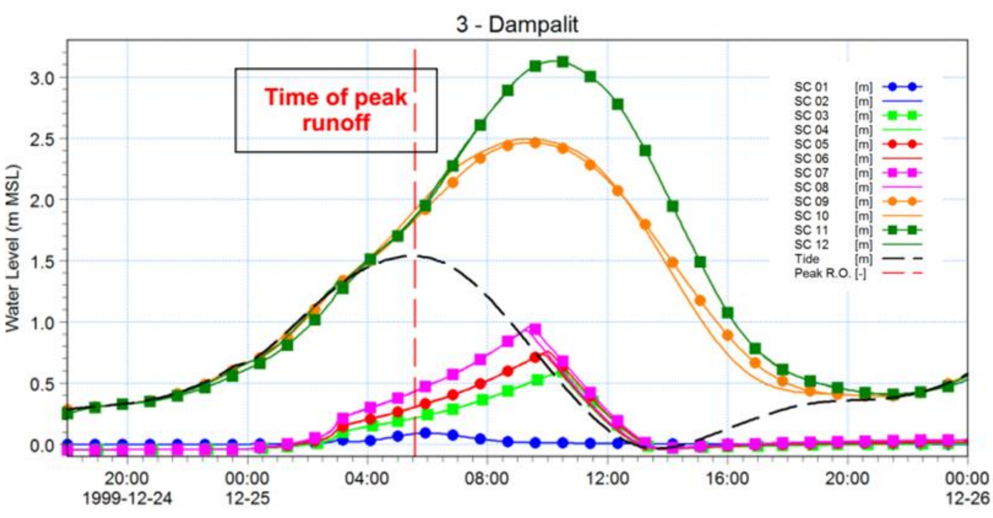


Figure 2-55 Time series of water levels at Dampalit

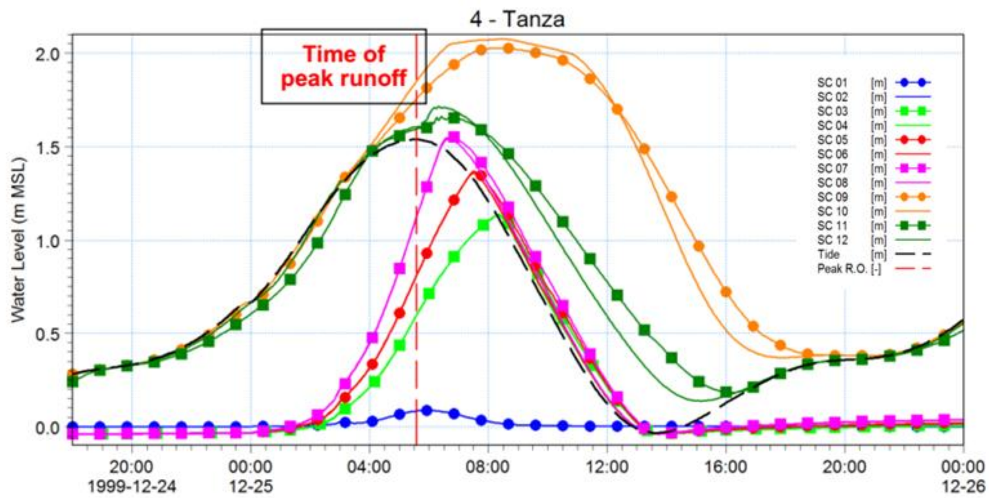


Figure 2-56 Time series of water levels at Tanza

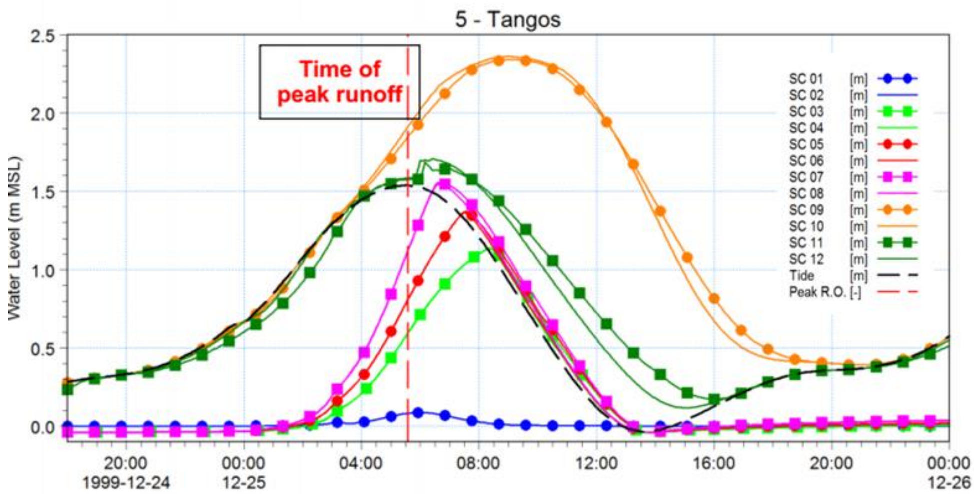


Figure 2-57 Time series of water levels at Tangos

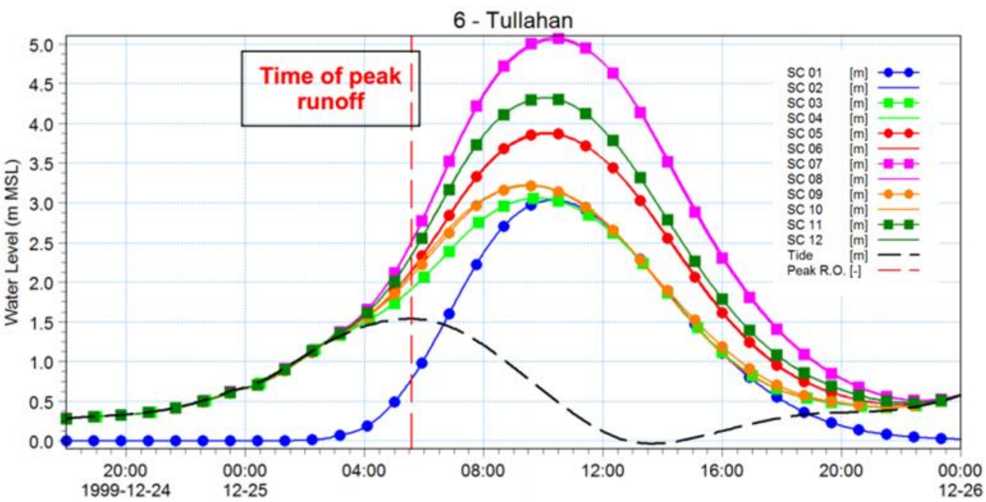


Figure 2-58 Time series of water levels at Tullahan

A summary of the differences of peak water levels between baseline and future scenarios are illustrated in Figure 2-59, which shows a difference of ±5 cm at the most over the range of events simulated. From these comparisons, it is safe to assume that there is little backwater effect when the floodplains are raised by the reclamation project, especially when the gates are fully functional at the time of flooding event.

Figure 2-59 Difference of peak water levels between baseline and future scenarios. Partially and non-operational flood gate scenarios are highlighted in red

A general overview of the floodwater flow direction are shown in Figure 2-60 which plots the flow paths of Scenarios 11 and 12, when all gates are non-operational. In the case seen in Scenario 11 (Baseline), the current land development area helps impede the tidal waters from coming into the river network, hence the change of flow paths in between Batasan River. Comparison to the flow paths in Scenario 12 shows that when the proposed land development area is raised up to 2.5 m, tidal waters flows all along Batasan River, but has little influence to other rivers in the area.

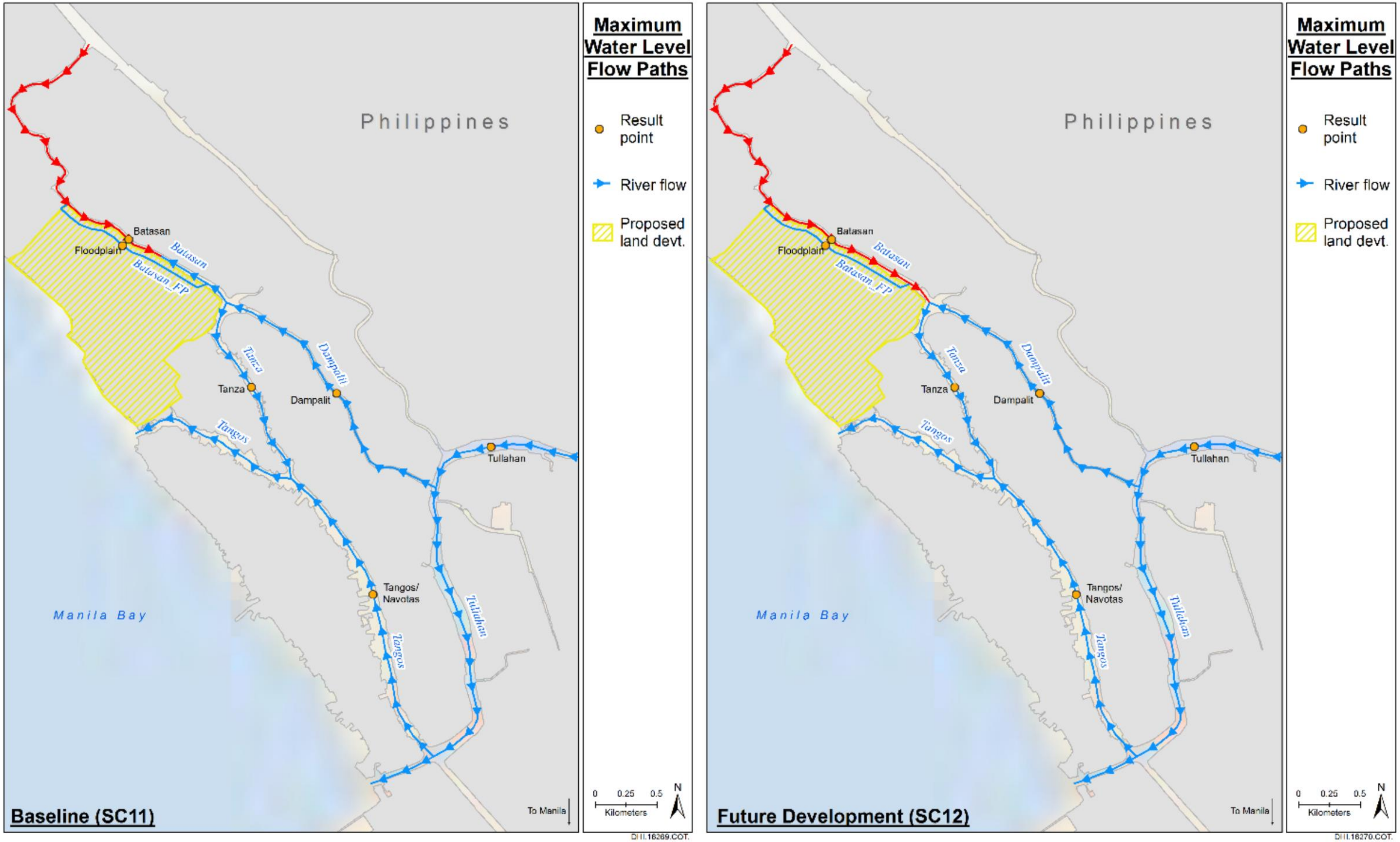


Figure 2-60 Flow paths during maximum water level at worst case scenarios: SC11 (baseline) and SC12 (future development).

The backwater influence of the development is relatively minor. In spite of the development removing the existing flood plain, the resulting increase in water level during extreme events has a maximum magnitude of 0.05m for the scenarios analyzed.

2.2.1.3.2 <u>Flushing Study</u>

Background

The City of Navotas proposed to develop the waterfront of Navotas by reclaiming approximately 576.7 ha of land along the coastline of and within the territorial and geographical jurisdiction of the City of Navotas, Philippines.

It is envisioned that the area would be developed primarily as an industrial complex that includes other mixed used developments of commercial, residential, institutional, port or port related facilities and tourism establishments

The existing shoreline behind the proposed reclamation profile encompass fringes of mangrove, which were observed to be denser along the northern side of the profile as compared to the southern end, and broken seawall. Hence, a channel was intended to be maintained as part of the proposed reclamation plan to preserve and minimize any potential impact to the existing mangrove fringe along the shoreline. Figure 2-61 on the planned channel.

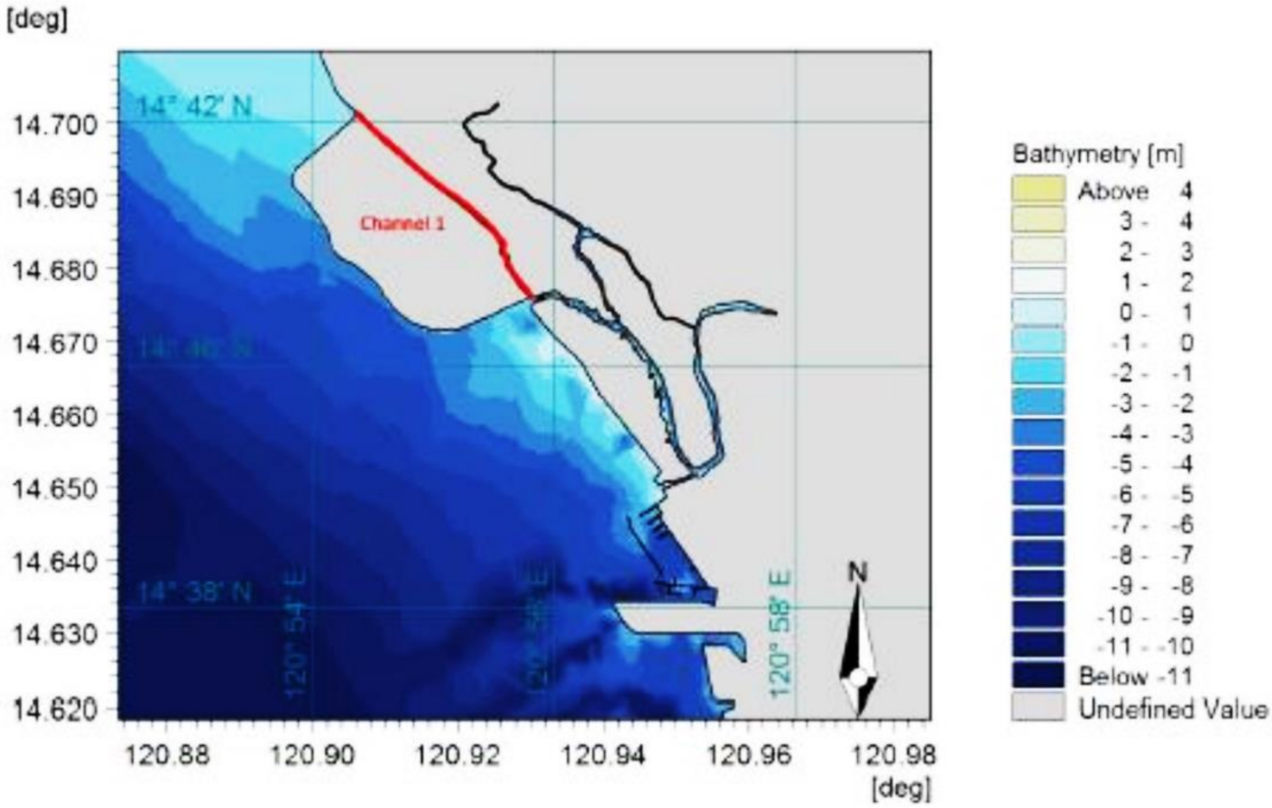


Figure 2-61 Planned channel (red line) along the footprint of the proposed reclamation

Objectives of this Study

The objective of this flushing study was to conduct a numerical model (based on available existing information) to assess the potential changes, if any, (due to the proposed reclamation) in the flushing capacity within the study area. In particular, the water exchange capacity of the intended channel between the proposed reclamation and the shoreline, under different configurations that were envisaged to be implemented, would also be assessed as part of this Study.

Numerical Model Setting

- Bathymetry Data

  Bathymetry data obtained from the following different sources were combined, using common references, to produce a consistent bathymetry dataset covering the entire study area for the flushing model:

  1. Admiralty Chart from C-MAP
  2. Navotas Manila Bay bathymetric and geophysical survey, dated Feb 2016, from the Client
  3. MetOcean, Flushing and Flooding Studies for Navotas Land Development from the Client

  The horizontal reference for the flushing model adopted for the Study was Longitude and Latitude geographical coordinates (WGS-84 datum). The vertical reference of C-MAP data was in Chart Datum (m CD) while the surveyed data provided by the Client were in meter Mean Lower Low Water (m MLLW). These data were synchronized to Mean Sea Level (MSL) in the hydrodynamic model used to couple with the flushing model.

  In addition, a detailed cross-section survey of the channels surrounding the development was extracted from the previous Study (MetOcean, Flushing and Flooding Studies for Navotas Land Development) and incorporated in the bathymetric dataset used in the numerical model for this Flushing Study.

  The coverages of the available bathymetry data from the different sources is as summarized in Table 2-21 and depicted in Figure 2-62. The surveyed data and the reclamation footprint is shown in Figure 2-63.

Table 2-21 Characteristics of bathymetric data collected and adopted for the flushing model

Source	Type	Geographical reference	Coverage
C-Map	Water depths	LONG/LAT (WGS-84)	Global
Survey data provided by Client	Water depths	LONG/LAT (WGS-84)	Local
River cross section survey from previous Study	Water depths	LONG/LAT (WGS-84)	Local

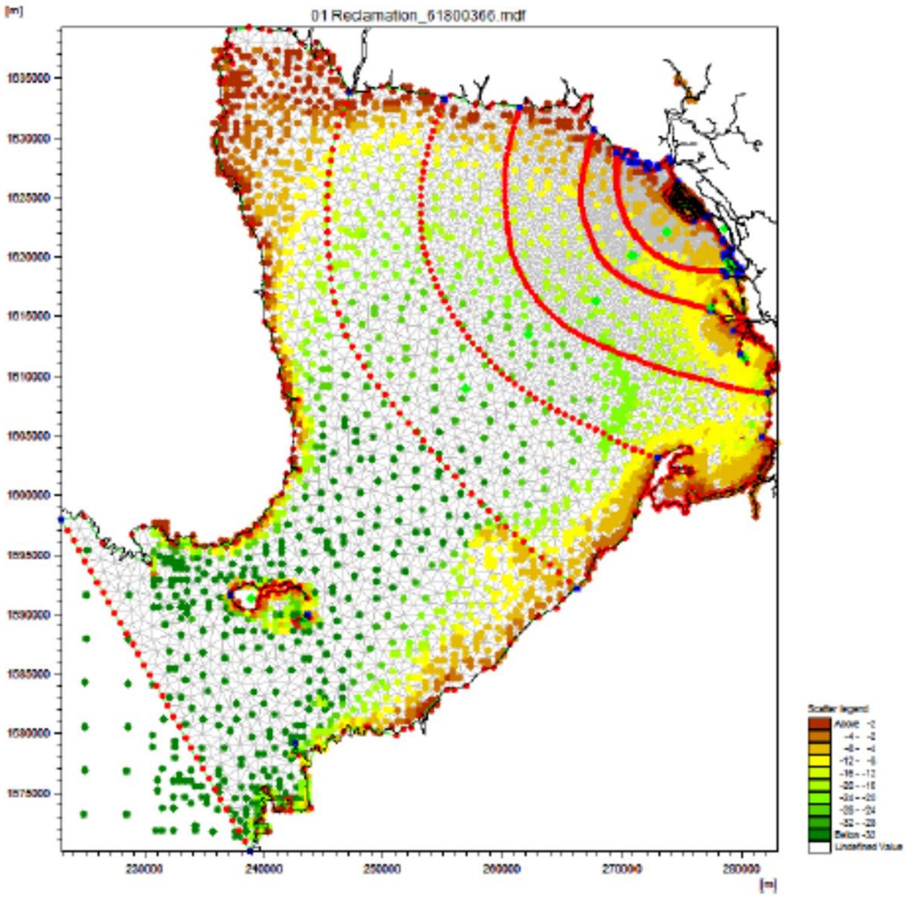


Figure 2-62 Spatial extents of CMAP data

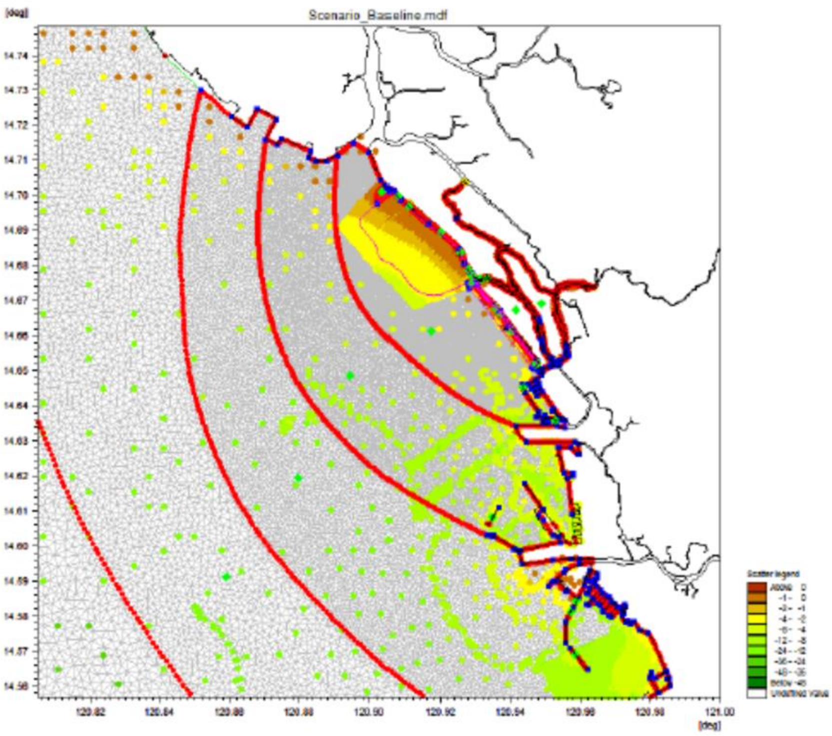


Figure 2-63 Local bathymetry data and reclamation footprint

- MIKE 21 Flow Model FM

The MIKE 21 Flow Model is a modelling system for two-dimensional free-surface depth integrated flows. The model system is based on the numerical solution of the two-dimensional incompressible Reynolds-averaged Navier-Stokes equations subject to the assumptions of Boussinesq and hydrostatic pressure. The model is applicable for the simulation of hydraulic and environmental phenomena in lakes, estuaries, bays, coastal areas, and seas wherever stratification can be neglected. The model can be used to simulate a wide range of hydraulic and related items, including tidal exchange and currents and storm surges.

The hydrodynamic (HD) module is the basic module in the MIKE 21 Flow Model. The HD module simulates water level variations and flows in response to a variety of forcing functions in lakes, estuaries, and coastal regions. The effects and facilities include:

- Bottom shear stress;
- Wind shear stress;
- Barometric pressure gradients;
- Sources and sinks (e.g. rivers, intake and outlets from power plants);
- Flooding and drying;
- Momentum dispersion;
- Tidal potential;
- Coriolis force;
- Precipitation/Evaporation;
- Ice coverage; and
- Wave radiation stresses

The model uses a flexible mesh (FM) based on unstructured triangular or quadrangular elements and applies a finite volume numerical solution technique. The model resolution adopted in this Flushing Study is at a grid size of 10 m by 10 m. The MIKE 21 Flow Model used for the present study was version 2016, Service Pack 3.

Local Tidal Flow Model

To provide high-resolution modelling results for the waters around the project site as well as computational efficiency, it was decided to pursue using the MIKE 21 Hydrodynamic Flow Model as discussed above. The numerical model allows flexible refinement (Figure 2-65) of the model bathymetry in local areas of interest in order to optimize computational speed. The resulting model extent and mesh are illustrated in Figure 2-64 and Figure 2-65. The resolution of the unstructured mesh applied by the model in terms of the characteristic element length (average cell size) is given in Table 2-22.

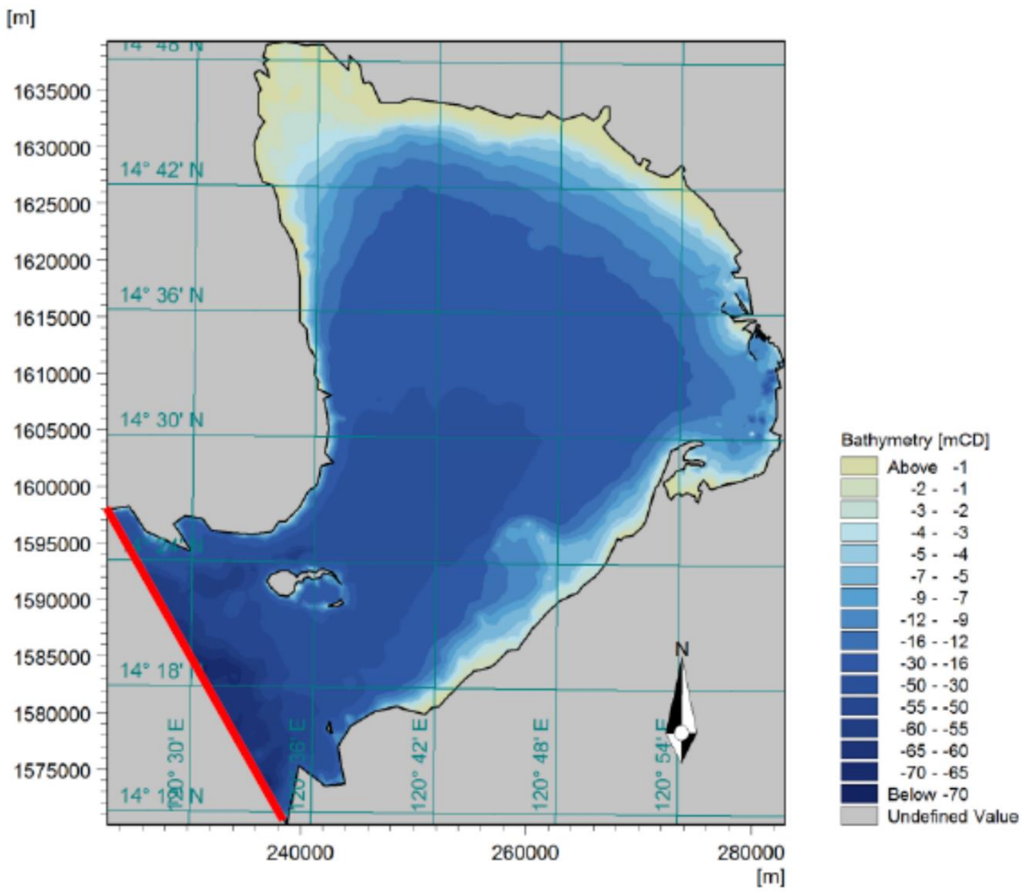


Figure 2-64 Local model domain of Manila Bay (tidal boundary indicated as red line)

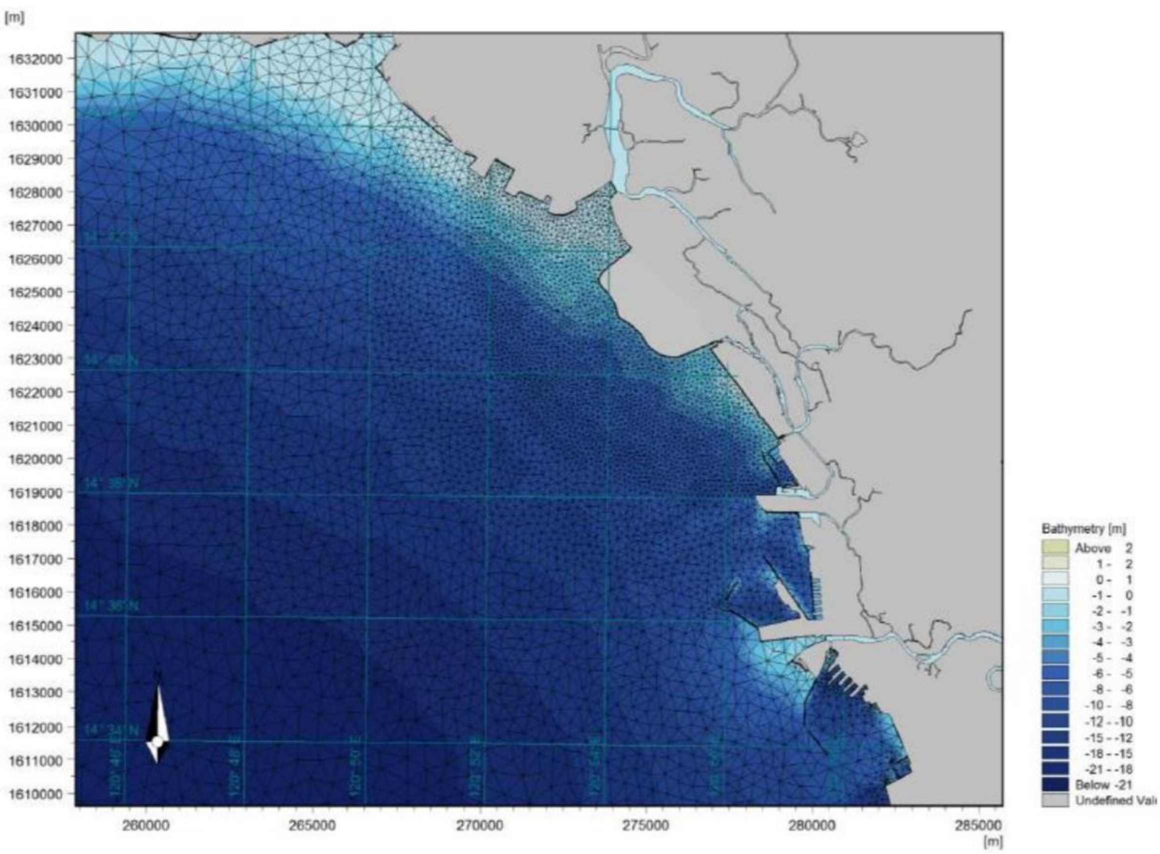


Figure 2-65 Interpolated bathymetry in flexible mesh

Table 2-22 Characteristic element length (average cell size) of the model

Region	Characteristic element length (m)
Offshore project vicinity	350 – 400
Project vicinity	25 – 30
Project site (channel and rivers)	10 - 20

The currents around the project area are predominantly wind-driven and weakly influenced by tidal components. However, at the open boundaries of the numerical model, tidal forcing was applied through a tidal prediction at each boundary node. The tidal constituents applied at the boundaries consisted of the major diurnal constituents K1, O1, P1 and Q1 and diurnal tidal constituents (M2, S2, N2, and K2). Each constituent represents a periodic change or variation in the relative positions of the Earth, Moon (Lunar) and Sun (Solar) and they are listed below for reference:

- K1: Lunar diurnal constituent;
- O1: Lunar diurnal constituent;
- P1: Solar diurnal constituent;
- Q1: Larger lunar elliptic diurnal constituent;
- M2: Principal lunar semidiurnal constituent;
- S2: Principal solar semidiurnal constituent;
- N2: Larger lunar elliptic semidiurnal constituent; and
- K2: Lunisolar semidiurnal constituent.

The above constituents were interpolated from a global tide model with a spatial resolution of 0.125 x 0.125 degrees (Anderson, O. 1995).

The entire project site and river network were connected and tide propagates freely from the shore to the river upstream with the integration of annual average river discharges from MIKE 11. A summary of the local flow model set-up for this Flushing Study is as tabulated below:

Table 2-23 Summary of the local flow model settings

Setting	Value
Density Approximation	Barotropic (depth-averaged model)
Eddy Viscosity	Smagorinsky approximation (with Smagorinsky coefficient of 0.28 applied)
Bottom Drag	Manning formulation (Manning number of 55m1/3/m)
Wind Forcing	CFSR wind
Boundary Conditions	KMZ Global Tide Model
Time domain	Temporally varying time-stepping applied (model time-step adjusts internally in response to the maximum estimated Courant number estimated before each computation)

- Hydrodynamic Model Validation

The HD model was calibrated against water level predictions at Corregidor and Manila stations from MIKE C-MAP (Figure 2-66). The validation of the variable tidal signal in the Manila Bay is shown in Figure 2-67 and Figure 2-69. It is noted that in the absence of year 2017 wind data for the model production runs, the tidal model validation and productions were carried out based on the data available in year 2016.

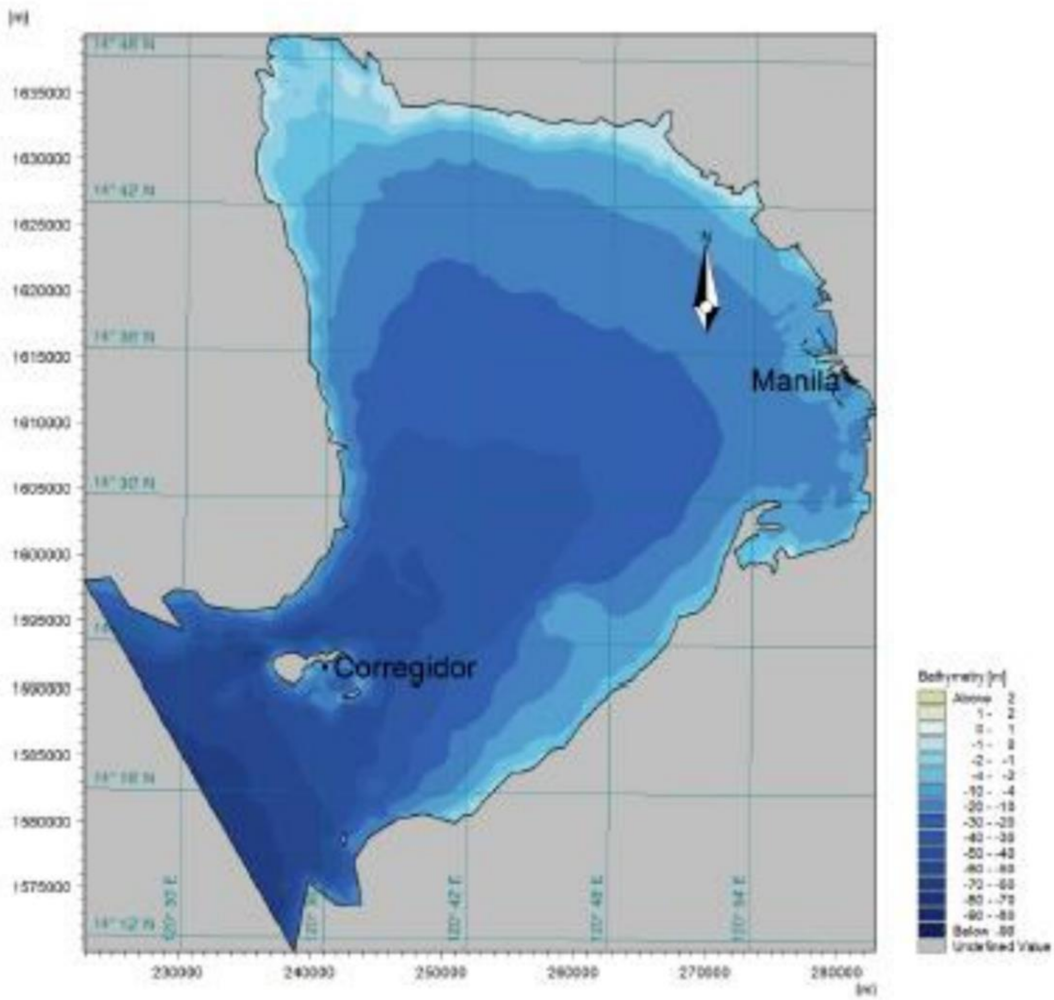


Figure 2-66 CMAP tidal stations of Corregidor and Manila

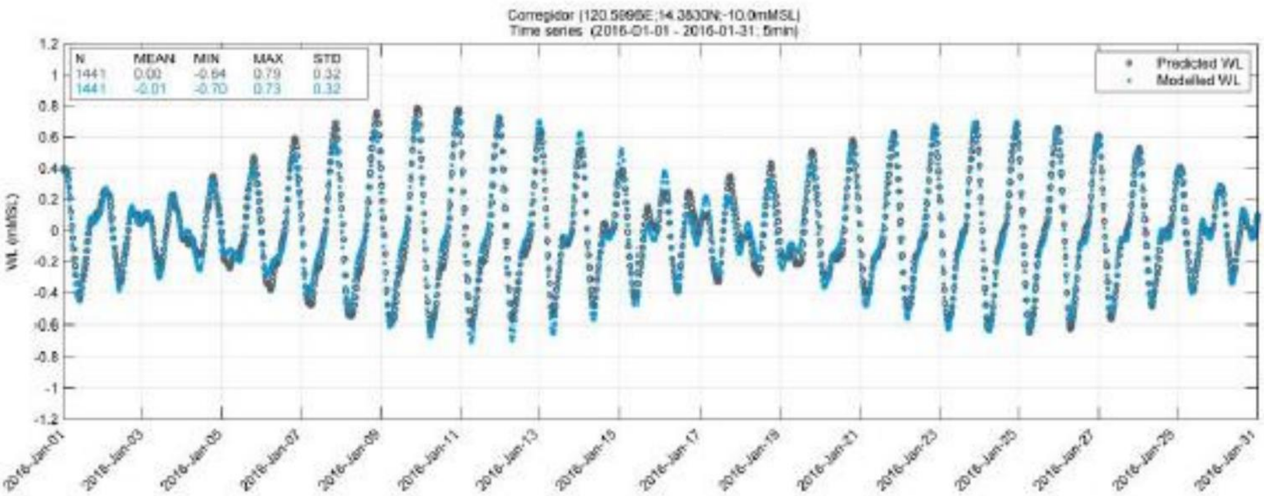


Figure 2-67 Time series comparison of modelled water level and predicted water level at Corregidor

The validation plots demonstrate a satisfactory comparison and Q-Q plots (Figure 2-68 and Figure 2-70) illustrates the quantitative performance of the model at both observation and CMAP tidal stations, which implies the model provides a good spatial and temporal representation of tidal elevation.

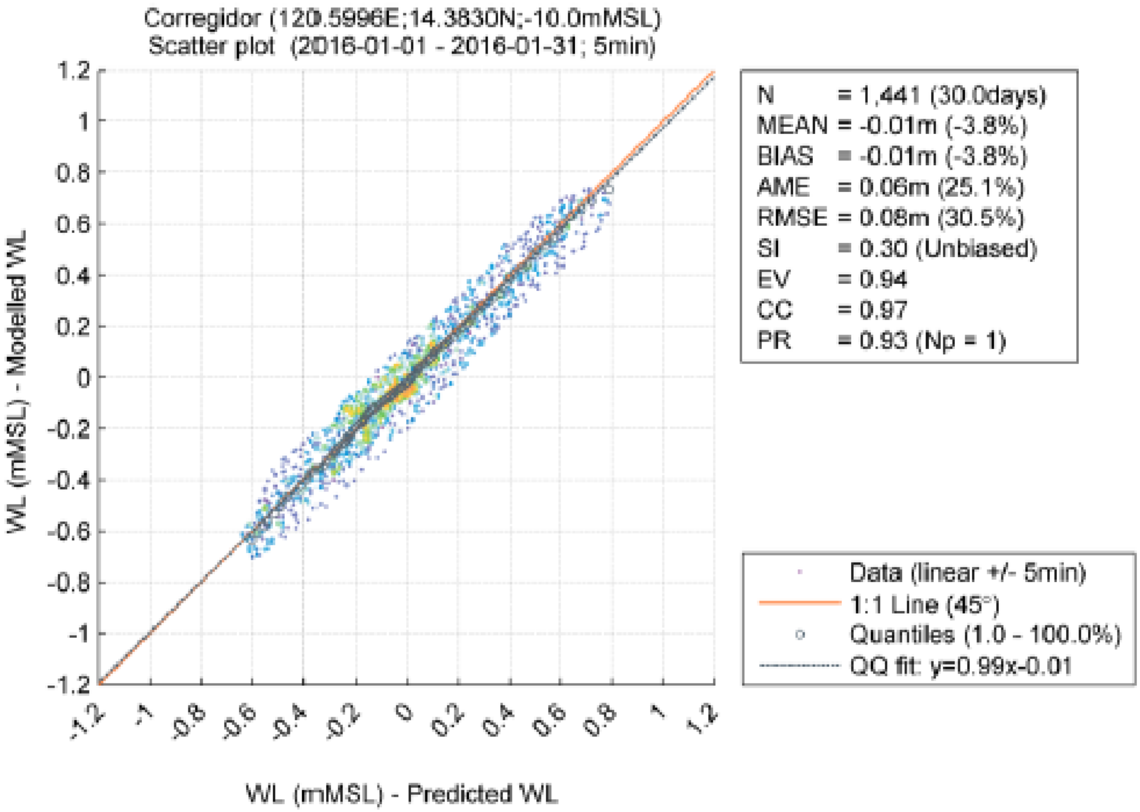


Figure 2-68 Q-Q plot of modelled water level and predicted water level at Corregidor station

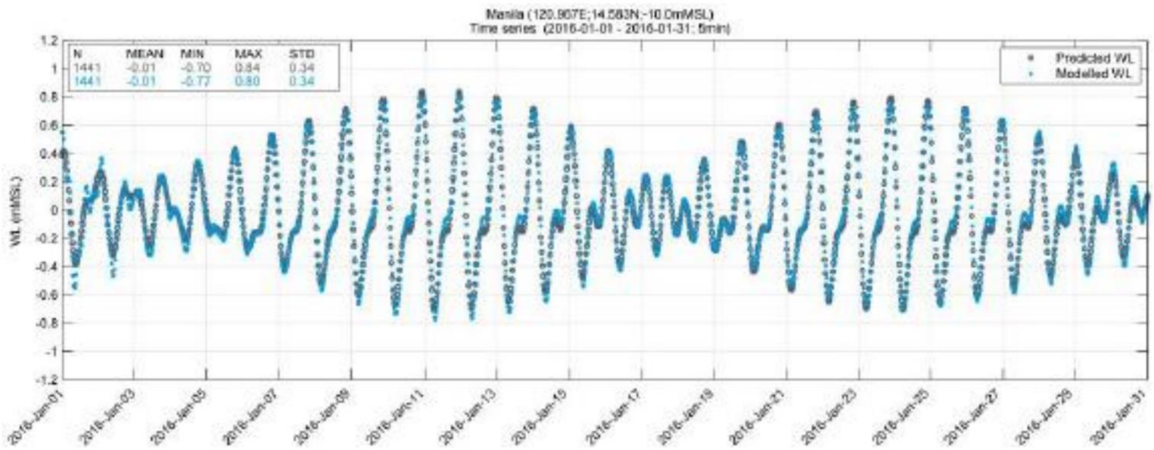


Figure 2-69 Time series comparison of modelled water level and predicted water level at Manila station

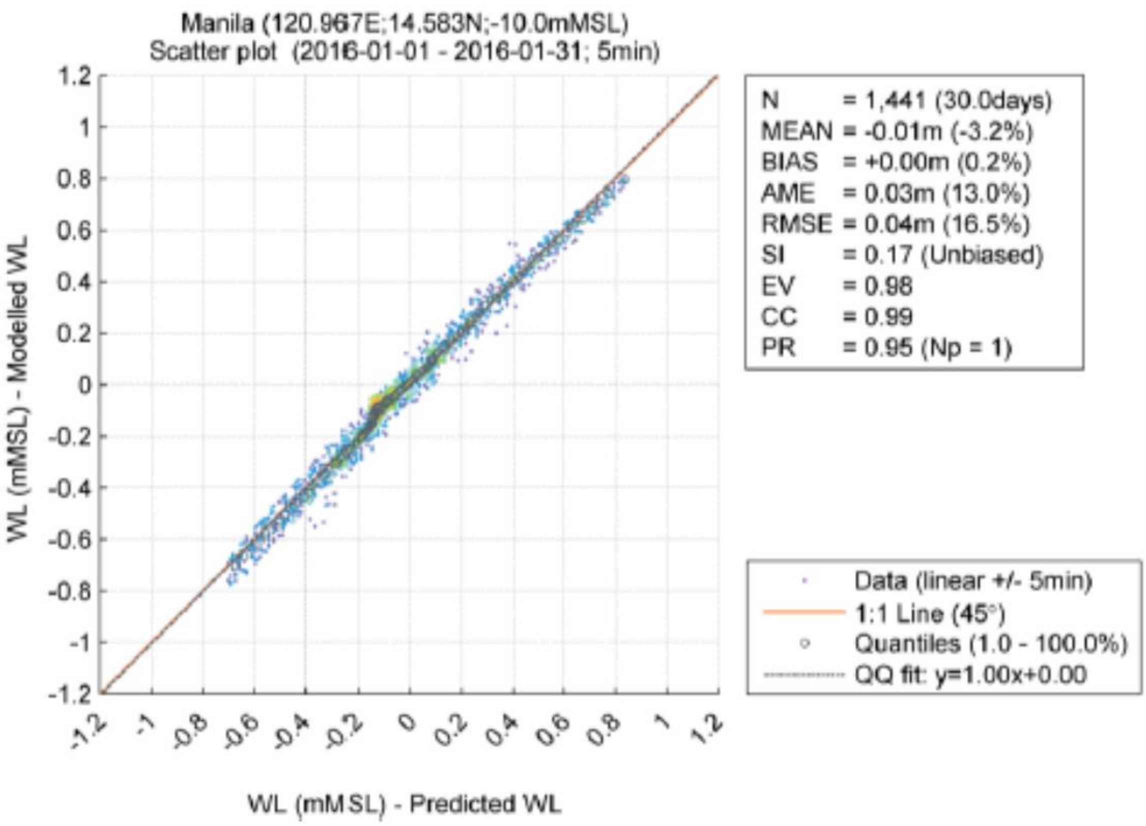


Figure 2-70 Q-Q plot of modelled water level and predicted water level at Manila station

- MIKE 11 Hydraulic Model

MIKE 11 hydrodynamic module (HD) uses an implicit, finite difference scheme for the computation of unsteady flows in rivers and estuaries. The module can describe sub-critical as well as super critical flow conditions through a numerical scheme which adapts according to the local flow conditions (in time and space).

Advanced computational modules are included for description of flow over hydraulic structures, including possibilities to describe structure operation. The computational scheme is applicable for vertically homogeneous flow conditions extending from steep river flows to tidal influenced estuaries. The system has been used in numerous engineering studies around the world and is very much suitable for the scope implemented under this Study.

MIKE11 hydraulic model was used to produce the annual average base flows from the rivers in the proposed development sites. These rivers include Kailugan River (i.e. Muzon-Dampalit and Navotas Rivers) and within the model domain as shown in Figure 2-71.

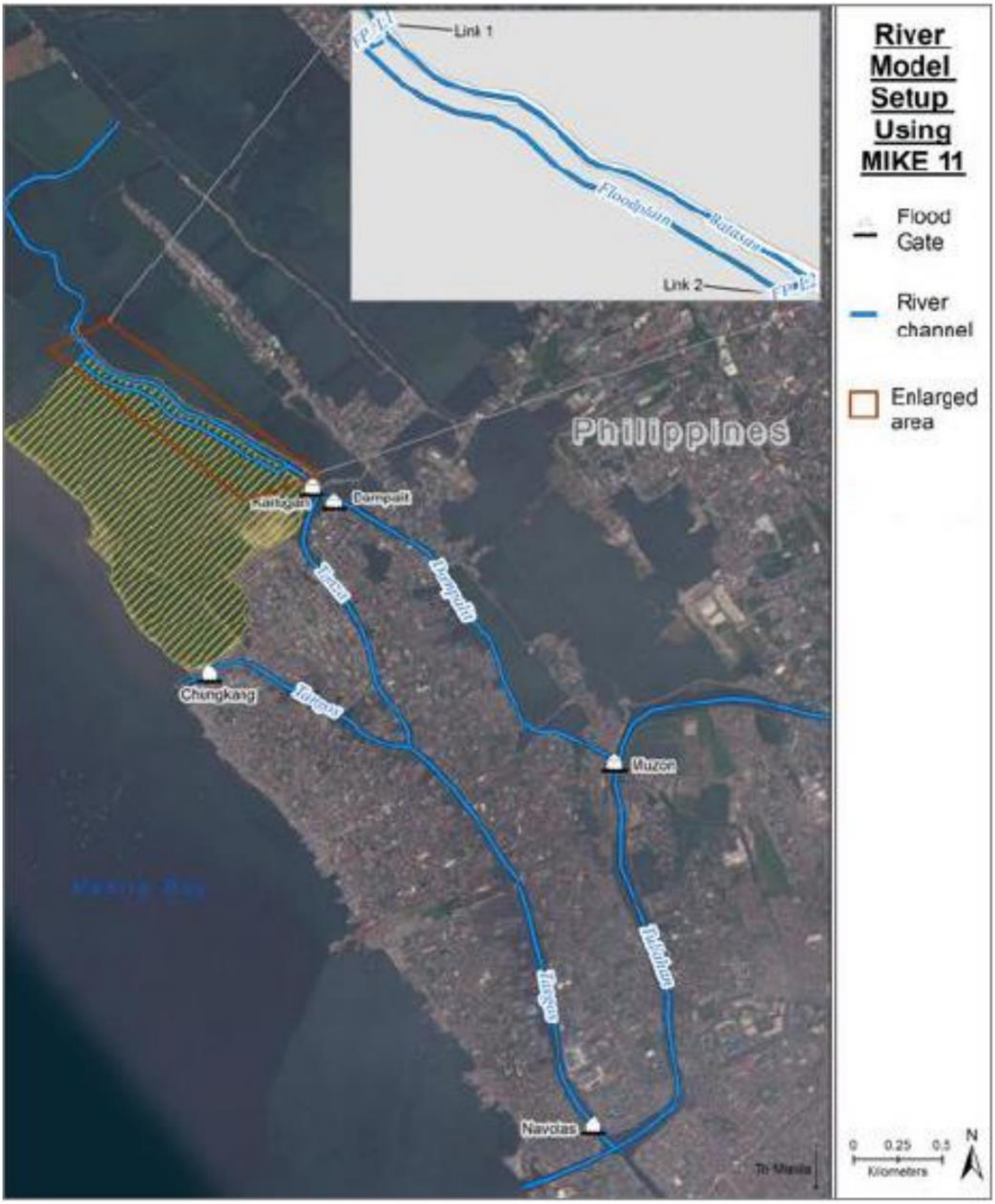


Figure 2-71 River network setup used in MIKE 11 model

The study area was schematized in MIKE 11 based on the cross sections extracted from the previous Study conducted in this area. The river model includes the discharge input from South Pinagkabalian and Spine. In addition, a water level boundary in Batasan River was assigned to reflect the river draining out from the river model towards Meycauayan River. A tidal water level will be assigned due to the point's proximity to Manila Bay. The annual average base flows were then coupled in the MIKE

21 flow model in order to mimic the reality where river discharges are seen to be very relevant, especially for this proposed development site.

Methodology

Approach and Modelled Scenario

The water recirculation assessment based on the application of MIKE 21 Transport model was conducted to determine the potential changes (due to the proposed reclamation) in the flushing capacity within the study area. The flushing capacity is a measurement of the natural self-cleansing capacity of the system. Hence, any changes in the flushing capacity (i.e. time needed for the system to be self-cleansed) may therefore influence the surrounding water quality.

In order to quantify the potential recirculation changes in the post construction stage (i.e. after the proposed reclamation is completed), the results are compared to the existing conditions (i.e. baseline condition) by carrying out numerical simulations with conservative tracers added within the following locations (Figure 2-72):

1. Water channel between the proposed 576.7 ha reclamation profile and existing shoreline
2. Existing marina; and
3. Rivers next to the proposed reclamation area.

The flushing models were initiated at mid-tide during a Neap period flood cycle, in which the water circulation will be poorer compared to Spring period, to assess the worst condition. It was noted that the coastal dike along the shore next to the proposed reclamation is currently being constructed (during the course of this Study) and is close to completion. Based on the dike geometry information provided by Client, it was incorporated in both the baseline and post-condition.

In terms of dimension, the intended channel between the proposed reclamation and existing shoreline was simulated based on a surface width of 50.2 m and toe-to-toe width of 30 m. The slope adopted for both side of the intended channel was 1:3. It should also be noted that the existing seabed fronting the shoreline, in which the intended channel is located, is currently an inter-tidal area (based on the bathymetric information available for this Study). Consequently, in order to ensure that the intended channel is below the lowest astronomical tide, the intended channel and the area adjacent to the channel openings were assumed to be deepened to -1 m MSL in order to be able to flush the water in and out the channel efficiently.

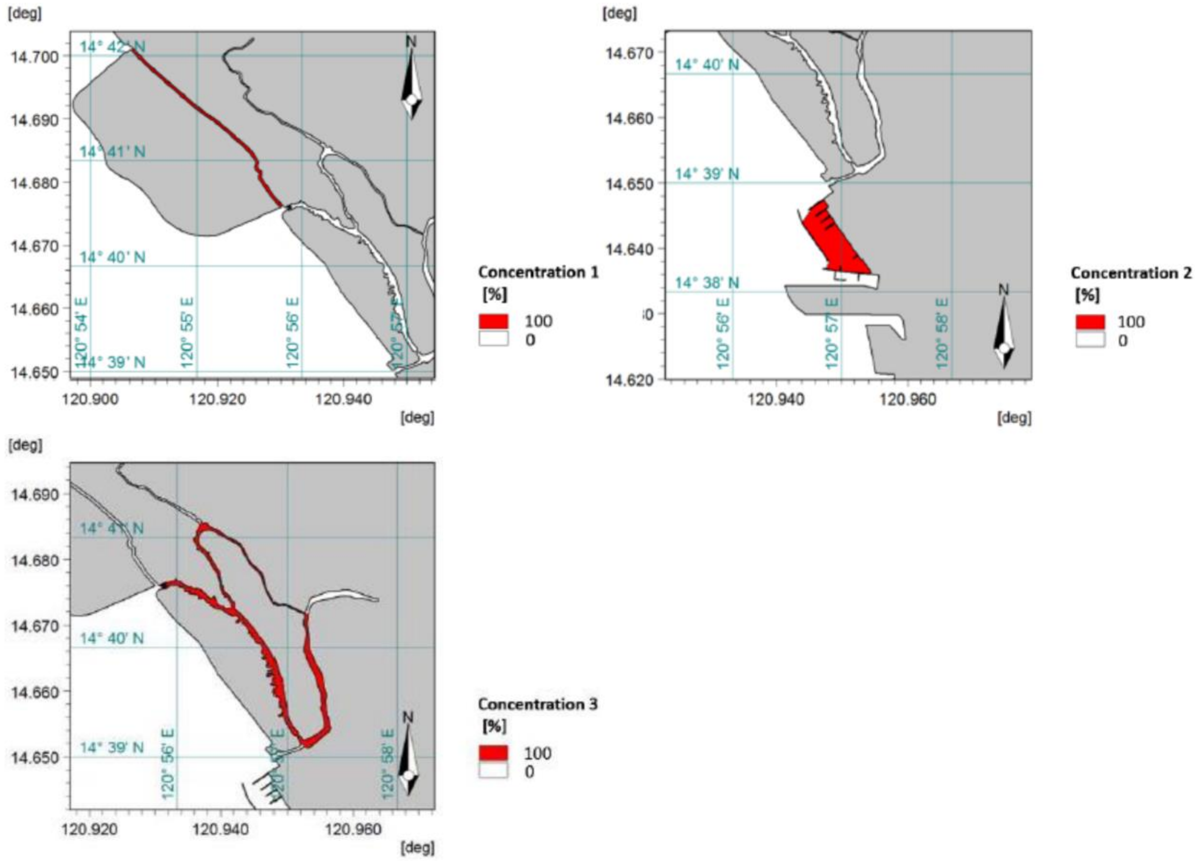


Figure 2-72 Initial 100% conservative tracer added at (1) concentration 1 within channel at proposed reclamation area (top left); (2) concentration 2 at existing marina (top right); and concentration 3 within the rivers adjacent to the proposed reclamation (bottom left).

The flushing capacity was modelled using the MIKE 21 Transport model, which simulates the spreading of a suspended conservative substance in an aquatic environment under the influence of the currents. The HD module provides background information for the transport, (i.e. currents and water depths) in each grid point. Other data required include substance concentrations and discharge quantities at the surrounding rivers. The system solves the equation of conservation of mass for a dissolved or suspended substance using a two-dimensional form. The concentration of the substance is calculated in each point of a flexible grid covering the area of interest.

Proposed Flushing Criteria Adopted

It was recognized that the main purpose of conducting this Study was to evaluate the relative flushing performance of channels surrounds the proposed reclamation area in terms of any significant differences in the residence times of the concentration tracers. The outputs can be used to infer implications for changes to water quality and eutrophication as a result of the proposed development.

A residence time analysis is used to evaluate the water exchange that may affect the water quality. The residence time can be conceived as a measure of water mass retention within the defined boundary and provides a description of mass balance and transport dynamics in the water body.

Based on this understanding, the following water flushing criteria in Table 2-24 was proposed for this Study. These suggested concentrations were typically utilized in Studies where a requirement to infer water quality is required, without the need to formulate comprehensive ecological models for a given area.

Table 2-24 Proposed flushing criteria

Residence Time at 20% Concentration	Flushing Criteria
≤ 1 Day	Very Good
2 Days	Good
3 Days	Moderate
≥ 4 Days	Poor

Modelled Results Extraction Points

In the tracer flushing approach utilized in this Study, the tracer concentration is used to infer implications for water quality in a given area. In the present case, to examine the expected incremental changes to the water quality as a result of the proposed development, six (6) locations have been selected to assess the flushing capacities of the representative areas and they are indicated in Figure 2-73 and tabulated in Table 2-25.

Table 2-25 Representative areas with its corresponding extraction locations

Representative Area	Extraction Points
Channel along proposed reclamation	Point 1 and 2
Channel opening to the west of the proposed reclamation	Point 3
River mouths	Point 4 and 5
Marina	Point 6

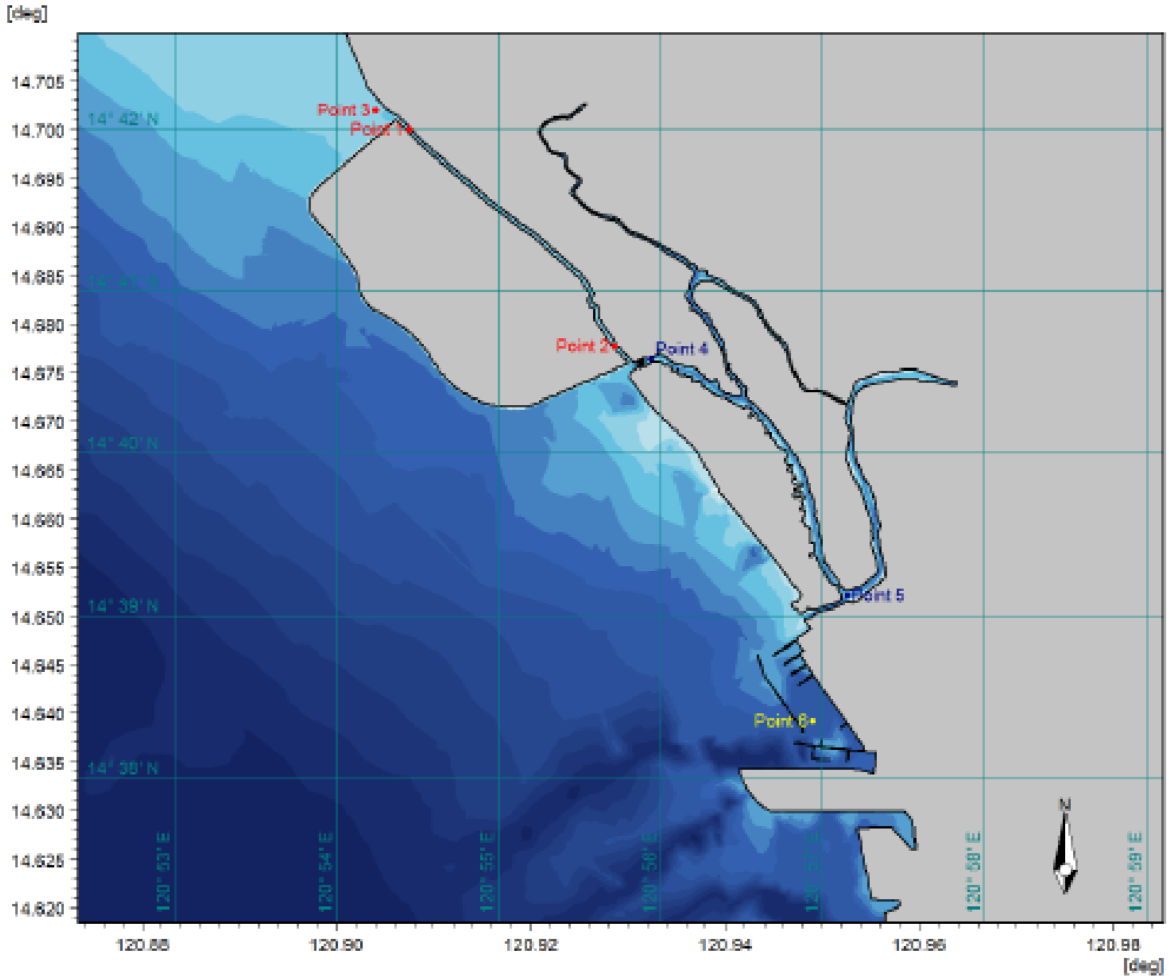


Figure 2-73 Extraction locations around the reclamation footprint (Points 1, 2, and 3), inside the rivers (Points 4 and 5), and marina (Point 6)

Results and Discussion

Figure 2-74 shows the 4-hourly concentration dilution during neap tide condition within the intended channel next to the proposed reclamation area. With the deepening of the channel to -1.0 m MSL, the conditions promoted flushing leads to flows along the channel. It is seen that the dilution has increased significantly to the eastern part of the channel in the post condition (Figure 2-75). As evidenced in the figures, the initial tracer is flushed out within a day. Separately, residence times at each representative area are further assessed and discussed in the time-series plots shown from Figure 2-76 to Figure 2-77 below.

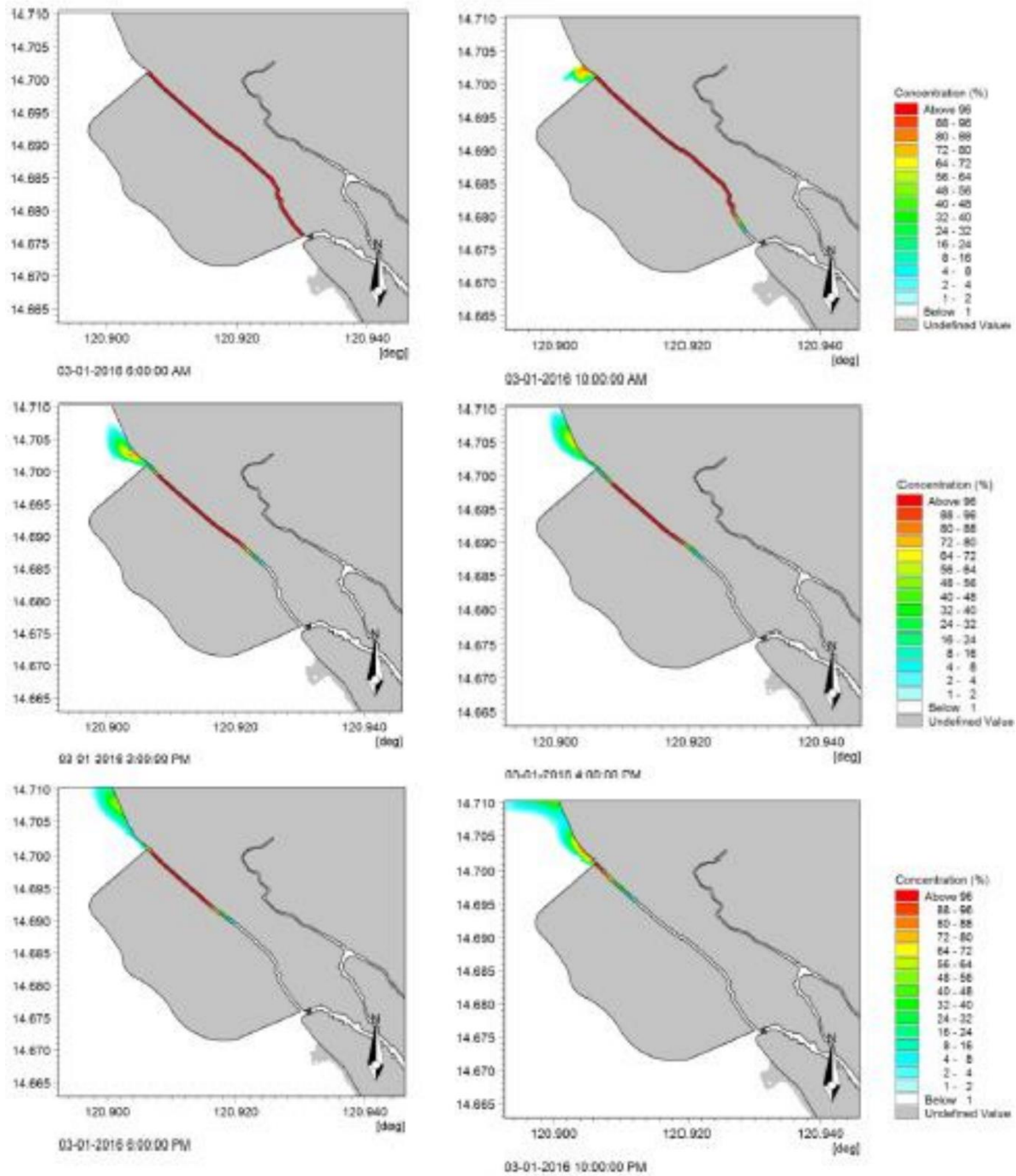


Figure 2-74 4-hourly concentration dilution of 576.7ha case (view from top to bottom, left to right)

Figure 2-75 shows the concentration at Point 1 and 2 within the intended channel next to the proposed reclamation. Flushing condition to the East (Point 2) is improved whereas it is slightly worsened to the West (Point 1) of the intended channel when compared to the baseline condition. The artificial channel directs the water flows westward alongshore. The tracer concentrations remain above 20% for a duration of approximately one (1) day and the residence time corresponds to “very good” flushing condition.

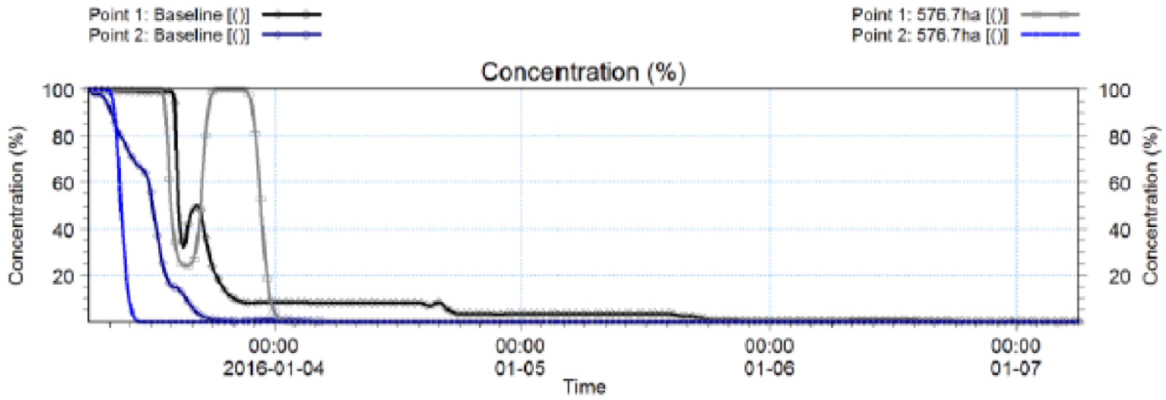


Figure 2-75 Concentrations at Point 1 and 2 in the channel for the proposed reclamation

As mentioned above, although water in the channel is being pushed out towards the west of the channel, Figure 2-76 showed that the tracer at the opening of the channel (Point 3) goes below 20% in less than one (1) day, of which it can be considered to corresponds to "very good" flushing condition. It is noted that the residence time for baseline is not presented here as the area is inter-tidal zone and the concentration of tracer becomes zero when the seabed is exposed. Hence, it does not provide a good relative comparison.

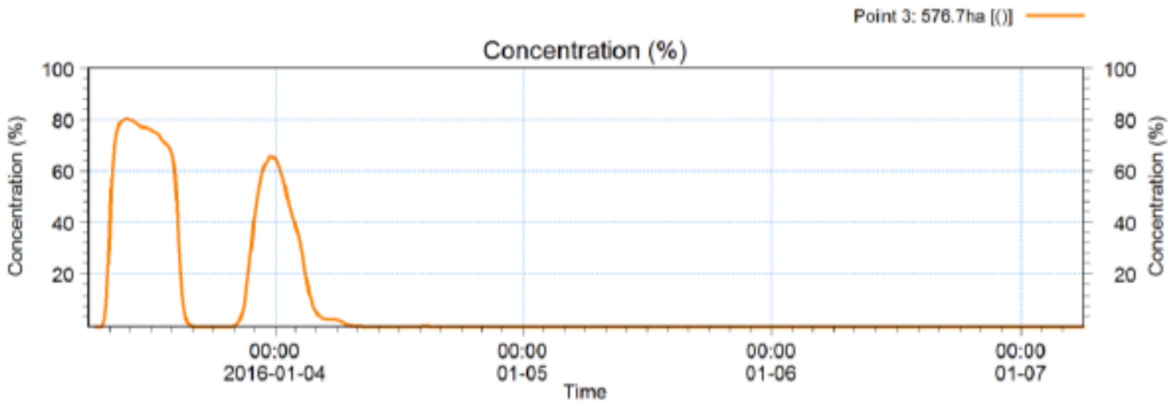


Figure 2-76 Concentration at the opening of the channel for the proposed reclamation

Figure 2-77 shows the tracer concentrations at both river mouths at Points 4 and 5. The difference in flushing capacity at Point 5 is seen to be negligible, whilst the flushing capacity at the river mouth (Point 4) adjacent to the proposed reclamation footprint is slightly decreased. However, the residence times in both Baseline and post-construction condition are more than four (4) days. Hence, the flushing capacity remains unchanged. It should be noted that this is a natural phenomenon at an estuarine system where the mixing within the river is affected by the amount of seawater received by the river due to the periodic rise and fall of the tide. The residence time, in general, is higher when a river is dominated (too) by seawater inflows.

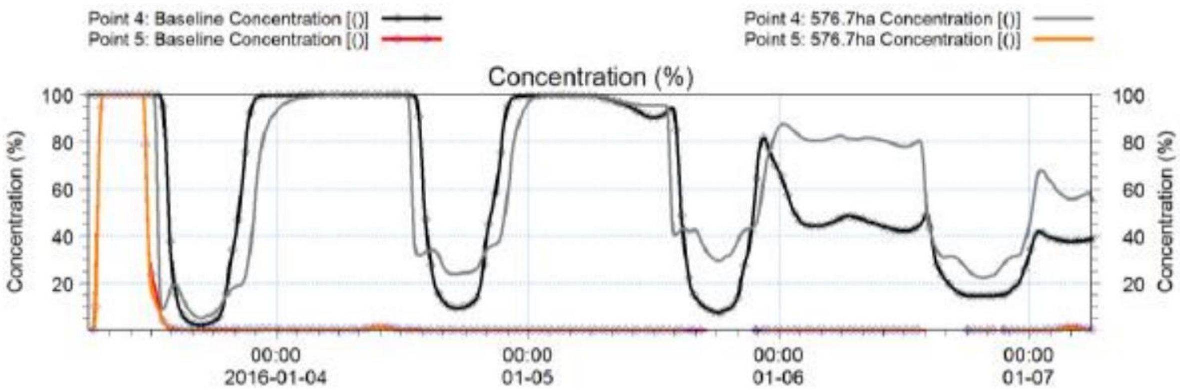


Figure 2-77 Concentrations at Points 4 and 5 at the river mouths

Figure 2-78 shows the tracer concentrations at the existing marina. Regional impact is negligible.

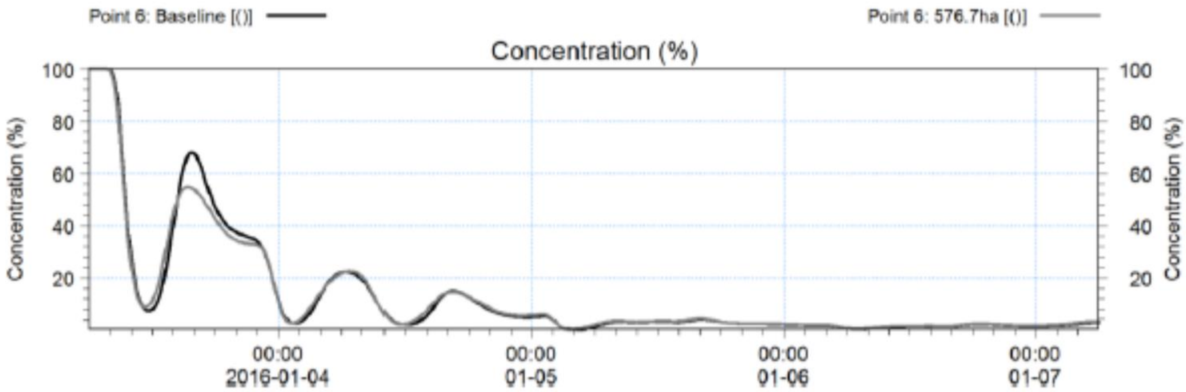


Figure 2-78 Concentration at the existing marina

Conclusion

The flushing assessment carried out for the proposed 576.7 ha reclamation profile suggested that the residence time of water in the intended channel and at the opening of the channel will not be significantly long (i.e. less than a day). As such water quality is not expected to be poor in the intended channel, at least not due to long residence times. The channel geometry is such that the initial volume of water is removed quickly on one tidal cycle. The volume of water in the channel is not in itself large relative to the surrounding water body and therefore recirculation is not a significant issue. Hence, from the modelled results of the intended channel at a surface width of 50.2 m (toe-to-toe width of 30 m), it can be concluded that the proposed reclamation is unlikely to pose any potential impact on the existing mangrove next to the intended channel, in terms of the flushing capacity (and thus water quality) within the area.

In addition, the proposed reclamation doesn't create any significant regional changes (in terms of flushing capacity) such as the rivers and the existing marina.

2.2.1.3.3 Environmental impacts and proposed mitigation measures

Based from the current characteristics and conditions of the project site and surrounding areas, the following are the potential impacts of the proposed rehabilitation project.

Induce higher flood levels

The reclaimed area might impede discharge of flood waters coming from the watershed due to restrictions of the two exit channels on both sides of the reclamation area. This could create a higher level of floods in the currently flood prone areas.

This can be mitigated by ensuring that the capacity of two exit river channels are maximized. Reforestation or tree planting in coordination with the LGUs in the watersheds draining to the area can be considered as a long term solution to this problem.

Unevenly distribution of sediments in the coastal area

Because of the reclaimed area, it can be expected that distribution of sediments in the coastal area will change. More sediment can be deposited in the area opposite side of the delta or reclaimed area.

Rehabilitation or desilting of affected area can be adopted to address the problem. This can also be addressed through erosion control measures like tree planting in the watersheds draining to the project site.

Limited access to the sea by the surrounding communities

At present the privately owned fishponds are being used as a free access to the sea. This may be affected once the project starts and operational. A clear designated exit way be identified for the communities.

2.2.2 Oceanography

This section presents the assessment of key impacts for the oceanography module, as stipulated Section 2.2 of the Technical Scoping Checklist, as follows:

- Change/disruption in water circulation pattern, littoral current, coastal erosion, and deposition and
- Change in bathymetry.

2.2.2.1 Methodology

General description of baseline data parameters and assessment methodology

Baseline data parameters that are required in the technical scoping checklist are presented, as follows:

- Bathymetric map;
- Analysis of available proximate tidal data; and
- Measurement of water currents.

The assessment methodology included detailed discussion on the input data used in hydrodynamic modeling using the Environmental Fluid Dynamics Code (EFDC). EFDC is the recommended model of the DENR, as indicated in the Technical Scoping Checklist. EFDC is also the recommended model of the U.S.EPA in assessing circulation and sedimentation patterns in coastal areas.

Oceanographic monitoring

Oceanographic baseline monitoring was conducted at the proposed project and vicinities from May 6 to 8, 2016. This activity involved tidal, currents, and sedimentation rate sampling (Figure 2-79). A tidal gauge was installed in Brgy. Tanza in order to compare the measured tidal heights with those of the predicted tidal heights at NAMRIA tidal stations. Current measurements were conducted using a SD 6000 current meter and drogues, including sampling of sedimentation rates using sediment traps on the above-mentioned dates. The following section presents the detailed discussion of the baseline oceanographic sampling.

Plate 2-1 to Plate 2-7 show the photographs taken during the oceanographic sampling from May 6-8, 2016.

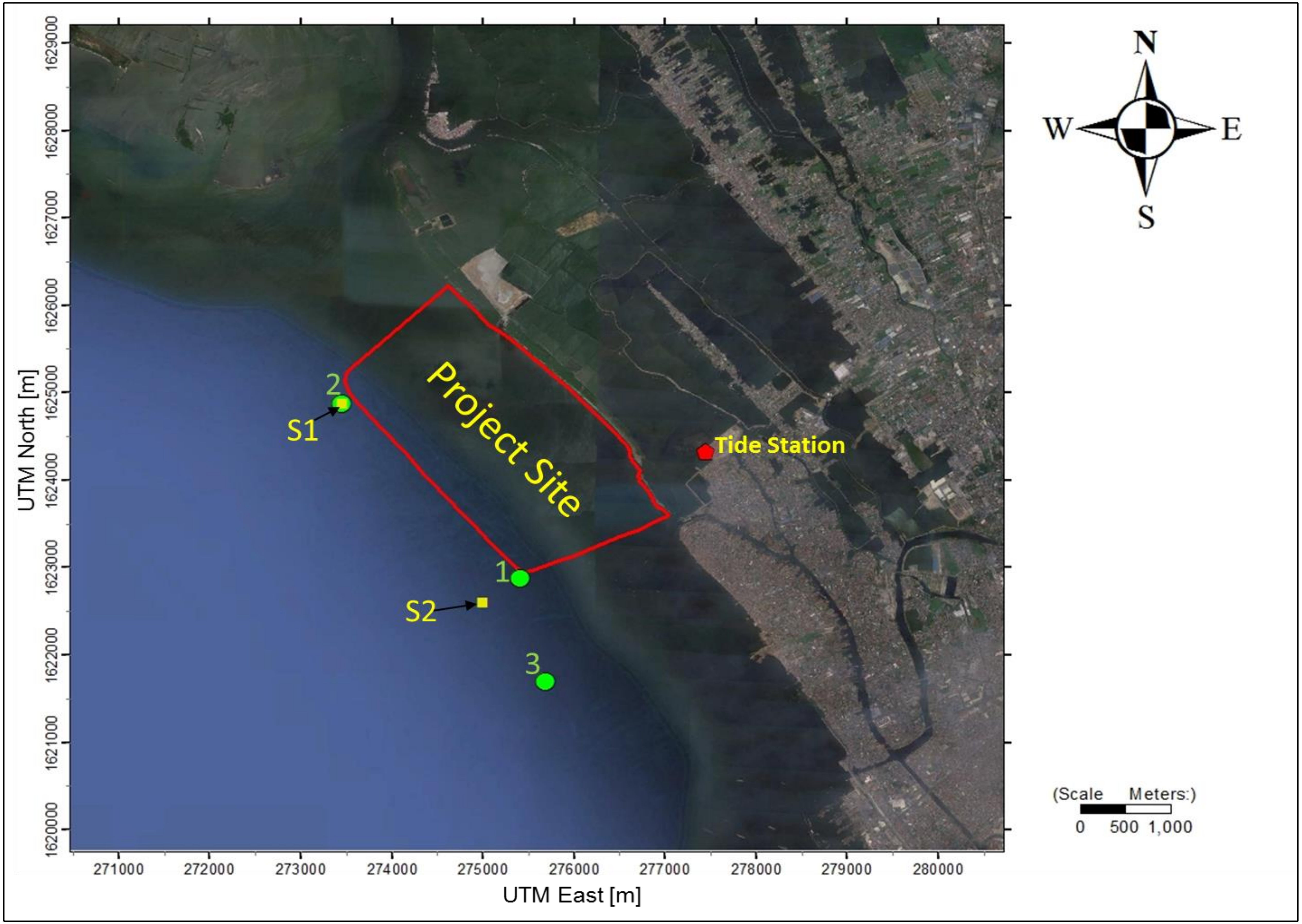


Figure 2-79 Oceanographic sampling stations (currents and tidal stations)

Plate 2-1 Tidal gauge installed east of the project site

Plate 2-2 An SD 6000 current meter used by Team 1 to measure continuous currents

Plate 2-3 An SD 6000 current meter and a drogue used by Team 1

Plate 2-4 GPSMap64S and Garmin Echomap Chirp 52DV used by Team 2 for determination of locations. Garmin Echomap for depth sounding and water temperature measurements

Plate 2-5 Deployment of drogues by Team 2

Plate 2-6 Sedimentation traps and samples of sediments taken at Stations S1 from May 7-8, 2016

Plate 2-7 Sedimentation traps traps samples of sediments taken at Stations S2 on May 9, 2016 from 9:00 AM to 11:07 A.M.

2.2.2.2 Baseline information

2.2.2.2.1 Bathymetry

The proposed reclamation project is located at the northeast part of Manila Bay – a semi-enclosed estuary with its mouth facing the South China Sea. Based on the latest bathymetric map from NAMRIA (Figure 2-80), the deepest part of Manila Bay is about 69 m located at the North Channel of Corregidor Island. Relatively shallower parts are found near the coast of Pampanga and Cavite City. At the proposed project site, the maximum depth is about depths 5.0 m below mean lower low water (MLLW).

Bathymetric data were processed using the orthogonal curvilinear grid generator (GEFDC) of the EFDC. The processed bathymetric data were then used as input data to the EFDC. Section 2.2.2.3.1 presents the detailed discussion on how the bathymetric data were processed using GEFDC. Figure 2-81 shows the three-dimensional view of the bathymetry of Manila Bay.

2.2.2.2.2 Tidal heights

Five (5) tidal stations of NAMRIA are found within Manila Bay (Figure 2-80). These tidal stations are the Manila South Harbor, Manila North Harbor, Navotas Port, Limay, Bataan, and Puerto Azul, Cavite. The closest tidal station at the project site is Navotas Port. A tide gage was established east of the project site from May 6-8, 2016 to determine hourly tidal heights during oceanographic survey and to compare observed tidal heights with those of the predicted tides in NAMRIA Tide Table.

A computer program was developed by the preparer of this module in order to determine the hourly predicted tidal heights based on the graphical method presented in NARMIA Tide Table. This program was based on mathematical formulation using (H-PI-M) in Figure 2-82 as series of polynomial curves. This program is able to automatically determine the hourly tidal heights using the predicted highs and lows of water in a day, as the graphical method in the tide table would require manual inputs of the high and low water points in a cross-section paper (Figure 2-82).

Figure 2-83 shows the plots of hourly tidal heights from May 6-8, 2016. It appears that the observed tidal patterns follow closely with those predicted at Navotas Port and Manila South Harbor. Tidal heights were generally semi-diurnal from May 6-8, 2016, although at times diurnal as tides are highly dependent on the phase of the moon.

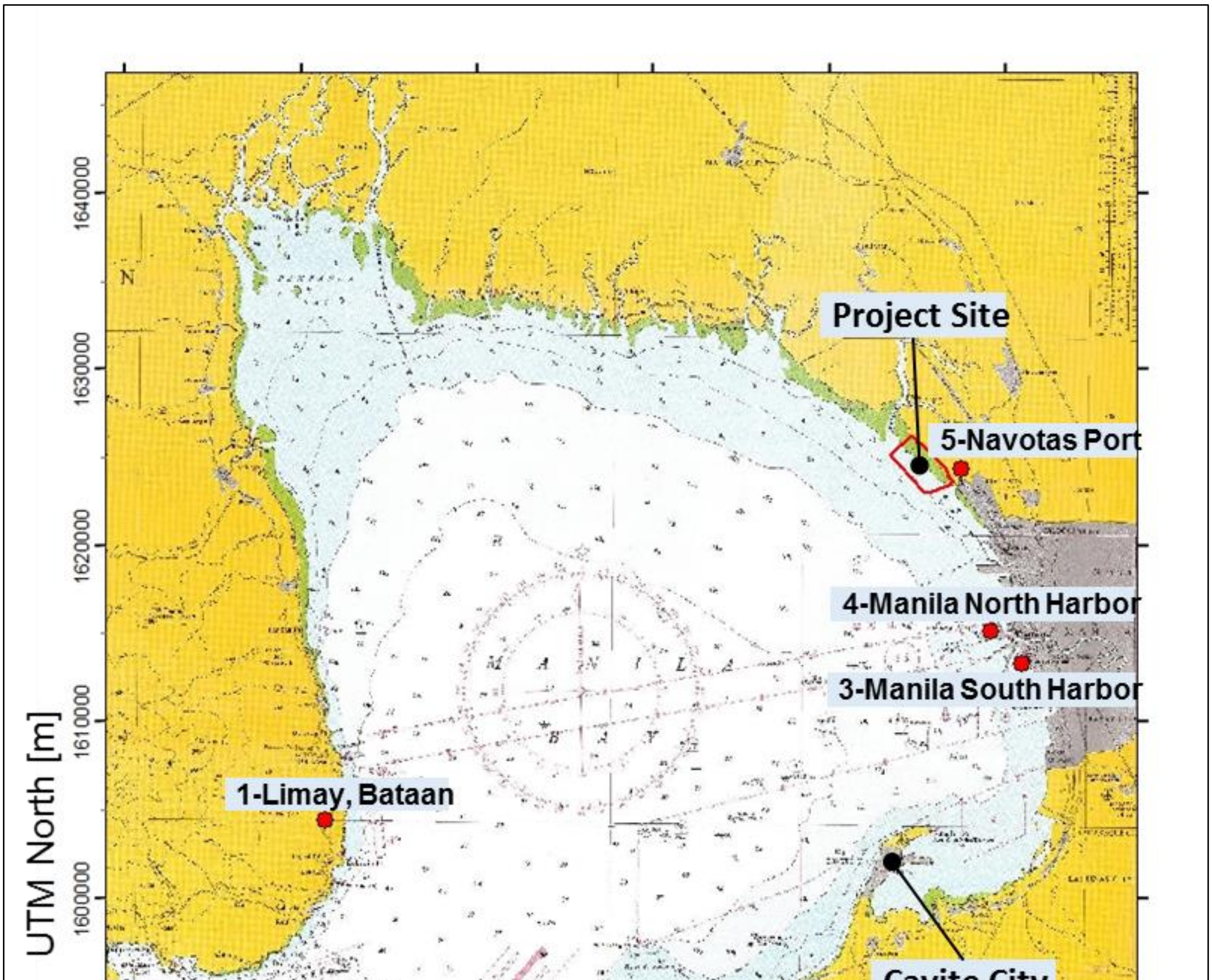


Figure 2-80 Bathymetric Map of Manila Bay and locations of NAMRIA Tide Stations
Source: NAMRIA

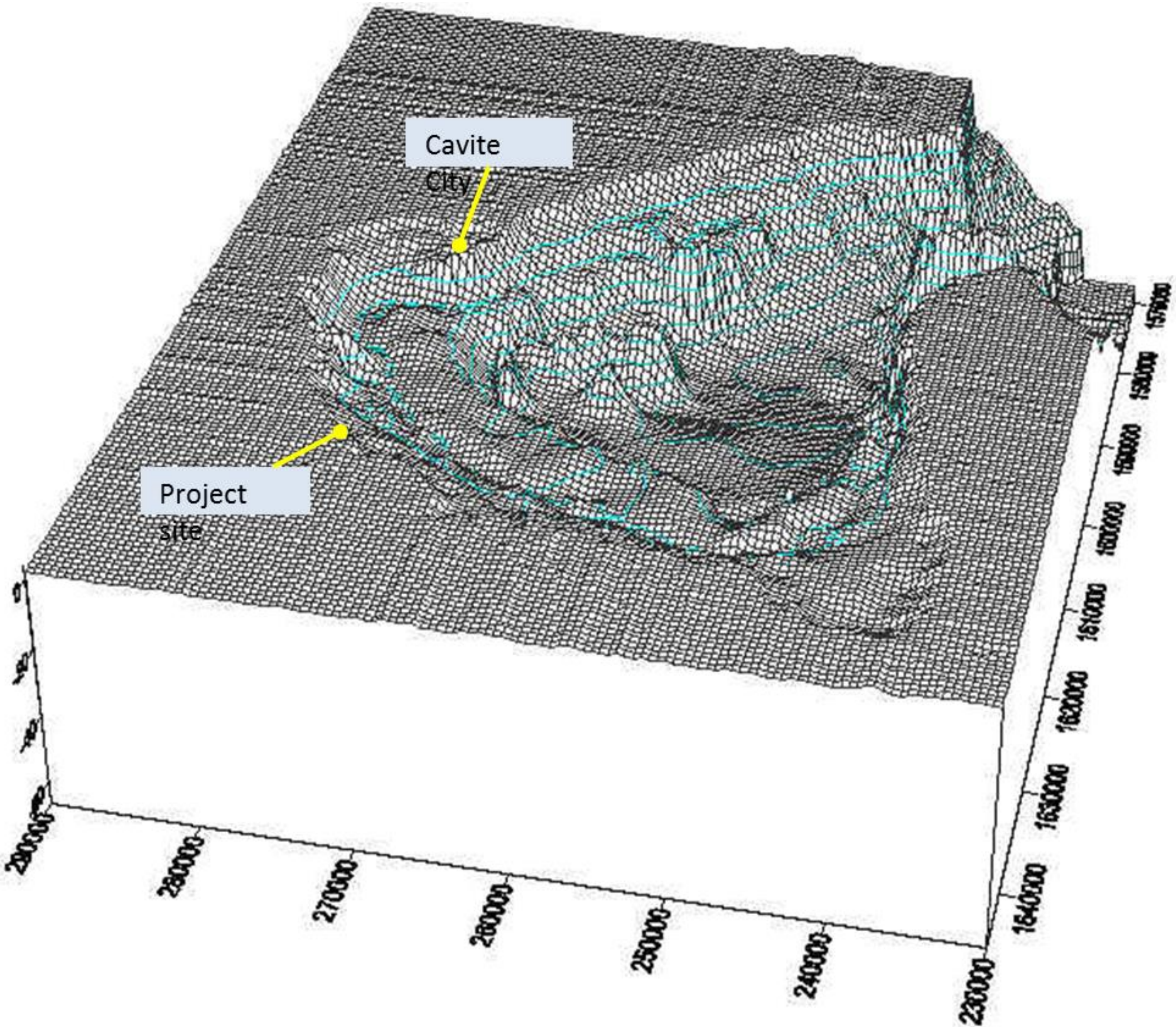


Figure 2-81 **Three-dimensional view of the bathymetry of Manila Bay**

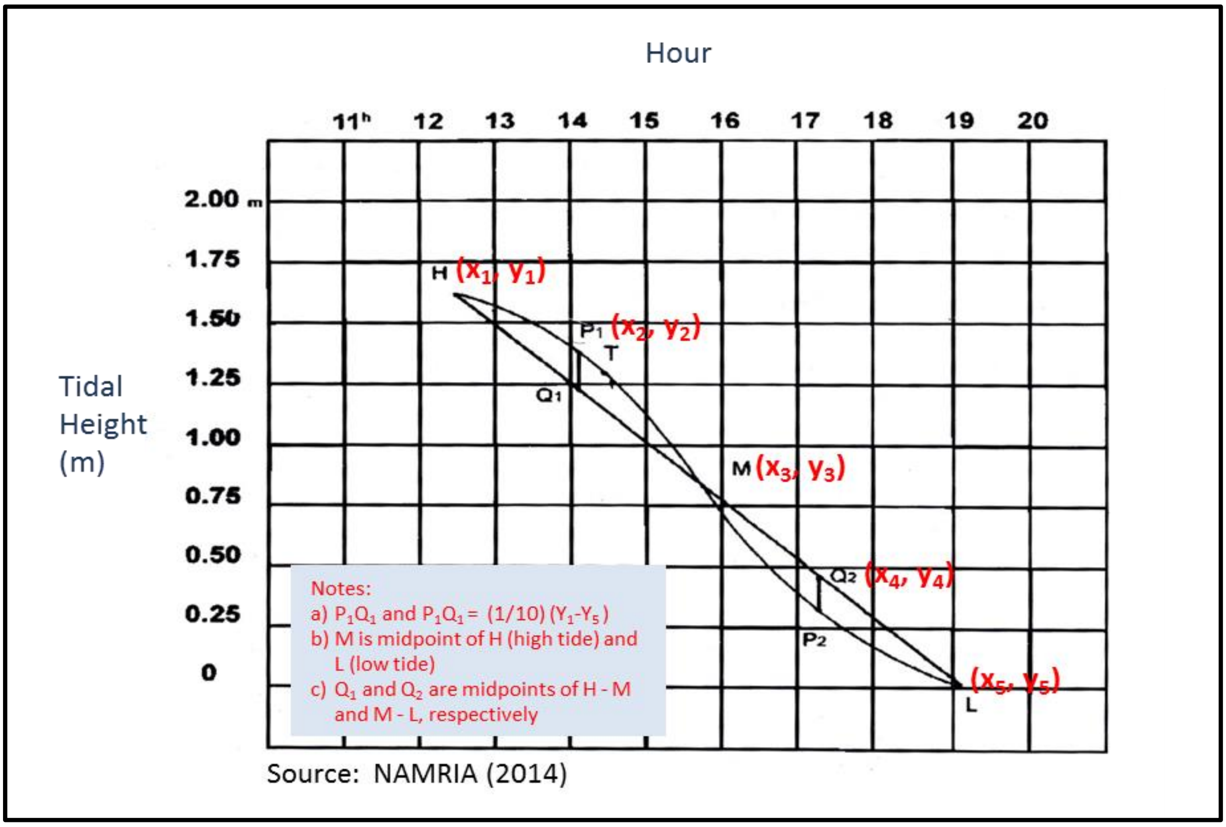


Figure 2-82 Graphical representation of tidal heights between high and low waters

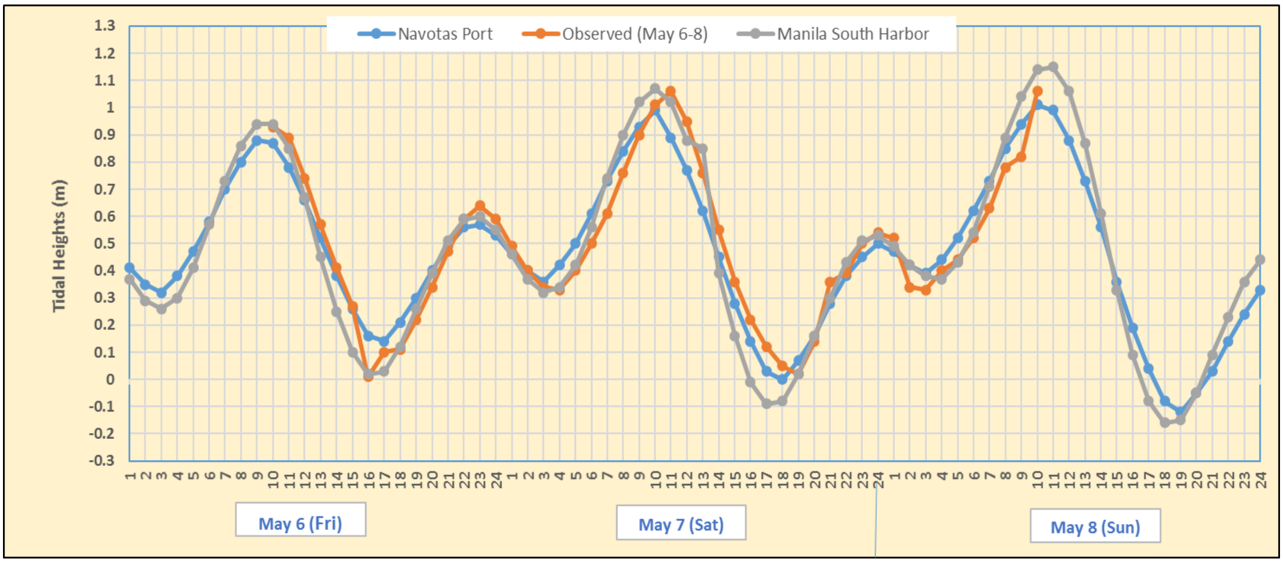


Figure 2-83 Observed and predicted tidal heights

2.2.2.2.3 Current measurements

Two (2 teams were deployed from May 6-8, 2010 to measure currents, including sounding and sedimentation rate sampling. The first team used and SD6000 current meter and a drogue while the 2nd team utilized two (2) drogues. The second team also conducted sound and sedimentation rate sampling using a GARMIN Echosounder Chirp 52DV and sedimentation traps, respectively. Plate 2-1 to Plate 2-7 show the photographs taken during monitoring.

Figure 2-84 shows the plot of the locations of the ocean current stations and drogue release locations. Table 2-26 to Table 2-28 show the results of continuous sampling of currents at Stations 1 and 2 on May 7, and 8, respectively. Results of initial drogue tracks are shown in Figure 2-85.

The following highlights the summary of the results of the current measurements using an SD6000 current meter and drogues:

1. Continuous monitoring at Station 3 on May 7, 2016 showed that currents tend to move away from coast (move generally toward the south-southeast direction) during slack water and ebb tide with increasing speeds at mid ebb to flood current tides (Figure 2-84);
2. Results of continuous monitoring at Station 2 on May 8 showed that currents tend to move towards the coast (or north-northeast directions) during flood tide, and reverses in direction to south-southerly directions during ebb tide. As shown in Figure 2-84, current speeds were relatively lower as its reaches the time of slack water, and changes in direction immediately after slack water, and consequently increases in speeds at mid ebb to flood tide
3. Random current measurements (30-minutes sampling) on May 7, 2010 (Table 2-26) showed consistent flows those of drogue measurements (Figure 2-85). Current directions generally move away from the coast (drains towards the mouth) during ebb tide (Figure 2-84).
4. Measured surface water temperatures at the continuous stations (Station 2 and 3) during daytime were relatively warmer, and ranged from 31.1 to 33.5 °C with an average of 31.6 °C.

Table 2-26 Measured currents at Stations 1, 2 and 3 on May 6, 2016

Temp	Date	Time Deployed/ Retrieved		Time		Long (Degrees)	Lat (Degrees)	cm/sec	SD	Station	Bottom, Depth, m
31.95	5/6/2016	Deployed	5/6/2016	10:29	am	120.91456	14.67014	1	38	Station 1	5
31.85	5/6/2016		5/6/2016	10:34	am	120.91456	14.67014	1	209		
31.85	5/6/2016		5/6/2016	10:39	am	120.91456	14.67014	2.2	145		
31.85	5/6/2016		5/6/2016	10:44	am	120.91456	14.67014	2	213		
31.8	5/6/2016		5/6/2016	10:49	am	120.91456	14.67014	0.8	10		
31.8	5/6/2016		5/6/2016	10:54	am	120.91456	14.67014	1	97		
32	5/6/2016	Retrieved	5/6/2016	10:59	am	120.91456	14.67014	1.6	257		
32.1	5/6/2016	Deployed	5/6/2016	11:34	am	120.89619	14.688	3.8	227	Station 2	4
32.05	5/6/2016		5/6/2016	11:39	am	120.89619	14.688	4.6	245		
32.05	5/6/2016		5/6/2016	11:44	am	120.89619	14.688	0.2	358		
32.05	5/6/2016		5/6/2016	11:49	am	120.89619	14.688	6.4	246		
32.05	5/6/2016		5/6/2016	11:54	am	120.89619	14.688	7.4	208		
32	5/6/2016	Retrieved	5/6/2016	11:59	am	120.89619	14.688	4.4	249		
32.15	5/6/2016	Deployed	5/6/2016	2:28	pm	120.91724	14.65954	3	307	Station 3	6
32.05	5/6/2016		5/6/2016	2:33	pm	120.91724	14.65954	4.2	316		
32.1	5/6/2016		5/6/2016	2:38	pm	120.91724	14.65954	4	308		
32.1	5/6/2016		5/6/2016	2:43	pm	120.91724	14.65954	4.6	346		
32.05	5/6/2016		5/6/2016	2:48	pm	120.91724	14.65954	4.8	319		
31.05	5/6/2016	Retrieved	5/6/2016	2:53	pm	120.91724	14.65954	2.8	314		
31.35	5/7/2016	Deployed	5/7/2016	9:38	am	120.91762	14.66421	0.6	108	Station 3	6
31.5	5/7/2016		5/7/2016	9:43	am	120.91762	14.66421	2.4	117		
31.5	5/7/2016		5/7/2016	9:48	am	120.91762	14.66421	3.4	181		
31.45	5/7/2016		5/7/2016	9:53	am	120.91762	14.66421	3.8	174		
31.5	5/7/2016		5/7/2016	9:58	am	120.91762	14.66421	3.2	149		
31.45	5/7/2016	Retrieved	5/7/2016	10:03	am	120.91762	14.66421	3.8	159		
31.15	5/8/2016	Deployed	5/8/2016	8:29	am	120.89687	14.68792	5.4	19	Station 2	4.2

Temp	Date	Time Deployed/ Retrieved		Time		Long (Degrees)	Lat (Degrees)	cm/sec	SD	Station	Bottom, Depth, m
31.15	5/8/2016		5/8/2016	8:34	am	120.89687	14.68792	5.4	22		
31.15	5/8/2016		5/8/2016	8:39	am	120.89687	14.68792	5.6	27		
31.15	5/8/2016		5/8/2016	8:44	am	120.89687	14.68792	6.2	28		
31.15	5/8/2016	Retrieved	5/8/2016	8:49	am	120.89687	14.68792	5.6	28		

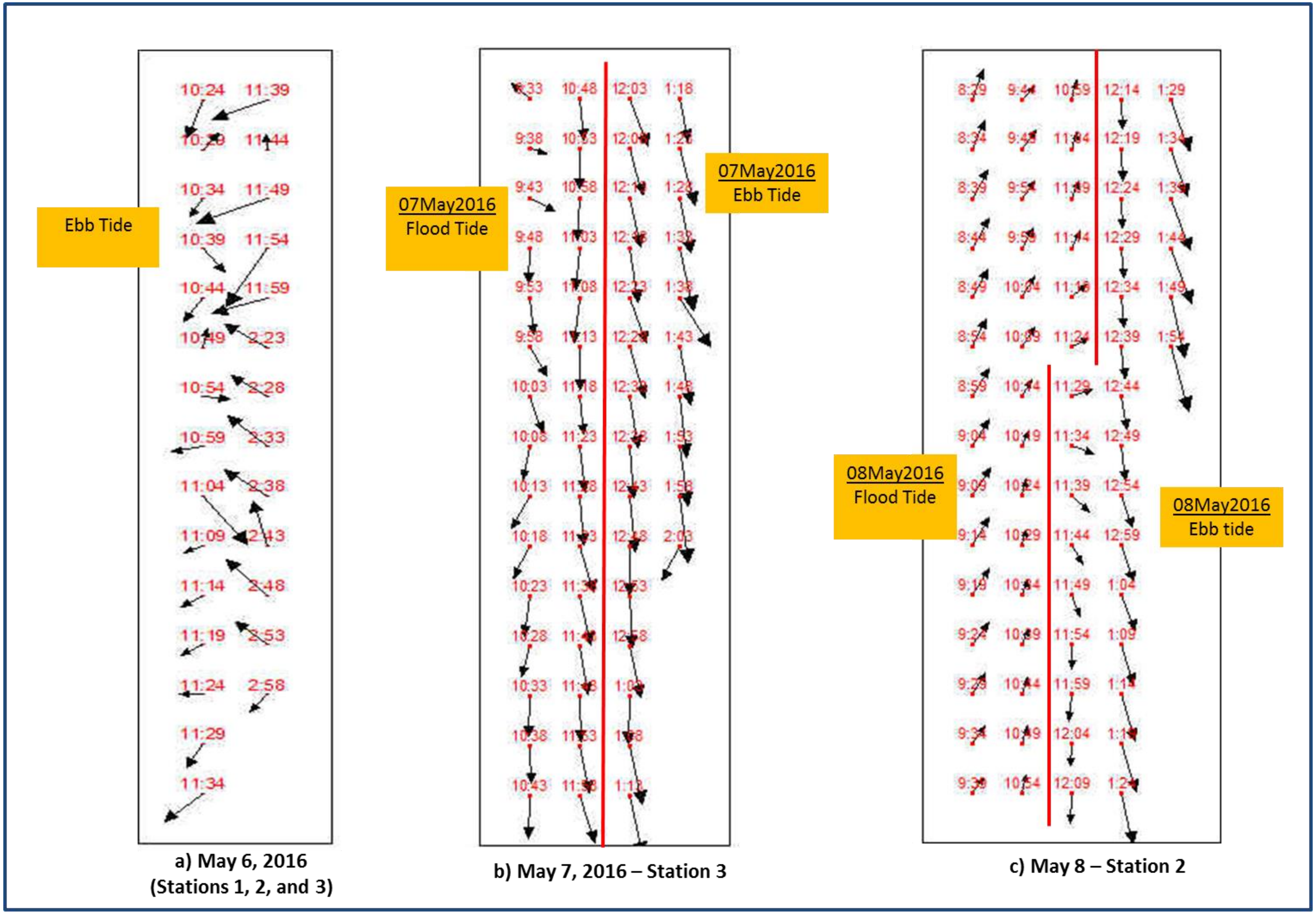


Figure 2-84 Plot of current vectors based on current measurements from May 6-8, 2016 using SD current meter

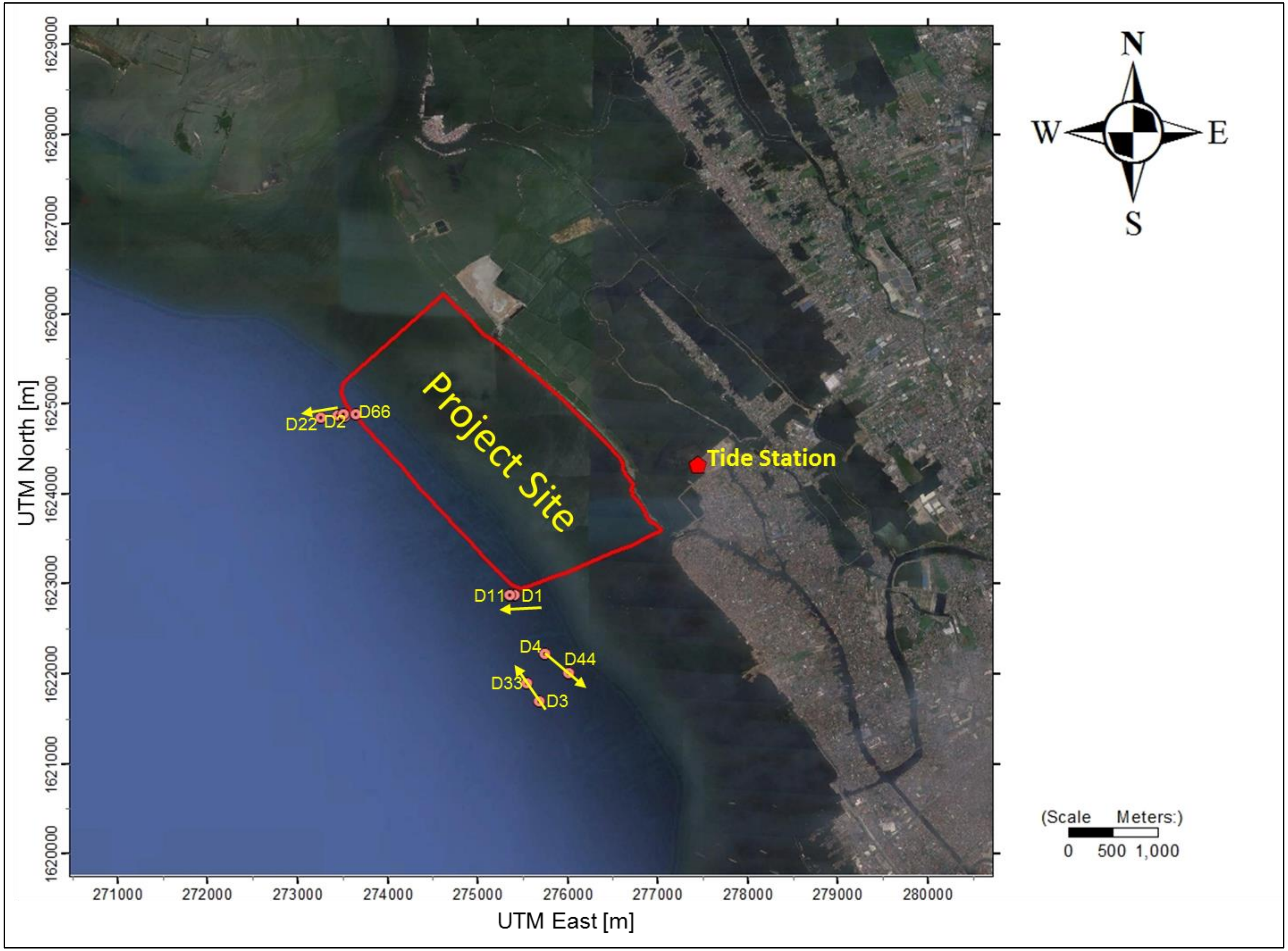


Figure 2-85 General directions of initial drogues tracks after released

Table 2-27 Measured currents at Station 3 on May 7, 2016

Temp (°C)	Current Speed (cm/s)	Current Direction (deg)	Date	Local Time	A.M./P.M.
32.40	1.60	309	5/7/2016	9:33	am
31.35	0.60	108	5/7/2016	9:38	am
31.50	2.40	117	5/7/2016	9:43	am
31.50	3.40	181	5/7/2016	9:48	am
31.45	3.80	174	5/7/2016	9:53	am
31.50	3.20	149	5/7/2016	9:58	am
31.45	3.80	159	5/7/2016	10:03	am
31.45	3.20	191	5/7/2016	10:08	am
31.40	3.60	209	5/7/2016	10:13	am
31.40	3.40	207	5/7/2016	10:18	am
31.40	4.20	188	5/7/2016	10:23	am
31.40	2.80	194	5/7/2016	10:28	am
31.50	4.20	182	5/7/2016	10:33	am
31.50	3.80	177	5/7/2016	10:38	am
31.50	4.60	182	5/7/2016	10:43	am
31.50	4.60	174	5/7/2016	10:48	am
31.45	4.40	180	5/7/2016	10:53	am
31.50	4.60	183	5/7/2016	10:58	am
31.50	4.60	185	5/7/2016	11:03	am
31.45	5.00	187	5/7/2016	11:08	am
31.50	4.60	179	5/7/2016	11:13	am
31.55	3.80	173	5/7/2016	11:18	am
31.50	5.00	173	5/7/2016	11:23	am
31.50	5.60	175	5/7/2016	11:28	am
31.50	5.40	162	5/7/2016	11:33	am
31.50	5.60	167	5/7/2016	11:38	am
31.50	5.60	170	5/7/2016	11:43	am
31.55	5.00	178	5/7/2016	11:48	am
31.50	5.40	168	5/7/2016	11:53	am
31.55	5.60	162	5/7/2016	11:58	am
31.65	6.00	159	5/7/2016	12:03	pm
31.60	5.60	164	5/7/2016	12:08	pm
31.65	5.80	167	5/7/2016	12:13	pm
31.70	6.60	171	5/7/2016	12:18	pm
31.70	5.60	159	5/7/2016	12:23	pm
31.70	6.20	163	5/7/2016	12:28	pm
31.70	6.00	170	5/7/2016	12:33	pm
31.65	6.00	175	5/7/2016	12:38	pm
31.70	6.60	174	5/7/2016	12:43	pm
31.70	5.40	179	5/7/2016	12:48	pm
31.70	6.00	177	5/7/2016	12:53	pm
31.65	6.20	168	5/7/2016	12:58	pm
31.65	5.40	182	5/7/2016	1:03	pm
31.70	7.20	167	5/7/2016	1:08	pm
31.90	7.40	167	5/7/2016	1:13	pm
31.85	4.80	168	5/7/2016	1:18	pm
31.90	7.20	164	5/7/2016	1:23	pm
31.90	6.80	168	5/7/2016	1:28	pm
31.90	8.00	167	5/7/2016	1:33	pm
31.95	7.00	148	5/7/2016	1:38	pm
32.05	7.20	169	5/7/2016	1:43	pm
32.00	7.40	173	5/7/2016	1:48	pm
32.05	7.20	172	5/7/2016	1:53	pm
32.15	8.40	172	5/7/2016	1:58	pm
33.45	3.80	207	5/7/2016	2:03	pm

Table 2-28 Current Vectors and Temperature at Station 2 on May 8, 2016

Temp (^{o}C)	Current Speed (cm/sec)	Current Direction (deg)	Date	Local Time	A.M./P.M.
31.15	5.40	19	5/8/2016	8:29	AM
31.15	5.40	22	5/8/2016	8:34	am
31.15	5.60	27	5/8/2016	8:39	am
31.15	6.20	28	5/8/2016	8:44	am
31.15	5.60	28	5/8/2016	8:49	am
31.15	5.40	25	5/8/2016	8:54	am
31.20	5.80	29	5/8/2016	8:59	am
31.15	5.40	31	5/8/2016	9:04	am
31.20	6.00	32	5/8/2016	9:09	am
31.15	5.80	30	5/8/2016	9:14	am
31.15	5.60	32	5/8/2016	9:19	am
31.15	4.20	35	5/8/2016	9:24	am
31.20	3.40	31	5/8/2016	9:29	am
31.20	2.40	33	5/8/2016	9:34	am
31.20	1.80	35	5/8/2016	9:39	am
31.15	1.40	42	5/8/2016	9:44	am
31.15	3.00	37	5/8/2016	9:49	am
31.15	2.40	34	5/8/2016	9:54	am
31.15	2.80	30	5/8/2016	9:59	am
31.15	3.40	30	5/8/2016	10:04	am
31.15	3.20	31	5/8/2016	10:09	am
31.20	1.80	29	5/8/2016	10:14	am
31.15	1.20	24	5/8/2016	10:19	am
31.15	1.20	13	5/8/2016	10:24	am
31.15	1.00	14	5/8/2016	10:29	am
31.10	1.00	20	5/8/2016	10:34	am
31.10	1.20	23	5/8/2016	10:39	am
31.10	1.20	19	5/8/2016	10:44	am
31.10	1.60	18	5/8/2016	10:49	am
31.15	1.80	13	5/8/2016	10:54	am
31.10	1.80	14	5/8/2016	10:59	am
31.15	1.40	19	5/8/2016	11:04	am
31.10	1.60	21	5/8/2016	11:09	am
31.15	1.80	24	5/8/2016	11:14	am
31.20	2.00	48	5/8/2016	11:19	am
31.10	1.80	60	5/8/2016	11:24	am
31.15	2.60	70	5/8/2016	11:29	am
31.20	3.00	108	5/8/2016	11:34	am
31.20	3.00	132	5/8/2016	11:39	am
31.15	2.60	151	5/8/2016	11:44	am
31.20	3.00	160	5/8/2016	11:49	am
31.25	3.40	179	5/8/2016	11:54	am
31.30	4.20	186	5/8/2016	11:59	am
31.45	2.80	185	5/8/2016	12:04	pm
31.60	5.20	183	5/8/2016	12:09	pm
31.50	5.00	177	5/8/2016	12:14	pm
31.60	5.60	178	5/8/2016	12:19	pm
31.85	5.00	178	5/8/2016	12:24	pm
31.95	5.00	175	5/8/2016	12:29	pm
31.90	5.20	176	5/8/2016	12:34	pm
31.95	5.40	174	5/8/2016	12:39	pm
32.00	6.00	170	5/8/2016	12:44	pm
31.95	6.40	174	5/8/2016	12:49	pm
32.25	6.20	160	5/8/2016	12:54	pm

Temp (°C)	Current Speed (cm/sec)	Current Direction (deg)	Date	Local Time	A.M./P.M.
32.35	7.40	162	5/8/2016	12:59	pm
32.25	7.40	158	5/8/2016	1:04	pm
32.20	8.80	163	5/8/2016	1:09	pm
32.20	10.80	164	5/8/2016	1:14	pm
32.15	11.00	163	5/8/2016	1:19	pm
32.15	11.60	167	5/8/2016	1:24	pm
32.10	12.40	160	5/8/2016	1:29	pm
32.25	11.00	161	5/8/2016	1:34	pm
32.40	12.80	160	5/8/2016	1:39	pm
32.35	14.00	160	5/8/2016	1:44	pm
32.20	14.80	167	5/8/2016	1:49	pm
32.40	16.00	164	5/8/2016	1:54	pm

2.2.2.2.4 Three-hourly and hourly meteorological conditions during monsoon peaks and transition seasons

Figure 2-86 shows the wind rose for Port Area, Manila and Sangley Point, Cavite during the peak of northeast monsoon (February) and wet season (August). Prevailing wind flows at both synoptic stations were generally from S-E and N-E quadrants, although PAGASA-Sangley Point Station showed prevailing winds from the east during the northeast monsoon season.

Wind speeds generally ranged from 1 to 5 m/s (Figure 2-86). At Port Area, about 25% of the recorded wind speeds were below 1 m/s (or at calm condition) while from 7 to 10% at Sangley Point, Cavite.

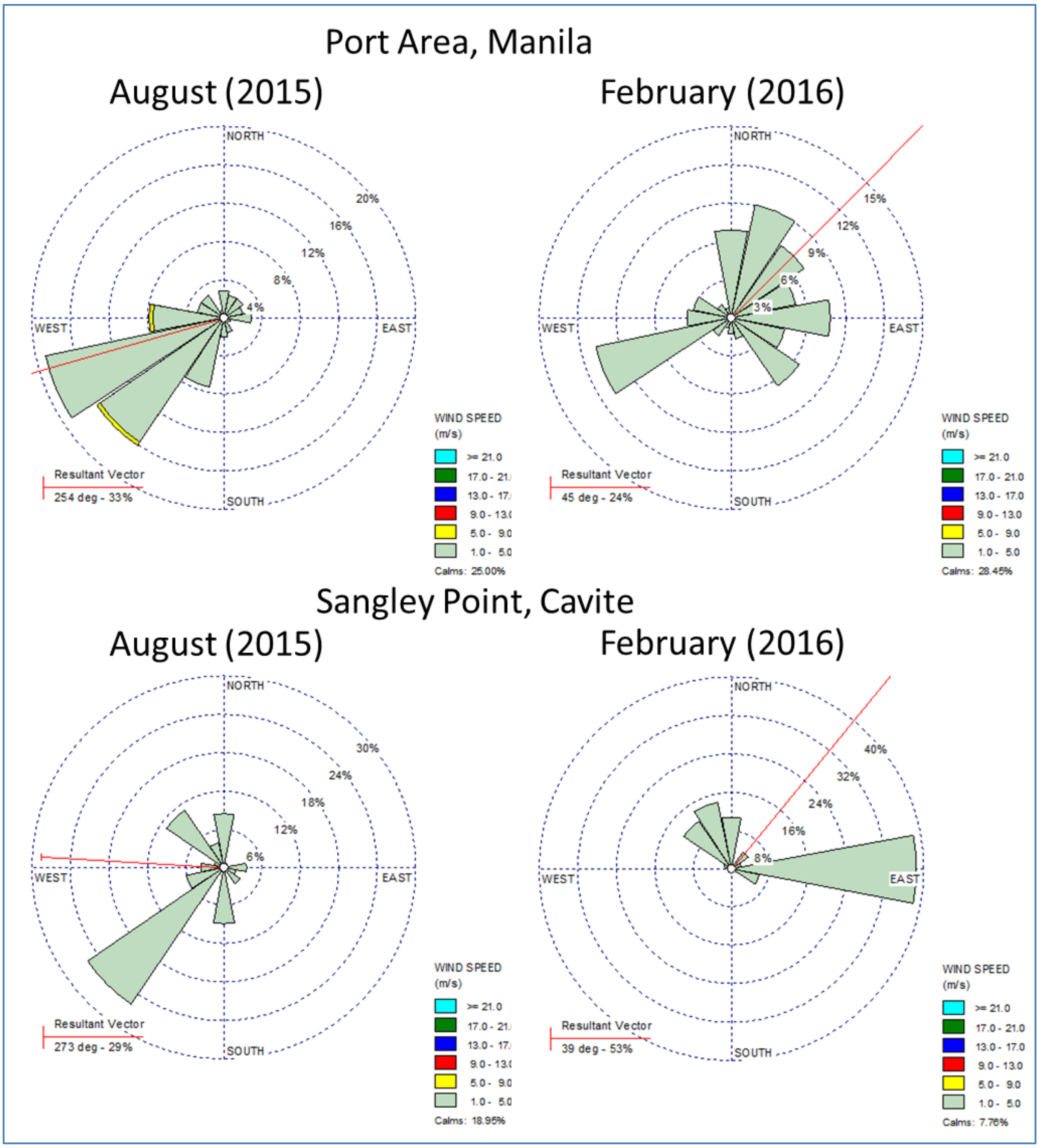


Figure 2-86 Wind roses for Port Area and Sangley Point during peaks of southwest (August) and northeast monsoon (February)

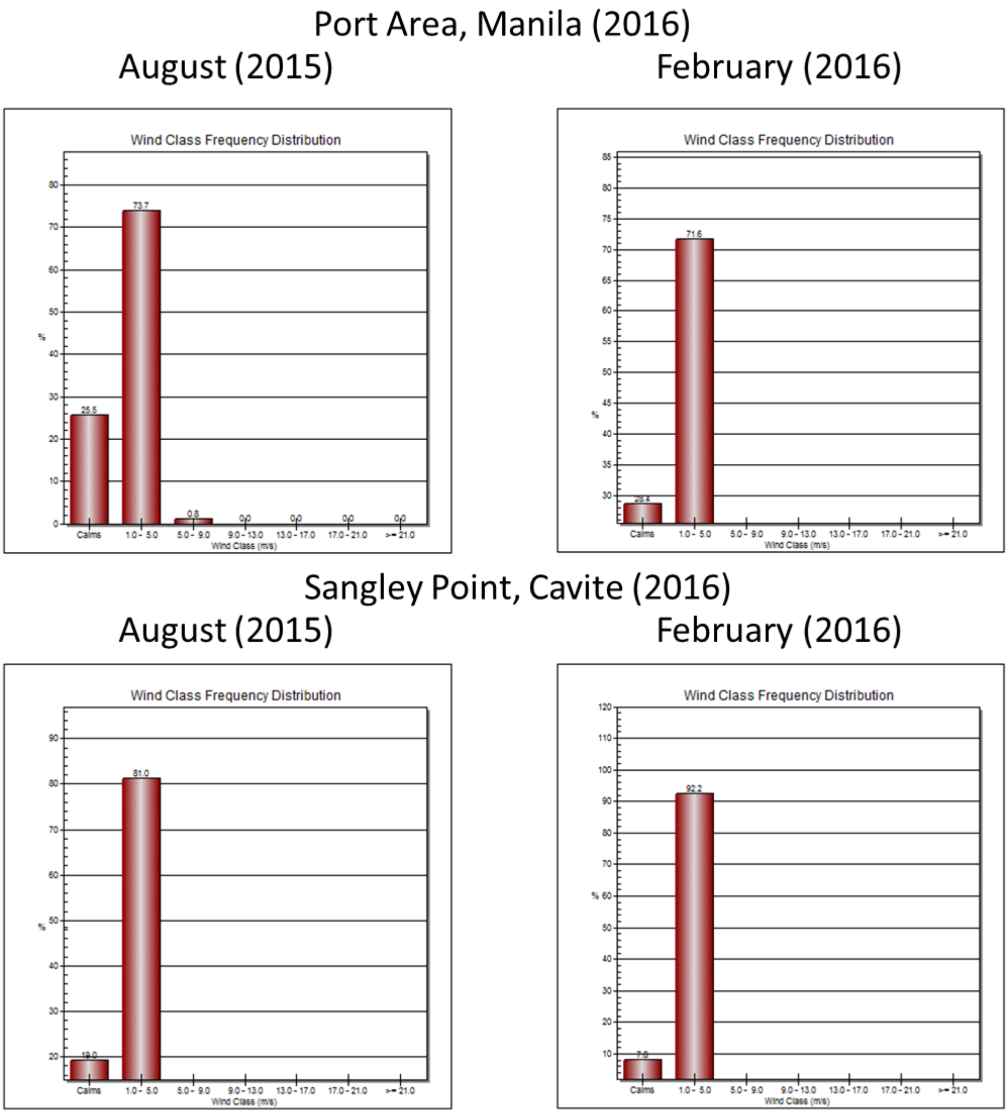


Figure 2-87 Wind speed classes for Port Area and Sangley Point during peaks of southwest (August) and northeast monsoon (February)

2.2.2.3 Impact assessment and modeling

2.2.2.3.1 Oceanographic modeling

EFDC model

The hydrodynamic model used in this study is the Environmental Fluid Dynamics Code (EFDC), which was originally developed by Dr. John M. Hamrick from the Virginia Institute of Marine Science (VIMS) and School of Marine Science of the College of William and Mary. It is a public domain, open source, surface water modeling system that has been applied to numerous water bodies, such as rivers, lakes, and estuaries (Tetratech 2007).

According to U.S.EPA website (www.epa.gov/exposure-assessment-models/efdc), EFDC has “evolved over the past two decades to become one of the most widely used and technically defensible hydrodynamic models in the world”. It is the recommended hydrodynamic model to be used for environmental impact assessment of proposed projects with possible impacts on coastal areas, as stipulated in the Technical Scoping Checklist of the DENR-EMB.

Grid generation using EFDC

EFDC includes a preprocessor program named GEFDC that generates a Cartesian or curvilinear-orthogonal grid files and other outputs files needed to run the EFDC. Inputs to the GEFDC are the bathymetry, which in this case is Figure 2-80, the boundary points, and cell definition input file (or cell.inp).

Figure 2-88(b) shows the input data file, cell.inp, containing the numerical values representing the boundary points, water cells, and land surfaces. The following cell definitions are used in this study following EFDC User's Manual (Tetratech 2007).

- 0 – as dry land cell (not bordering a water cell on a side or a corner land surface)
- 9- as dry land cell bordering a water cell or fictitious dry land cell bordering an open boundary water cell on a side or a corner
- 5 – as quadrilateral water cell

Figure 2-88(a) shows the plot of the output data file, "GRID.DXF", containing the generated cells based on cell definitions, bathymetry and boundary points. Sample screenshots of the output data files, DXDY.INP and LXLY.INP (originally DXDY.OUT and LXLY.OUT) are shown in Figure 2-89.

Tidal forcing

The highs and lows of water in February 2016 and August 2016 were processed using the computer program developed to compute the hourly tidal heights following NAMRIA's graphical method (please refer Section 3b above). Figure 2-90 shows the hourly predicted tidal heights in February 2016 and August 2016.

Wind and atmospheric forcing

Three-hourly data from PAGASA-Sangley Point for the months of August 2015 and February 2016 consist of cloudiness (okta), mean sea level pressure (mb), relative humidity (%), dry bulb temperature (ºC), wind direction (deg), wind speed (m/s) and rainfall (mm). These data were used to generate the required wind and atmospheric data files in EFDC simulations.

For meteorological parameters, such as wet bulb temperature and solar radiation, these were calculated following Stull (2011) and Kasten and Czepak (1980), respectively. Stull (2011) demonstrated the used of the following formula to calculate the wet bulb temperature (Tw) from dry bulb temperature (T) and relative humidity (RH),

$$T_w = T\,\mathrm{atan}[0.151\,977(\mathrm{RH\%} + 8.313\,659)^{1/2}] + \mathrm{atan}(T + \mathrm{RH\%}) - \mathrm{atan}(\mathrm{RH\%} - 1.676\,331) + 0.003\,918\,38(\mathrm{RH\%})^{3/2}\,\mathrm{atan}(0.023\,101\mathrm{RH\%}) - 4.686\,035.$$

Kasten and Czeplak (1980) indicated the following equation on total incoming solar radiation due to presence of cloudiness as,

$$R = R_o\left(1 + b_1 n^{b_2}\right)$$

where b_1 = -0.75, b_2 = 3.4 and n is the opaque cloud cover.

River inflows and concentrations

River inflows also influenced currents and sedimentation patterns in bays and estuaries. In this study, river discharges data were sourced out from the following studies.

- Pokavanich and Nadaoka (2006) on hydrodynamics simulation of Manila Bay - discharge flow rates of Bulacan-Meycauyan (Obando) at 180 m^3/s and minor rivers at 90 m^3/s, and water temperature of 29.5 ºC;
- Siringan and Ringor (1998) on changes in bathymetry and sediment rate study in Manila Bay – discharge rates of Pasig and Pampanga river basins; and
- WB Solutions (2008) on Maragondon River Project – discharge flow of Maragondon River with estimated main flow of 500,000 m^3/day;

During wet season when river inflows are expected higher due to frequent rainfall, discharge flows at Pasig and Pampanga Rivers as indicated in Siringan and Ringor (1998) were utilized in study. Increase in discharge flow of about 67% was assumed for other rivers during wet season, as based on data for Pasig and Pampanga Rivers.

Owing to absence of water quality data at river inflows, initial time constant inflow concentrations of 30 and 50 mg/l were used for the dry (February) and wet (August) simulations, respectively. These values were roughly estimated from Michigan standards (www.michigan.gov) wherein it cited perception of water quality as clear when TSS concentrations are less than 20 mg/l, appear cloudy between 40 to 80 mg/l, and appears "dirty" at concentrations over 150 mg/l.

Figure 2-91 shows the location of rivers considered in this study.

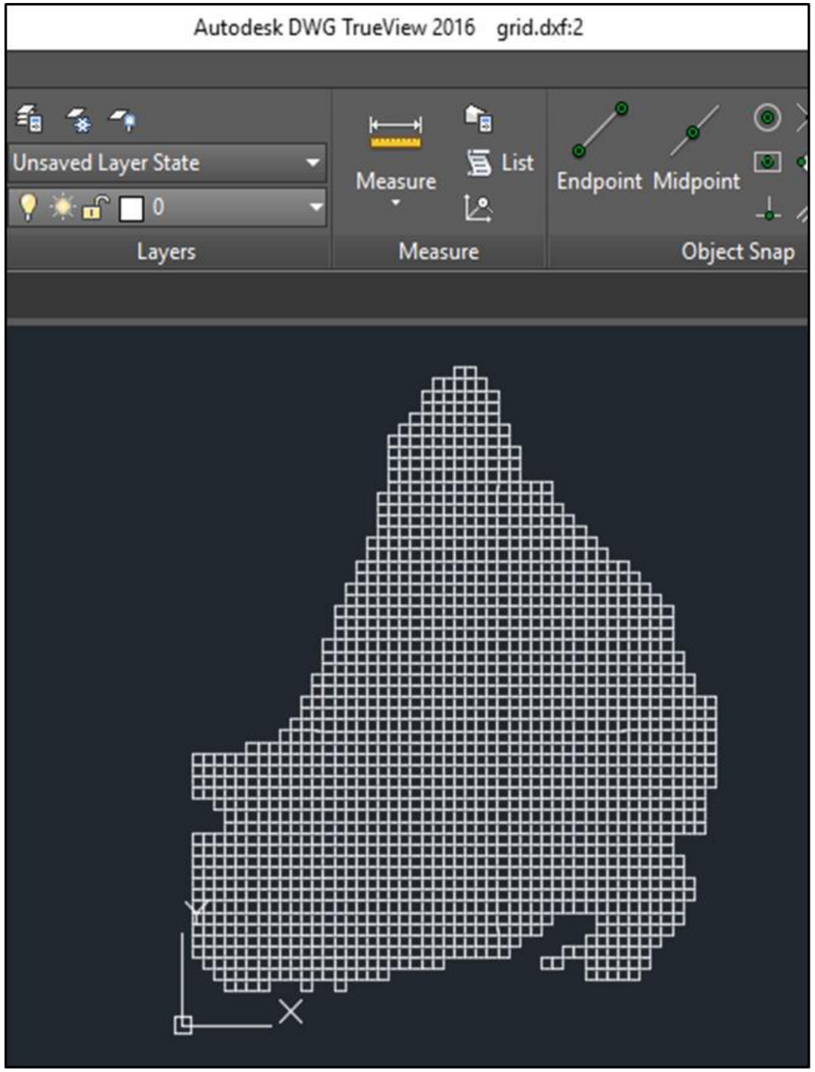
Sediments and water quality in Manila Bay

Manila Bay is generally overlay with mud and fractions of sandy mud and sand in Cavite area. Patches of sandy-mud are also found in Pampanga Bay and north of Pasig Delta River (Siringan and Ringor, 1998). Based on samples collected at Bataan, Cavite-Bataan, Pasig-River-Caloocan, and Cavite Bacoor by Siringan and Ringor (1998), the average fractions of sediments are as follows:

- Silt-clay – 73%
- Sand –23%
- Gravel -4%

The above average sediment fractions were used as initial cohesive and non-cohesive sediment data over the whole Manila Bay.

Average concentration of Total Suspended Solids (TSS) of 8 mg/l, which was based on water quality sampling in April 2016 by RHR Consult Services at ten (10) stations located at and in the vicinity of the proposed reclamation site, was used as initial sediment column concentrations for this study.



a) Generated grid (grid.dxf) using GEFDC

```
43  00000000000000095555555555555555555555599000000000000000
42  00000000000000995555555555555555555555599900000000000000
41  00000000000000955555555555555555555555559900000000000000
40  00000000000009955555555555555555555555555990000000000000
39  00000000000000955555555555555555555555555599000000000000
38  00000000000099555555555555555555555555555559900000000000
37  00000000000009555555555555555555555555555555590000000000
36  00000000000009555555555555555555555555555555590000000000
35  00000000000099555555555555555555555555555555590000000000
34  00000000000095555555555555555555555555555555599000000000
33  00000000000095555555555555555555555555555555559000000000
32  00000000009955555555555555555555555555555555599000000000
31  00000000009555555555555555555555555555555555559000000000
30  00000000099555555555555555555555555555555555559990000000
29  00000000095555555555555555555555555555555555555590000000
28  00000000995555555555555555555555555555555555555590000000
27  00000009955555555555555555555555555555555555555590000000
26  00009995555555555555555555555555555555555555555590000000
25  99999555555555555555555555555555555555555555555590000000
24  95555555555555555555555555555555555555555555555590000000
23  95555555555555555555555555555555555555555555555590000000
22  95555555555555555555555555555555555555555555555590000000
21  95555555555555555555555555555555555555555555555990000000
20  99995555555555555555555555555555555555555555555900000000
19  00095555555555555555555555555555555555555555555900000000
18  99995555555555555555555555555555555555555555555900000000
17  95555555555555555555555555555555555555555555999900000000
16  95555555555555555555555555555555555555555555599000000000
15  95555555555555555555555555555555555555555555590000000000
14  95555555555555555555555555555555555555555555599000000000
13  95555555555555555555555555555555555555555555590000000000
12  95555555555555555555555555555555555555555555559000000000
11  95555555555555555555555555555555555555555555599000000000
10  95555555555555555555555555555999955555555555555900000000
 9  95555555555555555555555555559909955555555555559900000000
 8  95555555555555555555555555999999555555555555599000000000
 7  95555555555555555555555555559999955555555555599000000000
 6  99555555555555555555555999999909559955555590000000000000
 5  09955555555555555559999990000000999995555990000000000000
 4  00995555599995995999900000000000000099999990000000000000
 3  00099999909999999000000000000000000000000000000000000000
 2  00000000000000000000000000000000000000000000000000000000
 1  00000000000000000000000000000000000000000000000000000000
c
c   123456789012345678901234567890123456789012345678901234567890
```

b). Input file cell.inp

Figure 2-88 Plots of a) output grid using the grid generator (GEFDC) of EFDC and b) cell.inp (input file to GEFDC)

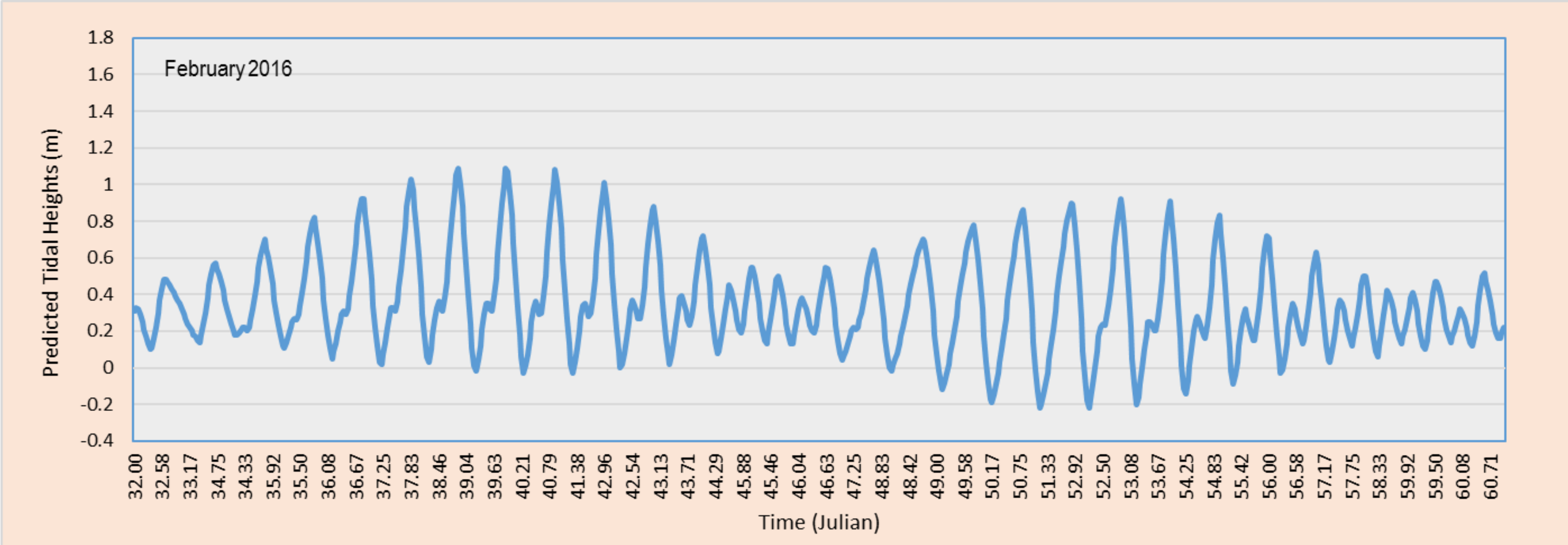
```
C dxdy.inp file, in free format across columns
C
C      I      J          DX             DY              DEPTH        BOTTOM ELEV
C
       5      4    0.99985E+03    0.99962E+03    0.35575E+01    -0.35575E+01
       6      4    0.99993E+03    0.99954E+03    0.37349E+01    -0.37349E+01
       7      4    0.10000E+04    0.99943E+03    0.34632E+01    -0.34632E+01
       8      4    0.10002E+04    0.99921E+03    0.31890E+01    -0.31890E+01
      12      4    0.10002E+04    0.99911E+03    0.15535E+01    -0.15535E+01
      15      4    0.10002E+04    0.99906E+03    0.34254E+01    -0.34254E+01
       4      5    0.99972E+03    0.99962E+03    0.82423E+01    -0.82423E+01
       5      5    0.99980E+03    0.99959E+03    0.81274E+01    -0.81274E+01
       6      5    0.99987E+03    0.99953E+03    0.81574E+01    -0.81574E+01
       7      5    0.99994E+03    0.99944E+03    0.78979E+01    -0.78979E+01
       8      5    0.10000E+04    0.99933E+03    0.64242E+01    -0.64242E+01
       9      5    0.10000E+04    0.99925E+03    0.43397E+01    -0.43397E+01
      10      5    0.99996E+03    0.99919E+03    0.35450E+01    -0.35450E+01
      11      5    0.99987E+03    0.99915E+03    0.38208E+01    -0.38208E+01
      12      5    0.99996E+03    0.99914E+03    0.37793E+01    -0.37793E+01
      13      5    0.99992E+03    0.99909E+03    0.42759E+01    -0.42759E+01
      14      5    0.99986E+03    0.99906E+03    0.50132E+01    -0.50132E+01
      15      5    0.10000E+04    0.99904E+03    0.49663E+01    -0.49663E+01
      16      5    0.10001E+04    0.99903E+03    0.47001E+01    -0.47001E+01
      17      5    0.10001E+04    0.99900E+03    0.39703E+01    -0.39703E+01
      18      5    0.10002E+04    0.99889E+03    0.34436E+01    -0.34436E+01
      19      5    0.10005E+04    0.99859E+03    0.34644E+01    -0.34644E+01
      38      5    0.99994E+03    0.10000E+04    0.75660E+00    -0.75660E+00
      39      5    0.99998E+03    0.10000E+04    0.16525E+01    -0.16525E+01
      40      5    0.10000E+04    0.10001E+04    0.18785E+01    -0.18785E+01
      41      5    0.10000E+04    0.10001E+04    0.18949E+01    -0.18949E+01
      42      5    0.10001E+04    0.10001E+04    0.13311E+01    -0.13311E+01
```

a) DXDY.inp –output data file from GEFDC containing grid distances and depth

```
C lxly.inp file, in free format across line
C
C     I     J     XLNUTME         YLTUTMN         CCUE           CCVE           CCUN
C
      5     4  0.449949E+04  0.349948E+04  0.100000E+01 -0.342969E-03 -0.165376E-03
      6     4  0.549938E+04  0.349936E+04  0.100000E+01 -0.405574E-03 -0.654130E-04
      7     4  0.649935E+04  0.349934E+04  0.100000E+01 -0.472870E-03  0.304978E-04
      8     4  0.749948E+04  0.349944E+04  0.100000E+01 -0.656376E-03  0.164198E-03
     12     4  0.114995E+05  0.349947E+04  0.100000E+01 -0.761388E-03  0.714057E-04
     15     4  0.144994E+05  0.349946E+04  0.100000E+01 -0.934600E-03  0.444160E-04
      4     5  0.349939E+04  0.449934E+04  0.100000E+01 -0.305261E-03 -0.288622E-03
      5     5  0.449915E+04  0.449908E+04  0.100000E+01 -0.330756E-03 -0.220528E-03
      6     5  0.549898E+04  0.449890E+04  0.100000E+01 -0.378234E-03 -0.147452E-03
      7     5  0.649889E+04  0.449878E+04  0.100000E+01 -0.440792E-03 -0.877124E-04
      8     5  0.749888E+04  0.449871E+04  0.100000E+01 -0.539423E-03 -0.516889E-04
      9     5  0.849890E+04  0.449865E+04  0.100000E+01 -0.639392E-03 -0.613626E-04
     10     5  0.949889E+04  0.449864E+04  0.100000E+01 -0.694887E-03  0.289449E-04
     11     5  0.104988E+05  0.449863E+04  0.100000E+01 -0.699703E-03 -0.428004E-04
     12     5  0.114987E+05  0.449859E+04  0.100000E+01 -0.734543E-03 -0.360587E-04
     13     5  0.124987E+05  0.449858E+04  0.100000E+01 -0.805763E-03  0.149654E-04
     14     5  0.134986E+05  0.449857E+04  0.100000E+01 -0.806860E-03 -0.443928E-04
     15     5  0.144985E+05  0.449851E+04  0.100000E+01 -0.821315E-03 -0.599555E-04
     16     5  0.154985E+05  0.449846E+04  0.100000E+01 -0.876873E-03 -0.424544E-04
     17     5  0.164986E+05  0.449850E+04  0.100000E+01 -0.907493E-03  0.124571E-03
     18     5  0.174987E+05  0.449869E+04  0.100000E+01 -0.929491E-03  0.241318E-03
     19     5  0.184991E+05  0.449900E+04  0.100000E+01 -0.115027E-02  0.378300E-03
     38     5  0.374999E+05  0.450000E+04  0.100000E+01 -0.710051E-04  0.299907E-04
     39     5  0.384998E+05  0.450004E+04  0.100000E+01 -0.101034E-03  0.472089E-04
     40     5  0.394998E+05  0.450008E+04  0.100000E+01 -0.107766E-03  0.356125E-04
     41     5  0.404999E+05  0.450010E+04  0.100000E+01 -0.972208E-04  0.841357E-05
     42     5  0.414999E+05  0.450008E+04  0.100000E+01 -0.819919E-04 -0.576572E-04
```

b) LXLY.INP –output data file from GEFDC containing distances x and y grids

Figure 2-89 Screenshot of output files as generated using GEFDC



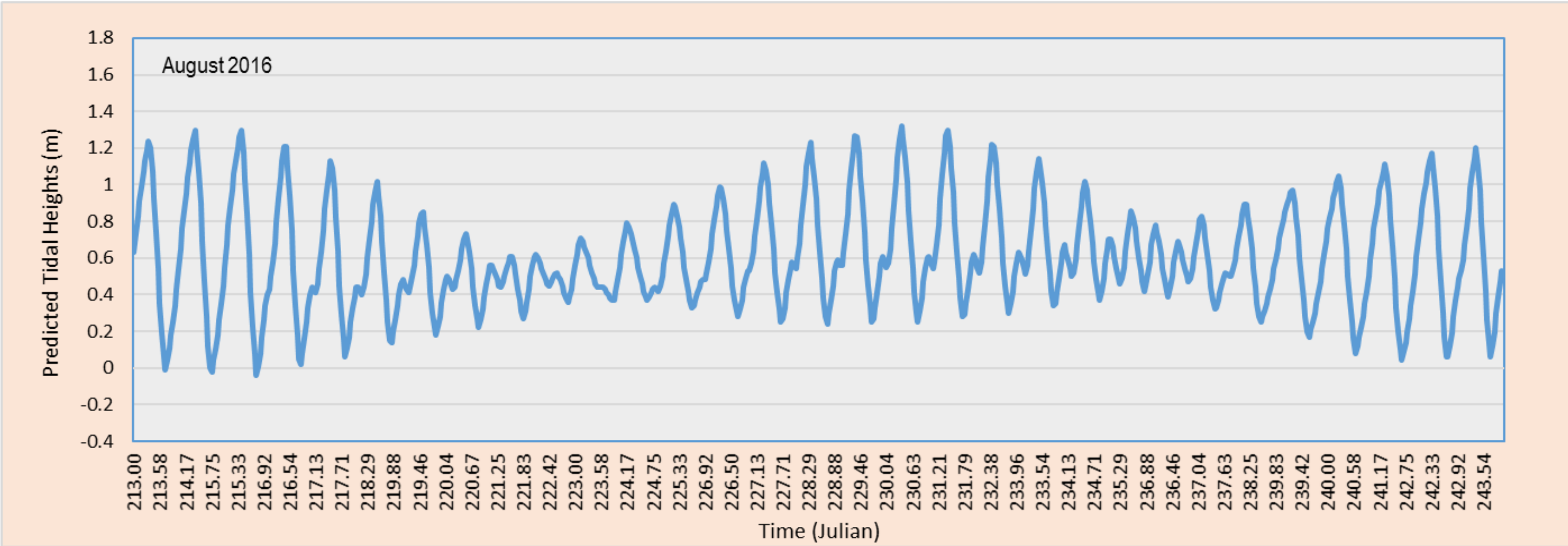


Figure 2-90 Predicted hourly tidal heights in February 2016 (above) and August 2016 (below)

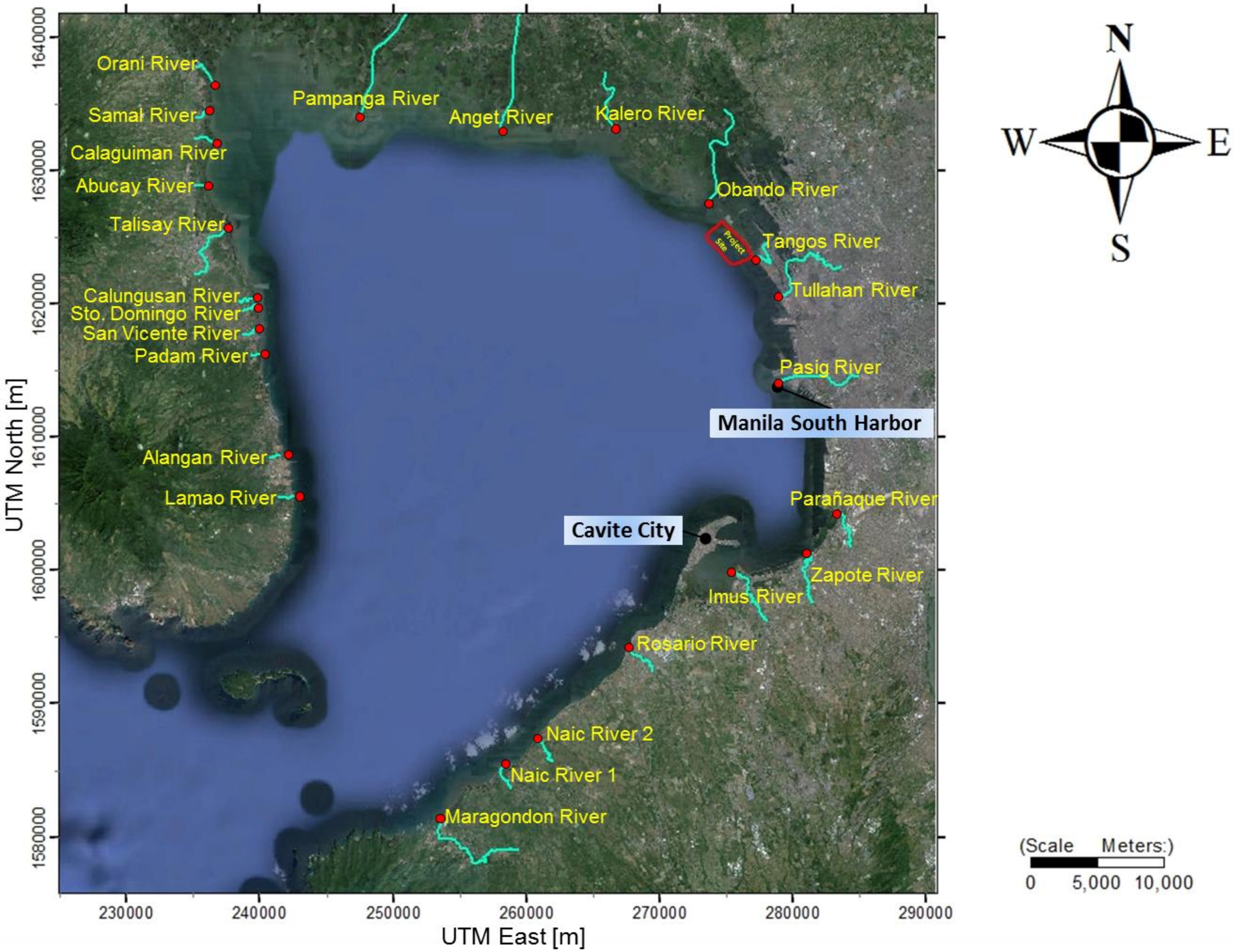


Figure 2-91 Locations of river inflows in Manila Bay

Modeling simulations/scenarios

Modeling simulations using EFDC included possible effects of tides, winds, atmospheric (e.g., air temperature, rainfall, solar radiation), and inflows of 26 rivers in Manila Bay. Three-dimensional depth-averaged simulations were applied over scenarios prior, during, and after reclamation works.

2.2.2.3.2 Environmental Impacts of the Project

The following presents the environmental impacts related to a) change/disruption in water circulation pattern, littoral current, and coastal erosion and deposition, and b) change in bathymetry:

Change/Disruption in water circulation pattern and other related impacts

Current patterns prior to reclamation. Figure 2-92 to Figure 2-94 show instantaneous current patterns during August 2015 and February 2016. Tidal currents are notable during flood and ebb tides with currents as seen February 2015 simulations (Figure 2-92 and Figure 2-93). Currents generally move north-northwest in the vicinities of the project site and in coastal areas of Pampanga. In coastal areas in Cavite during February 2015, currents tend to move westward due probably to the effect of flooding and to some extent, effect of wind flows on currents at shallow areas in Cavite area.

During persistent southwesterly winds in August 2015, currents move eastward offshore Cavite area tends to increase at shallower areas. The increased of river inflows in August 2015 during the wet season, tend to produce higher currents near the mouths of said rivers, specifically in Obando and Pampanga rivers.

Current patterns after reclamation works. Figure 2-92 to Figure 2-94 show the current patterns after completion of the reclaimed works. Due to the size of the reclaimed area, directions of prevailing currents parallel to the shoreline are expected to change with the completion of the reclamation project. There is also possible decrease on the spread of the freshwater or river discharges, especially near Obando river, thus resulting to higher sedimentation rate increases in a limited area.

Although wind waves were not included in the simulations, its effect are highly recognized especially on the formation of longshore currents and beach erosion. This could further increase formation of sediment beds to the east and south of the proposed reclaimed area, especially during wet season with the proposed site exposed to southwest wind flows.

Storm Surge Hazard. WMO defines storm surge as the “difference between the actual water level under the influence of a meteorological disturbance (storm tide) and the level which would have been attained in the absence of the meteorological disturbance”. Storm surge is caused primarily by the strong winds from a tropical cyclone (e.g., typhoon) blowing onshore that creates abnormal “piling” of water as the storm approaches land.

Based on storm surge map of PAGASA (Figure 2-105), storm surge of about 0.66 m was observed in Manila area south of proposed project site. Storm surges of 1.65 to 2.81 were also noted along Cavite coastline with the highest storm surge at Cavite City of 2.81 m.

Project Noah compiled storm surge events in the Philippines based on newspaper clippings and journals. A revised table (Table 2-29) presents the storm surge events that were recorded in Manila Bay, which includes coastal areas in Cavite fronting Manila Bay. There were twelve (12) storm surge events that were recorded in Manila Bay from 1589 to 2013 with recorded storm surge height ranging from 0.6 to 4 m. Storm surge height of 6 m was observed in July 2012, although the occurrence of the 6-m high storm surge was specified for areas in Cavite, Sorsogon, and other parts of Mindanao (not specifically in Manila Bay).

A storm surge modeling study conducted by Lapidez et.al. (2014) included simulations for selected areas in Leyte, Iloilo and Metro Manila. These areas were included in the storm surge simulations because of being prone to storm surges and have high in low-elevation coast zone (LECZ) population density. Results of said study using Typhoon Haiyan with track of Typhoon Georgia that crossed Manila Bay in 1964 showed that storm surge heights greater than 4 m could be generated in the coastal areas in Manila and Obando, Bulacan (Figure 2-96), and that these coastal areas are susceptible to high level of flooding (Figure 2-97). Thus, it follows that the proposed project site, which is to be located fronting said areas, are also prone to storm surge with heights greater than 4 m and high level of flooding.

The model used was the Storm Surge Model of Japan Meteorological Agency (JMA). This model was developed to simulate and predict the heights of storm surges generated by tropical cyclones. As discussed in Lapidez, et. al (2014), the model inputs were the typhoon best track data, domain bathymetry, central atmospheric pressure and maximum wind speed. Typhoon Haiyan's pressure and wind speed were inputted as the forcing parameters in the model. In addition, the FLO-2D two-dimensional flood routing model was used to simulate the storm tide inundation in the selected priority sites. Input parameters in the FLO-2D included the time series results from the JMA's Storm Surge Model and the tide levels from WXTide.

Table 2-29 Storm surges in Manila Bay

No.	Source no.	Date of Occurrence	Associated Tropical Cyclone	Surge Height (m)	Affected Areas	Casualties	Damage
1	5	June 29, 1589	Unnamed typhoon		Manila Bay		
2	5	August 29, 1863	Unnamed typhoon		Manila		Destroyed Bagumbayan drive due to inundation; several houses were unroofed
3	5	September 20 – 26, 1867	Unnamed typhoon		Manila Bay		17 ships were tossed onto Santa Lucia and Tondo shores
4	5	October 25,1873	Unnamed typhoon	0.6	Cavite		

No.	Source no.	Date of Occurrence	Associated Tropical Cyclone	Surge Height (m)	Affected Areas	Casualties	Damage
5	**5**	November 10 – 23, 1923	Unnamed typhoon		Western Carolines, N of Yap, Borongan, Samar, NE of Romblon, E of Manila, Eastern coast of Luzon, Lingayen Gulf, Balintang Channel		**16**
6	**1**	November 19, 1970	Typhoon Yoling (Patsy)	4	Manila Bay, southeast coast of Luzon		Destroyed $40M property; sank 21 fishing boats near the North Harbor
7	**9, 10**	June 23 – 25, 1972	Typhoon Konsing (Ora)		Manila Bay and Bicol region	1	Several ships washed ashore
8	**1**	July 2, 1983	Typhoon Bebeng (Vera)	4	Bataan and least 10 villages on Manila Bay's western banks	182	49,000 houses
9	**6, 7**	September 26 – 28, 2011	Typhoon Pedring (Nesat)	6	Coastal areas of Manila Bay, Brgys San Rafael 3 and 4, Cavite, Brgy. Pasungol, Santa, Ilocos Sur, and Sta Rita Aplaya, Batangas City	12	Damaged the breakwater and seawall along Roxas Boulevard
10	**2**	July 30 – 31, 2012	Typhoon Gener (Saola)		Zamboanga del Norte, Ternate, Cavite, Bulan, Sorsogon, and Sitio Tinago, Brgy. Tibpuan, Lebak Sultan Kudarat		214 houses
11	**3, 4**	August 22, 2013	Typhoon Maring (Trami)		Brgy. Mabolo, Naic, Cavite and Molo District, Iloilo		14 houses
12	**8**	October 11, 2013	Typhoon Santi (Nari)		Manila Bay		

Source: Project Noah website

__Effect of Seal Level Rise due to Climate Change__. The IPCC (2013) published projections of sea level rise in the world that are mainly caused by the warming of the ocean (thermal expansion) and the loss of land-based ice to increased melting. IPCC studies have shown that sea levels are gradually rising in the 20th century and about 70% of the coastlines in the world will experience sea change within 20% of the sea level. As shown in Figure 2-98, there appears a significant increase of projected sea level rise in the 21st century relative to the 1980 to 1999 mean.

Studies of sea level rise in Manila Bay pointed out an increase of sea level in the coastal areas of Manila Bay. Perez et al (1999) showed sea level rise vulnerability map with of 0.3 m (low estimate) to 1 m (high estimate) increase of sea levels, which would inundate about 2090 and 5555 ha of land in the coastal areas of Manila Bay and Cavite City, respectively (Figure 2-99).

The Marine Environment and Resources Foundation, Inc. (MERF, 2013) noted that there is an increased of sea level rise in the coasts of Manila and Legaspi between 0.2 to 0. 4 m in more recent years to the present, which was attributed mainly by climate change effects and other factors, such as land reclamation and ground subsidence.

Change in Bathymetry/Sedimentation Patterns

Twelve (12) horizontal locations were specified around the proposed project site in order to determine the time series of cohesive sediment concentrations before and during reclamation works (Figure 2-100). Simulations were also conducted to determine concentrations of sediments in Manila Bay considering river inflows during August 2015 and February 2016 including all other input parameters discussed in Sections 0 to 0.

Results of simulated cohesive sediment concentration at twelve (12) horizontal locations showed abrupt increased of sediment loads from initial concentration level of 8 mg/l to about 60 mg/l during reclamation works in February (Figure 2-101). Higher cohesive sediment concentrations are found in the vicinities of Obando river. Sediment concentrations also tend to significantly increase in the vicinities of the project site from the baseline February simulations (Figure 2-103) during reclamation works (Figure 2-104).

During wet season (August), significant higher concentrations of cohesive sediment concentrations than February simulations are noted near the river mouths of Obando river (Figure 2-102) prior to reclamation works. This is highly attributed to the significant increase of river discharges due with corresponding increase of cohesive sediment concentrations due to erosion. With the reclamation works, further increases of sediment loads are expected at almost all areas adjacent the proposed reclamation site, especially near the Obando River (Figure 2-104 and Figure 2-105). Also noted is the significant increase of sediment loads at areas near the mouths of all rivers in Manila Bay.

2.2.2.3.3 Proposed mitigation measures, adaptation, and monitoring program

Mitigation Measures to Reduce Siltation During Reclamation

Although the proposed project site and its vicinities have existing higher siltation rates from river inflows, reclamation works would likely contribute to further increases of cohesive sediment concentrations at and in the vicinities of the project site. To maintain the existing water quality (e.g., TSS) of the project site and vicinities to within its safe and satisfactory condition, the Revised Water Usage and Classification Criteria of the DENR requires that concentrations of TSS should not increase by more than 30 mg/l. Thus, mitigation measures should be implemented to mitigate or reduce excessive siltation arising from reclamation works.

One of the most effective mitigation measures to reduce siltation at nearby areas during reclamation works is to install silt curtains around the proposed project or dredging areas. Silt curtains are geotextile materials which minimize sediment transport from a disturbed area near or adjacent water body (USACE 1997). Silt curtains when properly designed, installed, and maintained for the project will minimize sediment transport at nearby areas because it limits transport of sediments within the dredging/reclamation area. The proposed project site is relatively shallow making it suitable for silt curtains to be installed.

Other effective measure is the early construction of bunds along the boundaries of the project site, especially along the northwest and southeast boundaries where currents generally move parallel to the shore. These bunds when completed during the early stage of the reclamation project would serve as siltation barriers until completion of the project (reclamation). As compared to silt curtains, it would be an effective mitigation measure especially during wet season where the proposed project site is exposed to high waves brought by persistent southwest wind flows. Although silt curtains are effective during relatively calm weather, it may likely be attached or displaced due to strong winds and waves during inclement weather (e.g., typhoons) and persistent southwest winds. The construction of the bunds during the early stage of the project, however, would require use of silt curtains in order to avoid dispersion of sediments at nearby areas.

To ensure the effectiveness of the mitigation measures, water quality monitoring should be regularly conducted during reclamation works. This is to determine possible increases of TSS with the existing baseline values prior to reclamation works. Water quality monitoring during wet season should also be conducted to determine background levels prior to reclamation works. Regular inspection and maintenance of silt curtains and bunds should be conducted to determine any damages, and to immediately conduct repairs or maintenance, when necessary.

Dredging Works to Improve Water Passage

Regular dredging works shall be conducted adjacent the proposed project site, specifically in the vicinities of the mouths of Obando River and Tangos River, where sediment deposition from these highly-silted river inflows would constrict waterways and current flows. Further, dredging works shall regularly be conducted adjacent and at immediate vicinities along the northwest and southeast project boundaries wherein accretion of sediments is likely due to the presence of the reclaimed project site.

Climate Change Adaptation Program

Adaptation program on the effects of frequent occurrences of intense tropical cyclones and related effects (e.g., strong winds and storm surges) in the future could be thought of learning to live with risks and to reduce such risk that are acceptable to within available resources (Ellis and Sherman, 2014). Adaptive measures, therefore, are necessary in order to reduce vulnerability to climate change impact (e.g., storm surges and sea level rise).

The following adaption measures could be considered in order to reduce vulnerability to risks associated with climate change impacts (e.g., extreme weather events and sea level rise).

1) Construction of storm surge barrier is one of the options that may have to be considered, although this will require thorough engineering analysis to determine its cost-effectiveness as there are other adaptation measures cited below to reduce risks from effects of extreme weather events;

2) Design and construct seawalls and levees around the reclamation area capable of withstanding high wind and wave impacts;

3) Increase the height of the reclaimed area to elevation above the projected sea level rise increase. Height between 3 to 5 m above highest high water level is recommended, though this needs further evaluation during final engineering design;

4) Design and construct drainage systems considering possible occurrences of future extreme rainfall events and frequent high rainfall;

5) Improve building designs, materials to be used, and building standards to withstand occurrences and recurrences of extreme weather events. Examples are to increase the height of a) ground floors above levels susceptible to flooding and b) height of electrical conduits/outlet above ground floor levels;

6) Prepare early warning systems and effective dissemination procedures to inform residents, workers, and people in the project site including adjacent barangays on the imminent danger pose by future extreme weather events (e.g., typhoons);

7) Prepare emergency preparedness and evacuation plans in the event of an incoming extreme weather events (e.g., typhoons) that would likely pass the area and its vicinities. The proposed project site is located within a zone in which five (5) cyclones occur within 3 years, and that the frequency of occurrences will likely increase in the future due to effects of climate change; and

8) Contribute to reducing climate change impact by including in the overall design of the future project utilization the following, as indicated in the sustainability framework plan of the project (Source: Pre-feasibility Studies for Navotas Coastal Bay Manila, 2013):

   - Optimize use of natural light and mitigate the solar heat gain by including in the overall project design the results of sun path analysis;
   - Use of Best Available Technologies (BAT) in order to reduce the energy use, maximize energy and water efficiency, and reduce environmental pollution by significant recycling;
   - Examine the use of renewable energy source, such as utilization of solar, wave/tidal, and wind energy resources to reduce use of electrical energy from fossil-fired power plants that have high carbon emissions; and
   - Recovery of wastewater for toilet flushing as this will reduce the demand of clean potable water and related costs on the supply of potable water.

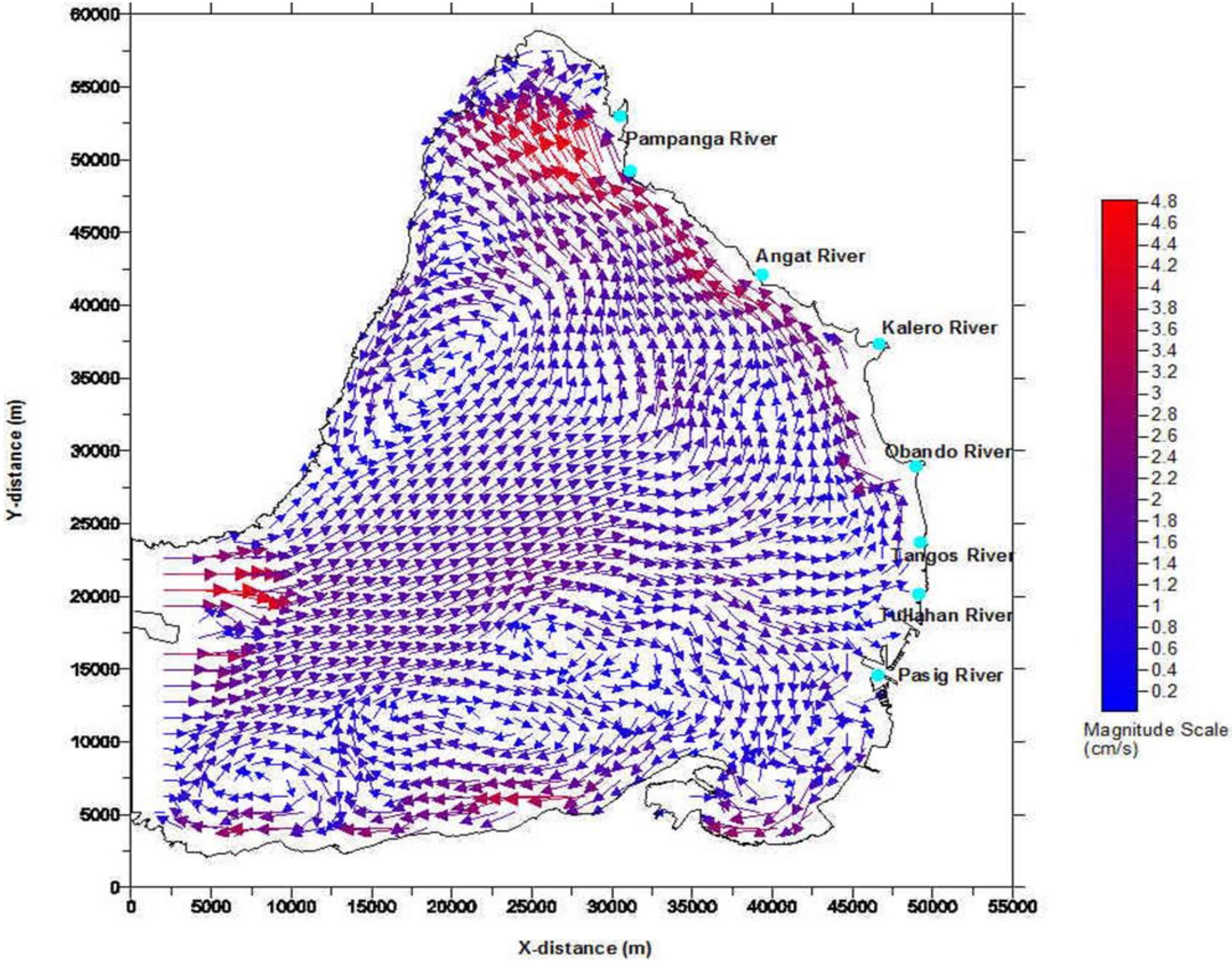


Figure 2-92 Simulated instantaneous current patterns during flood tide in February 2016

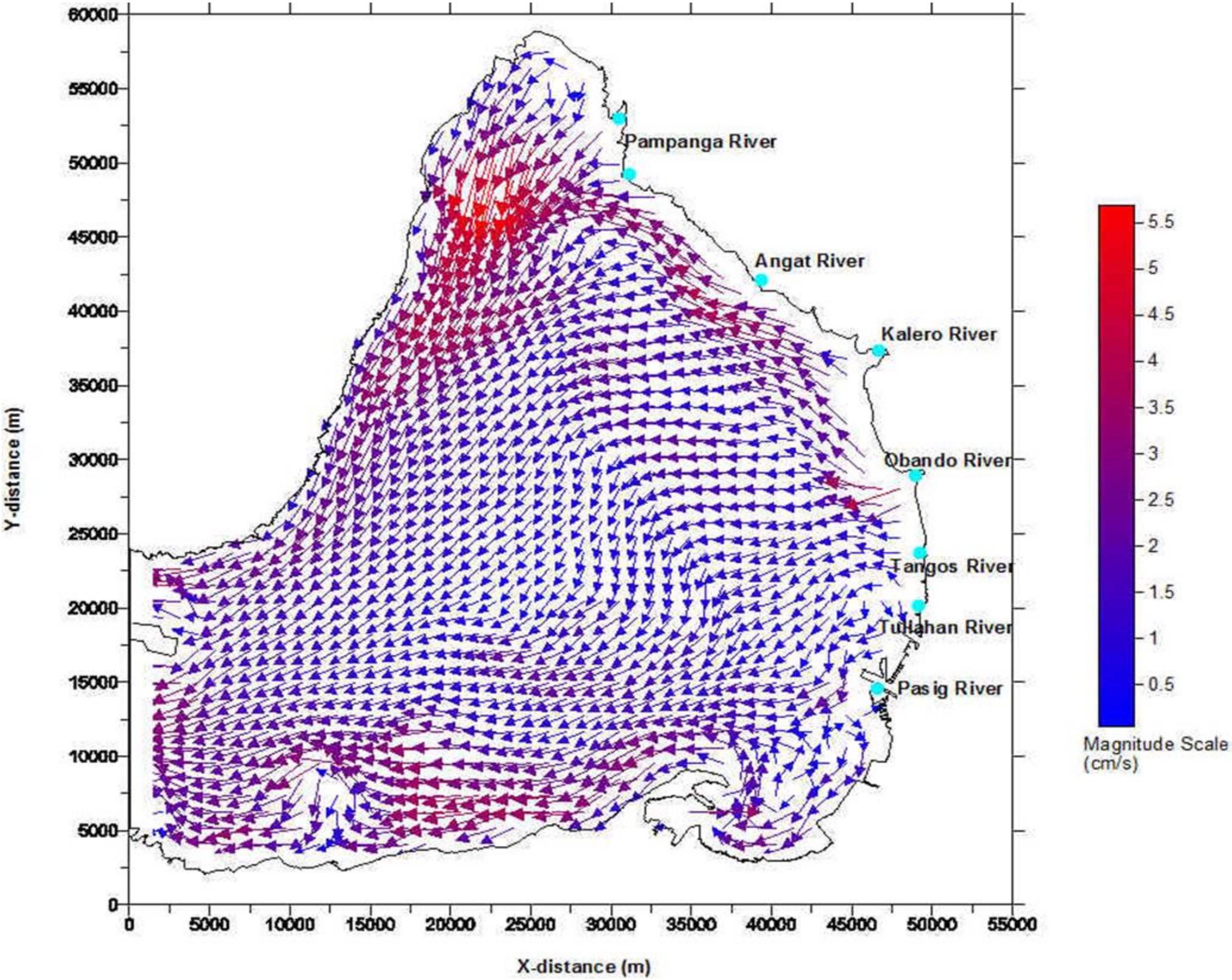


Figure 2-93 Simulated instantaneous current patterns during ebb tide in February 2016

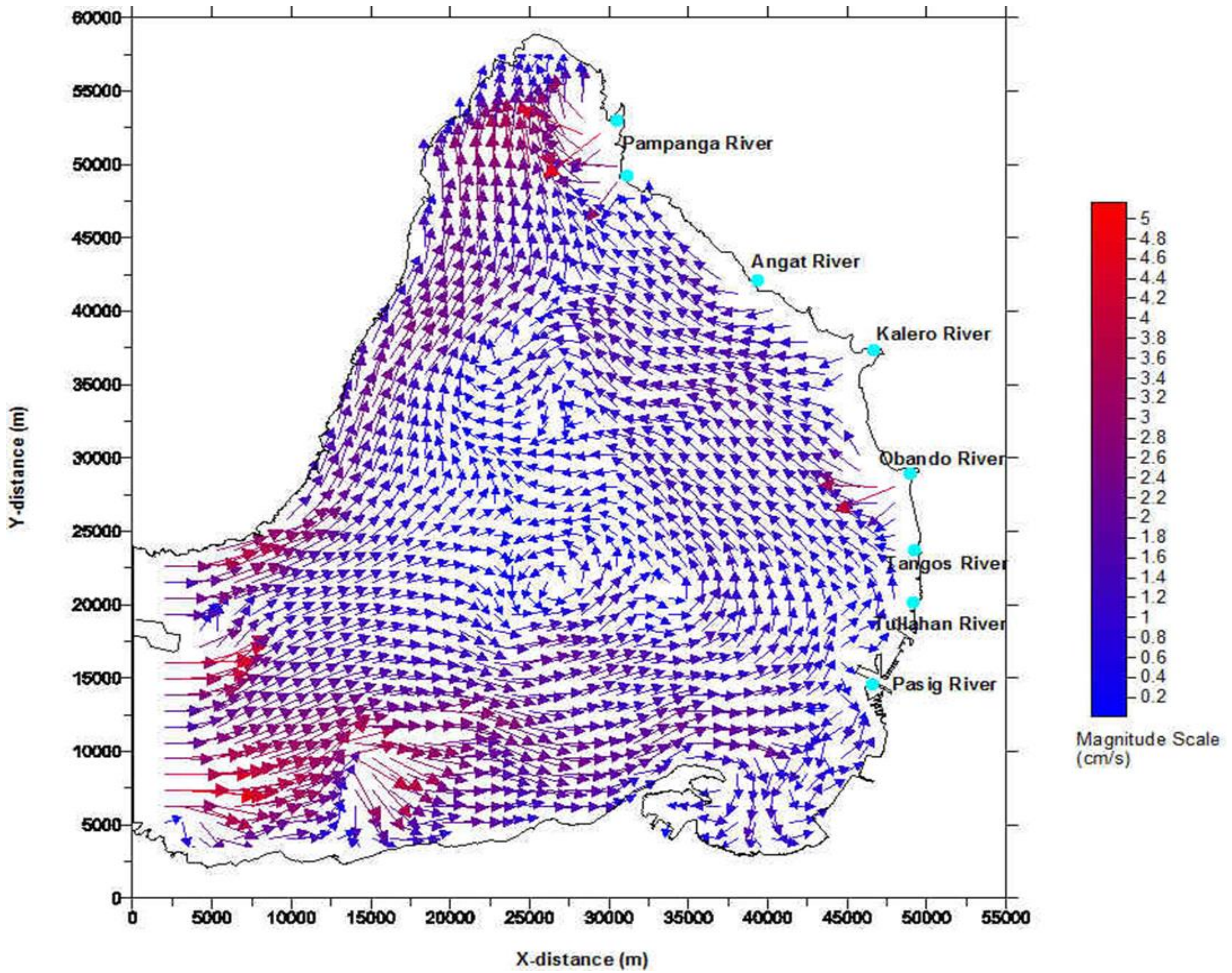


Figure 2-94 Simulated instantaneous current patterns during flood tide in August 2015

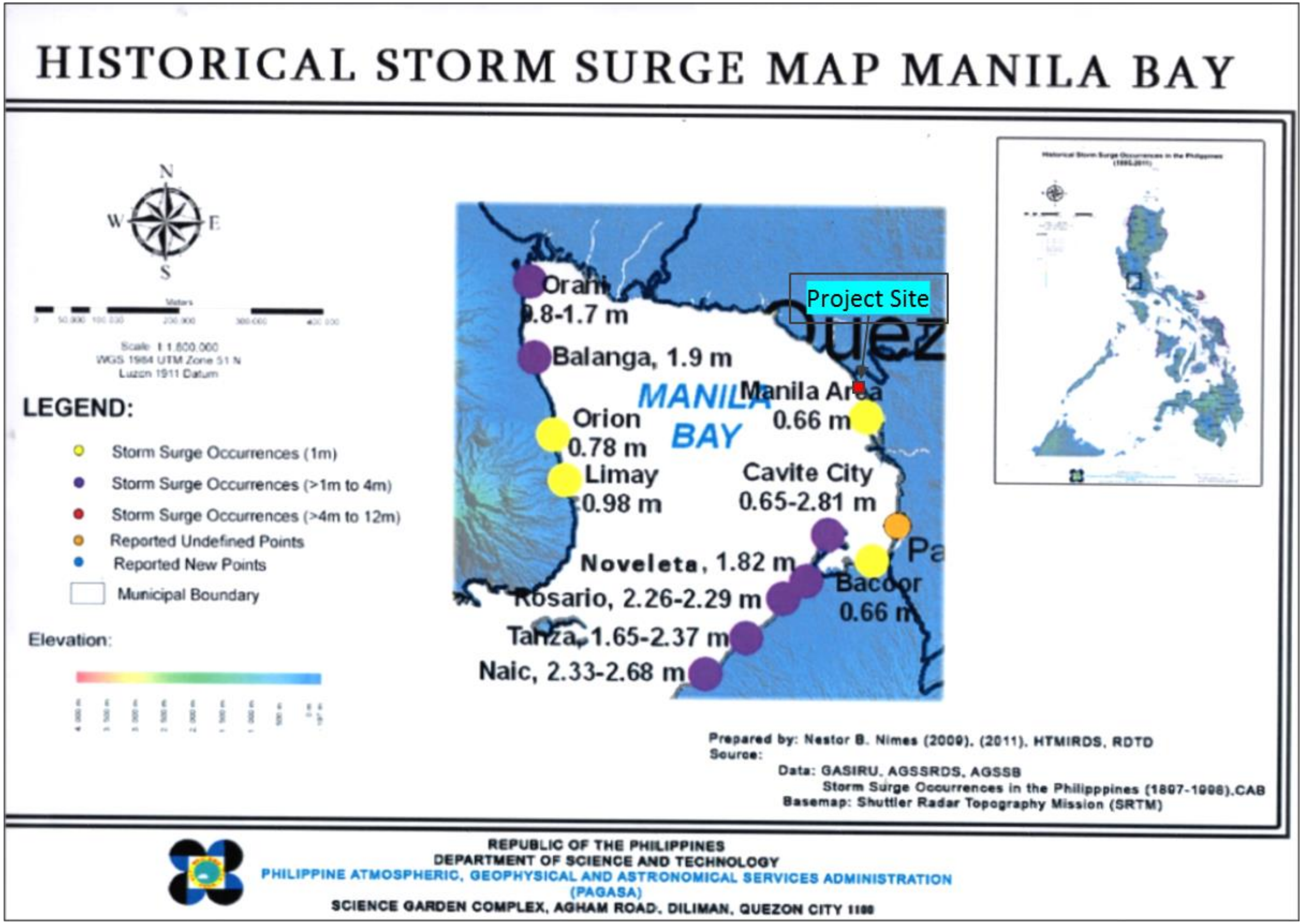


Figure 2-95 Historical storm surges in Manila Bay (Source: PAGASA)

The model used for the storm surge analysis was the Storm Surge Model of Japan Meteorological Agency (JMA). This model was developed to simulate and predict the heights of storm surges generated by tropical cyclones. As discussed in Lapidez, et. al (2014), the model inputs were the typhoon best track data, domain bathymetry, central atmospheric pressure and maximum wind speed. Typhoon Haiyan's pressure and wind speed were inputted as the forcing parameters in the model. In addition, the FLO-2D two-dimensional flood routing model was used to simulate the storm tide inundation in the selected priority sites. Input parameters in the FLO-2D included the time series results from the JMA's Storm Surge Model and the tide levels from WXTide.

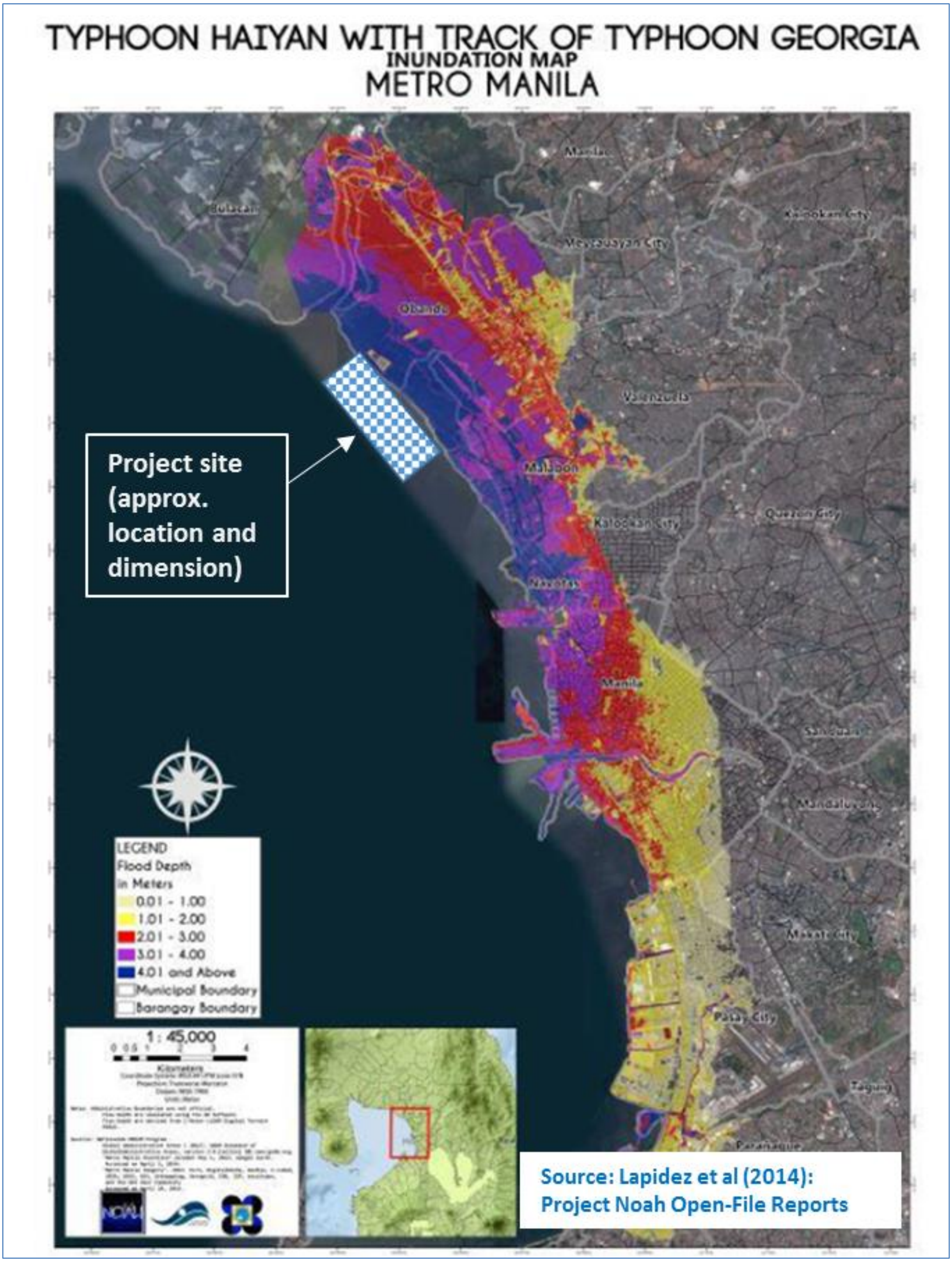


Figure 2-96 Predicted storm surge heights (Source: Lapidez et al, 2014)

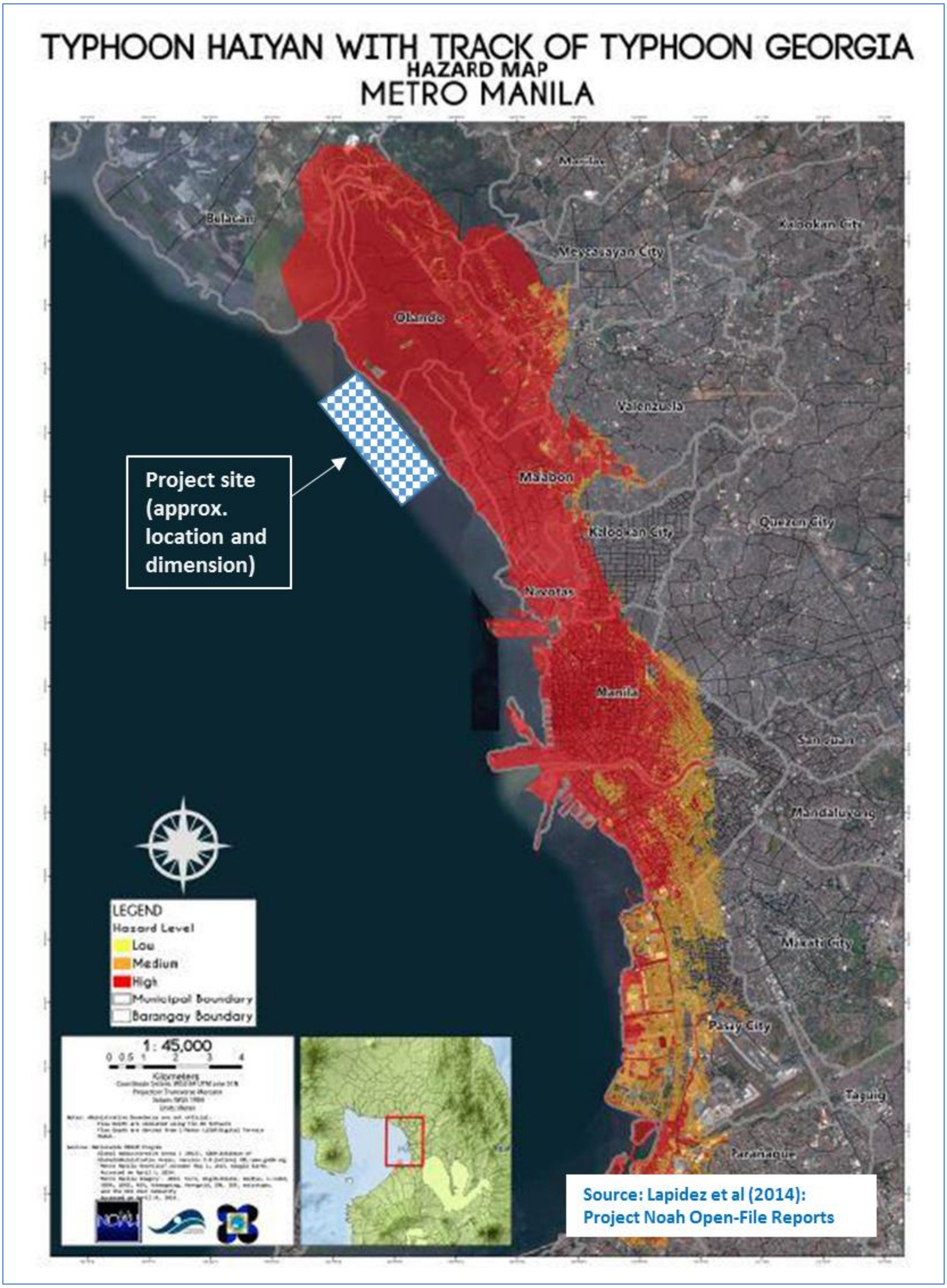
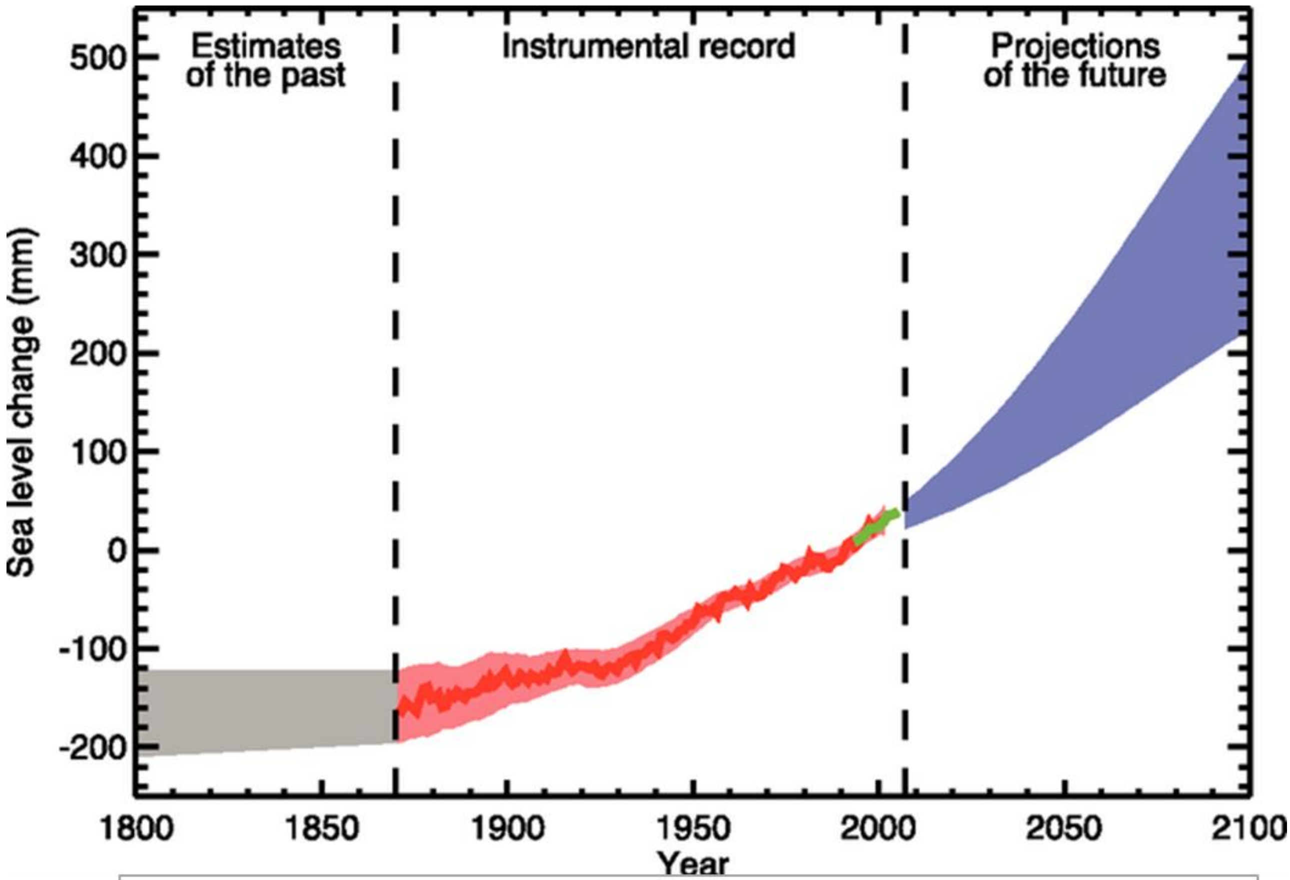


Figure 2-97 Hazard level map (Source: Lapidez et al, 2014)



FAQ 5.1, Figure 1. Time series of global mean sea level (deviation from the 1980-1999 mean) in the past and as projected for the future. For the period before 1870, global measurements of sea level are not available. The grey shading shows the uncertainty in the estimated long-term rate of sea level change (Section 6.4.3). The red line is a reconstruction of global mean sea level from tide gauges (Section 5.5.2.1), and the red shading denotes the range of variations from a smooth curve. The green line shows global mean sea level observed from satellite altimetry. The blue shading represents the range of model projections for the SRES A1B scenario for the 21st century, relative to the 1980 to 1999 mean, and has been calculated independently from the observations. Beyond 2100, the projections are increasingly dependent on the emissions scenario (see Chapter 10 for a discussion of sea level rise projections for other scenarios considered in this report). Over many centuries or millennia, sea level could rise by several metres (Section 10.7.4).

Figure 2-98 Sea level change (Source: IPCC 2013)

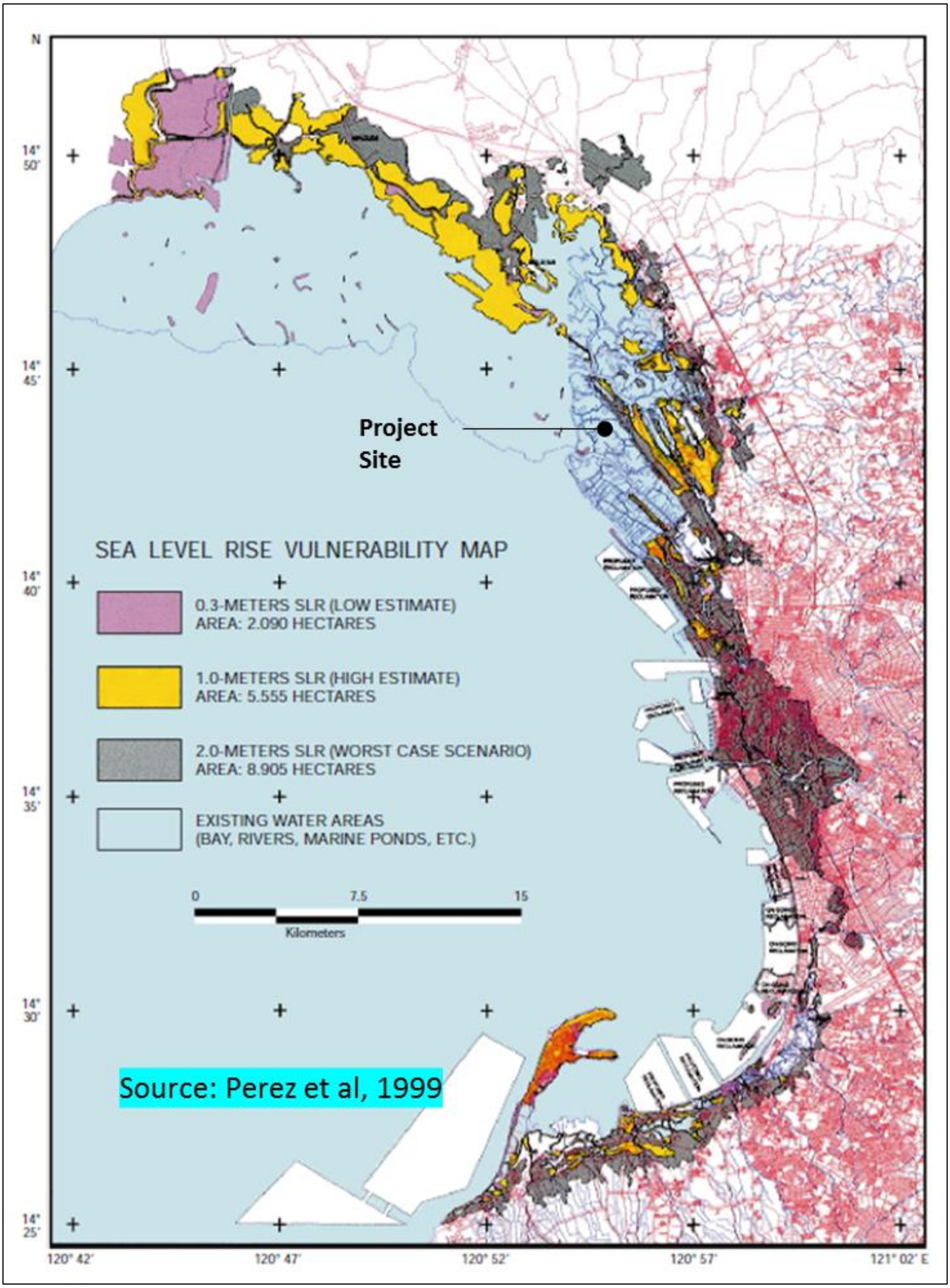


Figure 2-99 Sea level rise vulnerability map (Perez et al, 1999)

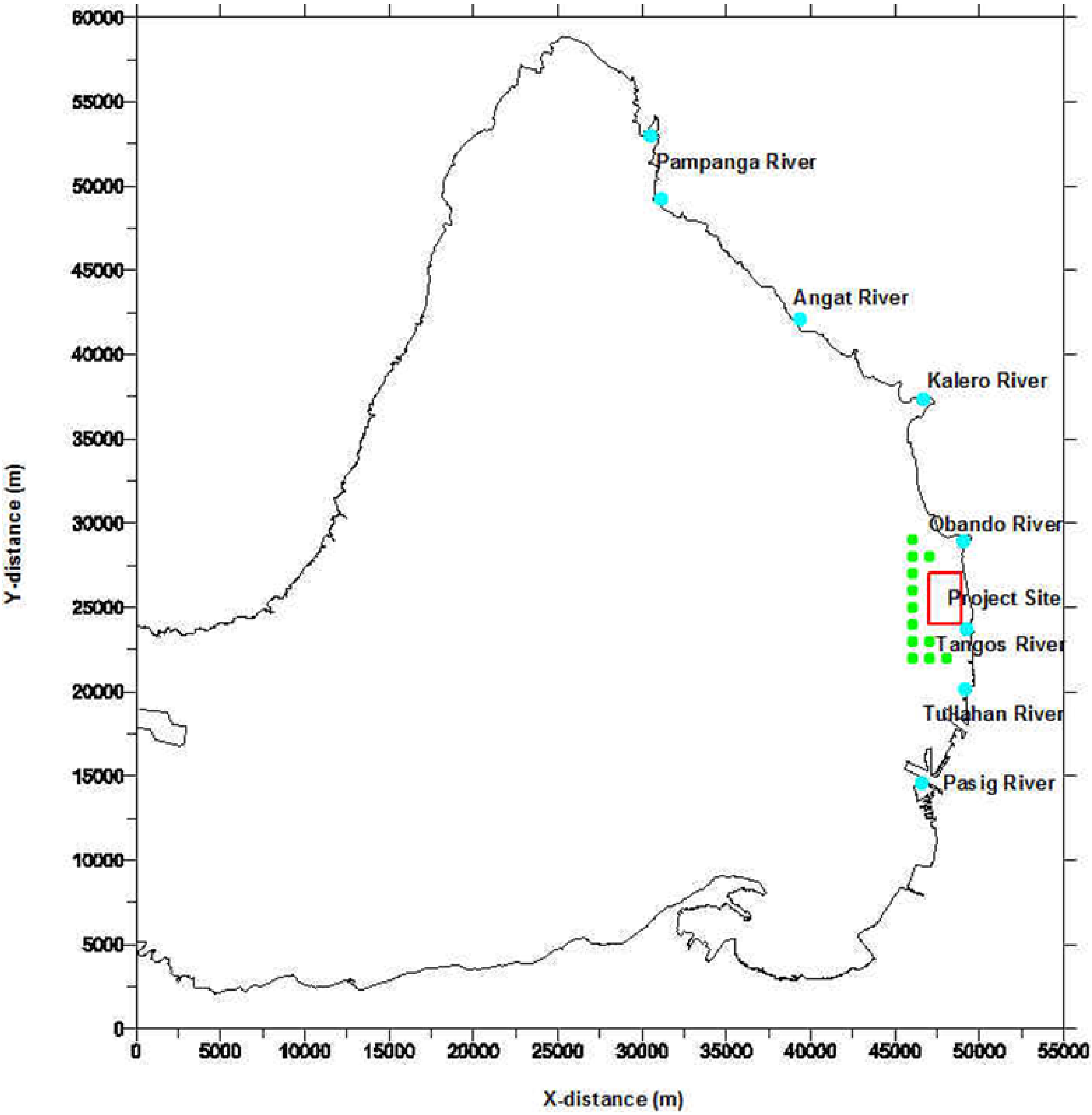


Figure 2-100 Horizontal locations where time series of cohesive sediment concentrations are calculated (represented as green circles in the vicinities of the proposed project)

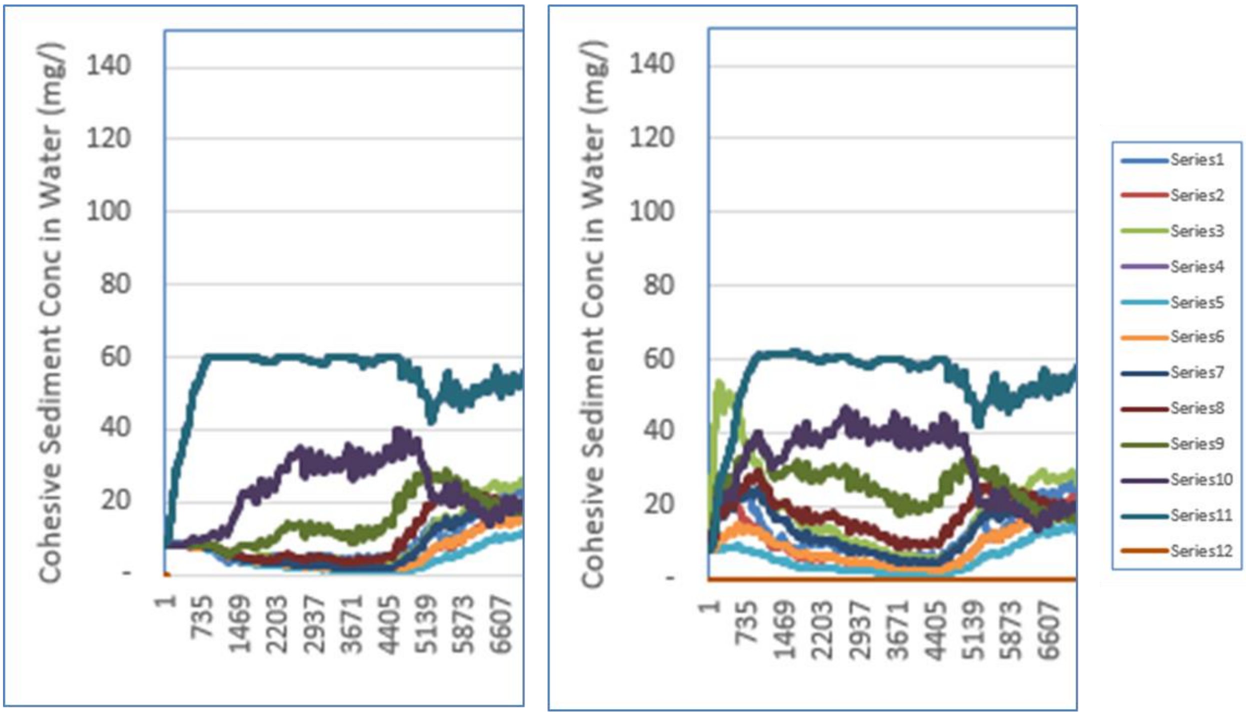


Figure 2-101 Time series of cohesive sediment concentrations in water column a) before (left) and, b) during (right) reclamation works in February

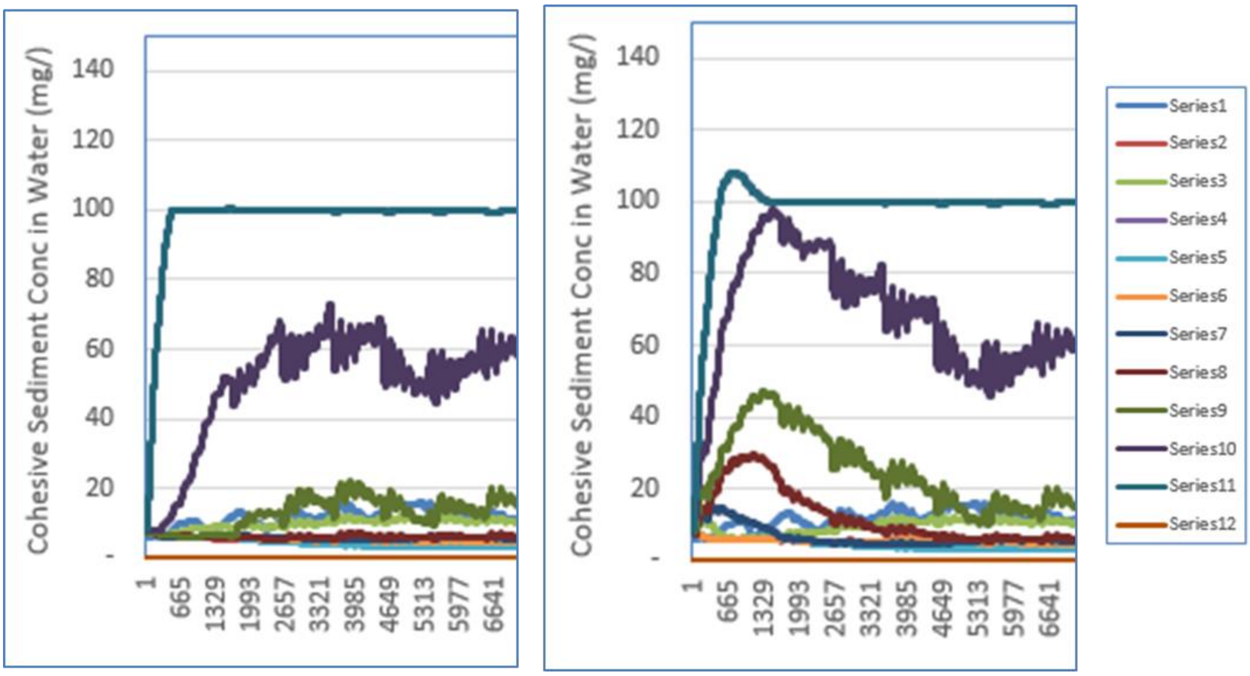


Figure 2-102 Time series of cohesive sediment concentrations in water column a) before (left) and b) during (right) reclamation works in August

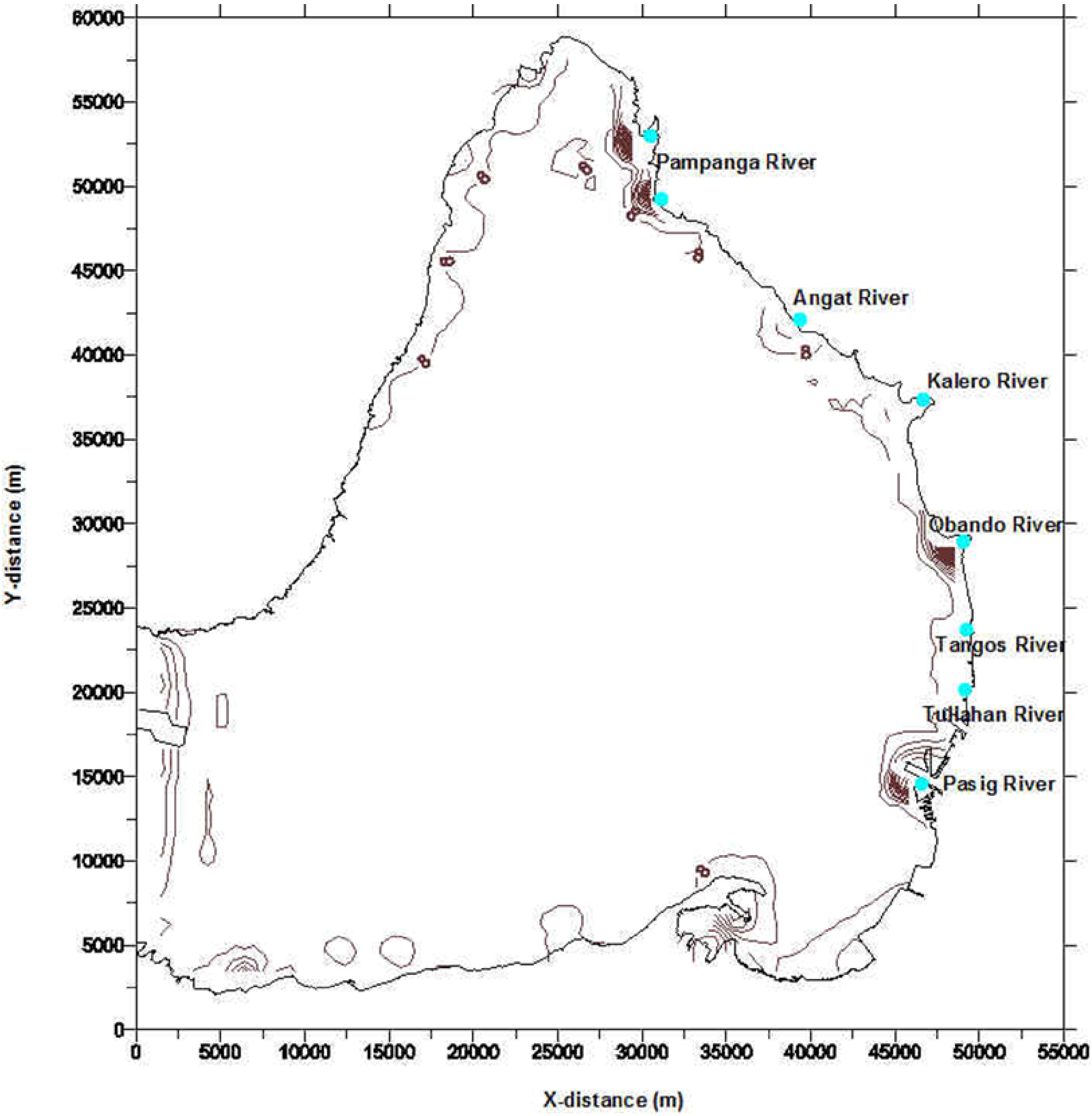


Figure 2-103 Simulated sedimentation patterns prior to reclamation works (February)

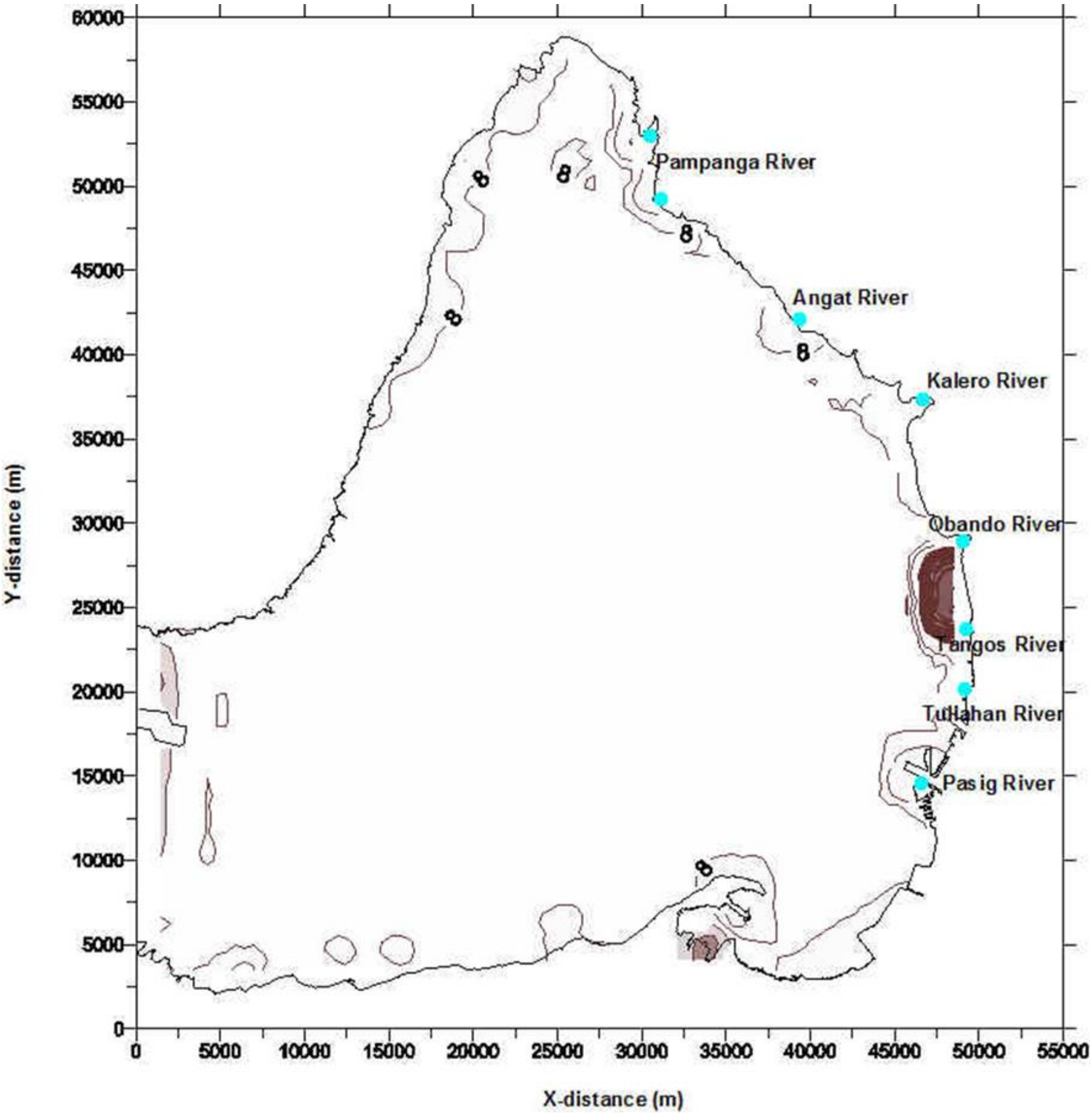


Figure 2-104 Simulated sedimentation patterns during reclamation works (February)

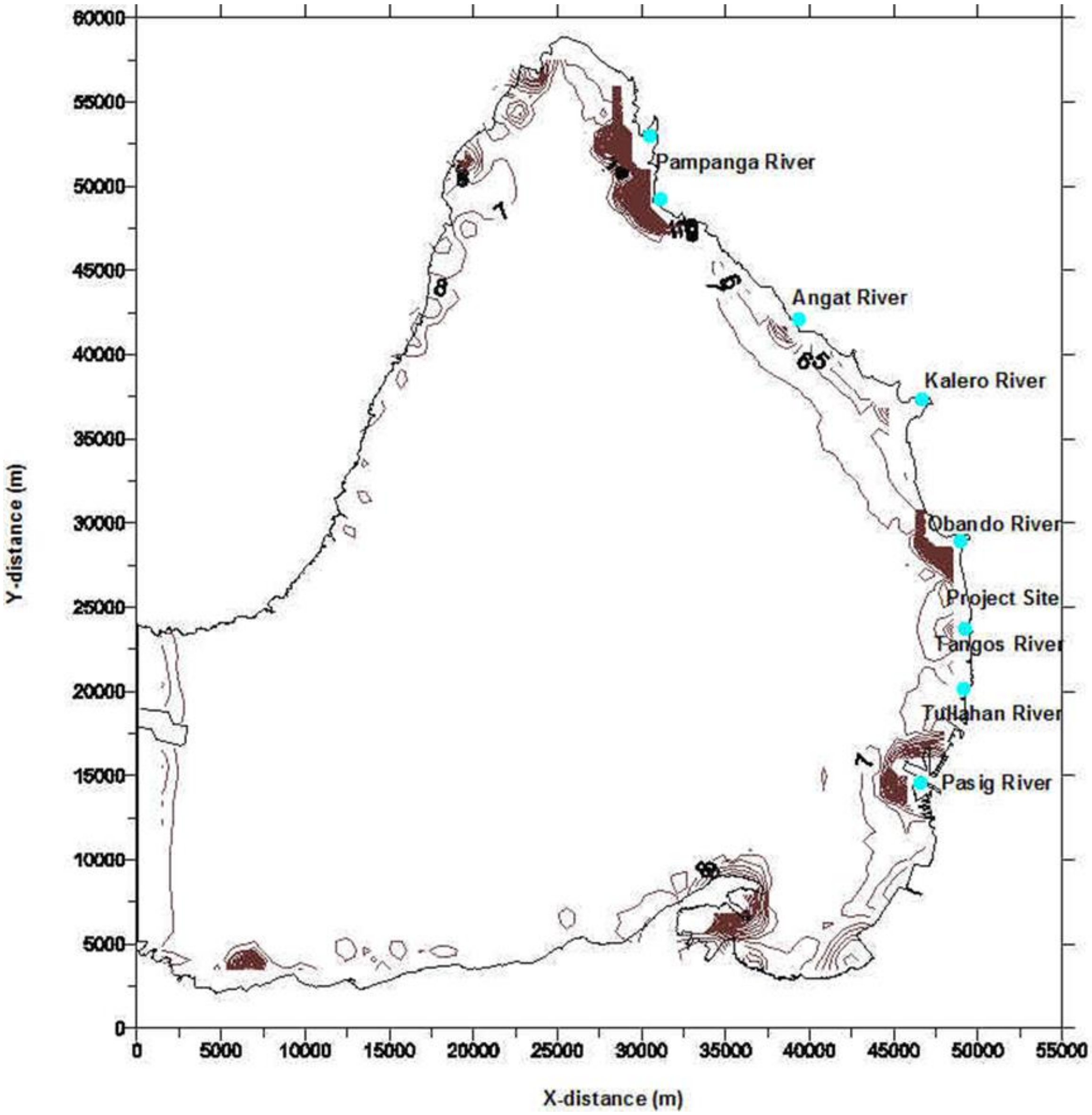


Figure 2-105 Simulated sedimentation patterns prior to reclamation works (August)

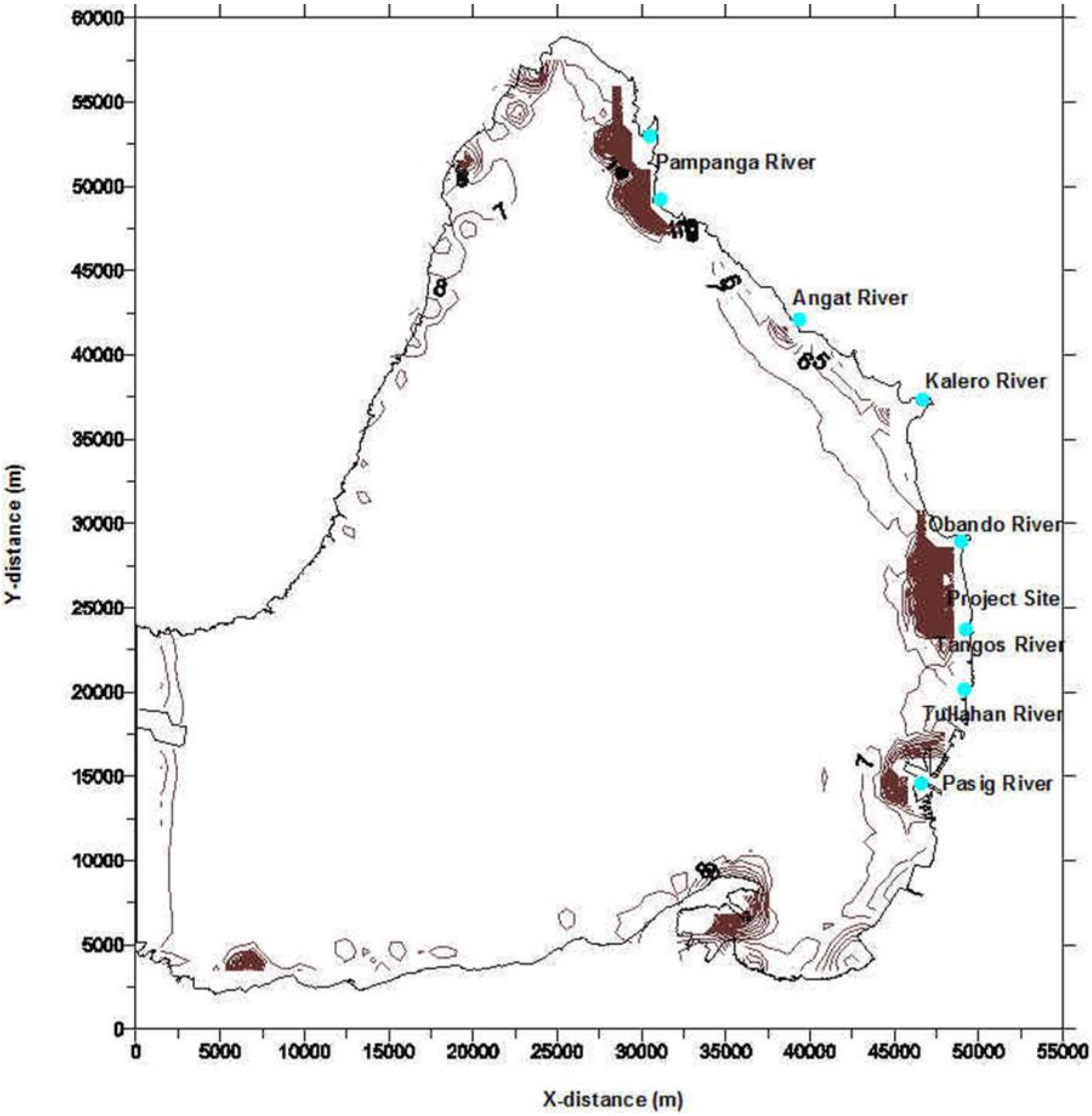


Figure 2-106 Simulated sedimentation patterns during reclamation works (August)

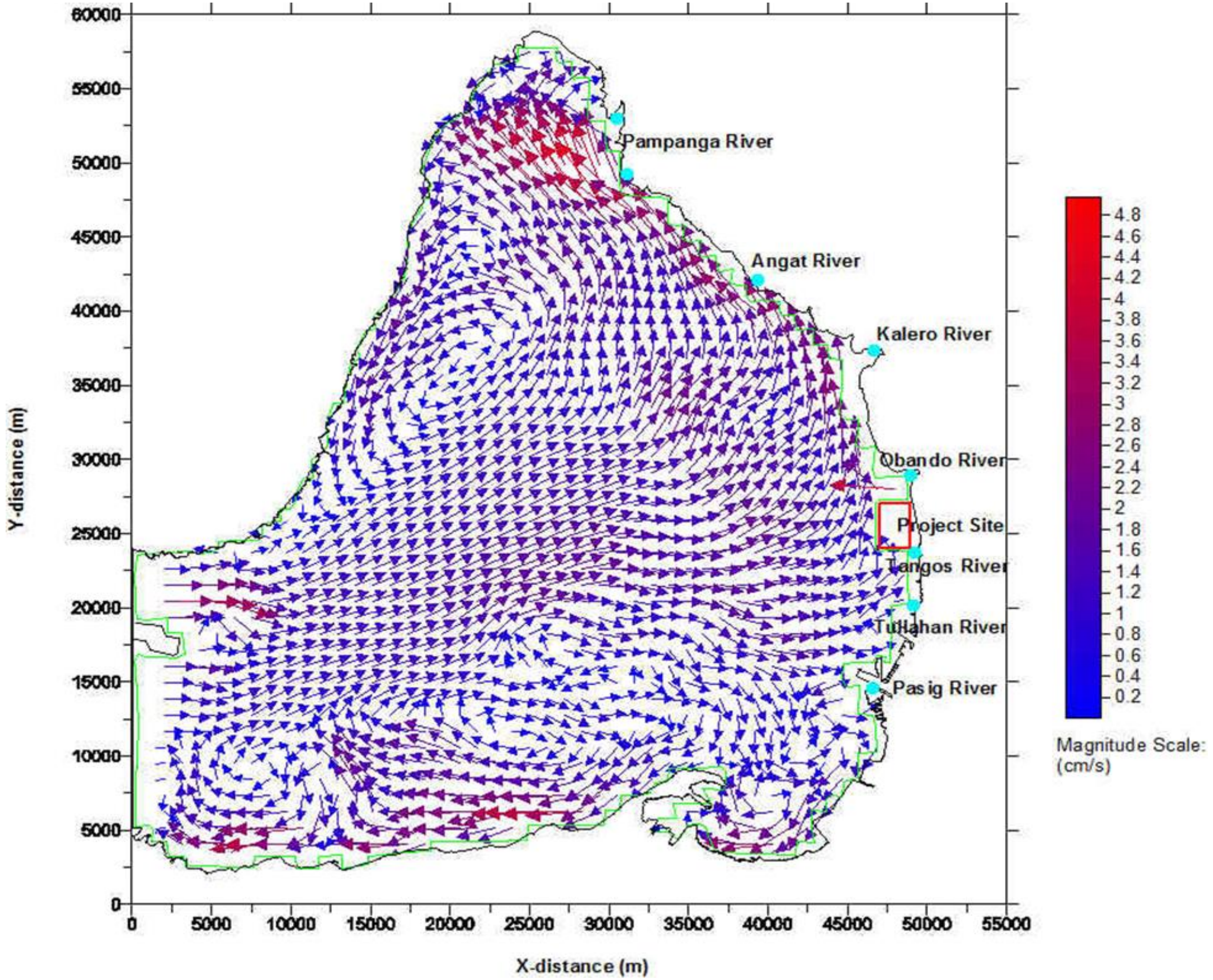


Figure 2-107 Simulated instantaneous current patterns during flood tide after reclamation works (February)

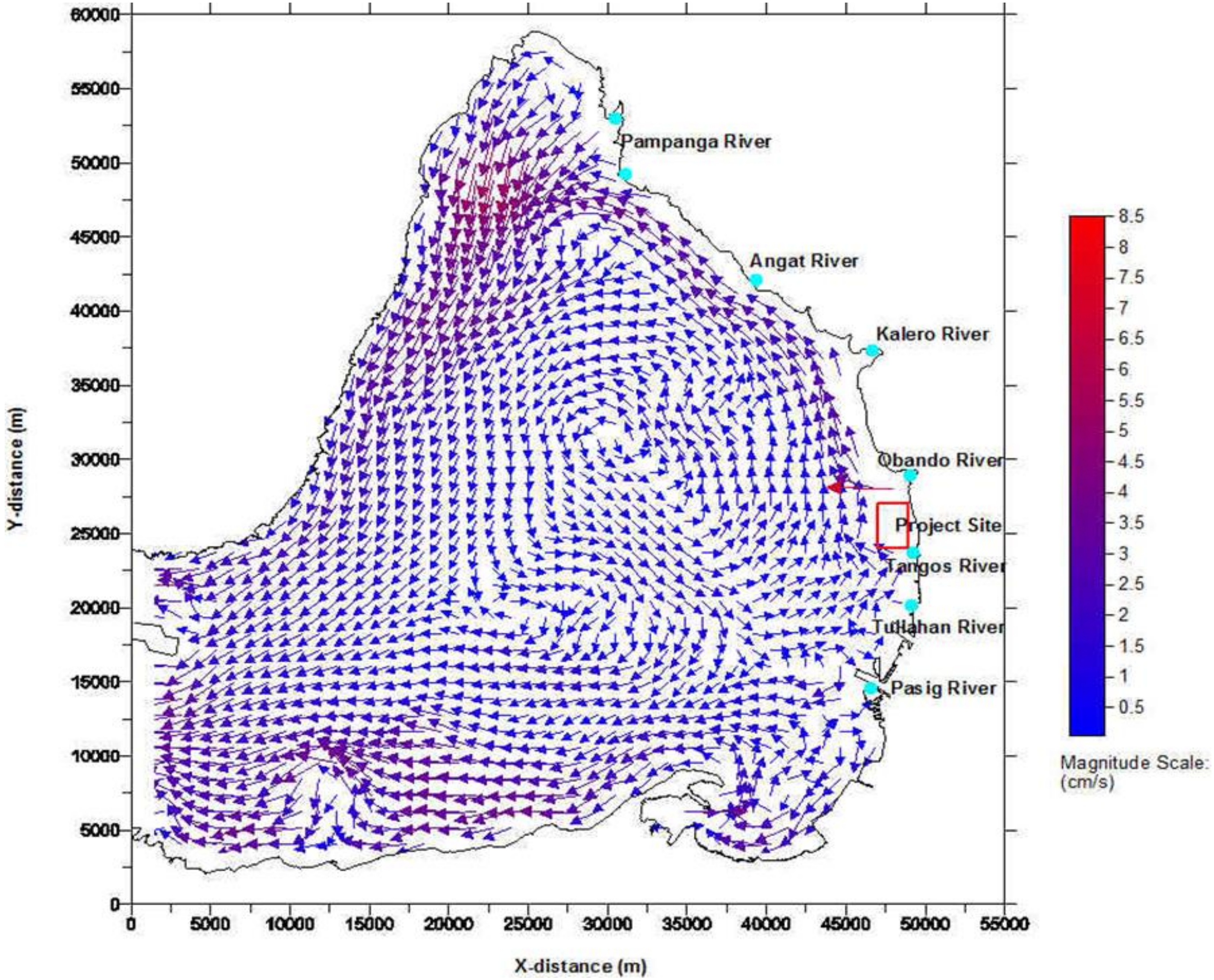


Figure 2-108 Simulated instantaneous current patterns during ebb tide after reclamation works (February)

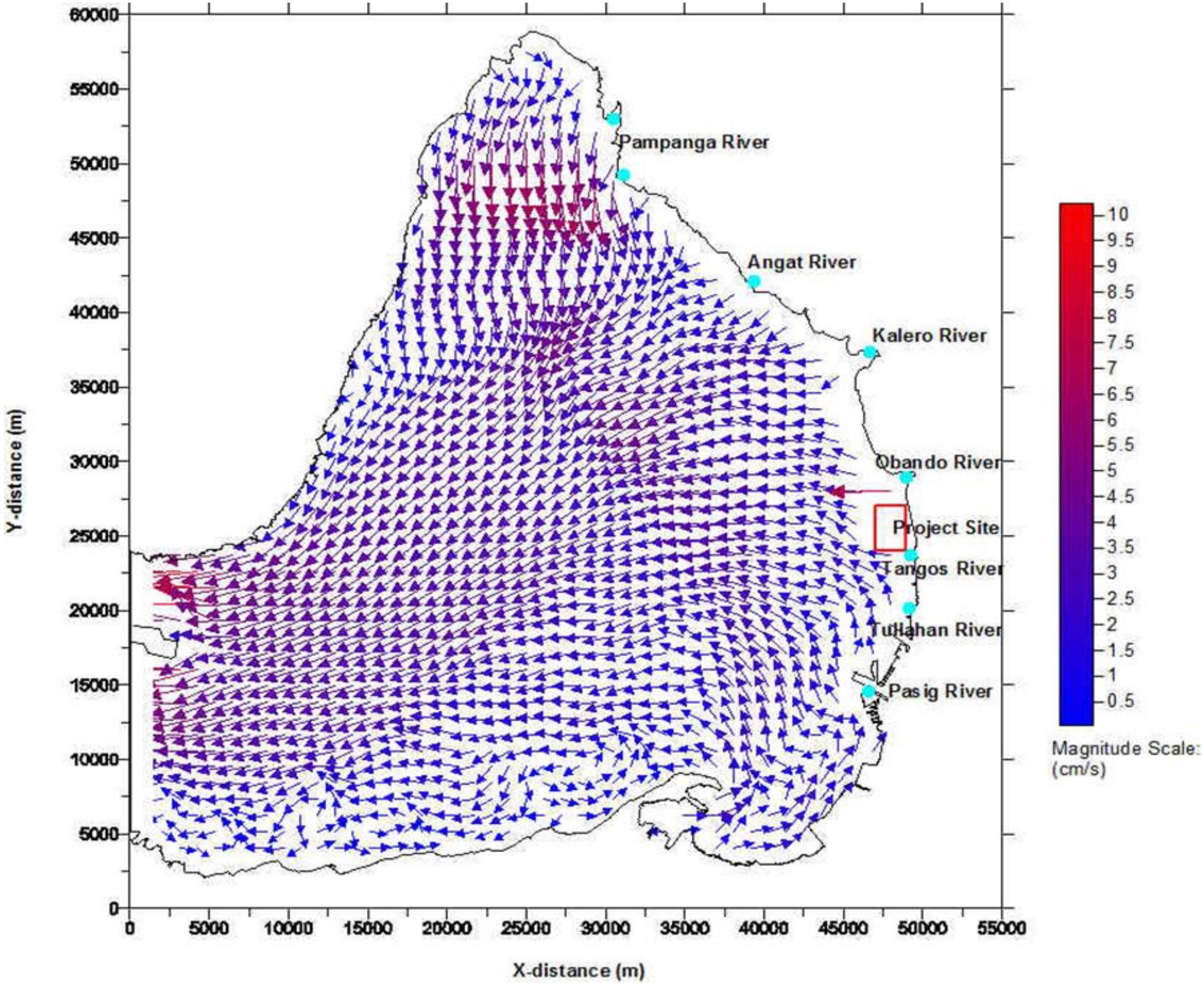


Figure 2-109 Simulated instantaneous current patterns during ebb tide after reclamation works (August)

2.2.3 Water Quality

This section presents the results of the marine water quality baseline study conducted on March 22, 2016, May 11, 2016 and January 25, 2017. The NAMRIA topographic map was used for initially identifying the possible locations of water sampling stations. The assessment of water quality focused on the marine water within the project area.

2.2.3.1 Methodology

In-situ water analysis and water sampling procedures were done following the guidelines presented in Water Quality Monitoring Manual Volume I: Manual on Ambient Water Quality Monitoring (EMB-DENR 2008). Ten (10) marine surface water samples were taken from strategically located sampling stations within the the project area. Parameters tested were: temperature, chemical oxygen demand (COD), total dissolved solids (TDS), pH, total suspended solids (TSS), oil and grease (O&G), arsenic (As), cadmium (Cd), chromium (Cr), lead (Pb), mercury (Hg) and biological oxygen demand (BOD). Another water quality sampling was conducted last January 25, 2017 to include the following parameters: Biochemical Oxygen Demand (BOD); Chloride (Cl-); Color (Apparent); Dissolve Oxygen (DO); Fecal Coliform; Nitrate as Nitrogen ($N0_3$--N); * Phosphate as Phosphorous ($P0_4^{3-}$-P); Ammonia as Nitrogen (NH_3-N); Total Suspended Solids (TSS); Sulfate ($S0_4^{2-}$); Arsenic (As); Cadmium (Cd); Hexavalent Chromium (Cr^{6+}); Lead (Pb); Mercury (Hg); Oil and Grease; Sulfactants (MBAS).

2.2.3.2 Results

The guidelines stipulated in DENR Administrative Order No. 2016-08 – Water Quality Guidelines and General Effluent Standards of 2016 were used in the assessment of the current status of surface water quality in the study area. Philippine fresh, coastal and marine waters are classified based on their beneficial use. Based on DENR Memorandum Circular No. 2010-08, Manila Bay is classified as Class SB.

Table 2-30 Marine Water Quality Sampling Stations

Sample ID	Date & Time of Sampling	Coordinates	Parameters	Location/ Description	Site Photos
S1	03-22-16 1058 H	14°40'26.7", 120°55'35.4"	Temp, BOD, TSS, COD, pH, TDS, Oil and grease, As, Cd, Pb, Hg, Cr	West of Barangay Tangos, Navotas City	
S2	03-22-16 1431 H	14°41'1.5", 120°55'12.4"	Temp, BOD, TSS, COD, pH, TDS, Oil and grease, As, Cd, Pb, Hg, Cr	Southwest of Isla Pulo, Barangay Tanza, Navotas City	
S3	03-22-16 1411 H	14°41'40.4", 120°54'38.1"	Temp, BOD, TSS, COD, pH, TDS, Oil and grease, As, Cd, Pb, Hg, Cr	Northwest of Isla Pulo; South of Navotas dumpsite	
	01-25-17 1354 H		Biochemical Oxygen Demand (BOD) Chloride (Cl-) Color (Apparent) Dissolve Oxygen (DO) Fecal Coliform B Nitrate as Nitrogen (N03--N)		

Sample ID	Date & Time of Sampling	Coordinates	Parameters	Location/ Description	Site Photos
			* Phosphate as Phosphorous (P043--P) Ammonia as Nitrogen (NH3-N) Total Suspended Solids (TSS) Sulfate (S042-) Arsenic (As) Cadmium (Cd) Hexavalent Chromium (Cr6t) Lead (Pb) Mercury (Hg) Oil and Grease Sulfactants (MBAS)		
S4	03-22-16 1331 H	14°42'44.8", 120°53'44.8"	Temp, BOD, TSS, COD, pH, TDS, Oil and grease, As, Cd, Pb, Hg, Cr	South of Taliptip, Bulacan; West of Salambao, Bulacan	
S5	03-22-16 1128 H	14°40'0.7", 120°55'24.4"	Temp, BOD, TSS, COD, pH, TDS, Oil and grease, As, Cd, Pb, Hg, Cr	Southwest of Tangos, Navotas City	

Sample ID	Date & Time of Sampling	Coordinates	Parameters	Location/ Description	Site Photos
	01-25-17 1322 H		Biochemical Oxygen Demand (BOD) Chloride (Cl-) Color (Apparent) Dissolve Oxygen (DO) Fecal Coliform B Nitrate as Nitrogen (N03--N) * Phosphate as Phosphorous (P043--P) Ammonia as Nitrogen (NH3-N) Total Suspended Solids (TSS) Sulfate (S042-) Arsenic (As) Cadmium (Cd) Hexavalent Chromium (Cr6t) Lead (Pb) Mercury (Hg) Oil and Grease Sulfactants (MBAS)		
S6	03-22-16 1227 H	14°40'34.2", 120°54'43.6"	Temp, BOD, TSS, COD, pH, TDS, Oil and grease, As, Cd, Pb, Hg, Cr	Northwest of Tangos, Navotas City	

Sample ID	Date & Time of Sampling	Coordinates	Parameters	Location/ Description	Site Photos
S7	03-22-16 1238 H	14°41'12.3", 120°54'3.8"	Temp, BOD, TSS, COD, pH, TDS, Oil and grease, As, Cd, Pb, Hg, Cr	West of Isla Pulo, Barangay Tanza, Navotas City	
S8	03-22-16 1319 H	14°41'56", 120°53'40.2"	Temp, BOD, TSS, COD, pH, TDS, Oil and grease, As, Cd, Pb, Hg, Cr	West of Barangay Tanza, Navotas City	
	01-25-17 1412 H		Biochemical Oxygen Demand (BOD) Chloride (Cl-) Color (Apparent) Dissolve Oxygen (DO) Fecal Coliform B Nitrate as Nitrogen (N03--N) * Phosphate as Phosphorous (P043--P) Ammonia as Nitrogen (NH3-N) Total Suspended Solids (TSS) Sulfate (S042-) Arsenic (As) Cadmium (Cd) Hexavalent Chromium (Cr6t) Lead (Pb) Mercury (Hg)		

Sample ID	Date & Time of Sampling	Coordinates	Parameters	Location/ Description	Site Photos
			Oil and Grease Sulfactants (MBAS)		
S9	03-22-16 1155 H	14°39'47.9", 120°54'35.5"	Temp, BOD, TSS, COD, pH, TDS, Oil and grease, As, Cd, Pb, Hg, Cr	West of Daanghari, Navotas City	
S10	03-22-16 1256 H	14°40'59", 120°53'31.7"	Temp, BOD, TSS, COD, pH, TDS, Oil and grease, As, Cd, Pb, Hg, Cr	West of Isla Pulo, Barangay Tanza, Navotas City	

Sample ID	Date & Time of Sampling	Coordinates	Parameters	Location/ Description	Site Photos
	01-25-17 1432 H		Biochemical Oxygen Demand (BOD) Chloride (Cl-) Color (Apparent) Dissolve Oxygen (DO) Fecal Coliform B Nitrate as Nitrogen (N03--N) * Phosphate as Phosphorous (P043--P) Ammonia as Nitrogen (NH3-N) Total Suspended Solids (TSS) Sulfate (S042-) Arsenic (As) Cadmium (Cd) Hexavalent Chromium (Cr6t) Lead (Pb) Mercury (Hg) Oil and Grease Sulfactants (MBAS)		

Table 2-31 Results of water quality analyses for marine waters

Sampling Station		Parameter										
		BOD mg/L	TSS mg/L	COD mg/L	pH	TDS mg/L	Oil & Grease mg/L	As mg/L	Cd mg/L	Pb mg/L	Hg mg/L	Cr^{6+} mg/L
S1	West of Barangay Tangos, Navotas City	583	6	1,487	7.6	35,268	<1.0	<0.001	<0.003	<0.01	<0.0001	<0.01
S2	Southwest of Isla Pulo, Barangay Tanza, Navotas City	406	8	1,606	7.5	35,306	<1.0	<0.001	<0.003	<0.01	<0.0001	<0.01
S3	Northwest of Isla Pulo; South of Navotas dumpsite	456	21	1,201	7.5	34,135	<1.0	<0.001	<0.003	<0.01	<0.0001	<0.01

Sampling Station			Parameter										
		BOD mg/L	TSS mg/L	COD mg/L	pH	TDS mg/L	Oil & Grease mg/L	As mg/L	Cd mg/L	Pb mg/L	Hg mg/L	Cr^{6+} mg/L
S4	South of Taliptip, Bulacan; West of Salambao, Bulacan	479	8	1,334	7.6	33,235	<1.0	<0.001	<0.003	<0.01	<0.0001	<0.01
S5	Southwest of Tangos, Navotas City	223	6	517	8	34,103	<1.0	<0.001	<0.003	<0.01	<0.0001	<0.01
S6	Northwest of Tangos, Navotas City	89	10	127	8.1	35,418	<1.0	<0.001	<0.003	<0.01	<0.0001	<0.01
S7	West of Isla Pulo, Barangay Tanza, Navotas City	99	4	180	8.2	35,111	<1.0	<0.001	<0.003	<0.01	<0.0001	<0.01
S8	West of Barangay Tanza, Navotas City	477	7	944	7.9	34,758	<1.0	<0.001	<0.003	<0.01	<0.0001	<0.01
S9	West of Daanghari, Navotas City	262	2	577	8.2	34,559	<1.0	<0.001	<0.003	<0.01	<0.0001	<0.01
S10	West of Isla Pulo, Barangay Tanza, Navotas City	334	6	585	8.2	35,007	<1.0	<0.001	<0.003	<0.01	<0.0001	<0.01
WQG (Class SB)		**n/a**	**50**	**--**	**7.0-8.5**	**--**	**2**	**0.01**	**0.003**	**0.01**	**0.001**	**0.05**

Table 2-32 Results of additional water quality analyses for marine waters

Parameters	Sampling Station				WQG (SB)	Units	Method
	S3	S5	S8	S10			
Biochemical Oxygen Demand (BOD)	2	5	6	3	n/a	mg/L	Azide Modification (Dilution Technique)
Chloride (Cl-)	26,126.7	28,691.8	24,131.5	31,257	n/a	mg/L	Argentometric
Color (Apparent)	5	10	5	10	50	ACU	Visual Comparison
Dissolve Oxygen (DO)	4	5	5	5	6 (min)	mg/L	Iodometric
Fecal Coliform	49	240	350	240	100	MPN/100mL	Multiple Tube Fermentation

Parameters	Sampling Station				WQG (SB)	Units	Method
	S3	S5	S8	S10			
Nitrate as Nitrogen (NO_3--N)	0.23	0.24	0.2	0.21	10	mg/L	Brucine Sulfate
Phosphate as Phosphorous (PO_4^{3-}-P)	0.22	0.14	0.17	0.19	0.5	mg/L	Stannous Chloride
Ammonia as Nitrogen (NH_3-N)	<0.2	<0.2	<0.2	<0.2	0.05	mg/L	Distillation /Titrimetric
Total Suspended Solids (TSS)	27	8	6	9	50	mg/L	Gravimetric (dried at 103-105 °C)
Sulfate (SO_4^{2-})	2,516	2,540	2,488	2,399	250	mg/L	Gravimetric
Arsenic (As)	<0.001	<0.001	<0.001	<0.001	0.01	mg/L	Hydride Generation AAS
Cadmium (Cd)	<0.003	<0.003	<0.003	<0.003	0.003	mg/L	Flame AAS
Hexavalent Chromium (Cr^{6+})	<0.01	<0.01	<0.01	<0.01	0.05	mg/L	Diphenylcarbazide
Lead (Pb)	<0.02	<0.02	<0.02	<0.02	0.01	mg/L	Flame AAS
Mercury (Hg)	<0.0001	<0.0001	<0.0001	<0.0001	0.001	mg/L	Cold Vapor AAS
Oil and Grease	<1.0	<1.0	<1.0	<1.0	2	mg/L	Gravimetric (Petroleum Ether Extraction)
Sulfactants (MBAS)	0.73	0.1	0.66	0.37	0.3	mg/L	Methylene Blue

2.2.4 Freshwater Ecology

No freshwater areas will be affected by the project.

2.2.5 Marine ecology

2.2.5.1 Methodology

2.2.5.1.1 Benthic (corals) community assessment

Table 2-33 and Figure 2-110 show the location of spot dives for coral and reef fish survey along the coastal waters of Navotas City, Manila Bay conducted on April 4, 2016.

Manta Tow Technique

The manta tow technique was used to provide an overview of the general reef condition of the sites. This was done by towing an observer behind a motorized outrigger boat (banca) at a speed of 1.5 to 2.0 knots. The tow path followed the reef edge with observation recorded every two minutes. Percentage cover of hard coral (HC), dead coral (DC), soft coral (SC), macro-algae (MA), others (OT) and biotic component (R, RCK, S) observed for the 2-minute tow were noted. At each interval, the approximate position of the observer was noted by a second observer (on board) using a global positioning system (GPS).

2.2.5.1.2 Reef associated fish community assessment

Fish Visual Census

Fish Visual Census (FVC) technique (English, et al., 1997) was used to determine the species diversity, abundance and biomass in different survey stations. This procedure was done on the same transects laid for the coral survey. After the line had been laid, observers waited for about 5-10 minutes before the actual census to allow for the disturbed fish community to return to their normal behavior. Starting at one end of the line, all fishes within a 5m x 5m imaginary quadrat were identified up to species level (if possible) and their numbers and estimated sizes recorded. Observer swam to and briefly stop at every 5-m mark along the line until the transect line was completed. The faster moving fishes were counted first before the slower ones. Each transect covers an area of 250 m^2 (50m long x 5m width). All fish sizes of major, indicator and target species were estimated to the nearest centimeter using the total length (TL). Target species are the commercially-important fishes, coral indicator species are coral-associated, and major species are those that belong to neither group. Fish density and biomass were then computed using Reef Sum (Uychiaoco, 2000). Fish biomass was based from the relationship, W=alb, where W was the weight in grams; a and b were the growth coefficient values taken from published length-weight data; and L is the length of the fish in cm (English, et al., 1997).

2.2.5.1.3 Seagrass community assessment

Table 2-34 shows the location of spot dives for seagrass survey along the coastal areas of Navotas City, Manila Bay conducted on April 4, 2016 while the map is shown in Figure 2-110.

A total of 10 stations in coastal waters of Navotas City, Manila Bay were surveyed within the primary impact area (Figure 2-110, Table 2-34). No seagrasses were observed in any of these stations. Freshwater input from multiple streams, high turbidity of the coastal waters, and the presence of silt and muddy substrate may have prevented the recruitment and growth of seagrasses in the area.

2.2.5.1.4 Fisheries and associated invertebrates

The study was conducted in the coastal barangay of Navotas City. Primary data were gathered through key informant survey. Several male fishers were interviewed as fishing in the Philippines is normally practiced by males. These fishers were interviewed about their fishing activities such as fishing gears, catch composition and their fishing ground.

2.2.5.1.5 Phytoplankton and zooplankton community sampling and analysis

Replicate samples of phytoplankton were collected from the 10 stations using alpha water bottle (2.2-liter capacity). Composite samples from three relative depths (near surface, mid-depth and near-bottom) were collected to cover communities on the entire column. Samples were preserved with Lugol's solution and were allowed to settle in the laboratory. After settling, phytoplankton samples were decanted and placed in a Sedgewick-Rafter counting chamber. Samples were identified and enumerated using an inverted microscope. Phytoplankters were identified down to the lowest taxonomic level. Species counts were expressed as number per liter (no./L).

Plate 2-8 shows the processing of phytoplankton samples.


Plate 2-8 Sieving, identification and counting of phytoplankton samples using a compound microscope.

For zooplankton, two vertical tows were undertaken using a zooplankton net with 0.5-meter (m) mouth diameter and 0.33 mm mesh to collect zooplankton from the 10 sampling stations. Samples were preserved with 5% neutral formalin. Dye was added to facilitate sorting and identification. The preserved samples were identified, enumerated, and counted in the laboratory using a stereomicroscope. Identification was done down to the lowest practical taxonomic level. Results were expressed in number per cubic meter (no./m^3).

Plate 2-9 shows the collection/sampling of zooplankton samples using a zooplankton net, while Plate 2-10 shows the sampling and processing of zooplankton samples at the laboratory.

Diversity, species richness and evenness were computed using a Primer E software.

Plate 2-9 Collection/sampling of zooplankton samples

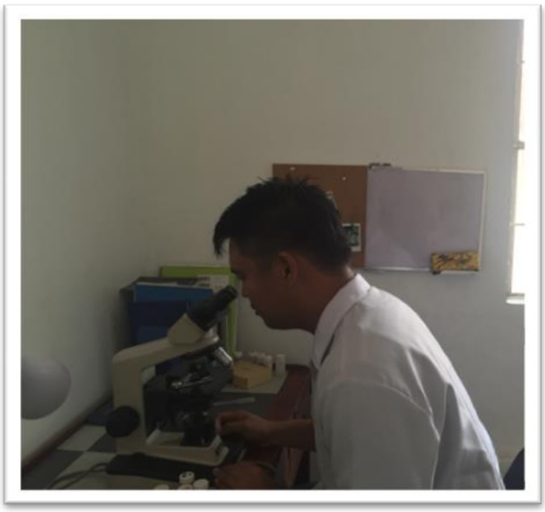


Plate 2-10 Sieving, identification and counting of zooplankton samples using a compound microscope at the laboratory

2.2.5.1.6 Benthic macroinvertebrates (soft bottom community) sampling and analysis

Replicate samples were obtained from locations consistent with the stations of marine plankton survey stations using a grab sampler (Plate 2-11) aboard a motorized boat. Benthic macroinvertebrates in each sample were identified down to the lowest practicable taxonomic level and enumerated as much as possible. The motorized boat was anchored at each sample location, and sample positions were recorded using a Global Positioning System (GPS) unit.

The benthic samples were taken with a portable gravity grab sampler deployed over the side of the boat. The grab sampler was lowered through the water column with the jaws open and locked. Benthic samples were then placed in a pre-labeled plastic bag. The grab samples for faunal analysis were fixed immediately with 10% formalin and brought to the laboratory for processing. In the laboratory, the samples were wet sieved using different openings. The collected samples were further sorted and identified in the laboratory using a dissecting microscope and readily available taxonomic keys. Plate 2-12 shows the processing of samples.

Quantities are expressed as numbers of individuals per square meter (individuals/m^2).

Plate 2-11 Portable sampler and sieve used in the study

Plate 2-12 Sorting, counting and identification of benthic macroinvertebrates under a stereo microscope

Figure 2-111 shows the sampling map for phytoplankton, zooplankton and benthic macroinvertebrates assessment.

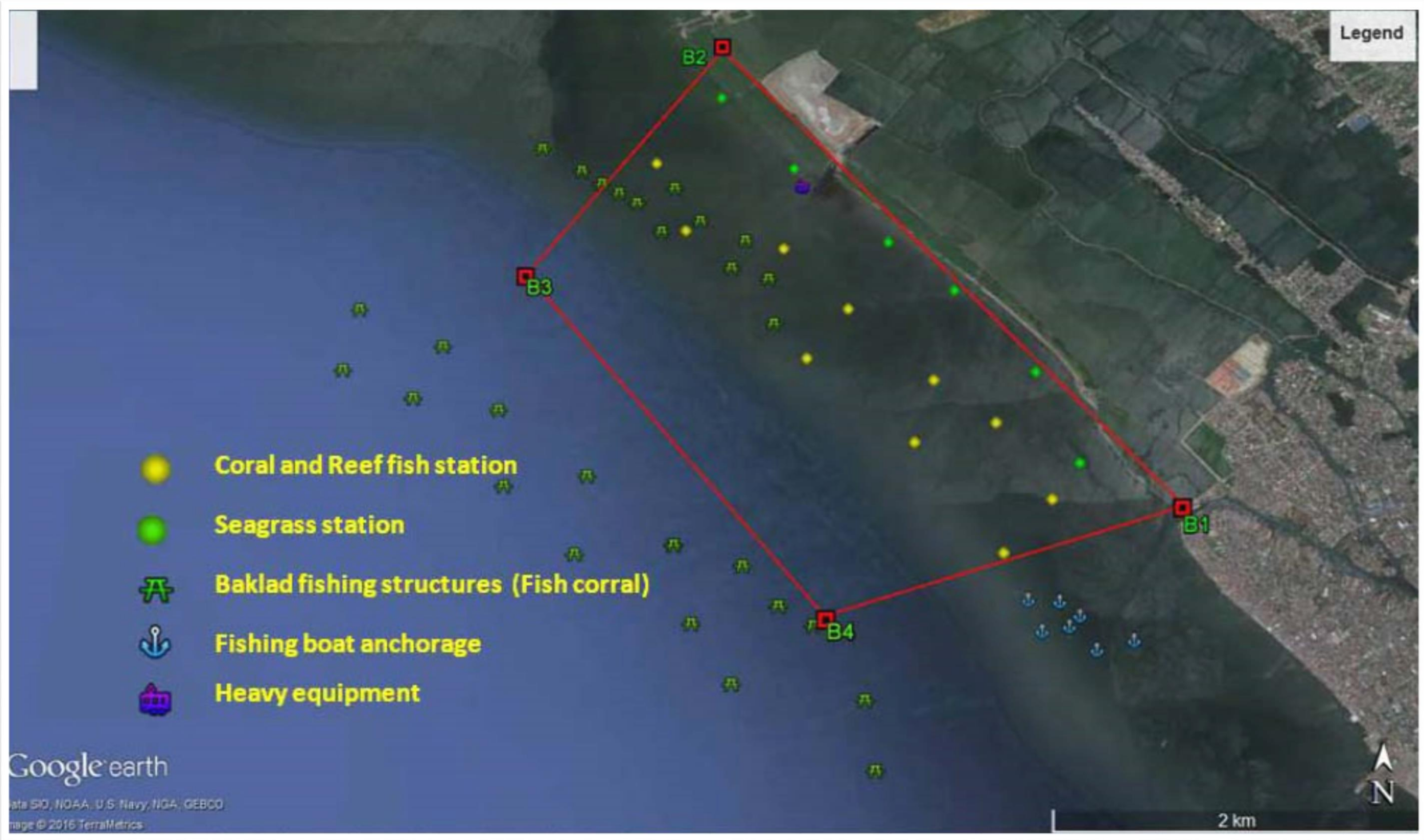
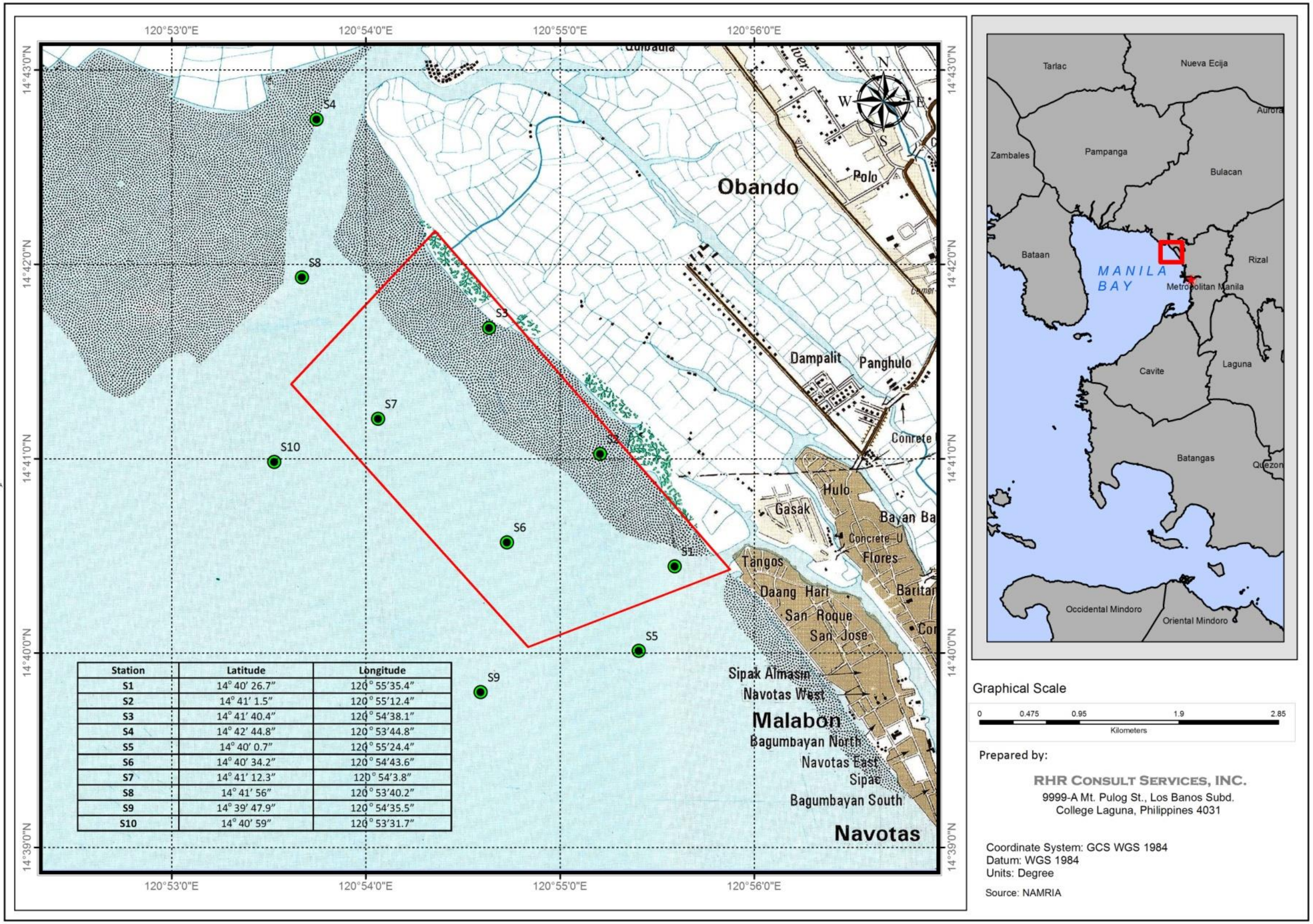


Figure 2-110 Map showing the marine resources in the coastal area of Navotas City, Manila Bay, April 4, 2015



Station	Latitude	Longitude
S1	14° 40′ 26.7″	120° 55′35.4″
S2	14° 41′ 1.5″	120° 55′12.4″
S3	14° 41′ 40.4″	120° 54′38.1″
S4	14° 42′ 44.8″	120° 53′44.8″
S5	14° 40′ 0.7″	120° 55′24.4″
S6	14° 40′ 34.2″	120° 54′43.6″
S7	14° 41′ 12.3″	120° 54′3.8″
S8	14° 41′ 56″	120° 53′40.2″
S9	14° 39′ 47.9″	120° 54′35.5″
S10	14° 40′ 59″	120° 53′31.7″

Figure 2-111 Sampling map for phytoplankton, zooplankton and benthic macroinvertebrates assessment.

2.2.5.2 Baseline information

2.2.5.2.1 Benthic (corals) community assessment

No live coral and other benthic organisms were recorded across the ten (10) spot dive stations (Figure 2-110, Table 2-33). The substrate was usually muddy of about 30 to 70 cm deep (Plate 2-13). This kind of environment is impossible for coral and other benthic organism to survive. In addition, the water was turbid and the salinity was low considered as the major limiting factors for coral growth. The 1991 Mt. Pinatubo explosion contributed to the increase in silt plus the silt coming from the river basin. Layers of silt blanket the bottom substrate making difficult for coral recruits to settle and propagate. Furthermore, suspended silt reduces light penetration that is needed for coral growth.

2.2.5.2.2 Reef associated fish community assessment

The associated reef fishes were also absent across the impact area. In the absence of coral reefs, it is doubtful for reef fish species to thrive. However, other fish species (e.g., aligasin/ kapak/Mugilidae, kanduli/Plotosidae, kitang/Scatophagidae, buga-ong/Terapontidae), bakoko (Haemulidae), bangus/Chanidae and others) can thrive in silted and brackish environments. These species are among the major fish catch in the impact area and along the Manila Bay.

Table 2-33 Location of spot dives for coral and reef fish survey along the shallow waters of Navotas City, Manila Bay, April 4, 2016

Station No	Latitude	Longitude	Remarks
1	14.673569	120.920790	Muddy/silted
2	14.679554	120.916267	Muddy/silted
3	14.684309	120.910381	Muddy/silted
4	14.691989	120.903448	Muddy/silted
5	14.696256	120.901656	Muddy/silted
6	14.690880	120.909165	Muddy/silted
7	14.687238	120.912818	Muddy/silted
8	14.6830.84	120.917514	Muddy/silted
9	14.680670	120.920857	Muddy/silted
10	14.676450	120.923639	Muddy/silted

2.2.5.2.3 Seagrass community assessment

A total of 6 spot dive stations were done for seagrass along the impact area (Figure 2-110, Table 2-34). There was no seagrass species observed in any of these stations. Freshwater input from multiple streams along the coastal areas bringing silt and turbid water. The presence of silt and muddy substrate will prevent recruitment and growth of seagrasses

Table 2-34 Location of spot dives for seagrass survey along the impact area

Station No	Latitude	Longitude	Remarks
1	14.678445	120.925315	Muddy/silted
2	14.683590	120.923290	Muddy/silted
3	14.688396	120.918983	Muddy/silted
4	14.691325	120.915279	Muddy/silted
5	14.695950	120.909862	Muddy/silted
6	14.700594	120.905519	Muddy/silted

2.2.5.2.4 Associated invertebrates

Alimasag (blue crabs), hipon (shrimps), talaba (oyster) and tahong (mussel) were the dominant Invertebrates and considered as the major fishery catch (Table 2-35). The talaba and tahong were cultured along the fish corral structures. Small shell locally known as tutukaw (Plate 2-18) were commonly found in a muddy substrate. However, this species is not palatable for human consumption because of unwanted muddy odor.

2.2.5.2.5 Fisheries

Fishing is a major source of livelihood as well as an important way of life to millions of people living in many coastal areas. The small scale municipal fishery is, however, seriously threatened and might collapse due to multiple factors such as increasing population, lack of alternative livelihoods, unregulated and often destructive fishing practices, coastal pollution and irresponsible coastal development and others (Muallil et al. 2013). Fisheries are generally acknowledged as under an open access regime (Hardin 1968) where fishing areas are public entities and hence anyone can harvest the resources without restrictions (Benjamin 2001). In effect, the resources under this scheme may be susceptible to overharvesting if these are not placed under any regulating measures. Given the inability of the traditional fishery management to address collapse of some fisheries worldwide (Bruno et al. 2011), traditional or rights-based community management framework (Pollnac 1984) is thought to be an alternative approach.

Majority of the fishers along Navotas coastal areas are generally exploiting the shallow water of Manila Bay (Plate 2-14, Navotas CLUP 2011). Most of them fish as far as Cavite and Pampanga areas. Fish coral were among the visible fishing gears observed within the project adjacent areas (Plate 2-15). These structures were used as fish trap as well as for talaba and tahong culture structure. Fishing nets were the major fishing gear for catching crabs and fishes (Plate 2-16). The dominant fish catch were aligasin/kapak (Mugilidae), kanduli (Plotosidae), kitang (Scatophagidae), buga-ong (Terapontidae), bakoko (Haemulidae), bangus (Chanidae) and others aside from blue crab (Portunidae). Trawl was also observed within the impact area. Other fish identified were sap-sap (Slip mouth/*Leiognathus sp.*), Asohos, (Sillago/ *Sillago sp.*), Malakapas (Mojarra/*Gerres sp.*) and Salinas (Navotas CLUP, 2011).

The average catch rates (± standard deviation) in Manila Bay such as Pampanga municipalities (i.e., Sasmuan, Lubao and Macabebe) at 3.7±2.3 kg/trip/fisher based in 2014 fisheries survey. The high variability in catch rates, as shown by high standard deviation value, is normally expected in small-scale fisheries due to its multi-species and multi-gear nature in addition to the behavioral heterogeniety of fishers. Nearly half of the fishers reported a low catch rate (41%) based on Mamauag et al. (2013) category of catch rates for small-scale fisheries all over the country. About 9% reported high catch rates of greater than 8 kg/trip/fisher while 51% with medium catch rate (3-8kg/trip/fisher). Overall higher catch rates were reported by gill netters targeting tilapia, shrimp and crabs and other fish such as sardines and Mugilidae (Banak), Plotosidae (catfish). During high season, normal catch rates are doubled and tripled with some fishers saying that catches could reach more than 15 kg up to 50 of kg per trip especially for gill netters in months from January to March. During low season, the majority of fishers reported catches of less than 1 kg with some saying that their catches are not even enough to cover for the day's fishing costs.

Possible displacement of local fishers from their traditional fishing ground due to coastal development is considered as one of the potential impact of the project. To address this, it is recommended that the fisher folk that would be affected (if any) would be given priority for any opportunities (e.g., livelihood). Also, a 20-meter channel shall be established to serve as access by fisher folks possibly to be affected by the project.

Table 2-35 Fish species and invertebrates caught in the impact and outside the impact area in Navotas shallow water

English name	Family names	Scientific names	Local names	Impact area	Outside impact
Fish					
Mullet	Mugilidae	*Mugil spp.*	Aligasin/kapak	yes	yes
Mullet	Mugilidae	*Mugil cephalus*	Banak	yes	yes
Herrings	Clupeidae	*Anodontostoma chacunda*	Kabasi	yes	yes
Catfish	Plotosidae	*Arius manillensis*	Kanduli	yes	yes
Milk fish	Chanidae	*Chanos chanos*	Bangus	yes	yes
Grunts	Haemulidae	*Pomadasys argenteus*	Bakoko	yes	yes
Spotted scat	Scatophagidae	*Scatophagus argus*	Kitang	yes	yes
Grunts	Terapontidae	*Terapon jarbua*	Bugaong	yes	yes
Invertebrates					
Oyster	Ostreidae	*Crassostrea iredalei*	Talaba	yes	yes
Mussel	Mytilidae	*Perna viridis*	Tahong	yes	yes
Blue crab	Portunidae	*Portunus pelagicus*	Alimasag	yes	yes
Shimp	Penaeidae	*Litopenaeus vannamei*	Hipon	yes	yes

Table 2-36 Fishing gears and fisheries activities in the impact and adjacent areas

Fishing gear	Impact area	Outside impact area	Total
Fish corral (Baklad)	10	18	28
Lift net (stationary)	0	1	1
Gill net (Lambat)	12	6	18
Trawl	1	0	1
Commercial fishing (anchorage)	0	10	10
Total	**23**	**35**	**58**

Plate 2-13 Muddy substrate and silted water observed in the impact area

Plate 2-14 Fishers prepare their nets along the coast

Plate 2-15 Fishing activities using (A) fish corral and large fishing boat observed within the impact and adjacent areas

Plate 2-16 Fishing activities using (A) trawl fishing and (B) fishing nets were observed within the impact area

Plate 2-17 Two common fish catch (a. Aligasin b. kapak) or *Mugil spp.* using gill net along the impact area

Plate 2-18 Dominant invertebrate shell found in a muddy substrate

Plate 2-19 Survey team sampling along the impact area

2.2.5.2.6 Phytoplankton community assessment

Detailed phytoplankton community assessment in the proposed project

Phytoplankton plays an important role in the marine ecology of bays, rivers and reservoirs and certain assemblages of these organisms are also considered as good indicators of different environment conditions (e.g. hydrodynamics and trophic state) (Padisak et al., 1999). The structure of algae communities, determined by indicators such as specific composition, cellular density, species richness and uniformity, can be used to evaluate the aquatic system quality, and the specific diversity measurements could constitute an appropriate index to compare environment conditions (Rosa et al., 1988). These microscopic, single-celled plants are found in greatest abundance in nearshore coastal areas, typically within the upper 50 m (160 ft) of the water column.

The name “phytoplankton” consists of two Greek words meaning “plant” (phyto) and “wanderer” (plankton). There are two major groups of phytoplankton—(1) fast-growing diatoms, which have no means to propel themselves through the water, and (2) flagellates and dinoflagellates, which can migrate vertically in the water column in response to light. Each group exhibits a tremendous variety of cell shapes, many with intricate designs and ornamentations. All species of phytoplankton are at the mercy of oceanic currents for transport to areas that are suitable for their survival and growth. Thus, physical processes can play a significant role in determining the distribution of phytoplankton species. Rapid cell division and population growth in phytoplankton can produce millions of cells per liter of seawater, resulting in visible blooms or “red tides” (Langlois, G.W. and Smith, P.).

A total of 29 phytoplankters were identified belonging to class Bacillariophyceae (diatoms) with thirteen species, Pyrrophyceae (dinoflagellates) with sixteen species, Cyanophyceae (blue-green algae) with one species, silicoflagellate with two species and a single species of marine ciliate.

Diatoms were the most diverse and most abundant group in all sampling stations accounting for 94% of the phytoplankton community (Table 2-37). It was followed by dinoflagellates and marine ciliate which only constituted about 2% while cyanophyte and silicoflagellate only comprised 2% of the community respectively. Among the diatoms, the small centric chain forming diatom, Skeletonema was the most abundant accounting for 38%, followed by another centric diatom, followed by *Chaetoceros* with 26% and the pennate diatom *Pseudonitzschia* with 27% (Figure 2-112, Figure 2-113, Table 2-37).

Diatoms (class Bacillariophyta) are found in marine and freshwater ecosystems as well as brackish water (Bold, 1978). Diatoms are estimated to be responsible for 20% to 25% of all the organic carbon fixation, are major sources of atmospheric oxygen, and are a major food source for aquatic microorganisms and insect larva (anonymous, 1999). Another important use of diatoms in the biological realm is in water quality testing. Research by Dixit et al (1999) show that diatoms can be used for present water quality but also used to determine former water quality and trends over the years. The high reproductive rates of diatoms makes them respond quickly to environmental changes and many diatom species, as well, have specific tolerances for water quality.

Among the dinoflagellates, the thecate dinoflagellate, Diplopsalis recorded the highest relative density with 0.92%. *Trichodesmium* was the only cyanophyte observed and a marine ciliate of the genus *Litonotus* was also observed (Plate 2-20D). The highest recorded mean cell density of *Skeletonema* is 285,000 cells/L found in station NVPH6 which in overall has the highest mean cell abundance with 28,819 cells/L while the lowest was found in station NVPH1 with only 2,340 cells/L (Figure 2-112, Table 2-37).

The values of various ecological indices derived from each station using the Primer E software is also shown in Table 2-37. Generally, the Shannon diversity index (H'), whose value is normally used to indicate the species diversity in a particular area.

In terms of species richness, station NVPH7 has the most number of species with 17 while station NVPH2, NVPH3 and NVPH4 had the lowest with seven. The computed diversity index was relatively low ranging from 0.97 to 1.67 which indicates a relatively low diversity with the highest value observed in station NVPH1 and while the lowest in station NVPH (Figure 2-113,Table 2-37).

The evenness values on the other hand ranges from 0.83 to 0.97 with the highest values found in station 5 and lowest in station NVPH2 and NVPH3. The Shannon diversity index of all the stations was below two (<2) which is categorized overall as low based on the Wilhm criteria (1975) classifying the diversity index <3.0 as low diversity and community stability.

Photomicrographs of common phytoplankton genus/species is shown in Plate 2-20.

Table 2-37 Phytoplankton composition and abundance (cells/L) in Navotas area Manila Bay during the April 4, 2016 sampling

TAXA	STATIONS										GRAND	Imp
	NVPH1	NVPH2	NVPH3	NVPH4	NVPH5	NVPH6	NVPH7	NVPH8	NVPH9	NVPH10	TOTAL	Val
Cyanophyte	**495**				**3,400**	**1,615**	**3,360**	**350**	**1,105**	**665**	**10,990**	**0.60**
Trichodesmium	495				3,400	1,615	3,360	350	1,105	665	10,990	0.60
Diatoms	**31,275**	**12,600**	**4,600**	**67,200**	**135,419**	**412,342**	**382,543**	**80,371**	**304,664**	**272,831**	**1,703,845**	**93.57**
Amphora			300		510						810	0.04
Chaetoceros	5,040			2,200	83,229	11,875	68,000	1,700	122,778	174,167	468,989	25.75
Cymbella					0						0	0.00
Ditylum						380					380	0.02
Melosira						760	960		1,360	855	3,935	0.22
Nitschia			250		0		240	300			790	0.04
Odontella	90	2,430			0			150			2,670	0.15
Pleurosigma	315	1,890	500	1,800	3,570		640	1,900	340		10,955	0.60
Pseudonitzschia	6,345	3,960	2,850	18,300	20,315	113,472	147,000	22,800	78,271	71,589	484,902	26.63
Rhizosolenia	405			11,300	5,440			4,750	3,910	5,795	31,600	1.74
Skeletonema	19,080	3,690		32,400	20,400	285,000	165,143	48,571	97,750	20,425	692,459	38.03
Surirella		630			0						630	0.03
Thalassiosira			700	1,200	1,955	855	560	200	255		5,725	0.31
Dinoflagellates	**3,780**	**360**		**1,700**	**9,010**	**17,480**	**9,040**		**8,925**	**1,045**	**51,340**	**2.82**
Ceratiumfusus						1,140					1,140	0.06
Ceratiumlineatum					0					285	285	0.02
Dinophysis miles	45				0	285	320				650	0.04
Diplopsalis	630				2,550	7,410	2,480		3,230	475	16,775	0.92
Fragilidinium									340		340	0.02
Gonyaualx scrippsae					340		160				500	0.03
Gonyaulax spinifera	360				0		400		1,020		1,780	0.10
Gymnodinium					0						0	0.00
Gyrodinium							800		340		1,140	0.06
Protoperidinium conicum	540				5,100	665	80			95	6,480	0.36

TAXA	STATIONS										GRAND	Imp
	NVPH1	NVPH2	NVPH3	NVPH4	NVPH5	NVPH6	NVPH7	NVPH8	NVPH9	NVPH10	TOTAL	Val
Protoperidinium pellucidum									1,275		1,275	0.07
Protoperidinium sp	360			1,700	595	1,615	320				4,590	0.25
Protoperidnium latispinum	1,350				0	2,945	3,920		2,210	190	10,615	0.58
Protoperidnium oceanicum	495					3,420			510		4,425	0.24
Prtoperidnium divergins					0						0	0.00
Scrippsiella		360			425		560				1,345	0.07
Protozoan		**37,050**	**13,400**		**0**			**50**			**50,500**	**2.77**
Litonutus		37,050	13,400		0			50			50,500	2.77
Silicolagellate	**1,890**		**600**		**510**	**855**		**450**			**4,305**	**0.24**
Favella	900				0			350			1,250	0.07
Tintinopsis	990		600		510	855		100			3,055	0.17
Grand Total	**37,440**	**50,010**	**18,600**	**68,900**	**148,339**	**432,292**	**394,943**	**81,221**	**314,694**	**274,541**	**1,820,980**	**100**
Mean Abundance	**2,340**	**7,144**	**2,657**	**9,843**	**5,705**	**28,819**	**23,232**	**6,768**	**20,980**	**27,454**		
Richness	**16**	**7**	**7**	**7**	**14**	**15**	**17**	**12**	**15**	**10**		
Evenness	**0.60**	**0.50**	**0.50**	**0.70**	**0.57**	**0.36**	**0.44**	**0.44**	**0.49**	**0.42**		
Diversity	**1.67**	**0.98**	**0.98**	**1.37**	**1.50**	**0.98**	**1.24**	**1.11**	**1.34**	**0.97**		

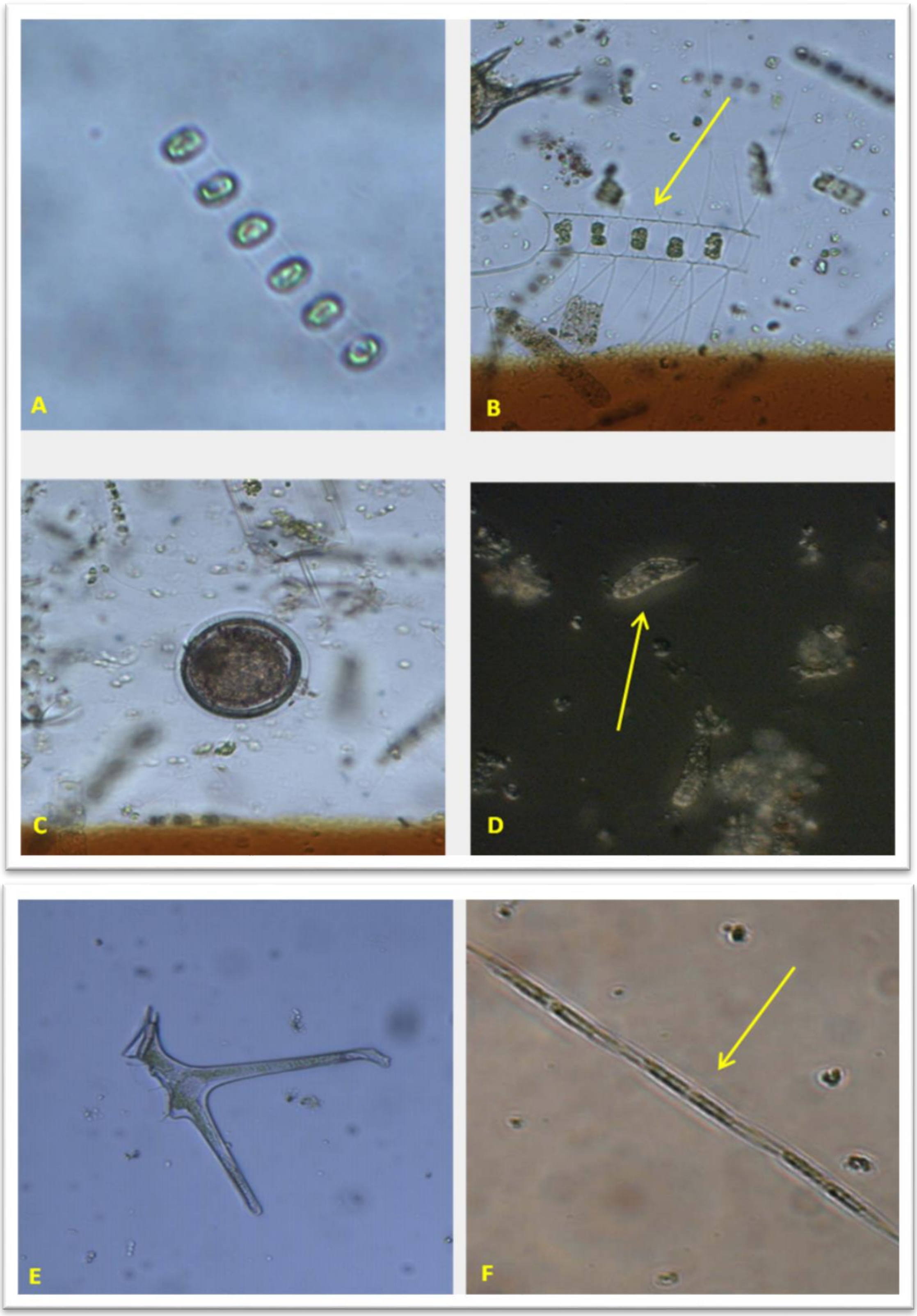


Plate 2-20 Photomicrographs of dominant phytoplankton species (A) Skeletonema spp. (B) Chaetoeros spp. (C) Diplopsalis spp (D) Litonutos spp. and potentially toxic phytoplankton species (E) Dinophysis miles (F) Pseudonitzschia spp. observed in Navotas area of Manila Bay during the April 4, 2016 sampling

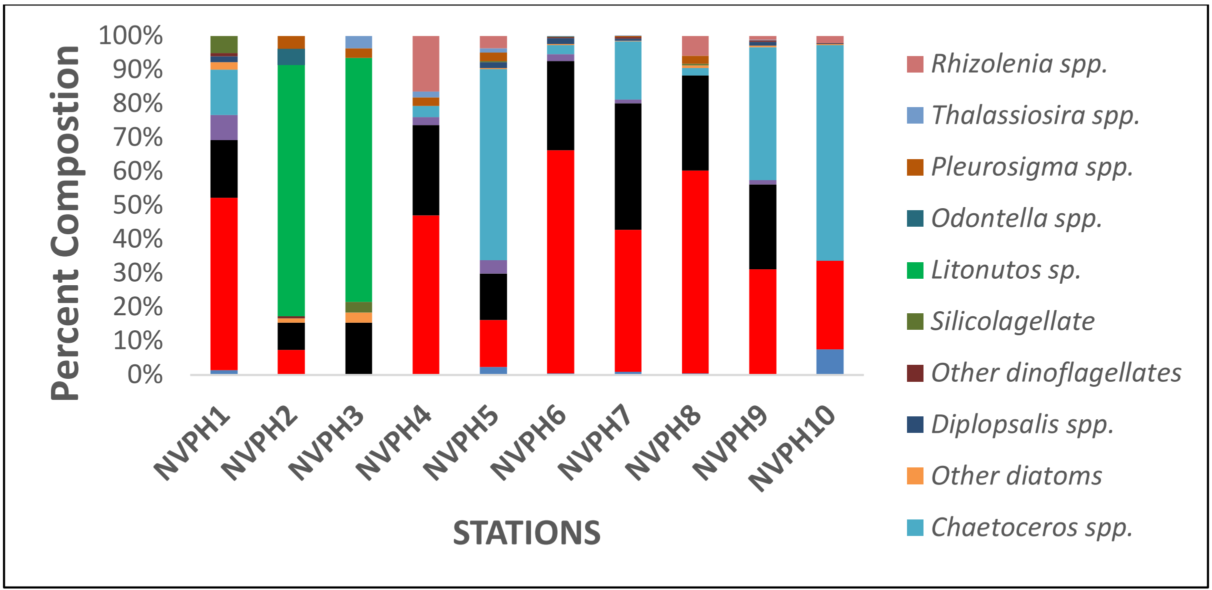


Figure 2-112 Percent composition of important phytoplankton genus observed in 10 stations in Navoatas, Manila Bay, April 4, 2016

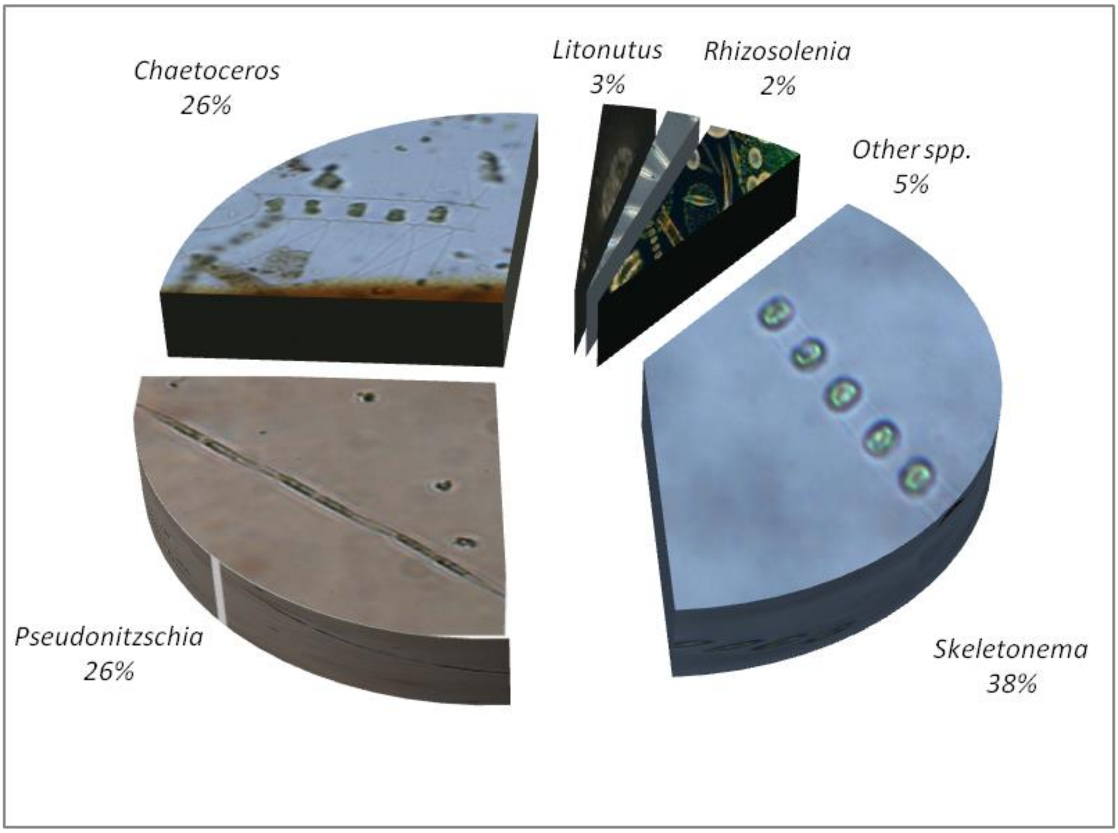


Figure 2-113 Top 5 Phytoplankton Species Observed Over the 10 (510) Stations in Navotas City, Manila Bay, on April 4, 2016

Historical occurrence of red tide, fish kill or any related event in Manila Bay

Redtide is a marine phenomenon that poses great risk to the health and economic livelihood of people in coastal areas. Paralytic shellfish poisoning (PSP) develops when a person consumes molluscs containing toxic dinoflagellates and suffers neurological and/or gastrointestinal manifestations. Red tide is a natural coastal phenomenon in many parts of the world. It refers to the visible red-brown discoloration in the sea brought about by sudden population growth of minute marine organisms called dinoflagellates (Hartigan-Go, K.Y., 1991).

From 1983 to 2001, a total of 42 toxic outbreaks have resulted in a total of 2,107 paralytic shellfish poisoning cases with 117 deaths. Earlier, only a few coastal areas of the country were affected in scattered locations, but today, this has grown to a total of 20 coastal areas.

During the 1991 *Pyrodinium* red-tide outbreak in Manila Bay, around 38,500 fisher folks were displaced from their livelihood due to the red tide scare (Environmental Monitor 2003). A total of 66 cases of Paralytic Shellfish Poisoning (PSP) and 8 deaths were reported by Department of Health (DOH) in 1991 (Hartigan-Go, K.Y., 1991). An Inter-Agency Committees on Environmental Health chaired by the Department of Health (DOH) created the National Red Tide Task Force (NRTTF) composed of different government agencies and academic institutions chaired by the Bureau of Fisheries and Aquatic Resources (BFAR), Department of Agriculture (DA) was formed in response to the red-tide phenomenon.

The National Red Tide Task Force (NRTTF) is mandated to monitor toxic red tides in our country. This is to protect the public from the illness and death caused by the red tide toxin and also to mitigate its negative impact to the shellfish industry. A regular issuance of the red tide update is also being undertaken (www.wepa-db.net).

As early as 1988, a Red Tide Monitoring Programme was in place at the Manila Bay by DA-BFAR. The two major components of this programme are to conduct phytoplankton surveillance, and if there is suspicion of toxicity, to then proceed with shellfish toxicity monitoring.

In the study conducted by Chang et al in 2009, Manila Bay is thought to be highly eutrophicated with high Nitrogen concentration particularly Ammonium. Among phytoplankton, the centric diatom, Stephanopyxis spp. were dominant, and they occupied 44% of total phytoplankton biomass. The small Cyclopoida Oithona spp. Occupied 42% of total mesozooplankton abundance. Consequently, the plankton community of Manila Bay showed a structure composed of higher microbial activity and primary production but lower secondary production, particularly with lower mesozooplankton abundances.

2.2.5.2.7 Zooplankton community assessment

Detailed zooplankton community assessment in the proposed project

A total of 18 zooplankton groups were observed from samples taken from ten stations combined (Table 2-38). The zooplankton community was represented by eleven major zooplankton groups namely copepods (cyclopoid, calanoid, harpacticoid, nauplius and copepodite), larvaceans, heterepods, cladoeceran, chaetognaths, foraminiferans, polychaetes (adult and trocophore) bivalve veliger, hydromedusae larvae, turbillarian and unidentified eggs (Figure 2-114).

In particular, the larval zooplankton forms constituted 53% of the total zooplankton density. Of which, the copepod nauplii and copepodite forms alone accounts for nearly 40% making was the most abundant larval form of zooplankton. They are also among the most widely distributed group found at high density in most sampling station (8 stations in particular). Adult form of zooplankton, on the other hand, accounted for nearly 47% of the total density of zooplankton. Of these calanoid copepod account for 22% making it the most abundant adult zooplankton form (Figure 2-115). This is followed by cyclopoid copepod accounting for about 13% (Figure 2-115).

Ecologically, Turner (2004) stated that these dominant groups serve as important links in marine food webs, serving as major grazers of phytoplankton, as components of the microbial loop, and as prey for ichthyoplankton and other larger pelagic carnivores.

Photomicrograph of the dominant zooplankton group is shown in Plate 2-21.

The other important groups of zooplankton include the larvaceans (8%), and unknown zooplankton egg. Twelve other groups make up the rest of the zooplankton composition each contributing at less than 10%. The highest mean individual density was recorded in Station NVZP5 and lowest at NVZP3.

In terms of species richness, station 4 recorded the highest with 16 while station NVZP1 and NVZP5 while station NVZP2 and NVZP3 had the lowest both with 2 respectively. The index of species diversity (H') for zooplankton varied little across stations (1.02-1.84) (Table 2-38). The index of evenness is quite variable (0.58-0.91). The lowest measured index of evenness and diversity indicated the presence of very abundant group during the survey which is the copepod nauplii and copepodite.

Table 2-38 Zooplankton composition and abundance in Navotas area, Manila Bay during the April 4, 2016 sampling

Taxa	STATIONS										Grand	Imp
	NVZP1	NVZP2	NVZP3	NVZP4	NVZP5	NVZP6	NVZP7	NVZP8	NVZP9	NVZP10	Total	Values
Adult forms	**358,729**	**315,278**	**202,101**	**147,130**	**2,875,609**	**941,329**	**885,876**	**121,261**	**203,545**	**577,201**	**6,628,058**	**46.87**
Adult polychaete									2,887		2,887	0.02
Calanoid	85,893	121,261	80,840	67,906	1,846,626	139,623	437,886	64,672	67,848	233,629	3,146,184	22.25
Chaetognaths	15,158						33,684			8,246	57,087	0.40
Cladoceran					24,252		6,737				30,989	0.22
Cyclopoid	191,996			45,271	838,431	162,143	333,467	32,336	112,599	90,703	1,806,945	12.78
Foraminiferans		194,017	121,261								315,278	2.23
Harpacticoid	5,053				38,110	108,095	10,105		8,661	8,246	178,270	1.26
Larvacean	50,525			33,953	128,190	531,468	63,999	24,252	11,549	236,377	1,080,313	7.64
Turbellarian	10,105										10,105	0.07
Larval forms	**505,253**	**121,261**	**101,051**	**995,954**	**1,710,814**	**1,499,821**	**1,364,182**	**315,278**	**150,132**	**750,361**	**7,514,105**	**53.13**
Barnacle nauplius	10,105			33,953	20,788	22,520	10,105		4,331	10,994	112,795	0.80
Bivalve veliger					155,214		6,737	16,168	2,887	68,714	249,720	1.77
Crustacean zoae	30,315				48,504	130,615	6,737		17,323	21,989	255,483	1.81
Heteropod	25,263				20,788	13,512					59,562	0.42
Hydromedaue larvae	25,263	48,504	80,840								154,607	1.09
Nauplius	338,519	72,756	20,210	169,765	1,320,009	1,301,646	1,340,604	299,110	121,261	643,166	5,627,045	39.79
Polychaete trocophore	75,788			22,635	41,575	9,008			4,331		153,337	1.08
Salp larvae										5,497	5,497	0.04
Unidentified egg				769,601	103,938	22,520					896,058	6.34
Grand Total	**863,982**	**436,538**	**303,152**	**1,143,083**	**4,586,423**	**2,441,150**	**2,250,058**	**436,538**	**353,677**	**1,327,561**	**14,142,163**	**100**
Mean Abundance	**71,998**	**109,135**	**75,788**	**163,298**	**382,202**	**244,115**	**225,006**	**87,308**	**35,368**	**132,756**		
Richness	**12**	**4**	**4**	**7**	**12**	**10**	**10**	**5**	**10**	**10**		
Evenness	**0.74**	**0.91**	**0.90**	**0.58**	**0.62**	**0.63**	**0.51**	**0.63**	**0.69**	**0.65**		
Diversity	**1.84**	**1.26**	**1.25**	**1.13**	**1.54**	**1.44**	**1.17**	**1.02**	**1.58**	**1.49**		

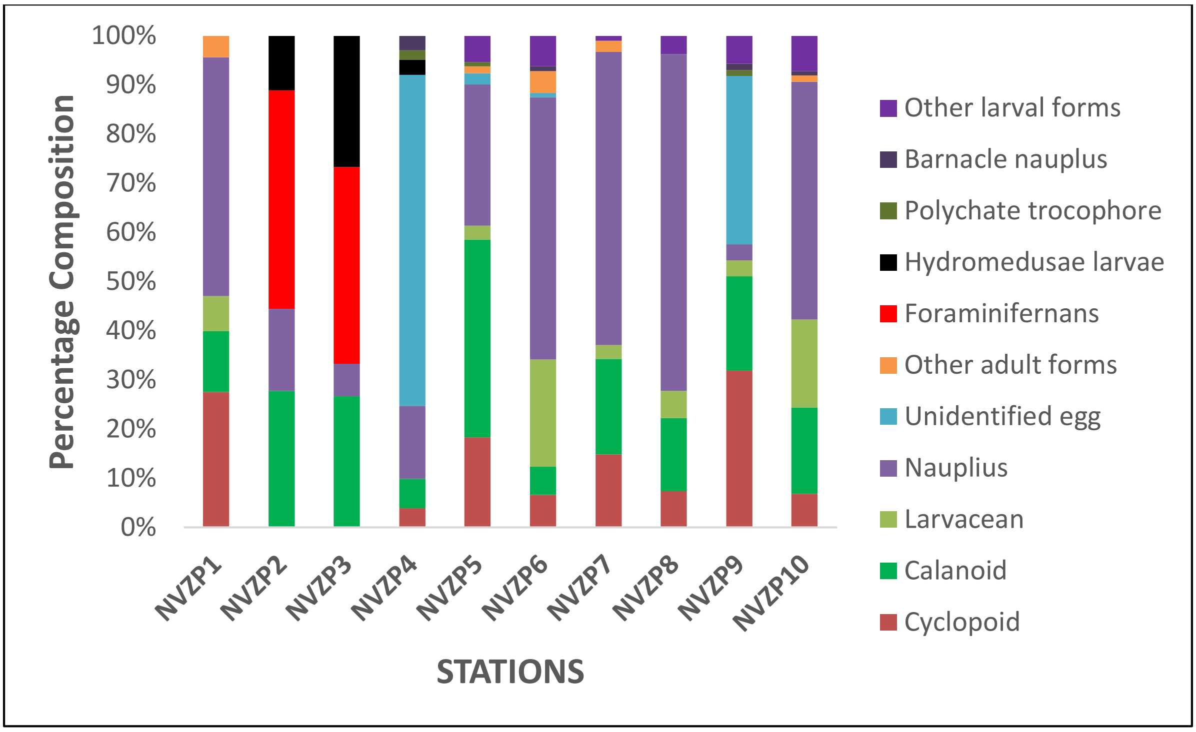


Figure 2-114 Percent composition of common zooplankton group observed in 10 stations in Navotas area , Manila Bay during the April 4, 2016

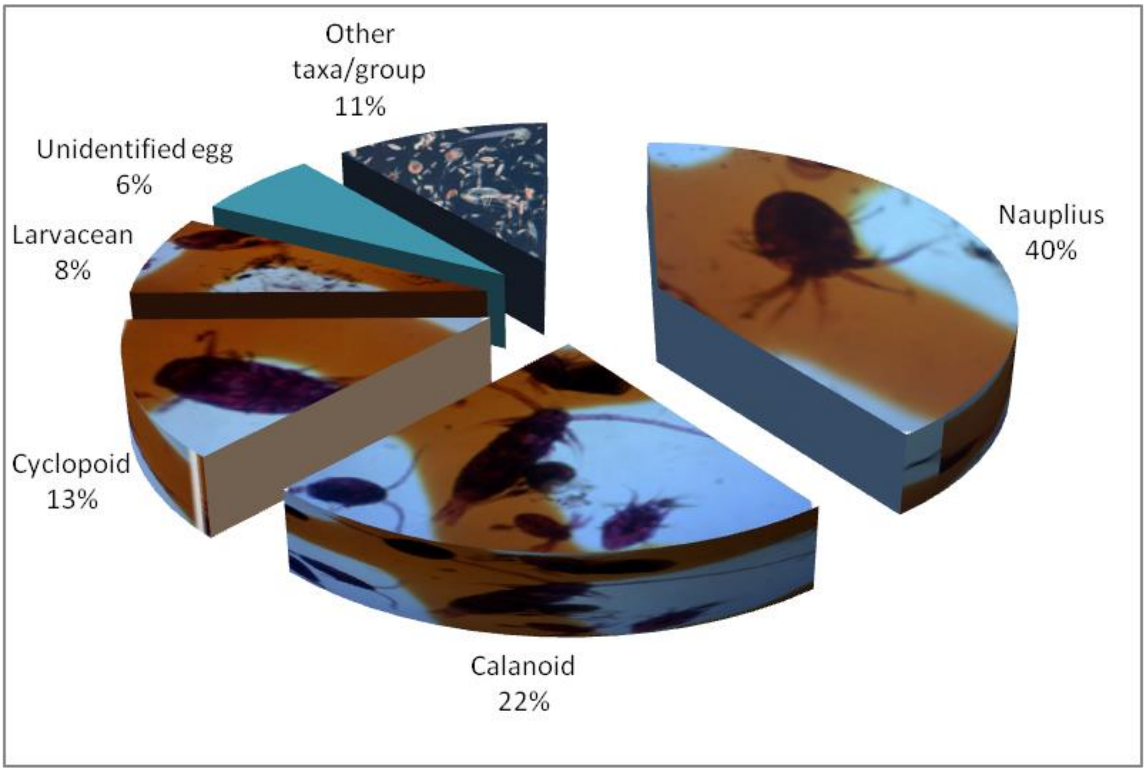


Figure 2-115 Top 5 zooplankton species observed over the 10 (10) stations in Navotas City, Manila Bay, on April 4, 2016

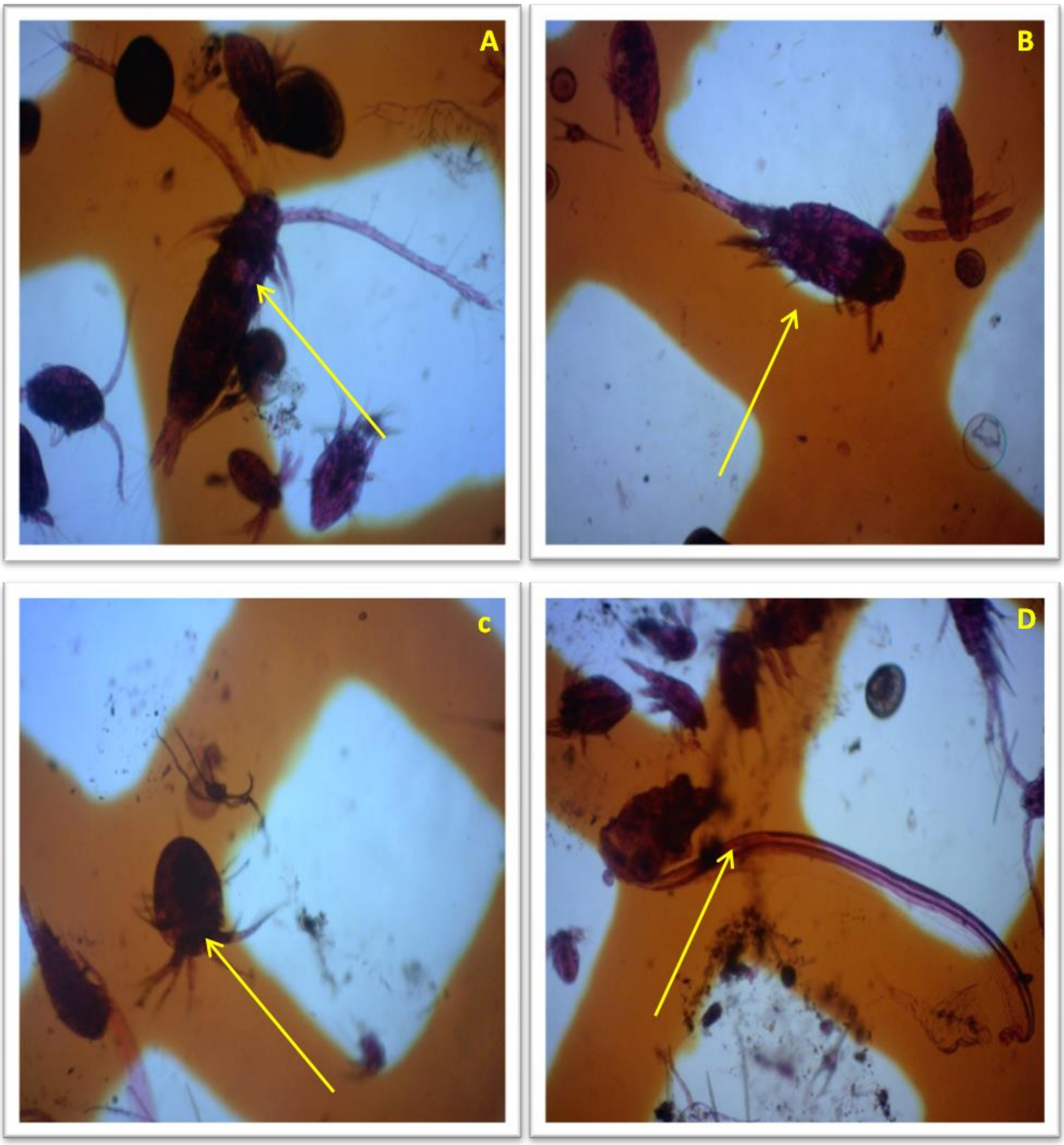


Plate 2-21 Photomicrographs of common zooplankton groups observed in Navotas area, Manila Bay during the sampling period. (A) Calanoid copepod (B) Cyclopoid copepod (C) Nauplius (D) Larvacean

Plankton observed in 10 sampling stations were species commonly found in tropical marine environment. There were no rare or endemic zooplankton species recorded during this sampling. Generally, phytoplankton abundance and growth depends on factors like nutrients, light attenuation, water movement and grazers (Reynolds 2006). Manila Bay, a highly eutrophic embayment (Chang et al 2009), incidences of hypoxia and anoxia, frequency blooms of harmful microalgae and persistent red tides (Jacinto et al 2006; Azanza et al 2004) are commonly occur. In this survey, high concentration of phytoplankton was generally observed similar to previous sampling in the bay (Azanza and Miranda 2001). In particular, Station NVPH1, located near the mouth of Navotas River harbored the high number of phytoplankton species. However, the high number of foraminiferans that were found in station

NVPH2 can explain why this area serves as habitat for crabs in which serves as their foods. A study conducted by Comoglio et al (1999) showed that foraminiferans serve as natural food diet of crabs. The most abundant phytoplankton species particularly *Skeletonema* was found at Station NVPH5 which explain why this area had high concentration of zooplankton grazers i.e. calanoid and cyclopoid copepods which then serves as food to higher trophic level (i.e planktivorous fishes) possibly indicates why this area serves as good fishing ground as reflected by several motorized banca with fish nets observed during the sampling period. Stations NVPH2 and NVPH3 had the lowest number of phytoplankton species observed and also among that has the lowest diversity index in the site. The relatively shallow depth of the area explains why phytoplankton community here is less diverse and almost an absence of dinoflagellates which since they generally favors a deeper stratified water. Also, the occurrence of a marine ciliate of the genus *Litonutus* abundant in these stations is indicative of poor water conditions (Zhou et al 2006). The site is also located along the canal/tunnel going to Navotas reclamation area. A high concentration of bivalve veliger was observed in station NVPH5 and NVPH10 also indicate a good recruitment habitat which reflects to good fishing ground and presence of shellfish (*Perna viridis*) farming in the area.

The potentially harmful phytoplankton found during this sampling period are *Pseudonitzschia spp* and *Dinophysis* miles. Some species of *Pseudonitzschia* is capable of producing toxins associated with Amnesic Shellfish Poisoning (ASP) while *Dinophysis* miles is known to produce okadaic acid, toxin associated with Diarhhetic Shellfish Poisoning (FAO,2000). Although identification of *Pseudoniztschia* to species level is crucial, it is not possible for this analysis since imaging need more powerful microscope. A high density of *Pseudonitzschia* was observed during the sampling period with cell densities reaching up to 1.47 x 105 cells/L particularly in station NVPH7. Similar to the reports of Bargu et al (2012) where *Pseudonitzschia* bloom that can reach up to 105 cells/L. Although some species are toxic, there are no documented reports of ASP poisoning in Manila Bay so threat due to this organism is minimal. *Pyrodinium bahamense*, a toxic dinoflagellate with long history of harmful algal bloom in Manila bay was not found during the sampling period.

Generally, there is insufficient information on the direct and indirect effects of suspended sediment plume during reclamation on planktonic communities to judge/assess with certainty the impacts on planktonic activities found in the site. The increased load of suspended solids would reduce light penetration which then reduces depth of photosynthetic activity by the phytoplankton. Also, high sediment loads would reduce the grazing success of zooplankton. However, it is important to note that increase in turbidity can be also cause by natural process such as storms or typhoons and turbulent waves during monsoons. Plankton communities are resilient and population could be replenished from other parts of Manila Bay due to water circulation and current system.

2.2.5.2.8 Benthic macroinvertebrates (soft bottom) community assessment

The taxonomic listing, abundance and distribution of benthic macroinvertebrates observed over the five established sampling stations established at the project site is presented in Table 2-39.

Figure 2-116 shows the Relative Abundance (RA) of benthic macroinvertebrates Phyla in the ten stations located in the vicinities of the project site in Manila Bay, Navotas City. RA is the ratio of individuals in a certain taxon to the total number of individuals of all taxa which is affected by various factors. A community dominated by relatively few species could indicate environment stress (Plafkin et al., 1989 in ESS Group, Inc. (2001)). High percent contribution by a taxon generally indicates community imbalance (Bode, 1988).

Seventeen (17) representatives/taxa were recorded under five (5) Phyla and seven (7) Classes respectively.

The results from this survey demonstrate that the benthic communities within the Manila Bay Study Area are primarily made up of polychaetes (PhylumAnnelida). The most striking feature of the results is the abundance of the representative species Family Nereididae within nearly all of the stations sampled.

The annelids (Phylum Annelida) were the most dominant of the benthic population by Phylum with RA of 76%, followed by mollusks (Phylum Mollusca) with RA of 13.00%. The third most dominant benthic macroinvertebrates are the arthropods with 5% followed by Phylum Nemertea, Annelida and Cnidaria with 2% RA, respectively.

The annelids, completely dominated by the Class Polychaeta (polychaetes), are comprised of 8 Families and Class Echiura. The most dominant annelids were representatives of Family Nereidae with 30%, followed by Family Nereidae with 4.65%, Family Spionidae (21%) and Family Nephtyidae (6%), Amphinomidae and Syllidae (3%). The least species with RA of 0.76% are Families of Goniadidae and Glyceridae, respectively (Table 2-39).

Table 2-39 Taxonomic listing, abundance and distribution of benthic macroinvertebrates sampled at Navotas City, Manila Bay, April 4, 2016

BENTHOS TAXA	STATIONS										Grand	Imp.
	NVBN1	NVBN2	NVBN3	NVBN4	NVBN5	NVBN6	NVBN7	NVBN8	NVBN9	NVBN10	Total	Values
Phylum Cnidaria												
Class Anthozoa												
Order Actiniaria	91										91	1.52
Phylum Nemertea												
Class Rynchocoela	45		91								136	2.27
Phylum Annelida												
Class Polychaeta												
Family Spionidae	136		545	45	91	45		182	45	182	1273	21.21
Family Capitellidae	91	91	136								318	5.30
Family Amphinomidae	45						136				182	3.03
Family Nephtyidae	227	45				45				45	364	6.06
Family Syllidae	91									91	182	3.03
Family Nereidae	182		727	273	45			545			1773	29.55
Family Goniadidae	45										45	0.76
Family Glyceridae	45										45	0.76
Class Echiura	318	182									500	8.33
Phylum Mollusca												
Class Pelecypoda												
Family Tellinidae	227					91					318	5.30
Family Mytilidae								364			364	6.06
Family Veneridae	45										45	0.76
Class Gastropoda												
Family Cerithiidae										45	45	0.76
Phylum Arthropoda												

BENTHOS TAXA	STATIONS										Grand	Imp.
	NVBN1	NVBN2	NVBN3	NVBN4	NVBN5	NVBN6	NVBN7	NVBN8	NVBN9	NVBN10	Total	Values
Subclass Crustacea												
Class Malacostraca												
Order Amphipoda												
Gammaridae		91						182			273	4.55
Order Decapoda												
Family Pinnotheridae										45	45	0.76
TOTAL	**1,591**	**409**	**1,500**	**318**	**136**	**182**	**136**	**1,273**	**45**	**409**	**6,000**	**100.00**
Mean Abundance	**122**	**102**	**375**	**159**	**68**	**61**	**136**	**318**	**45**	**82**	**353**	
Richness	**13**	**4**	**4**	**2**	**2**	**3**	**1**	**4**	**1**	**5**	**17**	

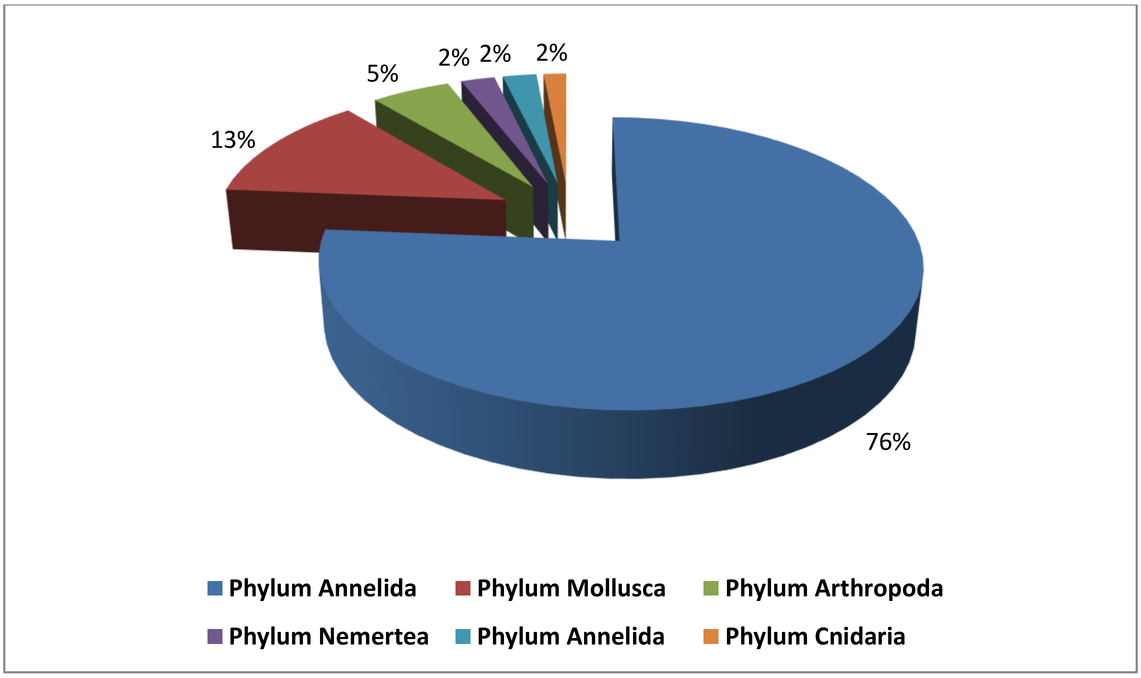


Figure 2-116 Relative abundance of soft-bottom communities by phylum over the ten sampling stations in Manila Bay, Navotas City on April 4, 2016

Again, from Table 2-39 and Figure 2-117, the benthic community was most abundant at Station NVBN 1 with 1,591 individuals/m^2. Station NVBN 2 was second with a total density of 1,500 individuals/m^2 followed by Station NVBN 8 with 1,273 individuals/m^2. The lowest density was observed at Station NVBN 9, with 45 individuals/m^2.

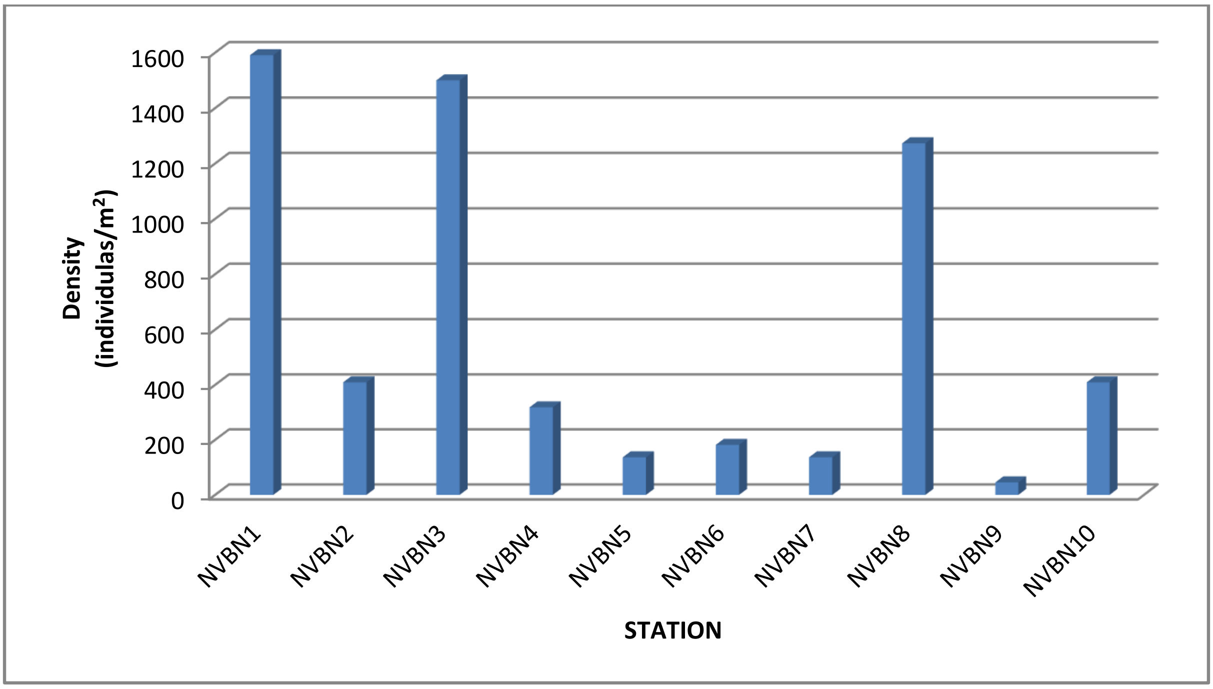


Figure 2-117 Total Mean Densiy of Soft-bottom Communities Over the Ten Sampling Stations in Manila Bay, Navotas City on April 4, 2016

Station NVBN 1 is the most abundant in terms of total number of taxa/species (richness) with 13 groups/species followed by Station NVBN 10 with 5. Stations NVBN 2, NVBN 3 and NVBN 8 recorded 4 groups/species. and 12 taxon/species. Stations NVBN 7 and NVBN 9, recorded only one group/species.

Figure 2-118 shows the top five benthic macroinvertebrates species observed at Manila Bay during the April 4, 2016 sampling. From the ten stations sampled, representatives from Family Nereidae emerged as the most dominant in all stations with 29.55% RA. Representatives from Family Spionidae ranked second with a 21.21% RA. This was followed by representatives from Class Echiura, ranking third, with 8.33% RA. Representatives from Families Mytilidae and Nepthyidae ranked fourth in terms of total mean density having a 6.06% RA apiece. Family Capitelidae ranked fifth with 5.30% RA. Other benthic macroinvertebrates (11 species/groups) contributed 23.48% RA.

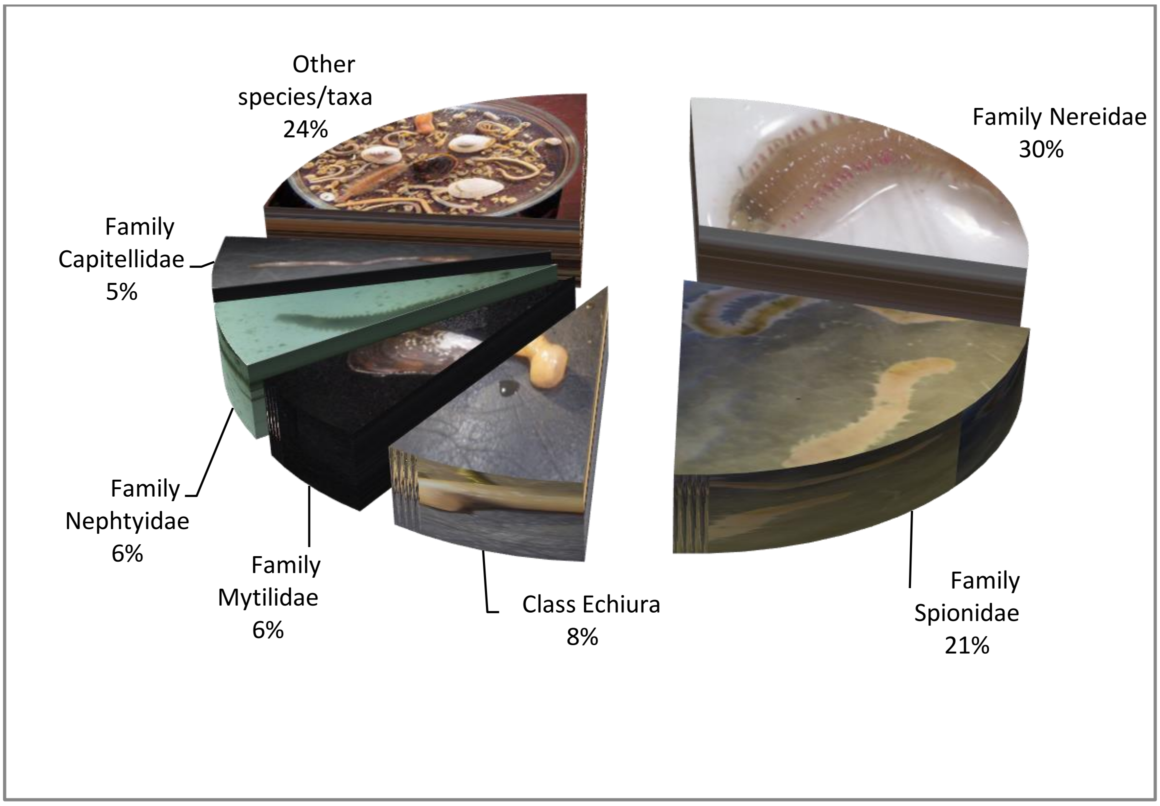


Figure 2-118 Top 5 benthic macroinvertebrates species/taxa observed over the five (5) stations in Batangas Bay, Brgy. Simlong, Batangas City on October 29, 2015

Meiobenthic organisms, because of their contact with sediments, their relative abundance, their ubiquity, and sedentary nature, are considered to be good bioindicators of the long-term environmental status of sediments contaminated by hydrophobic organic micropollutants (Louati *et al* 2014).

The first and second most dominant benthic macroinvertebrates are from Family Nereididae (Class Polychaeta) (formerly spelled Nereidae) and Spionidae, are a family of polychaete worms. They may be commonly called ragworms or clam worms. Ragworms are predominantly marine organisms. They are commonly found in all water depths, foraging in seaweeds, hiding under rocks or burrowing in sand or mud. Ragworms are important food sources for a number of shore birds (wikipedia). The Family Nereididae is one of the most diverse and abundant taxa among benthic families both in marine and brackish water ecosystems. Its representatives play important roles in the energy transfer within a given ecosystem as customers of plants and small invertebrates, or as prey of many benthic animals. Apart from their ecological importance, they are widely used by humans as bait for fish or as the live diet of cultured animals such as fish.

The genus *Polydora* (Polychaeta, Spionidae) includes many species well known for their activity as borers. They often become harmful invaders by reducing the growth rate and meat yield of, or inducing the mortality of commercially important mollusk species (Sato-Okoshi, *et al*, 2013).

Plate 2-22 shows the photomicrographs of Family Nereididae (Class Polychaeta) and Spionidae.

Plate 2-22 Photomicrographs of Family Nereididae (upper photo) and Spionidae (lower photo) observed in Navotas area, Manila Bay during the sampling period

Polychaetes from the families Nererididae and Dorvilleidae are suitable for assessing the toxicity of sediments. They are good monitors of the presence and bioaccumulation potential of anthropogenic compounds such as PCBs, PAH and metal organic complexes as the polychaetes accumulate deleterious materials within their tissues in concentrations proportional to concentrations found in the environment. Species of Nereidae and Nephytidae are accepted as indicators of early successional phases of environmental discovery after pollution has been abated (Pearson & Rosenberg, 1978 in http://lkcnhm.nus.edu.sg/polychaete/ Introworms.html).

The third most abundant benthic fauna are called "spoon worms" or Echiurans (Class Echiura). Spoon worms are worms belonging to Phylum Echiura. Some scientists place them in Phylum Annelidae like the more familiar earthworm. Spoon worms are not segmented like other annelids. There are only about 150 species of spoon worms, but they can be quite common in some marine ecosystems. Echiurans may be important food for some fishes. In a study of Leopard sharks off California, large, meaty spoon worms were found to be their favorite food. Most are deposit feeders, collecting edible bits from the bottom of the sea. They do this by placing the prostomium against the surface and forming a kind of gutter over the surface. Tiny hairs on the surface of the prostomium bring edible bits to the mouth. Echiurans are exclusively marine and they are mostly infaunal, occupying burrows in the seabed.

Plate 2-23 shows the photomicrograph of Class Echiura.

Plate 2-23 Photomicrograph of a representative species from Class Eciura observed in Navotas area, Manila Bay during the sampling period

The fourth most dominant benthic macroinvertebrates are representatives from Family Mytilidae. The Mytilidae are a family of small to large saltwater mussels, marine bivalve mollusks in the Order Mytiloida. Mussel is the common name used for members of several families of clams or bivalve molluscs, from saltwater and freshwater habitats.

Perna viridis (*P. viridis*), commonly known as Asian green mussel or tahong, is one of the marine resources that is harvested in the coastal areas of Manila Bay. Green mussels generally grow on hard surfaces, and is said to be invasive for its wide range of tolerance. However, a recent report showed that there is a decline in the population of this aquatic species. According to DENR (2004), the decline in mollusk production is attributed to the high levels of heavy metals, oil and grease, and suspended solids in Manila Bay. This problem in green mussel population tremendously affects the livelihood of people living in the coastal areas of the bay which rely mostly on fisheries and aquaculture. As a common and affordable food and rich source of iodine, green mussels are available in the local markets in the cities and municipalities around Manila Bay.

Plate 2-24 shows the photomicrograph of a representative from Family Mytilidae.

Plate 2-24 Photomicrograph of a representative species from Family Mytilidae observed in Navotas area, Manila Bay during the sampling period

The fifth most dominant benthic macroinvertebrates are representatives from Family Nephtyidae. Nephtyidae is a taxonomic family of worms. They are commonly referred to as catworms. Nephtyids are active predators, with a strong muscular proboscis, armed with two well-developed jaws. They can dig relatively fast through sandy sediments. They can also swim with sinuous movements. Nephtyids are important in the diet of demersal predatory fishes.

Plate 2-25 shows the photomicrograph of a representative from Family Nepthyidae.

Plate 2-25 Photomicrograph of a representative species from Family Nepthyidae observed in Navotas area, Manila Bayz during the sampling period

Another dominant benthic macroinvertebrates are representatives from Family Capitellidae. They are pollution tolerant polychaetes species. Thread-like sediment dwellers that live in unlined, rambling burrows and are considered to be relatively non-selective particle feeders. Capitellid worms are long, fragile, and difficult to collect intact. Locally very dense around organic effluent discharges. The Capitellidae found in many sediment types, often in high abundance, from the intertidal to the deep-sea. Most live in mucous-lined tubes or burrows (Blake 2000) and they are generally regarded as non-selective deposit feeders. There is evidence, however, that at least a few species may exhibit some selection of food material (Fauchald & Jumars 1979). Many species (for example the *Capitella capitata* species complex) are opportunistic and have been recommended in the past as indicator organisms for environmental disturbances such as pollution (Reish 1957, 1979; Grassle & Grassle 1974, 1976). Pearson & Rosenberg (1978) as well as Warren (1991) point out, however, that rich abundances of such opportunists as *C. capitata* may reflect high organic enrichment, regardless of its cause (in Dean, H.K., 2001).

Plate 2-26 shows the photomicrograph of a representative from Family Capitellidae.

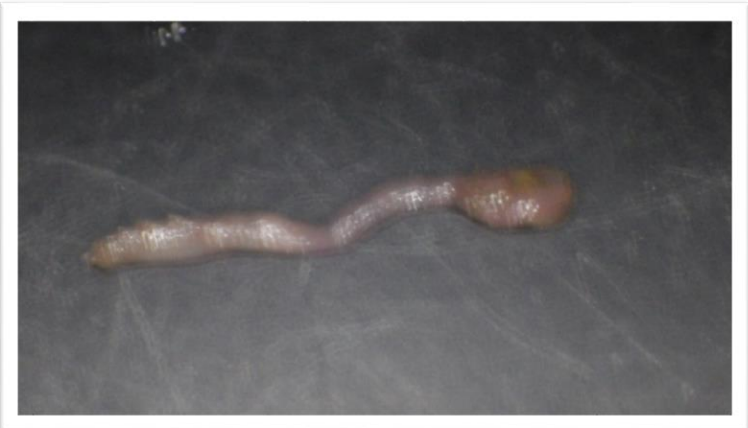


Plate 2-26 Photomicrograph of a representative species from Family Nepthyidae observed in Navotas area, Manila Bay during the sampling period

Photomicrographs of the other benthic macroinvertebrates observed in Manila Bay, Navotas City are shown in Plate 2-27 and Plate 2-28.


Rhynchocoela


Amphinomidae


Goniadidae


Glyceridae

Plate 2-27 Photomicrographs of other benthic macroinvertebrates observed in Navotas area, Manila Bay during the sampling period


Syllidae


Actiniaria


Veneridae


Cerithiidae

Plate 2-28 Photomicrographs of other benthic macroinvertebrates observed in Navotas area, Manila Bay during the sampling period

2.2.5.3 Potential impacts and options for prevention, mitigation or enhancement

Impact assessment

Expectedly, the key impacts of the proposed Reclamation Project in Navotas City on the marine ecosystems (i.e., shellfish, plankton and soft-bottom communities) would be the likely increase in sediment load of reclamation materials. Many of the organisms living in the top substrate (benthic macrofauna) are not able to tolerate the disturbance experienced during reclamation. These organisms would be adversely affected by the reclamation works as, unlike mobile species (e.g. fishes), they are unable to migrate from the site when the reclamation commences. Reclamation operations could have adverse impacts on both marine water quality and ecology unless otherwise controlled. As reported in *Environmental impacts of land reclamation: a case study of the proposed Lantau Port Development* (Chan et al, 2000), the following are the potential impacts in relation to water quality:

- Removal of habitat
- Entrainment of organisms during dredging
- Increased suspended sediment
- Increase level of nutrients
- Increased turbidity
- Depletion of dissolved oxygen

The potential impacts to marine ecological resources may arise during the reclamation. They may be derived from direct disturbance to the habitat and indirect disturbances through changes to key water quality parameters.

Direct impacts mainly come from habitat loss of areas proposed to be reclaimed at Manila Bay Navotas City area. According to the proposed reclamation works plan, potential habitat loss will occur by reclaiming areas of intertidal habitat of low ecological value and soft-bottom subtidal habitat of low ecological value.

If a carefully-designed silt management scheme would not be put in place, the adjacent coastal habitats could be adversely affected. The expected deterioration of the water quality particularly in the vicinity of the project site could impact on the composition and abundance of marine organisms. If such deterioration in coastal water quality would approximate the present condition then, the species composition and abundance of marine organisms might also significantly decrease. It is therefore strongly recommended that a well-designed silt-control scheme should be implemented to prevent silt and/or coarser sediment from being discharged into the coastal waters. In addition, silt-control measures, the existing stretch of should be protected and even enhanced to further mitigate the residual sediment load of the project.

Possible displacement of local fishermen from their traditional fishing grounds due to establishments of the reclamation area is considered as a potential issue in the implementation of this Project due to the consideration that Manila Bay is as a major fishing ground by local artisanal fisher folks.

In relation to the benefits of the reclamation to the ecology of Metro Manila, there is insufficient information on the direct and indirect effects of suspended sediment plume during reclamation on planktonic communities to judge assess with certainty the impacts on planktonic activities found in the site. The increased load of suspended solids would reduce light penetration which then reduce depth of photosynthetic activity by the phytoplankton. Also, high sediment loads would reduce the grazing success of zooplankton. However, it is important to note that increase in turbidity can be also cause by natural process such as storms or typhoons and turbulent waves during monsoons. Plankton communities are resilient and population could be replenished from other part of Manila Bay due to water circulation and current system.

For planktonic organisms, there is no direct benefit of reclamation on their ecology but the impacts are expected to be negligible and only for the duration of the construction. Although planktonic communities are episodically exposed turbid waters during bad weather or waves caused monsoon winds, they would be generally negatively affected by overflow of material released during reclamation activities. The overflow material released during infilling and the sediments disturbed during piling would increase the turbidity of the water column. This would subsequently result to low light penetration affecting photosynthetic activity of phytoplankton and thus affecting the primary production in the area. On the other hand, Zooplankton most from larval stages of benthic species and fishes are also generally adapted to episodic high levels of suspended sediments. In addition, they also have shorter life cycle and there are studies that showed that their recovery to stressful environmental conditions could be relatively quick (Clarke & Wilbur 2000).

In Manila Bay, elevated nutrient levels originate from sewage discharges, agricultural and aquaculture runoffs. Expanding urban area increased sewage discharges into the bay. Miller et al. (2011) studied these sources of nutrient in Manila Bay and the rivers discharging into it by isotopic analysis of nitrogen.

Manila Bay is considered to be highly eutrophicated (Chang et al., 2009), which may cause to hypoxia and have significant effects on the species composition.

Dissolved oxygen (DO) in the water column is vital for most marine organisms, hence low levels of DO is detrimental for these species. These low levels may be caused by decomposition of organic material, nitrification, and sediment oxygen demand as well as high levels of total organic carbon in surface sediments, and high nitrate and phosphate concentrations which instigate phytoplankton activity (Jacinto et al., 2011). The depletion of DO to levels below 2.8 mg/L is named as hypoxia. Studies in Manila Bay show that in general the DO levels are low near the bottom, highest levels being close to the mouth of the bay and lowest on the northwest (Chang et al., 2009).

Because of the present water quality condition in the Manila Bay Navotas Area, the proposed project will not affect the instruction of the Supreme Court "Continuing Mandamus" making the water of Manila Bay into 'SB classification".

Impact mitigation

The coral reefs, associated reef fishes and seagrasses in the impacted areas were absent. The water is turbid and the salinity is very low, which are the limiting factors for coral and seagrass growth. Layers of silt blanket the bottom substrate making it difficult for coral recruits and seagrass to settle and propagate. Furthermore, suspended silt reduces light penetration. This kind of environment is impossible for coral and other benthic to survive. There were no important species and habitats in the proposed project.

The following matrix shows the significant impacts and recommended mitigation for marine ecology (plankton and benthic macroinvertebrates (soft-bottom fauna) communities).

Key Impacts	Recommended Mitigation
Pre-construction phase	
Pre-construction activities will not cause any environmental impact to the aquatic flora and fauna of the direct, primary and regional impact zones.	
Reclamation phase	
***Potential oil contamination of the water bodies*.** Maintenance of heavy equipment/vehicles generate oil and oily wastewater. Oil Could leak from heavy equipment machinery and trucks/vehicles used at the project site. Accidental, but substantial, oil spill from the used oil storage facility could cause formation of thin film of oil on water surface. This film could inhibit gaseous exchange between lifeforms in the water and the atmosphere. Ingestion of oil may also have short and long-term effects on certain marine species of fishes and benthic macrofauna. Oil can clog gills and suffocate fish. Oil coated phytoplankton and macrophytes may not be able to obtain energy from the sun for photosynthesis. Oil can kill plankton/ larva. Some oil can be consumed by plankton and larva and can be transferred through the food chain to kill juvenile fish. The presence of oils in the sea water could create adverse effects on alga, microproducers and benthic fauna, depending on the extent, frequency and duration of contamination.	The project shall be equipped with oil-water separator to remove oil from effluents prior to discharge to the water bodies.
***Potential increase in turbidity of water bodies*.** Unmanaged spoils/earthworks can contribute to turbidity of the river system. This can affect or harm the aquatic flora/fauna in the water bodies.	The Contractor will be required to comply with the Company's TOR, which include among others, the Civil Works Guidelines. This will ensure proper management of spoils and will prevent/minimize sedimentation and water pollution around the construction site. Construction of sediment/settling pond(s) and related structure(s) would mitigate massive siltation/sedimentation of the water bodies. Application of other appropriate BMPs to protect the easements of the water bodies.
Post Reclamation Decommissioning phase	
Potential oil contamination of the water bodies.	Strict implementation of corporate good housekeeping and safety procedures.
Potential increase in turbidity of water bodies.	Strict implementation of corporate good housekeeping and safety procedures.
Operation phase	

Key Impacts	Recommended Mitigation
Potential increase in turbidity of water bodies.	Strict implementation of corporate good housekeeping and safety procedures.
Potential oil contamination of the water bodies.	Strict implementation of corporate good housekeeping and safety procedures. Proper handling, storage and disposal of used/waste oil will be implemented.
Possible displacement of local fishers	Provision of livelihood assistance, All fish corals "baklad" in the impacted zone should be paid and provision of fishers with other fishing gears (e.g., motorized boat, fishing nets), Involvement of fishers in the project with incentives/honorarium Provision of scholarship for the fishers' children.
Potential contamination of the water bodies by toxic chemicals. Release of toxic chemicals into the water bodies could cause fishkills and deaths of other aquatic organisms.	Strict implementation of corporate good housekeeping and safety procedures.

2.3 Air

2.3.1 Meteorology

This section presents the following requirements in the standard Technical Scoping Checklist.

- Climatological normal and extreme values of rainfall, temperature, and prevailing winds at two (2) PAGASA's synoptic stations in the vicinity of the project site;
- Impact of the project in terms of change in local climate (e.g., local temperature);
- Medium to long term climate change projections at the region where the proposed project is located; and
- Projected greenhouse gas (GHG) emissions of the project and corresponding mitigation and/or sequestration measures.

2.3.1.1 Methodology

2.3.1.1.1 Climatological normal, extremes and projected climate

Climatological normal and extreme values from two (2) synoptic stations of PAGASA, namely: Port Area, Manila, and Sangley Point, Cavite, were used to characterize the long-term meteorological conditions of the project site (Figure 2-119). Normal values at the two (2) stations (Port Area and Sangley Point) were interpolated to determine the projected climate values at the proposed project site.

In addition, three-hourly data for the months of August, 2015, February 2016, and April 2016 from the above-mentioned synoptic stations representing the southwest, northeast, and northeast to transition seasons, respectively, were also processed to determine and compare meteorological conditions at both stations. The three-hourly meteorological data were also used to generate the meteorological input data files needed in the oceanographic modeling using the Environmental Fluid Dynamics Code (EFDC) model.

In terms of climate change projections, projected climate data in the NCR by PAGASA (2011) were used to discussed the projected changes of rainfall, air temperature, and extreme weather events from 2006 to 2035 (centered in 2020) and from 2036 to 2065 (centered in 2050).

2.3.1.1.2 Greenhouse gas emissions (GHG)

GHG emissions were estimated from the type of equipment to be used during project construction. Using the estimated annual fuel consumptions of the reclamation equipment, GHG emissions were then determined using the GHG calculation tools of the World Research Institute (WRI).

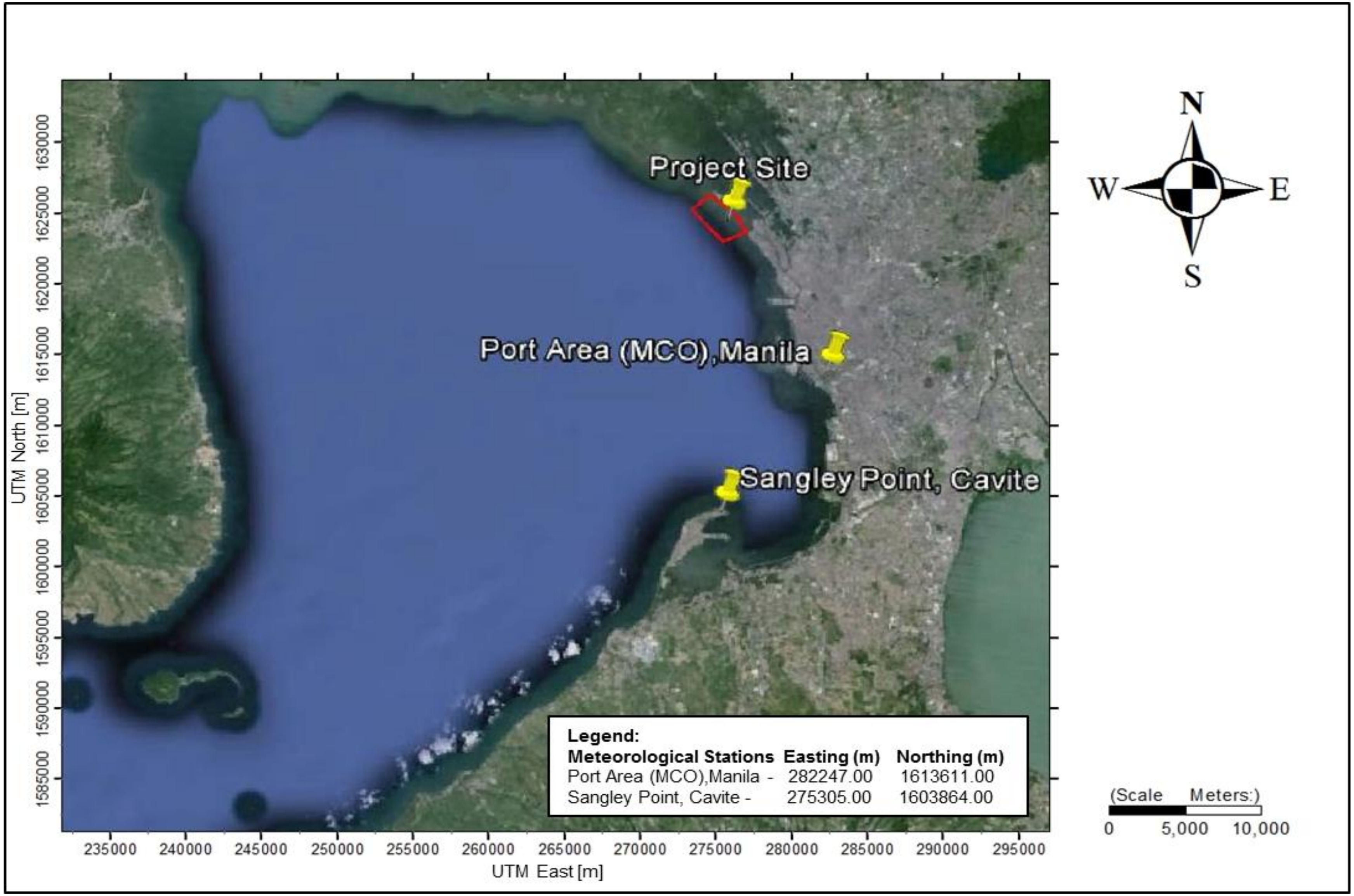


Figure 2-119 Locations of PAGASA-Port Area and Sangley Point Stations

2.3.1.2 Baseline information

2.3.1.2.1 Climate

The proposed project site belongs to an area zoned as Type 1 climate (Figure 2-120). This type of climate is characterized by two (2) pronounced seasons, which are dry from November to April and wet during the rest of the year (PAGASA 2015). High rainfall is expected during the southwest monsoon season that normally occurs in the Philippines from June to September. PAGASA-Port Area and Sangley Point Stations are located in an area zoned as Type 1 climate.

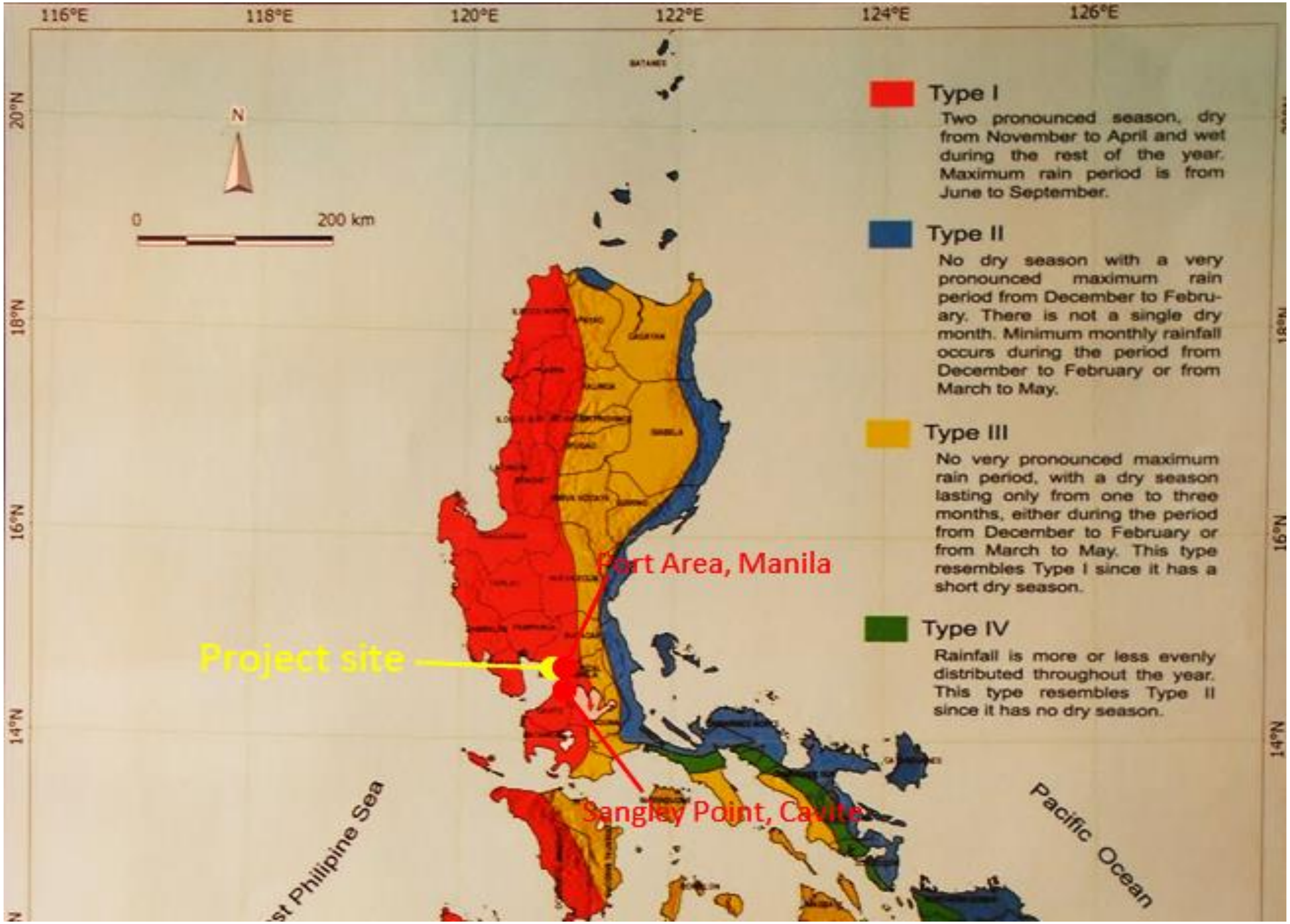


Figure 2-120 Climate map of the Philippines showing the project site and PAGASA Port Area and Sangley Point stations, 1951-2010

2.3.1.2.2 Rainfall

Based on the climatological normal values at PAGASA-Port Area and Sangley Point (Table 2-40 and Table 2-41), rainfall patterns in the project area follow closely with those of the two (2) aforementioned synoptic stations (Figure 2-121). As the proposed project area belongs to Type 1 climate, high rainfall is expected during wet season or southwest monsoon season, which occurred from June to September. August has the highest monthly average rainfall followed by July and September. Months with less rainfall are January, February and March. These months are within the northeast monsoon season that is characterized by colder and less humid air.

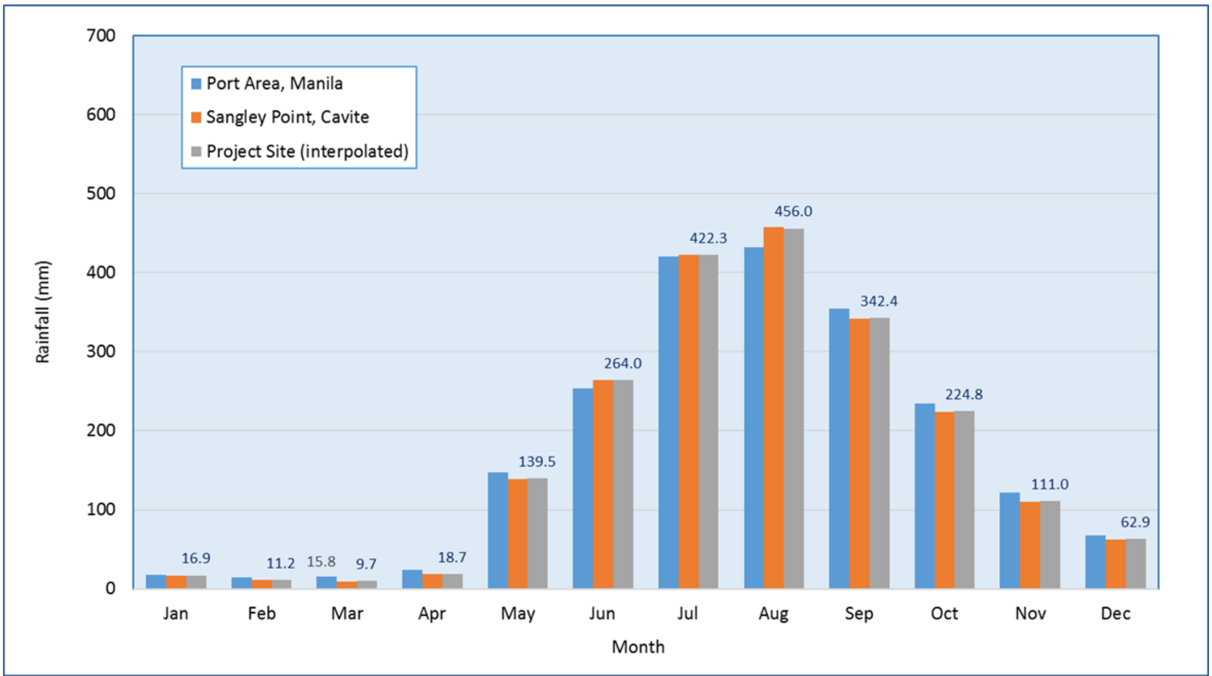


Figure 2-121 Monthly average rainfall and number of rainy days at PAGASA-Port Area Station, PAGASA-Sangley Point Station, and project site

Projected rainfall in 2020 and 2050

Figure 2-122 shows the projected amount of rainfall in the National Capital Region (NCR) in 2020 and 2050. The projected decrease and increase of rainfall in the NCR during dry and wet seasons, respectively, resembled with the projected trends in the Philippines in 2020 and 2050. Rainfall appears to decrease during the dry months (December to February and from March to May), but tend to increase during the southwest monsoon (June to August) and with slight increase from September to November (Figure 2-122).

Extreme recorded rainfall events

Based on the rainfall records at PAGASA-Sangley Point Station from 1974 to 2015 (Table 2-42) and PAGASA-Port Area Station from 1865 to 2015 (Table 2-43), the highest recorded daily rainfall at both stations was 475.4 mm on August 19, 2013 at PAGASA-Sangley Point Station (Figure 2-123). This occurred during the passage of Tropical Storm Maring (International codename Trami), which enhanced the southwest monsoon in the Philippines. At PAGASA-Port Area Station, the highest recorded rainfall from 1986 to 2005 was 403.1 mm on September 1, 1970.

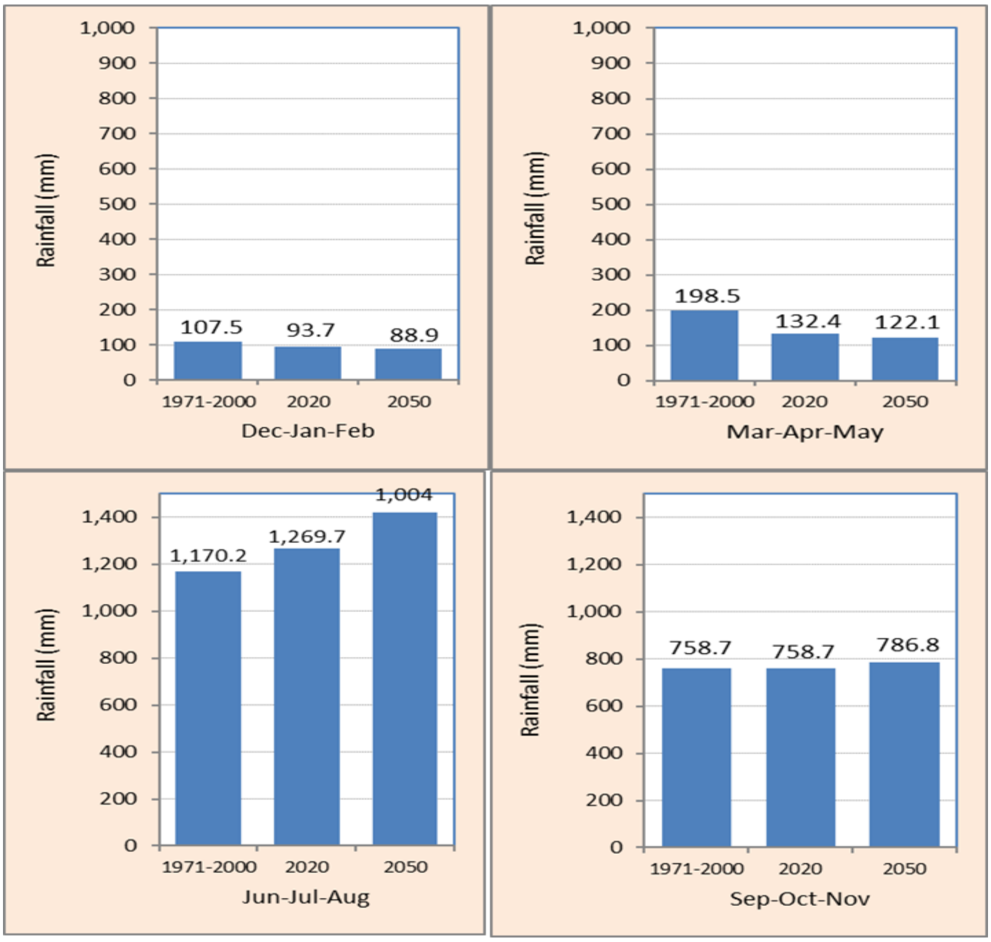


Figure 2-122 Projected change of rainfall in the National Capital Region (NCR) in 2020 and 2050

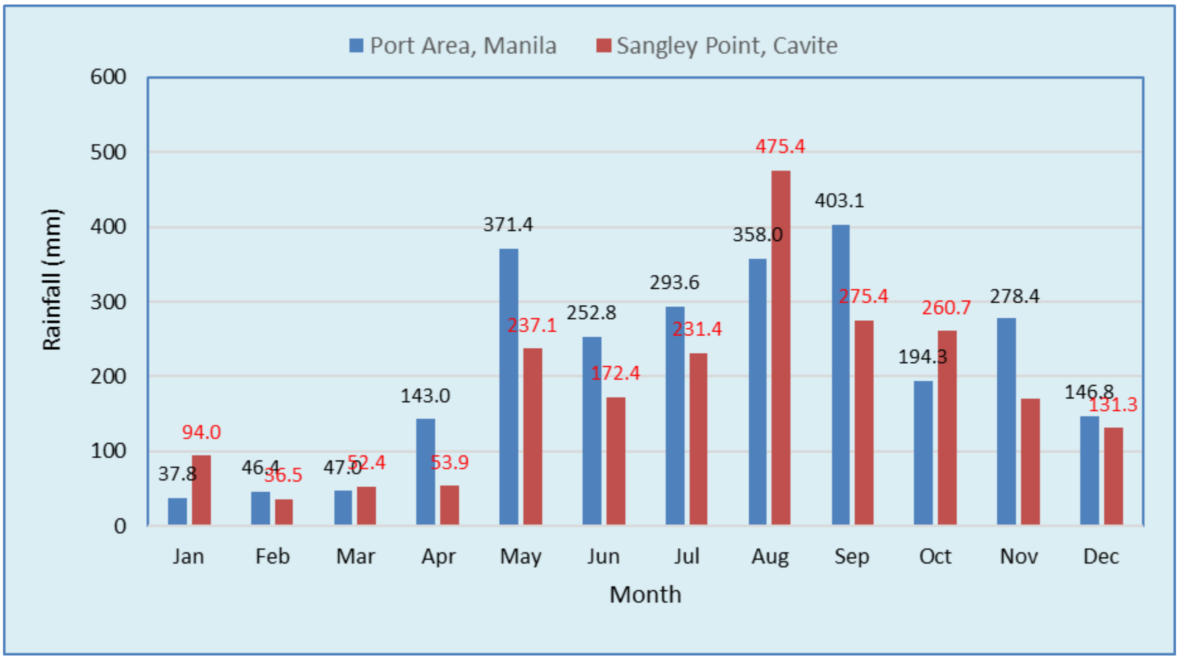


Figure 2-123 Plot of extreme recorded daily rainfall in each month
Source: PAGASA Port Area and PAGASA-Sangley Point, Cavite

Table 2-40 Climatological Normals of PAGASA-Port Area, Manila (1981-2010)

Month	Rainfall			Temperature (°C)					Vapor Pressure (mbar)	%RH	MLSP (mbar)	Wind		Cloud Amt. (okta)	No. of Days	
	Amount (mm)	No. of Rainy Days	Max	Min	Mean	Dry Bulb	Wet Bulb	Dew Pt.				Direction (16pt)	Speed (m/s)		TSTM	LTNG
JAN	17.3	4	29.6	23.8	26.7	26.7	22.9	21.4	25.3	72	1012.6	N	2	7	0	0
FEB	14.2	3	30.6	24.2	27.4	27.4	22.9	21.2	24.9	69	1012.4	E	3	6	0	0
MAR	15.8	3	32.1	25.3	28.7	28.5	23.7	21.9	26	67	1011.7	SE	3	6	0	1
APR	23.7	4	33.5	26.6	30.1	30	24.9	23.1	28	66	1010.2	SE	3	6	2	2
MAY	147.2	10	33.2	26.9	30	30	25.7	24.3	30	71	1008.6	SW	3	6	9	9
JUN	253.5	17	32.2	26.4	29.3	29.3	25.8	24.6	30.8	76	1008.1	SW	3	7	11	9
JUL	420.5	21	31.2	25.9	28.5	28.5	25.6	24.6	30.8	79	1007.7	SW	3	7	12	9
AUG	432.4	21	30.8	25.8	28.3	28.2	25.6	24.7	31	81	1007.3	SW	4	7	11	7
SEP	355.1	20	31	25.7	28.4	28.3	25.5	24.6	30.7	80	1008.2	SW	3	7	12	8
OCT	234.8	17	31.1	25.7	28.4	28.3	25.2	24.1	29.9	78	1009	SW	3	7	7	6
NOV	121.7	12	30.9	25.1	28	28	24.5	23.2	28.3	75	1010.1	N	3	7	3	1
DEC	67.4	7	29.8	24.2	27	27	23.4	22	26.3	74	1011.8	N	2	7	1	0
Annual	2103.6	139	31.3	25.5	28.4	24.6	24.6	23.3	28.5	74	1009.8	SW	3	7	68	52

Source: Climate and Agrometeorology Division, PAGASA

Latitude: 14°35’13.10” N
Longitude: 120°58’43.44” E
Elevation: 15.0 m

Notes:

VP – Vapor Pressure
mbs – millibar
MSLP – mean sea level pressure
Dir – direction
TSTM – thunderstorm
LTNG – lightning

Table 2-41 Climatological Normals for PAGASA-Sangley Point, Cavite (1981 to 2010)

Month	Rainfall (mm)	No of rainy days	Temperature(°C)						VP (mbs)	RH (%)	MSLP (mbs)	Wind (m/s)		Clouds (Okta)	No. of days With	
			Max	Min	Mean	Dry Bulb	Wet Bulb	Dew Pt.				Dir.	Speed		TSTM	LTNG
Jan	16.9	4	30	23.3	26.6	26.8	23.9	22.8	27.7	79	1012.5	ESE	3	5	0	0
Feb	11.1	2	30.8	23.6	27.2	27.4	24.1	22.9	27.7	76	1012.7	ESE	3	5	0	0
Mar	9.4	2	32.7	24.6	28.6	28.7	25	23.7	29.1	74	1012.1	ESE	3	4	1	1
Apr	18.5	2	34.4	25.9	30.1	30.3	26	24.6	30.6	71	1010.5	ESE	3	4	2	5
May	139.1	10	34.1	26.1	30.1	30.3	26.5	25.3	32	74	1008.8	ESE	3	5	11	16
Jun	264.5	15	32.8	25.8	29.3	29.5	26.4	25.4	32.3	78	1008.4	ESE	3	6	14	18
Jul	422.4	20	31.7	25.3	28.5	28.6	26	25.1	31.8	81	1008	W	3	6	16	17
Aug	457.2	21	31.3	25.2	28.3	28.2	25.8	25	31.5	83	1007.6	SW	3	7	13	14
Sept	341.8	19	31.4	25.2	28.3	28.4	25.9	25.1	31.7	82	1008.4	W	3	6	15	16
Oct	224.3	15	31.4	25.3	28.4	28.4	25.8	24.9	31.4	81	1009.3	ESE	3	6	9	14
Nov	110.5	11	31.1	25	28.1	28.1	25.3	24.3	30.3	80	1010.4	ESE	3	6	4	5
Dec	62.7	7	30	23.9	27	27.1	24.3	23.3	28.4	79	1011.9	ESE	3	5	1	1
Annual	2078.4	127	31.8	24.9	28.4	28.5	25.4	24.4	30.4	78	1010.1	ESE	3	5	86	107

Source: Climate and Agrometeorology Division, PAGASA

Notes:

VP – Vapor Pressure
mbs – millibar
MSLP – mean sea level pressure
Dir – direction
TSTM – thunderstorm
LTNG – lightning

Table 2-42 Climatological Extremes for PAGASA-Port Area, Manila (as of 2015)

MONTH	TEMPERATURE (°C)				GREATEST DAILY RAINFALL (mm)		HIGHEST WIND (m/s)			SEA LEVEL PRESSURE			
	HIGH	DATE	LOW	DATE	AMT.	DATE	SPD	DIR	DATE	HIGH	DATE	LOW	DATE
JAN	36.5	01-30-1984	14.5	01-11-1914	37.8	01-08-1955	18	E	01-15-1987	1022.4	01-09-1914	1003.3	01-05-1999
FEB	35.6	02-25-1906	15.6	02-18-1920	46.4	02-03-1986	25	SE	02-26-1962	1021.4	12-01-1962	1002.7	02-18-1998
MAR	36.8	03-23-1966	16.2	03-10-1911	47.0	03-25-2009	27	SSE	03-16-1962	1020.5	03-30-1958	997.3	03-27-1991
APR	38.0	04-30-1915	17.2	04-02-1923	143.0	04-29-1905	24	WSW	04-18-1962	1018.8	04-01-1958	998.1	04-29-1905
MAY	38.6	05-17-1915	20.0	05-01-1921	371.4	05-19-1976	35	E	05-17-1989	1015.9	05-09-1937	987.4	05-23-1964
JUN	37.6	06-04-1912	20.1	06-04-1973	252.8	06-27-1985	47	SW	06-29-1964	1021.6	06-28-1993	974.6	06-29-1964
JUL	36.5	07-02-1973	19.4	07-14-1970	293.6	07-29-1919	31	WSW	07-24-1968	1014.9	07-29-1987	990.7	07-16-2014
AUG	35.6	08-09-1964	18.0	08-14-1974	358.0	08-07-2012	34	S	08-04-1989	1015.2	08-12-1958	990.8	08-31-1920
SEP	35.3	09-18-1903	20.2	09-02-1970	403.1	09-01-1970	34	SW	09-13-1961	1015.2	09-20-1965	986.7	09-27-1906
OCT	35.8	10-01-1968	19.5	10-26-1913	194.3	10-15-1918	41	W	10-26-1978	1017.0	10-28-1960	977.9	10-14-1970
NOV	35.6	11-04-1966	16.8	11-03-1911	278.4	11-18-1923	56	WNW	11-19-1970	1019.0	11-29-1985	966.5	11-19-1970
DEC	34.6	12-14-1947	15.7	12-03-1992	146.8	12-15-2015	41	W	12-14-1964	1020.9	12-08-1960	97.1	12-26-1947
Annual	38.6	05-17-1915	14.5	01-11-1914	403.1	09-01-1970	56	WNW	11-19-1970	1022.4	01-09-1914	966.5	11-19-1970
Period of Record	1885-2015				1865-2015		1948-2015			1885-2015			

Source: Climate and Agrometeorology Division, PAGASA

Table 2-43 Climatological Extremes for PAGASA-Sangley Point, Cavite (as of 2015)

MONTH	TEMPERATURE (°C)				GREATEST DAILY RAINFALL (mm)		HIGHEST WIND (m/s)			SEA LEVEL PRESSURE			
	HIGH	DATE	LOW	DATE	AMT.	DATE	SPD	DIR	DATE	HIGH	DATE	LOW	DATE
JAN	34.8	01-25-1999	19.0	01-03-1982	94.0	01-12-1977	17	ESE	01-19-2010	1023.4	01-16-1999	1001.9	01-31-2001
FEB	35.2	02-28-1998	18.0	02-01-1982	36.5	02-27-2012	15	ESE	02-27-1992	1019.9	02-03-1993	1005.4	02-21-2001
MAR	36.6	03-29-1981	19.1	03-25-1980	52.4	03-22-2013	24	ESE	03-23-1998	1020.5	03-05-2005	1003.9	03-06-1999
APR	37.8	04-07-1983	21.5	04-03-2007	53.9	04-24-1975	16	ESE	04-05-1996	1017.5	04-14-1993	1002.0	04-30-1988
MAY	38.5	05-16-1987	22.0	05-15-1980	237.1	05-26-1997	27	SW	05-22-1976	1015.5	05-25-1983	993.4	05-22-1976
JUN	38.4	06-04-1987	22.0	06-16-1981	172.4	06-27-1985	25	SE	06-08-2011	1014.3	06-08-1997	997.6	06-28-2004
JUL	36.3	07-25-2007	21.2	07-15-1982	231.4	07-20-2002	54	E	07-13-2010	1013.8	07-29-1983	986.1	07-15-2014
AUG	36.5	08-16-2009	22.0	08-02-1994	475.4	08-19-2013	30	W	08-18-1990	1014.5	08-13-2005	998.1	08-17-1990
SEP	35.6	09-02-1996	21.0	09-16-1979	275.4	09-22-2013	44	NNW	09-28-2006	1015.6	09-18-2005	984.3	09-28-2006
OCT	35.8	10-08-1996	21.0	10-24-1988	260.7	10-05-1986	45	NW	10-21-1994	1016.4	10-27-1993	990.3	10-21-1994
NOV	36.4	11-08-1978	21.5	11-26-1982	171.2	11-02-2000	49	NW	11-03-1995	1017.5	11-30-1989	977.0	11-03-1995
DEC	34.0	10-06-1998	20.0	12-24-1985	131.3	12-10-2006	22	NNW	12-05-1993	1019.1	12-31-1992	997.9	12-02-2004
Annual	38.5	05-16-1987	18.0	02-01-1982	475.4	08-19-2013	54	E	07-13-2010	1023.4	01-16-1999	997.0	11-03-1995
Period of Record	1974-2015				1974-2015		1974-2015			1974-2015			

Source: Climate and Agrometeorology Division, PAGASA

Projected extreme rainfall events

The projected extreme weather events in 2020 and 2050 were simulated by PAGASA (2011) based on a) increase or decrease of the number of dry days, which is defined as days with rainfall equal or less than 2.5 mm/day, and b) increase or decrease of days with rainfall greater than 200 mm. The projected extreme weather events were reckoned from the baseline years (1971 to 2000).

At the NCR where the proposed project site is located, there would be decreased of dry days from the baseline years (1971 to 2000) of 7380 days to 6455 days (2006 to 2036) and 6382 days (2036 to 2065) (Figure 2-124) in 2020 and 2050, respectively. In terms of rainfall greater than 200 mm, there would be slight increase in rainfall from 2036 to 2065 (centered at 2050). From 2006 to 2035 (centered in 2020), it appears that there would be no increased on days with rainfall greater than 200 m as compared to the baseline year (1971 to 2000).

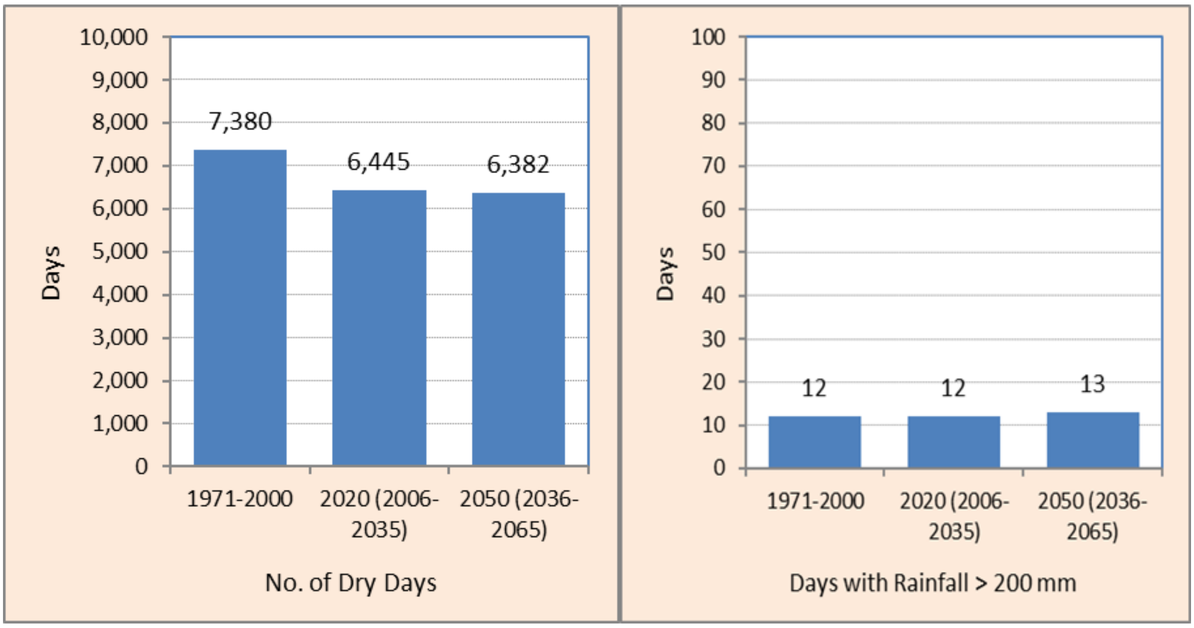


Figure 2-124 Projected number of dry days with rainfall greater than 200 mm in the NCR

2.3.1.2.3 <u>Ambient air temperature</u>

Figure 2-125 shows the plot of the monthly average air temperatures at PAGASA-Sangley Point and Port Area Stations. High temperatures are expected in dry season in April and May. On the contrary, December and January are the coldest months when northeast winds brought colder and less humid air from higher latitudes.

The differences on air temperature could be due to difference on elevations of the aforementioned stations, with PAGASA Port Area Station at relatively higher elevation (about 15 m) than PAGASA-Sangley Point Station (at 3 m).

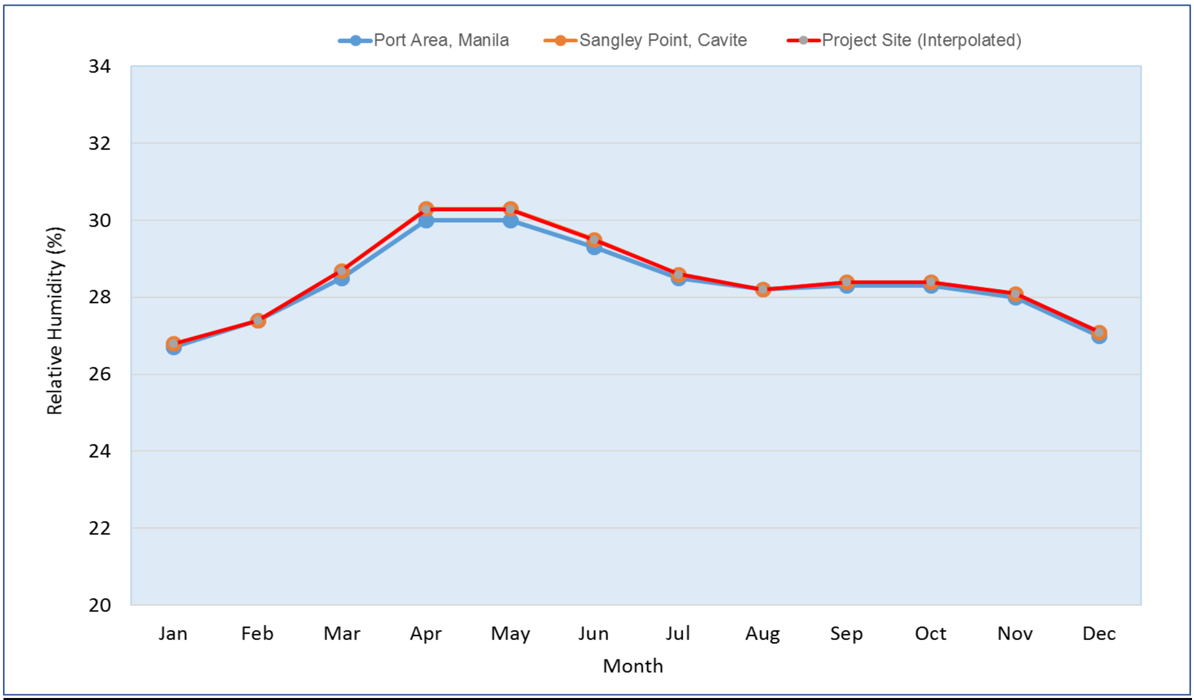


Figure 2-125 Average air temperatures at PAGASA-Port Area, Manila and Sangley Point, Cavite

Projected temperature in 2020 and 2050

Figure 2-126 shows the projected air temperatures in the NCR in 2020 and 2050. It appears that there would be increased of ambient air temperature in all months of the year as reckoned from the baseline years (1971 to 2000). The highest increase on ambient air temperature would be during the dry season (about 1 to 1.1ºC) and from 0.9 to 1.0ºC in the wet season. PAGASA (2011) noted that increases of ambient air temperature in 2020 and 2050 in the Philippines were generally due to increase of GHG emissions as modelled using increase of GHG at medium-case scenario.

Extreme temperature events

Based on historical records of air temperature at PAGASA-Sangley Point from 1974 to 2015 and at PAGASA- Port Area from 1885 to 2015 (please refer Table 2-42 and Table 2-43 and Figure 2-127), Sangley Point, Cavite recorded extreme temperature of 38.5ºC on May 16, 1987 followed by 38.4ºC on June 4, 1987. At PAGASA-Port Area Station, the highest recorded air temperature was 38.6ºC on May 17, 1915 followed by 38ºC on April 30, 1915.

In terms of lowest recorded ambient air temperatures, PAGASA-Port Area Station recorded the lowest at 14.5ºC on January 11, 1914 and PAGASA-Sangley Point at 18ºC on February 1, 1982.

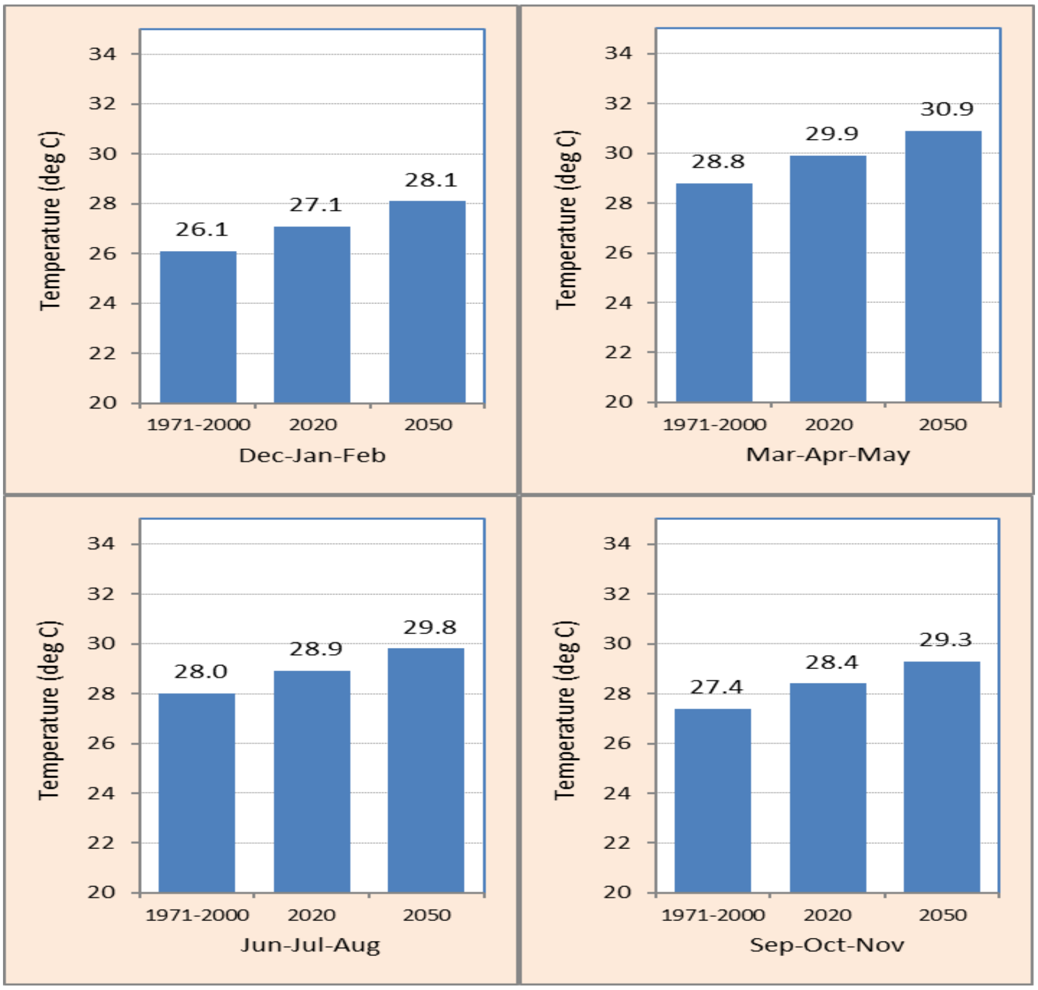


Figure 2-126 Projected change in temperatures in 2020 and 2050 in the NCR

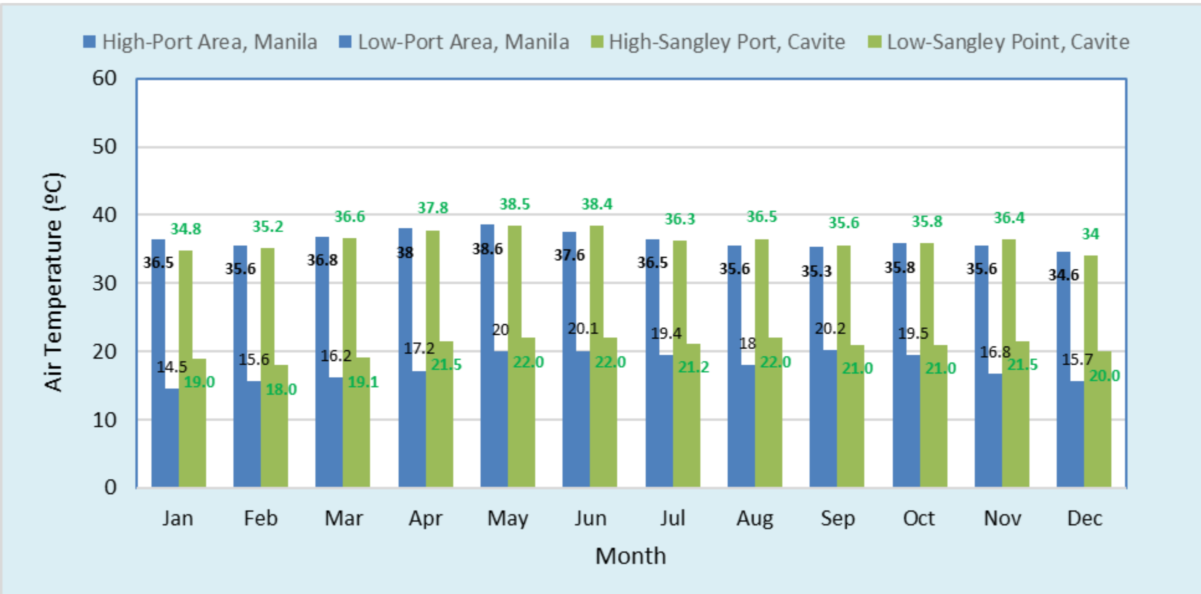


Figure 2-127 Monthly highest and lowest recorded temperatures at PAGASA-Port Area, Manila and PAGASA- Sangley Point, Cavite

Projected extreme temperature events

In the NCR, days with air temperatures greater than 35ºC are expected to increase by 1,176 and 2,118 days from 2006 to 2035 (centered in 2020) and from 2036 to 2065 (centered in 2050) as compared to the baseline years (1971 to 2000) (Figure 2-128). The projected increase of extreme temperature events could be associated with the increase of air temperatures due to increase in GHG emissions under medium-case scenario.

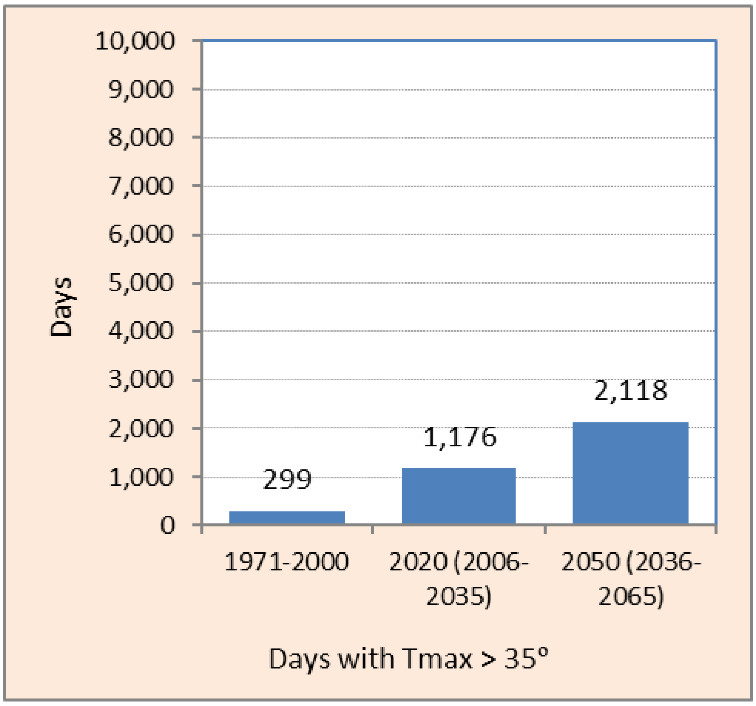


Figure 2-128 Projected number of days greater than 35°C in the NCR

2.3.1.2.4 Wind speeds and wind directions

Figure 2-129 and Figure 2-130 show the annual and monthly wind roses for PAGASA-Port Area and Sangley Point Stations, specifically the wind roses when monsoon winds are its peak; that is, January and February for the northeast monsoon and August to September for the southwest monsoon). In addition, prevailing wind speeds and directions were extracted from the climatological normal averages from 1981 to 2010, as shown in Table 2-44).

The annual wind roses at both stations (Port Area and Sangley Point) showed varying (Figure 2-129) dominant wind flows (At PAGASA-Port Area Station, the annual wind rose shows prevailing southwest and east winds with relatively lower frequencies of wind flows from the north, east, and southeast. At PAGASA-Sangley Point, dominant winds are from the southwest, followed by east and southwest and north directions. Presence of structures in the vicinities of the above-mentioned synoptic stations and relative locations of both stations with Manila Bay could alter the prevailing wind northeast and southwest winds in the Philippines.

In January and February when the northeast monsoon is usually at its peak (Figure 2-129), prevailing winds at PAGASA-Port Area Station are from the north, east and west directions while at PAGASA-Sangle Point from east-southeast and east directions. During southwest monsoon, winds coming from the southwest and west directions prevail at both stations (Port Area and Sangley Point). During transition from southwest to northeast monsoon in November, both stations (Port Area and Sangley Point) show prevailing winds from the north, although east-southeast winds prevail at PAGASA-Sangley Point Station (Figure 2-130).

Wind speeds at both stations (Port Area and Sangley Point) show average of 3 m/s with Sangley Point generally showing consistent monthly average wind speeds through the year (Table 2-44). At PAGASA-Port Area Station, however, wind speeds in August tend to increase to 4 m/s when southwest monsoon is at its peak, and decrease to 2 m/s in December and January during northeast monsoon.

Table 2-44 Climatological monthly average wind speed and directions at PAGASA-Port Area, Manila, and PAGASA-Sangley Point, Cavite (1981 to 2010)

Month	Port Area, Manila		Sangley Point, Cavite	
	Wind Direction	Wind Speed (m/s)	Wind Direction	Wind Speed (m/s)
January	N	2	ESE	3
February	E	3	ESE	3
March	SE	3	ESE	3
April	SE	3	ESE	3
May	SW	3	ESE	3
June	SW	3	ESE	3
July	SW	3	W	3
August	SW	4	SW	3
September	SW	3	W	3
October	SW	3	ESE	3
November	N	3	ESE	3
December	N	2	ESE	3
Annual	**SW**	**3**	**ESE**	**3**

Extreme recorded winds

The proposed project site is located in a zone wherein about five (5) tropical cyclones pass over the area in 3 years (Figure 2-131). The highest monthly recorded wind speeds at PAGASA-Port Area and Sangley Point Stations vary from 18 to 56 m/s and 15 to 56 m/s, respectively. The greatest wind speeds were recorded at said synoptic stations on the following dates:

- Port Area, Manila – 56 m/s (201.6 km/h) on November 19, 1970; and
- Sangley Point, Cavite – 54 m/s (195.4 km/h) on July 13, 2010

Greatest recorded wind speeds at both stations were due to passage Typhoon Yoling in November 19, 1970 and Typhoon Basyang in July 13, 2010. Based on the new tropical cyclone category of PAGASA, the foregoing greatest recorded wind speeds are within category, Typhoon, with maximum wind speed of 188 to 220 km/h. Maximum wind speeds exceeding 220 km/h are categorized under Super Typhoon.

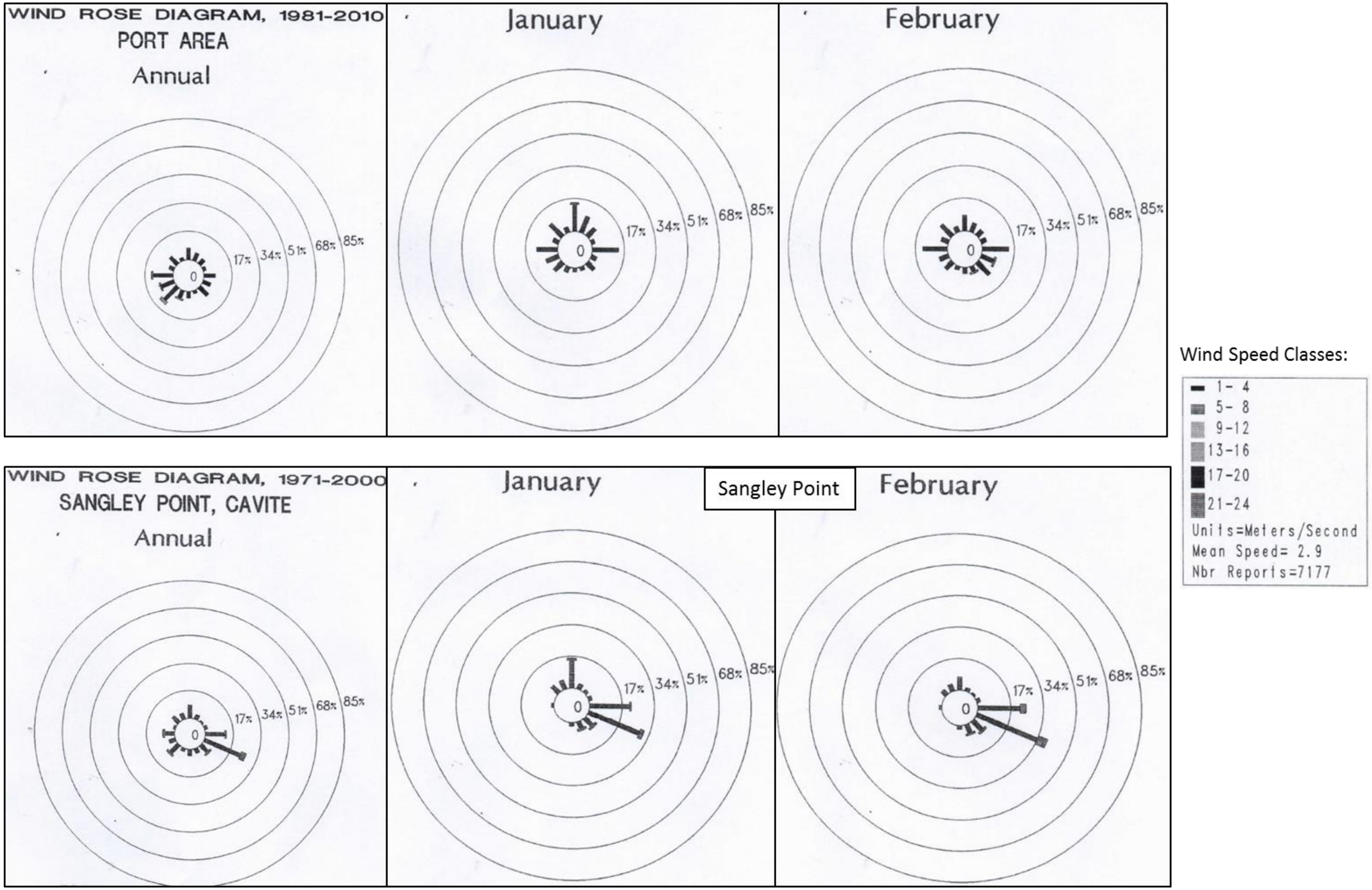


Figure 2-129 Annual January and February wind roses for Port Area, Manila and Sangley Point, Cavite
(Source: PAGASA Wind Rose Diagrams from Port Area and Sangley Point Synoptic Stations, 1981-2010)

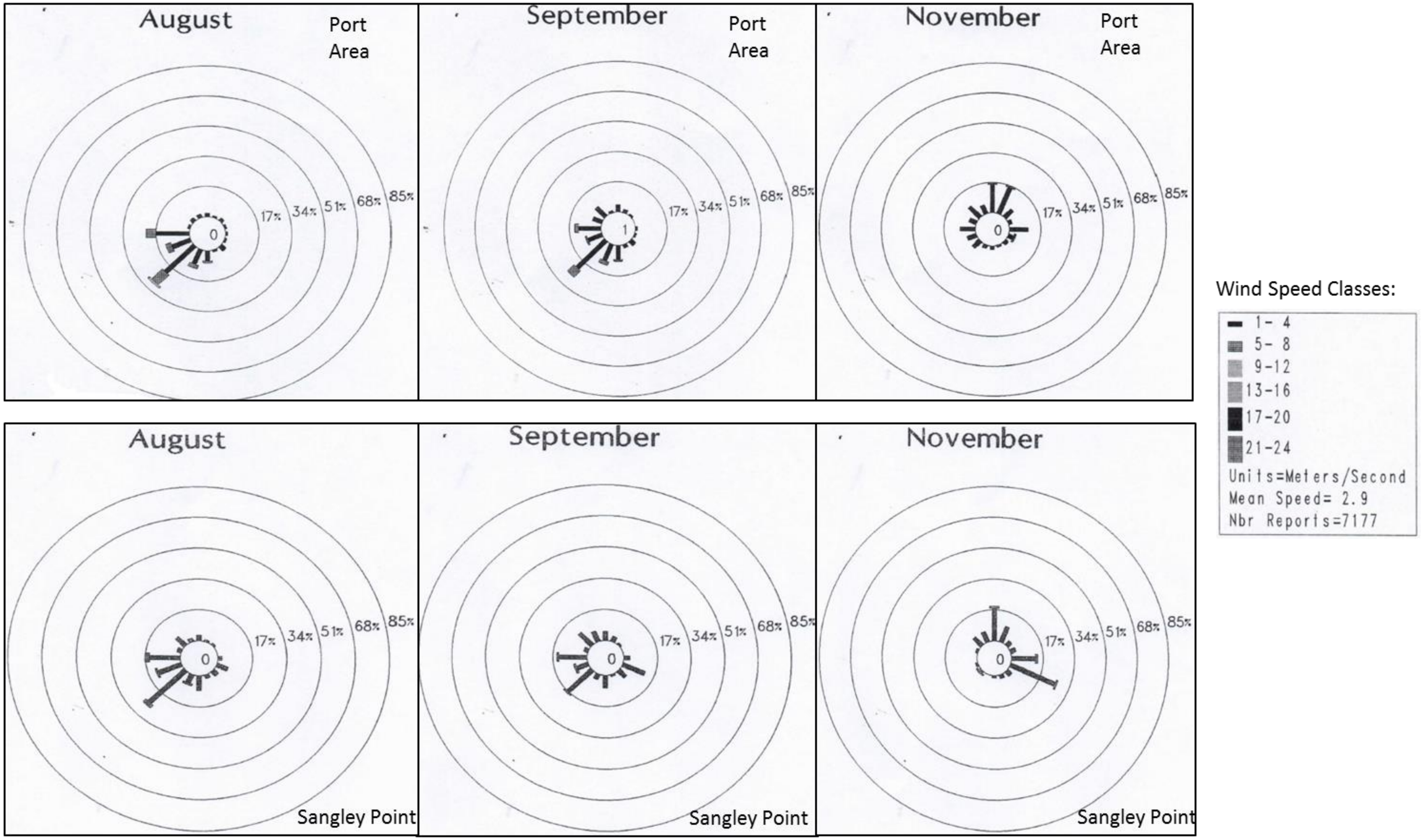


Figure 2-130 August, September, and November wind roses for Port Area, Manila and Sangley Point, Cavite
(Source: PAGASA Wind Rose Diagrams from Port Area and Sangley Point Synoptic Stations, 1981-2010)

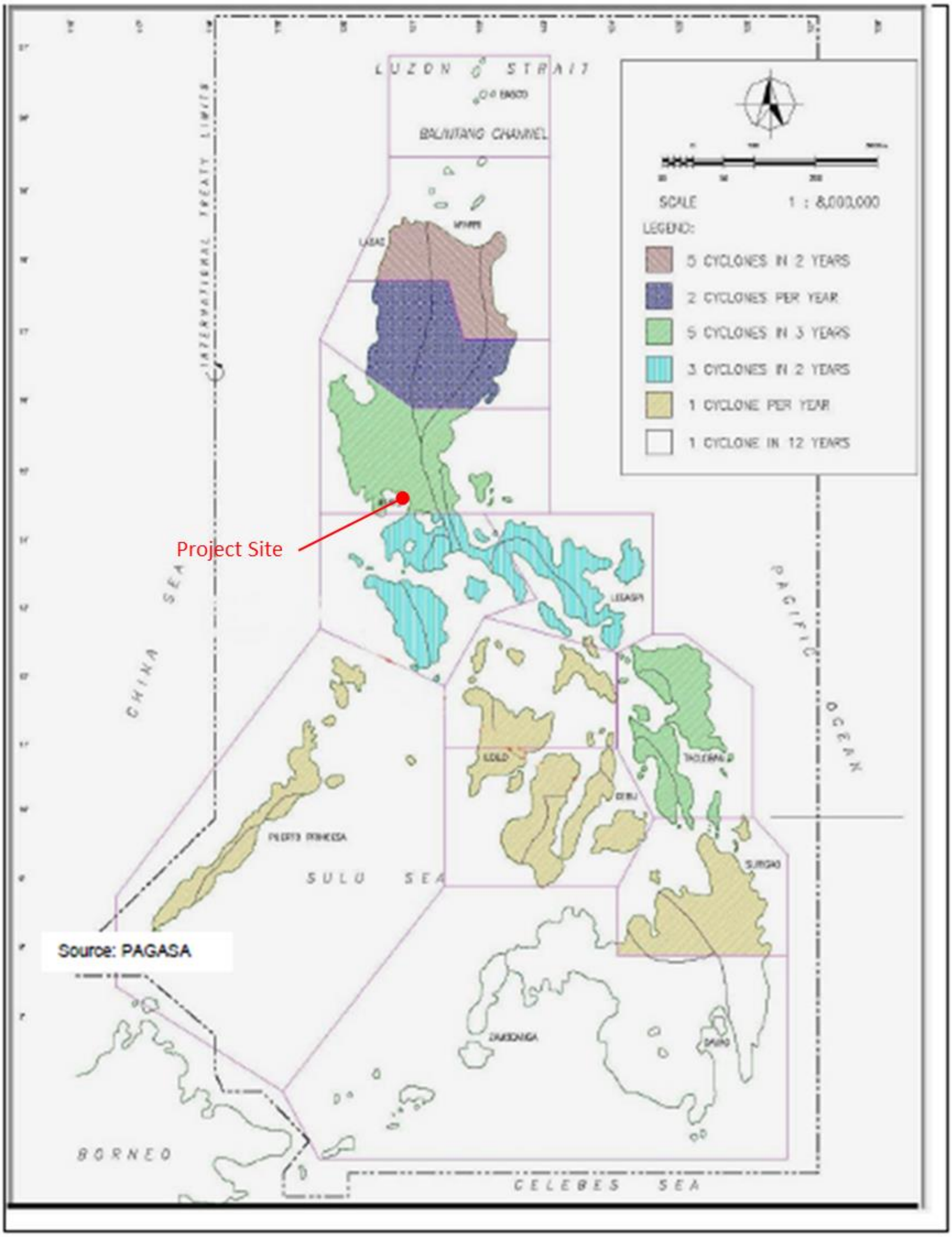


Figure 2-131 Typhoon frequency map
Source: EPRMP PGPP II (2011)

2.3.2 Air quality

2.3.2.1 Methodology

Berkman Systems, Inc. (BSI), a third-party environmental service provider, was commissioned by RHR Consult Services, Inc. (RHR) to conduct baseline ambient monitoring of Total Suspended Particulates (TSP), Particulate Matter less than 10 µm (PM_{10}), Sulfur Dioxide (SO_2), and Nitrogen Dioxide (NO_2). Baseline monitoring was conducted at five (5) locations shown in Figure 2-132. Table 2-45 shows the coordinates (in WGS84 UTM) and the elevations of the air sampling stations.

Table 2-45 Coordinates and elevations of the air sampling stations

Station ID	Location	Easting (m)	Northing (m)	Elevation amsl (m)
1	Navotas Pier, Navotas Masipag & Gasak Ext. at the back of Tanza Elementary School	279018.34	1621423.36	6
2	Navotas City Hall Park	278367.70	1622182.46	3
3	Near Bagong Silang St. corner A. Pascual, Navotas City	277490.85	1623761.71	4
4	Obando Church, Bulacan	277830.17	1627293.10	6
5	Balawas Rd., Brgy. Lawa near Emong Malunggay Pandesal	276820.34	1628829.36	4

*amsl – above mean sea level

The methods of air sampling and analysis were in accordance with the prescribed methods in the Philippine Clean Air Act (PCAA) of 1999 and its implementing rules and regulations (DAO 2000-81). Table 2-46 presents the air pollutants and the corresponding methods of sampling and analysis.

Table 2-46 Sampling and analytical procedures used on baseline ambient air sampling

Pollutant	Method of Sampling and Analysis
Total Suspended Particulates (TSP)	High Volume-Gravimetric Method
Suspended Particulates less than 10 µm (PM_{10})	High Volume-Gravimetric Method
Sulfur Dioxide (SO_2)	Impinger-Pararosaniline Method
Nitrogen Dioxide (NO_2)	Impinger -Griess Saltzman Reaction

Plate 2-29 to Plate 2-31 show in detail the descriptions of the air sampling stations and the photographs taken during sampling. The results of air monitoring are presented in the next section.

Figure 2-132 Locations of ambient air sampling stations (Source: BSI, 2016)

Station	Sampling Observations	Photo Documentations
A1 Navotas Pier, Navotas Masipag & Gasak Ext. at the back of Tanza Elementary School	The station was located on a dry ground beside a pond and a paved road covered with dusts. Vehicles were passing by along the road. The area experienced a sunny weather with partly cloudy skies. Wind blows from southeast at light air condition. No rainfall was observed.	 
A2 Navotas City Hall Park	The station was located on a concreted area of the park. Ground is dry and covered with dusts. There were continuous construction activities at the neighboring manpower center. The area experienced a sunny weather with cloudy skies. Wind blows from southeast at light air condition. No rainfall was observed.	 

Plate 2-29 Sampling observations and photo documentation at Stations A1 and A2 (Source: BSI, 2016)

Station	Sampling Observations	Photo Documentations
A3 Near Bagong Silang St. corner A. Pascual, Navotas City	The station was located on a concreted path walk beside a paved access road. Ground is dry and covered with dusts. Vehicles were passing by along the road. The area experienced a sunny weather with partly cloudy skies. Wind blows from the southeast at light air condition. No rainfall was observed.	 
A4 Obando Church, Bulacan	The station was located on a concreted area at the front of the church. Vehicles were passing along the nearby paved roads (20 m south and 30 m east of the station). The area experienced a fair weather with partly cloudy skies. Wind blows from southwest at light air condition. No rainfall was observed.	 

Plate 2-30 Sampling observations and photo documentation at Stations A3 and A4 (Source: BSI, 2016)

Station	Sampling Observations	Photo Documentations
A5 Balawas Rd., Brgy. Lawa near Emong Malunggay Pandesal	The station was located on a dry ground beside a paved road and a pond. Vehicles were passing by along the road. The area experienced a fair weather with partly cloudy skies. Wind blows from southwest at light air condition. No rainfall was observed.	 

Plate 2-31 Sampling observations and photo documentation at Station A5 (Source: BSI, 2016)

2.3.2.2 Applicable Air Quality Standards and Impact Assessment Methodology

The dispersed emissions arising from the reclamation works/operation of the project shall comply with the National Ambient Air Quality Standards (NAAQS) set for the relevant air pollutants, such as TSP, PM_{10}, SO_2, and NO_2. Monitoring shall be done outside the project perimeter, preferably downwind of the project site where area sensitive receptors (ASRs) are located. Table 2-47 presents the NAAQS for TSP, PM_{10}, SO_2, and NO_2.

Table 2-47 National Ambient Air Quality Standards (NAAQS) for SO_2, NO_2, TSP, and PM_{10}

Pollutant	Concentration ($\mu g/Nm^3$)[1]	Averaging Time (min)	Reference
Sulfur Dioxide (SO_2)	340	60	Table 3 of DAO 2000-81
Nitrogen Dioxide (NO_2)	260	60	Table 3 of DAO 2000-81
Total Suspended Particulates (TSP)	300	60	Table 3 of DAO 2000-81
Particulate Matter less than 10 microns (PM_{10})	200	60	Table 3 of DAO 2000-81

Notes: $\mu g/Nm^3$ – microgram per normal cubic meter

As this proposed project will mainly involve reclamation works and that there is no significant stationary source of emissions (e.g., such as power plants), impact assessment involved qualitative description of the expected impacts to the air environment. To mitigate or lessen the anticipated impacts related to air quality, proposed mitigation measures including proposed air monitoring are presented in the succeeding section.

2.3.2.3 Baseline Air Quality

Table 2-48 shows the results of baseline air sampling conducted last April 16, 2016. Ambient PM_{10}, SO_2, and NO_2 were within the ambient standards of 200, 340, and 260 $\mu g/Nm^3$, respectively. Measured TSP, however, were relatively high at Stations 3 and 4 as compared to the ambient standard of 340 $\mu g/Nm^3$. The observed TSP concentrations ranged from 124.1 to 844 $\mu g/Nm^3$.

BSI (2016) noted that high TSP concentrations during air sampling were due to fugitive emissions from vehicular traffic, as these stations were located beside the road. Monitoring was done during dry season where fugitive dust emissions are expected higher. Particulate emissions emanating from the tail pipes of vehicles also contributed to the total TSP in the area.

Table 2-48 Results of baseline monitoring of TSP, PM_{10}, SO_2, and NO_2 (in $\mu g/Nm^3$)

Station ID	Location	Date /Time of Sampling	TSP	PM_{10}	SO_2	NO_2
1	Navotas Pier, Navotas Masipag & Gasak Ext. at the back of Tanza Elementary School	April 20, 2016/ 1405H-1505H	124.1	65.5	13.2	2.4
2	Navotas City Hall Park	1023H-1123H	337.0	44.5	4.9	7.0
3	Near Bagong Silang St. corner A. Pascual, Navotas City	1545H-1645H	785.8	44.6	10.9	2.4
4	Obando Church, Bulacan	1840H-1940H	844.0	25.5	6.5	2.3

Station ID	Location	Date /Time of Sampling	TSP	PM_{10}	SO_2	NO_2
5	Balawas Rd., Brgy. Lawa near Emong Malunggay Pandesal	2003H-2103H	203.6	<1.7	2.5	<0.2

2.3.2.4 Potential impacts and options for prevention, mitigation or enhancement

The construction/operation of the proposed project will use marine and heavy equipment that are expected to generate air emissions. These equipment and activities include, among others, exhaust emissions from marine vessels that will be used for reclamation works, exhaust emissions from vehicles and other heavy equipment during reclamation/civil works, and release of fugitive emissions arising from vehicular traffic and wind erosion at open and dry surfaces.

The above-mentioned sources and activities, if not properly mitigated, will result to dispersion of air pollutants to levels exceeding ambient standards, specifically for suspended particulates during windy and dry periods. Thus, the following are the recommended mitigation measures, including air quality monitoring to be undertaken during reclamation works.

a) Regular maintenance works of all vehicles (land and marine) to be used for the project;
b) Frequent water spraying at dry and unpaved reclaimed sites near ASRs, especially during dry periods where fugitive dusts are potentially dispersed by winds;
c) Reduction of wind speeds by installing temporary wind barriers at the area, if necessary. These wind barriers could be strategically located at areas close to the ASRs (e.g., Brgy. Tanza);
d) Provide wheel washing facilities for vehicles leaving the project site. This wheel washing facility is intended to remove muds from the tires of the heavy equipment and other vehicles, which are potential sources of dust if detached from vehicles traveling outside the project site (e.g., paved or unpaved roads);
e) Impose speed limits within the project site and along access roads. Reduction of vehicular speed will significantly reduce generation of fugitive emissions;
f) If possible, re-route vehicles at considerable distances from the ASRs. This measure (re-routing) is effective means of decreasing release of fugitive emissions to nearby ASRs, especially during very dry conditions where wetting of dry surfaces would be effective for short duration; and

Conduct regular visual inspection at the project site (including monthly sampling of TSP, PM_{10}, SO_2, and NO_2) to determine areas with high fugitive emissions, and to implement mitigation measures as necessary.

2.3.3 Noise

This section presents a) applicable noise standards and methodology utilized in this study, b) characterization of ambient noise level using DENR standard methods and procedures for sampling and measurement; and c) identification and assessment of the expected impact of the project to existing or background noise levels.

2.3.3.1 Methodology

2.3.3.1.1 Ambient noise standards

Ambient noise standards have been established by then National Pollution Control Commission (NPCC) (now DENR) since 1978 and 1980 for the purpose of prohibiting, limiting, or regulating noise emission by any person or organization at residential, commercial, light and heavy industrial, and other noise sensitive areas, such as schools, hospitals, and special homes for the aged (Table 2-49). In the absence of the official classification of the area, the primary land use of the area should be used.

The ambient noise standards are subdivided into four (4) periods, namely: morning, daytime, evening, and nighttime, with time periods shown in Table 2-49. Correction factors of +5 dBA and +10 dBA apply at areas directly facing two-and four-lane roads, respectively. Note that noise standards stipulated in NPCC MC No 2, Series of 1980 have not been revised since its issuances in 1980.

Table 2-49 Environmental quality standards for noise in general areas (NPCC 1980)

Category	Maximum Allowable Noise (dBA) by time periods		
	Daytime (9:00 A.M. to 6:00 P.M).	Morning/Evening (5:00 A.M. to 9:00 AM/ 6:00 P.M. to 10:00 P.M.	Nighttime (10:00 P.M. to 5:00 A.M).
AA	50	45	40
A	55	50	45
B	65	60	55
C	70	65	60
D	75	70	65

- Class AA- a section of contiguous area which requires quietness, such as areas within 100 meters from school site, nursery schools, hospitals and special house for the aged
- Class A - a section of contiguous area which is primarily used for residential area
- Class B - a section of contiguous area which is primarily a commercial area
- Class C - a section of contiguous area reserved as light industrial area
- Class D-a section which is primarily reserved as heavy industrial area

The applicable noise standards for construction activities are specified in Memorandum Circular No. 002, Series of 1980, of the National Pollution Control Commission (NPCC). These standards specify a maximum noise level that shall be allowed from specific construction activities at a distance of 30 m, as shown in Table 2-50.

Table 2-50 Noise standards for construction activities (Source: NPCC 1980)

Classification	Particulars	Maximum Noise Level at 30 meters *
Class 1	Work which requires pile drivers (excluding manual type), pile extractors, reveting hammers or combination thereof. The classification does not include work in which pile drivers are used in combination with earth auger	90
Class 2	Work which requires rock drills, or similar equipment like jack hammers or pavement breakers	85

Classification	Particulars	Maximum Noise Level at 30 meters *
Class 3	Work which requires air compressor (limited to those compressors which use power other than electric motors with rated with rated output of 15 kW or more). Air compressors power rock drills, jack hammers, pavement breakers are excluded	75
Class 4	Operation involving batching plant (limited to those with a mixer capacity of 0.5 or more cubic meters) and /or asphalt plants (limited to those with mixer capacity of 200 kg or more). Batching plants for the making of mortar are excluded	75

2.3.3.1.2 Baseline noise monitoring

Berkman Systems Incorporated (BSI) was commissioned by RHR Consult Services, Inc. (RHR) to conduct ambient air and noise monitoring in the vicinities of the proposed project site. Noise monitoring was conducted on April 20, 2016. Figure 2-133 and Table 2-51 indicate the location of the monitoring stations and description of the sampling stations, respectively.

Table 2-51 Location of noise sampling stations

Station ID	Location	Easting (m)	Northing (m)	Elevation (m)
1	Park / Open space near Police Station	279018.34	1621423.36	6
2	Near memorial Garden	278367.70	1622182.46	3
3	Beside Tanza Elementary School	277490.85	1623761.71	4
4	Near Basketball Court / Obando Church	277830.17	1627293.10	6
5	Along Paliwas Road, Obando, Bulacan	276820.34	1628829.36	4

A sound level meter (SLM) with wind screen and attached on a tripod was used to measure noise levels at A-weighting mode at each station per monitoring period specified above. A-weighting mode was selected as the ambient noise standards are based on A-weighting. A total of 50 readings were recorded per station wherein the median of the seven maximum-recorded noise levels represents the noise level comparable to the standard.

Statistical analysis of noise data involved computation of the median of the seven (7) highest noise readings, the 90th percentile (L_{90}), and the equivalent noise levels (L_{eq}). Noise sources were noted at the time of monitoring.

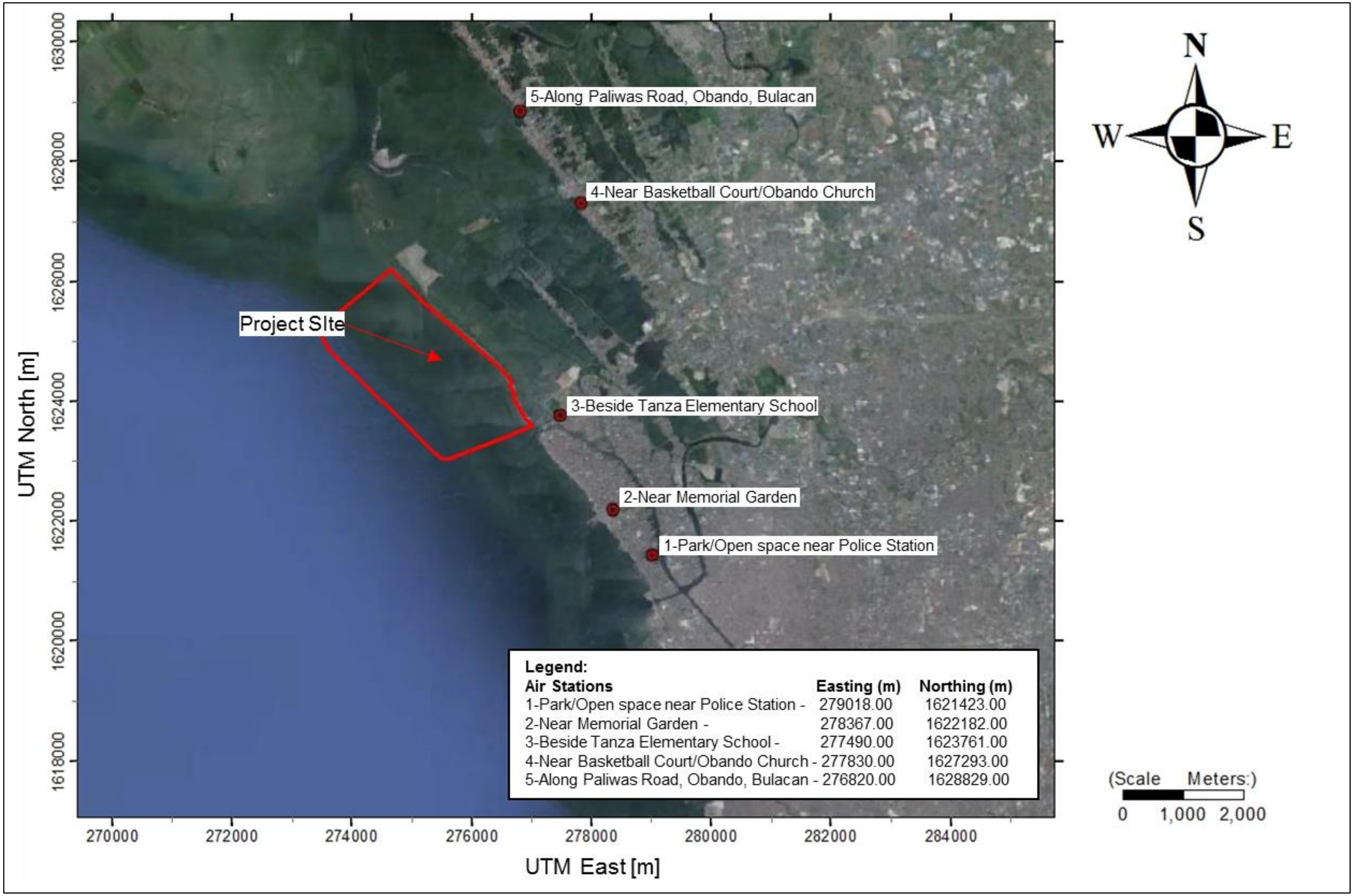


Figure 2-133 Location of noise sampling stations

2.3.3.2 Baseline information

Figure 2-134 to Figure 2-138 show the plots of measured noise levels at each of the noise sampling stations on April 20, 2016. The summary results of noise monitoring are presented in Table 2-52 and Figure 2-134 to Figure 2-138.

Observed noise levels were generally higher than prescribed ambient noise standards for residential areas even if a correction factor of +5 dBA is added to the noise standard. As high as 73.6 dBA and 72.3 dBA (median of 7 highest) were measured at Station No. 5 (Balawas Road) and Station 2 (Navotas City Hall Park). The other three (3) stations (Stations 1, 3, and 4) showed noise levels ranging from 55.6 to 68.9 dBA.

Background noise levels, which can be estimated based on noise exceeding 90th of the time (or L_{90}) (please refer to Figure 2-139), also showed relatively values. At Stations 2, 4, and 5, background noise levels (or L_{90}) ranged from 52.0 to 66.3 dBA, which were still higher than the daytime noise standard of 55 dBA (without +5 dBA correction factor). At the other two (2) stations, background noise levels ranged from 48.6 to 52 dBA, which were also higher than evening and morning noise standards set for residential areas.

In summary, baseline noise levels in the vicinities of the proposed project site were generally higher than noise standards prescribed for residential areas. High noise levels were due generally due to vehicular noise traffic and from community noise during daytime at the time of monitoring.

Table 2-52 Measured noise levels on April 20, 2016

Sta ID	Location	Time	Total Rea-dings	Range (dBA)	L_{90} (dBA)	Median of 7 highest (dBA)	Sources of Noise
1	Navotas Pier, Navotas Masipag & Gasak Ext. at the back of Tanza Elementary School	(Daytime) 1350H to 1400H	50	47.9 to 59.7	48.6	55.6	Community activities
2	Navotas City Hall Park	(Daytime) 0948H to 0958H	50	64.2 to 73.3	66.3	72.3	Continuous passof vehicles and activities at nearby manpower center
3	Near Bagong Silang St. corner A. Pascual, Navotas City	(Daytime) 1535H to 1545H	50	50.1 to 69.2	52.0	63.9	Continuous passing of vehicles
4	Obando Church, Bulacan	(Evening) 1830H to 1840H	50	53.9 to 69.6	56.4	68.9	Continuous passing of vehicles
5	Balawas Rd., Brgy. Lawa near Emong Malunggay Pandesal	(Evening) 1953H to 2003H	50	54.2 to 75.6	56.2	73.6	Continuous passing of vehicles

Notes: L90 – Median of 45 and 46^{th} readings

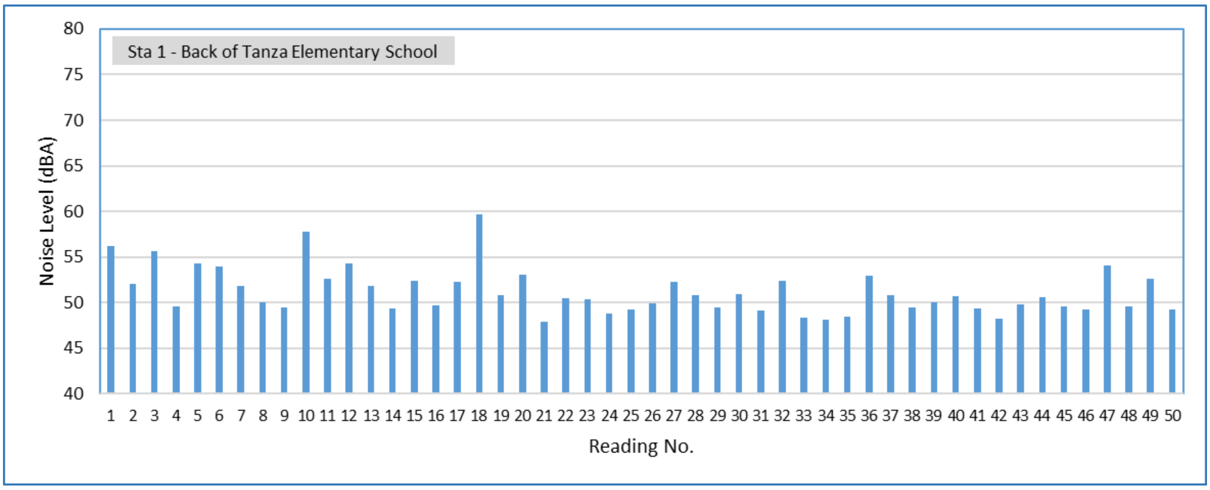


Figure 2-134 Plot of measured noise levels at Station 1

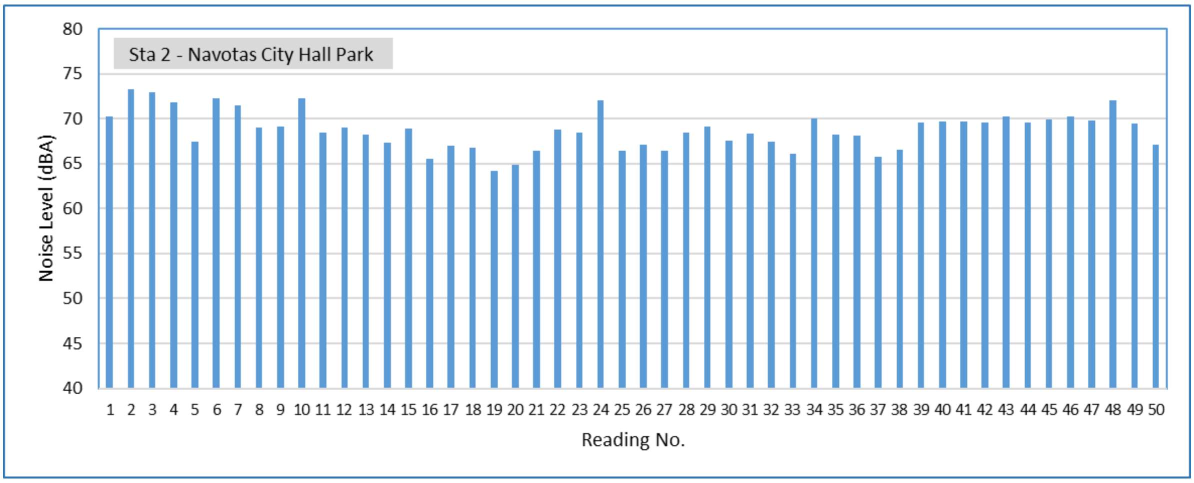


Figure 2-135 Plot of measured noise levels at Station 2

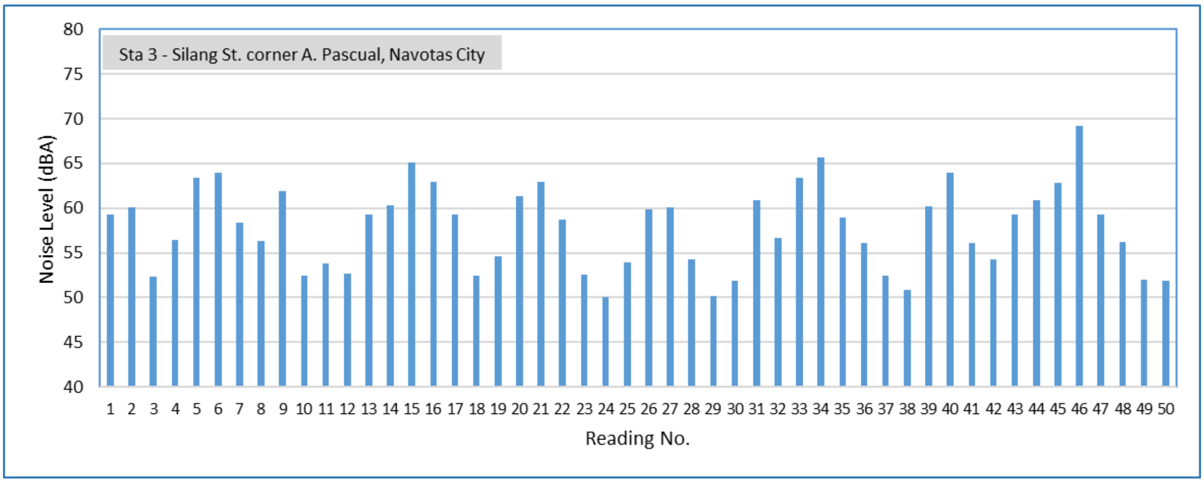


Figure 2-136 Plot of measured noise levels at Station 3

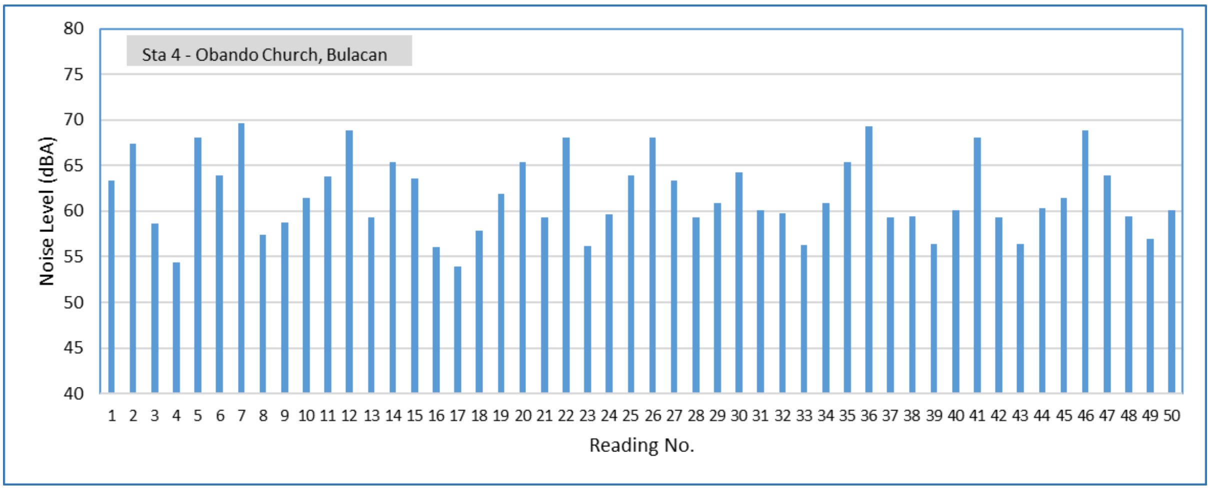


Figure 2-137 Plot of measured noise levels at Station 4

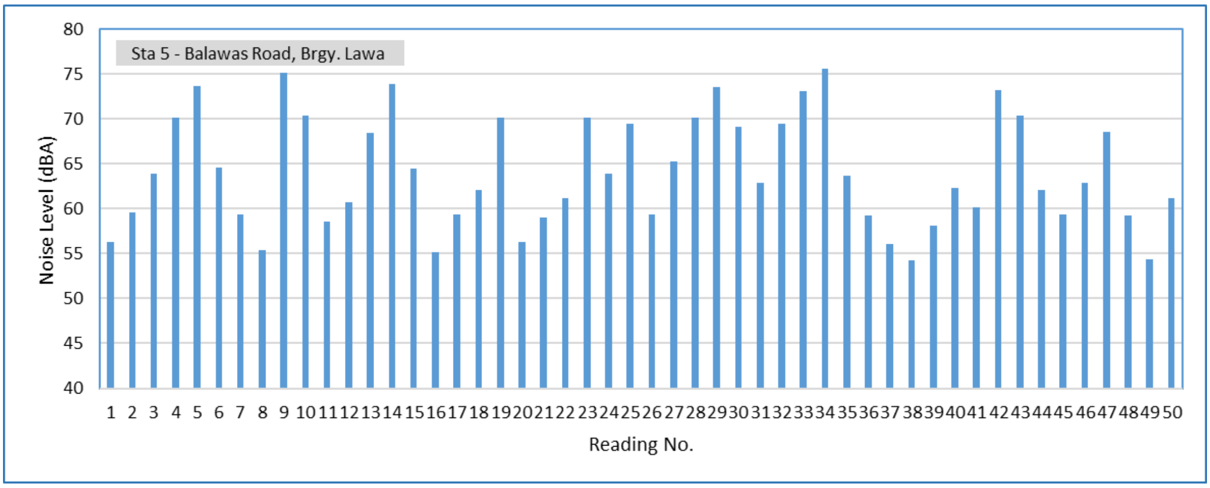


Figure 2-138 Plot of measured noise levels at Station 5

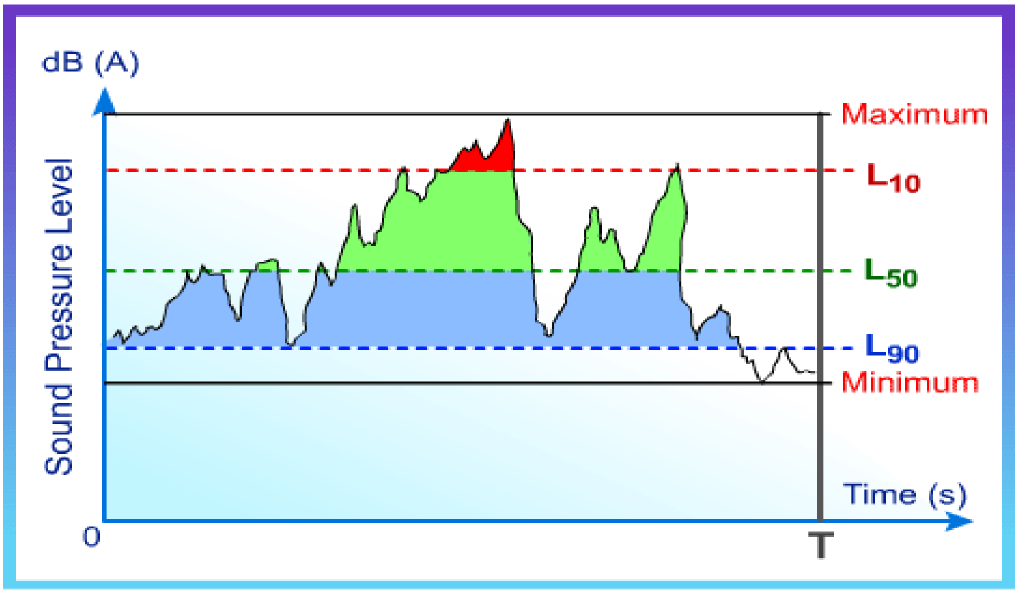


Figure 2-139 Illustration of L_{10}, L_{50}, and L_{90} noise levels

(Source: www.epd.gov.hk)

2.3.3.3 Impact assessment/noise modeling

A Sound Propagation Model (SPM9613 Version 2 or SPM9613V2) was used to assess the expected noise emissions from reclamation and other heavy equipment to be used during reclamation works. Noise input data were estimated based on the following:

a) Type and number of equipment to be utilized during reclamation works,
b) Sound power level of each of the equipment, and
c) Assumed locations of the equipment in the proposed site.

The following presents in detail the SPM9613, sound power input data, which were obtained from the RCNM of U.S. FHA and other related EIA studies on reclamation, details on noise modeling, and results.

2.3.3.3.1 Sound propagation model (SPM9613 Version 2)

SPM9613V2 is a noise attenuation model developed based on ISO-9613-1 and ISO 9613-2. ISO 9613-1 (1993E) specifically addresses atmospheric attenuation while ISO 9613-2(1996E) specifies an engineering method for calculating environmental noise from a variety of noise sources. SPM9613V2 was developed by Power Acoustics, Inc. in Orlando, Florida.

Although SPM9613V2 is generally used for stationary noise sources and mobile sources (e.g., railroad), it was utilized in this study by assuming that reclamation and other heavy equipment are operated simultaneously over time at the proposed project site.

2.3.3.3.2 Equipment and sound power level

Table 2-53 shows the reclamation equipment to be used during operation and the estimated sound power level and sound level at 50 ft (or 15.24 m). Sound level data from U.S. FHWA (2006) (shown in Table 2-53) were used to compute the sound power level using the following formula.

$$Lw = Lp + 10log(4\pi r^2)$$

where:

Lw = sound power level (in re dBA re 1 PW);

Lp = sound level at distance, r, from the equipment; and

r = distance from the noise source (or 15.24 m)

As there is no available sound level data at various octave band center frequencies (e.g., 16 Hz to 8000 Hz), sound power data were assumed at frequency centered at 1000 Hz.

Plate 2-32 shows the screenshot of control panel in SPMP9613 indicating the source input files.

Table 2-53 Reclamation equipment and estimated sound pressure and/or power levels

Equipment	No of Units	Spec Lmax (dBA)	Source of Information
Cutter Suction Dredger (CSD) at Borrow Area	2	(103)	EIA Tai) Sheltered Boat Anchorage (2000)
Cutter Suction Dredger (CSD) at Reclamation Site	2	(103)	EIA Tai) Sheltered Boat Anchorage (2000)
Split Hopper Barge (SHB) with tugboat	14	(104) 110	EIA Tai) Sheltered Boat Anchorage (2000)
Tug Boat	14	(110)	EIA Tai) Sheltered Boat Anchorage (2000)
Backhoe Dredger	2	80.0	U.S. FHWA (2006)
Excavator	4	85.0	U.S. FHWA (2006)
Bulldozer	4	85.0	U.S. FHWA (2006)
Clamshell and Barge	2	104	EIA Tai) Sheltered Boat Anchorage (2000)
Wheel Loader (as front end loader)	4	80.0	U.S. FHWA (2006)
Vibratory Roller (as roller)	4	85.0 (108)	U.S. FHWA (2006)

Notes
1) Sound level (in dBA) at 50 feet (or 15.24 m) unless otherwise specified.
2) Values in parenthesis under column Spec Lmax are sound power level (in dBA re 1PW)

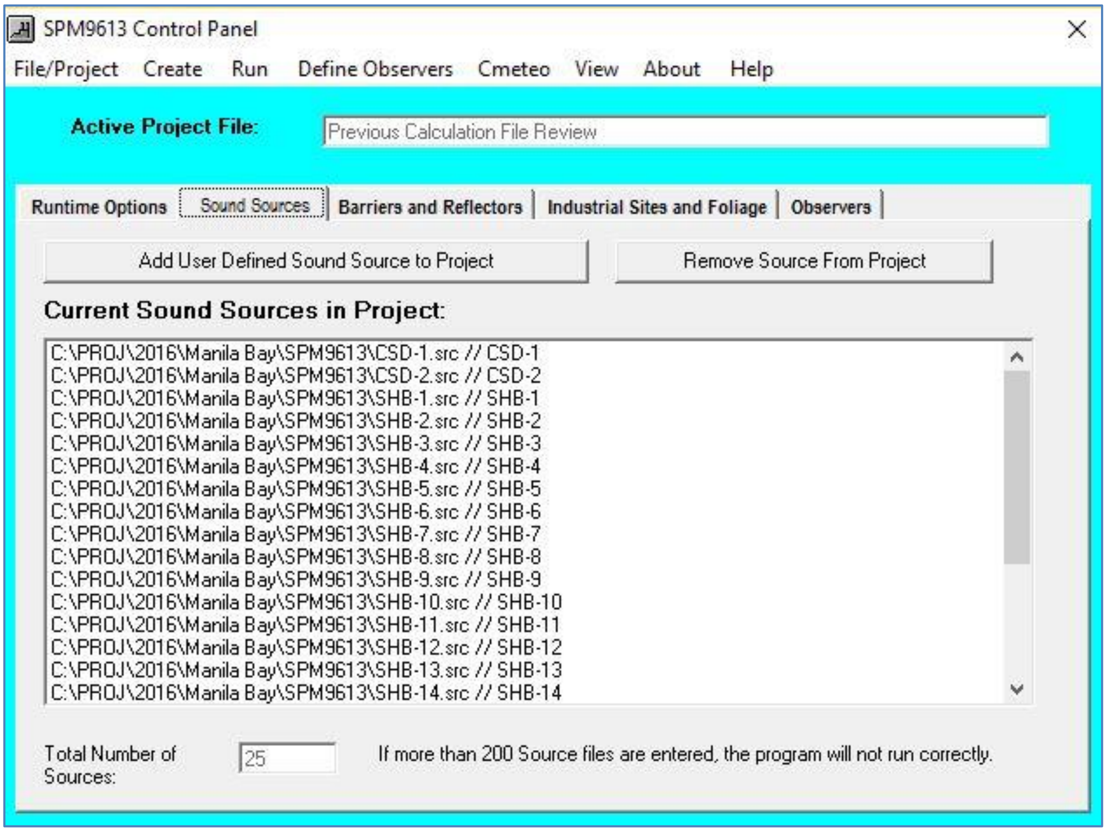


Plate 2-32 Screenshot of control panel indicating the source input files in SPM9613V2

2.3.3.3.3 Noise receptors

Noise receptors (or observers) are locations within the modeling domain where noise levels are calculated. In this case, noise receptors are automatically generated by SPM9613V2 using maximum of 11 by 11 grid points. Plate 2-33 shows the screenshot of the noise receptors indicating the grid points and locations of sound sources (represented as dots).

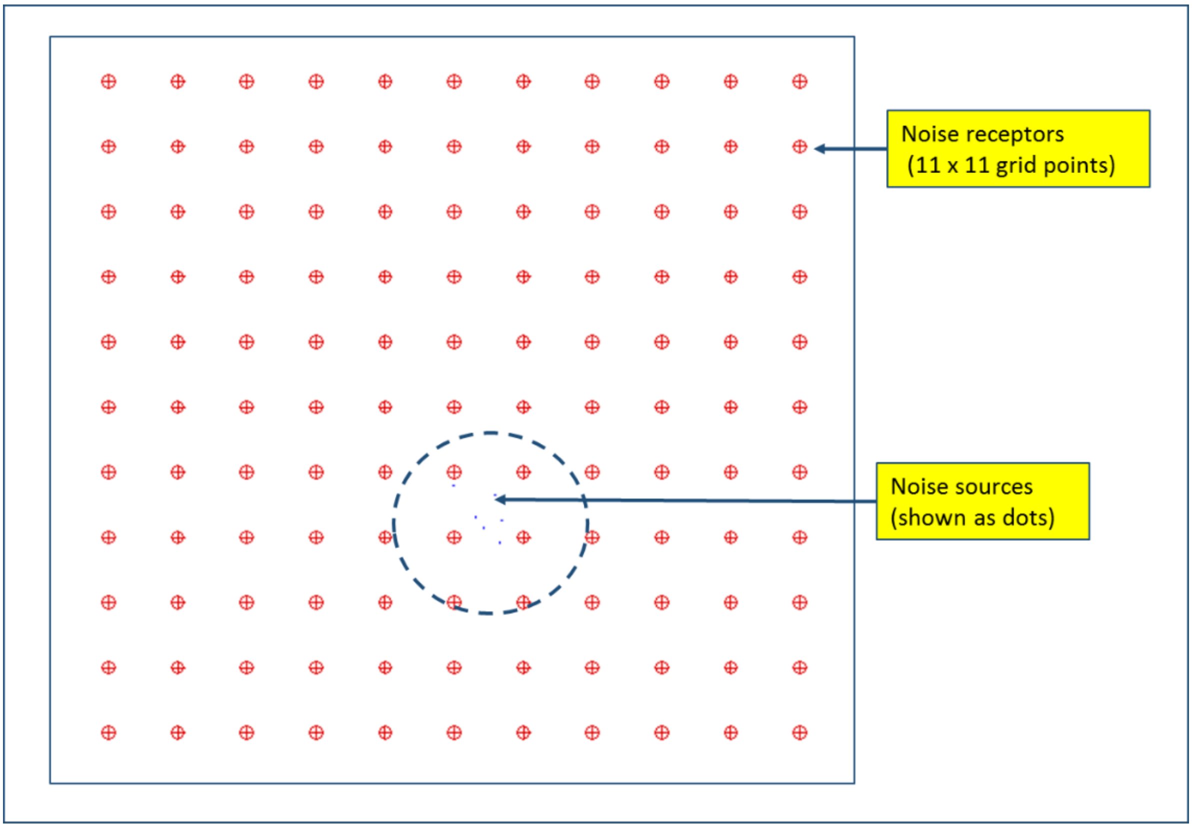


Plate 2-33 Screenshot of noise receptors indicating the grid points and noise sources

2.3.3.3.4 Barriers and foliage

Noise attenuation or reduction due to barriers and foliage, such as the existing mangroves fronting the proposed project site and houses or structures, were not included as this case assumed screening modeling. More detailed noise assessment using numerous barriers and foliage may be including later depending on the preliminary noise screening results. Thus, modeling results in this case are expected higher than those considering existing structures as barriers.

2.3.3.3.5 Modeling results

Noise modeling results showed that cumulative impacts arising from the operation of the reclamation equipment, which were extracted from Figure 2-140 and Figure 2-141, plus the background (L_{90}) and median noise levels, as shown in Table 2-54, would result from none to moderate effects when compared with the corresponding impact categories by Wilson (1986) shown in Table 2-55. The predicted noise levels at two (2) closest receptors or noise stations (Tanza Elementary School and Obando Church) of 55 and 48 dBA, respectively, when added to L_{90} and the median noise levels, would result to the following increase of noise levels.

- Tanza Elementary School = 2.7 to 7.6 dBA
- Near Obando Church = .0 to 1.5 dBA

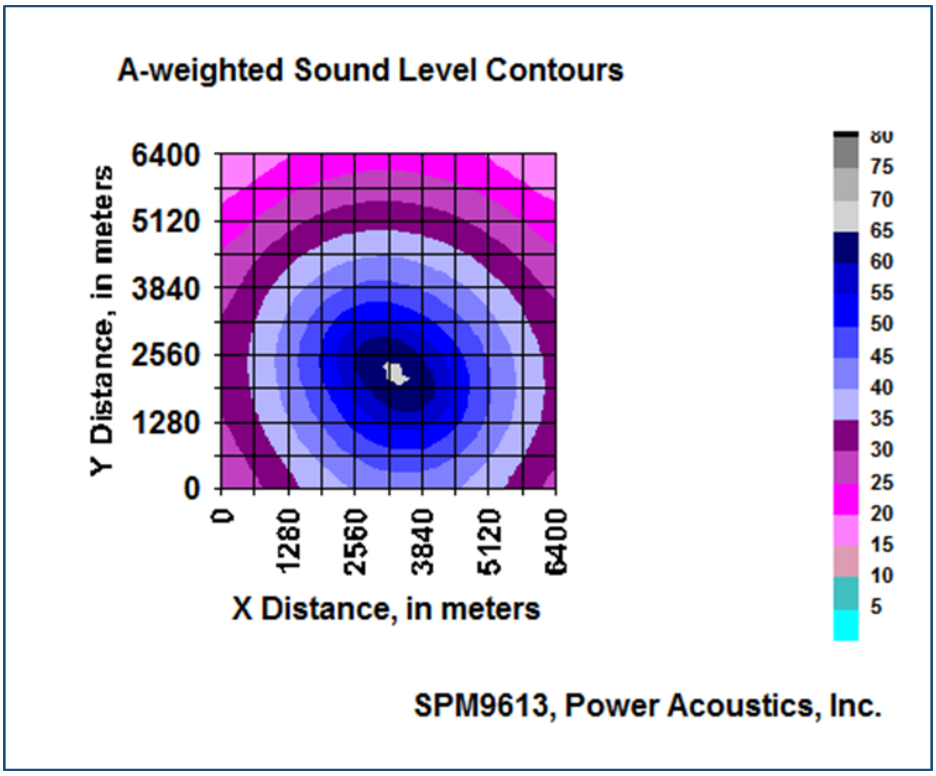


Figure 2-140 Screenshot of predicted noise level from SPM9613V2

The higher range of values above (7.6 and 1.5 dBA) correspond to differences between predicted plus background noise (or L_{90}).

Thus, when compared with the corresponding impact categories (Table 2-55), it appears that operation of reclamation equipment would have none to minor effect (or not likely perceived) during daytime. However, at nighttime when equivalent noise levels would tend to reach its background levels (L_{90}), noise from reclamation operation would be noticeable (perceived as moderate effect) at residences in Brgy. Tanza.

Table 2-54 Cumulative noise impact (predicted plus background and median noise levels)

Location	Predicted Noise Level (dBA)	Median plus Predicted (dBA)		L_{90} plus Predicted (dBA)	
		Median	Cumulative	Median	Cumulative
Tanza Elem School	55	55.6	58.3	48.6	55.9
Beside Obando Church	48	68.9	68.9	52.0	53.5

Table 2-55 Noise level increases and corresponding impact categories

Category	Increase (dBA)	Effect
I	< 5	None to Minor
II	5 to 10	Moderate
III	> 10	Significant to Severe

Source: Wilson (1986)

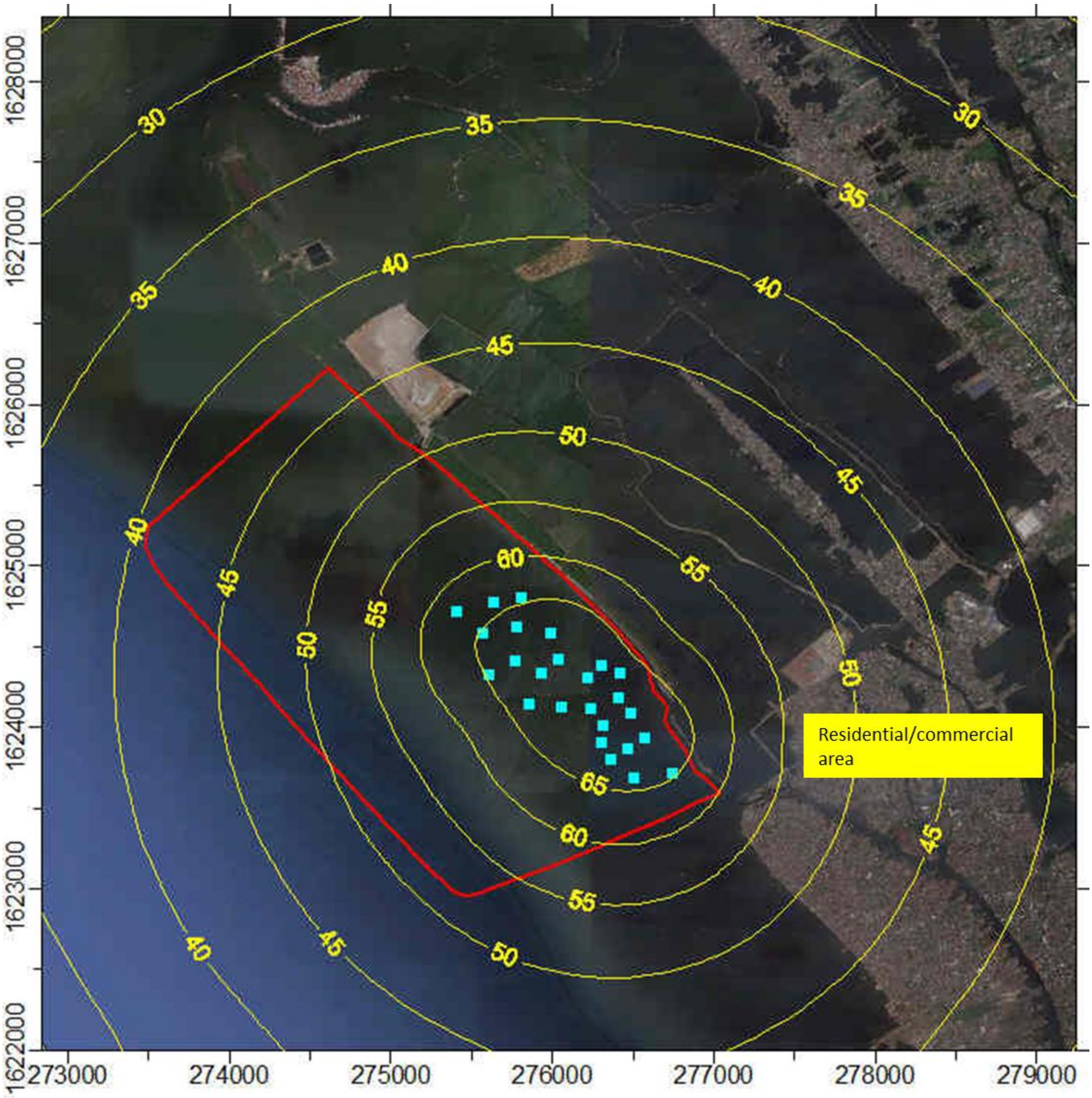


Figure 2-141 Predicted noise levels (in dBA) arising from the operation of the reclamation equipment (represented as blue-colored polygons)

2.3.3.4 Potential impacts and options for prevention, mitigation or enhancement

As discussed in the noise modeling results, the operation of reclamation equipment would have none to minor effect during daytime. However, at nighttime when equivalent noise levels would tend to reach its background levels (L_{90}), noise from reclamation operation would be noticeable (perceived as moderate effect) at residences in Brgy. Tanza.

Thus, it is recommended to monitor noise levels especially at nighttime periods (10:00 P.M. to 5:00 P.M) at residences closest to reclamation works. Proposed mitigation measures to lessen noise impact at residential areas would include a) conducting reclamation works during nighttime at the project area relatively far from the Barangay Tanza, and b) reduce the number of equipment to be operated at nighttime and inform the residents and barangay officials prior to conducting reclamation works, if equipment need to be operated near residential areas.

2.4 People

The study focuses on the impact areas of the proposed project. Navotas City is considered the indirect impact area based on the social impacts the project may induce. On the other hand, Barangay Tanza is deemed as direct impact areas where the project components are to be located. The following sections present the demographic and socio-economic profile of the impact areas as well as the issues/concerns/possible impacts regarding the project and corresponding proposed mitigation/enhancement measures.

2.4.1 Methodology

Various methods were employed in gathering information on the socio-economic conditions and perceptions of the impact community. The summary and details of these activities/methods presented in the following table and sections, respectively:

Table 2-56 Date, location and participants by activities conducted for the Project

Activity	Date	Location/Venue	Participants
Site Visit	March 22, 2016	Barangay Tanza and Navotas City	
Public Scoping	May 24, 2016	Pangisdaan Hall, 4th Floor, Navotas City Hall Building, Navotas City	75
Perception Survey	May 17-20, 2016	Barangay Tanza	100

2.4.1.1 Site visit/reconnaissance

During the reconnaissance survey, the general condition of the Impact areas and communities were observed and noted. In this method, one can generalize the socio-economic and demographic conditions of the covered areas and communities. Brief random interviews of the residents within the area were also conducted to research on the general situation of the area and the communities and help determine the perception of the respondents towards the project.

The Site Visit/Ocular Inspection/ Area reconnaissance/ Preliminary Survey was conducted on March 22, 2016.

2.4.1.2 Public scoping

The Public Scoping was held on May 24, 2016 (Tuesday) at Pangisdaan Hall, 4th Floor, Navotas City Hall Building, Navotas City which was attended by the City of Navotas and Barangay LGU Officials. Aside from the officials and residents of barangays of the area, also present in the activity were the EIA Preparers, representatives of various sectors of the community, institutions, DENR-EMB Representatives, among others. A total of 75 participants have attended the activity

The issues and concerns during public scoping were summarized in Section 2.4.4.

2.4.1.3 Review of secondary data

Socio-demographic and economic data were procured from pertinent documents from respective government institutions such as Municipal and Provincial LGUs, as well as online sources for background information. All sources were exhausted in the study. These sources include:

- Comprehensive Land Use Plan of Navotas City (2016-2025)
- Socio-Economic Profile of Navotas City (2015)
- City Ecological Profile (2011)

Table 2-57 Checklist of available data sources/references

Document	Navotas City	Barangay Tanza
Comprehensive Land Use Plan of Navotas City (2016-2025)	✓	✓
Socio-Economic Profile of Navotas City (2015)	✓	✓
City Ecological Profile (2011)	✓	✓

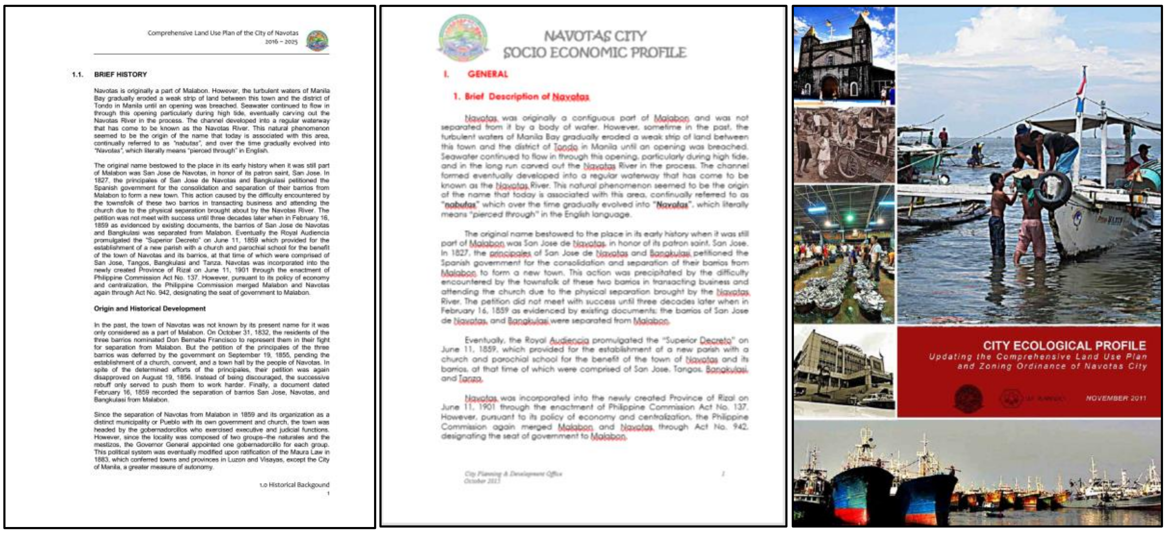


Figure 2-142 Document covers/pages obtained from LGUs

2.4.1.4 Perception survey

Table 2-58 presents the summary of Perception Survey conducted for the proposed project. Further details and photo documentation are shown in the succeeding sections.

Table 2-58 Method used for the perception survey

Method	Date	Location	No. of Respondents
Random Sample Interviews	May 17-20, 2016	Barangay Tanza	100

Random Interviews were held in the direct impact barangay, Barangay Tanza, on May 17-20, 2016. A Perception Survey Questionnaire served as a guide during the discussion, and with the contents not only focusing on the issues of the community and with regards to the project, but also the demographic data of the respondents. Individual Perception Survey Questionnaires utilized wherein the interviewers filled up/noted the responses of the interviewee/respondents to facilitate time and discourse.

A fixed sample number of 100 respondents was assigned for the Perception Survey. The numbers were estimated to roughly represent the population ratio distribution in the barangay while ensuring that all sectors are well represented in the community.

Figure 2-143 Random sample interviews conducted at Barangay Tanza, Navotas City

2.4.2 Baseline socio-economic conditions

Navotas was originally a contiguous part of Malabon and was not separated from it by a body of water. However, sometime in the past, the turbulent waters of Manila Bay gradually eroded a weak strip of land between this town and the district of Tondo in Manila until an opening was breached. Seawater continued to flow in through this opening particularly during high tide eventually carving out the Navotas River in the process. The channel created eventually developed into a regular waterway that has come to be known as the Navotas River. This natural phenomenon seemed to be the origin of the name that today is associated with this area, continually referred to as “nabutas” which over the time gradually evolved into “Navotas”, literally meaning “pierced through” in English.

The original name bestowed to the place in its early history when it was still part of Malabon was San Jose de Navotas, in honor of its patron saint, San Jose. In 1827, the principales of San Jose de Navotas and Bangkulasi petitioned the Spanish government for the consolidation and separation of their barrios from Malabon to form a new town. This action was precipitated by the difficulty encountered by the townsfolk of these two barrios in transacting business and attending the church due to the physical separation brought by the Navotas River. The petition did not meet with success until three decades later when in February 16, 1859 as evidence by existing documents, the barrios of San Jose de Navotas and Bangkulasi was separated from Malabon.

Eventually the Royal Audiencia promulgated the “Superior Decreto” on June 11, 1859 which provided for the establishment of a new parish with a church and parochial school for the benefit of the town of Navotas and its barrios, at that time of which were comprised of San Jose, Tangos, Bangkulasi and Tanza.

Navotas was incorporated into the newly created Province of Rizal on June 11, 1901 through the enactment of Philippine Commission Act No. 137. However, pursuant to its policy of economy and centralization, the Philippine Commission again merged Malabon and Navotas through Act No. 942 designating the seat of government to Malabon.

2.4.2.1 Demographic profile

2.4.2.1.1 Population and household profile

In 1990, the population of Navotas was 187,479. In 1995, during the mid-decade census, the Navotas population increased by 4.08 percent, logging a total population of 229,039. This increased further in 2000, to 230,403, a 0.12 percent growth. This is mainly due to the removal of structures along the riverbanks and other hazardous areas. As of August 1, 2007, the population of Navotas is 245,344. In 2010, the estimated total population is 268,688.

As of 2010, there are 135,421 males and 133,267 females, resulting in a sex ratio of 101.61. The general population density of the city is 251 persons per hectare. The densest barangay is Navotas West (1,270 persons per hectare), while the least dense barangay is San Rafael Village (96 persons/hectare).

Table 2-59 Total population and average annual growth rate in Navotas City (1903-2010)

Year of Census	Total Population	Average Annual Growth Rate
1903	11,688	-
1918	13,454	0.94
1939	20,861	2.11
1948	28,889	3.68
1960	49,262	4.55
1970	83,245	5.39
1975	97,098	3.13
1980	126,146	5.37
1990	187,479	4.04
1995	229,039	4.08
2000	230,403	0.12
2007	245,344	0.9

Year of Census	Total Population	Average Annual Growth Rate
2010	249,131	0.78

Source: Navotas City Socio-Economic Profile (2015)

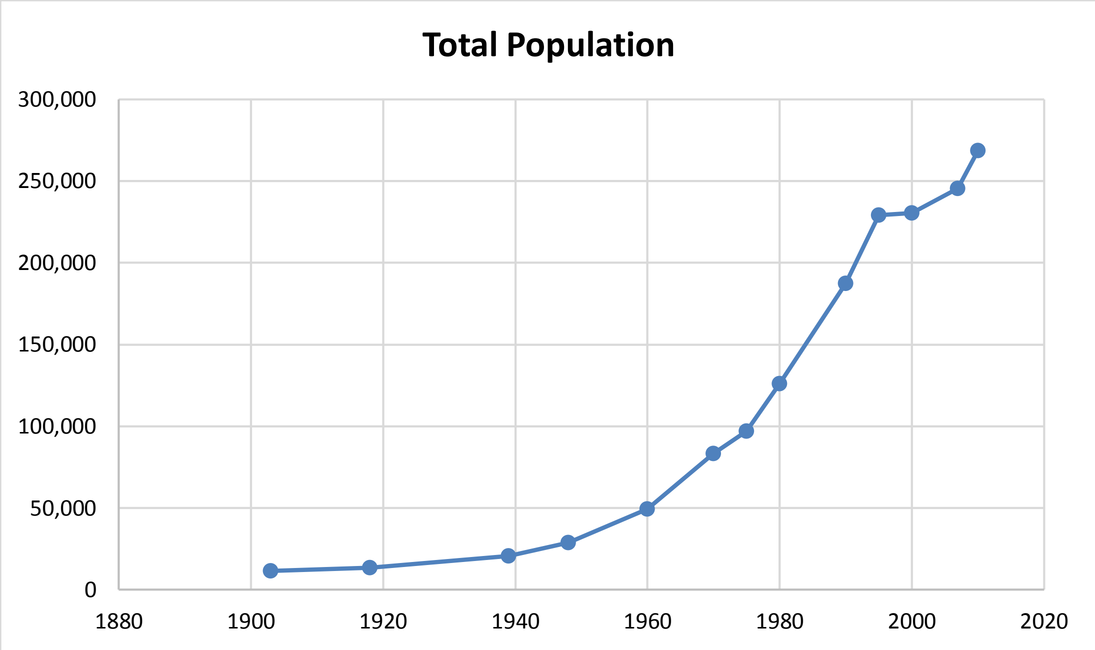


Figure 2-144 Population trend in Navotas City (1903-2010)

Source: Navotas City Socio-Economic Profile (2015)

Based on the results of the 2010 National Statistics Office (NSO) census, the City of Navotas is ranked 15th with a population of 249,131, a population density of 233 persons per hectare, and a growth rate of 0.78%, among the 17 cities and municipalities in Metro Manila. On the other hand, Barangay Tanza has a population density of 50.64 persons/ha which ranked last among the barangays of Navotas City.

Table 2-60 Population density in impact areas (2010)

Barangay	Population	Land Area (hectares)	Population Density/(ha)	Annual Growth Rate
Navotas City	249,131	1,069	233.05	0.78
Barangay Tanza	24,917	492	50.64	No data

Source: Navotas City Socio-Economic Profile (2015)

2.4.2.1.2 Gender and age profile

Presented in the following table and figure is the age and sex distribution in Navotas City as of 2010.

Table 2-61 Household population by age and sex in Navotas City (2010)

Age	Female	Male	All Ages
Under 5	13,461	14,610	28,071
5-9	13,003	14,117	27,120
10-14	12,725	13,224	25,949

Age	Female	Male	All Ages
15-19	12,361	12,398	24,759
20-24	11,689	11,784	23,473
25-29	10,957	10,997	21,954
30-34	9,583	10,315	19,898
35-39	8,485	8,827	17,312
40-44	7,624	7,801	15,425
45-49	6,435	6,567	13,002
50-54	5,347	5,415	10,762
55-59	4,004	3,892	7,896
60-64	3,023	2,686	5,709
65-69	1,751	1,404	3,155
70-74	1,284	878	2,162
75-79	813	419	1,232
80-84	381	204	585
85 and over	258	109	367
TOTAL	**123,184**	**125,647**	**248,831**

Source: Navotas City Socio-Economic Profile (2015)

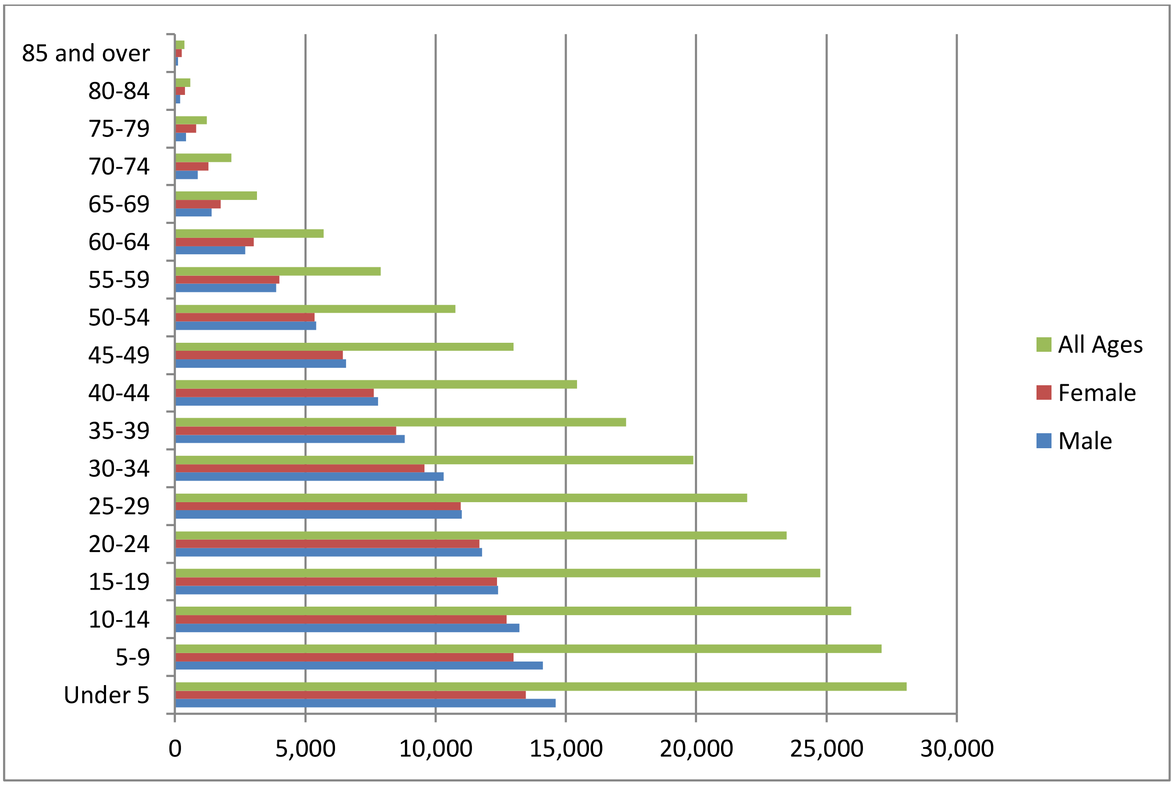


Figure 2-145 Age and sex in Navotas City, 2010

Source: Navotas City CLUP (2016-2025)

2.4.2.1.3 Literacy rate

Navotas fairs slightly better than NCR in terms of the population 7 years old and over having enrolled in secondary education. The number of high school graduates increased from 1990 to 1995 by 2.81%. However, in terms of elementary or primary education there was a marked decrease of 5.85%. About 15.16% reached tertiary education, a 1.67% increase from 1990's

13.49%, but much lower than NCR's 27.83% in 1995. College degree holders in Navotas amount to 6.60% in 1995, definitely lower than NCR's 15%.

The table shows increase in the number of students reaching pre-school and high school, showing that Navotas fairs better in terms of students reaching primary education (pre-school and elementary levels) and secondary education (high school level). However, in terms of post-secondary and tertiary education, Navotas still has to improve.

Table 2-62 NCR's and Navotas' percentage share of highest educational attainment household population 7 years old and over (1990 vs 1995)

Highest Educational Attainment	1990 % Share		1995 % Share	
	NCR	Navotas	NCR	Navotas
No Grade Completed	1.16	2.02	1.01	1.39
Pre-School	0.72	0.49	1.16	1.18
Elementary	30.42	45.94	26.62	40.11
1st – 4th Grade	13.21	18.87	11.62	15.67
5th – 7th Grade	17.22	27.08	15.00	24.43
High School	35.10	34.23	37.94	38.05
Undergraduate	13.96	17.34	14.50	18.35
Graduate	21.13	16.89	23.44	19.70
Post Secondary	3.70	3.01	3.40	2.42
Undergraduate	1.36	1.48	0.53	0.38
Graduate	2.35	1.53	2.88	2.04
College Undergraduate	14.56	7.86	12.83	8.56
Academic Degree Holder	13.37	5.63	15.00	6.60
Post Baccalaureate	0.00	0.00	0.41	0.10
Not Stated	0.98	0.82	1.62	1.57

Source: Navotas City Socio-Economic Profile (2015)

2.4.2.2 In-migration

2.4.2.2.1 Household profile

Total household population of the City of Navotas reached 248,831 in 2010, posting an increase of 8.32 percent compared to 229,717 in 2000. Household population accounted for 99.99 percent of the city total population.

In 2010, there were 59,296 households recorded in the City of Navotas. This showed an increase of 19.91 percent from 49,950 households in 2000. The average household size in 2010 was 4.2 persons, which is lower than the average household size in 2000 and 1990 census.

Table 2-63 Number of household population in Navotas City (2010)

Name of Barangay	No. of Household Population	Percent Share
Navotas City	59,296	100%
Tanza	5,034	8.49%

Source: Navotas City Socio-Economic Profile (2015)

In the 1990 Census, it was revealed that 9% of the total household population 5 years old and above are migrants, with 51% of these migrants being female and 49% male. The proximity of Navotas to the nearby Tagalog provinces and the existence of the biggest fishing port in the country may have attracted migrants into settling in the city.

2.4.2.2.2 Housing ownership profile

Table 2-64 presents the data on informal settler families on the impact areas (2011 and 2014), while Figure 2-146 presents the settlement map of Navotas City (2010).

Table 2-64 Informal settlers data in Navotas and Barangay Tanza (2011 and 2014)

Impact Area	No. of ISFs along waterways (June 2011)	No. of ISFs along waterways (June 2014)
Navotas	**7,364**	**5,953**
Tanza	2,054	1,996

Source: Navotas City CLUP (2016-2025)

2.4.2.3 Cultural/lifestyle change

2.4.2.3.1 Existing culture and lifestyle

A diversity of people forms the populace of Navotas. This is clearly evident from the variety of dialects and religions of the residents. Eighty-five percent (85%) of the residents speak Tagalog, while the remaining fifteen percent (15%) is composed of Ilokano, Cebuano, Waray, Bikolano, and Pampangueño. English though not habitually used is understood by many. Navotas reflects the national average in terms of the percentage of population practicing the Roman Catholic religion. On the other hand, a considerable number of the population is Iglesia ni Cristo. There are also a significant number of Born Again Christians and Protestants. A total of 4 other religious affiliations are present in the city.

2.4.2.3.2 Demographic data of indigenous peoples

Results of the secondary data gathering and actual surveys suggest that there are no indigenous people (IPs) present within the project site.

Figure 2-146 Settlement Map of Navotas City (population density, 2010)
Source: Navotas City CLUP (2016-2025)

2.4.2.4 Physical and cultural resources

2.4.2.4.1 Manila City

North of the Pasig (12 separate individual sites or areas explored)

Site 1: A Chinese builfing at corner of Pinpin and Dasmariñas
Site 2: Cosmopolitan building site, near Sta. Cruz bridge
Site 3: Great Eastern Hotel Site, Calle Echague
Site 4: Heacock building, corner David and Escolta
Site 5: Insular Life Building, Plaza Cervantes
Site 6: Reyes (now Soriano) building site, Plaza Cervantes
Site 7: Uy Yet building (China Bank Area), Calle Dasmariñas
Site 8: Cu Unjieng building site, Escolta and Pinpin
Site 9: Ideal Theater building site, Rizal Avenue
Site 10: Trade and Commerce building, Calle Juan Luna
Site 11: (Miscellaneous street excavations)
Site 12: Santo Tomas University Campus ("Bill's Site"), España

Excavations for building sites proved very interesting and informative regarding the history of Manila. Accurate chronology worked out for downtown area, showing regular subsistence of around 14 inches per century. Good series of datable Chinese and European porcelains obtained in great quantity; also contemporary native and southeastern Asia wares. Some whole pieces found as well as fragments and shreds.)

South of Pasig (14 individual sites or areas explored to some degree, and a few of them excavated extensively):

Site 1: Ermita School Garden (Agriculture and Commerce Building), Wallace Field
Site 2: Laong Laan Tennis Court Area, Wallace Field
Site 3: "Luis Dato" area, east of Tennis Court, Wallace Field
Site 4: Wallace Field, in general
Site 5: Calle Isaac Peral area (Taft to M. H. del Pillar)
Site 6: University of the Philippines Campus; especially area near Florida
Site 7: Weather Bureau and Ateneo Grounds
Site 8: Bureau of Science grounds (and fishpond area)
Site 9: Manila Walls and Moat area
Site 10: Various excavations inside Walled City
Site 11: Post-office building site
Site 12: Metropolitan Theater Building site
Site 13: Colgante Bridge Area (south approach, Quezon Bridge)
Site 14: New City Hall site

Sites 12-14 were very deeply excavated, and produced enormous collections of interesting ceramic and other material from the old Chinese Parian of the late 16th and early 17th centuries. Little modern material, except in upper soil layers.

The Ermita School Garden and most of the various Wallace Field areas lie on the site of old Bagumbayan – the "New Town" built in the last third of the 16th century by the Manila natives ejected from the pre-Spanish town by Goiti and Legaspi. Many interesting types of native pottery, “Manila-ware” clay-pipes, coins, beads, native jewelry, and other articles have been found.

The Ermita area was probably made up largely of sand dunes of various sizes, in pre-Spanish and early Spanish times. Some excavations show the remains of such dunes, and occasionally they contain interesting old objects, particularly on Isaac Peral, Florida, near the Weather Bureau (Ateneo), and the Bureau of Science. Deep borings for setting up telephone and electric-light poles have also often brought up interesting objects – along several streets in this area.

Results of the exploration indicate that downtown Manila was inhabited only from about 1480 to 1500 onwards.

2.4.2.4.2 Navotas

Navotas is a long, narrow, spleen-shaped island, in the then municipality of Malabon and inhabited largely by fishermen. It is interesting ethnographically on account of the many types among the thousands of small watercraft that line the shores.

It is interesting archaeologically because of two facts: First, it appears to have been a landing place or trade center for Arab and Chinese merchantmen in the Late Tang and Early Sung periods (9^{th} to 12^{th} century AD); and considerable numbers of ceramic fragments have been found in certain sand dunes along the shores. Second, the grounds around certain ancient ruins of Spanish stone buildings, near the South end of the island, have yielded many interesting fragments of 16^{th} and 17^{th} century ceramic wares – chiefly Chinese.

Further study, and some excavation, of the Tang-Sung ceramic fragment area was interrupted by the war, and should be resumed in the near future.

2.4.2.5 Public and social services

2.4.2.5.1 Water supply

The water supply system is administered by Maynilad Water Services, Inc. (MWSI), which is a distribution concessionaire of MWSS (Metropolitan Water and Sewerage System), handling the north side of Metro Manila. The water source is La Mesa Dam, where water is filtered and treated before it is distributed to the entire franchise area. Distribution lines of Maynilad Water Services, Inc. cover almost all barangays in Navotas, with barangay North Bay Boulevard South as the largest.

Table 2-65 Water needs per cubic meter per day per 2010 population in the impact areas

Barangay	2010 Population	Water Needs (m^3/day)
Navotas City	249,131	37,425
Tanza	24,917	3,619

Source: Navotas City Socio-Economic Profile (2015)

As of this date, Maynilad has already finished their project around Navotas that’s why they experienced high pressure water connection in all barangay. Many of Navoteños satisfied with the water coming from Maynilad, but the problem now is water consumption that they use. This project is with the cooperation of the Mayor and Maynilad Water Services Inc. (MWSI).

2.4.2.5.2 Sewerage

Maynilad Water Services, Inc. (Maynilad) is the water and waste water services provider for the West Zone (Metro Manila) and Cavite. It is the only service provider for the planning area regarding to sewerage and sanitations. Navotas city has an existing sewerage network, which is connected to the Dagat-dagatan Sewerage System.

Under the Dagt-dagatan Sewerage System, 67 km long sewers are collecting wastewater from Manila, Navotas, Malabon and Coocan to be treated at the Dagat-Dagatan Sewage and Septage Treatment Plant (DDSSTP). The plant is located in Maypajo, Caloocan City.

The Dagat-dagatan sewage treatment system is composed of two modules with aerated lagoon, facultative pond and polishing pond, where wastewater stays for more than 10 days to undergo biological treatment. This sewage treatment plant has a capacity of 26,000 m3/day. Table below shows the water demand forecast in Navotas for the 2015 to 2035.

Table 2-66 Water demand forecast in Navotas (2015-2035)

Navotas	2015	2020	2025	2030	2035
Water Demand (MLD)	33.71	33.77	44.12	50.8	52.66
Wastewater Generated (MLD)	26.97	30.22	35.3	40.64	42.13

2.4.2.5.3 Power supply

The table below presents the classification of MERALCO customers within the impact area as of December 2012.

Table 2-67 Households with electricity (2010)

Customer Classification	Number of Households being served by MERALCO
Residential	28,570
Commercial	2,596
Industrial	140
Streetlights	16
Total	31,322

Source: Navotas City Socio-Economic Profile (2015)

2.4.2.5.4 Communication

Major telecommunication companies like the Philippine Long Distance Telephone (PLDT) Company, Globe Telecom, Smart Communications and Sun Cellular render telephone services in Navotas. These networks are easily accessible and have good network coverage through mobile system and landlines. Access to National and International Distance Dialing as well as National and International Operator Assisted Long Distance services are also available via any of the major networks. Payphones and loading stations can be found in many sari-sari stores within the city.

There is a number of courier providers in Navotas, namely Navotas Postal Services and LBC Express which are both located in Barangay Sipac-Almacen. Major newspapers – both broadsheets and tabloids – are also available in the City of Navotas on a daily basis. In addition, televisions and radios are common such that everyone gets to know the news worldwide. Internet communication is also available for those who can afford to have computers. Presence of internet shops increases.

2.4.2.5.5 Peace and order

The protective service sector provides the security and public order in the locality. It facilitates effective operation of government operations/projects and secures the residents as they go about in their daily lives.

Police service

At present, the Navotas Police Station is ably manned by a total of 292 personnel broken down as follows:

Table 2-68 Number of personnel in Navotas Police Station as of 2015

Navotas Police Station Personnel	Number
Police Commissioned Officers	18
Police Non-Commissioned Officers	263
Non-Uniformed Personnel	11
Total	**292**

Source: Navotas City CLUP (2016-2025)

Crime rate

The Average Monthly Crime Rate for 2013 is presented in the following figure:

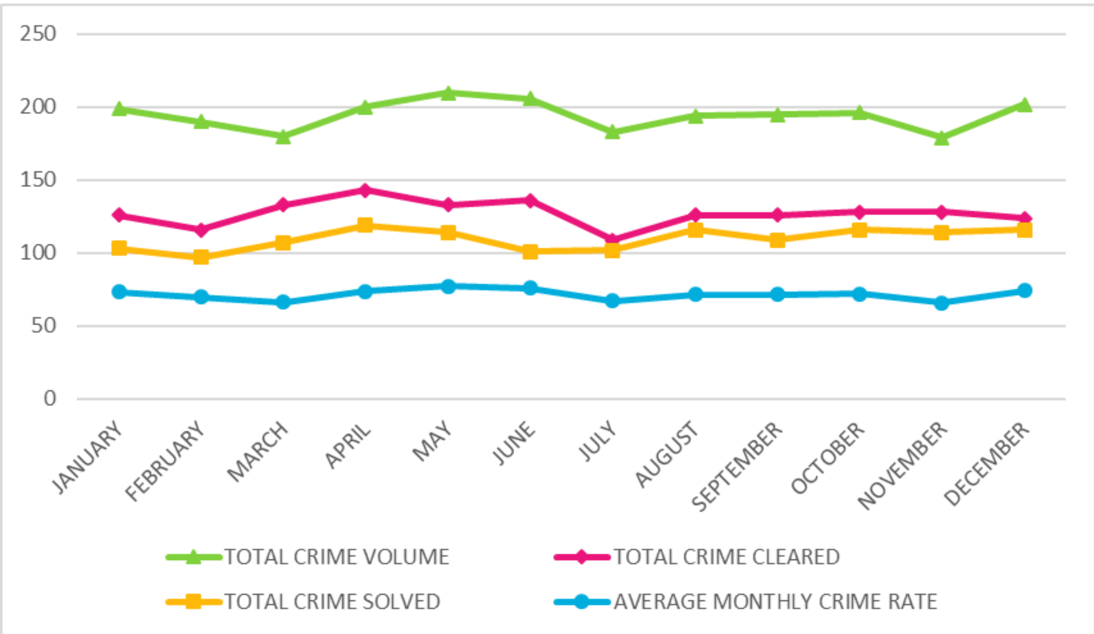


Figure 2-147 Monthly crime profile in Navotas City (2013)
Source: Navotas City Socio-Economic Profile (2015)

The Navotas City Jail is located at M. Naval St., Sipac, Navotas City, along Navotas River. The facility is currently situated at the back of the Navotas Sport Complex. The city jail can only accommodate 200 inmates. However, at present, it houses a total of 637 inmates which makes this jail 318.5% congested.

2.4.2.5.6 Education facilities

There are 15 public elementary schools in Navotas, 9 are located at District 1 and 6 are located at District 2. There are 5 public schools offering secondary education. Twenty-nine (29) private schools exist in the city offering pre-school, elementary, secondary and tertiary education. There are also 2 colleges in the city and a manpower-training center, which offers courses ranging from automotive to cosmetology classes.

Elementary level

The table below represents the comparison of gross enrolment of public elementary schools in three (3) school years. It was shown that there is a decrease in the number of enrollees in the city which may be attributed to the relocation and transfer of residence of the students.

Table 2-69 Gross enrolment in public elementary schools (2013-2016)

District	2013-2014			2014-2015			2015-2016		
	M	F	Total	M	F	Total	M	F	Total
Navotas I	10,926	9,795	20,721	10,480	9,515	19,995	9,626	8,997	18,623
Navotas II	6,141	5,672	11,813	6,188	5,687	11,875	5,851	5,424	11,275
Total	**17,067**	**15,467**	**32,534**	**16,668**	**15,202**	**31,870**	**15,477**	**14,421**	**29,898**

Source: Navotas City Socio-Economic Profile (2015)

In addition, the comparison of gross enrolment of private elementary schools from SY 2013-2014 to 2015-2016 is shown in the subsequent table.

Table 2-70 Gross enrolment in private elementary schools (2013-2016)

District	2013-2014			2014-2015			2015-2016		
	M	F	Total	M	F	Total	M	F	Total
Navotas I	374	345	719	427	378	805	270	228	498
Navotas II	414	367	781	346	304	650	528	481	1,009
Total	**788**	**712**	**1500**	**773**	**682**	**1455**	**798**	**709**	**1,507**

Source: Navotas City Socio-Economic Profile (2015)

Secondary level

Table 2-71 shows a comparative data on the gross enrolment in public secondary school for the last three consecutive years. Based on the data, Navotas NHS is the only school where there is an increased enrolment, while the rest is decreasing due to transfer of residence or relocation of the students.

For the private schools, it can be gleaned on Table 2-72 that Governor Pascual College is the only private secondary school in the city to have an increase in enrollment for the last three (3) years.

Table 2-71 Gross enrolment in public secondary schools (2013-2016)

School	2013-2014			2014-2015			2015-2016		
	M	F	Total	M	F	Total	M	F	Total
Navotas NHS	1759	1790	3549	1816	1746	3562	1799	1788	3587

School	2013-2014			2014-2015			2015-2016		
	M	F	Total	M	F	Total	M	F	Total
Tanza NHS	541	564	1105	560	547	1107	556	585	1141
Kaunlaran NHS	1859	1905	3764	2040	1998	4038	1872	1795	3667
San Rafael NHS	682	528	1210	569	433	1002	460	389	849
San Roque NHS	1286	1294	2580	1257	1325	2582	1193	1249	2442
Tangos NHS	761	695	1456	762	705	1467	719	686	1405
Total	6888	6776	13664	7004	6754	13758	6599	6492	13091

Source: Navotas City Socio-Economic Profile (2015)

Table 2-72 Gross enrolment in private secondary schools (2013-2016)

School	2013-2014			2014-2015			2015-2016		
	M	F	Total	M	F	Total	M	F	Total
San Jose Academy	254	218	472	230	216	446	210	229	439
Governor Andres Pascual College	483	439	922	592	582	1174	649	651	1300
La Naval Academy	83	104	187	74	92	166	73	86	159
Total	820	761	1581	896	890	1786	932	966	1898

Source: Navotas City Socio-Economic Profile (2015)

There are 15 elementary schools in Navotas which have 896 teachers for 35,256 students for school year 2013-2014. The teacher-student ratio is 39.35. There are 5.65 difference compared to the standard ratio of DepEd.

On the other hand, six (6) high schools were present in Navotas City for 13,710 students as of 2013-2014. The teacher-student ratio is 27.59 and its difference with the standard ratio of DepEd is 17.91.

Tertiary

There are 2 tertiary education institutions in Navotas, the Navotas Polytechnic College (NPC), a public tertiary school, and the Gov. Andres Pascual College, a private tertiary school. The Navotas Polytechnic College gives priority to poor but deserving students aiming for a college education. There are 9 courses being offered in NPC, 2 of which was offered last School Year 2009-2010 and these are the Computer Systems & Programming, and Computer Systems & Network Technician. The special course in Call Center started April 2008. There were 4,123 students enrolled in the institution for the school year 2015-2016.

Vocational/Non-formal education

As part of the initiative of the local government of Navotas, programs such as non-formal, continuing and vocational education are conducted in various institutions to educate and provide the residents knowledge for possible livelihood projects. The Navotas Manpower Training Center is one institution that provides skills training for out-of-school youth. The institution offers (7) hard trade courses like Shielded Metal Arc Welding, Electrical Installation and Maintenance, Consumer Electronics, Refrigeration and Air Conditioning, Automotive, Dressmaking and Gas Tungsten Arc Welding. The number of enrollees and graduates for each program are indicated in the table below.

Table 2-73 Navotas manpower and training center accomplishment (2015)

Trade Courses	Enrolees	Graduated
Automotive Servicing	82	56
Building Wiring Installation	68	47
Consumer Electronics	39	24
Shielded Metal Arc Welding	125	94
Refrigeration and Air Condition	24	23
Dress Making	24	24
Gas Tungsten Arc Welding	30	29

Source: Navotas City Socio-Economic Profile (2015)

2.4.2.5.7 Fire protection

The following data was taken from the Comparative Program Review and Mission Accomplishment Report of the Navotas City Fire Station for the CY 2014 and CY 2015. The Navotas City Fire Station has established various activities and accomplishments towards the betterment of fire services in the locality, as stated herein during the period under review.

For the year 2014 and 2015, there were zero fatalities in Civilian and Fire Fighter. However, the injuries acquired from the Fire Incidents decreased as of 2014 compared to 2015. Fire incidents AOR increased to 0.58% as seen on the table below while fire incidents within AOR increased to 0.09%.

Table 2-74 Fire incidence in Navotas City, 2014-2015

Causes of Fire	2014	2015
Electrical Connections	36	45
Electrical Appliances	1	2
Electrical Machineries	1	0
Spontaneous Combustion	1	0
Open Flame Due to Unattended Cooking / Stove	7	1
Open Flame due to Torch or Sulo	2	1
Open Flame due to Lighted Candle or Gasera	4	4
LPG Explosion Due to Lighted Candle or Gasera	1	2
LPG Explosion Due to Direct Flame Contact or Static Electricity	5	2
Lighted Cigarette Butt	0	1
Chemicals	0	0
Pyrotechnics	0	5
Lighted Matchsticks or Lighter	0	0
Incendiary Device/Mechanism or Ignite	0	0
Lightning	0	0
Bomb Explosion	0	0
Under Investigation	1	0
Others	0	2
Total	59	65
Intentional	0	0
Accidental	59	65
Under Investigation	0	0
Residential	23	27
Industrial	0	1
Mercantile	2	1
Storage	2	0
Mixed Occupancy	1	0

Causes of Fire	2014	2015
Business	1	1
Educational	0	0
Detention & Correction	0	0
Assembly	0	0
Health Care	0	0
Miscellaneous/Other	17	28
Grass/Rubbish & Forest Fires	5	2
Vehicular Fire		
Motor Vehicle	0	1
Ship/Water Vessel	6	4
Aircraft	0	0
Locomotive	2	0
Total	59	65
Firefighter	0	0
Civilian	0	0
Firefighter	0	1
Civilian	10	1

Source: Navotas City Socio-Economic Profile (2015)

2.4.2.5.8 Disaster risk management

In terms of institution, the Navotas City Disaster Risk Reduction and Management Council had been active in terms of performing its functions pursuant to Republic Act No. 10121 otherwise known as the Philippine Disaster Risk Reduction and Management Act of 2010. The Navotas City Disaster Risk Reduction and Management Office had already been institutionalized to take-charge of capacity building measures both on the part of the local government and the population.

A Joint Rescue Team was also organized in order to harness the support of the private and non-government organizations in terms of emergency and disaster preparedness and response. A network of volunteers is in close coordination with the rescue team, particularly in time of urgent needs. As to information dissemination, the city utilizes its social networking sites (i.e. Facebook, Twitter, and Website) in order to facilitate wide information sharing as to pre-, during, and post-disaster activities. The TxtJRT mechanism also enables the residents to obtain and provide information regarding disaste s and emergencies.

To address flooding, the City is continuously investing in the institution of mitigating easures like construction of additional pumping stations, river walls and coastal dikes in various strategic locations in the city, including those highly susceptible to flooding in order to minimize, if not completely eliminate, flood occurrence. At present, there are 40 “Bombastik” pumping stations around Navotas and the construction of a 3.5-kilometer coastal dike along Manila Bay has already started.

As part of the Oplan Likas Program of the national government and in coordination with the National Housing Authority, relocation of informal settler families (in-city and off-city), particularly in coastal areas and waterways are ongoing. Even though the fishponds in Barangay Tanza are considered to have a moderate risk from flooding, the city government cannot institute structural mitigating measures for the reason that these fishponds are privately owned. The table below elaborates the state of the adaptive capacity of the citizens in terms of insurance coverage, availability of alternative sites, capacity to relocate or retrofit, allocation of government resources for risk reduction, and capacity to conform to additional zoning regulations.

The following table presents the inventory of tools and equipment for disaster risk preparedness in Navotas City.

Table 2-75 Inventory of tools and equipment for disaster

Quantity	Unit	Description
2	Pcs	Trauma Kits
10	Pcs	Rescue Knives
1	Unit	Portable inflatable emergency and disaster lighting
1	Pc	Rescue can (life buoy can)
5	Pcs	Water rescue helmet
10	Pcs	Type 3 responder's life vest
1	Unit	Fiber glass rescue boat
2	Units	Amphibian
1	Unit	. Rubber rescue boat
50	Yards	Utility rope
1	Roll	Water rescue rope
10	Pcs	Harness
21	Pcs	Heavy duty flash lights
1	Roll	Nylon rope, 12 mm
1	Roll	Nylon rope, 14 mm
410	Pcs	First Aid kit with accessories
140	Pcs	Flashlights
1560	Pcs	Headlamp
1	Pc	Megaphone
11	Units	generator set
2	Pcs	life ring
6	Units	base radio
132	Units	handheld radio

Source: Navotas City CLUP (2016-2025)

2.4.2.6 Public health and safety

2.4.2.6.1 Health resources

Navotas City has 11 health centers located in 9 barangays, and an emergency and lying-in clinic which is located in Barangay San Jose. There are five (5) health centers which are Sentrong Sigla accredited namely Tanza Health Center, Tangos Health Center, San Roque Health Center, NBBN Health Center and Kaunlaran Village Health Center respectively. Two (2) additional health centers – Phase 2 Area 1 Health Center and Adolescent Friendly Health Care Center were constructed and renovated and are located in Barangay North Bay Boulevard South. For Philhealth accredited facilities, all except one (1), the Sipac Health Center are PHIC accredited. For Directly Observe Treatment Short Course (DOTS) accredited Health Center, there are three (3) - Bagumbayan Health Center, NBBN Health Center, and Tanza Health Center are DOTS accredited while NBBN Health Center served also the city's Private-Mixed DOTS unit. These health facilities provide basic health care services like Family

Planning and Counseling, Maternal and Child Care. Nutrition, Care for Elderly, Adolescent Youth Health Care Development, Management of Infectious Disease, Risk management of lifestyle related diseases among others.

The city had a total of 112 public health personnel in plantilla positions while 37 are employed on a contractual basis. There are four (4) physicians functioning as consultants who are part of the one hundred ninety informal personnel. This list includes only public providers.

There are seventeen (17) physicians. One (1) is the City Health Officer, One (1) is the Assistant City Health Officer. Ten (10) of them assigned in the health centers and, One (1) assigned in technical section, One (1) is assigned in the Animal Bite Center (1), and three (3) of them are assigned at the Navotas City Hospital. There are eleven (11) dentists, one (1) of whom functions as a supervisor. Twenty-one (21) nurses are health center based, one in technical section and two (2) are nurse supervisors in administration section. There are six (6) medical technologists in permanent positions; one (1) of whom is assign in Drug Testing Center. There are three (3) nutritionists and thirty-eight (38) midwives. Among the midwives, two (2) are in administrative functions, twenty-one (21) are health center based and eleven (11) are based in the lying in clinic. There are also six (6) sanitary health inspectors in the city. There are two (2) detailed staffs in the administration.

Table 2-76 Health personnel in Navotas City (2015)

Health Personnel	Number	Population Ratio	Ratio Per RHU Personnel Standards
Physician	15	17,320	1:20,000
Dentist	10	25,980	1:25,000
Nurse	19	13,673	1:20,000
Medical Technicians	6	43,300	1:45,000
Nutritionist/Dieticians	3	86,601	1:125,000
Midwife	38	6,836	1:10,000
Sanitary Inspector	6	43,300	1:40,000
Barangay Nutrition Scholar	19	-	-
Barangay Health Workers	190	-	-

Source: Navotas City Socio-Economic Profile (2015)

2.4.2.6.2 Morbidity and mortality

Overall morbidity in the city is 90,357. Half of these are infectious in nature, with respiratory disorders leading by a wide margin accounting to about 55.6%. Similarly, the majority of infant morbidities in the city are infectious, again with respiratory infections leading by a wide margin. Nutritional deficiencies such as avitaminosis also affected the infants.

Table 2-77 Leading causes of morbidity in Navotas City (2015)

Causes	Total	Rate
All Ages		
1. Acute Respiratory Tract Infection	50,323	193.69
2. Skin Infections (all types)	5,614	21.60
3. Allergies (all types)	4,246	16.34
4. Urinary Tract Infections	3,302	12.70
5. Gastroenteritis	3,033	11.67
6. Hypertension	2,717	10.45

Causes	Total	Rate
7. Conjunctivitis	1,865	7.17
8. Asthma	1,679	6.46
9. Trauma (all types)	1,328	5.11
10. Acid Peptic Disease	1,143	4.39
Under Five		
1. Acute Respiratory Tract Infection	23,733	550.30
2. Allergies (all kinds)	2,375	55.07
3. Skin Infections (all types)	2.340	54.26
4. Gastroenteritis (all types)	1,794	41.60
5. Trauma (all types)	975	22.61
6. Parasitism	861	19.96
7. Asthma	760	17.62
8. Conjunctivitis	624	14.47
9. Bronchitis	495	11.48
10. Urinary Tract Infection	409	9.48
Infant		
1. Acute Upper Respiratory Tract Infection	7,692	870.83
2. Allergies (all kinds)	954	108.00
3. Skin Infections (all types)	668	75.63
4. Gastroenteritis (all types)	481	54.45
5. Trauma (all types)	210	23.77
6. Parasitism	203	22.61
7. Asthma	182	20.60
8. Conjunctivitis	160	18.11
9. Ear Infections	83	9.40
10. Pneumonia	49	5.55

Source: Navotas City Socio-Economic Profile (2015)

There were a total of 1,080 deaths with the rate of 4.15 per 1,000 populations in 2015. There were more deaths among males compared with females. The city's mortality pattern illustrates a double-burden of disease, with non-communicable diseases as the main cause of mortality along with infectious illnesses.

The leading causes of mortality are myocardial infarction, followed by Pneumonia and Congestive Heart Failure. Tuberculosis remains as one of the leading causes of mortality accounting for 37 deaths. Other leading non-communicable illnesses include HCVD, Diabetes Mellitus, COPD, Status Asthmaticus. Other causes of mortality may or may not be caused by infectious diseases.

Table 2-78 Leading causes of mortality in Navotas (2015)

Causes	Male	Female	Total	Rate*
All Ages				
1. Myocardial Infarction	153	71	224	0.86
2. Pneumonia	76	79	156	0.59
3. Cancer (all kinds)	61	63	124	0.47
4. Congestive Heart Failure	55	17	72	0.27
5. Cerebrovascular Accident	40	18	58	0.22
6. HCVD	26	23	49	0.18

Causes	Male	Female	Total	Rate*
7. PTB	28	9	37	0.14
8. Medico Legal (GSW)	30	6	36	0.13
9. Senility	8	26	34	0.13
10. Diabetes Mellitus	14	19	33	0.12
Under Five				
1. Pneumonia	23		3.42	
2. Respiratory Distress Syndrome	5		0.74	
3. Aspiration (Meconium, Cord Coil)	4		0.59	
4. Dehydration	4		0.59	
5. Sepsis	3		0.45	
Status Asthmaticus	3		0.45	
Sudden Infant Death Syndrome	3		0.45	
Intrauterine Fetal Death	3		0.45	
6. Biliary Atresia	2		0.30	
Hydrocephalus	2		0.30	
7. Meningococcemia	1		0.15	
Anemia	1		0.15	
Ischemic encephalopathy	1		0.15	
Fetal Distress	1		0.15	
Acute Gastroenteritis	1		0.15	
Congestive Heart Failure	1		0.15	
Cerebral Hypoxia	1		0.15	
Uterine Placental Insufficiency	1		0.15	
Ventricular Septal Defect	1		3.42	
Infant				
1. Pneumonia	17		2.53	
2. Respiratory Distress Syndrome	5		0.74	
3. Aspiration (Meconium, Cord Coil)	4		0.59	
4. Sepsis	3		0.45	
Sudden Infant Death Syndrome	3		0.45	
Intrauterine Fetal Death	3		0.45	
5. Dehydration	2		0.30	
6. Status Asthmaticus	1		0.15	
Anemia	1		0.15	
Fetal Distress	1		0.15	
Ischemic Encepalopathy	1		0.15	
Cerebral Hypoxia	1		0.15	
Uterine Placental Insufficiency	1		0.15	
Biliary Atresia	1		0.15	

Source: Navotas City Socio-Economic Profile (2015)

2.4.2.6.3 Crude birth rate (CBR)

The city's crude birth rate (CBR, has been on an upward trend since its lowest point in 2008. This can be attributed to the city's initiative to collect data regarding hospital births outside the city. In 2015, Crude Birth Rate slightly higher from 24.03 per 1,000 population in 2014 to 25.89 in 2015. This rate is also slightly higher than the national average of 24. Having a young and expanding population brings with it many opportunities as well as a multitude of challenges, especially for the urban poor.

2.4.2.6.4 Crude death rate (CDR)

The city's crude death rate slightly decreased this year at 4.15 per 1,000 population. This is considered to be below the national average of 5. The CDR has increased slightly in 2014 but dropped slightly in 2015.

2.4.2.6.5 Infant mortality rate (IMR)

The city's infant mortality rate (IMR) dropped dramatically from 2011 to 2012 and slightly increased in 2013. In 2014, it increased at 10.80 per 1,000 live births, and that is still way below the 2016 national average of 17 per 1,000 live births. In 2015, it dropped again to as low as 6.5 per 1,000 live births. This can be attributed to the increase in attendance of birth by qualified health professionals both in the hospitals, and in public and private lying in clinics and that mothers tend to deliver their babies in accredited health facilities.

2.4.2.6.6 Environmental health and sanitation

The typical wastewater or sewage treatment facility used by the residents is the septic tank. However, the informal settlers do not have the capacity to construct and use septic tanks and thus significantly contribute to the pollution of the rivers and the Manila Bay with consequent effects on health and sanitation. Desludging or siphoning of septic tanks is a free service of the Maynilad Water Services, Inc. (MWSI).

2.4.2.7 Socio-economic profile

2.4.2.7.1 Main sources of income

Agricultural activities in the city are concentrated in the fisheries production. Crop and livestock productions are very minimal and limited to home and backyard production activities. The lack of available space for these activities was the primary reason given.

Fishery production in the city involves mostly marginal fisherfolks where 5,497 fisherfolks are registered for the year 2015. Of the 12 barangays involved in fishery production, Barangays Tangos, Tanza, and San Jose are the top three barangays with the most number of fishing boats. More than 60% of the fishing boats in the city are in Tangos. There are 374 registered boats for the year 2015 according to city department of agriculture.

In addition, based on the accomplishment report of the City Department of Agriculture for 2010, Fisheries & Aquatic Resources Management Councils (FARMCs) can be strengthened by conducting regular meetings and orientations to all Bantay Dagat personnel. In addition, Mayor John Rey Tiangco imposed all Barangay Captains to create Bantay Dagat personnel in their respective barangay to ensure the safety of Manila Bay from illegal dynamite fishing.

2.4.2.7.2 Average income

The average family income per year in Navotas City is P60,000.00 and the average family size is 4.65. It is estimated, based on these figures, that the income per capita in Navotas is P12,903.22.

2.4.2.7.3 Employment rate/profile

The labor force of the city as described in the DSWD NHTS-PR database for poor households is shown in the table below. The labor force of the city stands at 63,072.

Table 2-79 Labor force (age 15 years old & above) by highest educational attainment (2013)

Labor Force	No. of Grade Completed	Kinder or Daycare	Elementary (any level)	High school (any level)	College (any Level)
63,072	915	241	23,476	33,301	5,139

Source: Navotas City Socio-Economic Profile (2015)

2.4.2.7.4 Commercial establishments and financial institutions

The fishing industry comprises about 59.21% of the total number of industries established in Navotas. Other local industries include fishpond industry (3.29%), manufacturing (30.92%) and shipyard/shipbuilding maintenance and repair (6.58%).

Table 2-80 Business establishments in Navotas City (2015)

Type of Business Establishment	No. of Business Establishment
Industry	
- Fishing Industry	90
- Fishpond Industry	5
- Manufacturing Industry	47
- Shipyard	11
Commerce & Trade	948
Services	795

Source: Navotas City Socio-Economic Profile (2015)

Food manufacturing industries are involved mostly in the processing of fish sauce, dried smoked fish, fishmeal and bagoong. These are mostly small scale in nature and usually carried out in the homes. The small scale processing activities usually employ traditional methods of food processing that most often lack proper waste disposal systems.

Shipyards involving shipbuilding, repair and maintenance were major economic contributors in the past. Somehow, these declined in number. Together with the decline in number is the deterioration of the condition of a number of shipyards thereby causing not only water and air pollution, but noise pollution as well. On the other hand, Commercial and trade establishments comprise mostly of sari-sari stores (459), general merchandise (97), food and beverage (140) and pharmaceutical products (38)

A total number of 19 local financial institutions are located in Navotas. These institutions provide a number of services, which include, among others, the provision of loans and business financing. These institutions are mostly located in barangays North Bay Boulevard South and San Jose.

In terms of established cooperatives in the city, Navotas has a total of 8 active cooperatives, which are mostly multi-purpose, non-agricultural in nature. Most of these cooperatives are into savings and loan services.

2.4.2.8 Traffic

The City of Navotas is served by a network of roads, mostly concrete, and provides internal access within the city to all the barangays. Several roads serve as important linkages of the city to the rest of Metro Manila and other nearby municipalities and cities in Bulacan. The table below shows the list of all National Road Network by length and width.

Table 2-81 Existing national roads in Navotas City by length and width (2014)

Name of road	Length (km)	Width (m)	Concrete	Asphalt
1. C-3 Road	0.607	30	100%	-
2. Gov. A. Pascual St.	3.732	15	100%	-
3. M. Naval St.	4.410	15	100%	-
4. North Bay Boulevard	2.609	20	100%	-
5. R-10 Road	2.150	30	100%	-
6. C-4 Road	0.866	20	100%	-
7. Lapu-Lapu Ave.	1.006	20	100%	-

Source: Navotas City Socio-Economic Profile (2015)

The above specified width information clearly show that all these roads have a 2- way capacity, therefore these roads if used properly can accommodate at least 4 vehicles at a time. In terms of pavement type, all of the major roads in Navotas are of concrete type.

Since all of the barangays in Navotas can be classified as urban, the lack in road can be determined from the population. Based on the May 2010 census, the city has a total population of 249,131, and by applying the standard of 2.4 kilometers per one thousand population, we have computed the actual needed roads of the city. It is computed to be at 588.82 kilometers. However due to space constraints, this may not be realized. As a result, mobility in the city can be best achieved by traffic management.

Bridge and culvert

Having the aggregate shoreline and rivers within Navotas, it is empirical that bridges will provide easier access within the city and continuity of traffic. There are nine bridges around Navotas.

The main issue with the bridges is its capacity to service the transport links in the city. With the progress of time and continuous use of these infrastructures, it is expected that they will deteriorate and will require maintenance. Budgetary considerations pose part of the constraints, which is among the problems of the city government.

Table 2-82 Bridges in Navotas City (2015)

Name of bridge	Bridge description					
	Capacity (Ton)	No. of span	Length	Width	Type of construction	Year constructed
1. Spine Bridge (Left Lane Caloocan Boundary)	15	3	66.76	7.28	PCDG	1986
2. Spine Bridge (Right Lane Caloocan Boundary)	15	3	66.76	7.28	PCDG	1986
3. Tanza Bridge	20	3	45	6	PCDG	1996
4. R-10 Bridge	15	5	106.3	15	PCDG	1993
5. Maralla Bridge	20	3	48.05	13.9	PCDG/RCDG	1992
6. Bangkulasi Bridge (Cut-off Channel)	15	3	49.6	7.3	RCDG	1952
7. C-3 Bridge	15	3	73.6	8.6	PCDG	1982

Name of bridge	Bridge description					
	Capacity (Ton)	No. of span	Length	Width	Type of construction	Year constructed
(Left Lane Caloocan Boundary)						
8. C-3 Bridge (Right Lane Caloocan Boundary)	15	3	73.6	8.6	PCDG	1982
9. Estrella Bridge	20	3	79	7.3	PCDG	1996
10. C-4 Bridge 1	20	5	106.5	15.1	PCDG	1992
11. C-4 Bridge 2	20	3	73.5	15.3	PCDG	1993

Source: Navotas City Socio-Economic Profile (2015)

2.4.3 Perception survey

The survey was divided into three major components, namely (1) Socio-Demographic Profile of respondents (2) Disaster Response and (3) Perception of the proposed project.

2.4.3.1 Demographic profile of respondents

2.4.3.1.1 Gender

The respondents were composed of 26% males and 74% females.

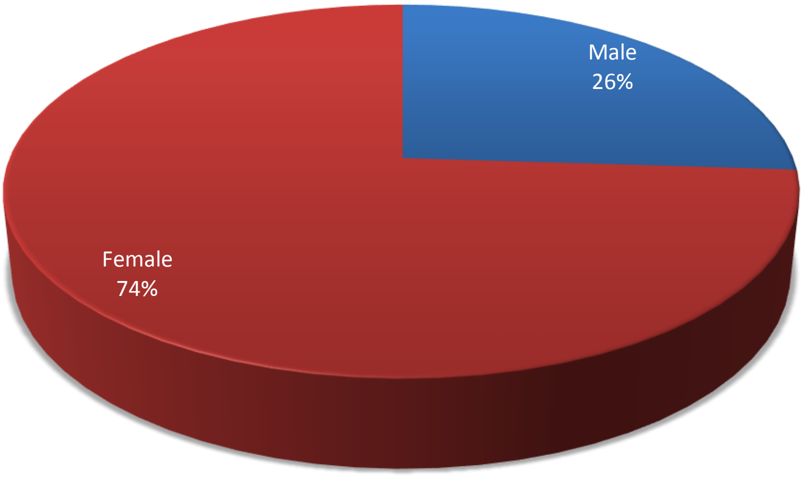


Figure 2-148 Gender of respondents

2.4.3.1.2 Age

More than half (53%) of the total number of respondents belong to 20-40 age group followed by 41-60 age group (34%).

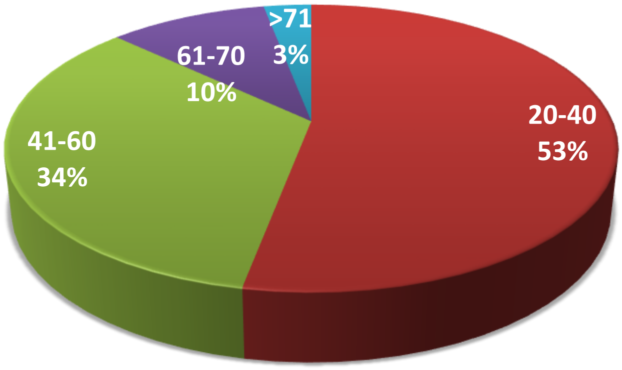


Figure 2-149 Age of respondents

2.4.3.1.3 Birth place

As observed in Figure 2-150, majority of the respondents were migrants who came from Luzon outside Navotas (34%), Visayas (15%) and Mindanao (4%). Forty-seven percent (47%) are born in Navotas City.

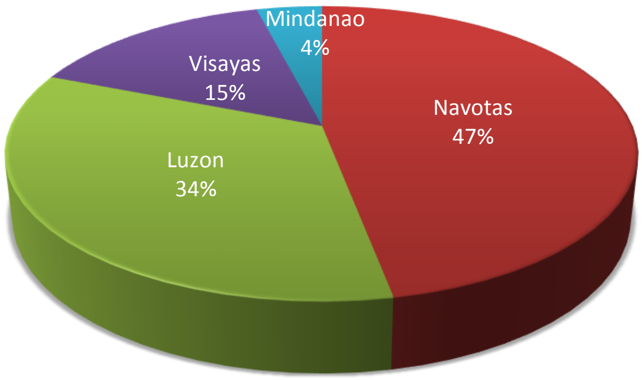


Figure 2-150 Place of birth of respondents

2.4.3.1.4 Civil status

Given the age group the respondents belong, 47% are married while 31% are single as can be seen in the following figure:

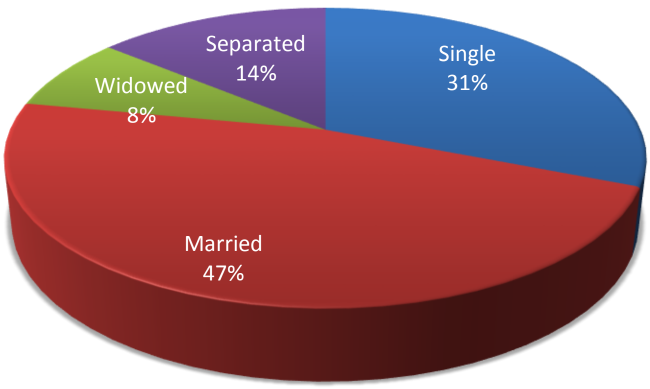


Figure 2-151 Civil status of respondents

2.4.3.1.5 Religion

Majority of the respondents are Roman Catholic as seen on Figure 2-152.

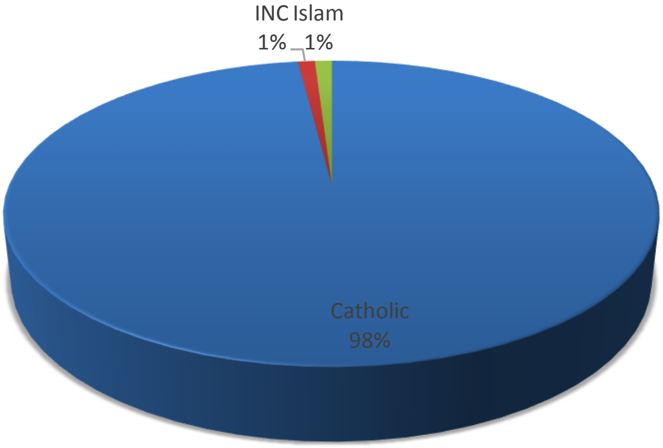


Figure 2-152 Religion of respondents

2.4.3.1.6 Settlement history

Twenty-nine percent (29%) of the total respondents have resided in the Barangay for 11-20 years. Moreover, approximately 25% of the total respondents have been living in the barangay for 21-30 years.

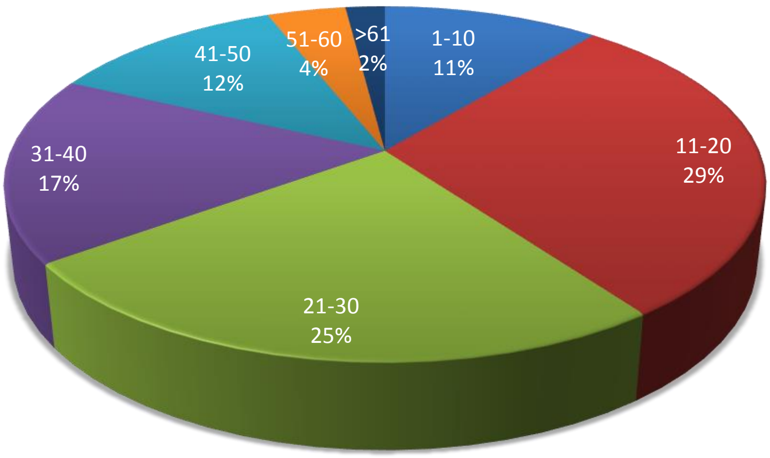


Figure 2-153 Years of residence in the barangay

2.4.3.2 Socio-economic profile of respondents

2.4.3.2.1 Income, livelihood and employment

The primary source of income of 33% of the total number of respondents is salary followed by fishing (20%) and selling (20%). Sixty percent (60%) of the respondents stated that the husband is the primary earner in the household while 14% has the wife as the primary earner.

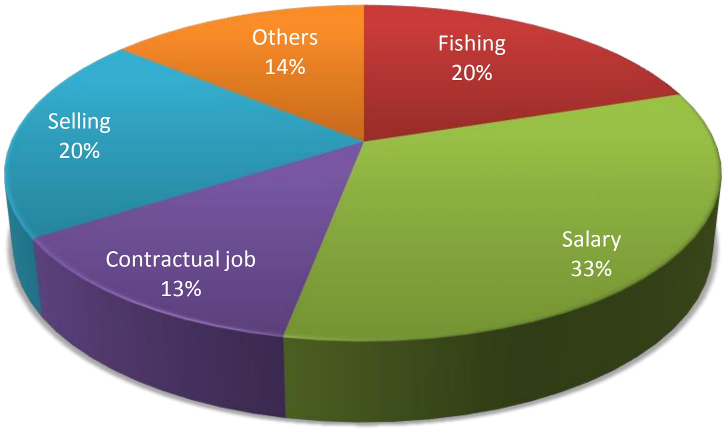


Figure 2-154 Main sources of livelihood of respondents

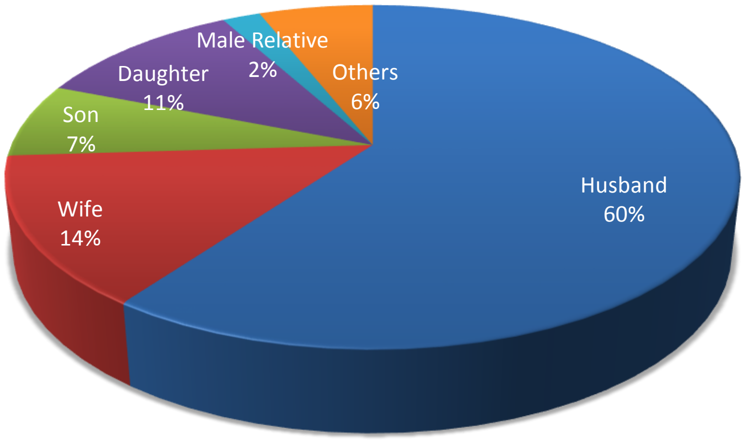


Figure 2-155 Primary earner in the household

The monthly poverty threshold for a family of five, according to NSO, is an average income of P8,022 per month. This amount is enough to cover a single family's basic food and non-food needs. Poverty threshold refers to the minimum income a family or individual must earn in order to be considered "not poor". Secondary data suggest that the average household size in Barangay Tanza is 4-5 persons.

In the following figure, it is observed that more than 35% of the respondents earn at least 10,000 pesos per month while the rest earn less than a thousand to 9,999 pesos monthly. It can be estimated that those whom classified as "poor" ranges from 29 to 65%.

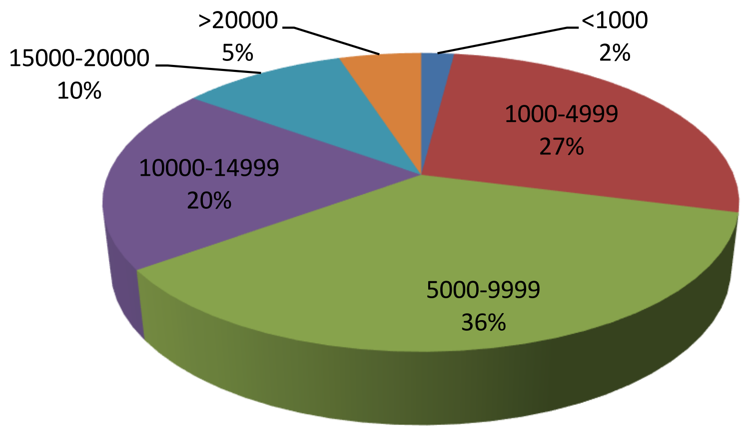


Figure 2-156 Monthly income of respondents

2.4.3.2.2 Housing condition

The largest percentage share of the respondents about their ownership status are tenants (37%) while 35% are owners. Sixty-eight (68%) considered their property as in a good condition.

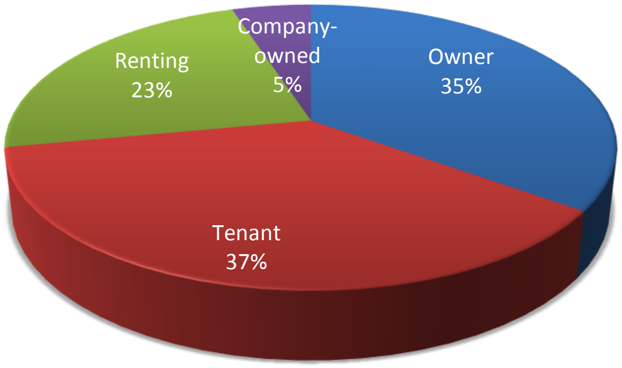


Figure 2-157 Landholding status of respondents

2.4.3.2.3 Educational attainment

In the following figure, 40% of the respondents are high school graduates and 31% are college graduates.

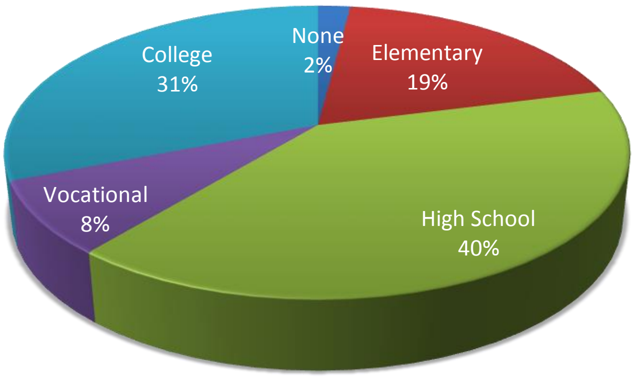


Figure 2-158 Educational attainment of respondents

2.4.3.2.4 Health profile

In 2015, the 72% of the respondents stated that at least one of their household members got sick. Fever, cough, diarrhea and highblood are the most prevalent in the Barangay. Majority of the respondents revealed that the primary source of treatment for such illnesses in the household was in the nearest health center of their community.

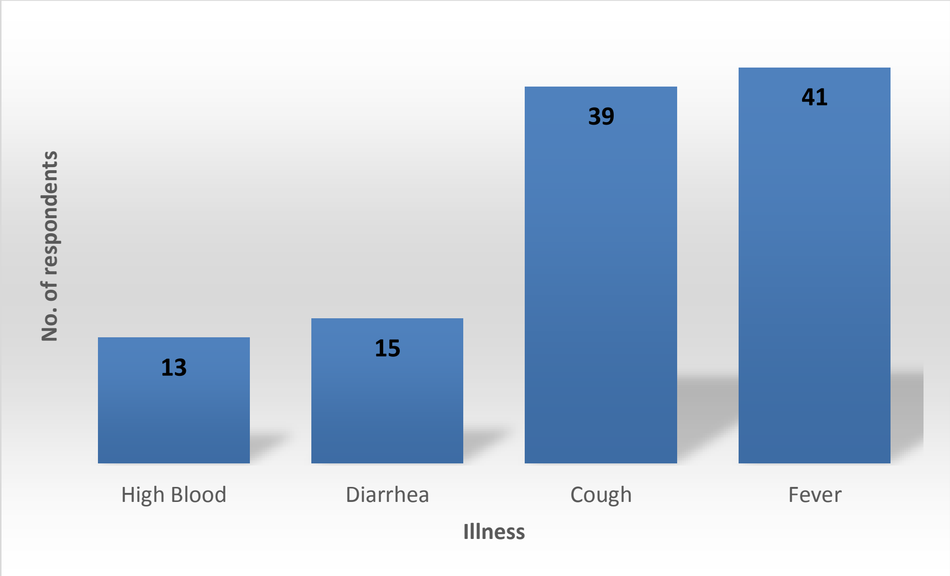


Figure 2-159 Common illnesses in the barangay

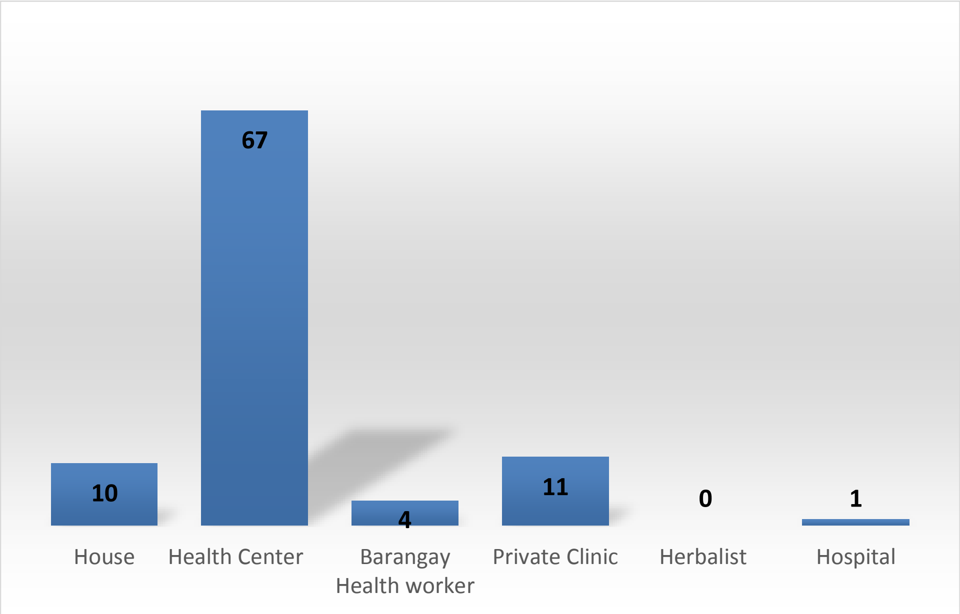


Figure 2-160 Sources of treatment for illness of respondents

2.4.3.2.5 Environmental health and sanitation

Unsanitary practices and facilities may cause diseases and infections that are detrimental to health and might even cause death.

Based on the following figures, 63% of the total number of respondents has access to improved sanitation facilities. Moreover, 93% of respondents have access to water supply system whereas the rest's sources are artesian well and deep well.

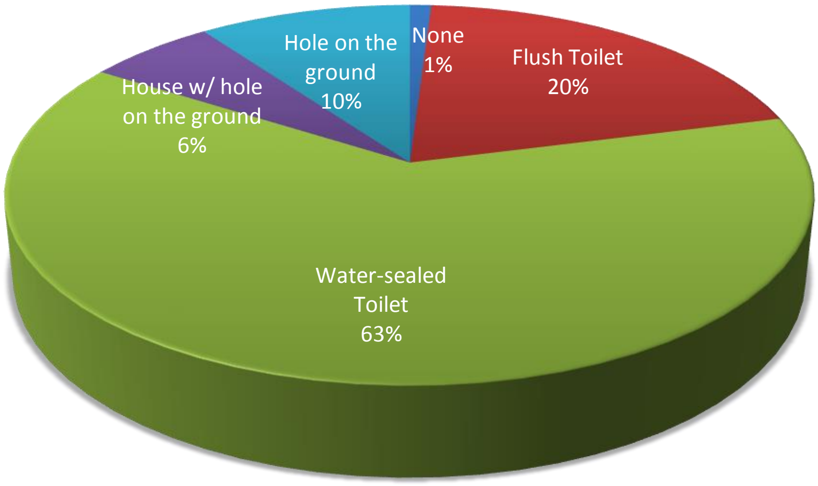


Figure 2-161 Type of toilet facility used by respondents

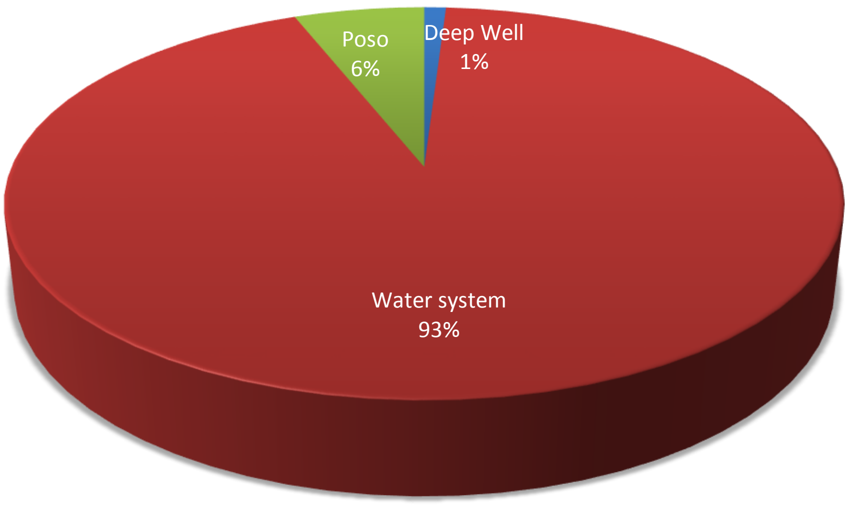


Figure 2-162 Sources of water supply

2.4.3.3 Disaster response

All respondents (100%) in the impact barangays have experienced typhoon/storm and flooding. Such calamities have affected health, properties, environment, food supplies and infrastructures.

Majority of the respondents stated that the levels of responses for disasters are not adequate. They also rated the level of community participation for disasters as not adequate.

In terms of disaster preparation, Barangay Tanza has enough/commensurate capability for disaster response according to 88% of the respondents such as trainings and seminars.

Eighty-five percent (85%) also stated that their community has enough/commensurate infrastructures and equipment allotted for disaster response.

2.4.3.4 Perception

2.4.3.4.1 Perceived community problems

The biggest problem faced by the community is flooding (32%). Twenty-five percent (25%) stated that the lack of livelihood is also one of the issues they have encountered. This is followed by Peace and Order (16%), Cleanliness and Sanitation (14%) Health (8%) and education (5%).

2.4.3.4.2 Project awareness and acceptability

Eighty-eight (88%) of the respondents stated that they have prior knowledge about the project. Most of them knew about the project from the barangay.

2.4.3.4.3 Perceived positive and negative impacts of the project

The respondents' perceive benefits from the proposed expansion project are:

1. Livelihood (21%)
2. Improvement of government service (15%)
3. Improvement of roads (11%)
4. Prevent destruction of properties/self-domain (7%)
5. Others (6%)

On the other hand, the perceived negative effects of the project to the community are:

1. Landslide/erosion (65%)
2. Flood (22%)
3. Loss of livelihood in fishing (20%)
4. Spread of Illness/Diseases (13%)
5. Water will be affected (4%)
6. Damage/destruction or loss of farm/agricultural lands (2%)

2.4.4 Public scoping

The issues and concerns raised during the public scoping are:

1. Opportunities for tricycle drivers
2. Loss of fishery resources/main source of livelihood
3. Loss/negative impact on mangrove areas
4. Conflict to other government projects in Barangay Tanza
5. Risks from chemicals found on dredged materials
6. Accumulation of silt
7. Alternative livelihood for fishermen
8. Impacts on shipyard industry
9. Increased flooding
10. Source of borrow materials
11. Heavy siltation due to strong current on the southern part of the proposed reclamation
12. Inclusion of housing projects on the reclamation area

13. Alternative plans on the construction of C5 and C6 road networks

2.4.5 Issues and concerns about the Project

Aside from the secondary data gathered for the study, stakeholder participation for the project were ensured to determine the current situation of the affected residents including the issues and concerns they are experiencing in their community. The following issues and concerns were summarized based on the results from the Review of secondary data, Perception Survey, and Public Scoping:

Table 2-83 Issues and concerns about the proposed project

Aspect	Issues and Concerns
Livelihood/Employment	1. Loss of fishery resources/main source of livelihood
	2. Opportunities for tricycle drivers
	3. Alternative livelihood for fishermen
	4. Impacts on shipyard industry
Public/Social Services	1. Inclusion of housing projects on the reclamation area
	2. Alternative plans on the construction of C5 and C6 road networks
	3. Spread of Illness/Diseases
	4. Conflict to other government projects in Barangay Tanza
Environment	1. Water will be affected (4%)
	2. Loss/negative impact on mangrove areas
	3. Risks from chemicals found on dredged materials
	4. Accumulation of silt
	5. Source of borrow materials
	6. Heavy siltation due to strong current on the southern part of the proposed reclamation
Disaster Risk Management	1. Erosion
	2. Increased flooding

2.4.6 Potential impacts and options for prevention, mitigation or enhancement

Impacts on physical resources

The single secondary data sourced by the EIA team regarding any archaeological study on the area is relatively old (The Philippine Journal of Science, Outline Review of Philippine Archaeology by Islands and Provinces, 1947). A review of the literature on the archaeological significance of the project area shows that the general area of the project site is rich with archaeological finds. Though the general area has already been systematically explored extensively, still it is of potential further or greater archaeological chance finds.

Potential Destruction, mishandling of Archaeological chance finds/ Workers lack of understanding and care to protect the environment and archaeological/ historical sites and cultural monuments.

1. Include the following specific requirement in bid and contract documents:
   a. Withholding of payment or penalty clauses, to ensure contractor's implementation of environmental and archaeological mitigation measures;
   b. Employment of a designated Environmental Specialist and a designated Archaeologist to oversee environmental and archaeological issues and mitigation; and
   c. Provision of environmental and archaeological orientation/workshop.

2. Environment Protection, Health and Safety Orientation Plan
    i. The purpose of this sub-plan is to document the approach of the general contractor (GC), Subcontractors (SCs), and their workers in the implementation of a training program for construction workers in relation to environmental, archaeological, and occupational health and Safety issues.
    ii. Orientation rationale. The implementation of the EMP will require the involvement of all construction personnel. The nature of the EMP is such that personnel at all levels have a degree of responsibility in relation to environmental, archaeological, and occupational health and safety issues and the implementation of measures contained in the EMP. As such, orientation for all personnel in relation to environmental and archaeological issues and the implementation of the EMP will be critical to ensuring the effectiveness of the EMP
    iii. Orientation objective. The objective is to raise and enhance the awareness of the construction workforce in relation relevant legislation and policy issues: a. General environmental awareness, including rules and regulations to be followed on archaeological, historical, cultural sites, construction site and in the construction camps

3. Physical Cultural Resources Plan
    i. The purpose of this sub-plan is to document the approach of the proponent and contractors and their workers to protect identified archaeological, historical, and cultural sites and monuments and to manage any physical cultural resources that are encountered during the construction works.
    ii. The plan should comply with procedures set by the NHCP.
    iii. For archaeological chance, find the procedures *set by NHCP shall be followed.*

In the event of archaeological chance finds:

i. Inform at once the respective institutions governing such matters, specifically the National Historical Commission of the Philippines (NHCP).
ii. Obtain necessary approvals for construction in areas where archaeological finds have been identified, and follow the archaeological chance-find procedures of the NHCP.
iii. Fix borders of archaeological sites to be excavated for preservation and/or investigated.
iv. Incorporate archaeological excavations in construction schedule.
v. To *avoid potential adverse impacts to historic and cultural resources, the Contractor* shall:
    (a) Protect sites of known archaeological, historic and cultural resources by the placement of suitable fencing and barriers.
    (b) Construction camps shall be located 500 meters away from cultural resources.
    (c) Adhere to accepted NHCP practice and all applicable historic and cultural preservation requirements of the NHCP.
    (d) In the event of unanticipated discoveries of cultural or historic artifacts (movable or immovable) in the course of the work, the Contractor shall take all necessary measures to protect the findings and shall notify the Engineer and the NHCP. If continuation of the work would endanger the finding, work shall be suspended until a solution for preservation of the artifacts is agreed upon.

Generation of local benefits from the Project

The benefits of the project will include items from the existing SDP containing the recommended programs and projects that the different sectors themselves identified. Likewise, these plans and programs were reviewed in reference with the Municipal Development Plans as well as the provisions of the Local Government Code (RA 7160) under which both laws mandated benefits for the host communities.

The Social Development Plan prepared for this project considered the articulated wishes of the community and Local Government of the impact areas, their concerns and issues concerning the environment, health and vulnerable groups and the measures to address them as recommended in the EIS. Focus will be centered on the mitigating measures to abate the possible negative impacts of the project and enhance the positive impacts.

Traffic congestion

Vehicular Traffic

Traffic build-up is very common in the area. Vehicular traffic congestion experienced daily by commuters and drivers is brought about by the over-loaded transport infrastructure, the presence of incorrectly executed infrastructure, and poor traffic management.

It is inevitable that there will be an increase in vehicular traffic. Such situation will pose risks to the residents living along the periphery of the road and school children crossing the streets. However, this increase is expected to be minimal during construction and operation phase to cause traffic congestion. The proponent will strictly comply with traffic rules and implement speed limits to ensure safety of the potentially affected communities.

Access for fishermen

Possible displacement of local fishers from their traditional fishing ground due to coastal development is considered as one of the potential impacts of the project. Increase in sea traffic due to the use of large ships and vessels during reclamation is also unavoidable. To address these impacts, it is recommended that the fisher folk that would be affected (if any) would be given priority for any opportunities (e.g., livelihood). Also, a 20-meter channel shall be established to serve as access by fisher folks possibly to be affected by the project. The proponent will strictly comply to sea traffic rules and consider peak hours of fishing activities during reclamation activities.

CHAPTER 3 ENVIRONMENTAL MANAGEMENT PLAN

The PRA and Navotas City are committed to operate the Project in a manner that will prioritize the protection of the existing environment, safety and health of the people and compliance with environmental laws, rules and regulations and other applicable legislations.

This section provides the Project's Impact Management Plan (IMP), which serves as the action plan for implementing the mitigating and enhancement principles, practices and measures aimed at minimizing and/or eliminating the potential impacts of the proposed Project to the surrounding environment.

The identified environmental impacts and corresponding proposed preventive, mitigation and/or enhancement measures for each environmental component during the Project's pre-construction, construction, operation and abandonment phases are detailed in Table 3-1.

Table 3-1 Impact management plan

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact (+/-)	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee/ financial arrangement
I. Pre-construction Phase						
Geotechnical investigation	Land Water	*Contamination of soil, groundwater, and surface water.* (-) Drilling fluid may potentially leak into receiving environment if not managed properly	▫ Use appropriate drilling fluid ▫ Implement proper bunding to avoid spillage into receiving environment. ▫ Prepare emergency spill kits in case of potential leaks.	Proponent / Contractor	Php200,000.00	Part of the project cost
Increased movement of heavy equipment on site and delivery of materials	Air	*Generation of dust* (-) Increased particulate matter due to movement of vehicles (-) Health effects due to inhalation of dust by residents living in areas adjacent to project site	▫ Implement dust suppression techniques. ▫ Cover trucks with tarpaulin loaded with spoils/filling materials when in transit. ▫ Pre-wetting of road surface to minimise dust.	Proponent / Contractor	Php50,000.00 / quarter.	Part of the project cost
	People	*Threat to public safety* (-) Possible injury or fatality as a result of heavy equipment and delivery trucks movement in the project site	▫ Implement speed limits and safety devices /signs. ▫ Ensure competency of drivers to drive safely. ▫ Engage local communities and inform them of site activities through IECs, posting construction “off limits” and safety signage	Proponent / Contractor	Php50,000/year on safety signages and Php50,000.00 on trainings/seminars	Part of the project cost
		Traffic congestion (-) Rapid deterioration of existing national/ municipal/ barangay road condition as a result of heavy equipment movement	▫ Coordinate with DPWH and Municipal Engineering Department in road maintenance and necessary improvements to accommodate increased vehicle movement.	Proponent / Contractor		Part of the regular coordination of the Proponent with the LGU
Increased manpower requirements	People	*Opportunities for local employment* (+) Employment opportunities and benefits of employees and potential livelihood/business opportunities	▫ Implement priority local hiring policy for qualified local workers. ▫ Provide skills training for local residents	Proponent / Contractor	No cost will be incurred.	Employment generated together with the origins of workers will be

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact (+/-)	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee/ financial arrangement
		(-) Employing outside workers may antagonize local communities				validated by the MMT.
II. Construction Phase						
Site preparation, ground levelling, and drainage improvements	Land	*Change in geomorphology* (-) The Project site's elevation will be altered. The elevation change will result in subsequent change in the hydrology surrounding the Project site	▫ Implement flood control measures which such as construction of proper and adequate drainage systems.	Proponent / Contractor	Php100,000.00/year – maintenance of the drainage facility	Part of project cost
Site preparation, excavation, and filling	Land	*Inducement of subsidence or collapse* (-) Minor subsidence may occur within the project site when the subsurface is disturbed during excavation activities for preparation of foundation (-) Minor settling may also occur as a result of additional loads from heavy machinery and structures	▫ Implement best engineering practices such as suitable backfilling material, proper slope, grading and contouring to minimise possibility of subsidence or differential settling.	Proponent / Contractor	Php10M – implementation of site preparation adhering to best engineering practices.	Part of project cost
Site preparation, ground levelling and drainage improvements	Land People	*Inducement of higher flood levels* (-) Occurrence, frequency and magnitude of flooding may be affected due to the change in drainage morphology and changes in ground elevation in the project site (-) Flooding may cause damage to property, assets, and may pose threat to public safety	▫ Implement best engineering practices such as suitable backfilling material, proper slope, grading and contouring to minimise possibility of subsidence or differential settling. ▫ Probable modification of drainage systems shall maintain natural outlets or consider similar transport regimes/streamflows as the pre-existing natural drainage ▫ Maximize the capacity of two exit river channels on both sides of the reclamation area through regular desilting and clearing operations	Proponent / Contractor	Php10M – implementation of site preparation adhering to best engineering practices and maintenance	Part of project cost

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact (+/-)	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee/ financial arrangement
Site preparation, excavation, and filling	Land	*Soil erosion from onsite activities* (-) Improper storage of construction materials and indiscriminate disposal of fill materials and excavated soils may affect erosion patterns.	▫ Implement best engineering practices such as suitable backfilling material, proper slope, grading and contouring to minimise possibility of subsidence or differential settling. ▫ Progressive ground preparation and clearing to minimize total area of land that will be disturbed at any one time, where practical.	Proponent / Contractor	Php100,000.00/year –ground stabilization and maintenance	Part of project cost
		Contamination of soil / disposal site (-) Excavated soil materials may contain contaminants that may potentially affect soil and ground and surface water quality	▫ Implement best engineering practices such as proper stockpiling and handling of excavated materials. ▫ Implement proper filling and disposal to avoid contamination of soil, groundwater, and surface water	Proponent / Contractor	Php 2,000,000.00 – Provision of proper waste disposal.	Part of project cost
Reclamation works	Water	(-) Degradation of water quality due to siltation brought about by reclamation activities	▫ Install silt curtains around dredging areas ▫ Early construction of bunds along boundaries of the project site ▫ Implement best environmental management practices such as, but shall not be limited to, removal of debris along the waterways, proper disposal of construction wastes, installation of silt traps at strategic locations, and spoils to be properly contoured to prevent erosion	Proponent / Contractor	Php10M – implementation of site preparation adhering to best engineering practices and maintenance	Part of project cost.
Generation of wastes		(-) Degradation of water quality due to runoff from sanitary sewage, waste water, solid wastes, and other construction materials that can harm aquatic flora/fauna	▫ Removal of debris along the waterways will be conducted, all construction wastes will be properly disposed, silt traps at strategic locations and spoils will be properly contoured to prevent erosion. ▫ Construction of sediment/ settling ponds and related structures to	Proponent / Contractor	Php50,000 / Year – provision for proper solid waste disposal	Part of project cost

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact (+/-)	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee/ financial arrangement
			mitigate siltation or sedimentation of water body ▫ Portalets will be provided for use of the workers and its corresponding wastewater will be properly disposed. ▫ Implementation of Solid waste management program and Hazardous waste management program. ▫ Use of DENR accredited haulers/TSD companies.			
Delivery of construction materials and equipment, construction works	Air People	*Generation of dust* (-) Air pollution from fugitive dust resulting from ground clearing operations, site preparation, structure erection, and vehicle movement. (-) Health effects due to inhalation of dust by residents living in areas adjacent to project site	▫ Implement dust suppression measures in active construction areas. ▫ Pre-wetting of road surface to minimise dust. ▫ Provision of tarpaulin cover on trucks loaded with construction materials ▫ Immediate hauling of spoils ▫ Impose speed restrictions/limits and proper signages	Proponent / Contractor	Php50,000/ year – operational expenses	Part of project cost
	Air	*Generation of air emissions* (-) Air pollution from SO_2 and NO_2 emissions from heavy equipment used in site preparation.	▫ Regular maintenance of heavy equipment, motor vehicles and all emission generating equipment	Proponent / Contractor	Php2,000,000 / year –cost of maintenance of heavy equipment	Part of the construction cost
Construction works	Air (noise)	(-) Generation of noise from construction activities	▫ Regular maintenance of motor vehicle mufflers ▫ Provision of noise cancelling ear protection to workers ▫ Proper scheduling of noisy activities during day time ▫ Reduce number of equipment to be operated at nighttime and inform	Proponent / Contractor	Php100,000.00	Part of project cost

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact (+/-)	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee/ financial arrangement
			barangay officials prior to conducting nighttime works ▫ Establishment of buffer zones along the perimeter of the construction site			
Site preparation activities	People	*Community protests or complaints* (-) Potential adverse community response resulting from access restrictions in working areas.	▫ Conduct of IECs to host and neighboring communities. ▫ Properly implement programs stipulated in the SDP	Proponent	Php150,000.00 / year	Part of project cost
Increased manpower requirements	People	*Opportunities for local employment* (+) Employment opportunities and benefits of employees and its multiplier effect or potential livelihood/business opportunities (-) Bringing in of outside workers may antagonise local communities	▫ Implement priority local hiring policy for qualified local workers. ▫ Provide skills training for local residents ▫ Coordinate with barangay or/and municipal LGU as to relevant ordinance on providing opportunities for local employment.	Proponent / Contractor	Php20,000 / year	Employment generated together with the origins of workers will be validated by the MMT.
Increased manpower requirements	People	*In-migration* (+) Workers will be required during construction (-) In-migrants may compete with locals for employment, project benefits, natural resources (i.e. water competition), local health, welfare services and infrastructure In-migration may also lead to proliferation of informal settlers in the project impact barangay	▫ Livelihood opportunities will be provided to local communities especially to host barangay ▫ Provide skills training for local residents ▫ Conduct consultation with barangay LGUs on requirements and process of hiring to maximize employment of local residents. ▫ Regular IEC and consultations with stakeholders (e.g. barangay LGU, local communities) will be conducted to ensure a sustainable community development plan. ▫ Coordination meetings shall be undertaken regularly with the LGUs to identify threats and vulnerabilities in the society as well as to develop	Proponent / Contractor	Php1M / year – SDP budget will be utilized for the implementation of activities such as, livelihood programs, education assistance, medical assistance, IEC, among others.	Part of project cost

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact (+/-)	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee/ financial arrangement
			programs to prevent foreseen social problems.			
Increased manpower requirements	People	*Cultural and lifestyle change* (-) Potential social tensions due to income and wealth disparity between those who will be benefited economically from the project and those who will not be benefited. (-) Workers and other in-migrants may introduce different lifestyles and patterns of behaviour leading to social tensions.	▫ The proponent will implement a code of conduct for employees, contractors, and subcontractors to prevent potential impacts on lifestyle and behaviour. ▫ IEC activities, open dialogue and communication with the stakeholders will be undertaken regularly by the proponent to address concerns of the people on the proposed project and promote transparency	Proponent / Contractor	Php1M / year – SDP budget that will be utilized for the implementation of activities such as, cultural activities, IEC, among others	Part of project cost
		Threat to delivery of basic services and resource competition (-) Unplanned population increase due to in-migration or increase in informal settlers/structures puts pressure on basic services (education, health and social welfare) and utilities (water, electricity and waste management).	▫ Develop and implement SDP, which shall involve improvement of basic services such as health and welfare, livelihood, infrastructure, education, among others	Proponent / Contractor	Php1M / year – SDP budget that will be utilized for the implementation of activities such as, cultural activities, IEC, among others	Part of project cost
Increased movement of heavy equipment on site and delivery of materials, Increased manpower requirements	People	*Traffic congestion* (-) Possible increase in traffic given the number of workers to be employed and delivery of some construction materials.	▫ Implement speed limits, vehicle load limits, vehicle maintenance requirements, and limiting driving hours. ▫ Signs for ongoing construction activities (i.e. speed limit, safety signages) shall be installed at strategic places to notify and warn the general public as necessary.	Proponent / Contractor	Php100,000/ year – Safety and health program will cover this activities.	Part of project cost
III. Operational Phase						

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact (+/-)	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee/ financial arrangement
Project Operations (General)	Land People	*Potential liquefaction or ground subsidence due to earthquakes* (-) Liquefaction and ground subsidence may occur due to earthquakes, which may cause damage to property, assets, and may pose threat to public safety	▫ Use appropriate soil compaction and more competent backfill materials to minimize possibility of subsidence or differential settling	Proponent	Php20,000 / year – cost incurred for regular inspection	Part of project cost
	Land	*Vegetation removal and loss of habitat*	▫ Design and construct appropriate buffer area between mangrove area and reclamation site ▫ Support active enforcement of existing laws and regulation pertaining to protection and rehabilitation of Mangrove Park with regular budget allocation ▫ Enhance vegetation cover and diversity of mangrove forest areas by planting a variety of mangrove and mangrove-associated species suitable to the condition of the area. This will supplement biodiversity value in the area by reintroducing key and important species to hasten the process of natural recovery and improve habitat quality. ▫ Establish mangrove nurseries within the Mangrove Park to provide reliable source of mangrove propagules for replanting and rehabilitation of the project area and even to adjacent areas of Manila Bay ▫ Conduct Information, Education and Communication (IEC) campaign on the importance of mangrove and its habitat especially to local residents	Proponent	Part of operation cost	Part of project cost

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact (+/-)	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee/ financial arrangement
			of Navotas to increase awareness and support from the locals ▫ Collaborate with other government agencies such as DENR, PPA, academe and NGOs on other conservation programs and activities such as ecotourism, bird watching, coastal clean-up, research studies and IEC.			
	Land People	*Potential flooding due to extreme weather events and potential threat to public safety* (-) Flooding brought about by extreme weather events may cause damage to property, assets, and may pose threat to public safety	▫ Design and construct appropriate drainage system that will support the transport regimes/streamflows of the pre-existing natural drainage	Proponent	~Php 5,000,000	Part of the project cost
Increased water demand for project activities	Water	*Possible water use competition* (-) Water use competition / reduction in water availability due to the project's use of water	▫ Comply with the requirements and mandates of the concerned water district as to the usage of water supply	Proponent	Php150,000/ quarter – cost to be incurred during quarterly monitoring of MMT, laboratory analysis, among others	Part of project cost
Generation of wastes	Water	(-) Degradation of ground, surface, or marine water quality due to runoff from sanitary sewage, waste water and solid wastes that can harm aquatic flora/fauna	▫ Proper storage and disposal of wastes and implementation of good housekeeping practices ▫ Use of DENR accredited haulers/TSD companies	Proponent	Php100,000/ year – annual maintenance budget.	Part of project cost
Emission of fugitive particles	Air	*Generation of air emissions* (-) Air pollution from SO_2 and NO_2 emissions from genset and vehicles	▫ Regular maintenance of heavy equipment, motor vehicles and all emission generating equipment	Proponent / Contractor	Php 50,000 / year – cost of maintenance of vehicles/equipment	Part of the project cost
Increased manpower requirements	People	*Opportunities for local employment*	▫ Implement priority local hiring policy for qualified local workers.	Proponent	Insignificant	Monitoring and validation activity of

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact (+/-)	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee/ financial arrangement
		(+) Employment opportunities and benefits of employees and its multiplier effect or potential livelihood/business opportunities (-) Bringing in of outside workers may antagonise local communities	▫ Coordinate with barangay or/and municipal LGU as to relevant ordinance on providing opportunities for local employment.			MMT, MRFC, LGU Officials, and other concerned agencies
Increased manpower requirements	People	*In-migration* (+) Employment opportunities during operation (-) In-migrants may compete with locals for employment, project benefits, natural resources (i.e. water competition), local health, welfare services and infrastructure In-migration may also lead to proliferation of informal settlers in the project impact barangays	▫ Livelihood opportunities and skills training will be provided to local communities specially to host barangay ▫ Conduct consultation with barangay LGUs on requirements and process of hiring to maximize employment of local residents. ▫ Conduct regular IEC and consultations with stakeholders (e.g. barangay LGU, local communities) ▫ Undertake regular coordination meetings with the LGUs to identify threats and vulnerabilities in the society as well as to develop programs to prevent foreseen social problems.	Proponent	Php1M / year – SDP budget that will be utilized for the implementation of activities such as, livelihood programs, cultural activities, IEC, among others.	Part of project cost
Increased manpower requirements	People	*Cultural and lifestyle change* (-) Potential social tensions due to income and wealth disparity between those who will be benefited economically from the project and those who will not be benefited (-) Workers and other in-migrants may introduce different lifestyles and patterns of behaviour leading to social tensions	▫ The proponent will implement a code of conduct for employees, contractors, and subcontractors to prevent potential impacts on lifestyle and behaviour. ▫ IEC activities, open dialogue and communication with the stakeholders will be undertaken regularly to address concerns of the people on the proposed project and promote transparency	Proponent	Php1M / year – SDP budget that will be utilized for the implementation of activities such as, cultural activities, IEC, among others.	Part of project cost

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact (+/-)	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee/ financial arrangement
Increased manpower requirements	People	*Threat to delivery of basic services and resource competition* (-) Unplanned population increase, due to in-migration puts pressure on basic services (education, health and social welfare) and utilities (water, electricity and waste management) (-) Population influx may create unmet demands for affordable housing leading to an increase in informal settlers and illegal structures	▫ Implement SDP that shall involve improvement of basic services such as health and welfare, livelihood, infrastructure, education, among others	Proponent	Php1M / year – SDP budget that will be utilized for the implementation of activities such as, cultural activities, IEC, among others.	Part of project cost
Increased manpower requirements	People	*Generation of local benefits from the project* (+) Employment opportunities and benefits of employees and its multiplier effect or potential livelihood/business opportunities (i.e. canteen, sari-sari store, boarding house, etc) are perceived as positive impacts of the project. (+) Improvement of basic services (i.e. electricity, water, health and education) and infrastructure (i.e. road, recreation and health facility) is expected as a result of the project (+) Increase in barangay income and IRA will also be a positive impact that may subsequently provide more funding for programs and projects of the barangay.	To further enhance the benefits from the project: ▫ The proponent shall develop and implement the SDP, which shall include improvement of basic services such as health and welfare, livelihood, infrastructure, education, among others	Proponent		Part of project cost
Increased movement of heavy equipment on site and delivery	People	*Traffic congestion* (-) Possible increase in traffic given the number of workers to be employed and	▫ Traffic management plan, in coordination with concerned LGUs and DPWH, will be prepared and implemented	Proponent	Php100,000 / year – for the implementation of the Safety programs	Part of project cost

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact (+/-)	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee/ financial arrangement
of materials, Increased manpower requirements		delivery of some construction materials. This has the potential to add traffic congestion and affect sensitive receptors such as schools and community centers that may potentially cause road accidents. (-) Heavy loads traversing infrastructure over or near load bearing limits	▫ IEC will also be conducted to communicate traffic impact and management plan to the community especially the host and neighboring barangays ▫ Proper scheduling of delivery of construction materials to avoid peak hours/ traffic congestion and minimize the occurrence of accidents. ▫ Installation of safety warnings and signages		/ policies, IEC campaigns, safety materials, etc.	
IV. Decommissioning Phase						
Clearing and removal of structures	Land Water People	*Ground and water contamination* (-) Clearing and removal of structures and facilities that may result to improper disposal of contaminated materials or release of toxic and hazardous wastes / compounds	▫ Proper implementation of the approved Abandonment/ Decommissioning Plan that details the decommissioning, rehabilitation, and social activities which shall include the methodology, timing, and techniques. ▫ Use of DENR accredited haulers/TSD companies for wastes classified under RA No. 6969.	Proponent / Contractor	Php2M – for the handling, transport, and disposal of all hazardous waste and chemicals.	Part of project cost

Legend:

+/- Positive or negative impact

CHAPTER 4 ENVIRONMENTAL RISK ASSESSMENT (ERA) AND EMERGENCY RESPONSE POLICY AND GUIDELINES

4.1 Environmental Risk Assessment (ERA)

This section discusses the Environmental Risk Assessment (ERA) of the proposed Project. An ERA is an evaluation tool for a project or an activity that determines the level of hazard that it may pose to humans, properties, and to the environment.

This section will discuss whether the proposed Project poses a significant risk to its surrounding environment. Also, this section will determine whether the surrounding environment poses significant risks to the proposed Project.

4.1.1 Methodology

The general guidelines and outline for an Environmental Risk Assessment (ERA) preparation are prescribed in Annex 2-7e of DAO 2003-03. However, the guidelines focused more on the risks and hazards posed by activities and/or manufacturing methods that involve chemical storage, processing, and use. Although this is applicable for the proposed Project, this shall only form part of the overall ERA. Major environmental risks identified were the geological hazards posed on the proposed Project.

4.1.2 Risk Screening Level

A risk screening level exercise refers to specific facilities or the use of certain processes that has the potential to pose significant risks to people and its surrounding environment. The Plant is covered by the risk screening level exercise, as indicated in Table 4-1.

4.1.3 Risk Identification and Analysis

The proposed Project entails risks that are natural, man-made, or a combination of both. Natural risks are hazards caused by phenomena such as earthquakes, geological instability and typhoons. Meanwhile, man-made risks are caused by accidents such as fires, structural/equipment failure, chemical spillages, and human error. Man-made risks could also be aggravated as a direct consequence of natural risks.

Table 4-1 Risk Screening Matrix

Activities Requiring Risk Screening Exercise[1]	ERA Applicability to the Project
1) Facilities for the production or processing of organic/inorganic chemicals using: Alkylation, Amination, Carbonylation, Condenstation, Dehydrogenation, Esterification, Halogenation, Hydrogenation, Hydrolysis, Oxidation, Polymerization, Sulphonation, Desulphurization, Nitration, Phosphorus, Distillation, Extraction, Solvation, Pesticides & pharmaceutical	Not Applicable

Activities Requiring Risk Screening Exercise[1]	ERA Applicability to the Project
prod. prod.	
2) Installations for distillation, refining, and other processing of petroleum products	Not Applicable
3) Installations for total or partial disposal of solid or liquid substances by incineration or chemical decomposition	Not Applicable
4) Installations for the production or processing of energy gases (e.g., LPG, LNG, SNG.)	Not Applicable
5) Installations for the dry distillation of coal or lignite	Not Applicable
6) Installations for the production of metals and non-metals by wet process or electrical energy	Not Applicable
7) Installations for the loading and unloading of hazardous materials as defined by RA 6969 (or DAO 29)	Not Applicable
CONCLUSION	**Risk screening level exercise is not applicable**

Note:
[1]Based on Annex 2-7e of DAO 30-2003 Revised Procedural Manual

4.1.4 Disaster risk reduction and climate change adaptation profile of Navotas City

Climate Change Projections and Impacts

The rainfall intensity in Navotas City is seen to increase particularly during the months of June to November or the period of the Southwest monsoon while a decrease in rainfall amount is expected from December to May (Navotas CLUP, 2016-2025). The climate data from PAGASA also revealed an increase in mean temperature from 0.90 C in 2020 to 1.8 0 C in 2050 for the months June-August and 1.00 C to 1.90 C for the months September-November for the year 2020 and 2050, respectively.

The change in the climatic conditions of Navotas likely will result to considerable impacts on the city's natural and built landscapes including its seascape. The following climate change impacts have been identified in the City's CLUP:

- Intensification of Rainfall, River Flow, and Flooding – The increase in the rainfall amount from June to November or during the Southwest Monsoon may increase not only in the frequency but also in the severity of flooding.
- Decrease of Rainfall from December to May – The decrease in the rainfall amount from the months of December to May or Northeast Monsoon can result to abnormally dry conditions which can intensify the effects of the El Niño phenomenon.
- Increase in Mean Temperature – The estimated increase in the mean temperature will contribute to a number of phenomena like sea level rise, increase in sea surface temperature, and stronger typhoons. It should be noted though that there are still no studies conducted regarding the sea level rise in the City.

Hazard Identification

As part of the preparation of the Navotas CLUP, several hazards were identified that are seen to affect the different components of the urban landscape that include the settlement areas, infrastructure, critical facilities, fishery production areas, and the human communities that are exposed to both geologic and hydro-meteorological hazards. These hazards seen to have impacts on Navotas include ground-shaking, liquefaction, tsunami, flood, severe wind, and storm surge. The City is most vulnerable to floods due to tidal inundations and severe winds brought about by typhoons and heavy monsoon rains. Table 4-2 below shows the different hazards affecting the barangays in Navotas. Note that Barangay Tanza, which will host the proposed reclamation project, like the rest of Navotas, is susceptible to all six (6) hazards.

Table 4-2 Hazard Exposure of the 14 Barangays in Navotas City

BARANGAY				EXPOSURE TO HAZARD							
GEOLOGIC HAZARD				HYDRO-METEOROLOGICAL HAZARD							TOTAL
Barangays		GROUND SHAKING	GROUND RUPTURE	LIQUEFACTION	LANDSLIDE	TSUNAMI	FLOOD	RAINFALL INDUCED LANDSLIDE	SEVERE WIND	STORM SURGE	
1.	*San Rafael Village*	✓	X	✓	X	✓	✓	X	✓	✓	**6**
2.	*North Bay Blvd. South*	✓	X	✓	X	✓	✓	X	✓	✓	**6**
3.	*North Bay Blvd. North*	✓	X	✓	X	✓	✓	X	✓	✓	**6**
4.	*Bangkulasi*	✓	X	✓	X	✓	✓	X	✓	✓	**6**
5.	*Bagumbayan South*	✓	X	✓	X	✓	✓	X	✓	✓	**6**
6.	*Bagumbayan North*	✓	X	✓	X	✓	✓	X	✓	✓	**6**
7.	*Navotas East*	✓	X	✓	X	✓	✓	X	✓	✓	**6**
8.	*Navotas West*	✓	X	✓	X	✓	✓	X	✓	✓	**6**
9.	*Sipac-Amacen*	✓	X	✓	X	✓	✓	X	✓	✓	**6**
10.	*San Jose*	✓	X	✓	X	✓	✓	X	✓	✓	**6**
11.	*Daanghari*	✓	X	✓	X	✓	✓	X	✓	✓	**6**
12.	*San Roque*	✓	X	✓	X	✓	✓	X	✓	✓	**6**
13.	*Tangos*	✓	X	✓	X	✓	✓	X	✓	✓	**6**
14.	*Tanza*	✓	X	✓	X	✓	✓	X	✓	✓	**6**
TOTAL		**14**	**0**	**14**	**0**	**14**	**14**	**0**	**14**	**14**	

4.1.4.1 Flood Characteristics

The City of Navotas is exposed to frequent flooding during high tides, typhoons and heavy monsoon rains, especially in areas located near Manila Bay, near the fishponds, and areas located along the waterways. Nearly 90% of the City is at risk of flooding, reaching flood heights of two (2) meters especially during overflows of the City's tributaries. To address the flooding problem, the City installed several mitigating programs that up to the present continue to address the issue on flooding. The City's flood mitigating programs have been considered effective since the worst flood event that occurred in September 2011 brought by Typhoon Pedring.

A study of the Mines and Geo-Sciences Bureau revealed that the northern portion of Navotas, specifically barangay Tanza, which is adjacent to the proposed reclamation project, has very high susceptibility to flooding due to its location. Areas along the Tanza River and the Navotas River are also observed to have a high susceptibility to flooding, as well as the areas located along the Manila Bay. The rest of Navotas would only experience low to moderate susceptibility to flooding.

Figure 4-1 shows the Flood Susceptibility Map of Navotas with the relative location of the reclamation project.

A study of the flood vulnerability of Navotas City as part of the CLUP 2016-2025 showed that around 9,161 and 9,917 individuals have the potential of being affected by very high and high susceptibility to flooding, respectively. As shown in Table 4-3, The said individuals are concentrated in three barangays, namely Tanza, Bangkulasi and North Bay Boulevard South with a combined land area of covering more than 15 hectares.

Table 4-3 Number of Potentially Affected Persons

Barangay	Very High Susceptibility		High Susceptibility	
	No. of Individuals	Area in hectares	No. of Individuals	Area in hectares
Tanza	6,073	2.4240	3,535	7.2307
Bangkulasi	598	0.4042		
North Bay Boulevard South	2,489	3.0832	6,382	7.9045
TOTAL	**9,161**	**15.9114**	**9,917**	**15.1352**

In terms of risks, the City may generally face low to moderate risks when it comes to flooding, except for some critical areas. It can be observed that high risk areas were noted in all barangays, particularly the area occupied by the informal settlements. High risks were evaluated in these areas due to the high vulnerability of structures, including the make-up of light to salvageable materials, and non-hazard resistant designs. A total of 48.02 hectares of land area is occupied by informal settlements which are mostly located in coastal areas facing Manila Bay. Aside from this, high risks were also observed in Barangay Tanza which is earlier noted to be very highly susceptible to flooding, where around 390.11 hectares of fishponds, despite the absence of structures, is very exposed to the risks of possible overflowing that will eventually cause losses on the part of fishpond owners.

As to critical facilities, all the schools at Barangay Tanza are identified to be at moderate risk. This is because the said schools are located at low lying areas and are adjacent to the fishponds. Mitigating measures are being employed in the area to avoid the adverse effects of floods such as an automatic suspension of classes upon declaration of storm signals 1 and 2 during the onslaught of a typhoon and the continuous operation of pumping stations (Navotas CLUP, 2016-2017). Figure 4-2 presents the Critical Facilities Map overlaid with the Flooding Susceptibility and relative location of the reclamation project.

Flood Risk Assessment

Navotas City generally has generally low to moderate flood risks, except for some critical areas. It can be observed that high risk areas were noted in all barangays, particularly the area occupied by the informal settlements. High risks were evaluated in these areas due to the high vulnerability of structures, including the make-up of light to salvageable materials, and non-hazard resistant designs. A total of 48.02 hectares of land area is occupied by informal settlements which are mostly located in coastal areas facing Manila Bay. Aside from this, high risks were also observed in Barangay Tanza which is earlier noted to be very highly susceptible to flooding, where around 390.11 hectares of fishponds, despite the absence of structures, is very exposed to the risks of possible overflowing that will eventually cause losses on the part of fishpond owners. Figure 4-3 provides the Flood Risk Map of Navotas City with the relative location of the proposed reclamation project

Flood Mitigating Measures

The City has put in place a number of initiatives to mitigate the effects of the flooding in Navotas. Foremost of these measures is to enhance the adaptive capacity of the City's government and its population that include, among others, the following:

- Institutionalization of the Navotas DRRMC and the DRRMO
- Creation of a Joint Rescue Team
- Information dissemination
- Construction of additional pumping stations
- Relocation of informal settlers

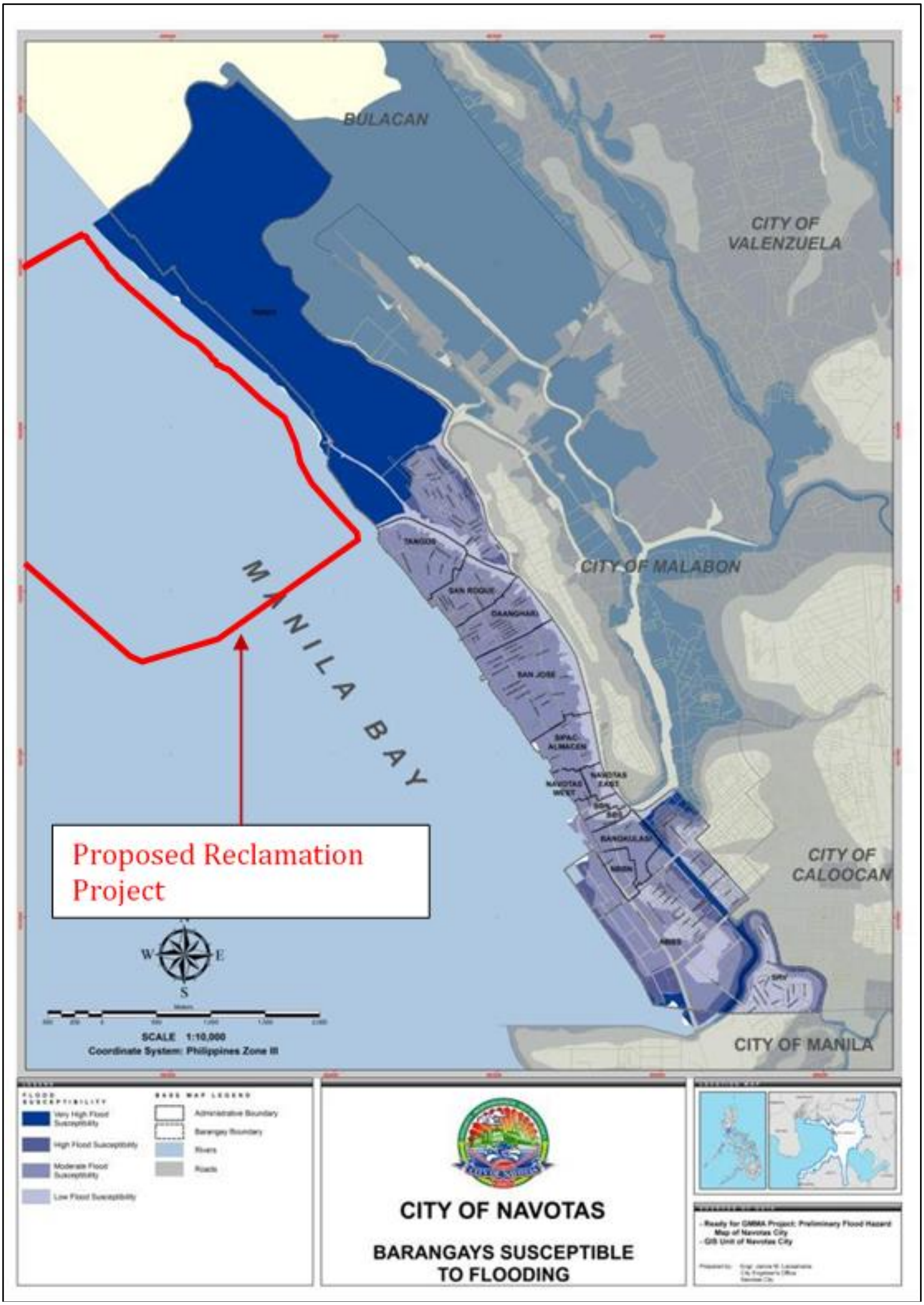


Figure 4-1 Flood Susceptibility Map of Navotas City with the Relative Location of the Reclamation Project

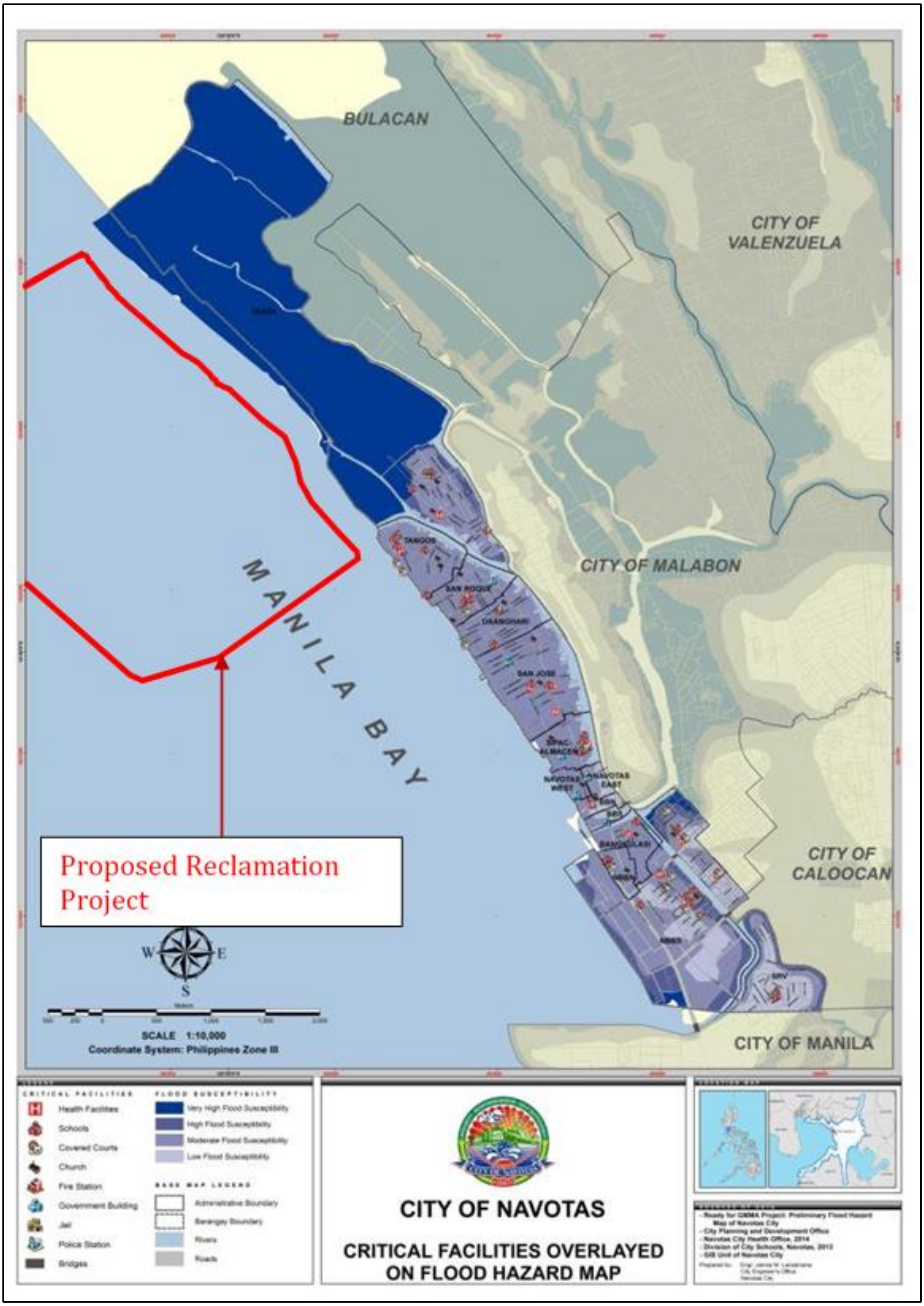


Figure 4-2 Critical Facilities Map of Navotas City with the Relative Location of the Reclamation Project

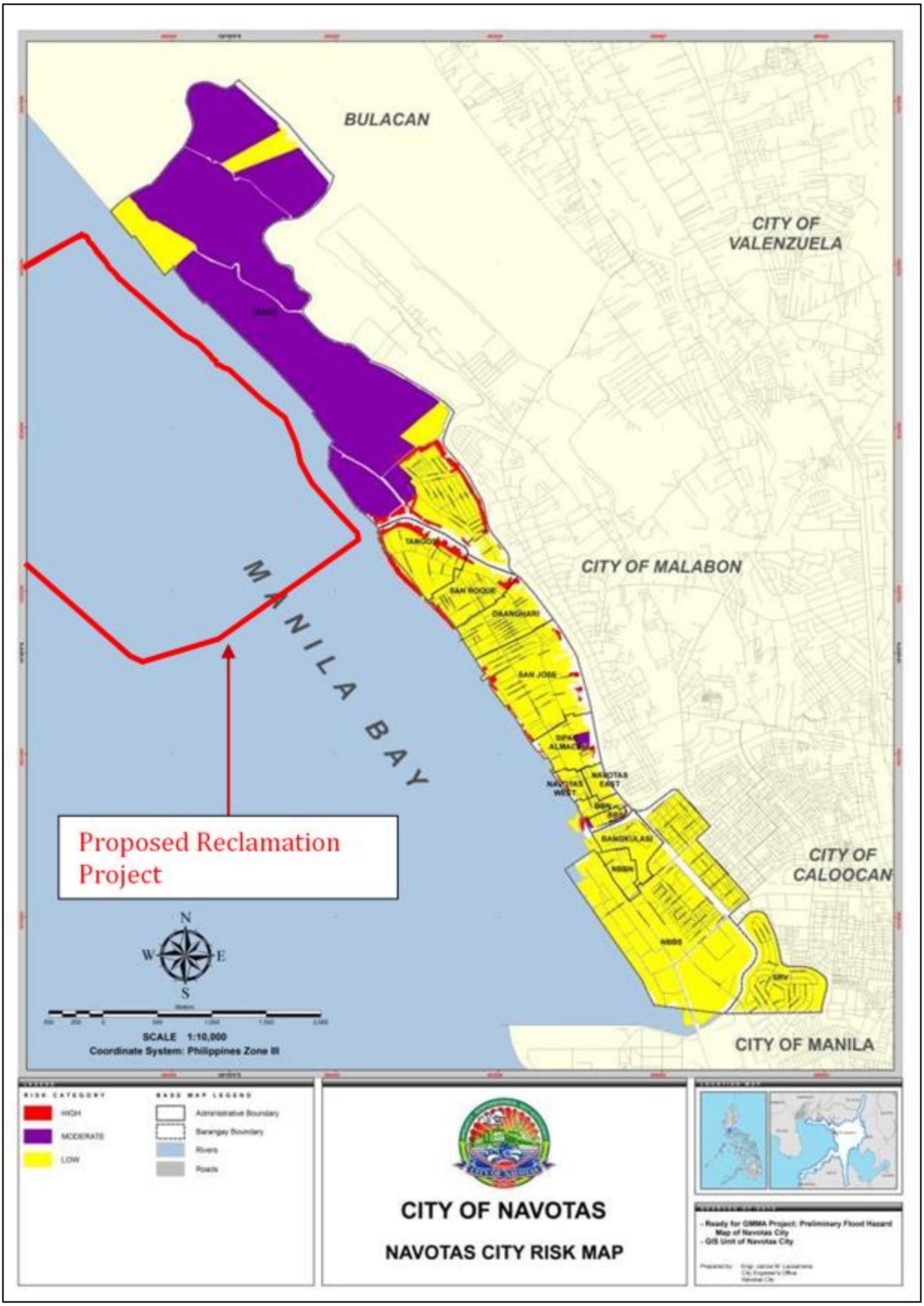


Figure 4-3 Flood Risk Map of Navotas City with the Relative Location of the Reclamation Project

4.1.4.2 Ground Shaking Characteristics

The Metro Manila Earthquake Impact Reduction Study of 2004 revealed three earthquake scenarios that may affect Navotas. These include the magnitude 7.2 West Valley Fault (WVF) Earthquake, the magnitude 7.9 Manila Trench Earthquake, the 1863 Manila Bay Earthquake model. Of the three, the WVF Earthquake is considered as the worst-case scenario based on the potential number of casualties and damaged structures it will generate. However, Navotas is not susceptible to ground rupture due to the fact that there are no fault lines located within the City. Nonetheless, the City is still susceptible to ground shaking, liquefaction, and tsunami caused by such earthquakes. Based on the 7.2 magnitude WVF earthquake scenario, Navotas would generally experience a Low VIII to High VIII Intensity level, which is described as Very Destructive according to the PEIS. The southern part of Navotas, specifically North Bay Boulevard South and San Rafael Village would experience slightly higher intensity level (high VIII) compared to the rest of Navotas but both are still considered as an Intensity VIII event. Figure 4-4 illustrates the Ground-shaking Hazard Map of Navotas City with the relative location of the proposed reclamation project.

4.1.4.3 Ground-shaking Risk Assessment

The results of the GMMA-Risk Analysis Project (RAP) of the PHIVOLCS disclosed the risk level of Navotas for a 7.2 magnitude earthquake. The RAP results show that Navotas have a low risk in terms of damaged structures, casualties and economic losses as compared to the rest of the cities in Metro Manila. The damaged structures and casualties, as identified by RAP are located in barangay North Bay Boulevard South. Other barangays that have more than a hundred casualties include Daanghari, Tangos, and Tanza. For damaged and collapsed structures, barangays San Rafael Village, Daanghari, Tanza, and San Jose were identified as risk areas.

4.1.4.4 Ground-shaking Mitigating Measures

The Navotas City government intends to strictly implement the building code to ensure that the structures and buildings in the City can optimally withstand such strong earthquakes. In addition, the City government will identify additional areas as evacuation sites to support the implementation of its evacuation plan. The City would impose height regulations for the stacking of industrial containers in storage facilities adjacent to residential areas to reduce the dangers to the communities around them.

Figure 4-4 Ground-shaking Hazard Map of Navotas City with the Relative Location of the Reclamation Project

4.1.4.5 Tsunami Characteristics

Although there is no historical incidence of tsunami in the Navotas City, the PHIVOLCS Tsunami Susceptibility Map as shown in Figure 4-5 still reveal that Navotas is susceptible to inundation with Tsunami of 5.5 meters height that can be generated by earthquake from the fault lines located west of Manila Bay. Figure 4-5 provides the Tsunami Hazard Map of Navotas City with the relative location of the proposed reclamation project.

Tsunami Mitigating Measures

The measures to address the impacts of tsunami as reflected in the Navotas CLUP 2016-2025 include the development of green linear parks along the coastal areas and river banks, the construction of the 3.5 kilometer coastal dike, and the implementation of a 20-meter easement along the coastlines of Navotas.

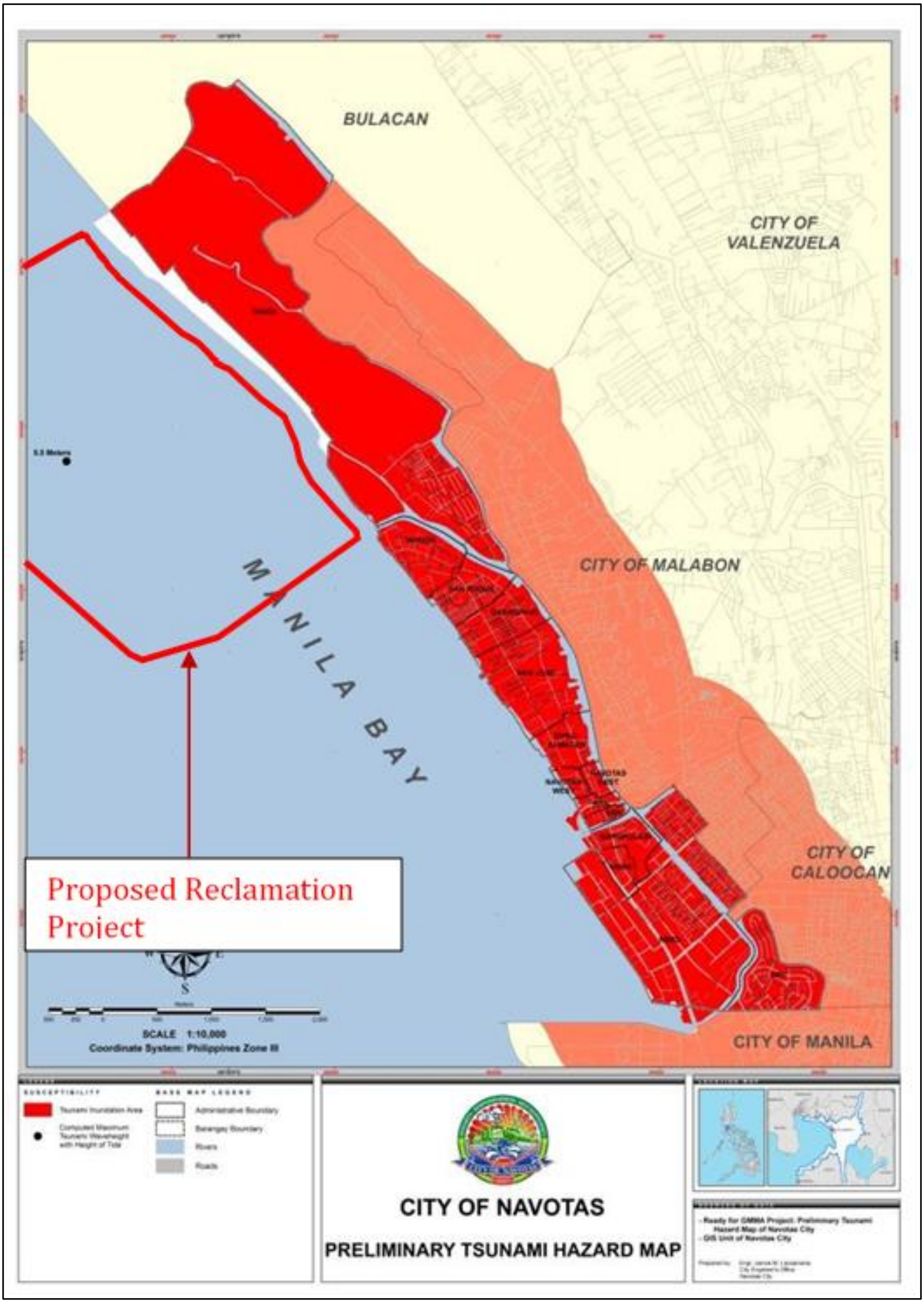


Figure 4-5 Tsunami Hazard Map of Navotas City with the Relative Location of the Reclamation Project

4.1.4.6 Liquefaction Characteristics

Liquefaction is often caused by severe shaking, especially those associated with earthquakes. Based on the PHIVOLCS liquefaction susceptibility map as shown in Figure 5, the entire city is considered to be highly susceptible to liquefaction. The susceptibility assessment was based on the geology, earthquake source zone, historical accounts of liquefaction, geomorphology and hydrology of the area, and preliminary microtremor survey data utilized to validate the type of underlying materials.

Liquefaction Mitigating Measures

The City of Navotas intends to strictly implement the building code to address the effects of liquefaction.

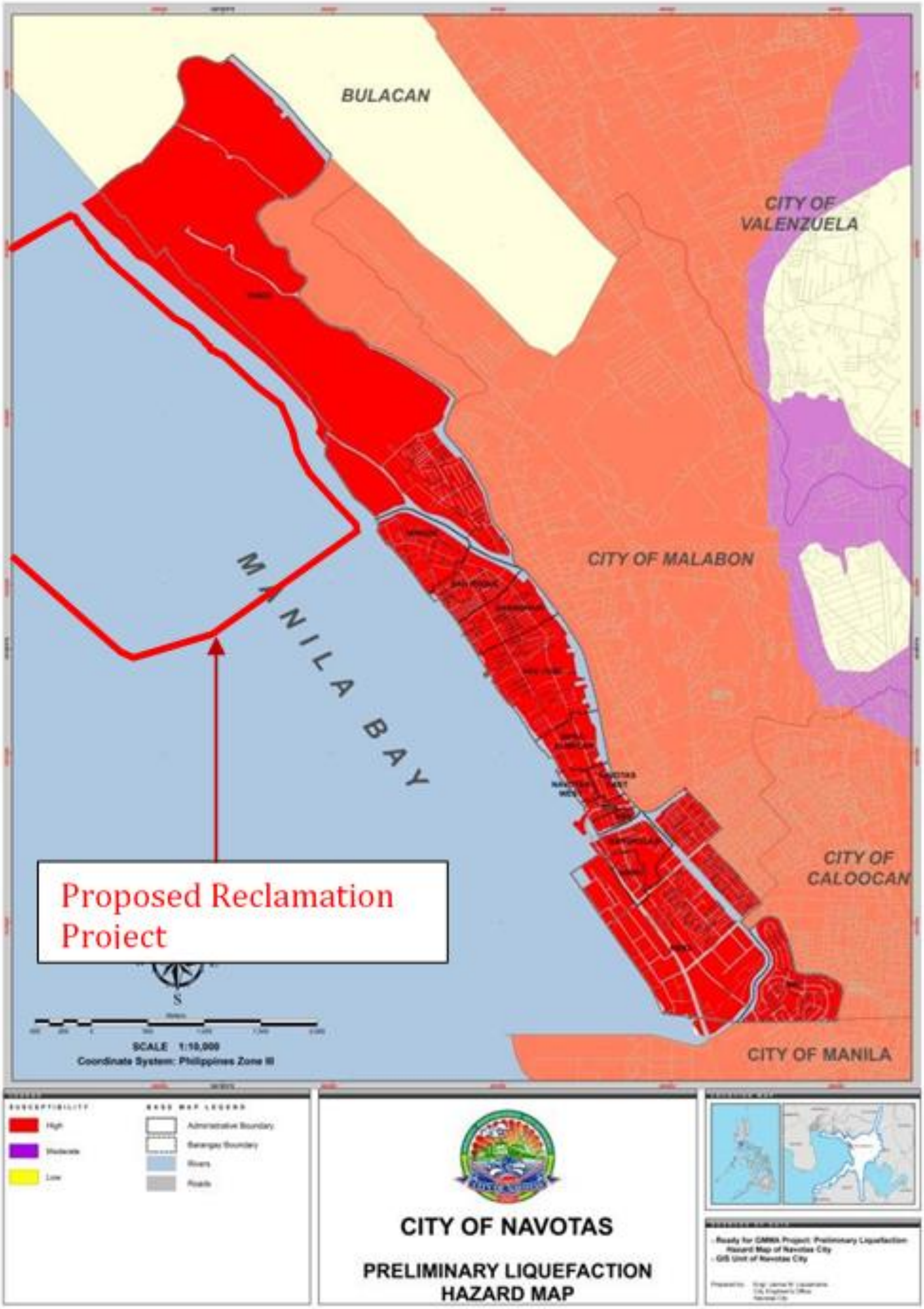


Figure 4-6 Liquefaction Hazard Map of Navotas City with the Relative Location of the Reclamation Project

4.1.4.7 Severe Wind Characteristics

As shown in the Severe Wind Hazard in Figure 7, most barangays would only experience minimal wind speeds. The assessment was part of the GMMA-RAP.

Severe Wind Mitigating Measures

The mitigating measures for severe wind identified in the Navotas CLUP include the incorporation of wind resistant designs for new structures, strict implementation of CLUP and Zoning Ordinance and design standards specified in these documents and development of green linear parks to act as wind brakes to adjacent residential areas.

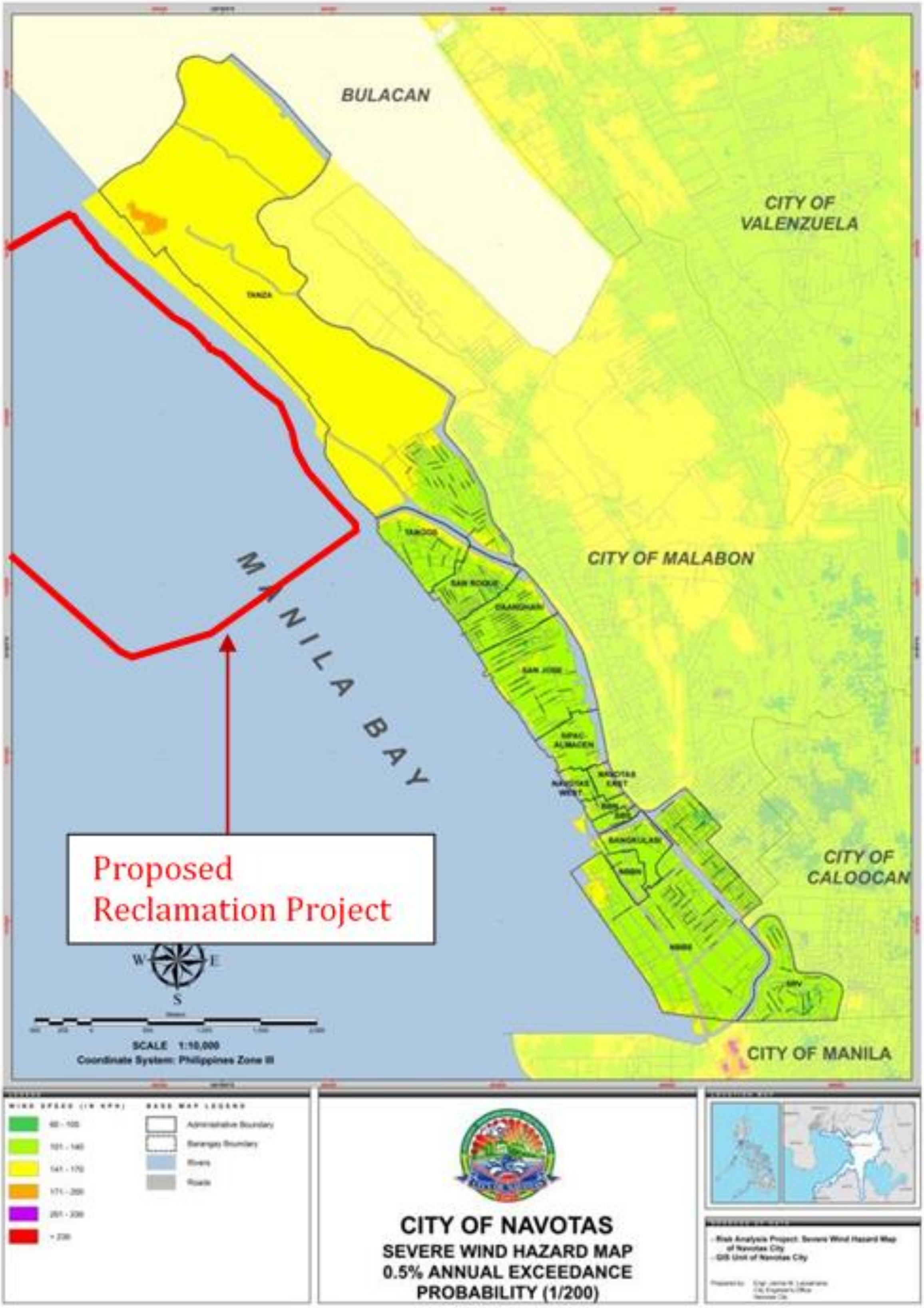


Figure 4-7 Severe Wind Hazard Map of Navotas City with the Relative Location of the Reclamation Project

4.1.4.8 Storm Surge Characteristics

Navotas has been assessed to be easily inundated by high tides. As shown in the Storm Surge Map in Figure 8, almost all barangays except the southern barangays (North Bay Boulevard North, North Bay Boulevard South and San Rafael Village) are susceptible to storm surges. Areas along the coast of Manila Bay and rivers are the most susceptible, as well as the northern fishpond areas of barangay Tanza which hosts the proposed reclamation project.

Storm Surge Mitigating Measures

The measures identified by the Navotas City LGU to mitigate the impacts of storm surges include the following:

- Development of Green Linear Parks along the coastal area and riverbanks
- Construction of the 3.5 Kilometer Coastal Dike
- 20 meter easement along the coast, which is considered as No Build Zone
- Mangrove Planting along the shoreline

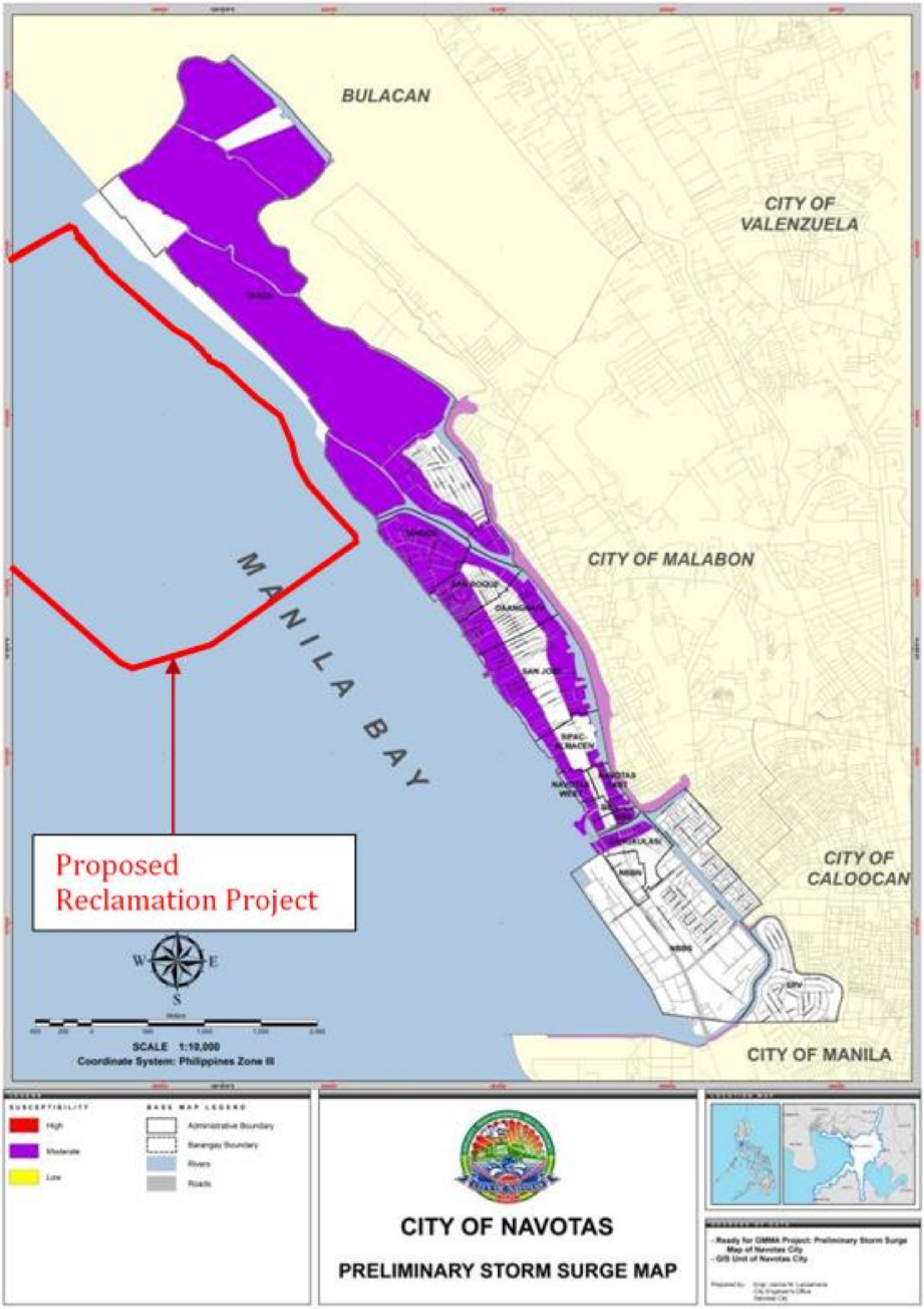


Figure 4-8 Storm Surge Hazard Map of Navotas City with the Relative Location of the Reclamation Project

4.2 Emergency Response Policy and Guidelines

4.2.1 Emergency response policy

The Project is committed to ensuring the health, safety and security of its personnel, assets and surrounding environment through the prevention of accidents by eliminating potential threats/hazards and anticipating other probable causes. Hence, the Project shall adhere to the primary approach to emergency response–that is the prevention of circumstances that can create emergency conditions.

The Project shall designate a safety officer, who will regularly conduct safety briefings and periodically conduct emergency response drills. The safety officer will supervise the daily safety performance of operations and maintenance procedures. The safety officer will inspect the work and crew situation to ensure maintenance of and compliance to safety guidelines.

Personnel selection and hiring policy will require all personnel to be capable of swimming and basic water survival skills.

Aside from the occupational safety accidents, the project area is also exposed to various geologic hazards such as ground shaking, liquefaction, surface rupturing, storm surges and coastal flooding.

The potential incidents and emergency situations that may be encountered in the future operation of the proposed Project are detailed in the table below.

Table 4-4 Emergency scenarios for the Project

Type of emergency situation	Possible causes	Potential effects
Occupational safety accidents	• Improper training and supervision of personnel • Equipment or facility failure • Lack of full understanding regarding the surrounding environment	• Injuries and fatalities to personnel • Partial or total loss of equipment
Earthquakes	• Movement/rupture of nearby fault lines • Volcanic eruption	• Failure of structures • Injuries or fatalities to personnel and communities
Tsunami	• Movement/rupture of nearby fault lines • Volcanic eruption • Intense earth movement	• Failure of structures • Injuries and fatalities to personnel and communities
Flooding	• Typhoon-prone area • Flood-prone/ topography of area • Complex weather systems	• Collapse of structures • Destruction of project facilities • Injuries and fatalities to personnel and communities
Storm surge	• Typhoon-prone area • Complex weather systems • Intense rainfall, wind and high tides	• Injuries and fatalities to personnel and communities

In order to reduce, if not eliminate, extreme emergency situations leading to loss of life and property, hereunder are the Project's initial safety guidelines which will be refined during construction.

4.2.2 Generic guidelines for the prevention, alleviation or response to emergency situations

4.2.2.1 Safety

1. All construction personnel, staff, and crew shall undergo proper and complete training for them to understand the job/tasks assigned to understand and implement necessary safety procedures.
2. All working personnel shall be required to don personnel protective equipment including life vest and whistle.
3. No work will be allowed under typhoon or extreme weather conditions.
4. Sea walls under construction shall be adequately braced and provided with cross-drain courses until the stability of the structure under construction is secured. The supervising structural engineer shall have added responsibility of checking or providing the safety officer with guidelines in checking the integrity/stability of all structures under construction.
5. The leadman for each phase/work sector shall likewise check his crew during work to ensure compliance with safety guidelines and to prevent progress of a critical condition into an emergency.
6. All safety guidelines promulgated by the Occupational Health and Safety Guidelines of the OHSC-DOLE shall be implemented.

4.2.2.2 Emergency response

The proponent shall designate a leadman (incident commander) to serve as the primary emergency respondent. The leadman shall have access to communications equipment at all working hours.

1. Equipment

A motorized transportation vessel with first aid facilities, stretcher, breathing equipment, a capable wireless communication equipment and trained first aid personnel will be available at site as long as there in on-going work.

2. Communication links

The wireless communication equipment shall have stored emergency numbers for the following:

- Hospital emergency numbers to call for an ambulance when necessary
- Boat-mounted crane in the event the emergency response will require removal of heavy rocks or equipment
- The supervisors and project manager in the event important decisions need to be made, following social protocol, for them to inform the concerned family/ies regarding any incident.

3. Emergency plan/response system

The Project shall establish an orderly and systematic approach in addressing emergency situations to ensure safety of personnel and property. The Project will follow the schematic diagram/procedure presented in Figure 4-9, while the roles and responsibilities of each personnel involved in the emergency plan are listed in Table 4-5.

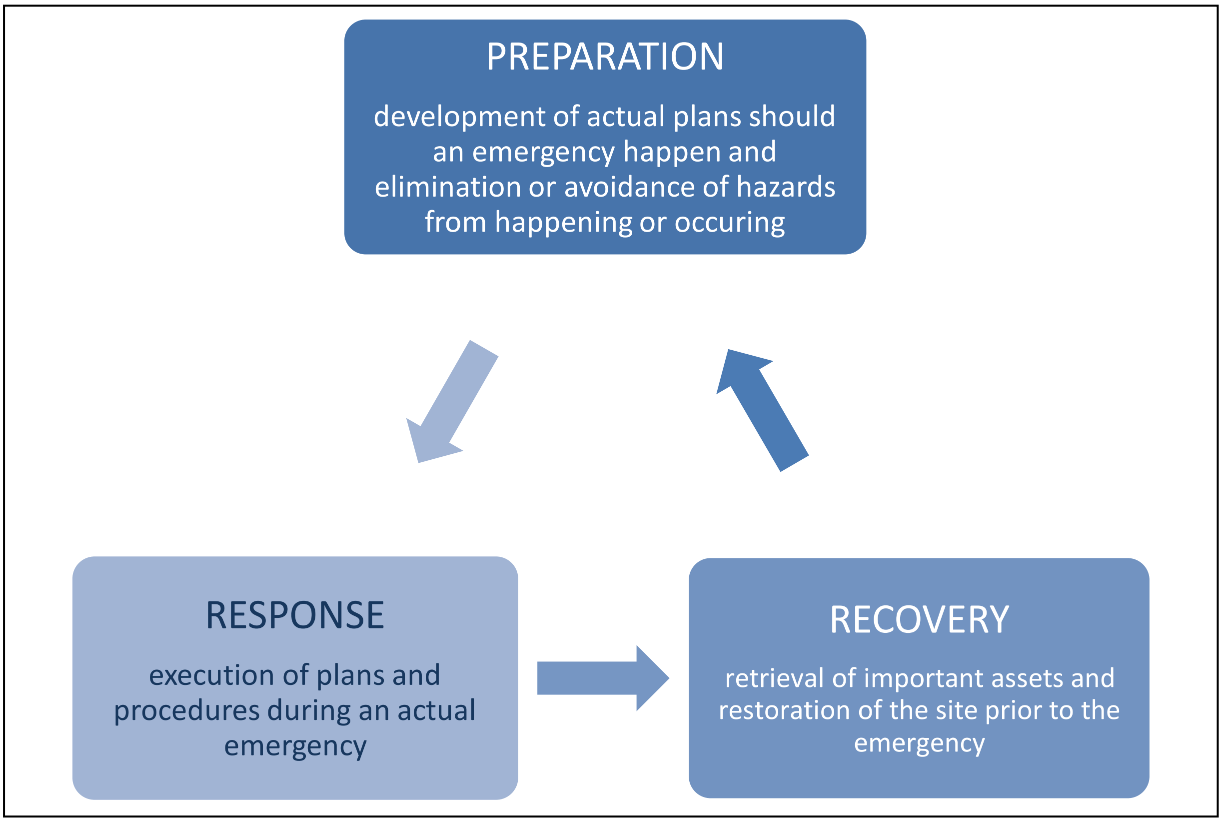


Figure 4-9 Emergency response procedure

Table 4-5 Key personnel in emergency response operations

Emergency response personnel	Roles and responsibilities
Leadman (incident commander)	• Overall in-charge of operations during an emergency event • Provides direction and orders to the response team in managing the emergency • Informs supervisor/project manager about the incident
Supervisor/ Project Manager	• Assists at site when necessary • Know the condition of people involved in the emergency, assess the situation, give instructions to First Aid Team in case necessary • Inform family/ies concerned, providing information of hospital location and other necessary details
Safety officer	• Supervises daily safety performance of operations and maintenance procedures, including emergency response procedures
Liaison officer	• Secures the necessary permits and training certification for the personnel
First aid team	• Performs the actual response, rescue and retrieval of personnel and equipment during an emergency event • Calls for ambulance or needed specialists to immediately assist case when necessary, or arrange for case forwarding to better equipped hospital, if needed equipment is not available in nearby hospital
Logistics team	• Provides the necessary supplies and equipment for the First aid team • Provides additional support/assistance to the First aid team

CHAPTER 5 SOCIAL DEVELOPMENT PLAN AND IEC FRAMEWORK

5.1 Social development plan

Indicative social development planning is necessary in formulating programs and strategies that would mitigate the major impacts of the project. This would guide the proponent in preventing/mitigating and/or enhancing a project's adverse and positive impacts on people's livelihood, health and environment.

Social Development Plan (SDP) aims to assess and identify the basic needs of the communities which will be affected by the project. SDP should be patterned in the Municipal and Barangay Development Plans of the host communities and in accordance with the mandated Corporate Social Responsibility. It aims to establish a strong relationship between the Project Proponent, community institutions, and stakeholders towards the goal of achieving an improved quality of life of the residents of the host localities.

The issues that were raised during the public scoping were considered and addressed in the formulation of SDP. Moreover, issues obtained from perception survey and Public Scoping were also included. These are the following:

- Opportunities for tricycle drivers
- Loss of fishery resources/main source of livelihood
- Loss/negative impact on mangrove areas
- Conflict to other government projects in Barangay Tanza
- Risks from chemicals found on dredged materials
- Accumulation of silt
- Alternative livelihood for fishermen
- Impacts on shipyard industry
- Increased flooding
- Source of borrow materials
- Heavy siltation due to strong current on the southern part of the proposed reclamation
- Inclusion of housing projects on the reclamation area
- Alternative plans on the construction of C5 and C6 road networks

The details of the indicative SDP indicating the major program and activities are presented in Table 5-1.

Table 5-1 Indicative Social Development Plan for the Host Municipalities and Barangays

CONCERN	Responsible Community Member/Beneficiary	Government Agency/Non-Government Agency and Services (Indicative Specific Services)	Proponent	Indicative Timeline	Source of Fund
1. Gender Responsive • Livelihood/Employment and Credit Facilities *Men* - Skills development for project employment - Training and workshop on Efficient Fishing Methods *Women, Youth and Elderly* - Livelihood trainings for skill development	• Barangay Kagawad for livelihood • Qualified identified workers within the area who will be affected by the project. • BFARMC President and qualified identified affected fisher folks. • Qualified identified affected residents in the vicinity of the project area	• LGU City Planning Officer • CSWD ○ Pro-poor Livelihood programs • MAO ○ Workshop on efficient fishing methods	Community Relations Officer	• Pre-construction • Construction • Operation	LGU-IRA/ PROPONENT
2. Health and Safety • Health & Safety Training for employees	• Barangay Kagawad for Health ▪ Barangay Health Workers ▪ Barangay Nutrition scholars • Barangays affected by the project • Project employees	• City Health Officer Maternal Care and Child Health Care -Prenatal, Intranatal, Postnatal -Child birth in health centers or hospitals Malnutrition -Supplemental feeding • Barangay Disaster Management	PROPONENT Community Relations Officer	• Pre-construction • Construction • Operation	LGU-IRA/ PROPONENT
3. Education and Recreation • Assistance for development of school facilities • Provision of scholarship to qualified students	• Barangay Kagawad for Education • Barangay Elementary/Primary School Principal	• CPDO & ME of the City • DEPED of the City • Barangay Elementary Schools - Sports and Recreation Program	PROPONENT Community Relations Officer	• Pre-construction • Construction • Operation	LGU-IRA/ PROPONENT
4. Environment and Sanitation	• Barangay Kagawad for Environment	• CAO/CENRO of the City • CHO of the City • Implement the Ecological Solid Waste Management (RA 9003) • Implement Clean & Green for Barangay buffer zones • Implementation of Health & Sanitation Program • Mangrove Reforestation	PROPONENT Community Relations Officer and Pollution Control Officer	• Pre-construction • Construction • Operation	LGU-IRA/ PROPONENT

CONCERN	Responsible Community Member/Beneficiary	Government Agency/Non-Government Agency and Services (Indicative Specific Services)	Proponent	Indicative Timeline	Source of Fund
		• Marine Sanctuary Establishment/Protection			
5. Peace and order • Entry of migrant workers • Conflict of project workers	• Barangay Kagawad for Peace and Order • Barangay Tanods	• PNP of the City	PROPONENT Chief Security Officer	• Pre-construction • Construction • Operation	LGU-IRA/ PROPONENT
6. Spiritual	• Barangay Assigned Catholic Priest, Pastor of different denomination	• Parish Priest and Pastor	PROPONENT Community Relations Officer	• Pre-construction • Construction • Operation	PROPONENT

5.2 Information, education and communication framework

A comprehensive and intensive Information Education Communication (IEC) Campaign to better inform and educate the communities and the general public as to the objective, necessity and benefits of the project, as well as the processes involved for the construction and operation of the project. These shall be done thru distribution and posting of written materials such as brochures, newsletters, media statements and articles, bulletins and posters, and online presence. Also as well as non-written types such as fora, symposia, community discussions and hearings, audio visual presentations (such as powerpoint and DVD), radio and TV programs and/or guestings, etc. The IEC materials and activities will also serve as a venue for continuous dialogue, feedback and check and balance mechanism for the parties involved.

Table 5-2 below presents the proposed IEC Plan for the Reclamation Project.

Table 5-2 Indicative Information, Education and Communication (IEC) Plan

NEEDS	IMPLEMENTATION	COMMUNITY IMPLEMENTATION PLAN (Strategies)	GOVERNMENT/ NON-GOVERNMENT AGENCY SERVICES	PROPONENT	COST ESTIMATE
Full Information about: ❑ The EIA process ❑ The operation of project ❑ The remuneration for identified land areas to be used by the project operation ❑ The consequential impacts on the residents of the community ❑ And the benefits of the Project on their Socio-cultural/economic and bio-physical environment of the affected residents as they address the major issues of: air and water Pollution using Information, Communication	Before project implementation	1. Primer/ Brochure (print media) This strategy is effective in explaining in detail the subject matter, done in a simplified manner and in the language of the people. This strategy likewise, uses illustrations to further clarify the processes that are to be done. A. The EIA process illustrated and simplified in the language of the affected community, B. The Reclamation Project: This shall contain: - the project description, project time frame, project facilities, management of Social and Environmental impacts, potential project benefits a graphic illustration about the project and mitigating measures - the process of Environmental Impact Assessment, roles and responsibilities of stakeholders - The Social Development and Management Plan • Gender Responsive Livelihood and Credit Facilities • Education and Recreation • Health and Safety • Environment and Sanitation R.A.9003 • Peace and order • Spiritual - On the residents who will be affected by the project activities showing their right to complain for violations of ECC conditions. 2. Consultations (These are face to face encounters where participants and facilitators of knowledge and skills develop strategies to respond to the needs of the communities in the context of what is appropriate for their capabilities and	1. Barangay Broadcast using Sound System 2. Commercial Broadcasting Stations 3. Municipal & Barangay Information Officers 4. Elementary and High School Students 5. Barangay Committee on Education and Culture 6. Sangguniang Kabataan Barangay	Community Relations Office Corporate Communication	

NEEDS	IMPLEMENTATION	COMMUNITY IMPLEMENTATION PLAN (Strategies)	GOVERNMENT/ NON-GOVERNMENT AGENCY SERVICES	PROPONENT	COST ESTIMATE
and Information process	During project operations	resources) ❑ Using the interpersonal approach CRO maintain a regular consultation with the barangays for an open dialogue on the issues, problems and concerns related to the implementation and sustainability of the project. (Multi-partite Monitoring Team) ❑ Group discussion of the sectoral groups which will be affected in the project activities, the legal processes with the application of priority job placement, and other benefits ❑ Workshops on Solid Waste Management and Preparation of IEC materials ❑ Community-Based Solid Waste Management and information about R.A.9003 3. Stakeholders Consultation ❑ Using the feed-back mechanism through information booths in the project affected City and barangay. 4. Community Forum and phone Patch up 5. This strategy enables the Company to discuss the progress of the project with key-persons of the company/resource persons weekly. This also encourages multi-sectoral interest groups to ask questions through phone patches.			

CHAPTER 6 ENVIRONMENTAL COMPLIANCE MONITORING

As required under DENR Memorandum Circular 2010-14 and the Revised Procedural Manual for DAO 2003-30, the following section presents the environmental compliance monitoring plan for the project to monitor the identified key environmental impacts of the Project. This monitoring plan includes "Environmental Quality Performance Level" (EQPL) values, which are threshold/limit levels identified for each critical parameter associated with the identified significant project impacts. The limit level shall be the regulated threshold of pollutant (standard that must not be exceeded) while the action level is set lower than the limit level wherein management measures must be implemented so as not to reach the regulated threshold.

The following mechanisms and monitoring schemes are discussed in the succeeding subsections:

- Self-monitoring plan;
- Multi-sectoral Monitoring Framework; and
- Environmental Guarantee and Monitoring Fund/ Contingent Liability and Rehabilitation Fund Commitments

6.1 Self-monitoring plan

The proponent will undertake regular self-monitoring for parameters indicated in Table 6-1. A quarterly environmental monitoring report in the form of the Self-Monitoring Report (SMR) will be prepared by the proponent and submited to the DENR-EMB accordingly.

Table 6-1 Self-monitoring plan

Module	Environmental Sector	Parameters to be monitored	Sampling and Measurement			Lead Person / Office	Annual Estimated Cost	EQPL Management Scheme					
			Methods	Frequency	Location			EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
CONSTRUCTION PHASE													
Land													
Geology and Geomorphology	Geohazards	Liquefaction and ground subsidence monitoring	Periodic monitoring of ground stability	5 years or immediately after a major geologic event has taken place	Project area	Engineering Department	No additional cost; in-house	Noticeable ground subsidence and surface creep	Continuous occurrence of ground subsidence and creep	Significant ground subsidence and surface creep; Formation of cracks in columns, beams, pavement; Misalignment of structures; Impoundment of water due to liquefaction	Increase in monitoring frequency and measurement of magnitude of movement for cracks and surface creep	Check impact of ground subsidence to integrity of infrastructures. Implement necessary engineering measures.	Temporary cessation of construction; Retrofitting of damaged structures; Implement necessary engineering measures. Consider abandonment or relocation if necessary
Water													
Water Quality	Ambient Water Quality (marine water)	▫ pH ▫ Temperature ▫ Total Dissolved Solids ▫ Conductivity ▫ Total Suspended Solids ▫ Biochemical Oxygen Demand (BOD); ▫ Chloride (Cl-); ▫ Color (Apparent); ▫ Dissolve Oxygen (DO); ▫ Fecal Coliform; ▫ Nitrate as Nitrogen (N03--N); ▫ Phosphate as Phosphorous (P043--P); ▫ Ammonia as Nitrogen (NH3-N); ▫ Total Suspended Solids (TSS); ▫ Sulfate (S042-); ▫ Arsenic (As); ▫ Cadmium (Cd); ▫ Hexavalent Chromium (Cr6+); ▫ Lead (Pb); ▫ Mercury (Hg); ▫ Oil and Grease; ▫ Sulfactants (MBAS)	In-situ measurement and laboratory analyses	Monthly sampling, Quarterly Reporting through the SMR	Baseline water quality monitoring stations (may be adjusted accordingly)	PCO	Php 50,000 per sampling station	▫ pH below 6.8 and above 8.3 ▫ Temp: 2.6°C rise in the receiving water body ▫ DO: 7 mg/L ▫ TSS: 40 mg/L ▫ As:0.003 ▫ Cd: 0.001 ▫ Cr+6: 0.03 ▫ Cu:0.009 ▫ Pb:0.008 ▫ Hg:0.001	▫ pH below 6.9 and above 8.4 ▫ Temp: 2.8°C rise in the receiving water body ▫ DO: 7 mg/L ▫ TSS: 45 mg/L ▫ As:0.005 ▫ Cd: 0.002 ▫ Cr+6: 0.04 ▫ Cu: 0.01 ▫ Pb:0.009 ▫ Hg:0.001	▫ pH below 7.0 and above 8.5 ▫ Temp: 3°C rise in the receiving water body ▫ DO: 6 mg/L ▫ TSS: 50 mg/L ▫ As:0.01 ▫ Cd: 0.003 ▫ Cr+6: 0.05 ▫ Cu:0.02 ▫ Pb:0.01 ▫ Hg:0.001	▫ Re-conduct testing to verify ▫ Investigate the source ▫ If the problem is within the construction area, conduct adjustments/ appropriate corrective action at identified pollutant source.	▫ Re-conduct testing to verify ▫ Investigate the source ▫ If the problem is within the construction area, conduct adjustments/ appropriate corrective action at identified pollutant source. ▫ If source is not project construction, inform MMT regarding possible source for the group's investigation and coordination with LGU	▫ Re-conduct testing to verify ▫ Temporarily stop construction works: investigate source ▫ If the problem is within the construction area, conduct adjustments/ appropriate corrective action at identified pollutant source. ▫ If source is not project construction, inform MMT regarding possible source for the group's investigation and coordination with LGU
Air													
Air Quality	Ambient Air Quality	TSP SO2 NO2	TSP Hi-volume/ Gravimetric 1-hour averaging period	Monthly sampling, Quarterly Reporting through the SMR	Baseline air quality monitoring stations (may be adjusted accordingly)	PCO	Php 50,000 per sampling station	TSP: 161 ug/ncm SO2: 126 ug/ncm NO2:	TSP: 184 ug/ncm SO2: 144 ug/ncm NO2:	TSP: 230 ug/ncm SO2: 180 ug/ncm NO2:	▫ Check weather condition during sampling and if location is downwind of construction site	▫ Check weather condition during sampling and if location is downwind of construction site	▫ Check weather condition during sampling and if location is downwind of construction site ▫ Conduct visit at said sampling station and

Module	Environmental Sector	Parameters to be monitored	Sampling and Measurement			Lead Person / Office	Annual Estimated Cost	EQPL Management Scheme					
								EQPL Range			Management Measure		
			Methods	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
			SO2 and NO2 24-hr gas bubbler					105 ug/ncm	120 ug/ncm Complaint lodged by community	150 ug/ncm Complaint lodged by community	▫ Check possible source ▫ If source is project construction, inform contractor for their corrective action (i.e. dust suppression) ▫ If source is not project construction, inform MMT regarding possible source for the group's investigation and coordination with LGU	▫ Conduct visit at said sampling station and conduct retesting using a 3rd party DENR accredited sampling firm to confirm ▫ If source is project construction, inform contractor for their corrective action, and conduct retesting to confirm results of the mitigation measures ▫ If source is not project construction, inform MMT regarding possible source for the group's investigation and coordination with LGU	conduct retesting using a 3rd party DENR accredited sampling firm to confirm ▫ If source is project construction, immediately stop all works involving soil excavation and movement, increase the frequency of the contractor's dust mitigation, resume work only upon visual clearing of the sampling station, and conduct retesting at the said sampling station ▫ If source is not project construction, inform MMT regarding possible source for the group's investigation and coordination with LGU
Noise	Ambient noise levels	Noise levels	24hr sound measurements using sound meter	Monthly sampling, Quarterly Reporting through the SMR	Baseline noise level monitoring stations (may be adjusted accordingly)	PCO	Php 10,000 per sampling station	71dB (daytime) 66dB (morning/ evening) 61dB (night time)	73dB (daytime) 68dB (morning/ evening) 63dB (night time)	75dB (daytime) 70dB (morning/ evening) 65dB (night time)	Identify possible noise source	▫ Conduct visit at said sampling station and conduct retesting using a 3rd party DENR accredited sampling firm to confirm ▫ If source is project construction, inform contractor for their corrective action, and conduct retesting to confirm results of the mitigation measures ▫ If source is not project construction, inform MMT regarding possible source for the group's investigation and coordination with LGU	▫ Conduct visit at said sampling station and conduct retesting using a 3rd party DENR accredited sampling firm to confirm ▫ If source is project construction, reduce use of noisy equipment or reschedule source of noise, conduct retesting at the said sampling station and resume work only upon clearance of the sampling station, ▫ If source is not project construction, inform MMT regarding possible source for the group's investigation and coordination with LGU
People													

Module	Environmental Sector	Parameters to be monitored	Sampling and Measurement			Lead Person / Office	Annual Estimated Cost	EQPL Management Scheme					
								EQPL Range			Management Measure		
			Methods	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
	Workers	Health and safety of workers	Review of health and safety records of company Incident reports	Annual	Project site	PCO	Part of the construction cost	Negative verbal feedback of worker	Formal complaint lodged by worker	Multiple complaints lodged by workers	Proponent to investigate the subject of negative feedback. Coordinate with contractor and MMT.	Investigate cause of complaint, determine and address the root cause. Coordinate with contractor and MMT.	Release official statement for general consumption and employees. Coordinate with contractor and MMT.
	Social Development and Management Plan	Projects initiated by the Proponent under the approved SDP	Community Coordination, social engagements	Quarterly	Host barangay	Community Relations Officer	Part of the SDP Cost	Negative verbal feedback of community	Formal complaint lodged by the community	Multiple complaints by the community	Proponent to investigate the subject of negative feedback. Coordinate with barangay LGU and MMT.	Investigate cause of complaint, determine and address the root cause. Coordinate with barangay LGU and MMT.	Conduct consultation with concerned members of the community. Release official statement. Coordinate with barangay LGU and MMT.
	Information, Education, and Communication	Implementation of IEC activities	Community Coordination, social engagements	Quarterly	Host barangay	Community Relations Officer	Part of the SDP Cost	Negative verbal feed back to the Proponent	Formal complaint lodged by the community	Multiple complaints by the community captured by local media organizations	Proponent to investigate the subject of negative feedback. Coordinate with barangay LGU and MMT.	Investigate cause of complaint, determine and address the root cause. Coordinate with barangay LGU and MMT.	Conduct consultation with concerned members of the community. Release official statement. Coordinate with barangay LGU and MMT.
OPERATIONAL PHASE													
Land													
Geology and Geomorphology	Geohazards	Liquefaction and ground subsidence monitoring	Periodic monitoring of ground stability	5 years or immediately after a major geologic event has taken place	Project area	Engineering Department	No additional cost; in-house	Noticeable ground subsidence and surface creep	Continuous occurrence of ground subsidence and creep	Significant ground subsidence and surface creep; Formation of cracks in columns, beams, pavement; Misalignment of structures; Impoundment of water due to liquefaction	Increase in monitoring frequency and measurement of magnitude of movement for cracks and surface creep	Check impact of ground subsidence to integrity of infrastructures. Implement necessary engineering measures.	Temporary cessation of construction; Retrofitting of damaged structures; Implement necessary engineering measures. Consider abandonment or relocation if necessary
Water													
Water Quality	Ambient Water Quality (marine water)	▫ pH ▫ Temperature ▫ Total Dissolved Solids ▫ Conductivity ▫ Total Suspended Solids ▫ Biochemical Oxygen Demand (BOD); ▫ Chloride (Cl-); ▫ Color (Apparent); ▫ Dissolve Oxygen (DO); ▫ Fecal Coliform; ▫ Nitrate as Nitrogen (N03--N); ▫ Phosphate as Phosphorous (P043--P); ▫ Ammonia as Nitrogen (NH3-N); ▫ Total Suspended Solids (TSS);	In-situ measurement and laboratory analyses	Monthly sampling, Quarterly Reporting through the SMR	Baseline water quality monitoring stations (may be adjusted accordingly)	PCO	Php 50,000 per sampling station	▫ pH below 6.8 and above 8.3 ▫ Temp: 2.6°C rise in the receiving water body ▫ DO: 7 mg/L ▫ TSS: 40 mg/L ▫ As:0.003	▫ pH below 6.9 and above 8.4 ▫ Temp: 2.8°C rise in the receiving water body ▫ DO: 7 mg/L ▫ TSS: 45 mg/L ▫ As:0.005 ▫ Cd: 0.002	▫ pH below 7.0 and above 8.5 ▫ Temp: 3°C rise in the receiving water body ▫ DO: 6 mg/L ▫ TSS: 50 mg/L ▫ As:0.01 ▫ Cd: 0.003 ▫ Cr+6: 0.05 ▫ Cu:0.02	▫ Re-conduct testing to verify ▫ Investigate the source ▫ If the problem is within the construction area, conduct adjustments/ appropriate corrective action at identified pollutant source.	▫ Re-conduct testing to verify ▫ Investigate the source ▫ If the problem is within the construction area, conduct adjustments/ appropriate corrective action at identified pollutant source. ▫ If source is not project construction, inform	▫ Re-conduct testing to verify ▫ Temporarily stop construction works: investigate source ▫ If the problem is within the construction area, conduct adjustments/ appropriate corrective action at identified pollutant source. ▫ If source is not project construction, inform MMT regarding possible source for

Module	Environmental Sector	Parameters to be monitored	Sampling and Measurement			Lead Person / Office	Annual Estimated Cost	EQPL Management Scheme					
								EQPL Range			Management Measure		
			Methods	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
		▫ Sulfate (S042-); ▫ Arsenic (As); ▫ Cadmium (Cd); ▫ Hexavalent Chromium (Cr6+); ▫ Lead (Pb); ▫ Mercury (Hg); ▫ Oil and Grease; ▫ Sulfactants (MBAS)						▫ Cd: 0.001 ▫ Cr+6: 0.03 ▫ Cu:0.009 ▫ Pb:0.008 ▫ Hg:0.001	▫ Cr+6: 0.04 ▫ Cu: 0.01 ▫ Pb:0.009 ▫ Hg:0.001	▫ Pb:0.01 ▫ Hg:0.001		MMT regarding possible source for the group's investigation and coordination with LGU	the group's investigation and coordination with LGU
Air													
Air Quality	Ambient Air Quality	TSP SO2 NO2	TSP Hi-volume/ Gravimetric 1-hour averaging period SO2 and NO2 24-hr gas bubbler	Monthly sampling, Quarterly Reporting through the SMR	Baseline air quality monitoring stations (may be adjusted accordingly)	PCO	Php 50,000 per sampling station	TSP: 161 ug/ncm SO2: 126 ug/ncm NO2: 105 ug/ncm	TSP: 184 ug/ncm SO2: 144 ug/ncm NO2: 120 ug/ncm Complaint lodged by community	TSP: 230 ug/ncm SO2: 180 ug/ncm NO2: 150 ug/ncm Complaint lodged by community	▫ Check weather condition during sampling and if location is downwind of construction site ▫ Check possible source ▫ If source is project construction, inform contractor for their corrective action (i.e. dust suppression) ▫ If source is not project construction, inform MMT regarding possible source for the group's investigation and coordination with LGU	▫ Check weather condition during sampling and if location is downwind of construction site ▫ Conduct visit at said sampling station and conduct retesting using a 3rd party DENR accredited sampling firm to confirm ▫ If source is project construction, inform contractor for their corrective action, and conduct retesting to confirm results of the mitigation measures ▫ If source is not project construction, inform MMT regarding possible source for the group's investigation and coordination with LGU	▫ Check weather condition during sampling and if location is downwind of construction site ▫ Conduct visit at said sampling station and conduct retesting using a 3rd party DENR accredited sampling firm to confirm ▫ If source is project construction, immediately stop all works involving soil excavation and movement, increase the frequency of the contractor's dust mitigation, resume work only upon visual clearing of the sampling station, and conduct retesting at the said sampling station ▫ If source is not project construction, inform MMT regarding possible source for the group's investigation and coordination with LGU
Noise	Ambient noise levels	Noise levels	24hr sound measurements using sound meter	Monthly sampling, Quarterly Reporting through the SMR	Baseline noise level monitoring stations (may be adjusted accordingly)	PCO	Php 10,000 per sampling station	71dB (daytime) 66dB (morning/ evening) 61dB (night time)	73dB (daytime) 68dB (morning/ evening) 63dB (night time)	75dB (daytime) 70dB (morning/ evening) 65dB (night time)	Identify possible noise source	▫ Conduct visit at said sampling station and conduct retesting using a 3rd party DENR accredited sampling firm to confirm ▫ If source is project, do corrective action, and conduct retesting to confirm results of the	▫ Conduct visit at said sampling station and conduct retesting using a 3rd party DENR accredited sampling firm to confirm ▫ If source is project, reduce use of noisy equipment, conduct retesting at the said sampling station and resume operation

Module	Environmental Sector	Parameters to be monitored	Sampling and Measurement			Lead Person / Office	Annual Estimated Cost	EQPL Management Scheme					
								EQPL Range			Management Measure		
			Methods	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
												mitigation measures ▫ If source is not project inform MMT regarding possible source for the group's investigation and coordination with LGU	only upon clearance of the sampling station, ▫ If source is not project, inform MMT regarding possible source for the group's investigation and coordination with LGU
People													
	Workers	Health and safety of workers	Review of health and safety records of company Incident reports	Annual	Project site	PCO	Part of the construction cost	Negative verbal feedback of worker	Formal complaint lodged by worker	Multiple complaints lodged by workers	Proponent to investigate the subject of negative feedback. Coordinate with contractor and MMT.	Investigate cause of complaint, determine and address the root cause. Coordinate with contractor and MMT.	Release official statement for general consumption and employees. Coordinate with contractor and MMT.
	Social Development and Management Plan	Projects initiated by the Proponent under the approved SDP	Community Coordination, social engagements	Quarterly	Host barangay	Community Relations Officer	Part of the SDP Cost	Negative verbal feedback of community	Formal complaint lodged by the community	Multiple complaints by the community	Proponent to investigate the subject of negative feedback. Coordinate with barangay LGU and MMT.	Investigate cause of complaint, determine and address the root cause. Coordinate with barangay LGU and MMT.	Conduct consultation with concerned members of the community. Release official statement. Coordinate with barangay LGU and MMT.
	Information, Education, and Communication	Implementation of IEC activities	Community Coordination, social engagements	Quarterly	Host barangay	Community Relations Officer	Part of the SDP Cost	Negative verbal feed back to the Proponent	Formal complaint lodged by the community	Multiple complaints by the community captured by local media organizations	Proponent to investigate the subject of negative feedback. Coordinate with barangay LGU and MMT.	Investigate cause of complaint, determine and address the root cause. Coordinate with barangay LGU and MMT.	Conduct consultation with concerned members of the community. Release official statement. Coordinate with barangay LGU and MMT.

6.2 Multi-sectoral monitoring framework

The Monitoring Framework, as stated in Annexes 3-2 and 3-4 of DAO No. 2003-30, presents a proposed program wherein the proposed Project's environmental compliance will be verified and reported to concerned stakeholders. These stakeholders are composed of government regulators and recognized non-governmental organizations (NGOs) that have valid issues and concerns on the proposed Project.

6.2.1 Multi-partite monitoring team

The MMT's objective is to provide a venue to discuss the important concerns of the Project. These concerns may involve the following items:

- Verify compliance with ECC and EMP
- Validate the Project's conformance to government standards and submission of necessary post-ECC requirements
- Identify the legitimate concerns of the host community in relation to the implementation of the Project
- Determine the extent and scale of environmental impacts generated by the Project
- Provide additional information, education and communication (IEC); and
- Integration/documentation of complaints, suggestions and compromise agreements.

The proponent will regularly conduct meetings with the MMT members after the formation of the MMT Team. These meetings shall be conducted quarterly and annually. Special meetings may also be held if necessary, most especially during emergency situations or other important occasions that require immediate resolution.

Table 6-2 provides the possible members of the MMT and their respective roles and responsibilities.

Table 6-2 Members and respective roles of the MMT

MMT Member	Role	Responsibilities
EMB Regional Office Director or representative	Chairman	• Provide leadership to team and ensure proponent's compliance to ECC and other relevant laws and regulations
LGUs: • City of Navotas • Barangay Tanza	Member	• Participate in monitoring activities • Provide information to the MMT regarding environmental and socio-economic conditions, as well as issues, problems and suggestions of stakeholders • Participate in the review and verification of reports • Concur with the compliance monitoring and verification reports
DENR-NCR	Member	• Ensure compliance of project to environmental laws, rules and regulations • Provide information necessary for compliance to environmental requirements and commitments • Preparation and review of MMT reports
Non-governmental organizations (NGOs)	Member	• Participate n monitoring activities

MMT Member	Role	Responsibilities
Local Peoples' Organizations (POs)		• Participate in the review and verification of reports • Concur with the compliance monitoring and verification reports • Provide information regarding plans and programs of the respective organizations that may be affected by the Project • Advice MMT of any complaints, issues and recommendations concerning the project
PRA and Navotas City	Member/Secretariat	• Provide necessary budget for the operational requirements of MMT monitoring activities • Prepare all information relevant to the project's compliance to the ECC and relevant laws and regulations and make available to the MMT • Allow MMT members to inspect and observe operation activities of the project • Participate in actual monitoring activities and meetings • Concur with the compliance monitoring and verification reports

6.3 Environmental guarantee and monitoring fund commitment

6.3.1 Environmental monitoring fund

An environmental monitoring fund (EMF) amounting to Six Hundred Thousand Pesos (Php 600,000) will be established in support of the compliance monitoring activities and fund the annual work and financial plan (AWFP) of the MMT. The AWFP will be proposed by the MMT and concurred by the project proponent for the approval of the EMB Regional Director.

The EMF will be utilized to cover all expenditures of the MMT operations to include the following expenses:

- Monitoring cost (equipment, laboratory service fee)
- Hiring of outside experts (technical and financial)
- Preparation and distribution of MMT reports
- Public information campaign (i.e. IEC framework)
- MMT meetings and plant visits
- Transportation
- Meals and accommodation
- Allowances/honoraria
- MMT trainings
- Others

6.3.2 Environmental guarantee fund

An environmental guarantee fund (EGF) will be established in accordance with the guidelines of the DAO 2003–30 through a MOA with EMB (NCR) Regional Office and the proponent.

Generally, EGF has two major components, as follows:

- The Trust Fund amounting to Five Million Pesos (Php 5,000,000) will be established 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
- The Environmental Guarantee Cash Fund amounting to One Million Pesos (Php 1,000,000) will be used for immediate rehabilitation and compensation of affected communities in case of damage or accidents. This can also be utilized for community-based environmental programs and information campaign. The Environmental Guarantee Cash Fund will also be used to cover the operational costs of the EGF Committee, in line with the Project's MMT Manual of Operations that will be approved prior to project implementation

6.3.3 EMF and EGF administration and management

The EMF will be managed and administered by the MMT Executive Committee of the Project. The disbursement of the EMF will be carried out according to the annual monitoring work and financial plan submitted by the MMT, which will be reviewed and concurred with by the Proponent and approved by EMB.

An EGF Committee will be formed to manage, control, and operate the EGF in accordance with the agreed internal procedures established regarding the mechanisms for fund disbursement, processing, validation, accounting and documentation. The committee will be composed of the MMT Officers, with the EMB Regional Director as the Chairperson.

CHAPTER 7 DECOMMISSIONING / ABANDONMENT / REHABILITATION POLICY

Once the Project is completed, there are no plans to abandon the reclaimed area as it shall be maintained to perpetuity.

The project shall be implemented by phase/section, such that each section is secured from erosion on a compartmentalized basis. Should the completion of a phase/section under construction be deferred for another time, the filled materials will be protected from erosion through appropriate engineering measures such as the use of anchored fine mesh geotextile to minimize loss of filled materials. The specific phase/area shall also be secured from illegal encroachment.

In the future, should the facilities within the Project area be removed, the proponent shall ensure that the abandonment will be in accordance with the applicable laws and regulations of the national and local government units.

CHAPTER 8 INSTITUTIONAL PLAN FOR ENVIRONMENTAL MANAGEMENT PLAN IMPLEMENTATION

The institutional organization of the proposed Project is shown in Figure 8-1. The Project will be headed by the Project Manager and supported by the Assistant Project Manager.

The objective of this organization is to achieve the following:

- Implementation of company policies
- Economical and safe operations and maintenance of the project
- Environmental compliance and sustainability; and
- Promotion and enhancement of the social acceptability of the project.

The implementation of the Environmental Management Plan (EMP) provided in this document will be specifically handled by the Environmental, Health and Safety Department. The proponent, through the said department, is committed to comply with the conditions that will be stipulated in the ECC and other related environmental laws.

The proponent will also establish a partnership with relevant government agencies, various stakeholders and local host communities in relation to the project. This partnership is necessary to maintain a transparent and positive relationship for the project and its stakeholders, as well as to ensure compliance with environmental protection and enhancement measures.

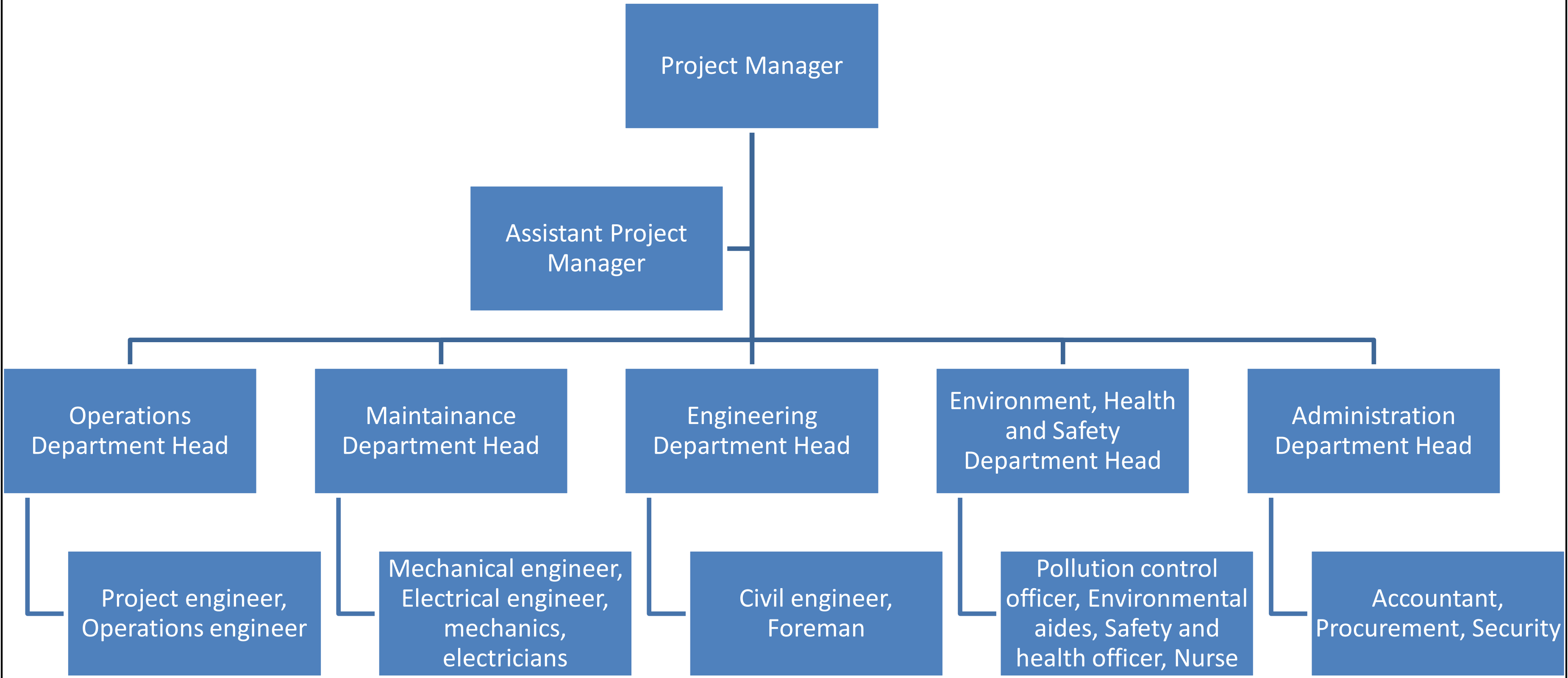


Figure 8-1 Organizational chart for Construction and Operation Phases

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