# MAKATI PUBLIC RAIL TRANSPORT SYSTEM PROJECT

## ENVIRONMENTAL IMPACT STATEMENT

City Government of Makati

Philippine Infradev Holdings Inc.

Lichel Technologies, Inc.

October 2019

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# EXECUTIVE SUMMARY

## I. PROJECT FACT SHEET

| | |
|---|---|
| **Name of Project** | **MAKATI PUBLIC RAIL TRANSPORT SYSTEM PROJECT** |
| **Project Location** | Makati City |
| **Project Proponent** | **Philippine Infradev Holdings Inc.**<br>35/F Rufino Pacific Tower, 6784 Ayala Avenue, Makati City<br>Antonio L. Tiu<br>President and CEO<br><br>**City Government of Makati**<br>Barangay Poblacion, Makait City<br>Hon. Mar-Len Abigail Binay<br>City Mayor |
| **Name of Consultant** | **Lichel Technologies Inc** |
| **Consultant's Address** | 1403 Prestige Tower Condominium F. Ortigas Jr. Road Ortigas Center Pasig City. |
| **Contact Person** | **Rachel A. Vasquez** |
| **Position/ Designation** | Managing Director |
| **Contact No** | T: (02) 6330094 F:(02) 6378209 |
| **E-mail Address** | ravasquez@licheltechnologies.com |
| **Estimated Project Cost** | Php 151,857,675,296.23 (US$ 2,883,410,000.00) |

The City Government of Makati, through the Makati City PPP Selection Committee, has awarded the project for the construction, establishment, management, and operation of a subway system within the Makati City (the "**Makati Subway System**") under a Public-Private Partnership (PPP) to the original proponent Philippine Infradev Holdings, Inc. (the "**Private Proponent").**

The project is envisioned to provide an alternative means of transport within the City of Makati. This will generally improve the traffic situation within the project area due to expected shift of commuters from road-based to rail-based transport system. The project also aims to introduce a developed Transit Oriented Development (TOD). These are areas along the project alignment that can be tapped for development once the project is operational and will be linked by the operation of the project. As these sites generally form a series of development zones that sweep along the northern stretch of Makati, parallel to the Pasig River and J. P. Rizal Boulevard, the collective TODs also enable for Makati a rebirth of its urban identity, to supplement the traditional Central Business District of Makati.

### A. Basic Design Information

| **Operation Details** | | |
|---|---|---|
| | **Day 1** | **Ultimate Phase** |
| Passenger Demand (pphpd-passenger per hour per direction) | 21,000 pphpd | 31,300 pphpd |
| Operating Hours | 18 hours (h) | |
| Maximum Train Speed | 80km/h | |
| Train Capacity | 6-car train (approximately 140 m long, 225 pax/car) 1350 pax | |
| Journey Time (Round Trip) | 33.4 minutes (min) | |
| Peak headway | 3 min | 2 min |
| Off-Peak Headway | 6 min | 4 min |

| | | |
|---|---|---|
| Train in service | 12 | 8 |
| **Train Dimension** | | |
| | **DM-car (m)** | **M-car/T-car (m)** |
| Length | 24.4 m | 22.8 m |
| 6-Car Train Length | 140 | |
| Width (at door threshold) | 3 | |
| Height (from top of rail) | 3.81 | |
| Nominal car floor height (from top of rail) | 1.13 | |
| Door Opening Width | 1.40 | |
| **Tunnels** | | |
| Radius | | |
| Preferable Minimum Radius | 300 m | |
| Absolute Minimum Radius | 250 m | |
| Difficult Situation Radius | 225 m | |
| Preferable Gradient | 3% | |
| Difficult Gradient | 3.50% | |
| Minimum Radius at Station | 2000m | |

The estimated total project area is 301 hectares divided into tunnels, stations and depot area. The breakdown of each area is presented below.

| Component | Area |
|---|---|
| Tunnel | 3,000,000 $m^2$ (300 ha) |
| Stations | 4,070 $m^2$ (0.40 ha) |
| Depot Area | 5,000 $m^2$ 5.00 (ha) |
| **Estimated Total Area** | **3,010,000.00 $m^2$ (301 Has)** |

## II. PROCESS DOCUMENTATION

### EIA Team

| NAME | SPECIALIZATION |
|---|---|
| Rachel A. Vasquez | Project Director/Peer Reviewer/ Water Quality |
| Emmanuel Cleofas | Report Reviewer |
| Mark Anthony Abrenica | Project Manager/ Report Writer/ Land Use and Classification/ People |
| Jan Paolo Pollisco | Terrestrial Flora and Fauna |
| Roberto Pagulayan | Freshwater Ecology |
| Franklin D. Ramones | Hydrology/ Hydrogeology |
| Perfecto Evangelista | Pedology |
| Ronald Pahunang | Meteorology/ Air Quality |
| Anacleto Suelto, Jr. | Geology/Geological Hazards/Disaster Risk Reduction |
| Elijah Dave Alderete | Water Quality |
| Lynnette Lyzellle Ferrer | Environmental Researcher |
| Allen Villanueva | Environemental Specialist |

**EIA Schedule**

| Activity | Date Completed/ Target Date |
|---|---|
| Information Education Campaign (IEC) Activities | 3rd Week of May (May 20, 2019) |
| Preparation for Public Scoping | 4th Week of May |
| Public Scoping | 1st Week of June (June 03, 2019) |
| Technical Scoping with Environmental Management Bureau | 2nd Week of June |
| Baseline Data Preparation | 3rd Week of June to 4th Week of July |
| Laboratory Analysis | 1st to 3rd Week of July |
| Impact Identification and Assessment | 1st to 3rd Week of July |
| Preparation of EIS | 1st to 3rd Week of July |
| Submission of Draft EIS to Proponent | 1st to 3rd Week of July |
| Submission of Draft EIS to EMB | 4th Week of July |
| Preparation of Reply to request for AI | 2nd to 3rd Week of August |
| Preparation for the Public Hearing | 1st to 4th Week of August |
| Public Hearing/Consultation (Tentative) | 1st Week of September |
| Integration of Comments | 4th Week of August to 1st Week of September |
| Submission of Final EIS Report | 3rd Week of September |

**EIA Study Area**

The proposed Makati Public Rail Transport System is located in Makati City. The Project is composed of ten (10) stations beginning from near the intersection of Ayala Avenue and EDSA, towards Paseo de Roxas, Metropolitan Avenue, and JP. Rizal Avenue. The table below shows the location of the stations. The status of the properties to be traversed by the whole project alignment is presented in **Annex 1.**

| Station | Location |
|---|---|
| **1** | Near the junction of Ayala Avenue and EDSA (Interchange with MRT3 Ayala Station) |
| **2** | At the junction of Ayala Avenue and Paseo de Roxas |
| **3** | At the junction of Ayala Avenue and Metropolitan Avenue (existing Fire Station) |
| **4** | At the junction of J. P. Rizal Avenue and Sacramento, southeast of the Circuit |
| **5** | Along J. P Rizal Avenue, in front of the Makati City Hall |
| **6** | Along J. P Rizal Avenue, between Estrella and Camia Street |
| **7** | Near the junction of J. P. Rizal Avenue and Guadalupe Bridge, adjacent to Kennely Binay Park (Interchange with MRT3 Guadalupe Station) |
| **8** | Along J. P. Rizal Extension, in front of the University of Makati |
| **9** | Along J. P. Rizal Extension between 4th Avenue and Kalayaan Avenue |
| **10** | Along J. P. Rizal Extension between 25th Avenue and Sampaguita Street |

**EIA Methodology**

Environmental studies focused on the identified location of each component as the direct impact area. All information and data gathered were compiled and analyzed based on the Guidelines of DAO 03-30. Field investigations and sampling were conducted, together with the secondary data gathered, and the critical parameters for the environmental conditions were established. The EIA methodology for each study modules are provided in Section 2 and are summarized in the table below.

| Modules | Methodologies Used for Assessment |
|---|---|
| Land Use and Classification | • Review of existing literature (Comprehensive Land Use Plan) and maps of the project area.<br>• Site Reconnaissance |
| Geology/Geomorphology | • Review and analysis of existing information from relevant government agencies and institutions, including |

| Modules | Methodologies Used for Assessment |
|---|---|
| | - Mines and Geosciences Bureau (MGB);<br>- Philippine Institute of Volcanology and Seismology (PHIVOLCS);<br>- National Mapping and Resource Information Authority (NAMRIA)<br>- University of the Philippines Nationwide Operational Assessment of Hazards (UP-NOAH)<br>• Ground validation |
| Pedology | • Review of existing literature (Soil Series and Types of Bureau of Soils and Water Management) and maps of the project area.<br>• Site Reconnaissance |
| Terrestrial ecology | • Inventory of flora (in the depot area)<br>• Observation of existing terrestrial fauna<br>• Review of existing literature |
| Hydrology/Hydrogeology/ Geology Engineering | • Review and analysis of existing literature (Feasibility Study conducted in 2018, meteorological Data frm PAgASA, and geologic data from MGB) |
| Water Quality | • In-situ water quality assessment<br>• Grab sampling for laboratory analysis<br>• Review and analysis of existing literature from Pasig River Rehabilitation Commission |
| Freshwater Ecology | • Collection and identification of planktons<br>• Collection of sediment sample<br>• Observation on the whole stretch of Pasig River<br>• Review of relevant secondary information |
| Meteorology/Climatology | • Review and analysis of secondary information from various agencies and institutions:<br>- Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA)<br>- Manila Observatory<br>- European Commission<br>- World Bank<br>- Philippine Infradev Holdings Inc. |
| Air Quality and Noise | • Conduct of ambient air and noise quality monitoring (1 hour and 24 hours)<br>• Inventory of equipment to be sued during the construction phase for Greenhouse Gases (GHG) Emission estimation<br>• Conduct of noise modeling<br>• Review and analysis of primary and secondary information |
| People | • Review and analysis of primary and secondary information for the analysis of socioeconomic condition<br>• Conduct of household and perception surveys<br>• Conduct IEC for public participation |

**Summary of IEC Activity**

The initial Information, Education and Communication Activity for the proposed Makati Public Rail Transport System (Makati Subway) Project was conducted last May 20 2019 at the Executive Lounge, 22nd Floor Makati City Hall Building 1. The activity was attended by around 31 participants representing the following sector2/offices:

- City Vice Mayor Monique Yazmin Q. Lagdameo
- Atty. Claro F. Certeza, Municipal Administrator
- Atty. Michael Arthur R. Camiña, Law Department

- Department of Environmental Services (LGU)
- Urban Development Department (LGU)
- Makati Social Welfare Department (LGU)
- Ospital ng Makati
- University of Makati
- Barangay San Lorenzo
- Barangay Poblacion
- Barangay Valenzuela
- Barangay Olympia
- Barangay Santa Cruz
- Barangay Guadalupe Viejo
- Barangay Urdaneta
- Senior Citizen's Organization

The program started at around 10:30 AM. A briefer on the proposed project and the Environmental Impact Statement System was presented to the participants. An open forum followed the presentation wherein the participants were given the opportunity to raise their issues, concerns and suggestions regarding the proposed project for consideration in the EIA study. The complete proceedings and issues raised during the activity were presented in **Annex 2**.

**Summary of Public Scoping**

The Public Scoping for the proposed Makati Public Rail Transport System was conducted last June 03, 2019 at the Executive Lounge, 22nd Floor, Makati City Hall Building 1, Makati City. The activity started around 10:00 am. The representative from the Environmental Management Bureau-National Capital Region (EMB-NCR), Mr. Aris Carino, explained the purpose and objective of the scoping activity. The representative from Philippine Infradev Holdings Inc and Lichel Technologies Inc presented a brief description of the project and the Environmental Impact Assessment process. The stakeholders were given the opportunity to raise their comments, suggestions, issues, concerns, and problems regarding the project through an Open Forum. The representatives from the proponent and LTI responded to the queries whenever possible, while those comments, issues and concerns raised that were not immediately responded to were noted and will be included in the EIA study. After the open forum, Mr. Carino of the EMB presented the next steps in the EIA process that will be undertaken after the Public Scoping. A total of 35 participants attended the Public Scoping Activity. The attendees represented the following offices:

- Barangay Cembo
- Barangay Guadalupe Nuevo
- Barangay Olympia
- Barangay Poblacion
- Barangay San Antonio
- Barangay San Lorenzo
- Barangay Sta Cruz
- Barangay Urdaneta
- Barangay Valenzuela
- City Legal Office (Makati LGU)
- Information and Community Relations Department (ICRD, Makati LGU)
- Office of the Vice Mayor
- Ospital ng Makati

The complete public scoping documentation including the issues and concerns raised and response of the proponent and consultant were submitted to EMB-DENR and is presented in Annex 3

**Summary of Public Hearing**

The Public Hearing was held last September 23, 2019 at HPSB Multimedia Room 507, University of Makati. The activity started around 9:30 am by discussing the prepared brief presentation on Environmental Impact Assessment (EIA) process, project description and results of the EIA. Afterwards, an open forum was facilitated to solicit the stakeholders' issues, concerns and

recommendations for consideration in the EIA study. Representatives from the following sectors/offices/barangays were present during the Public Hearing:

- Department of Transportation
- Department of Transportation- Rail Sector
- Department of Transportation- MRT3/OOD
- Environmental Management Bureau- Department of Environment and Natural Resources
- Philippine Infradev Holdings Inc.
- City Government of Makati
- Department of Environmental Services- Makati City
- Urban Development Department- Makati City
- University of Makati
- City Social Welfare and Development Office- Makati
- Ospital ng Makati
- Consultants of City Government of Makati
- Lichel Technologies Inc
- Office of the Vice Mayor
- Homeowners Associations of Guadalupe Mansions
- Homeowners Associations of Guadalupe BLISS
- Barangay San Antonio
- Barangay Cembo
- Barangay West Rembo
- Barangay San Lorenzo
- Barangay Valenzuela
- Barangay Guadalupe Nuevo
- Barangay Olympia

The complete public scoping documentation including the issues and concerns raised and response of the proponent and consultant were submitted to EMB-DENR and is presented in Annex 4**.**

## III. EIA SUMMARY

### Summary of Alternatives

Siting

| Items | Alternative 1 (Base Scheme) | Alternative 2 (Proposed Project) | Alternative 3 | Alternative 4 |
|---|---|---|---|---|
| Number of Stations | 9 (No station 6) | 10 (with Station 6) | 8 (No Station 4 and 6) | 10 stations |
| Alignment length | 10.1 km | 10.1 km | 9.7 km | 10.1 km |
| Difference from Base Scheme | • No station 6 | • Locations of Stations 1 to 5 and the railway alignment in between are same as those of<br>• Base Scheme;<br>• Station 6 will be added in between Stations 5 and 7, which is to be located at the junction of J. R. Rizal Avenue and | • This option will void a tight turning curve between Stations 3 and 4. | • This option will pass through the Mile Long Area in Amorsolo Street, Legazpi Village Makati City . |

| | | | | |
|---|---|---|---|---|
| | | Estrella-Pantaleon Bridge<br>• Locations of Stations 7 to 10 and the railway alignment in between are same as those of Base Scheme | | |
| Advantages | • Entire subway alignment is outside the footprint of Pasig River | • With Station 6, Rockwell area will be served/accommodated<br>• Additional development may be needed to construct station 6 due site constraints | • This option would cost less than the base scheme. | • This will have greater potential for future connectivity with other mode of transportation, i.e railway system (PNR).<br>• This will avoid vehicular congestion along Ayala Avenue which is the Central Business District of Makati (during construction). |
| Disadvantages | • Less passengers/area will be served.<br>• Savings in terms of investment cost deemed not sufficient grounds to remove station 6. | • Inclusion of Station 6 would mean more passenger/area served. | • Less passengers/area will be served.<br>• Savings in terms of investment cost deemed not sufficient grounds to remove station 4 and 6. | • Less accessible to Makati CBD. |

Technology Selection/ Operation Process

Different construction methods will be adopted to different portions along the subway alignment, for example, stations will be constructed by cut and cover method, tunnel will be constructed by Tunnel Boring Machine (TBM) method. All major operational areas including train services, central control, and station and depot operations will run according to the base scheme.

Resources

The Project will only require significant sources of power, water and raw materials during construction. In terms of natural resources, one option that was considered is to have temporary reclamation in the river and build a station box under the river bed. This will impose additional requirement of approval from the National Governmentand Pasig River Rehabilitation Commission (PRCC), where significant impact on the overall program is envisaged.

**Summary of Main Impacts**

The summary of the project's main impacts and its mitigation are summarized below. It is expected that there will be minimal impacts on various environmental aspect upon adoption of these mitigating measures.

| Project Phase / Environmental Aspect | Potential Impact | Mitigating Measures |
|---|---|---|
| • Acquisition of Right of Way | • Loss of land and crops ownership<br>• Damage to Properties | • Avert negative perception of people through IEC<br>• Land Acquisition and Resettlement Plan (LARP) Framework must be finalized for equitable compensation and acquisition scheme of affected families and properties |
| • Site Preparation - Vegetation Clearing, Grubbing, and stripping | • Vegetation loss<br>• Removal of economically and ecologically important species<br>• Habitat fragmentation | • Avoid unnecessary cutting of vegetation<br>• Inventory of biota and riparian zone as basis for species and volume replacement<br>• Compensate through planting indigenous tree species suitable in the area<br>• Implement Watershed Management Plan |
| • Earthworks (Soil excavation; stockpiling; hauling of raw materials to construction site; Grading and road construction) | • Change in topography<br>• Underground openings will be subjected to differed loads of the surrounding earth/rock materials.<br>• Seepage (piping) of underground openings.<br>• Increased soil erosion<br>• Destruction or disturbance of aquatic life due to works in rivers.<br>• Change in physico-chemical characteristics of the river. (TSS, TDS, Oil and Grease, and Heavy Metals)<br>• Increase in Total Suspended Particulate (TSP) within and around the Project site.<br>• Noise pollution | • Optimized project footprint to minimize land disturbance<br>• The excavation works will have temporary support for the maintain stability.<br>• Use engineering and vegetative measures<br>• Limit construction activities during dry season<br>• Adequate positioning of stockpile areas away from river/creek.<br>• Road-bank soil erosion prevention/minimization (use of biological or non-biological structures)<br>• Minimize area of earth moving and efficient collection of excess earth materials<br>• Regular sprinkling of water along the access road during dry season,<br>• Impose speed limits in construction area.<br>• Maintenance of construction equipment<br>• Use of good quality fuel to reduce $SO_x$ and $NO_x$ emissions<br>• Use of mufflers and exhaust silencers<br>• Periodic inspection and maintenance of equipment<br>• Construction works should be done during daytime only |

| Project Phase / Environmental Aspect | Potential Impact | Mitigating Measures |
|---|---|---|
| • Use of Vehicles and Heavy Equipment | • Oil and grease leaks from heavy equipment and vehicles<br>• Increase in $SO_x$ and $NO_x$ concentrations from vehicle emission | • Periodic inspection and maintenance of equipment<br>• Designation of motor pool with complete facilities<br>• Equipment should always be in good running condition |
| • Construction of Structures | • Temporary increase of illness to workers due to increase of Pollutants.<br>• Accidents to workers and exposure to occupational hazards<br>• Increased income and business opportunities<br>• Increase in traffic volume due to entry and exit of vehicles, trucks, and heavy equipment.<br>• Temporary disruption of income sources/ livelihood for those who will be displaced/ relocated<br>• Permanent and temporary dislocation of households and loss/destruction of properties, trees, and crops.<br>• Temporary disruption of access to institutional and basic services for those who will be displaced/ relocated | • Priority of hiring of qualified laborer are given to the residents in the area<br>• Provision of temporary housing and sanitary facilities such as temporary septic tanks.<br>• Proper orientation of workers on waste management and disposal<br>• Hiring of physically fit workers<br>• Provisions of protective and safety gears to workers<br>• Provisions of emergency medical facilities<br>• Prioritization of local supplier or service provider<br>• Re-routing of traffic near construction sites.<br>• Put up signages indicating passage of trucks and heavy equipment.<br>• Coordinate with LGUs<br>• Provision of livelihood training, livelihood assistance and subsistence allowance for displaced families<br>• Implementation of mutually acceptable compensation scheme<br>• Implementation of an IEC program<br>• Ensure provision of institutional facilities (health center, barangay hall, school, churches) at relocation site |
| • Subway Operations | • Increase in particulate matter in station<br>• Increase in vehicle concentration along stations<br>• Change in water quality due to feeds and excrements in Aqua culture<br>• Employment opportunities<br>• Increased source of livelihood for locals | • Regular air quality monitoring<br>• Regular water quality monitoring<br>• Prioritization of host communities in employment<br>• Assistance to LGUs in formulation and implementation of alternative sources of livelihood |

| Project Phase / Environmental Aspect | Potential Impact | Mitigating Measures |
|---|---|---|
| • Host communities | • Monetary and non-monetary benefits to host communities<br>• Increase in access/mobility of goods and services<br>• Increased risky behaviors as a result of increase in income | • Proper utilization of resources.<br>• Conduct IEC Program<br>• Formulate agreements to displaced/affected settlers<br>• Ensure proper signages<br>• Conduct IEC Program; conduct financial literacy programs |
| • Generation of Solid waste | • Change in water quality due to improper waste disposal<br>• Change in water quality (Oil and Grease) due to improper waste disposal | • Implementation of solid waste management including provision of waste bins.<br>• Disposal thru DENR accredited third party service provider |
| • Use of vehicles for mobility in maintenance and operations | • Change in TSP, $SO_x$, and $NO_x$ levels in air | • Periodic maintenance of vehicles |
| • Dismantling/ removal of facilities such as camps, storage yards, workshop areas and motor pool | • Land and water pollution | • Allocate certain percentage of the construction cost for clean-up after construction<br>• Salvage materials that are usable which can be used by the local workers or residence |

**Risks and Uncertainties**

The Environmental Impact Statement was prepared based on the latest available information and as a result of the different scenario analysis, modeling and comparison with standards. This should serve as guide to local, regional and national decision makers in decisions concerning project-related activities. However, this should not be the sole basis of decision making since it is possible that there are project-related risks that is not within the scope of this assessment and may not have been considered in the related management plans. Hence, this assessment will only help as a guide and as supplement to the wide array of information available to decision makers. In the determination of risks and uncertainties, natural and man-made hazards were assessed to aid decision makers in reducing risks for the multipurpose project. All findings were discussed in **Section 3**.

# 1 PROJECT DESCRIPTION

## 1.1 Project Location and Area

### 1.1.1 Project Location

The proposed Makati Public Rail Transport System is located in Makati City **(Figure 1-1)**. The Project is composed of ten (10) stations beginning from near the intersection of Ayala Avenue and EDSA, towards Paseo de Roxas, Metropolitan Avenue, and JP. Rizal Avenue. **Figure 1-3** shows the alignment of the proposed project while **Table 1-1** shows the location of the stations. The proposed rail lines will be located underground accessible through the stations located at ground level.

**Table 1-1: Location of the Stations in the Base Scheme**

| Station | Location | N | E |
|---|---|---|---|
| **1** | Near the junction of Ayala Avenue and EDSA | 14˚33'07.57" | 121˚01'38.87" |
| **2** | At the junction of Ayala Avenue and Paseo de Roxas | 14˚33'23.25" | 121˚01'17.26" |
| **3** | At the junction of Ayala Avenue and Metropolitan Avenue | 14˚33'49.45" | 121˚00'58.37" |
| **4** | At the junction of J. P. Rizal Avenue and Sacramento Street | 14˚34'14.76" | 121˚01'13.28" |
| **5** | Along J. P. Rizal Avenue between F. Zobel Street and Pertierra Street. | 14˚34'06.92" | 121˚01'39.08" |
| **6** | Along J. P. Rizal between Estrella and Camia Street | 14˚34'01.92" | 121˚02'18.40" |
| **7** | Near the junction of J. P. Rizal Avenue and Guadalupe Bridge | 14˚34'04.02" | 121˚02'53.76" |
| **8** | Along J. P. Rizal Extension, near Gen Arellano Street. and Sir Balden Powell Road. | 14˚33'50.45" | 121˚03'29.19" |
| **9** | Along J. P. Rizal Ext. between 4$^{th}$ Avenue and Kalayaan Avenue | 14˚33'20.30" | 121˚01'53.63" |
| **10** | Along J. P. Rizal Ext. between 25$^{th}$ Avenue and Sampaguita Street | 14˚32'58.81" | 121˚03'49.19" |

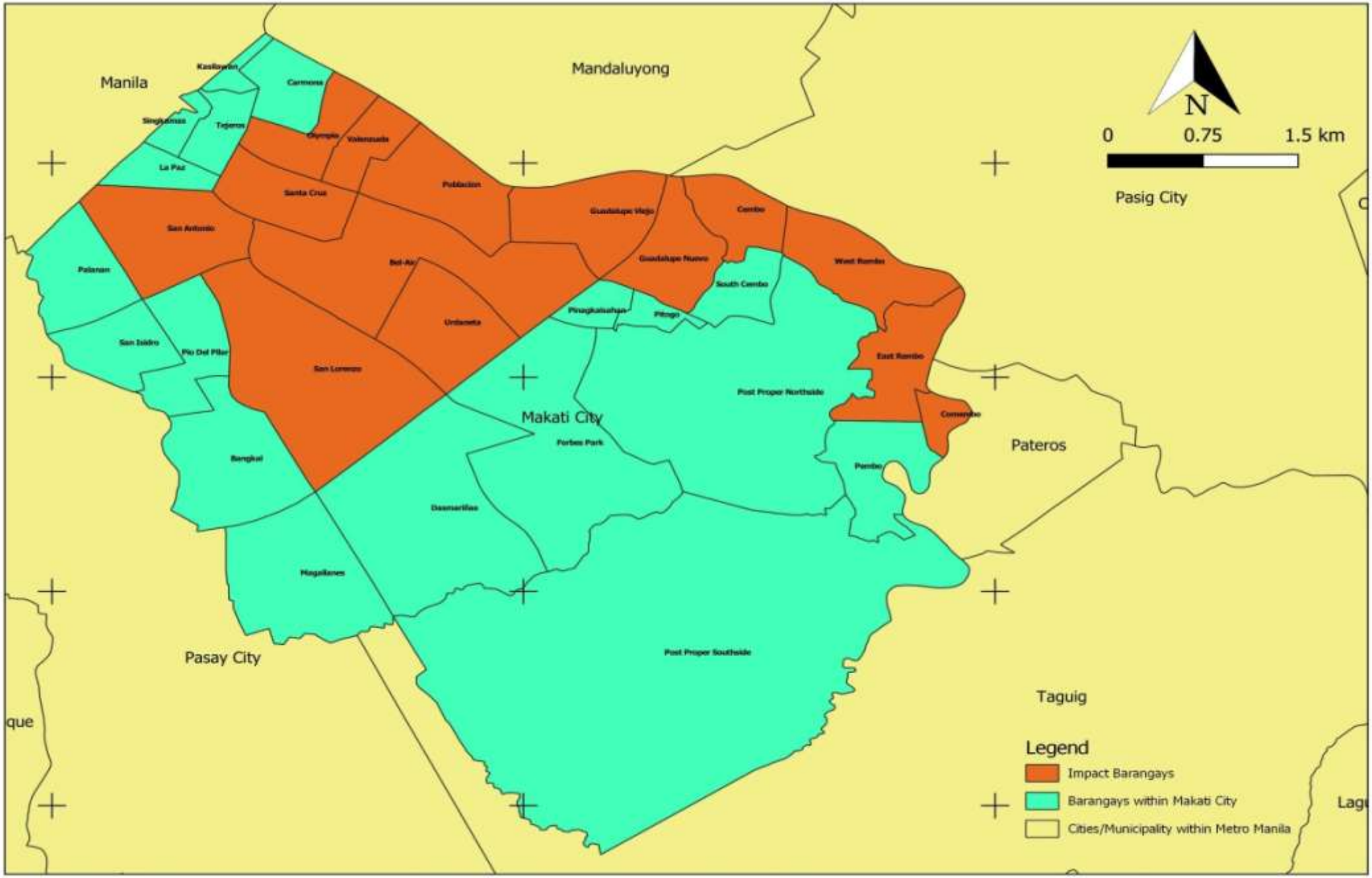
### 1.1.2 Accessibility of Project Site

The project is located along major thoroughfares within Makati City (i.e., Ayala Avenue, Paseo deRoxas, and J.P. Rizal Avenue). The project is readily accessible as it is envisioned to connect to other existing transport nodes.

### 1.1.3 Direct and Indirect Impact Areas

Section 10 of DENR Administrative Order 15 series of 2017 (DENR DAO 2017-15) provided guidelines on defining the Direct Impact Areas (DIA) for the impact on land, water, air and people. Based on these guidelines, the DIA and Indirect Impact Areas (IIAs) will be identified. For impacts on land, this includes areas that may be inundated and may experience disturbance. For water, this includes portions of water bodies that traverses the project (Pasig River, Ayala Creek, Amorsolo Creek, San Jose Creek, and Pinos Creek) and may be affected during construction.

For the people component, identified DIA are the barangays where the facilities are located and the settlements near/within the proposed facilities which may necessitate involuntary relocation and settlements that might experience competition in resource use with the project. Considered as IIA in the assessment is the remainder of city where the DIA barangays are located since the impacts (positive and negative) will have a corresponding effect on these areas.



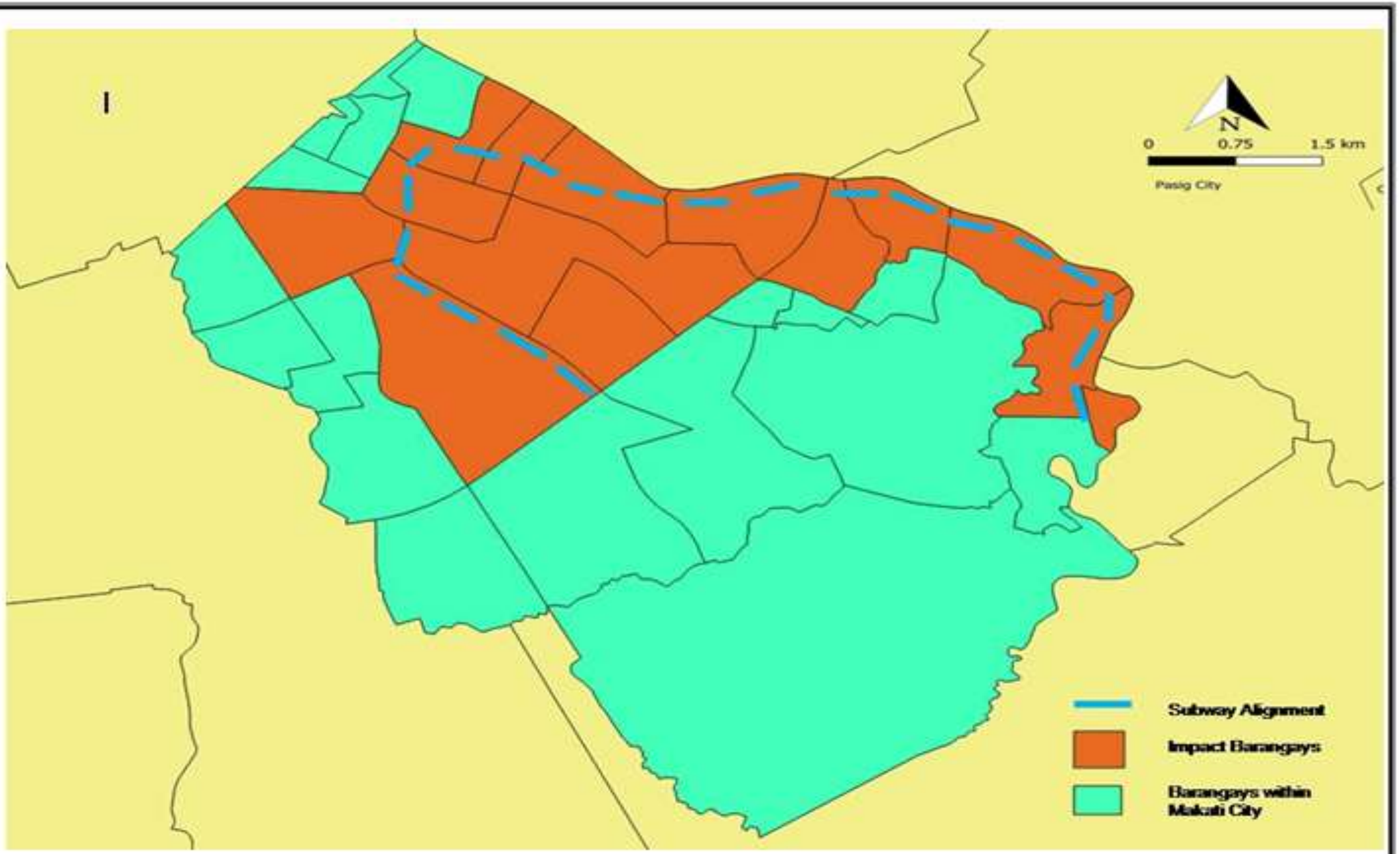

Lichel Technologies, Inc.
Unit 1403 Prestige Tower Condominium
F. Ortigas, Jr. Road, Ortigas Center, Pasig City

FIGURE TITLE :

**Administrative Map**

FIGURE NO.:

**1-1**



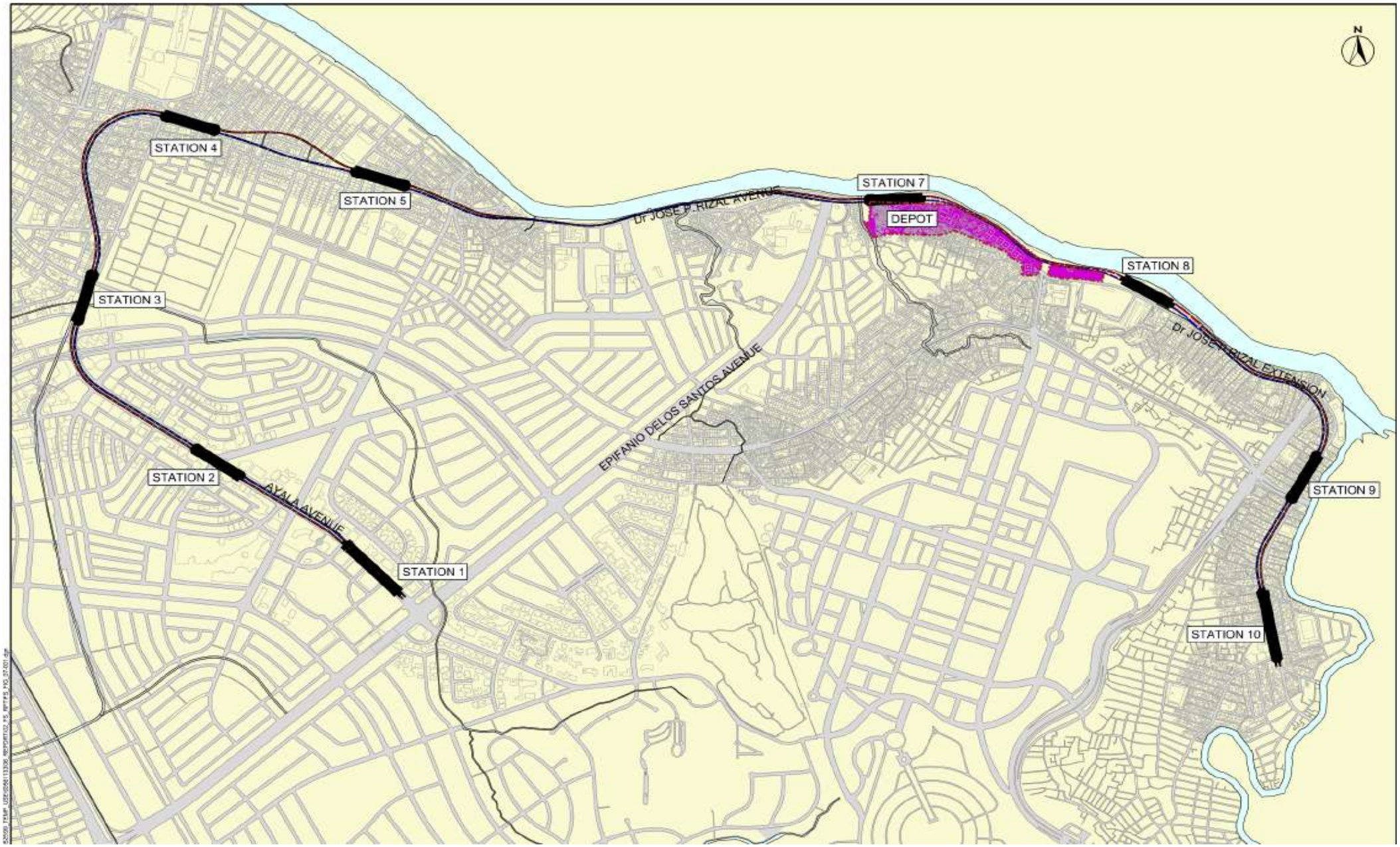

Lichel Technologies, Inc.
Unit 1403 Prestige Tower Condominium
F. Ortigas, Jr. Road, Ortigas Center, Pasig City

FIGURE TITLE:

**Impact Areas Map**

FIGURE NO.:

**1-2**




Lichel Technologies, Inc.
Unit 1403 Prestige Tower Condominium
F. Ortigas, Jr. Road, Ortigas Center, Pasig City

FIGURE TITLE :

**Project Location Map**

FIGURE NO.:

**1-3**

## 1.2 Project Rationale

Philippines, as one of the dynamic developing countries in Asia was facing significant challenges due to rapid urbanization and deteriorating public transport systems. An inadequate public transport system in a highly urbanize city like Makati can cause numerous problem to its citizens on their day to- day life. Having minimal railway services, people are forced to commute by buses or jeepney that would take long hours due to heavy traffic congestion in the whole City.

Makati is a known major generator of traffic in greater Manila, owing to its nature of being a central business district with a large residential population and predominantly service oriented economy. Based on 2011 estimates, Makati City generates 594,872 vehicle trips daily. This is equivalent to about 13% of the 4.5 million Metro Manila vehicle trips per day. The major destinations of Makati City internal traffic reckoned from Barangay Poblacion are the Makati Central Business District and clusters of barangays in Northwest and Northeast. Approximately 11% of internal traffic crosses Epifanio delos Santos Avenue (EDSA), making this a major traffic issue considering that EDSA is a 10-lane highway with commuter rail line at the center.

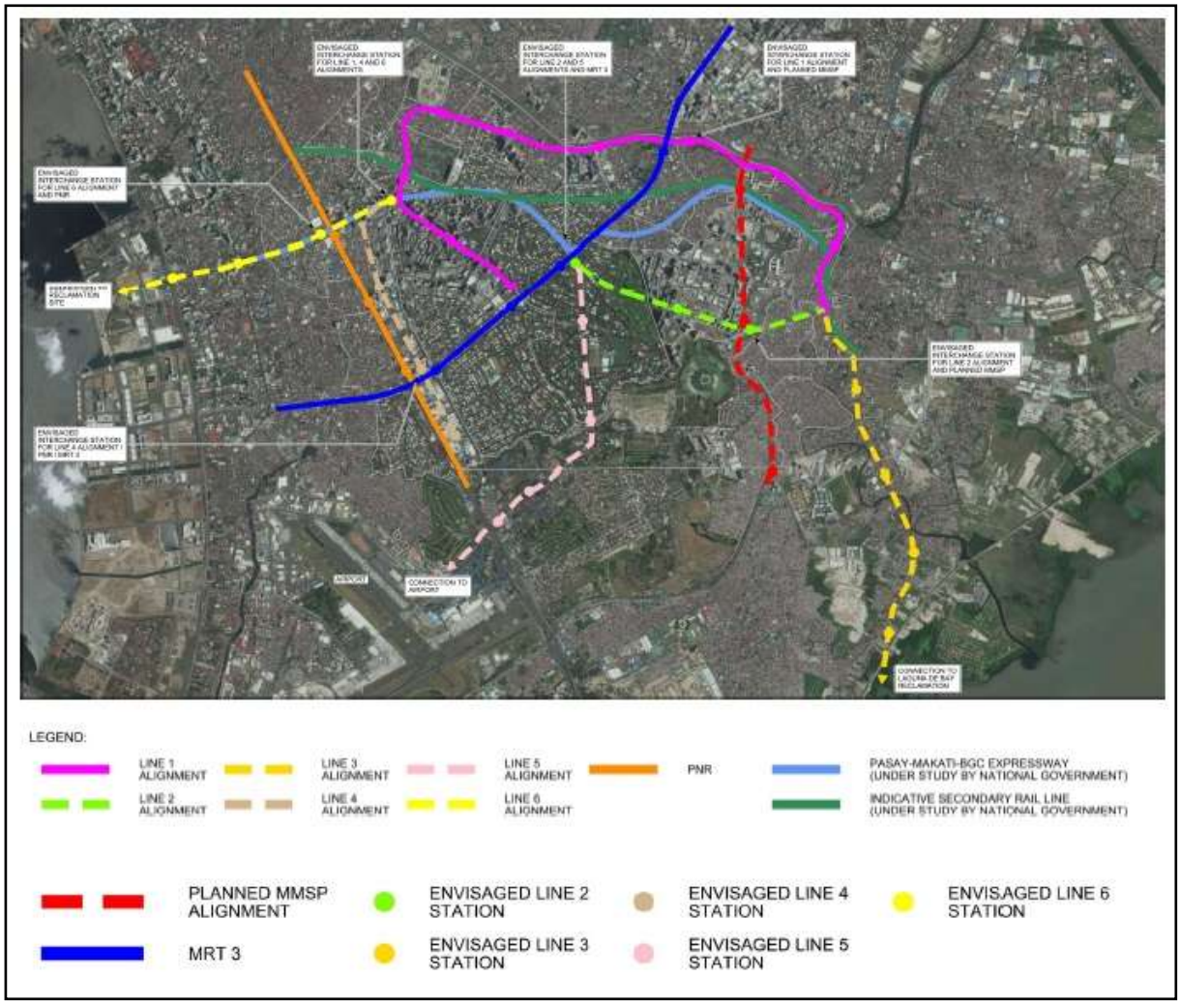



**Figure 1-4: Opportrunity for Linkage with MMSP**

Relatively, the Japan International Cooperation Agency (JICA) has assumed to commence the operation of the porposed Metro Manila Subway Project (MMSP) in 2028. The objectives of MMSP are to ease traffic congestion in EDSA and expand the transport network eastward. MMSP is designed for a better connectivity via a north-south backbone for the Greater Capital Region. There

are two proposed stations within Makati City, Kalayaan Avenue Station and BGC Station. Therefore, there is an opportunity to be connected with the Metro Manila Subway Project by having a common station in Station 8 (University of Makati).

The project is envisioned to generally improve the traffic situation within the project area due to expected shift of commuters from road-based to rail-based transport system. The project also aims to develop Transit Oriented Development (TOD). These are areas along the project alignment that can be tapped for development once the project is operational and will be linked by the operation of the project. As these sites generally form a series of development zones that sweep along the northern stretch of Makati, parallel to the Pasig River and J. P. Rizal Boulevard, the collective TODs also enable for Makati a rebirth of its urban identity, to supplement the traditional Central Business District core of Makati.

At large, the proposed project will pave the way for: convenient mass transport, increased work productivity, more jobs and business opportunities, increased profits for prospect investors, and reduced air pollution.

## 1.3 Project Alternatives

Standards/Criteria

Where possible the assumptions have been made so as not to exclude any one of the potential rail systems/Rolling stock suppliers, but a refinement of the alignment and clearance standards will be necessary once the system to be provided has been identified. It is anticipated that the project-specific criteria will be developed as the design progresses further, and the alignment will be reviewed when the actual railway system is selected.

Based on the patronage forecast, 6-car trains will be adopted at Day 1 for this subway. Related platform length is incorporated in the alignment designed accordingly.

Train with a design maximum speed of 80 km/h has been adopted. In general, a desirable minimum radius of 300m has been used; with this radius and full cant, no speed restrictions are required. Where the various constraints do not allow this radius to be achieved, a reduced radius of 225m is used in the alignment design, resulting in restriction on the speed to around 60 km/h.

Key Assumptions

- Design speed = 80km/hr;
- Rolling stock is assumed to adopt “China Type A” metro. The anticipated tunnel size wit outer diameter of 6.7m is to cope with the structural gauge of China Type A metro, allowance of overhead current supply equipment, walkways at both sides, etc.
- Overhead cable system is adopted;
- Direct Current (DC) power supply with acceleration/deceleration of 1m/s2;
- Trains are right hand running;
- Preferable minimum radius = 300m;
- Absolute minimum radius = 250m;
- Very difficult situation radius = 225m;
- Preferable gradient = 3%;
- Difficult situation gradient = 3.5%; subject to case by case review;
- Maximum gradient for depot connecting lines = 4%;
- Minimum radius at station platform = 2000m;
- Minimum station overrun track length = 80m to be provided at the terminus station.
- Excavation with a further 10m extent beyond the end of overrun track is anticipated for temporary bulkhead wall installation allowing for future subway alignment connection, I any;

- No additional refuge siding; and
- Cross-over to be provided in front of the island platform terminus stations.

Site Constraints

For a project as complex as this one, there are numerous constraints which dictate the alignment. Based on the available information collected during the duration of this study, the constraints include, but not limited to: high-rise buildings, bridges, culverts and rivers/creeks The key constraints and related alignment assumptions from the start of the alignment (Station 1) to the end of the alignment (Station 10) are briefly described below:

- Buildings with 4-storey height or above, where tunnels will inevitably run underneath or nearby. It is assumed that buildings with less than 4-storey height will have shallow foundations. Majority of the alignment is designed to run under public road corridor or run underneath the low-rise buildings to avoid clashing with the uncertain foundations/basements of the buildings with 4-storey height or above.
- At Station 1, the EDSA-AYALA flyover is located near the station box, and therefore the abutment section of the flyover needs to be temporarily demolished with temporary closure of this flyover during the excavation of the station box there. After the the station cofferdam there is constructed and the abutment reinstated, the flyover can then be reopened;
- From the as built drawing of the EDSA-AYALA flyover it is noted that there is an existing tunnel box running underneath the flyover and it is unsure how far this tunnel box extended along Ayala Avenue. Its function is also unknown at for this study it is assumed it has to be retained at its current position during the station construction and dictate the track level at Station 1. Due to the lack of as-built information showing the extent of this tunnel box, the track level of Station 2 is assumed the same as Station 1 to avoid any impact to this tunnel box in case it extends to the station 2 area. These should be further verified at next design stage;
- Two existing pedestrian underpass are identified at locations near Station 1 and in between Station 1 and 2, The subway tunnels will run under these underpasses to avoid impacting them during the subway construction;
- One other identified existing pedestrian underpass is located at Station 2 which is required to be demolished during the station construction;
- At Station 3, a high-rise building is under construction behind the fire station, where the alignment cannot run underneath this building due to its deep pile foundations;
- Creeks near Station 3 require temporary diversion;
- Power substation near Station 3 will not be relocated;
- High-rise building at Rockwell Center near Estrella-Pantaleon Bridge constrains the positions of the subway alignment and station;
- Sta. Monica Bridge (near Station 8) has an impact on the arrangement of the depot layout. RCBC culvert is identified at the same location which requires permanent diversion for the depot construction

### 1.3.1 Siting Alternatives

The summary of siting alternatives is discussed below in **Table 1-2**

**Table 1-2: Summary of Siting Alternatives**

| Items | Alternative 1 (Base Scheme) | Alternative 2 (Proposed Project) | Alternative 3 | Alternative 4 |
|---|---|---|---|---|
| Number of Stations | 9 (No station 6) | 10 (with Station 6) | 8 (No Station 4 and 6) | 10 stations |
| Alignment length | 10.1 km | 10.1 km | 9.7 km | 10.1 km |
| Difference from Base Scheme | • No station 6 | • Locations of Stations 1 to 5 and the railway alignment in between are same as those of | • This option will void a tight turning curve between Stations 3 and 4. | • This option will pass through the Mile Long Area in Amorsolo Street, Legazpi Village |

| | | | | |
|---|---|---|---|---|
| | | • Base Scheme;<br>• Station 6 will be added in between Stations 5 and 7, which is to be located at the junction of J. R. Rizal Avenue and Estrella-Pantaleon Bridge<br>• Locations of Stations 7 to 10 and the railway alignment in between are same as those of Base Scheme | | Makati City . |
| Advantages | • Entire subway alignment is outside the footprint of Pasig River | • With Station 6, Rockwell area will be served/accommodate d<br>• Additional development may be needed to construct station 6 due site constraints | • This option would cost less than the base scheme. | • This will have greater potential for future connectivity with other mode of transportation, i.e railway system (PNR).<br>• This will avoid vehicular congestion along Ayala Avenue which is the Central Business District of Makati (during construction). |
| Disadvantages | • Less passengers/area will be served.<br>• Savings in terms of investment cost deemed not sufficient grounds to remove station 6. | • Inclusion of Station 6 would mean more passenger/area served. | • Less passengers/area will be served.<br>• Savings in terms of investment cost deemed not sufficient grounds to remove station 4 and 6. | • Less accessible to the bulk of passengers within the CBD. |

### 1.3.2 No Project Option

If the project is note realized, the existing traffic situation on the City will continue to be felt. In addition, the development along the alignment will not be realized, hence, impeding the additional employment that these developments will entail.

## 1.4 Project Components

The summary of the project component is shown in **Table 1-3** below. Details are described in the succeeding sections.

**Table 1-3: Summary of Project Components**

| **Operation Details** | | |
|---|---|---|
| | **Day 1** | **Ultimate Phase** |
| Passenger Demand (pphpd- passenger per hour per direction) | 21,000 pphpd | 31,300 pphpd |
| Operating Hours | 18 hours | |
| Maximum Train Speed | 80km/h | |
| Train Capacity | 6-car train (approximately 140 m long, 225 pax/car)<br>1350 pax | |
| Journey Time (Round Trip) | 33.4 minutes | |
| Peak headway | 3 min | 2 min |
| Off-Peak Headway | 6 min | 4 min |
| Train in service | 12 | 8 |
| **Train Dimension** | | |
| | **DM-car (m)** | **M-car/T-car (m)** |
| Length | 24.4 m | 22.8 m |
| 6-Car Train Length | 140 | |
| Width (at door threshold) | 3 | |
| Height (from top of rail) | 3.81 | |
| Nominal car floor height (from top of rail) | 1.13 | |
| Door Opening Width | 1.40 | |
| **Tunnels** | | |
| Radius | | |
| Preferable Minimum Radius | 300 m | |
| Absolute Minimum Radius | 250 m | |
| Difficult Situation Radius | 225 m | |
| Preferable Gradient | 3% | |
| Difficult Gradient | 3.50% | |
| Minimum Radius at Station | 2000m | |

### 1.4.1 Stations

#### 1.4.1.1 Stations Description

There will be ten (10) stations along the subway alignment. All of these stations will be underground and the construction of stations will be carried out by Cut and Cover Method.

The proposed size of the underground station is approximately 250m long by approximately 23m wide except at the locations for TBM launch and reception at the two ends of the cofferdam. The excavation depths of the underground stations are listed below:

- Station 1: approximately 31.7m
- Station 2: approximately 27.5m
- Station 3: approximately 22.7m
- Station 4: approximately 21.5m
- Station 5: approximately 22.2m
- Station 7: approximately 20.9m
- Station 8: approximately 19.5m
- Station 9: approximately 23.9m
- Station 10: approximately 23.6m

Diaphragm wall panels with 1.2m are generally proposed along the length of the cofferdams. At the "soft eye" locations for TBM launch and reception at the two ends of the cofferdams, the diaphragm wall panels are reinforced with glass fibre reinforcement. The numbers of layers of the proposed temporary struts are subjected to the excavation depth of the cofferdams and the encountered ground conditions.

Upon reaching the final formation level, a 300mm thick temporary base slab (lean will be constructed within the most area of the cofferdam. At the ends of the cofferdam, where TBM launching and reception will take place, the temporary base slab is thickened locally to approximately 1000mm at the two ends

The stations in general comprise two levels, concourse and platform. Typical station section is shown in **Figure 1-5.** Stations will also consist of entrances, ventilation shafts, traction substation, heat rejection plant room, and other facilities.

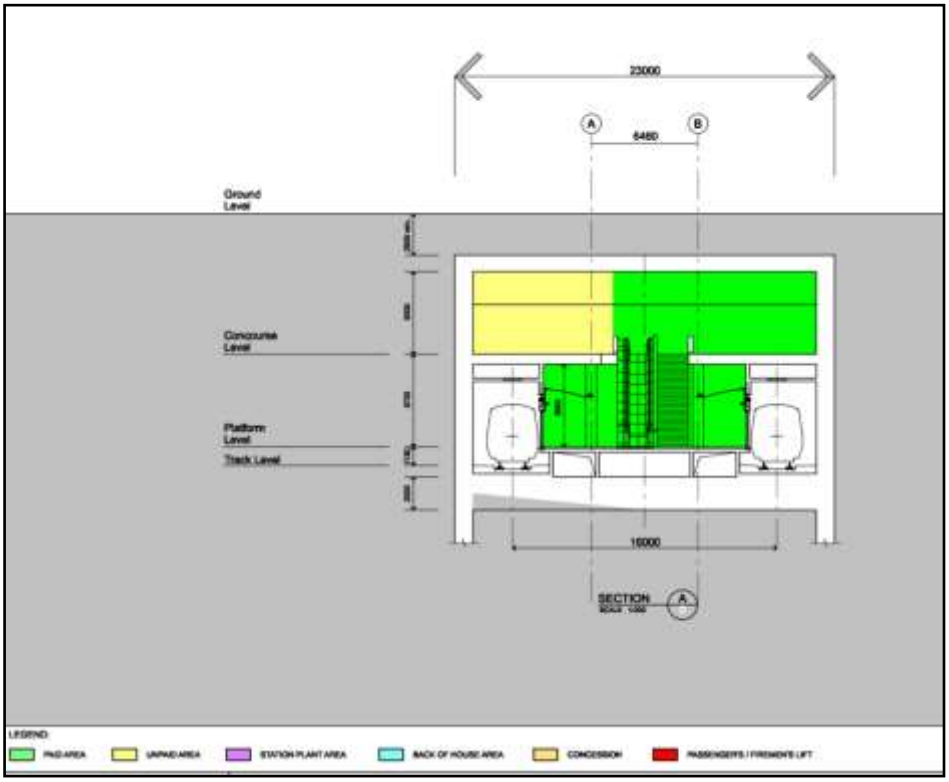



**Figure 1-5: Station Cross Section**

Source: Makati Public Rail Transport System Technical Component Report Philippine Infradev Holdings Inc. (July 2018)

A cross turnout section with length of approximately 150m will be provided at the 2 island platform terminus stations (i.e., Stations 1 and 10) before approaching the station which allow the trains to board passengers at both side of the island platform. An overrun section with length of approximately 80m will be provided beyond the station. The turnout section, same as the station box, will be carried out by Cut and Cover Method.

#### 1.4.1.2 Station Plans

Stations with island platform are proposed for all the ten stations of this subway alignment. Island platform station reduces the confusion of passengers; they only need to make decision to choose the right platform at the platform level. It also reduces the number of vertical links and reduces the overall width of the station box. Furthermore, it is ideal for Tunnel Boring Machine (TBM) tunnels construction as the island platform configuration allows enough separation between the two TBM bores at approaches to the station.

There are 5 types of station layout have been developed to suit specific constraints and requirements at various station sites. Width of all 5 types of station is typically 23 m, but some with potential Transit Oriented Development (TOD) on top may have to be increased slightly to allow bigger column size.

- **Type 1** station layout: This is a typical island platform station with length of 240m. Type1 station layout applies to Stations 4, 7 and 9, layout is presented in **Figure 1-6**;
- **Type 2** station layout: This layout is developed for those stations with traction power substation (TPSS) providing 2 TPSS rooms located at the platform level; station length is slightly increase to 253m to cater for these extra plant rooms. Type 2 station layout applies to Stations 3, 5, and 8, layout is presented in **Figure 1-7**;
- **Type 3** station layout: This layout is developed for l terminus Station 10 with a 122m long turnout section in front. Commercial area linking to the station concourse level will be provided above the turnout section. There will also 2 TPSS rooms provided in this station. This station layout is presented in **Figure 1-8;**
- **Type 4** station layout: This layout is developed for terminus Station 1 with a 122m long turnout section in front. Commercial area linking to the station concourse level will be provided above the turnout section. There will also be 2 TPSS rooms provided in this station. This station layout is presented in **Figure 1-9**;
- **Type 5** station layout: This is a typical island platform station with length of 240m. Type 5 station layout applies to Station 2, layout is presented in **Figure 1-10;**
- Typical sections for all types of station are shown in **Figure 1-11**.
- Station 1 and Station 7 can interchange with MRT's Ayala Station and Guadalupe Station, respectively. The estimated travelling time for these two interchanges (from platform to platform) are approximately 8 minutes and 7 minutes respectively, which is marginally tolerable in rail planning.

#### 1.4.1.3 Station Operations

To enhance passenger perception, stations will be designed in a customer-friendly manner. They will be modern and simple structures offering an open and bright travelling environment conducive to easy and direct accessibility. Whenever it is technically and commercially viable, grade-separated pedestrian links will be provided connecting the stations with nearby buildings.

Full-height platform screen doors will be installed at the station platforms in respect of passengers' safety and to provide a full air conditioned environment at the platform.

To assist passengers, a system of information and direction signage should be well-planned and installed in public areas of the stations.

Stations will be equipped with provisions including station control room, customer service centre, real time CCTV, centralized public announcement system, etc. for daily operation and maintenance.

Fare collection system will be convenient and user-friendly, and will be designed to achieve a high level of security to protect revenue from being loss through the misbehaviours of both passengers and staff.

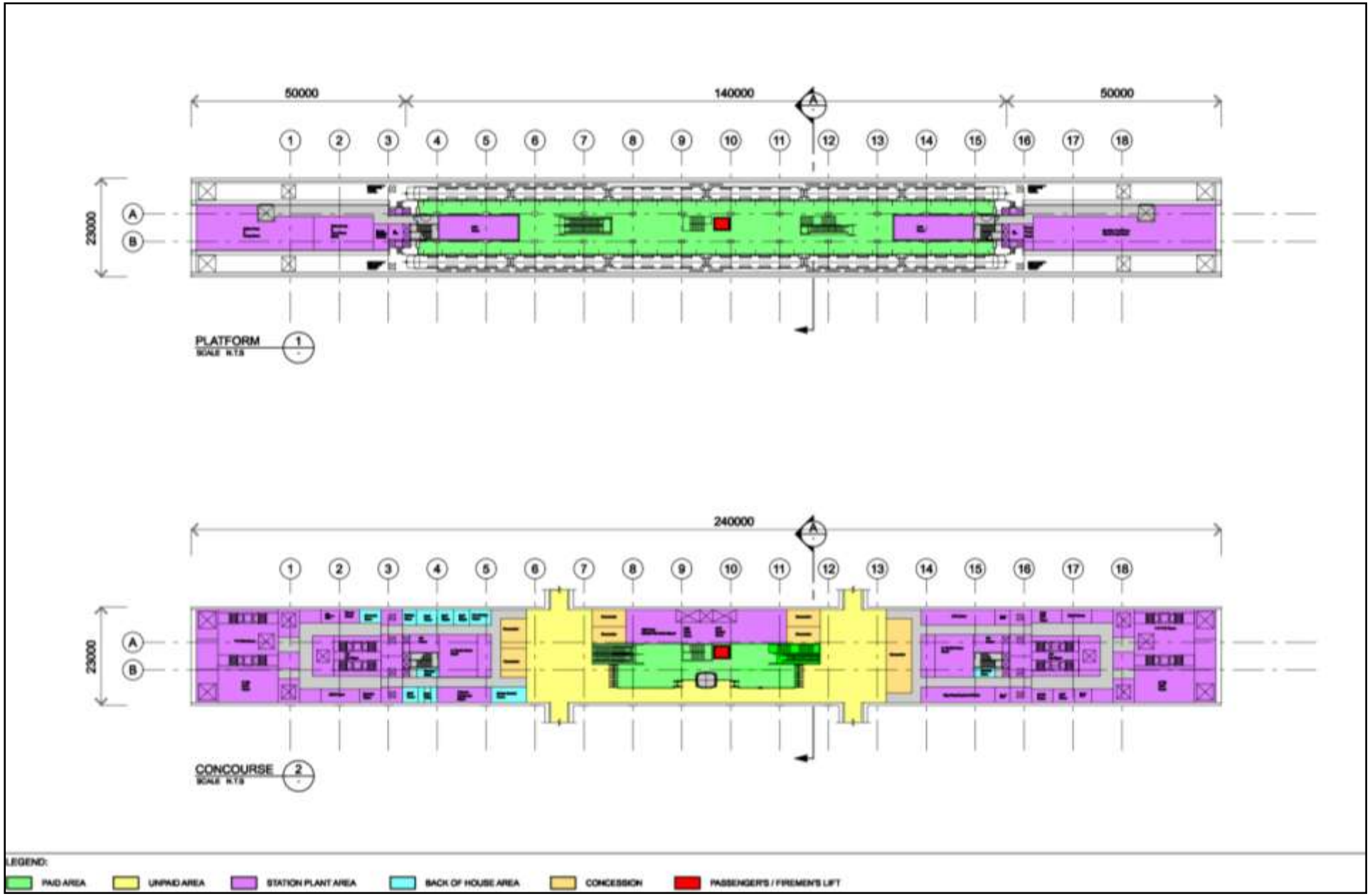



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FIGURE TITLE :

**Type 1 Station Layout**

Source: Makati Public Rail Transport System Technical Component Report
Philippine Infradev Holdings Inc. (July 2018)

FIGURE NO.:

**1-5**

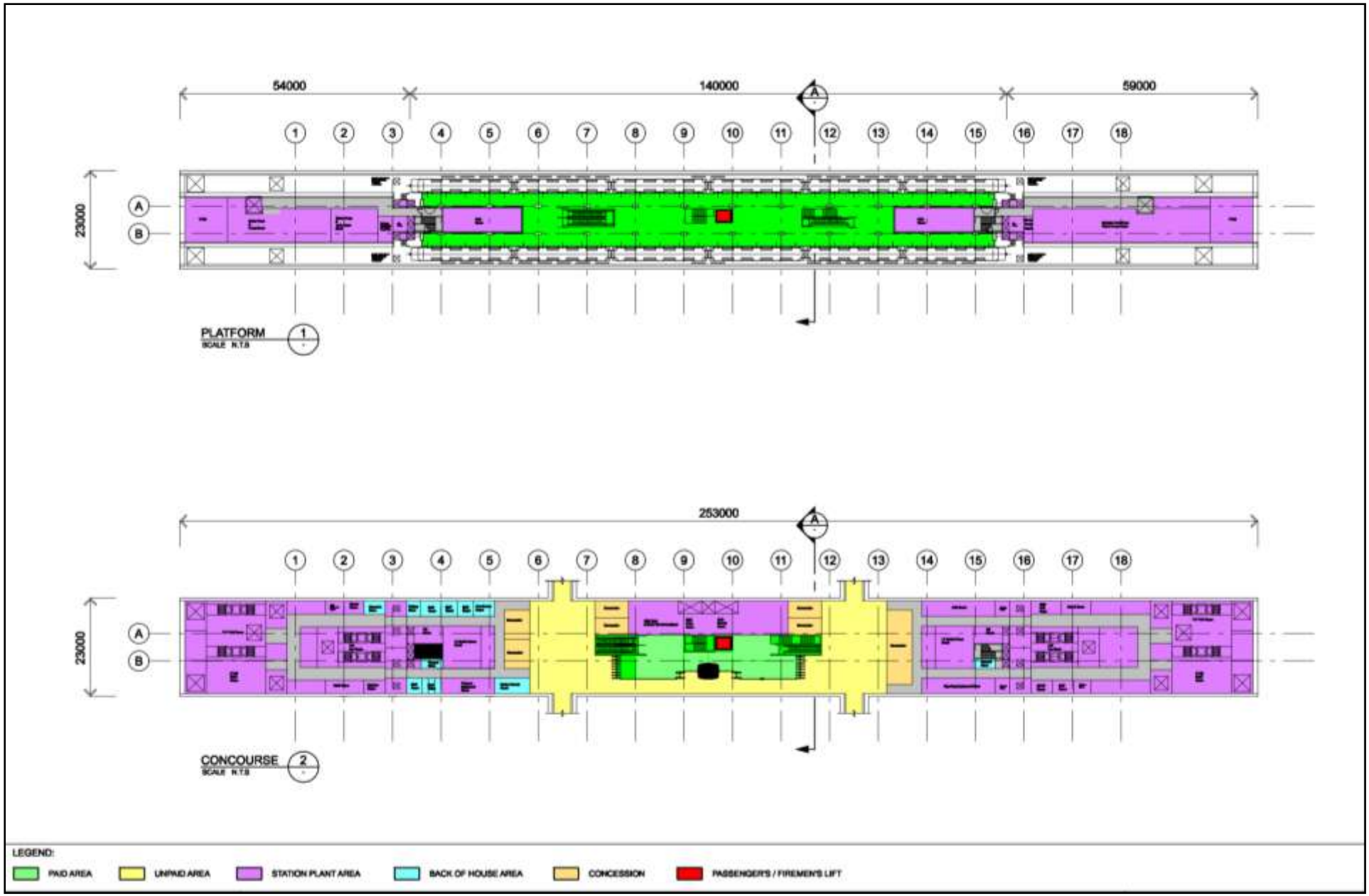


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FIGURE TITLE :

**Type 2 Station Layout**

Source: Makati Public Rail Transport System Technical Component Report
Philippine Infradev Holdings Inc. (July 2018)

FIGURE NO.:

**1-6**

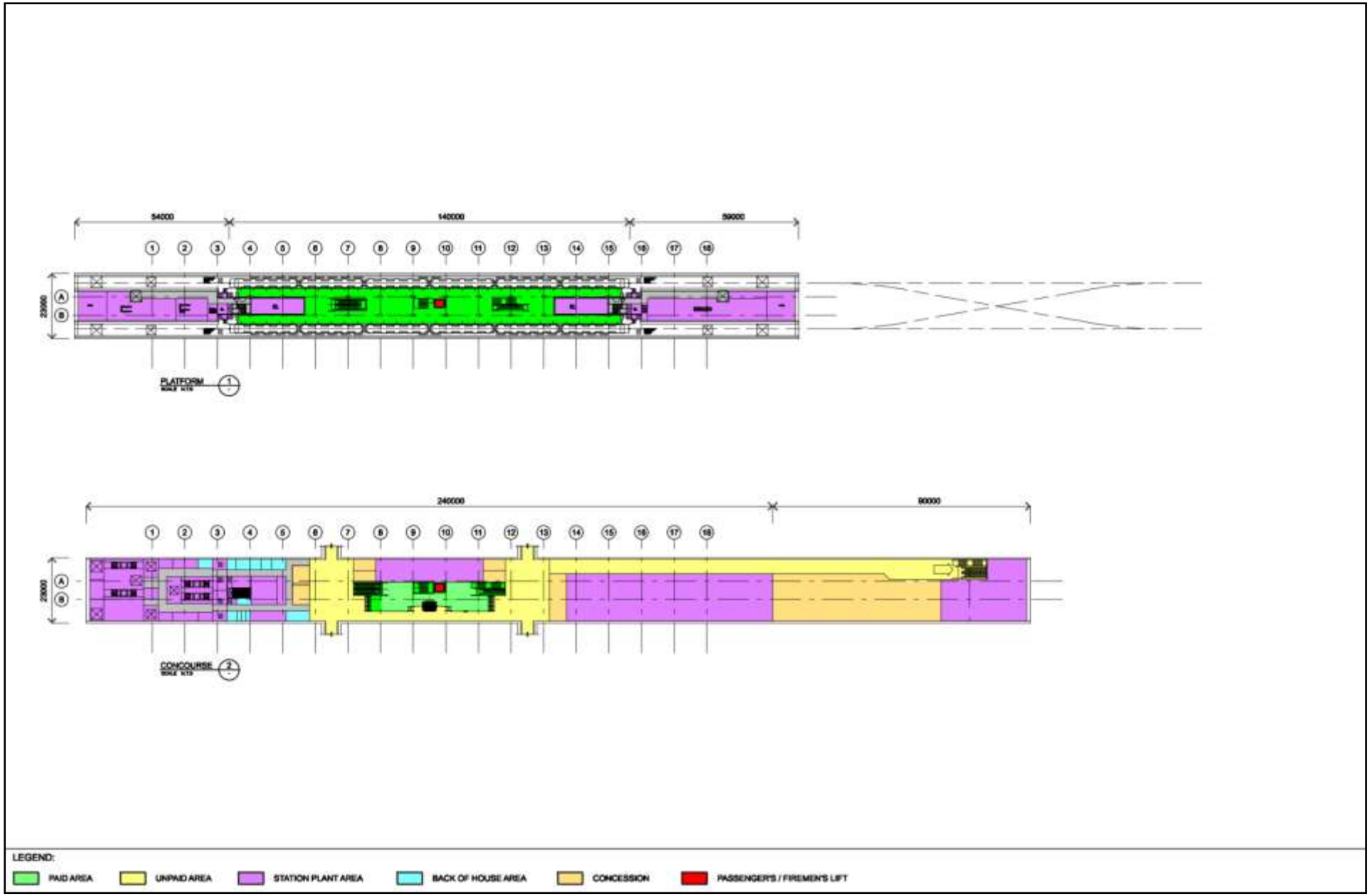


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FIGURE TITLE :

**Type 3 Station Layout**
Source: Makati Public Rail Transport System Technical Component Report
Philippine Infradev Holdings Inc. (July 2018)

FIGURE NO.:

**1-7**

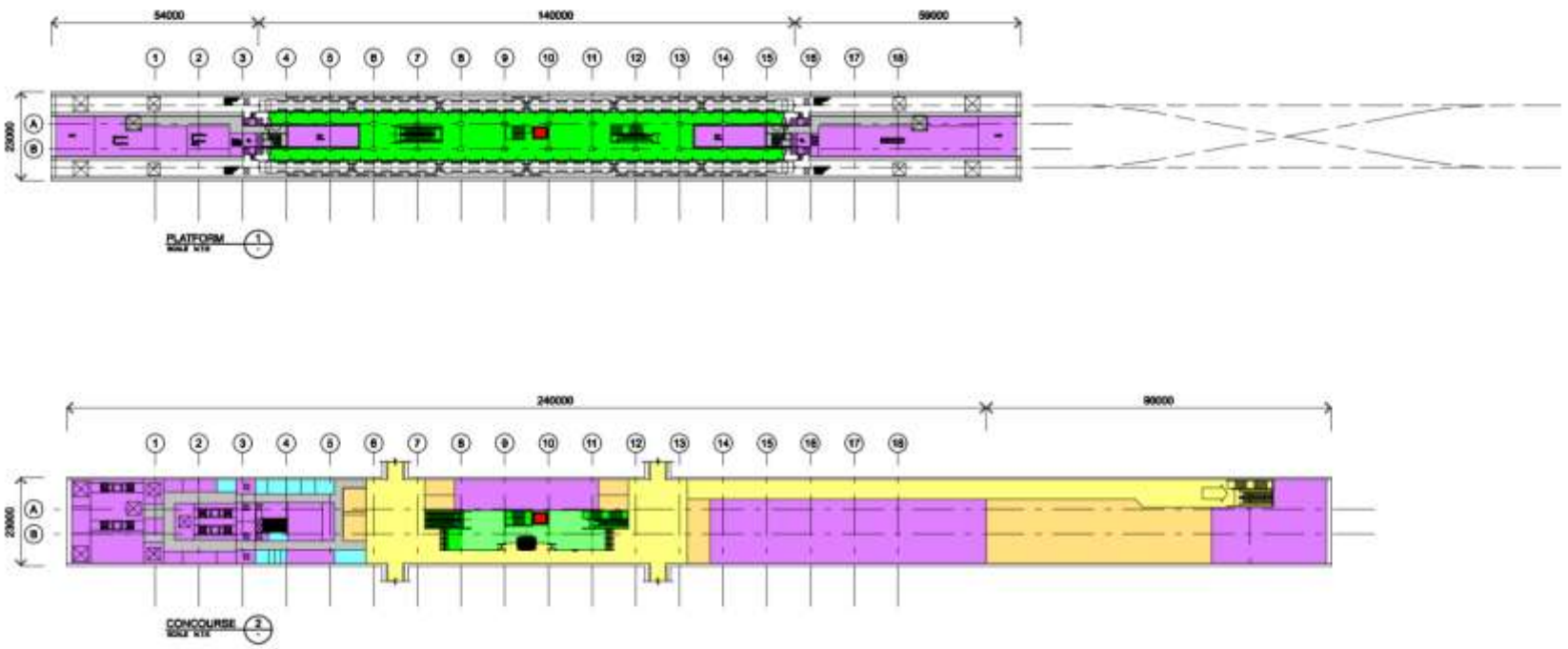


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FIGURE TITLE :

**Type 4 Station Layout**

Source: Makati Public Rail Transport System Technical Component Report
Philippine Infradev Holdings Inc. (July 2018)

FIGURE NO.:

**1-8**

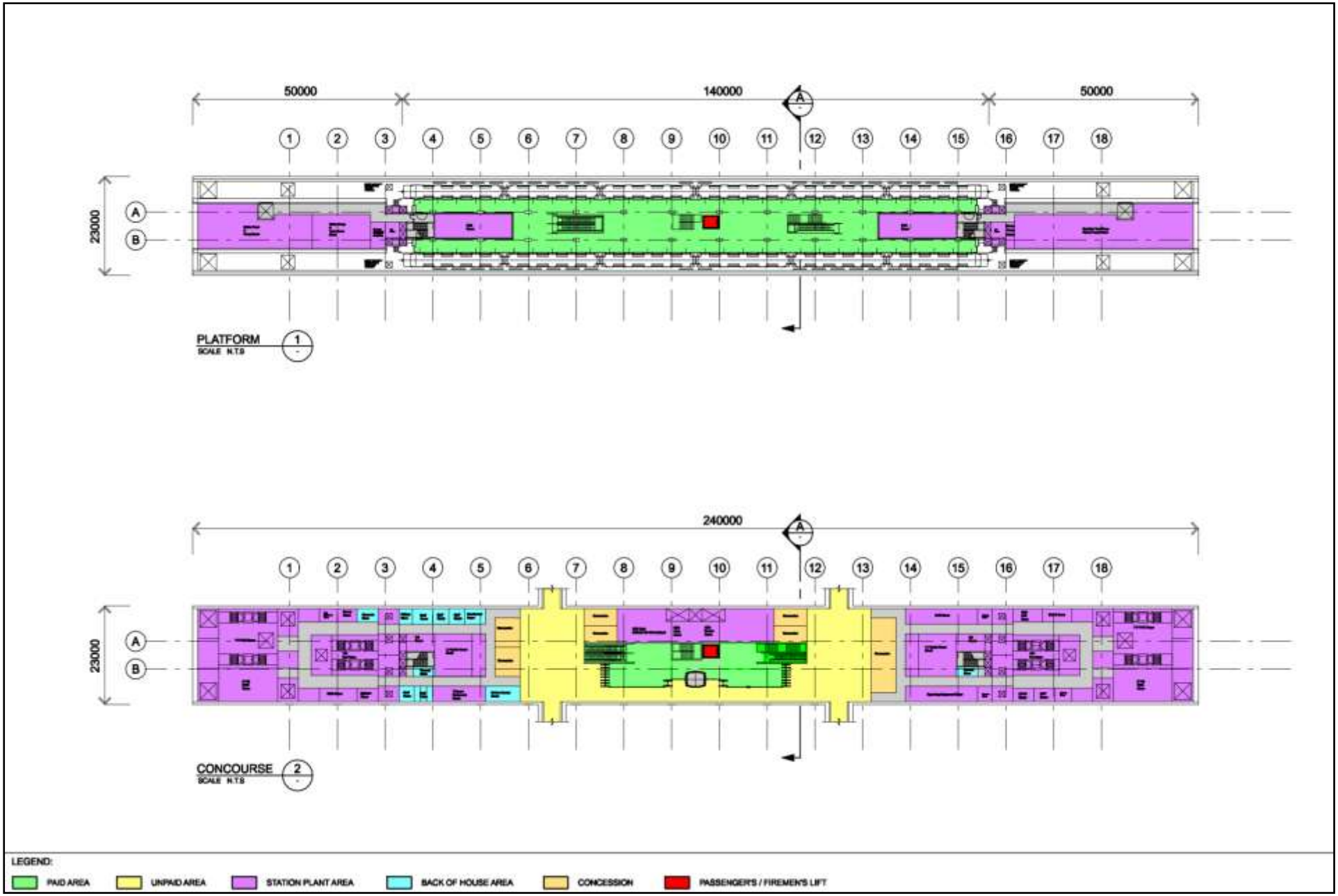


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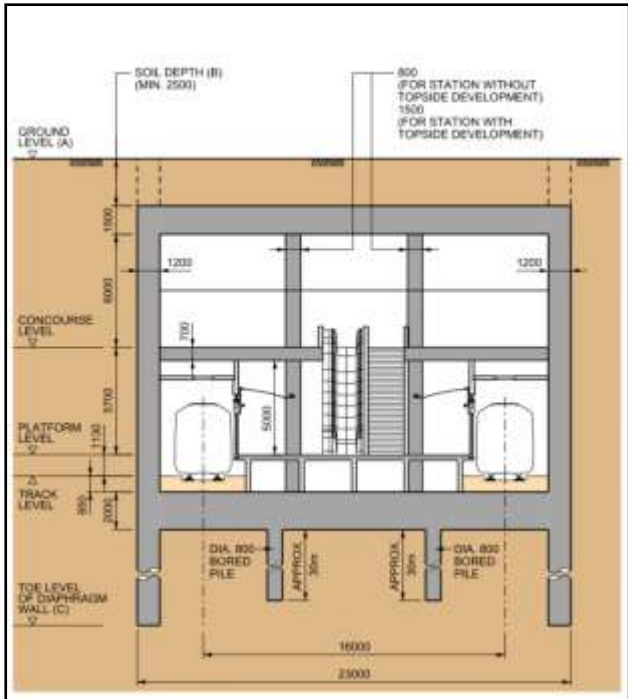
FIGURE TITLE :

**Type 5 Station Layout**

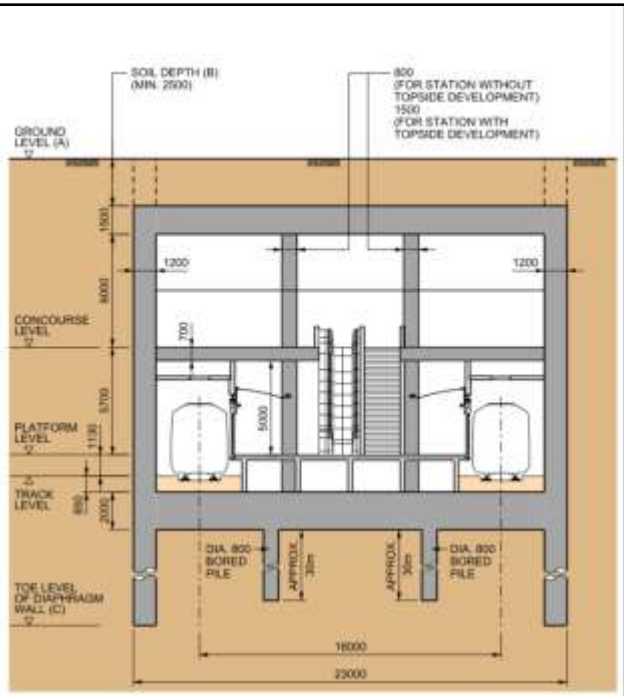
Source: Makati Public Rail Transport System Technical Component Report
Philippine Infradev Holdings Inc. (July 2018)

FIGURE NO.:

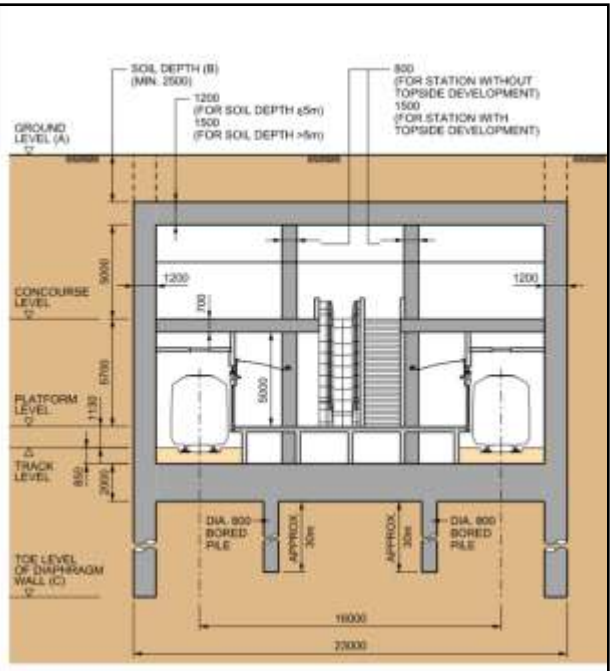
**1-9**




TYPICAL STATION SECTION (TYPE 4)




TYPICAL STATION SECTION (TYPE 5)




TYPICAL STATION SECTION (TYPE 1, 2, 3)

| STATION | STATION TYPE | TRACK LEVEL (mPD) | TENTATIVE GROUND LEVEL (mPD) | TENTATIVE SOIL DEPTH (m) | TENTATIVE TOE LEVEL OF DIAPHRAGM WALL (mPD) |
|---|---|---|---|---|---|
| | | | A | B | C |
| 1 | TYPE 4 | -14.33 | 14.20 | 11.00 | -49.16 |
| 2 | TYPE 5 | -14.33 | 10.00 | 11.00 | -44.96 |
| 3 | TYPE 2 | -15.46 | 4.12 | 6.24 | -41.31 |
| 4 | TYPE 1 | -15.49 | 2.83 | 4.86 | -40.10 |
| 5 | TYPE 2 | -15.12 | 3.91 | 5.70 | -40.44 |
| 7 | TYPE 1 | -12.46 | 5.25 | 4.88 | -36.47 |
| 8 | TYPE 2 | -11.88 | 4.56 | 3.33 | -34.52 |
| 9 | TYPE 1 | -14.57 | 6.17 | 7.41 | -41.62 |
| 10 | TYPE 3 | -14.26 | 6.19 | 7.12 | -40.01 |

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FIGURE TITLE :

**Typical Station Section**

Source: Makati Public Rail Transport System Technical Component Report
Philippine Infradev Holdings Inc. (July 2018)

FIGURE NO.:

**1-10**

Ticket gates will be provided to separate the paid and unpaid areas at the Station concourse level. Both contactless smart card and single-ride magnetic/contactless ticket for multiple and single journeys will be used as the medium to travel. There will be sufficient number of Card Validators, Automatic Ticket Vending Machines, operating through a user-friendly man-machine interface, provided at each station.

### 1.4.2 Trains and Railway System

Grade GoA (Grade of Automation) 2 will be employed for the Makati Subway Operation, which is a semi-automatictrain operation (STO) where starting and stopping is automated, but a driver operates thedoors, drives the train if needed and handles emergencies. The trains will draw power from a nominal 1,500 V DC Overhead Contact System via roofmounted pantograph. The proposed train formation is shown in **Figure 1-12** below:

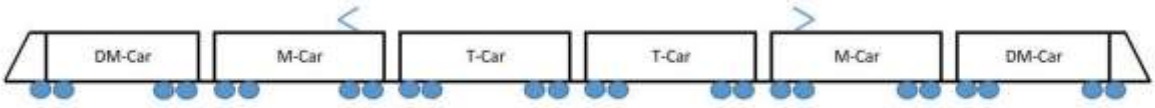


**Figure 1-12: Proposed 6-Train Formation**

Whereas DM is Motor Car with Driving Cab, M is Motor car and T is trailer car. Each M car will be equipped with one roof mounted pantograph for power collection. In line with GoA 2 operation, the trains will be provided with a fully equipped driver cab at each end. The key dimensions of the trains are provided in **Table 1-4**.

**Table 1-4: Key Train Dimension**

| | DM-car (mm) | M-car/T-car (m) |
|---|---|---|
| Length | 24.4 | 22.8 |
| 6-Car Train Length | 140 | |
| Width (at door threshold) | 3 | |
| Height (from top of rail) | 3.81 | |
| Nominal car floor height (from top of rail) | 1.13 | |
| Door Opening Width | 1.40 | |

#### 1.4.2.1 Design Life

The trains will be designed to operate for at least 30 years, with an average annual running distance of 145,000 km.

#### 1.4.2.2 Train Design

The car body will be made of aluminium alloy or stainless steel. The passenger saloon will be provided with stanchions, handrails and wheelchair space with ergonomic consideration. To allow speedy boarding and alighting of passengers, five pairs of doors will be provided on each side of a car.

The doors will be electrically driven bi-parting doors, and will have an interior release handle for emergency evacuation purpose. Audible and visual indication for door closing and opening will be provided. The doors will be equipped with obstruction detection to minimize possibility of passenger or other objects being trapped between a pair of door leaves.

The train interior will follow the most common arrangement in Asia, i.e., longitudinal seats along both sides of the trains. Longitudinal seats will be provided along the window bays of each car. Wheelchair space will be provided at some or all cars. Seats will either be made of stainless steel or fire resistant Glass Reinforced Fiber (GFR). Suitable stanchions, handrails and strap hangers with ergonomic considerations will be provided along the car for passenger's use.

Passenger Emergency Communication (PEC) will be provided by means of a duplex communication system for communication between passengers and the train driver, or in between the passenger and the OCC via the train radio if the emergency call is not attended by the train driver.

LCD type passenger information displays will be provided in the saloon area for displaying of operational messages including dynamic route map, and other infotainments including news and advertisements.

Train borne public address (PA) system will be provided to support the following functions:

- automatic broadcasting of pre-recorded messages during normal, abnormal and emergency operation;
- direct broadcast of messages by the train driver or from Operation Control Center (OCC); and,
- broadcast of selected pre-recorded or ad-hoc messages by the train driver from the driving console.

The trains will be equipped with a video surveillance system comprising in-car CCTV cameras, train end CCTV camera, video recording system, and video transmission system to enable real time viewing by the train operator and the OCC, when necessary. Each train will have event recorders with a capacity sufficient for storing data for a desired period.

Each car will be equipped with two roof mounted package type air-conditioning units, one at each end, with adequate cooling capacity commensurate with Manila's climate. Cooling air will be evenly distributed along a car using ceiling mounted air ducts. These air-conditioning units will also provide ventilation to the train using the on train battery for a fixed period in the event that the traction power is not available.

A walk-through gangway will be provided at all intermediate car ends to allow free movement of passengers between cars. A fully equipped driver cab will be provided at each end of a train. The driver cab will be provided with power operating side sliding door for getting access from a platform, as well as a manual operated cab/saloon hinged door for getting access from the saloon.

The driver cab will be equipped with a driving console, all required operating buttons, switches and indicators. Additionally, all operational information and health status, as well as certain control functions of the train will be provided to the driver through a touch-screen type LCD display of the Train Management System.

An ergonomically designed driver seat will be provided inside the driving cab. Additionally, a foldable instructor seat will also be provided. The bogies will be of a proven design with suspension stiffness optimized to achieve various performance requirement including derailment resistance, ride quality, curving and running stability. Motor and trailer bogies will have identical wheelbase and as many identical parts as possible for interchangeability. Flange lubrication system will be provided on the bogies and wheels will have noise damping device to mitigate wheel squeal on tight curves. Obstacle detector/defector and derailment detector will be installed on the end bogies.

Power collection will be through roof mounted pantographs. The pantographs will be equipped with auto-drop functions to minimize damage to the pantographs and the overhead wire in case of failure. The propulsion system and associated components will use AC driven, rotary motors technology with wheel slip/slide protection function.

The braking system will comprise of regenerative braking to be implemented by the propulsion system, friction brake to be implemented by the electro-pneumatic (EP) friction brake system, and the spring applied park brake system. The pneumatic friction brake system will adopt tread brake and will have wheel slide protectionfunction. Dual pipe compressed air system will be adopted to facilitate the implementation of rescue brake design.

Static inverters will be provided for auxiliary power supply. Backup batteries will have sufficient capacity to maintain emergency ventilation and operation of other essential loads such as lighting, communication, door control, etc., for fixed periods.

Train Management system (TMS) will be used in the trains to provide real-time control and monitoring, diagnostic and reporting of the train-borne equipment. The TMS will control and monitor all non-safety critical systems and will only monitor vital or safety critical systems. The TMS stores data on train performance, equipment conditions, distance covered and fault history which will be used for corrective and preventive maintenance planning purpose. This information can be downloaded manually from the train onto maintenance computers and can also be uploaded automatically onto the Computerized Maintenance Management system (CMMS) via a wireless data communications network.

Couplers will be installed for all car ends. Train ends will be equipped with automatic couplers and all other car ends will be equipped with semi-permanent couplers.

### 1.4.3 Tunnels

The majority of the subway alignment is proposed to run under public road corridor to minimize impacts to the private land. As roads in Makati are very congested and to construct the tunnels by open cut method will have significant impacts to the already very congested traffic.

In general, TBMs come in a variety of sizes and configurations and can deal with ground conditions that range from loose soil to extremely hard rock under very high hydrostatic pressure. As TBMs remain below ground, their use can avoid many environmental issues and disruption to the existing at-grade traffic. As such, it is recommended that most of the subway tunnels to be constructed by using TBM tunneling method except for tunnel section between Station 7 and Station 8 where non-congested urban areas are anticipated. Besides, due to the site constraints, the overrun tunnels emerging from Station 1 and Station 10 are envisaged to be constructed by mined tunneling method.

The proposed subway alignment includes seven sections of bored tunnel constructed using TBMs as follows:-

- Station 1 to Station 2 (Ch359 to Ch910 Up Track)
- Station 2 to Station 3 (Ch1160 to Ch1990 Up Track)
- Station 3 to Station 4 (Ch2236 to Ch3210 Up Track)
- Station 4 to Station 5 (Ch3470 to Ch4081 Up Track)
- Station 5 to Station 7 (Ch4330 to Ch6370 Up Track)
- Station 8 to Station 9 (Ch7980 to Ch8860 Up Track)
- Station 9 to Station 10 (Ch9110 to Ch9560 Up Track)

The location of these tunnel sections is presented in **Annex 5.** The tunnels of the above mentioned sections will be designed as twin bores. The proposed tunnels will be constructed as twin single bore single track tunnel with an outer diameter of approximately 6.7m.

The TBM moves forward as it excavates the tunnel by extending the pushing jacks at the back. When the advancement of the machine reaches distance of the length of a ring, the excavation stops and the pushing jacks are retrieved, a concrete circular ring in form of a numbers of segments were then put together at the tail of the shield. The pushing arms are once again extended in full contact with the concrete ring just erected and excavation is resumed. The cycle of excavation and ring erection is repeated as the TBM is advanced to form the lining of the tunnel. There will be a launch shaft at the starting point of the TBM drive and a retrieval shaft at the destination of receiving the TBM. Cofferdams of the stations could be considered to serve as launching or retrieval shaft for saving the need of extra land acquisition.

### 1.4.4 Power Supply

Traction power supply for metros can be AC or DC. However, apart from metros in India, almost all other metros used DC. The major disadvantage of an AC system is that heavy transformers have to be installed on the trains to convert the AC power to DC. The transformers can also be perceived as a major fire risk by the railway regulator. Since the Makati Subway is entirely underground, fire safety is of utmost importance. Therefore, DC traction power will be adopted.

For DC traction power system, it can be 750V using third rail, or 1,500V using overhead line. There is no distinct advantage of one system over the other and in many cases the selection is based on precedence or aesthetic consideration. In the case of Makati subway, since all existing transit systems in Manila use the overhead line system, it is considered appropriate to use the same to minimize any potential regulatory issue. Training for operation and maintenance staff will also be simpler as a pool of personnel familiar with the overhead line system is available locally.

Therefore 1,500 V DC Overhead line system is selected for the Makati subway.The Power Supply and Distribution (PS&D) system will comprise the following: an AC power supply and distribution network and a DC power supply and distribution network.

#### 1.4.4.1 AC Power Supply and Distribution Network

The AC power supply and distribution network will be a 33kV 3-phase system. It will consist of a 33kV internal ring network running through the up and down track of the complete alignment. Infeed to the 33kV network will be derived from the 33kV system of the local power supply company.

The network will be designed to maintain regular train services under the outage of any major component in the system. This includes the infeed from the local power supply company system and individual 33kV substation. In general, an (N – 1) security criteria need to be fulfilled.

The alignment will be divided into two electrical sections the power supply of which will be fed from two separate 33kV open ring circuits. Each open ring will consist of two main feeder circuits running along the two tracks in opposite direction along the alignment. Each feeder will be turned in and out of a 33kV board at each passenger station which will supply all E&M services (including traction power supply) in that station. The feeders of the two tracks will be connected together at the ends of the ring via separate normally–open interconnectors.

Infeed to each 33kV ring will be connected to two different and independent 33kV sources at a Bulk Feeder Substation (BIS) to be established by the local power supply company. Normally open points

will be established such that the two 33kV substations at each passenger stations will be fed from different sources. This will ensure the security criteria mentioned above to be accomplished.

Detailed operational requirements of the 33kV network need to be discussed and agreed with, the local power supply company in particular, the switching / interlocking arrangements undernormal and emergency situations. The available capacity of the local power supply company's network will affect the back-up arrangement between the two 33kV rings via the twointerconnectors.All associated 33kV/415V transformers and the downstream equipment are not considered aspart of the PS&D System mentioned in this section.

#### 1.4.4.2 DC Power Supply and Distribution Network

The trains to be adopted will be designed to operate at 1,500V DC and supplied via an Overhead Contact System (OCS). To provide traction supply to the OCS, Traction Power Substations (TPSS) will be established at a number of selected passenger stations. At each selected passenger stations, there will be two rectifier substations which supply traction power to the two tracks. Each DC traction power substation will include a rectifier transformer, a rectifier, DC switch board, negative busbar and the associated protection equipment. The rectifier transformers will be fed from one of the two 33kV substations at that passenger station.

The negative return will make use of the running rails connected back to the negative busbars of the TPSS. For stray current consideration, the running rail will be insulated from earth. As a second line of defense for stray current containment, a stray current collection mat will be included in the trackwork system.

### 1.4.5 Water Supply

Water supply needs of the Project during construction and operation will be sourced from the local water utility provider.

### 1.4.6 Transit Oriented Development (TOD)

With the requirement of 41.1ha of land for the construction and operation of the subway, depot, temporary works, and traffic diversions, new Transit Oriented Development (TOD) can be realized on these lands after the subway needs for the sites are complete. Of this land, 33.5ha are parcels owned by private or public sector, excluding roads. As these sites generally form a series of development zones that sweep along the northern stretch of Makati, parallel to the Pasig River and J. P. Rizal Boulevard, the collective future TODs also enable for Makati a rebirth of its urban identity, to complement the Central Business District core of Makati.

TOD land use zoning should be of mixed-uses, to allow for development flexibility, adaptation to market conditions, and evolution of development activity to meet evolving patterns of next-generation urban TODs. The accompanying land use distribution concept is an illustration of a potential scenario, considering a snapshot of demand by broad traditional use categories: commercial/retail, office, residential, hotel and civic.

Development site selection is based on the lands required for construction and operation of the subway asset. Sites are further assessed for suitability based on potential and ease of acquisition, proximity to stations, need during subway construction, cohesiveness to enhance value through size, and strategic value in location and neighboring uses.

The selected TOD sites total of 32.26 ha of saleable land, excluding roads and open space. Once construction is complete, these sites shall be cleared and available for vertical development, designed to be built above or adjacent selected stations. These parcels are grouped into Zones, which include the areas on the following pages.

Extra demand on utility infrastructure shall be borne by the developers of the new TOD, and provided through underground connection to existing and new grids and water supply networks.

Extra demand on transport facilities, particularly roads, shall be offset by a change in parking provision standards for new TOD; in particular to lower parking provision ratios to potentially a quarter of existing parking code requirements. This can help offsets the up to 4.5 times increase in FAR, and assumes both a high transit ridership enabled by the subway, and an evolution of car ownership patterns in the Makati workforce of today and tomorrow.

## 1.5 Process Technology

### 1.5.1 Train Services

Trains will run between the terminal stations on an 18-hour operating day, 365-day year basis. The first passenger trains dispatched from the depot will commence service at around 0600 h every morning from the two terminus stations. Thereafter, trains will call at everyintermediate station. Services will continue until around 0000 h of the next morning whentrains will be withdrawn one-by-one back to the depot for stabling and maintenance.

Trains will normally be dispatched from the depot stabling area to join revenue service. However, in order to build up the morning service more efficiently, it may consider to outstable a certain number of trains on the running line subject to confirmation at the operation stage. At the end of the traffic hours, or the scheduled withdrawal as per the Working Timetable, trains will automatically be withdrawn from the running line to the designated stabling tracks inside the depot.

Trains will be dispatched at different frequencies, or service headways, during different time periods of the day. However, actual implementation will be subject to confirmation at the operational stage with due consideration being given to passenger demands.

Regulations of normal train services will be managed centrally from the control centre located at the depot. Trains will be designed to be driven by a driver on the main lines and the depot in/out tracks.

Track diagram of this subway alignment is shown in **Figure 1-13.** A turnout section will be provided to tracks before approaching terminal stations (Stations 1 and 10) to allow trains to be stopped at either side of the platform for passenger to alight and board, and then depart at the correct right-hand running track.

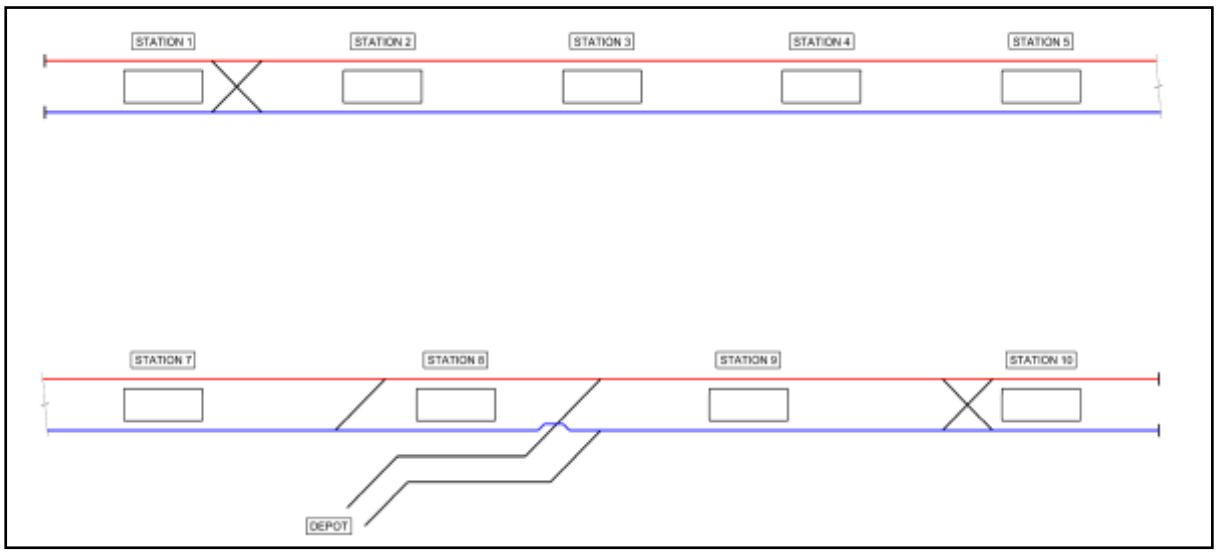


**Figure 1-13: Track Diagram**

Makati Public Rail Transport System Technical Component Report
Philippine Infradev Holdings Inc. (July 2018)

Refuge sidings are typically provided in approximately 8km spacing to allow failed trains to be pushed into it and clear the running line during operation hours. As the proposed alignment is only approximately 10km with depot approximately in between the two ends, it can be assumed that failed train can be pushed into the depot to avoid a stalled train from blocking the normal service and no need for additional refuge siding.

Whenever normal service is affected for a certain period, a decision may be made to implement a degraded service plan to minimize the adverse impact on passengers.

Train services will have to be suspended whenever a certain part of the running line is declared not safe, or not able to pass through. An appropriate contingency plan will be prepared and exercised to minimize or to contain the “suspended area” by implementing some partial services. When a short “degraded operation” service is implemented, consideration, such as running of emergency buses over the suspended section, may be given subject to further analysis and justification.
A degraded operation is also possible with two possible short loops by providing a single turnout in the cut and cover tunnel section between Station 7 and Station 8, in the event that one section is block.

Detrainment (i.e., evacuation of passengers) from an incident train in the tunnel will always be treated as the last resort. All possible attempts will be considered to move the train into the station platform, where detrainment will be much safer and more efficient.

### 1.5.2 Central Control Operations

The centralized control centre for the subway is proposed to be located with the depot. This control centre, combining both running line and depot train operations control functions, will be the central hub, the overall command unit, responsible for the whole subway operations.

The control centre will be manned by appropriate controllers throughout the day. It will operate on a 24-hour/365-day basis to manage the daily train services as well as maintenance activities during non-traffic hours. A team of controllers will be expected on duty on a shift basis to cover the 24-hour operations.

The main control centre will be responsible for the following activities: Monitoring and controlling the daily running lines and depot train operations to ensure safe and timely services in accordance with the working timetable:

- Acting as the fault management centre for all system/equipment, be system-wide or station-based;
- Preventing and reacting to incidents, or service disruptions, to ensure an efficient recovery of service with the support of Roving Teams;
- Monitoring and controlling all trackside engineering works during non-traffic hours, or during traffic hours in case of emergencies, to ensure safe and efficient operations.

The control centre will be able to monitor the real time status of every station via CCTV and disseminate information to the stations via a Centralised Public Address System. When there is a need, passengers in stations will be able to communicate the duty controllers in the control centre.

### 1.5.3 Waste Management System

#### 1.5.3.1 Generation of Construction Debris and Solid Waste

Construction activities may generate various types of solid waste, including debris from clearing activities, cut soil, building waste, construction debris, and domestic waste and recyclables from the construction camp. In order to effectively manage waste materials that will be generated during the construction of the Project, a Construction Waste Management Plan should be prepared and implemented. The Construction Waste Management Plan will focus on the waste management hierarchy of avoid, reuse, recycle, and disposal, and will be disseminated and explained to all construction personnel of the Project.

Approximately 430,000 $m^3$ of soil is estimated to be excavated by the TBM during the construction of the subway track. Cut soil may be sold, donated to individuals or companies requiring backfill, or may be used as soil cover in landfills. Prior to use however, soils along the tunneling route should be characterized (through drilling) for potential contamination. Contaminated soils should be disposed in a treatment, storage, and disposal facility, consistent with the requirements of Republic Act 6969.

The spoil generated by cut and cover excavations and by TOD piling at this site will be removed using the barging point planned for tunnel spoil disposal at the river frontage of the site. At this moment, a site has yet to be identified where tunnel spoil is to be dumped.

A Waste Management Plan for the operations phase of the Project should also be developed and implemented to ensure the proper management and disposal of general refuse and wastes that will be generated once the subway and the TODs are operational. The Project's Waste Management Plan should be aligned with the Makati City Government's own solid waste management plan.

#### 1.5.3.2 Generation of Fugitive Dust and Gaseous Pollutants

During the construction phase of the Project, activities such as excavation works and earthmoving activities, vehicle and heavy equipment movement, delivery to and unloading of materials in the site, cement mixing, and the use of generator sets may generate fugitive dust and gaseous pollutants (SOx and NOx). Since the project site is located in a heavily built-up area, majority of the stations and TODs are surrounded by populated locations (termed sensitive receivers) which may be impacted by dust and vehicle and plant emissions.

Construction activities may also contribute to the already elevated recorded TSP and PM10 concentrations in Makati City. While these air quality impacts associated with the construction phase

are expected to be localized and temporary, the following mitigating measures are recommended to be implemented to minimize the generation of fugitive dusts and gaseous pollutants:

- Properly operate and maintain all emission sources pursuant to the Philippine Clean Air Act of 1999 (R.A. 8749) and its Implementing Rules and Regulations (DAO 2000-81);
- Install when applicable, the appropriate air pollution control device/s such that air pollution sources would conform to the Philippine Clean Air act of 1999 (R.A. 8749) and its Implementing Rules and Regulations (DAO 2000-81);
- Maintain and service vehicles and heavy equipment according to manufacturer recommendations through a regular vehicle maintenance and repair program;
- Strictly enforce good housekeeping practices to minimize/control emission of air pollutants;
- Implement dust suppression measures (e.g. apply water on unpaved roads and work areas whenever visible dust is observed) to reduce dust during construction activities;
- Maintain access roads in good working order;
- Minimize earthmoving activities during adverse meteorological conditions;
- Minimize the area of disturbed land as far as practicable;
- Re-vegetate construction areas as soon as practicable;
- Cover stockpiles or provide physical barriers around stockpiles wherever practicable;
- Locate stockpiles away from sensitive receivers as much as practicable;
- Prohibit burning of waste materials onsite;
- Clean and seal trucks before coming out of the construction site;
- Schedule earthwork and material transport preferably at night, to make full use of
- vehicles and minimize heavy traffic;
- Instruct drivers on the benefits of driving practices that reduce both the risk of accidents and fuel consumption, including measured acceleration and driving within safe speed limits;
- Maintain positive relations with the community through a continuing stakeholder engagement program; and
- Provide construction workers with appropriate personal protective equipment (PPE) (e.g. face mask) as necessary.

#### 1.5.3.3 Wastewater Management

The operation of the subway and the TODs will generate stormwater runoff and sanitary wastewater streams. It is recommended that these two wastewater streams are separated to reduce the volume of wastewater requiring treatment. Stormwater runoff from the site will be collected by an onsite drainage system. If deemed necessary, collected stormwater will be treated prior to discharge to nearby creeks. Effluent from the subway stations and various establishments in the TODs will be treated as required to ensure compliance with the DENR Administrative Order 2016-08 General Effluent Standards prior to discharge to public sewers or surface waters.

## 1.6 Project Size

The total length of the project alignment is 10.1 km with 9 stations. The passenger capacity of the project ranges from 21,000 pphpd to 31,300 pphpd.

## 1.7 Description of Project Phases

### 1.7.1 Pre-Construction Phase

This phase will include the completion of all regulatory requirements and acquisition of all land requirements for the project. The Pre-construction Phase also includes selection and awarding of contracts to contractors for the construction of the project.

The list of identified Approvals and Permits (APs) for the Project, their corresponding issuing agency or body, and their project timing is summarized in **Table 1-5.** A total of 39 potential APs were identified for the Project. These APs are required for the lawful and official construction and operation of the Project, which are governed by several tiers of administration in the Philippines. However, the identified APs are only an indicative list and as government agencies may require additional permits at their discretion.

**Table 1-5: Approvals and Permits to be Secured**

| Agency | Approvals/ Permits | Classification | Project Stages | | |
|---|---|---|---|---|---|
| | | | Pre-Construction | Construction/ Excavation | Operations |
| Securities and Exchange Commission | Registration of Corporations and Partnerships | Precursor | ✓ | | |
| Land/Property Owner | Right-of-Way/ Land Acquisition | Precursor | ✓ | | |
| Stakeholders | Acquiescence/ SLO | Precursor | ✓ | | |
| LGU Barangay | Barangay Clearance | Precursor | ✓ | | |
| LGU City | Endorsement | Precursor | ✓ | | |
| Department of Environment and Natural Resources Environmental Management Bureau National Capital Region (DENR EMB NCR) | Environmental Compliance Certificate (ECC) | Primary | ✓ | | |
| LGU City | Prior Informed Consent Certificate | Precursor | ✓ | | |
| DENR Protected Areas, Wildlife and Coastal Zone Management Service (PAWCZSM) NCR | Gratuitous Permit (GP) | Precursor | ✓ | | |

| Agency | Approvals/ Permits | Classification | Project Stages | | |
|---|---|---|---|---|---|
| | | | Pre-Construction | Construction/ Excavation | Operations |
| DENR-Community Environment and Natural Resources Office (DENR-CENRO) | Tree Cutting Permit | Secondary | ✓ | | |
| DENR EMB NCR | Pollution Control Officer Registration | Conditionality | | ✓ | ✓ |
| DENR EMB NCR | Permit to Operate Air Pollution Sources and Control Facilities | Conditionality | | ✓ | ✓ |
| DENR EMB NCR | Hazardous Waste Generator Registration (DENR ID) | Conditionality | | ✓ | ✓ |
| DENR EMB NCR | Wastewater Discharge Permit | Conditionality | | ✓ | ✓ |
| Department of Labor and Employment (DOLE) Bureau of Local Employment | Alien Employment Permit | Secondary | | | ✓ |
| DOLE Bureau of Working Conditions | Registration of Establishment | Secondary | | | ✓ |
| DOLE Bureau of Working Conditions | Application for Crane and Hoist Installation | Secondary | | ✓ | |
| DOLE Bureau of Working Conditions | Application for Electrical Wiring Installation | Secondary | | ✓ | |
| DOLE Bureau of Working Conditions | Permit to Operate Internal Combustion Engine | Secondary | | | ✓ |
| DOLE Bureau of Working Conditions | Registration of Safety Engineer and Safety Inspector | Secondary | | ✓ | ✓ |

| Agency | Approvals/ Permits | Classification | Project Stages | | |
|---|---|---|---|---|---|
| | | | Pre-Construction | Construction/ Excavation | Operations |
| Department of Public Works and Highways (DPWH) | Excavation/ Digging Permit | Secondary | ✓ | | |
| Metro Manila Development Authority (MMDA) | Road Diggings and Excavation Permit/Traffic Clearance | Secondary | ✓ | | |
| LGU Barangay | Business Clearance | Secondary | ✓ | | |
| LGU City | Drilling/Excavation Permit | Secondary | ✓ | | |
| LGU City | Zoning/ Locational Clearance | Precursor | ✓ | | |
| LGU City | Building Permit | Precursor | ✓ | | |
| LGU City | Sanitary Permit | Precursor | ✓ | | |
| LGU City | Electrical Permit | Precursor | | ✓ | |
| LGU City | Mechanical Permit | Precursor | | ✓ | |
| LGU City | Plumbing Permit | Precursor | | ✓ | |
| LGU City | Height Clearance Permit | Precursor | | ✓ | |
| LGU City | Mayor's or Business Permit | Secondary | ✓ | | |
| LGU City | Civil/Structural Permit | Precursor | | ✓ | |
| LGU City | Sanitary Inspection & Health Certificate (SIHC) | Precursor | ✓ | | |
| LGU City | Certificate of Final Electrical Inspection (CFEI) | Precursor | ✓ | | |
| LGU City | Fire Safety Inspection Certificate (FSIC) | Precursor | ✓ | | |

| Agency | Approvals/ Permits | Classification | Project Stages | | |
|---|---|---|---|---|---|
| | | | Pre-Construction | Construction/ Excavation | Operations |
| LGU City | Certificate of Occupancy | Secondary | | ✓ | |
| NTC Regional and Central Office | Permit to Install Communications Equipment | Secondary | | ✓ | ✓ |
| Philippine National Police (PNP)<br>If acquiring chemicals controlled by PNP | License to Possess Explosives of Explosives Ingredient (Purchaser's License) | Secondary | | ✓ | ✓ |
| Philippine National Police (PNP)<br>If acquiring chemicals controlled by PNP | Permit to Purchase and Move Explosives or Explosives Ingredients | Secondary | | ✓ | ✓ |
| Philippine Drug Enforcement Agency (PDEA)<br>If acquiring chemicals controlled by PDEA | P-3 License (End-user license to use PDEA controlled chemicals | Secondary | | ✓ | ✓ |

### 1.7.2 Construction/ Development Phase

All ten underground stations and the two terminal crossover boxes will be constructed by cutand cover techniques because their design and the track arrangement do not permit them tobe constructed by mining methods. As with all large, open excavations, extensive use will be made of temporary decking to provide local traffic crossings of the excavation and working platforms for construction. Buried utilities will be diverted or suspended under the decking orboth.

Construction of Station 1 in Ayala Avenue uniquely requires partial demolition of a flyover at the south end of the station box that occupies the central portion of the Avenue. Overrun tunnels are mined parallel to the remaining portion of the viaduct with a mined connection to a draught relief shaft in Makati Club car park. The south station ventilation shaft is also situated in the car park, connected to the station with a shallow, cut & cover duct under the EB carriageway of Ayala Avenue. To the station and crossover box in front of it are constructed in two or three, narrow, longitudinal strips. Extensive use of temporary traffic decking will be made. A portion of the station will be constructed by a Top Down method so as to maintain the necessary number of traffic lanes and minimise the duration of flyover closure.

Construction of Stations 4, 5, 9, and 10 requires demolition to create space for the temporary traffic diversions essential for building the station (and crossover box at station 10). Less demolition is required at Station 3, which has fewer buildings surrounding it, and no demolition at all at Station 2,

where the street (Ayala Avenue) appears to be wide enough to accommodate both the excavation for the station and the required number of traffic lanes. (The positions of existing basements have yet to be verified to confirm the location of stationexternal walls.)Stations 7 and 8 are large, cut and cover excavations lying just outside the depot boundary. The running tunnels between Stations 7 and 8 are more efficiently constructed by cut and cover techniques, as are the depot approach tracks which pass Station 8 in tunnel from their connection with mainline east of the station. The spoil generated by cut and cover excavations and by TOD piling at this site will be removed using the barging point plannedfor tunnel spoil disposal at the river frontage of the site.

Because depot facilities (workshops; plant building) are largely framed structures and stabling tracks are simply ballasted tracks, they can be built and equipped relatively quickly. The depot area has therefore been used to initially re-route the existing road, under which the stations are to be built, well away from station construction. Traffic management in this area must be carried out in conjunction with the piling for the TDO podium above the depot, requiring local road diversions as construction progresses over the depot and station sites.

The station and crossover walls are constructed in vertical concrete panels, reinforced with steel bars lowered into pre-excavated trenches excavated along the alignment of the walls. Where TBMs are to pass through the diaphragm wall (and if ground conditions permit) the normal steel reinforcement in the wall may be replaced by steel-fibre reinforced concrete or glass-fibre bar reinforcement (GFRP).

Where running tunnels are not deeply buried below streets, it can be cost-effective to construct them by a cut and cover technique. This technique has not been used for the majority section of Makati Subway running tunnels because alternative traffic routes via existing roads are unavailable without greatly increasing traffic congestion. Where construction does take place in existing roads, extensive demolition is undertaken to construct temporary roads into which traffic may be diverted. In ground conditions such as found here, bored tunneling is much faster and far less disruptive.

Bored tunneling has been adopted to construct running tunnels between: Stations 1 and 5; Stations 5 and 7; and Stations 8 and 10, using four Tunnel Boring Machines (TBMs) of the EPBM (Earth Pressure Balance Machine) type.

TBMs operate most efficiently with long tunnel drives, a large area at the launching point to support their operations and a reliable supply of electrical power. If TBMs are to be operated 24/7 either the excavated spoil must be constantly removed from the launching point (but this may be forbidden in certain hours by noise control regulations or traffic controls) or it must be temporarily stored at the site and then removed at an accelerated rate during permitted hours.

### 1.7.3 Operation Phase

Details of the Station Operation are described in Section 1.4.1.3 above.

### 1.7.4 Abandonment Phase

Initially, the project concession period is 30 years after which Revolving concession renewals at 30 year intervals would be an alternative to maintain operational responsibility outside of the City, and would require consideration of asset replacement expenses. If the project is to be abandoned, a detailed abandonment plan would be submitted a year before abandonment.

The Approval and Permit (AP) needed for this stage is typically an abandonment plan to be submitted to the Department of Environment and Natural Resources – Environmental Management Bureau (DENR-EMB) as stipulated in the project's Environmental Compliance Certificate (ECC) and will not

be discussed here. The proponent must also be aware and be sensitive to local APs to be secured prior to abandonment or closure of a project.

## 1.8 Manpower Requirements

The estimated manpower requirements are shown in **Table 1-6.**

**Table 1-6: Manpower Requirements**

| Facilties | Construction Phase | | | Operation Phase | | |
|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
| Station and Depot | 776 | 2260 | 1015 | | | |
| Tunnel | | 422 | 482 | 181 | | |
| Rail | | | | 447 | | |
| Electromechanical | | | | 154 | 370 | 51 |
| **Total** | **776** | **2682** | **1497** | **782** | **370** | **51** |

## 1.9 Project Investment Cost

The project cost is estimated at Php 151,857,675,296.23 as of 2nd Quarter 2018.

## 1.10 Project Schedule

The Project schedule is given in **Table 1-7** below. The project schedule from conceptualization up to the commercial operations of the project is expected to be completed in five years.

**Table 1-7: Construction Implementation Schedule**

| Phase | Year 1 | | | | Year 2 | | | | Year 3 | | | | Year 4 | | | | Year 5 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Conceptual Study | | | | | | | | | | | | | | | | | | | | |
| Engineering Design | | | | | | | | | | | | | | | | | | | | |
| Permits and Approvals | | | | | | | | | | | | | | | | | | | | |
| Preparatory Works | | | | | | | | | | | | | | | | | | | | |
| Construction Period | | | | | | | | | | | | | | | | | | | | |
| Operation Phase | | | | | | | | | | | | | | | | | | | | |

# 2 ANALYSIS OF KEY ENVIRONMENTAL IMPACTS

## 2.1 Land

### 2.1.1 Land Use and Classification

The study on soils and landuse covered the review of existing literature and maps of the project area. This was followed by a fieldwork last July 27, 2019. Existing land uses were based from the CLUP of Makati City and the Landuse Map prepared by the Philippine Infradev Holdings, Inc. (2018). The verification and identification of the different land uses was done with the aid of google earth imagery interpretation.

#### 2.1.1.1 Compatibility with Existing Land Use

The Local Government Unit (LGU) of Makati has identified 11 types of general land use for the whole City, as indicated in ther Comprehensive Land Use Plan (CLUP). As of 2012, most of the land (Area is 9. 57 $km^{2)}$ in the city is covered by residential zones, which comprise 35% of the total land area of Makati. This is followed by commercial zones and special mixed use zones, with 14.8% and 14.6% respectively. The total area covered by each land use as of the year 2012 is shown in **Table 2-1**.

**Table 2-1: Existing Land Use Distribution in Makati City**

| Land Use Type | Area (sq. km) | Percentage (%) |
|---|---|---|
| Residential | 9.57 | 35 |
| Roads | 6.45 | 23.6 |
| Commercial | 4.06 | 14.8 |
| Special Mixed-Use | 4 | 14.6 |
| Recreational | 1 | 3.6 |
| Cemetery | 0.87 | 3.2 |
| Institutional | 0.85 | 3.1 |
| Open spaces | 0.31 | 1.1 |
| Utility | 0.12 | 0.4 |
| Government Center Zone (GCZ) | 0.07 | 0.3 |
| Riverside Development Zone (RDZ) | 0.06 | 0.2 |
| Industrial | 0.02 | 0.1 |
| Total | 27.37 | 100 |

The existing land use of Makati City, as indicated in their CLUP **(Figure 2-1),** identified that majority of the project site covers both residential and commercial areas. Residential homes and small businesses or enterprises characterize the residential areas covered by the Project. Commercial areas, on the other hand, are characterized by tall commercial buildings, and are mostly concentrated in the central business district of the city. The Philippine Infradev Holdings, Inc. (2018), identified that other land use covered by the proposed project (**Figure 2-2)** includes the following:

- Central business district;
- Open space;
- High density residential;
- Low density residential;
- Medium density residential;
- Special Precincts for Urban Redevelopment (SPUR);
- Heritage preservation zone;
- Riverside development zone;
- High density commercial;
- Recreational;
- Government center zone;

- Planned unit development; and
- Institutional.

In general, in an urbanized area like Makati City, Roads, Railways and other means of transportation and communication are parts or components of the system. Therefore, the construction of the subway in Makati City is highly compatible with the existing landuse, and it will improve the means of transportation and communication of the people and visitors of Makati City.

In the subway alignment, there will be no significant changes in the existing land use since improvements will be done under the ground. However, there will be an actual change in the land use among areas where the ten (10) stations, staging areas and depot are located (mostly residential and commercial),To mitigate this, inventory of the affected household assets should be conducted prior to construction/site preparation. Appropriate compensation packages should be provided to affected landowners, and owners of other improvements. Relevant provisions of RA 10752 (ROW Acquisition for National Government Projects) should serve as basis for the compensation of affected lots, crops and other improvements. A separate Land Acquisition and Resettlement Framework is attached in this report.

# City of Makati
# EXISTING LAND USE MAP

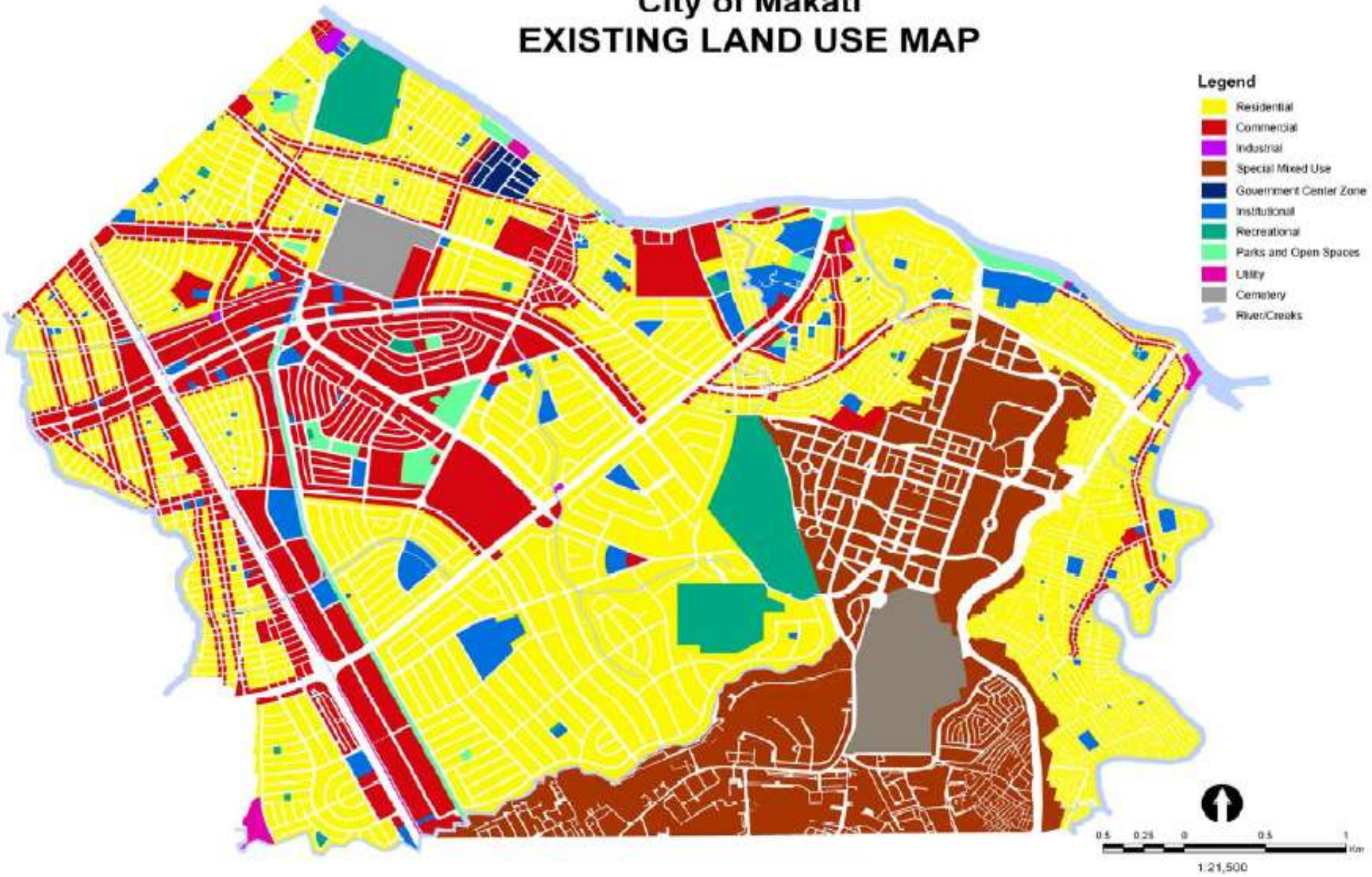



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FIGURE TITLE :

**Existing Land Use Map**

FIGURE NO.:

**2-1**

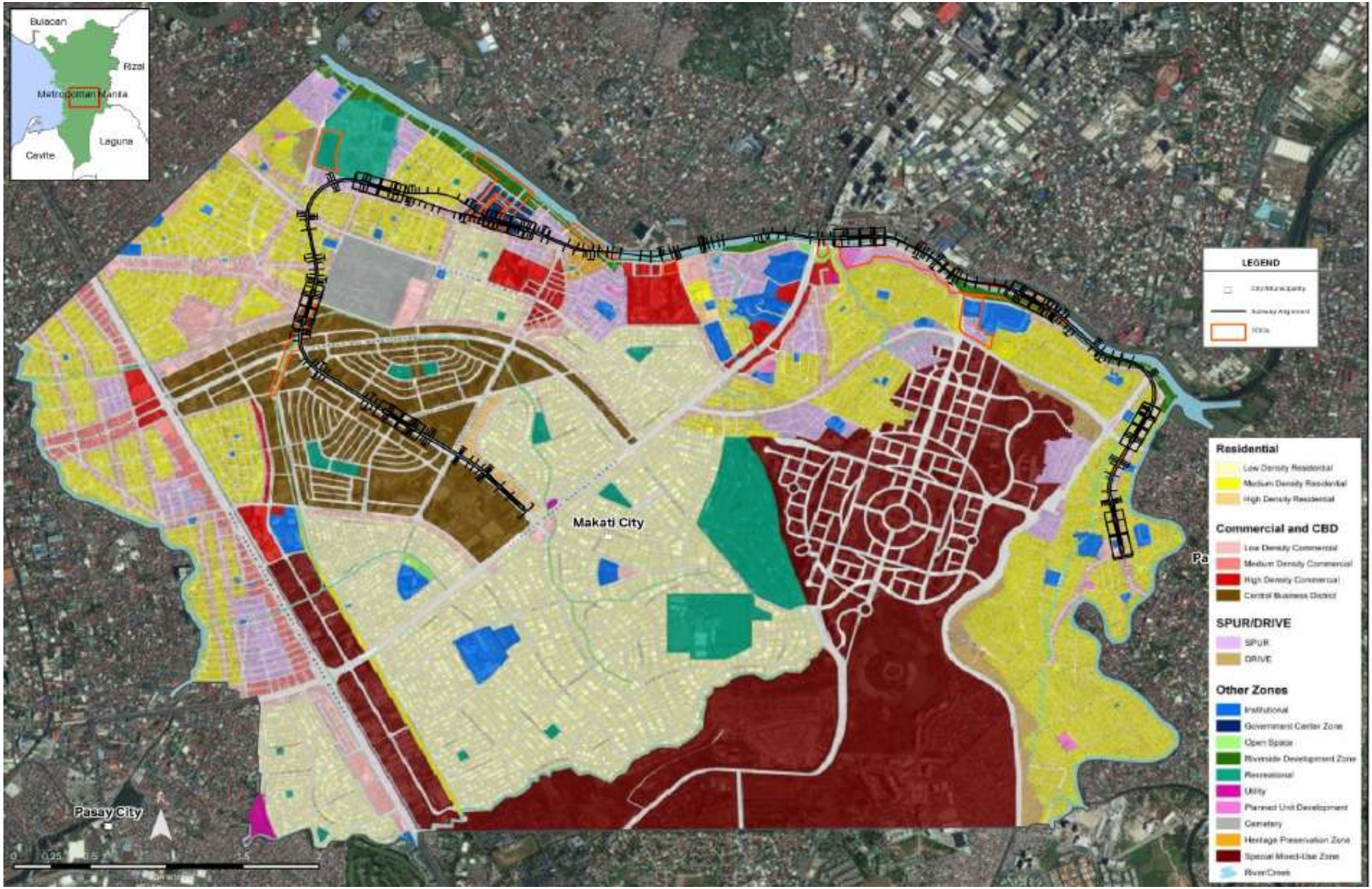


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FIGURE TITLE :

**Land Cover Map**

FIGURE NO.:

**2-2**

2.1.1.2 Compatibility with Classification as an Environmentally Critical Area

The Project is considered as Environemntally Critical Project (ECP) located within Environmentally Critical Areas (ECA) as defined by Presidential Proclamation 2146 and further clarified in Section 3.b of EMB Memorandum Circular 005 Series of 2014 “Technical Definition of ECA and Corresponding Operationalization Guide of the Revised Guidelines for Coverage and Screening and Standardized Requirements under the Philippines EIS System”. The Memorandum Circular states that an area is environmentally critical if it exhibits any of characteristics described in the 12 categories that define environmentally critical areas**. Table 2-2** shows a brief description of the ECA categories and the site characteristics that qualifies the project area under each category. **Figure 2-3** shows the ECA within the proposed project site.

**Table 2-2: Criteria for Environmentally Critical Areas**

| ECA Categories | Technical Definition (EMB MC 2014-05) | Project Site Characteristics |
|---|---|---|
| Areas declared by law as national parks, watershed reserves, wildlife preserves, and sanctuaries | Areas declared under RA 7586 (NIPAS Act)<br><br>Areas declared by other NGAs, LGUs, International commitments and declarations | **Not Present** |
| Areas set aside as aesthetic, potential tourist spots | Aesthetic potential tourist spot declared by the LGU, DOT or other appropriate authorities for tourism development.<br><br>Class 1 and 2 Caves | **Not Present** |
| Areas which constitute the habitat for any endangered or threatened species of indigenous Philippine wildlife (flora and fauna) | Areas identified as Key Biodiversity Areas or local conservation areas | **Not Present** |
| Areas of unique historic, archaeological, geological, or scientific interests | Areas declared as historic sites,<br><br>Barangay or municipality of cultural or scientific significance to the nation<br><br>Barangay or municipality where archaeological, paleontological, and anthropological sites/reservations are located | **Present**<br><br>The project site alignment traverses Barangay Poblacion, which is the host barangay of the Makati Poblacion Heritage Conservation Project. The Church of San Pedro Makati, which is located approximately 115 m away from the subway alignment, is the nearest cultural heritage site declared by the National Historical Commission. |
| Areas which are traditionally occupied by cultural communities or tribes | Areas issued with CADT or CALT<br><br>Areas that are historically/traditionally occupied as ancestral lands or ancestral domains of indigenous communities | **Not Present** |
| Areas frequently visited and/or hard-hit by natural calamities. | Geologic hazards Area | **Present**<br>The portion of the alignment along the banks of the Pasig River is highly susceptible to |

| ECA Categories | Technical Definition (EMB MC 2014-05) | Project Site Characteristics |
|---|---|---|
| | | flooding. These areas have flood heights greater than 1 m and are usually flooded for several hours during heavy rains. Also, proposed Station 4, 8, and 9 of the project are identified as areas which are highly susceptible to liquefaction. |
| | Areas Frequently visited by typhoons | **Present**<br>Makati City, located at the center of National Capital Region (NCR), is projected to experience approximately five tropical cyclones every three years |
| | Areas prone to volcanic activities/earthquakes | **Not Present** |
| Areas with critical slope | Areas with slope of 50% or more | **Not Present** |
| Areas classified as prime agricultural lands | Lands that can be used for various or specific agricultural activities and can provide optimum sustainable yield with a minimum of inputs and development costs | **Not Present** |
| Recharge areas of Aquifers | Sources of water replenishment where rain water or seepage actually enters the aquifers. Areas under this classification shall be limited to all local or Non-national watersheds and geothermal reservations. | **Not Present** |
| Water bodies | All natural water bodies (e.g. rivers, lake, bay) that have been classified or not | **Present**<br>There are small creeks which are being traversed by the project alignment. These creeks however, are not used for fishery activities, and are mostly used for discharging domestic and industrial wastewater. A section of the project site is also situated next to the Pasig River, which is a major river system in Metropolitan Manila. |
| Mangrove areas | | **Not Present** |
| Coral reefs | | **Not Present** |

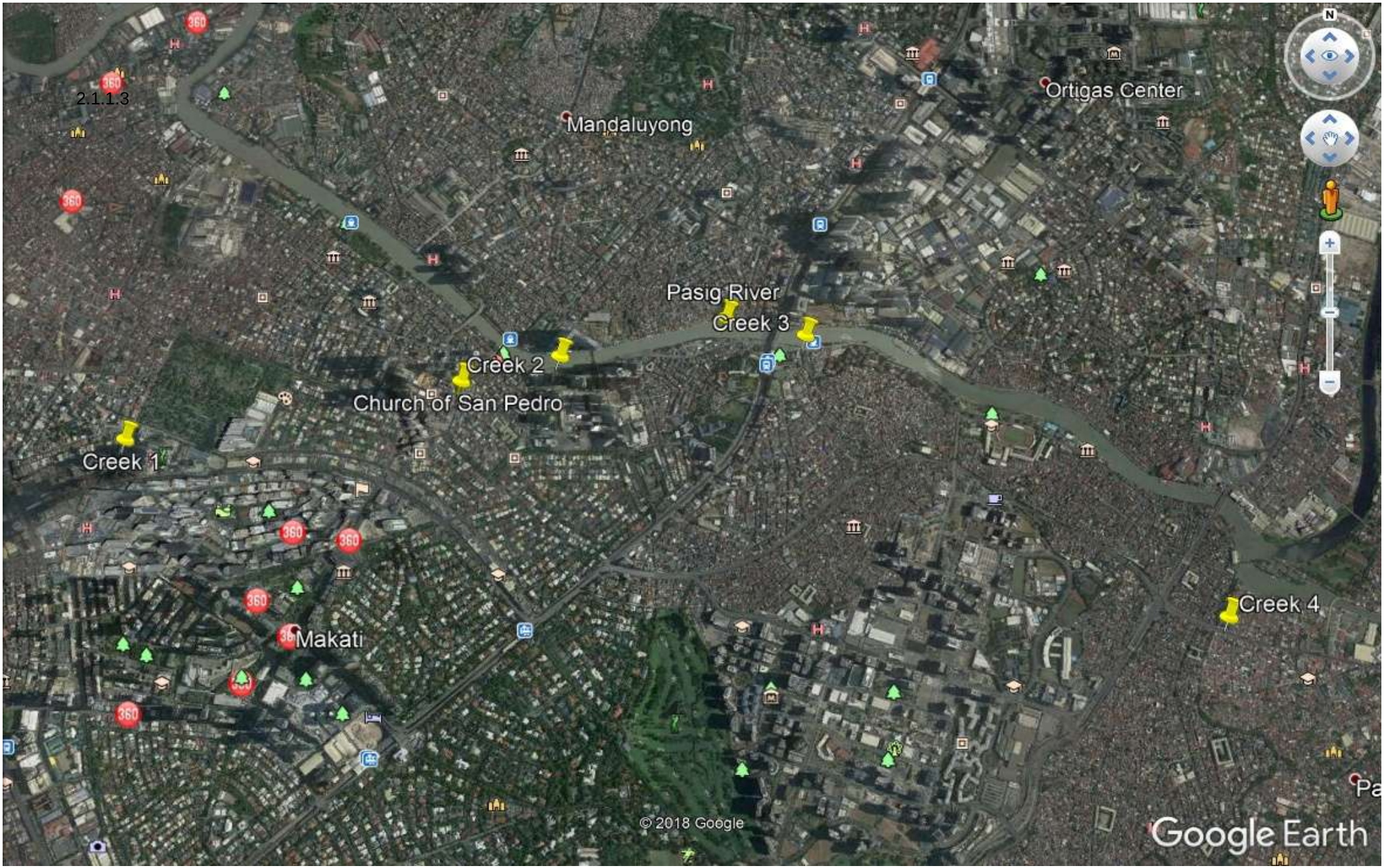


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FIGURE TITLE :

**ECA Map**

FIGURE NO.:

**2-3**

#### 2.1.1.4 Existing Land Tenure Issues

The project area is neither covered under the Comprehensive Agrarian Reform Program (CARP), nor under any Ancestral Domain territory. The proposed subway alignment, subway stations, and TOD's have tenured occupants holding land titles and informal settlers (mostly between Station 7 and 8).

#### 2.1.1.5 Impairment of Visual Aesthetics

The project alignment will traverse urban areas mostly occupied by residential and commercial establishments. Based on the field survey conducted along the alignment, there are no visually significant landforms, landscapes and structures that will potentially be affected by the project. However, visual changes will mostly be apparent during the construction phase.

#### 2.1.1.6 Devaluation of Land Value

Construction activities may generate various types of solid waste, including debris from clearing activities, cut soil, building waste, construction debris, and domestic waste and recyclables from the construction camp. In order to effectively manage waste materials that will be generated during the construction of the Project, a Construction Waste Management Plan should be prepared and implemented. The Construction Waste Management Plan will focus on the waste management hierarchy of avoid, reuse, recycle, and disposal, and will be disseminated and explained to all construction personnel of the Project.

Approximately 430,000 m3 of soil is estimated to be excavated by the TBM during the construction of the subway track. Cut soil may be sold, donated to individuals or companies requiring backfill, or may be used as soil cover in landfills. Prior to use however, soils along the tunneling route should be characterized (through drilling) for potential contamination. Contaminated soils should be disposed in a treatment, storage, and disposal facility, consistent with the requirements of Republic Act 6969, An Act to Control Toxic Substances and Hazardous and Nuclear Wastes, Providing Penalties for Violations Thereof, and for Other Purposes.

Waste Management Plan for the operations phase of the Project should also be developed and implemented to ensure the proper management and disposal of general refuse and wastes that will be generated once the subway and the TODs are operational. The Project's Waste Management Plan should be aligned with the Makati City Government's own solid waste management plan.

### 2.1.2 Geology/ Geomorphology

This section presents the information on the baseline assessment of the geologic and geomorphic features of the project area including the relevant natural hazards that could impact the subway project.

Although site preparation before the construction of the project facilities will have minimal impact on the topography, knowledge of the subsurface properties of the rock mass is essential to determine the appropriate engineering designs for subway. Lastly, the relevant natural geohazards and its potential risk to the project are identified, and the corresponding mitigation measures applied or recommended is also presented.

Secondary information on geology, geomorphology and geohazards wasobtained from the Technical Component of the Feasibility Study for the Project prepared by AECOM in July 2018. Various government agencies were cited in the Feasibility Study, namely:

- Mines and Geosciences Bureau (MGB);
- Philippine Institute of Volcanology and Seismology (PHIVOLCS);
- National Mapping and Resource Information Authority (NAMRIA)
- University of the Philippines Nationwide Operational Assessment of Hazards (UP-NOAH)

A site visit was undertaken on July 2019 to validate and to supplement the available information.Other sources of information are from the Makati City Government and from published and unpublished reports of individuals as well as fromthe internet listed under the references.

2.1.2.1 Change in Surface Landform/ Geomorphology/ Topography/ Terrain/ Slope

2.1.2.1.1 Geomorphology

Makati City is at the southern portion the Guadalupe-Bulacan Ignimbrite Plateau (**Figure 2-4**). The Guadalupe Plateau is a relatively high plateau that spans a north-south direction. It underlies the majority of the Metropolitan Manila area from Muntinlupa City at the south, to Quezon City and Caloocan City at the north of the metropolis. The Guadalupe Plateau is bounded by the coastal and intertidal flats of Manila to the west and the alluvial plains of the Marikina River valley to the east.The eastern limit of the plateau is interpreted to coincide with the fault scarp of West Valley Fault forming steep slopes that drops to the Marikina-Laguna Lowland. The city is principally drained by the Pasig River which serves as the only outlet of the Laguna Lake to the Manila Bay.

2.1.2.1.2 Topography and Slope

Makati City lies on a plateau with generally flat terrain. Around 76% of the city has slope gradients ranging between 0 to 3%. Gentle to moderate slopes ranging from 3 %to 12% are found mostly in the eastern parts of the city, particularly in the Guadalupe, Cembo, Pitogo, Pinagkaisahan and Pembo districts. These slope gradients comprise around 20% of the city. Moderate to steep slopes (>12% gradient) can be found mostly adjacent to Fort Bonifacio Ridge, in the West Rembo, East Rembo at Comembo districts. These slopes make up about 4% of the city's area. The slope map of the city is shown in **Figure 2-5**

Elevation along Ayala Avenue is from 20 m to 40 m and decreases to about 15 m northwards along South Avenue. Elevation along J.P Rizal beside Pasig River up to the end of the route at J.P. Rizal Extension isfrom 8 m to 12 m. **Figure 2-6** is a surface elevation map showing the subway route.

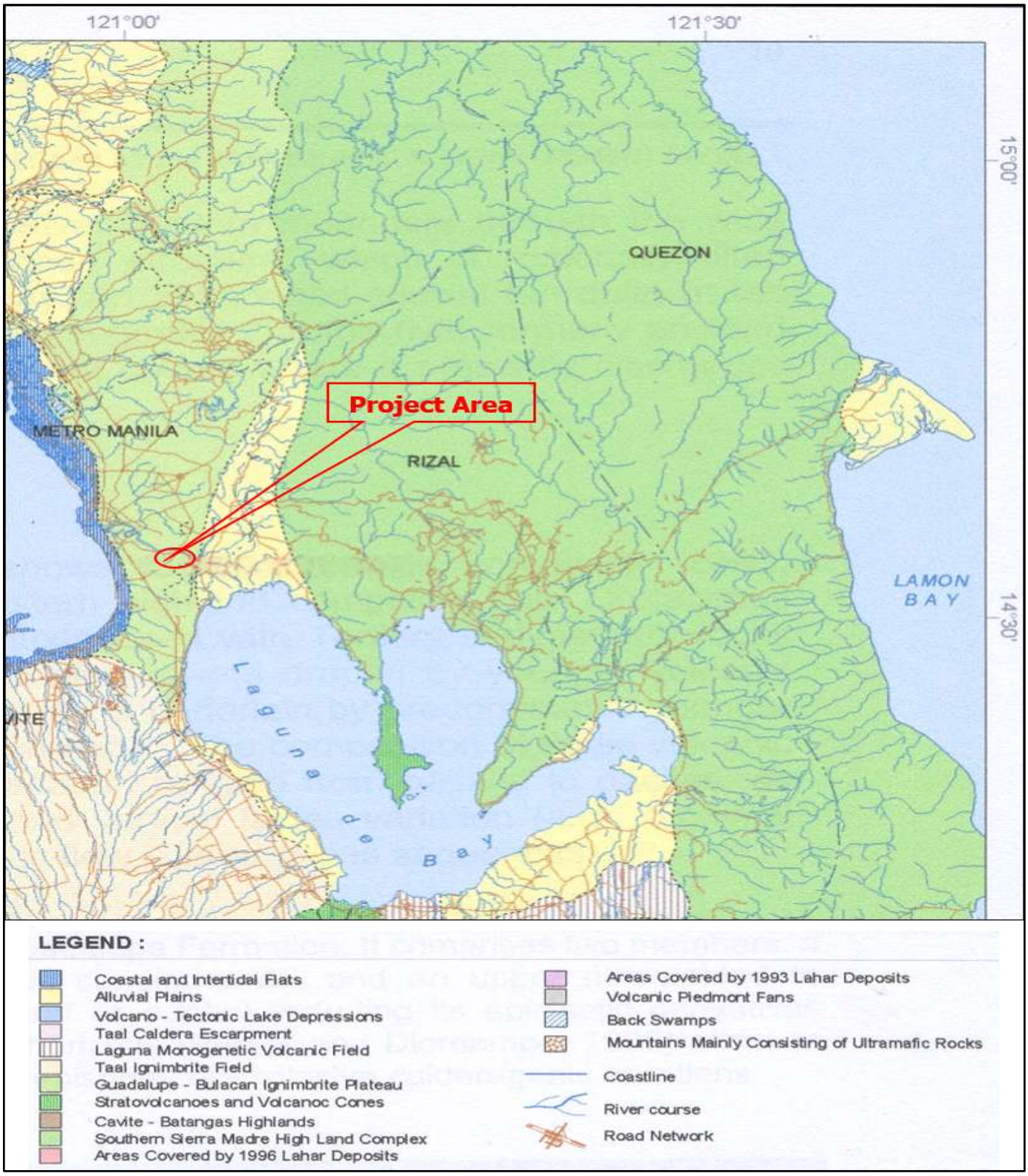


**Figure 2-4: Regional Geomorphological Map**

**(Source: MGB and Nikko Exploration & Dev. Co. Ltd. 1997)**

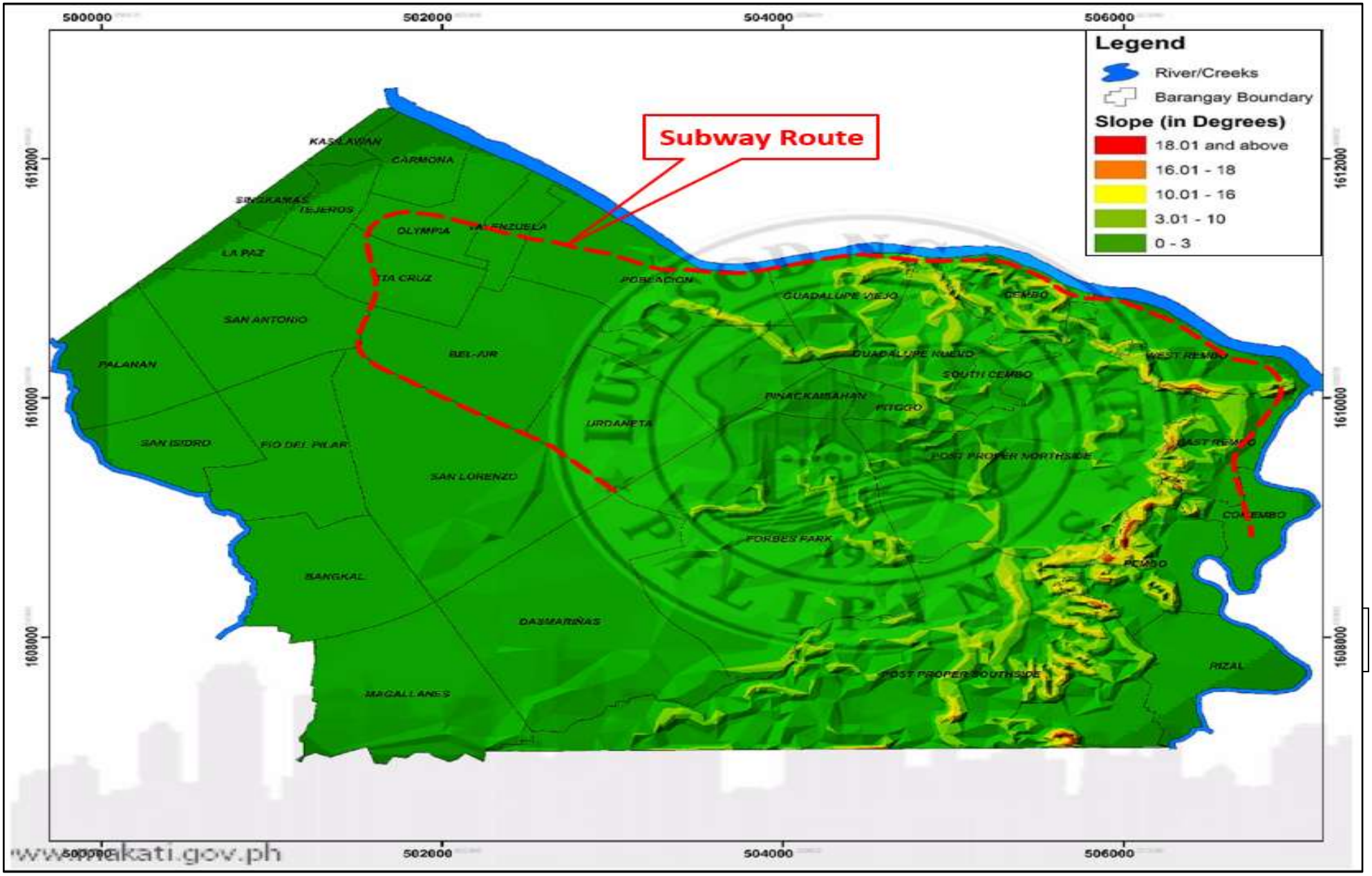


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FIGURE TITLE :

**Slope Map**
**(Source: Makati City, CLUP)**

FIGURE NO.:

**2-5**

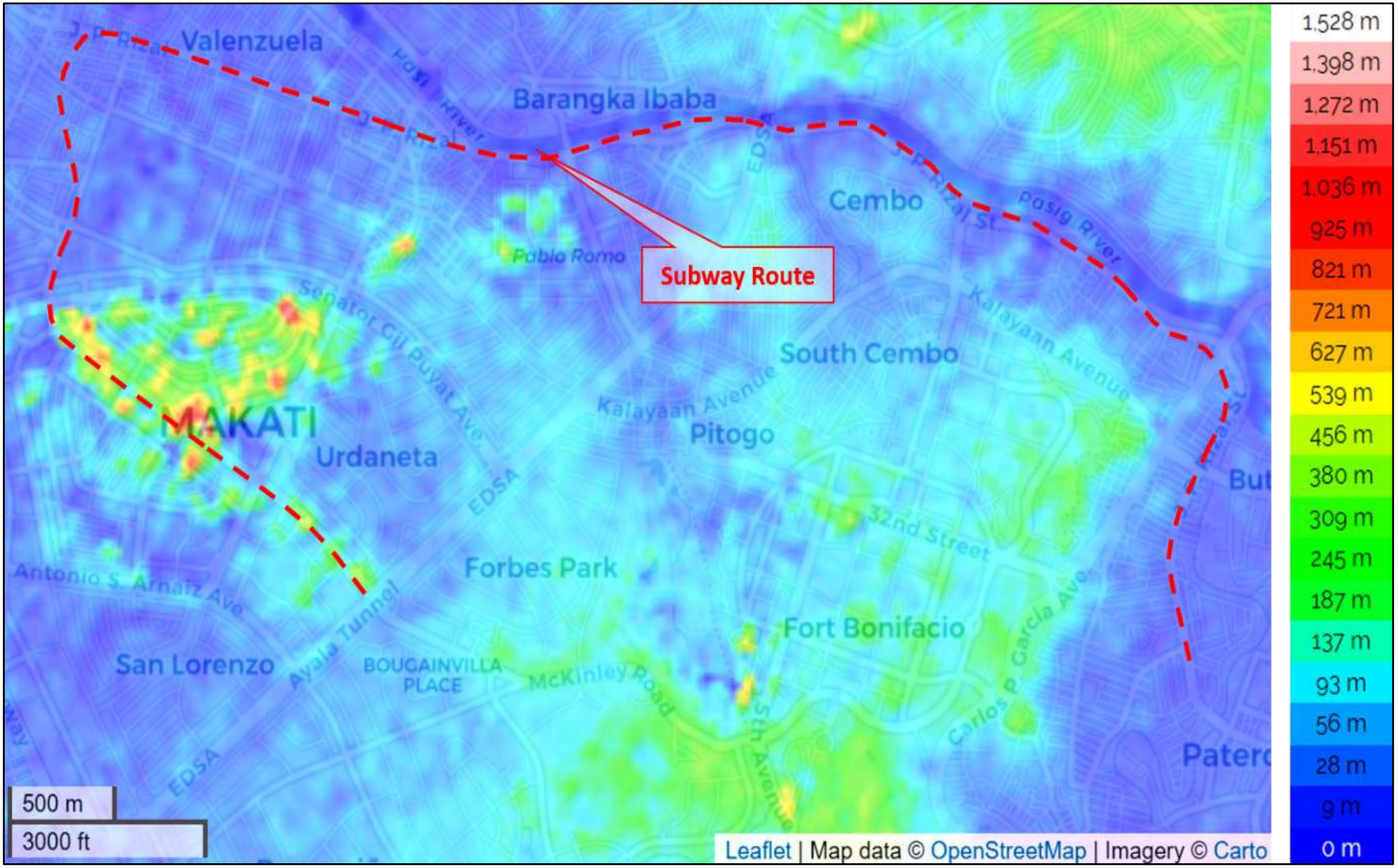


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FIGURE TITLE :

**Surface Elevation Map Showing the Proposed Subway Route.**

**(Source: Topographic-Map.Com)**

FIGURE NO.:

**2-6**

2.1.2.1.3 Impact Assessment

In as much as the construction and operation of the subway will be limited below ground surface, there will be no notable changes in surface landform except at the depot area where surface grading will consequently occur from the construction of the depot facilities. Subtle changes in surface configuration are unavoidable. Project development should be optimized to minimize surface disturbances.

2.1.2.2 Change in Sub-surface Geology/ Underground Conditions

2.1.2.2.1 Tectonic Setting

The Philippine Archipelago is situated in a complex tectonic zone created by the interaction between the Philippine Sea Plate and the southeastern edge of the Eurasian Plate (Aurelio, 2000). The formation of this so-called Philippine Mobile Belt (PMB) is controlled by subductions, collisions and major strike-slip faults.

In Luzon Island, where the project area is situated, three active subduction systems of opposing polarity were identified: the eastward-dipping Manila Trench on the west and the westward dipping Philippine Trench together with the recently developing east Luzon Trough (Cardwell et al., 1980) along the east.

The Manila Trench represents the morphologic expression of the subduction of the oceanic crust of the West Philippine Sea[1] under the Luzon Arc (Aurelio, 2000). Onshore, the tectonic structure depicts a linear alignment of volcanic landforms that lies sub-parallel to the trench. The southern termination of the subduction zone passes through the collision zone of Mindoro-Panay ( Rangin et al., 1988; Marchadier and Rangin, 1990; Aurelio, 2000). In the southern part of the Island, the distribution of volcanic features appear to be structurally controlled along a series of NE-SW trending tensional lineaments that defines a rift structure referred to as the Macolod Corridor (Defant et.al, 1988; Foster et al 1990).

The Philippine Trench, found along the Pacific margin of the PMB, is an expression of the subduction-collision dynamics between the Philippine Sea Plate and the PMB (Cardwell, Isacks, & Karig, 1980). A short subduction zone called the East Luzon Trough, located east of northern Luzon, is considered as the northward continuity of the Philippine Trench. The latter is separated from the main trace of the Philippine Trench by what is attributed to be the East-West Transform Fault (Hamburger, Cardwell, & Isacks, 1983).

2.1.2.2.2 Seismecity

The earthquake catalog search from the National Earthquake Information Center (NEIC) of the United States Geological Survey (USGS) listed 338 earthquakes from June 1928 to present with magnitude ≥ M 5.0 and within the 200-km radius from the project site (**Figure 2-8).** The highest among these is the July 16, 1990 earthquake at M 7.7 that produced a 125 km-long ground rupture that stretches from Dingalan, Aurora to Kayapa, Nueva Vizcaya as a result of strike-slip movements along the NW segment of the Philippine Fault Zone and its splay, the Digdig Fault (Punongbayan et.al., 1991).

On April 22, 2019, a moderate earthquake of Magnitude 6.1 shook the provinces of Zambales, Pampanga and vicinity. The epicenter is located 18 km east of Castillejos, Zambales, on a

[1] West Philippine Sea is the official designation by the Philippine government of eastern parts of the South China Sea which are included in the Philippines' exclusive economic zone (https://en.wikipedia.org/wiki/Main_Page).

mountainous area, at a depth of 10 kilometers. In Makati City, the earthquake registered an Intensity V (Strong) ground shaking based on the PHIVOLCS Earthquake Intensity Scale (PEIS).

Events tend to cluster in the offshore region along Verde Island Passage between the southwest coast of Batangas and Mindoro Island. Moderate to deep (>150 km) foci seismic events with a predominant thrust focal mechanism solution indicate active convergence along the southern extension of the Manila Trench system. In contrast, shallow seismic events (< 70 km) appear to have originated from the movements of regional faults (e.g. Mindoro Fault, Lubang Fault) and their minor splays.

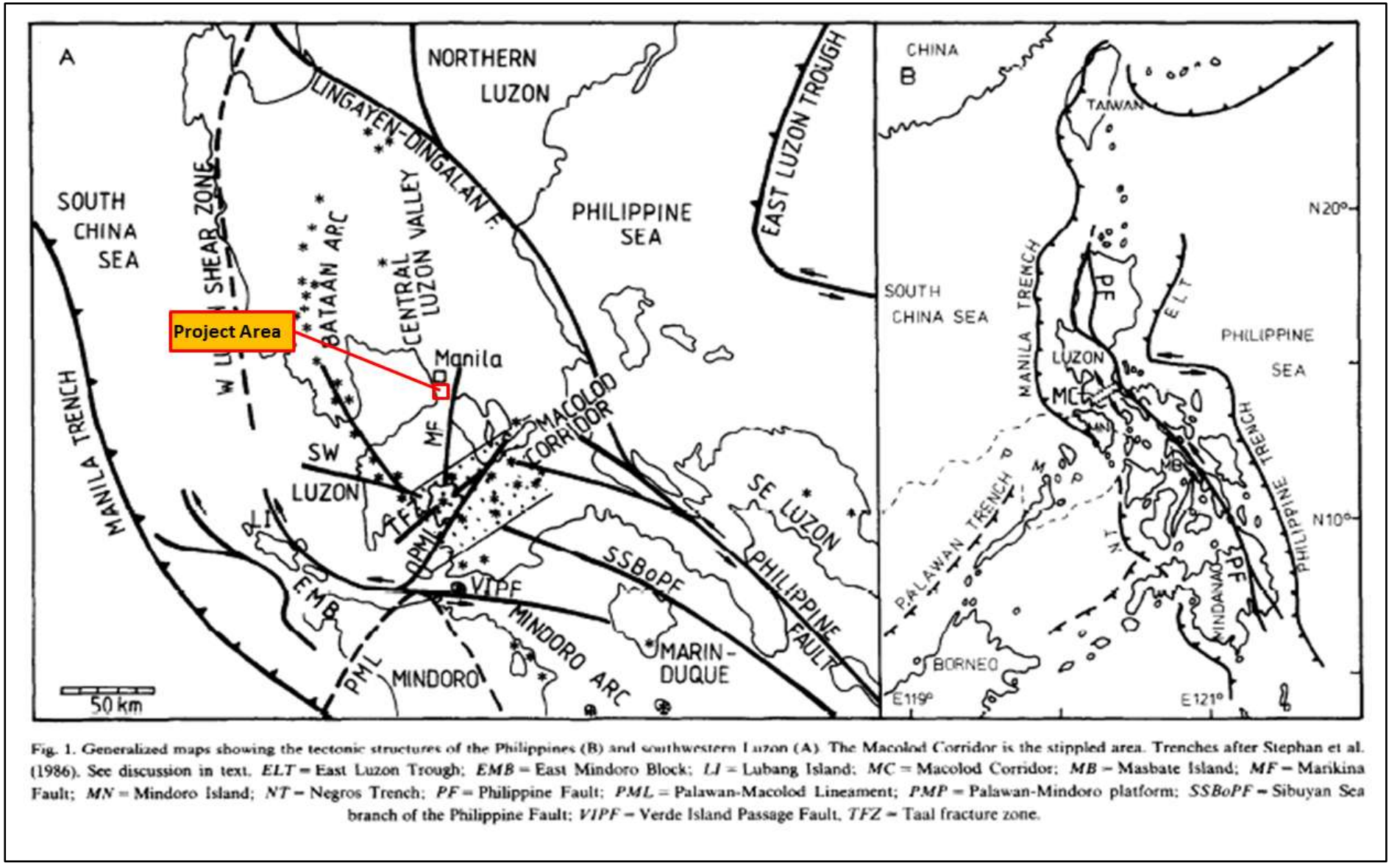


Fig. 1. Generalized maps showing the tectonic structures of the Philippines (B) and southwestern Luzon (A). The Macolod Corridor is the stippled area. Trenches after Stephan et al. (1986). See discussion in text. *ELT* = East Luzon Trough; *EMB* = East Mindoro Block; *LI* = Lubang Island; *MC* = Macolod Corridor; *MB* = Masbate Island; *MF* = Marikina Fault; *MN* = Mindoro Island; *NT* = Negros Trench; *PF* = Philippine Fault; *PML* = Palawan-Macolod Lineament; *PMP* = Palawan-Mindoro platform; *SSBoPF* = Sibuyan Sea branch of the Philippine Fault; *VIPF* = Verde Island Passage Fault, *TFZ* = Taal fracture zone.

**Figure 2-7: Regional Tectonic Map of Luzon**

**(Source: Forster et al., 1990)**

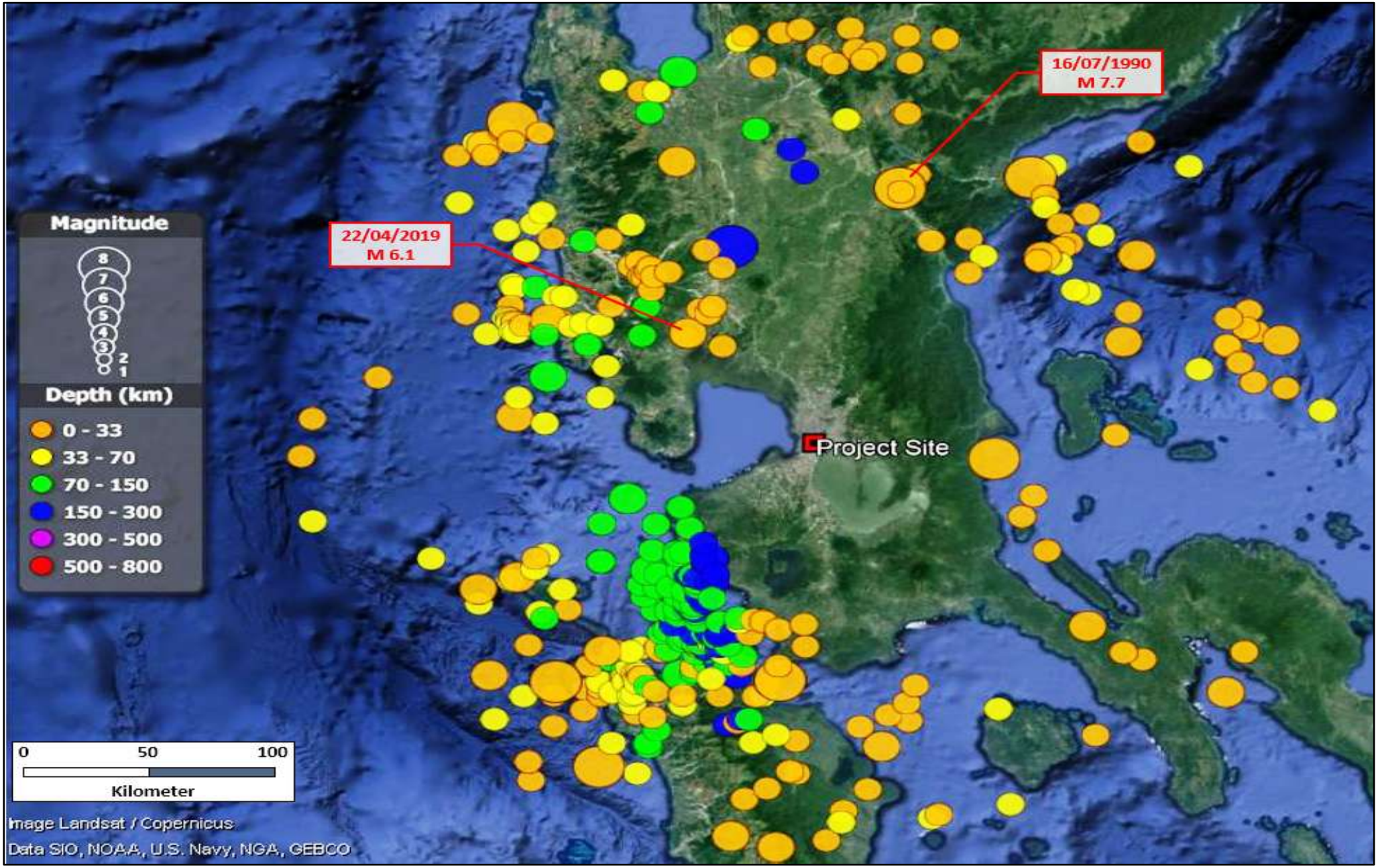


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FIGURE TITLE :

**Regional Seismecity Map**

FIGURE NO.:

**2-8**

2.1.2.2.3 Geologic Setting

A. General Geology

From the Geological Map of the Manila and Quezon City Quadrangle (Sheet 3263-IV) published by the Bureau of Mines and Geosciences (BMG, 1983), the project area is underlain by the Diliman Tuff, which is the lower member of the Guadalupe Formation **(Figure 2-10**).

The Guadalupe Formation was named by Smith (1913 cited in MGB, 2004, p.83) to denote the tuff sequence typically exposed along Pasig River in Guadalupe, Metro Manila. Alvir (1929 cited in MGB, 2004, p.83) in describing the same tuff sequence in the Angat-Novaliches region referred to the section as Guadalupe Tuff Formation. Teves and Gonzales (1950 cited in MGB, 2004, p.83) in their work in the Balara area, Quezon City, included in their Guadalupe Formation, two members: the lower Alat Conglomerate and the upper Diliman Tuff. The Diliman Tuff, which is of interest, is a sequence of flat-lying, medium to thin bedded, fine grained vitric tuffs, and welded pyroclastic breccias with minor fine to medium grained tuffaceous sandstone. Dark mafic minerals and bits of pumiceous and scoriaceous materials are dispersed in the glassy tuff matrix. The thickness of the Diliman Tuff is from 1,300m to 2,000m (MGB, 2004).

The most significant structure in the project region is the active Valley Fault System consisting of the East Valley Fault (EVF) and West Valley Fault (WVF). Regional geomorphic considerations suggest a predominant vertical displacement along the 40 km-long mapped trace of the fault, with the eastern portion as the downthrown block. However, studies established a right-lateral displacement for recent movements along the fault trace (Rimando et al., 1995; Nelson et al., 2000). Mapping along the southern extension of the WVF, in the Muntinlupa and Biñan area, by PHIVOLCS (1999) appears to validate this sense of movement for the WVF.

In addition, results of paleoseismic study at the northern portion of the WVF suggest multiple rupture events along the fault sometime 200-400 years ago generating earthquakes of Ms 6-7 for an annual probability occurrence rate of 0.5% to 0.25% (Nelson et al., 2000). The last major earthquake from the WVF happened in 1658. Recent pronouncements by PHIVOLCS indicated a magnitude 7.2 earthquake resulting from the movement of the WVF may strike Metro Manila any time based on historical data (Philstar, 2015).

B. Site Geology

The following sections on site geology were culled from AECOM's review of the geological and geotechnical information relevant to the proposed alignment. The geological information, which was gathered from previous ground investigations, and geotechnical studies are of limited extent, density, depth and level of details.**Table 2-3** and **Table 2-4** are the lists of available ground investigation reports and geotechnical studies. The tabulated summary of available ground investigation data is presented in **Annex 5**. Hence, the resulting geological model presented below is preliminary.

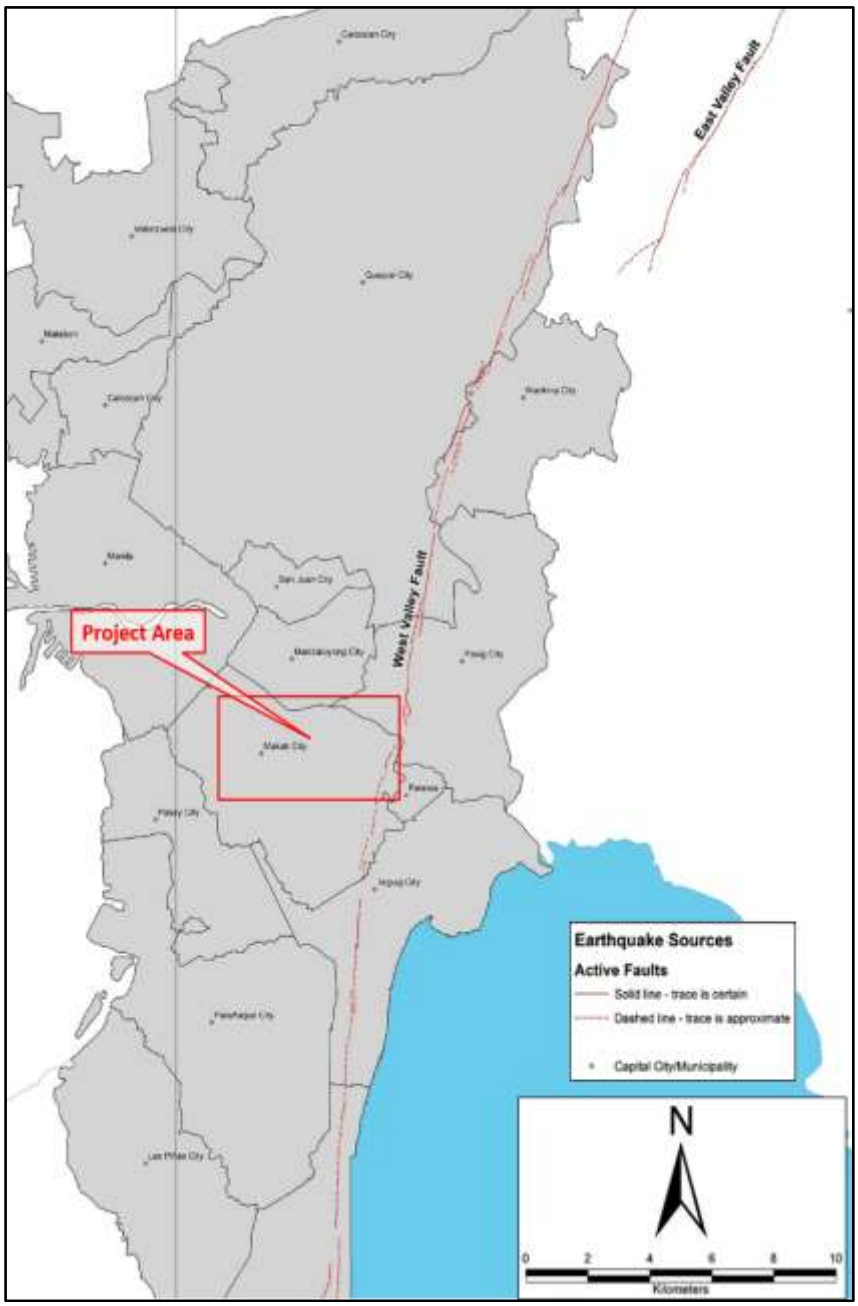



**Figure 2-9. Valley Fault System**

(Source:PHIVOLCS)

**Table 2-3: List of Available Ground Investigation Report**

(Source: Technical Component, 2018 FS)

| Available Ground Investigation Report | Available Boreholes |
|---|---|
| Borehole logs, Proposed INTERCON Block Redevelopment 13 | 13 |
| Geohazard Assessment Report, ATG Diamond Project Site, Ayala Triangle,Makati City | 8 |
| Soil Investigation, Proposed 4-Storey Building with Basement and Roofdeck, Makati Police Station, Ayala Avenue Extension corner Yakal Street, Makati City | 2 |
| Soil Investigation, Proposed 20-Storey Building with 2 Basements, MorongStreet, Makati City | 8 |

| Available Ground Investigation Report | Available Boreholes |
|---|---|
| Factual Report, Proposed 60-Storey Building, Kalayaan Ave., cor. Salamanca St., Makati City | 4 |
| Factual Soils Report for the Proposed 10-Storey Hop Inn Building with Basement in Makati Avenue, Makati City | 3 |
| Soil Investigation Report, Proposed Administrative and Library BuildingUniversity Compound, J. P. Rizal, Makati, Metro Manila | 3 |
| Soil Investigation Report, Proposed 12-Storey College of Nursing Building MakatiUniversity, J. P. Rizal Extension, West Rembo, Makati City | 2 |
| Geotechnical Evaluation Report for the Proposed Comembo CommunityComplex, Talisay St. cor. Kamagong St., Brgy. Comembo, Makati City | 3 |
| Geotechnical Evaluation Report, Construction of 4-Storey with Deck CentralizedWarehouse, Sultana St., Brgy. Olympia, Makati City | 2 |
| Geohazard Assessment Report, Jazz Residences, Nicanor Garcia St., Bel-Air | 8 |
| Soil Investigation Report, Proposed 4-Storey Multi-Purpose Hall, Mabini Street,Barangay Poblacion, Makati City | 2 |
| Geohazard Assessment Report (GAR), Proposed Project Unicorn, BrgyCarmona, Makati City | 9 |
| Soil Investigation, Proposed 8-Storey Building with Basement, J. P. Rizal Street, Makati City | 2 |
| Geotechnical Evaluation Report, Proposed 4-Storey with Roofdeck, 4186 Ponte St., Brgy Tejeros, Makati City | 2 |
| Geotechnical Evaluation Report, Proposed 4-Storey with Roofdeck, 2956 Kalayaan Ave. corner Kakarong St., Makati City | 1 |
| Geotechnical Evaluation Report, Proposed 3-Storey with Deck, 160 Caimito St. corner Molave St., Cemo, Makati City | 1 |
| Geotechnical Evaluation Report, Proposed 3-Storey Residential Building, Visita St., Vito Cruz, Makati City 1 | 1 |
| Geotechnical Investigation, Proposed 5-Storey Commercial Bldg. with Roofdeck, 7036 Biak na Bato Street, Brgy Olympia, Makati City | 1 |
| Geotechnical Evaluation Report, Proposed 3-Storey with Roofdeck & Lower Ground, 134 J. P. Rizal St., Brgy East Rembo, Makati City | 1 |
| Soil Investigation Report, Proposed 4-Storey Building with Roofdeck, Metropolitan Avenue corner Yague St. Makati City | 2 |
| Proposed 3-Storey 4-Units Residential Bldg. with Basement & One Unit Commercial, 40-A Lapu St., Brgy. West Rembo, Makati City | Strata Description |
| Geotechnical Investigation of Proposed 5-Storey Carpark Building at Ayala Avenue, corner Paseo de Roxas, Makati City | Strata Description |

**Table 2-4: List of Available Geotechnical Studies**

(Source: Technical Component, 2018 FS)

| Available Geotechnical Studies |
|---|
| Liquefaction Hazard Map of Metro Manila. PHIVOLCS-DOST |
| Geological Map of Manila and Quezon City Quadrangle. Sheet 3263-IV. BMG-DENR |
| Distribution of Active Fault and Trenches. PHIVOLCS-DOST |
| Makati Risk-Sensitive Urban Redevelopment Planning. EMI |
| Earthquake Impact Reduction Study for Metropolitan Manila. JICA, MMDA, PHIVOLCS |
| Metro-Manila and Metro-Cebu Groundwater Assessment. PIDS |
| Groundwater Supply in Metro-Manila: Distribution, Environment and Economic Assessment. PIDS |

| Available Geotechnical Studies |
| --- |
| Profile of Makati City – Environmental Management. |

C. Bedrock Lithology

Based on the relevant ground investigation data, the study area typically underlain by highly weathered locally moderately weathered weakly-cemented Guadalupe Tuff Formation (GTF). The GTF bedrock recorded in available ground investigation records is typically consists of intercalated tuffaceous sandstone/siltstone with thin beds of agglomeratic tuff and tuffaceous shale down to 90 m depth (deepest available borehole within the study area).

The GTF within the study area is classified as a weak rock, since the unconfined compressive strength (UCS) of the intact core samples is predominantly between 1-5 megapascals (MPa), some of the samples may have UCS up to 7.5MPa, but rarely exceed 10 MPa. The GTF at the study area is generally described as highly weathered, but locally moderately weathered or completely weathered. The average rock quality designation (RQD) of GTF is approximately between 20-40%. RQD and UCS of GTF is highly variable, which subject to various factors such as the weathering state. Inferred geological longitudinal sections are presented in **Annex 6.**

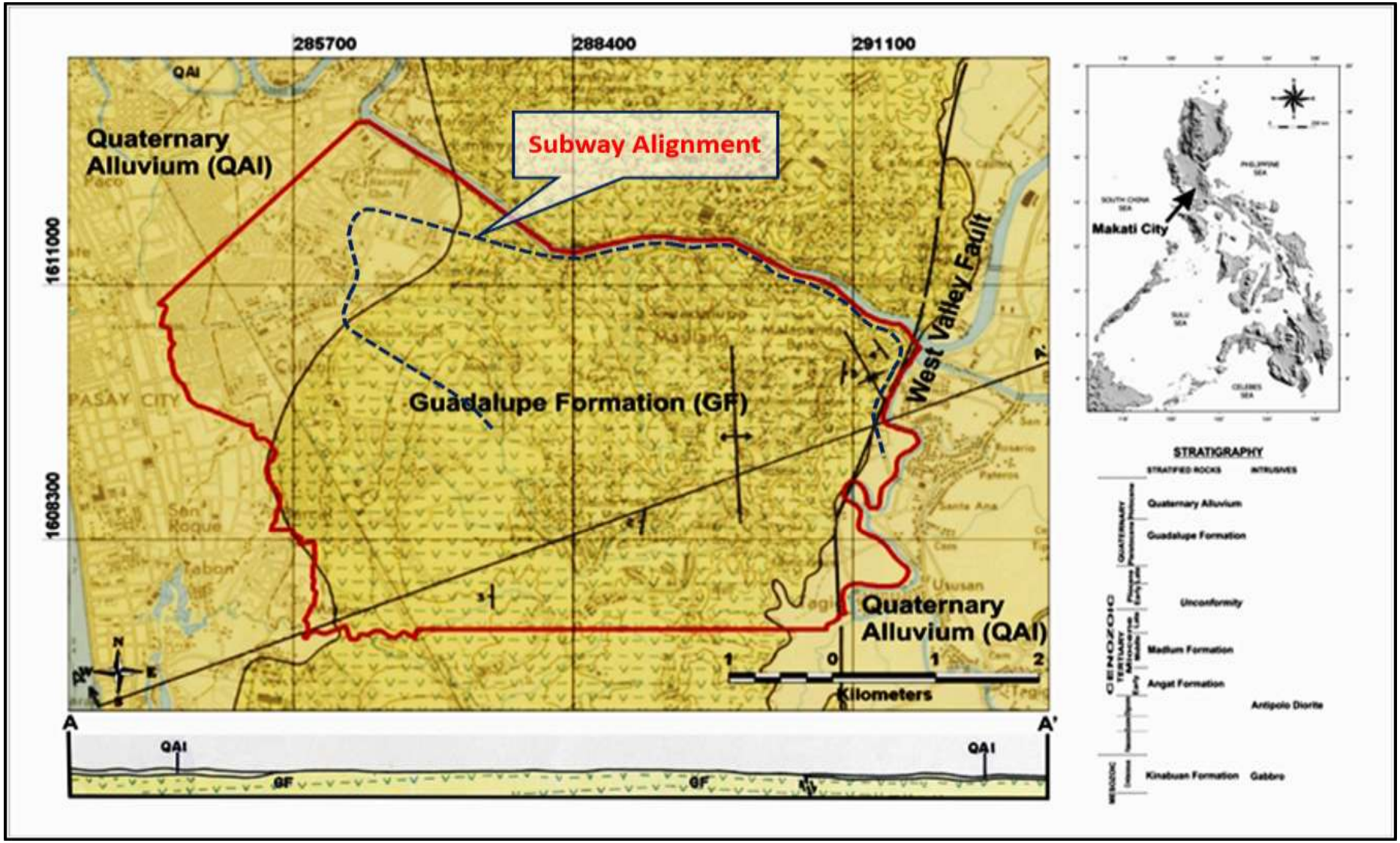



**Figure 2-10: Geologic Map**

Source: Geologic Map of Manila and Quezon City Quadrangle. Sheet 3263-IV. MGB, 1983

D. Surficial Deposits

The GTF is overlain by a relatively thin layer of soil varying from 1 m to 14.5 m thick. However, ground investigation records reveal that the alluvium gradually thickens up to 27 m to further northwest of the proposed alignment.

The surficial soil layer is consisting of a heterogeneous mix of clayey/silty sand and sandy silt/clay. Low lying areas, including the alluvial plain at northwest and east of study area and the riverbank of Pasig River, generally consists relative thicker soil layer between 5m to 14.5m, probably with the presence of alluvium deposits. However, the surficial soil layer was notdifferentiated into fill, alluvium or residual soil in the borehole logs. The surficial soil at the lowlying area was generally described as loose to medium dense clayey/silty sand or medium stiffto very stiff sandy silt/clay, locally consists of shell fragments. The average standard penetration test (SPT) N-value is around 25 for the loose material.

For relative higher elevation area at Guadalupe Plateau, the surficial soil layer is generally between 1m to 5m thick, which generally described as medium dense to very dense silty/clayey sand or stiff to hard sandy silt/clay. This probably represents the residual soil with localized thin layer of fill.

Recommended Geotechnical Properties

The geotechnical parameters for different soil and weak rock have been developed using thefield and laboratory test data of the available ground investigation records. The properties for each soil type have been collected and summarized in tabular or graphical formats. The design parametersadopted in the current FS are summarized below.

1. Bulk Densities

In view of limited laboratory testing record, the design bulk densities based on conservative assumptions are summarized in **Table 2-5** below:

**Table 2-5: Summary of Bulk Density**

| Soil Type | Design Bulk Density ($Mg/m^3$) |
|---|---|
| Residual Soil | 19 |
| Highly Weathered GTF | 19 |

2. Moisture Content

The moisture contents for residual soil stratum obtained from existing ground investigation information are summarized in **Table 2-6** below. Moisture contents for weak rock layer are not available at this stage.

**Table 2-6:.Summary of Moisture Content**

| Soil Type | Moisture Content (%) | | |
|---|---|---|---|
| | Max | Min | Mean |
| Residual Soil | 80.00 | 5.00 | 34.08 |

3. Atterberg Limits and Plasticity Index

Except weak rock layer, the maximum, minimum and average values of the Atterberg limitsand the Plasticity Index (PI) for residual soil layer obtained from existing ground investigation information are summarized in **Table 2-7** below.

**Table 2-7: Summary of Liquid Limit, Plastic Limit and Plasticity Index (KTN)**

| Soil Type | Liquid Limit (%) | | | Plastic Limit (%) | | | Plasticity Index (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Max. | Min. | Mean | Max. | Min. | Mean | Max. | Min. | Mean |
| Residual Soil | 90.00 | 21.00 | 45.24 | 40.00 | 10.00 | 23.77 | 59.00 | 5.00 | 21.69 |

4. Soil Stiffness

Standard penetration tests have been carried out in the residual soil stratum. The SPT N-valuesobtained under the existing ground investigation are used to determine the Young's Modulus (E').

For the feasibility study of this project, the Young's Modulus of soil under drained condition, E'is derived from SPT N-values using the following empirical relationship: E'(MN/m2) = f x N, where the design value of f is adopted as 1. For weak rock layer where SPT N-values are not available, conservative values of N=50 is adopted.

The SPT N-Values for residual soil are plotted against depths below ground as shown in **Annex 7** From the SPT graph, the SPT N-value various with depth. The summary of soil stiffness parameters are tabulated below

**Table 2-8: Summary of Soil Stiffness Parameters**

| Soil Type | SPT N-Value |
|---|---|
| Residual Soil (Depth < 10m) | 15 |
| Residual Soil (Depth ≥ 10m) | (z-1.18)/0.59 where z = depth of soil |
| Highly Weathered GTF | 50 |

5. Shear Strength Parameters and Permeability of Soil

Information on triaxial tests with pore water measurements and permeability test are notavailable at current stage, the drained shear strength parameters and permeability of soil areassumed based on the conservative value as summarized in **Table 2-9** below:

**Table 2-9: Design Drained Shear Strength Parameters and Permeability**

| Soil Type | Cohesion c'(kPa) | Friction Angle Φ' (°) | Permeability (m/s) |
|---|---|---|---|
| Residual Soil | 0 | 30 | $10^{-4}$ |
| Highly Weathered GTF | 5 | 35 | $10^{-6}$ |

6. Unconfined Compressive Strength of Weak Rock

The UCS of weak rock layer based on existing GI information is summarized in **Table 2-10** below:

**Table 2-10: Summary of UCS Test Results**

| Soil Type | Max. (MPa) | Min. (MPa) | Mean (MPa) |
|---|---|---|---|
| Highly Weathered GTF | 3.61 | 0.049 | 2.6 |

2.1.2.3 Impact Assessment

The construction and operation of project components will have a change in the sub-surface geology and underground conditions in the project area. Approximately 430,000 cubic meters ($m^3$) of soil is estimated to be excavated by the Tunnel Boring Machine (TBM) during the construction of the subway track. Cut soil may be sold, donated to individuals or companies requiring backfill, or may be used as soil cover in landfills.

The excavation works will have temporary support for the maintain stability. The cut-and-cover tunnel will be designed to withstand the permanent loads including all worst case combination of applied loading and effect without causing distress during the design life of the tunnels. These measures will maintain the equilibrium between the ground and the structure.Detailed impact assessment on the affected buildings, affected utilities and other geotechnical features will be assessed in the later stage of the project.

2.1.2.4 Inducement of Subsidence, Liquefaction, Landslides, Mud/Debris Flow

The project is not expected to induce subsidence, liquefaction or any natural hazards. However, the project is vulnerable to natural hazards that should be considered in the development of the project. Natural hazards are discussed in **Section 4**.

2.1.3 Pedology

Soil study was made based on the established soil series and soil types in the Makati City by the Bureau of Soils and Water Management (1989 and 2014 reports). Soil types in the representative sites of the soil mapping units were checked from the on-going borehole drillings along the subway alignment for the geotechnical study.

Soil erosion susceptibility or erosion potential of the project area was not done due to the fact that the whole subway alignment are already paved with cement and/or with existing structures (houses or buildings). However, mitigating measures were given to the possible areas with possibility of erosion. These are where excavations will be done on relatively small areas along the alignment. Thus, the potential erosion will be merely confined in these small areas.

2.1.3.1 Soil Erosion/ Loss of Top Soil/ Overburden

2.1.3.1.1 Soil Type

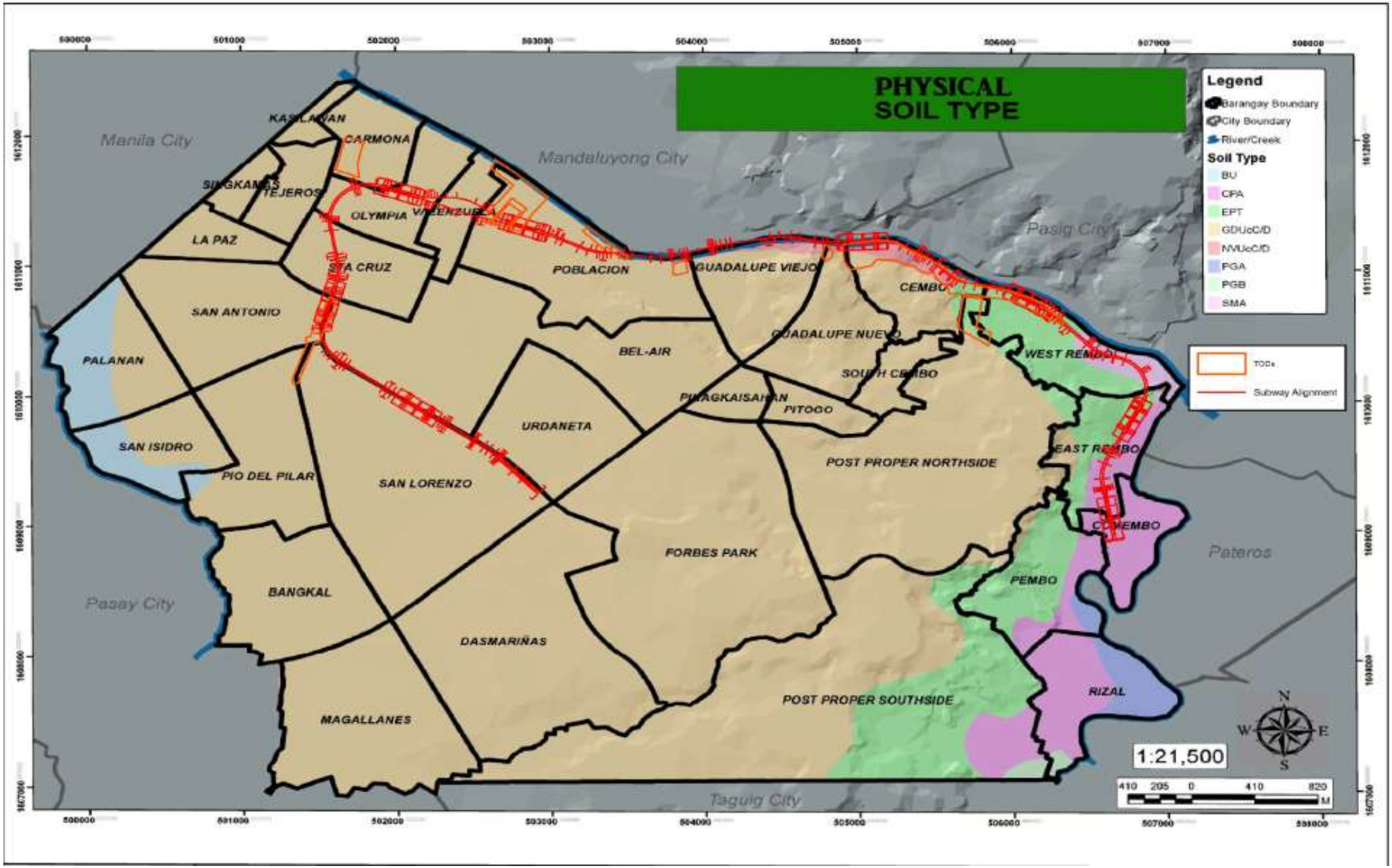
The soil map of Makati City **(Figure 2-11)** indicates the presence of eight (8) soil types, namely: BU, Guadalupe Series, NvucC/D, Escaprment, Cupang Series, SmA, Pinagbuhatan A and Pinagbuhatan B. Of these, three are the most common: Guadalupe Series, scarpment (or Miscellaneous Soil Type) and Cupang Series. The descriptions of these soil types are taken mostly from Carating, Galanta & Bacation (2014).

Guadalupe Series is the most widespread type in Makati City. It is a residual soil of water laid volcanic tuff, found generally on rolling to gently rolling areas of volcanic footslopes and on flat areas of slightly degraded tuffaceous plains of residual volcanic footslopes. Guadalupe Series soils are shallow to moderately deep, poorly drained clayey soils. The surface soil is dark brown to nearly black clay, reaching down to depths of 2-3 cm. The subsoil is light brownish black clay, reaching down 50-80 cm from the surface, and containing spherical tuffaceous concretions. It is underlain by hard and massive tuff. Due to burial by urban development and industrialization, Guadalupe Series soils on volcanic plains are considered as extinct.

San Manuel Series is found on the level to nearly level (0-3% slopes) of Pasig River in Barangays Guadalupe Viejo, Cembo and West Rembo. San Manuel Series developed from the weathering of alluvial deposits on the river terraces. It is a member of the fine loamy, mixed, isohyperthermic family of FluventicEutropepts. These soils are deep and well drained. A horizon is brown, brown to dark brown, dark yellowish brown friable to firm clay loam,silty clay loam or silt loam. Cambic B horizons are brown to dark brown, dark yellowish brown , dark brown friable to slightly firm silty clay loam, clay loam, silt loam or fine sandy loam. C horizons below 100-150 cm from the surface are dark yellowish brown, yellowish brown, brown to dark brown composed of weakly stratified loamy and sandy deposits.

Escarpment or Miscellaneous Soil Type dominates the relatively hilly strip of land along the West Valley Fault zone. The product of faulting and erosion, it is typically clay-rich and poorly draining. It is found in West Rembo, East Rembo, Pembo and Post Proper Southside barangays. Cupang Series soil is found in barangays East Rembo, Comembo, Pembo, Rizal and Post Proper Southside. It belongs to fine, mixed and isohyperthermic *Vertic Topaquepts*. These are moderately deep and poorly drained soils occurring on nearly level (0-2% slope) minor alluvial plains.

Cupang Series is found in Barangays East Rembo, Comembo, Pembo, Rizal and Post Proper Southside. It belongs to fine, mixed, isohyperthermicVerticTropaquepts.Cupang soils developed from the weathering of alluvial deposits on level to nearly level (0-3% slopes) minor alluvial plain. The soils are moderately deep to deep and poorly drained. Horizons are very dark gray or dark gray clay. B Horizons are gray, dark olive gray, olive gray clay with grayish brown mottles. Few weathered tuffaceous fragments sometimes are present in the horizon. C Horizon below 64-130cm from the soil surface are loam, sandy loam, sandy clay, gravelly clay or weathered volcanic tuff.




Lichel Technologies, Inc.
Unit 1403 Prestige Tower Condominium
F. Ortigas, Jr. Road, Ortigas Center, Pasig City

FIGURE TITLE :

**Soil Type**

FIGURE NO.:

**2-11**

#### 2.1.3.1.2 Soil Profile

As earlier discussed, based on borehole data gathered from various building projects located in the northern part of Makati City, it can be generalized that the upper 3 m of the ground profile is composed of soft and loose alluvial soil. At 4-9 m below the ground, the substrate transitions to different mixtures of dense silt and clay. These upper layers may belong to the Quaternary Alluvium or Manila Formation. Underlying these are sandstones or tuff rock believed to belong to the Diliman Tuff member of the Guadalupe Formation.

#### 2.1.3.1.3 Soil Use

Before the Second World War, much of Makati City was covered in swampland, ricefield, sugar plantations and grass land. After the war, it was progressively converted to a financial and commercial center which led to in-migration of residents. Today, around 35% of the land is used for residences, followed by roads (23.5%), commercial space (15%), recreational (3.7%), cemetery (3.2%), institutions (3.1%), and parks (1.1%). The rest is divided between industrial, utility, government, and riverside development use. There are no more lands in the city being used for agriculture. The soil resources of the

#### 2.1.3.1.4 Soil/Rock Properties

Based on the relevant ground investigation data, the geological profile of the study area can be divided into 2 layers namely residual soil and highly weathered Guadalupe Tuff Formation. The residual soil is considered to be loose material and mainly consist of Silty Sand and Silty Clay with an average SPT N-value of around 25. In addition, the highly weathered Guadalupe Tuff Formation is considered to be weak rock layer with an average UCS of 2625 kN/m2. In view of limited GI and testing results, a conservative assumption on the design parameters will be made for the design and assessment purposes in this feasibility study stage.

#### 2.1.3.1.5 Impact Assessment

Excavation and earthmoving activities as well as vehicle and equipment movement on unpaved surfaces have the potential to induce erosion and siltation. Water bodies located nearest the project site are the Pasig River and at least 6 creeks draining Makati City. These water bodies are currently impacted by domestic wastewater and effluent discharge and improper disposal of solid wastes. Silt-laden surface runoff from the project site may find its way to surface waters or drainage systems especially during periods of heavy rainfall.

The Subway Project as an underground infrastructure includes ten stations, two terminal crossover boxes and a depot. The Subway will be done through tunneling, while the stations will be dug via cut and cover technique. The depot will be with structures. The tunneling will bring out its excavated spoils through its launching point, then to be hauled by trucks. However, during night time the hauling may stop to avoid noise pollution, therefore temporary stockpile of excavated materials will be at or near the launching points. For stations with the cut and cover technique, temporary stockpile of excavated materials is expected. Also the construction of the depot will involve excavation and earth movement. These stockpiles of excavated materials are subjected to erosion with heavy rainfall. The eroded materials will impact on the following:

- Sedimentation of the Creeks and Pasig River;
- Sedimentation of the adjacent lower areas which may cause slippery surface for the walking public and motor vehicles; and
- Sediments to clog the drainage ways/filters of the adjacent lower areas to cause flooding.

Mitigation measures to minimize erosion and limit the discharge of sediments from the project site include:

- Installing erosion and sediment control measures such as silt screens, temporary drain channels, and sumps or settling ponds to control surface water runoff from areas disturbed by construction;

- Proper management of stockpiles to prevent them from contaminating waterways;
- Excavated stockpiles should be covered with vinyl, canvass or plastic sheets as protection against the erosive heavy rainfall.
- Scheduling excavation and earthmoving activities ( Nov.-April) to avoid periods of heavy rainfall and strong winds as much as practicable; and
- Re-vegetating or rehabilitating construction areas as soon as possible (if applicable).

#### 2.1.3.2 Change in Soil Quality/Fertility

Laboratory analysis for soil quality was not required during the Technical Scoping **.** However, soil quality will be affected by soil contamination with the spillage of oil and grease from the maintenance area of the trains in the depot. This happens with the improper handling or disposal of oil and grease. Cleaning/washing of coaches also pollute the soil with heavy metals such as Zinc and Copper. These heavy metals emanates from the wearing-out of the brake pads of the trains.
As counter measure, the following measures are advised:

- Proper handling/ safe keeping of oil and grease in the train maintenance area should be strictly implemented, and
- Water used in the cleaning of the coaches should be properly disposed.

### 2.1.4 Terrestrial Ecology

The proposed subway project is situated in an urban landscape, where majority are composed of concrete structures such as houses and buildings. Earthworks for the subway alignment and corresponding stations will be conducted mostly underground. As such, the depot between Station 7 and Station 8 was inventoried for tree species since there will be aboveground vegetation clearing on this area. The view of the vegetation in the proposed depot area is shown in **Figure 2-12.**

**Figure 2-12: Vegetation in the Depot Area**

For the depot, an inventory of all tree species was conducted. All Tree species with dbh > 5cm were listed. Herbs and shrubs were also identified on-site and listed without repetitions to determine presence and absence of flora species in the area. For terrestrial fauna, major animal groups (Birds, Mammals, and Herps) observed were also listed during the assessment. Parameters used in the assessment of terrestrial flora and fauna include the following:

$$Abundance\ (Abund) = Number\ of\ individuals\ in\ a\ species$$

$$Frequency\ (Freq) = \frac{Number\ of\ times\ a\ species\ occurred\ in\ all\ points}{Total\ number\ of\ points} \times 100$$

$$Dominance(Dom) = \frac{Basal\ Area}{Area} \times 100$$

$$Relative\ Abundance\ (RA) = \frac{Abund}{Total\ Abundance} \times 100$$

$$Relative\ Frequency\ (RF) = \frac{Freq}{Total\ Frequency} \times 100$$

$$Relative\ Dominance(RD) = \frac{Freq}{Total\ Frequency} \times 100$$

$$Importance\ Value\ (IV) = \frac{\sum of\ Relative\ Values}{\#\ of\ Relative\ Values\ Used}$$

Importance values would determine the ranks of the species within the sampled ecosystem and would identify which of them would be exerting the most influence on the ecosystem in terms of nutrient cycling, energy transfer, and micro-climatic effects.

Biodiversity Indices were used to determine the dominance and distribution of species found in the area. The indices used are as follows:

**Dominance (D)** is a measure ranging from 0 to 1, the former indicating if all taxa are equally present, or the latter, if one taxon completely dominates the community.

$$D = \sum_{i=1}^{S} \left[ \left( \frac{n_i}{N} \right)^2 \right]$$

**Shannon-Weiner Index (H')** is a measure of the average degree of "uncertainty" in predicting to what species an individual chosen at random from a collection of S species and N individuals will belong (Magurran 1988).

$$H' = \sum_{i=1}^{S} \left[ \left( \frac{n_i}{N} \right) \ln \left( \frac{n_i}{N} \right) \right]$$

**Pielou's Evenness Index (J')** expresses H' relative to the maximum value that H' can obtain when all of the species in the sample are perfectly even with one individual per species (Magurran 1988).

$$J' = \frac{H'}{\ln(S)}$$

Paleontological Statistics (PaST) V.10 software was used in the computations of the diversity parameters and indices. The computed values were then related to the Fernando Biodiversity Scale (1998) shown **Table 2-11**

**Table 2-11: The Fernando Biodiversity Scale**

| Relative Values | Shannon (H') Index | Pielou (J') Evenness Index |
|---|---|---|
| Very High | 3.5 and above | 0.75-1.00 |
| High | 3.0-3.49 | 0.50-0.74 |
| Moderate | 2.5-2.99 | 0.25-0.49 |
| Low | 2.0-2.49 | 0.15-0.24 |
| Very Low | 1.9 & below | 0.05-0.14 |

2.1.4.1 Vegetation Removal and Loss of Habitat

2.1.4.1.1 Terrestrial Flora

Overall, a total of 207 individual trees with 39 species were observed in the stations of the municipalities assessed for the Project. Overall dominance is at D = 0.07 which indicated that species were evenly distributed throughout the areas assessed. Diversity and evenness are High at H' = 3.04 and Very High at J' = 0.83, respectively. **Table 2-12** shows the summary of results for terrestrial flora inventory.

**Table 2-12: Summary of Results for Terrestrial Flora Diversity**

| Parameters | Depot |
|---|---|
| No. of Individuals | 207 |
| Species Richness | 39 |
| No. of Families | 19 |
| Dominance | 0.07 |
| Diversity Index (H') | 3.04 |
| Evenness Index (J') | 0.83 |

The area was dominated by planted trees and species for landscaping purposes, the highest number of individuals in a species is Mahogany (*Swietenia* macrophyla) with 33 individuals, then followed by Indian Lanutan (*Polyalthia longifolia*) of the Family Anonaceae with 22 individuals. Other top ranked species in terms of abundance include Mangga *(Mangifera indica*), Manila Palm (*Adonidia merrillii*), and Narra (*Pterocarpus indicus*).

Dominance indicate which species occupies the largest space within an assessed area. Dominance was highest with Mangga (*M. indica*), and then followed by Mahogany (*S. macrophylla*) and Narra (*P. indicus*). Indian lanutan (*P. longifolia*) and Niyog (*C. nucifera*) were also included in the top ranked species for dominance.

Importance Value ranks which species are most likely to contribute to environmental processes such as carbon storage and nutrient cycling. Mahogany (*S. macrophylla*) obtained the highest computed values, and then followed by Mangga (*M. indica*) and Narra (*P. indicus*). Other top-ranked species include Indian Lanutan (*Polyalthia longifolia*), Manila Palm (*Adonidia merrillii*), Niyog (*Cocos nucifera*), Langka (*Artocarpus heterophyllus),* Guava (*Psidium guajava*), Benjamin's Fig (*Ficus benjamina*), and Santol (*Sandoricum koetjape*).

The parameters taken for terrestrial flora species are shown in **Table 2-13,** including the importance value. **Table 2-14** shows checklist of flora species in the proposed depot area.

**Table 2-13: Computed Importance Values of Flora Species Found on the Proposed Depot Area.**

| Family Name | Scientific Name | Common name | Abund | RA | Freq | RF | Dom | RD | IV |
|---|---|---|---|---|---|---|---|---|---|
| Meliaceae | *Swietenia macrophylla* | Mahogany | 33 | 15.94 | 0.67 | 5.13 | 0.1419 | 14.83 | 11.97 |
| Anacardiaceae | *Mangifera indica* | Mangga | 19 | 9.18 | 0.67 | 5.13 | 0.1923 | 20.11 | 11.47 |
| Fabaceae | *Pterocarpus indicus* | Narra | 15 | 7.25 | 0.83 | 6.41 | 0.1145 | 11.97 | 8.54 |
| Annonaceae | *Polyalthia longifolia* | Indian Lanutan | 22 | 10.63 | 0.67 | 5.13 | 0.0868 | 9.08 | 8.28 |
| Arecaceae | *Adonidia merrillii* | Manila Palm | 18 | 8.70 | 0.50 | 3.85 | 0.0323 | 3.38 | 5.31 |
| Arecaceae | *Cocos nucifera* | Niyog | 8 | 3.86 | 0.67 | 5.13 | 0.0548 | 5.72 | 4.91 |
| Moraceae | *Artocarpus heterophyllus* | Langka | 10 | 4.83 | 0.83 | 6.41 | 0.0320 | 3.35 | 4.86 |
| Myrtaceae | *Psidium guajava* | Guava | 10 | 4.83 | 0.67 | 5.13 | 0.0247 | 2.58 | 4.18 |
| Moraceae | *Ficus benjamina* | Benjamin's Fig | 7 | 3.38 | 0.50 | 3.85 | 0.0226 | 2.36 | 3.20 |
| Meliaceae | *Sandoricum koetjape* | Santol | 6 | 2.90 | 0.33 | 2.56 | 0.0318 | 3.32 | 2.93 |
| Moraceae | *Ficus septica* | Hauili | 5 | 2.42 | 0.50 | 3.85 | 0.0208 | 2.18 | 2.81 |
| Fabaceae | *Tamarindus indica* | Sampalok | 3 | 1.45 | 0.50 | 3.85 | 0.0275 | 2.88 | 2.72 |
| Arecaceae | *Roystonea regia* | Royal Palm | 11 | 5.31 | 0.17 | 1.28 | 0.0138 | 1.44 | 2.68 |
| Fabaceae | *Leucaena leucocephala* | Ipil ipil | 4 | 1.93 | 0.50 | 3.85 | 0.0106 | 1.11 | 2.30 |
| Bombacaceae | *Ceiba pentandra* | Kapok | 2 | 0.97 | 0.33 | 2.56 | 0.0290 | 3.03 | 2.19 |
| Combretaceae | *Terminalia catappa* | Talisay | 4 | 1.93 | 0.33 | 2.56 | 0.0056 | 0.59 | 1.69 |
| Lythraceae | *Lagerstroemia speciosa* | Banaba | 2 | 0.97 | 0.33 | 2.56 | 0.0130 | 1.36 | 1.63 |
| Oxalidaceae | *Averrhoa bilimbi* | Kamias | 2 | 0.97 | 0.33 | 2.56 | 0.0081 | 0.85 | 1.46 |
| Bignoniaceae | *Spathodea campanulata* | African tulip | 2 | 0.97 | 0.17 | 1.28 | 0.0189 | 1.98 | 1.41 |
| Calophyllaceae | *Calophyllum inophyllum* | Bitaog | 2 | 0.97 | 0.33 | 2.56 | 0.0047 | 0.49 | 1.34 |
| Arecaceae | *Caryota rumphiana* | Takipan | 2 | 0.97 | 0.33 | 2.56 | 0.0029 | 0.30 | 1.28 |
| Fabaceae | *Acacia auriculiforis* | Auri | 2 | 0.97 | 0.17 | 1.28 | 0.0152 | 1.59 | 1.28 |
| Moraceae | *Ficus religiosa* | Sacred Bo Tree | 2 | 0.97 | 0.33 | 2.56 | 0.0023 | 0.24 | 1.26 |
| Lauraceae | *Persea americana* | Avocado | 2 | 0.97 | 0.17 | 1.28 | 0.0112 | 1.17 | 1.14 |
| Moraceae | *Artocarpus altilis* | Kamansi | 1 | 0.48 | 0.17 | 1.28 | 0.0108 | 1.13 | 0.96 |
| Arecaceae | *Hyophorbe indica* | Champagne Palm | 1 | 0.48 | 0.17 | 1.28 | 0.0076 | 0.79 | 0.85 |
| Sapotaceae | *Manilkara zapota* | Chico | 1 | 0.48 | 0.17 | 1.28 | 0.0076 | 0.79 | 0.85 |
| Myrtaceae | *Syzygium samarangense* | Makopa | 1 | 0.48 | 0.17 | 1.28 | 0.0065 | 0.68 | 0.81 |
| Apocynaceae | *Cascabela thevetia* | Lucky nut | 2 | 0.97 | 0.17 | 1.28 | 0.0011 | 0.11 | 0.79 |
| Moringaceae | *Moringa oleifera* | Malunggay | 1 | 0.48 | 0.17 | 1.28 | 0.0019 | 0.20 | 0.65 |
| Moraceae | *Ficus nota* | Tibig | 1 | 0.48 | 0.17 | 1.28 | 0.0011 | 0.12 | 0.63 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Anonaceae | *Annona reticulata* | Atis | 1 | 0.48 | 0.17 | 1.28 | 0.0009 | 0.10 | 0.62 |
| Apocynaceae | *Plumeria acuminata* | Kalachuchi | 1 | 0.48 | 0.17 | 1.28 | 0.0007 | 0.08 | 0.61 |
| Asparagaceae | *Dracaena fragrans* | Fortune Plant | 1 | 0.48 | 0.17 | 1.28 | 0.0003 | 0.03 | 0.60 |
| Moraceae | *Ficus ulmifolia* | Is-is | 1 | 0.48 | 0.17 | 1.28 | 0.0003 | 0.03 | 0.60 |
| Moraceae | *Ficus pseudopalma* | Niyog-niyogan | 1 | 0.48 | 0.17 | 1.28 | 0.0003 | 0.03 | 0.60 |
| Sapotaceae | *Chrysophyllum cainito* | Kaimito | 1 | 0.48 | 0.17 | 1.28 | 0.0003 | 0.03 | 0.60 |

**Table 2-14: Checklist of Flora Species Found in the Proposed Depot Area**

| Family Name | Scientific Name | Common name |
|---|---|---|
| Anacardiaceae | *Mangifera indica* | Mangga |
| Annonaceae | *Polyalthia longifolia* | Indian Lanutan |
| Anonaceae | *Annona reticulata* | Atis |
| Apocynaceae | *Cascabela thevetia* | Lucky nut |
| Apocynaceae | *Plumeria acuminata* | Kalachuchi |
| Araceae | *Dieffenbachia seguine* | Dumb Cane |
| Araceae | *Philodendron lacerum* | Bagawak |
| Araceae | *Zamioculcas zamiifolia* | Welcome plant |
| Arecaceae | *Adonidia merrillii* | Manila Palm |
| Arecaceae | *Caryota rumphiana* | Takipan |
| Arecaceae | *Cocos nucifera* | Niyog |
| Arecaceae | *Hyophorbe lagenicaulis* | Bottle Palm |
| Arecaceae | *Rhapis excelsa* | Rhapis |
| Arecaceae | *Roystonea regia* | Royal Palm |
| Asparagaceae | *Cordyline fruticosa* | Baston de San Jose |
| Asparagaceae | *Dracaena fragrans* | Fortune Plant |
| Asparagaceae | *Dracaena reflexa* | Song of Jamaica |
| Asparagaceae | *Dracaena sanderiana* | Lucky Bamboo |
| Asparagaceae | *Sansevieria trifasciata* | Bowstring Hemp |
| Aspleniaceae | *Asplenium nidus* | Pakpak Lawin |
| Basellaceae | *Basella alba* | Alugbati |
| Bignoniaceae | *Spathodea campanulata* | African tulip |
| Bombacaceae | *Ceiba pentandra* | Kapok |
| Calophyllaceae | *Calophyllum inophyllum* | Bitaog |
| Caricaceae | *Carica papaya* | Papaya |
| Combretaceae | *Terminalia catappa* | Talisay |
| Fabaceae | *Acacia auriculiformis* | Auri |
| Fabaceae | *Leucaena leucocephala* | Ipil ipil |
| Fabaceae | *Pterocarpus indicus* | Narra |
| Fabaceae | *Tamarindus indica* | Sampalok |
| Lamiaceae | *Vitex negundo* | Lagundi |
| Lauraceae | *Persea americana* | Avocado |

| | | |
|---|---|---|
| Lythraceae | *Lagerstroemia speciosa* | Banaba |
| Malvaceae | *Hibiscus rosa-sinensis* | Gumamela |
| Meliaceae | *Sandoricum koetjape* | Santol |
| Meliaceae | *Swietenia macrophylla* | Mahogany |
| Moraceae | *Artocarpus altilis* | Kamansi |
| Moraceae | *Artocarpus heterophyllus* | Langka |
| Moraceae | *Ficus benjamina* | Benjamin's Fig |
| Moraceae | *Ficus nota* | Tibig |
| Moraceae | *Ficus pseudopalma* | Niyog-niyogan |
| Moraceae | *Ficus religiosa* | Sacred Bo Tree |
| Moraceae | *Ficus septica* | Hauili |
| Moraceae | *Ficus ulmifolia* | Is-is |
| Moringaceae | *Moringa oleifera* | Malunggay |
| Musaceae | *Musa sp.* | Banana |
| Myrtaceae | *Psidium guajava* | Guava |
| Myrtaceae | *Syzygium samarangense* | Makopa |
| Nyctaginaceae | *Bougainvillea spectabilis* | Bougainvillea |
| Oxalidaceae | *Averrhoa bilimbi* | Kamias |
| Pandanaceae | *Pandanus sp.* | Pandan |
| Pteridaceae | *Polystichum sp.* | Sword Fern |
| Rutaceae | *Citrofortunella microcarpa* | Calamansi |
| Sapotaceae | *Chrysophyllum cainito* | Kaimito |
| Sapotaceae | *Manilkara zapota* | Chico |

2.1.4.1.2 Terrestrial Fauna

During the inventory, fauna species were also listed. Majority of the species observed include Eurasian Tree Sparrow (*Passer montanus*), and Glossy Starling (*Aplonis panayensis*). On the other hand, secondary data suggests (Ong et al. 1999 and Vallejo, 2009) that in total, 91 vertebrate species consisting of 5 species of amphibians, 11 species of reptiles, 64 species of birds and 10 species of mammals in the area. The study area conducted by Ong et al. at the University of the Philippines Diliman and Ateneo de Manila is approximately 10 km away from the proposed depot of the subway. A consolidated checklist for Metro Manila Fauna species is presented in**Table 2-15.**

**Table 2-15: Consolidated Checklist of Fauna Species Taken from Previous Studies**

| Group | Family Name | Scientific Name | Common Name |
|---|---|---|---|
| Amphibians | Bufonidae | *Rhinella marina* | Cane Toad |
| Amphibians | Ranidae | *Hylarana erythraea* | Common Green Frog |
| Amphibians | Ranidae | *Hoplobatrachus rugulosus* | East Asian Bullfrog |
| Amphibians | Ranidae | *Polypedates leucomystax* | Common Tree Frog |
| Amphibians | Ranidae | *Occidozyga laevis* | Puddle Frog |
| Birds | Ploceidae | *Passer montanus* | Eurasian Tree Sparrow |
| Birds | Pycnonotidae | *Pycnonotus goiavier* | Yellow-vented Bulbul |
| Birds | Columbidae | *Spilopelia chinensis* | Spotted dove |
| Birds | Columbidae | *Geopelia striata* | Zebra dove |
| Birds | Columbidae | *Phapitreron leucotis* | White-eared Brown dove |

| Group | Family Name | Scientific Name | Common Name |
|---|---|---|---|
| Birds | Laniidae | *Lanius cristatus* | Brown shrike |
| Birds | Laniidae | *Lanius validirostris* | Mountain Shrike |
| Birds | Laniidae | *Lanius schach* | Long-tailed shrike |
| Birds | Sylviidae | *Cincloramphus timoriensis* | Tawny Grassbird |
| Birds | Sylviidae | *Megalurus palustris* | Striated Canegrass Warbler |
| Birds | Sylviidae | *Phylloscopus cebuensis* | Lemon-throated Leaf-warbler |
| Birds | Motacillidae | *Motacilla cinerea* | Grey Wagtail |
| Birds | Motacillidae | *Anthus novaeseelandiae* | Richard's Pipit |
| Birds | Cuculidae | *Cacomantis variolosus* | Brush Cuckoo |
| Birds | Muscicapidae | *Rhipidura javanica* | Pied Fantail |
| Birds | Muscicapidae | *Ficedula narcissina* | Narcissus Flycatcher |
| Birds | Hirundinidae | *Hirundo tahitica* | Pacific swallow |
| Birds | Alcedinidae | *Halcyon coromanda* | Ruddy Kingfisher |
| Birds | Alcedinidae | *Halcyon chloris* | White-collared Kingfisher |
| Birds | Accipitridae | *Spilornis cheela* | Crested Serpent Eagle |
| Birds | Accipitridae | *Accipiter trivirgatus* | Crested goshawk |
| Birds | Ardeidae | *Bubulcus ibis* | Cattle egret |
| Birds | Ardeidae | *Ixobrychus cinnamomeus* | Cinnamon Bittern |
| Birds | Picidae | *Dendrocopos maculatus* | Philippine Pygmy Woodpecker |
| Birds | Apodidae | *Collocalia esculenta* | Glossy swiftlet |
| Birds | Apodidae | *Hirundapus celebensis* | Purple needle tail |
| Birds | Estrildidae | *Lonchura malacca* | Chestnut munia |
| Birds | Estrildidae | *Lonchura leucogastra* | White-bellied munia |
| Birds | Rallidae | *Amaurornis phoenicurus* | White-breasted waterhen |
| Birds | Rallidae | *Gallirallus torquatus* | Barred Rail |
| Birds | Sturnidae | *Acridotheres cristatellus* | Crested Myna |
| Birds | Turdidae | *Copsychus saularis* | Oriental Magpie Robin |
| Birds | Dicaedae | *Dicaeum australe* | Red-keeled Flowerpecker |
| Birds | Columbidae | *Chalcophaps indica* | Emerald Dove |
| Birds | Columbidae | *Streptopelia bitorquata* | Island Collared-dove |
| Birds | Nectariniidae | *Nectarina jugularis* | Olive-backed Sunbird |
| Birds | Cuculidae | *Cinnyris jugularis* | Philippine Coucal |
| Birds | Cuculidae | *Centropus bengalensis* | Lesser Coucal |
| Birds | Rallidae | *Gallirallus striatus* | Slaty-breasted Rail |
| Birds | Pittidae | *Erythropitta erythrogaster* | Red-Bellied Pitta |
| Birds | Psittacidae | *Loriculus philippensis* | Philippine Hanging Parrot |
| Birds | Accipitridae | *Accipiter soloensis* | Chines Goshawk |
| Birds | Artamidae | *Artamus leucoryn* | White-breasted Wood-swallow |
| Birds | Apodidae | *Collocalia troglodytes* | Pygmy Swiftlet |
| Birds | Dicaedae | *Dicaeum trigonostigma* | Orange-bellied Flowerpecker |
| Birds | Columbidae | *Ducula poliocephala* | Pink-bellied Imperial-pigeon |
| Birds | Ardeidae | *Nycticorax nycticorax* | Black-crowned Night-Heron |
| Birds | Oriolidae | *Oriolus chinensis* | Black-naped Oriole |

| Group | Family Name | Scientific Name | Common Name |
|---|---|---|---|
| Birds | Phylloscopidae | *Phylloscopus ijimae* | Ijima's Leaf-warbler |
| Birds | Psittacidae | *Psittacula krameri* | Ring-necked Parakeet |
| Birds | Zosteropidae | *Zosterops meyeni* | Lowland White-eye |
| Birds | Estrildidae | *Lonchura punctulata* | Scale-breasted Munia |
| Birds | Muscicapidae | *Muscicapa griseisticta* | Grey-streaked Flycatcher |
| Birds | Acanthizidae | *Gerygone sulphurea* | Golden-bellied Fly-eater |
| Birds | Campephagidae | *Lalage nigra* | Pied Triller |
| Birds | Phylloscopidae | *Phylloscopus borealis* | Arctic Warbler |
| Birds | Ardeidae | *Ixobrychus sinensis* | Yellow Bittern |
| Birds | Alcedinidae | *Alcedo atthis* | Common Kingfisher |
| Birds | Apodidae | *Apus pacificus* | Fork-tailed Swift |
| Birds | Charadriidae | *Charadrius dubius* | Little-Ringed Plover |
| Birds | Alcedinidae | *Halcyon smyrnensis* | White-throated Kingfisher |
| Birds | Meropidae | *Merops viridis* | Blue-throated Bee-eater |
| Birds | Muscicapidae | *Monticola solitarius* | Blue Rock-thrush |
| Birds | Nectariniidae | *Leptocoma sperata* | Purple-throated Sunbird |
| Mammals | Pteropodidae | *Cynopterus brachyotis* | Lesser Dog-faced Fruit Bat |
| Mammals | Pteropodidae | *Ptenochirus jagori* | Musky Fruit Bat |
| Mammals | Pteropodidae | *Rousettus amplexicaudatus* | Geoffroy's Rousette |
| Mammals | Pteropodidae | *Eonycteris spelaea* | Dawn Bat |
| Mammals | Vespertillionidae | *Myotis muricola* | Whiskered Myotis |
| Mammals | Soricidae | *Suncus murinus* | House Shrew |
| Mammals | Muridae | *Rattus norvegicus* | Brown Rat |
| Mammals | Muridae | *Rattus exulans* | Polynesian Rat |
| Mammals | Muridae | *Rattus tanezumi* | Oriental House Rat |
| Mammals | Muridae | *Rattus argentiventer* | Ricefield Rat |
| Reptiles | Gekkonidae | *Gekko gecko* | Tokay Gecko |
| Reptiles | Gekkonidae | *Hemidactylus frenatus* | Common House Gecko |
| Reptiles | Gekkonidae | *Hemidactylus stejnegeri* | Stejneger's leaf-toed gecko |
| Reptiles | Gekkonidae | *Cosymbotus platyurus* | Flat-tailed house gecko |
| Reptiles | Scincidae | *Eutropis multifasciata* | Common Mabuya |
| Reptiles | Elapidae | *Naja philippinensis* | Northern Philippine Cobra |
| Reptiles | Colubridae | *Rhabdophis spilogaster* | northern water snake |
| Reptiles | Emydidae | *Cuora amboinensis* | Southeast Asian Box Turtle |
| Reptiles | Gekkonidae | *Gehyra mutilata* | common four-clawed gecko |
| Reptiles | Colubridae | *Lycodon aulicus* | Indian Wolf Snake |
| Reptiles | Varanidae | *Varanus salvator* | Common Water Monitor |

2.1.4.2 Threat to existence and/or loss of important local species

Trees and ornamental plants will be temporarily cleared in the depot area to give way for structures during the construction phase. As such, there will be a temporary exposure of soil surface in this area. It is recommended that soil erosion in this area be minimized by using erosion control measures such as silt and sediment traps. Unnecessary clearing of vegetation should also be practiced in the construction phase to maintain soil protection in some areas of the depot.

1.1.1.1 Threat to Abundance, Frequency and Distribution of Important Species

2.1.4.2.1 Terrestrial Flora

Endemic species are those which are geographically bounded species known to exist in a specific island, region or country. From the inventoried area, 3 species are listed as endemic or can mostly be found within the country. These species include Niyog niyogan (*Ficus pseudopalma*), Is-is (*Ficus ulmifolia*) and Benjamin's Fig (*Ficus benjamina*).

Globally threatened species are those which are classified according to the conservation efforts and flora population of a single species. Classification includes Critically endangered, endangered, vulnerable, Near Threatened and Data Deficient. The globally threatened species include Bottle Palm (*Hyophorbe lagenicaulis*) listed as Critically Endangered, Narra (*P. indicus*) listed as Endangered, Mahogany (*S. macrophylla*) and Is-is (*F. ulmifolia*) both listed as vulnerable and Manila Palm (*Adonidia merrillii*) listed as Near threatened.

For local administrative order of DENR, DAO 2017-11, only 1 species was found to be Vulnerable and this includes Narra (*P. indicus*). Endemic and threatened species are found in**Table 2-16.**

**Table 2-16: Endemic and Threatened Species Found in the Proposed Depot Area.**

| Family Name | Scientific Name | Common name | IUCN 2019 | DAO 2017-11 | Geographic Distribution |
|---|---|---|---|---|---|
| Arecaceae | *Hyophorbe lagenicaulis* | Bottle Palm | Critically Endangered | | |
| Anacardiaceae | *Mangifera indica* | Mangga | Data Deficient | | |
| Caricaceae | *Carica papaya* | Papaya | Data Deficient | | |
| Fabaceae | *Pterocarpus indicus* | Narra | Endangered | Vulnerable | |
| Bignoniaceae | *Spathodea campanulata* | African tulip | Least Concern | | |
| Fabaceae | *Acacia auriculiformis* | Auri | Least Concern | | |
| Lauraceae | *Persea americana* | Avocado | Least Concern | | |
| Myrtaceae | *Psidium guajava* | Guava | Least Concern | | |
| Calophyllaceae | *Calophyllum inophyllum* | Bitaog | Least Concern | | |
| Bombacaceae | *Ceiba pentandra* | Kapok | Least Concern | | |
| Myrtaceae | *Syzygium samarangense* | Makopa | Least Concern | | |
| Fabaceae | *Tamarindus indica* | Sampalok | Least Concern | | |
| Meliaceae | *Sandoricum koetjape* | Santol | Least Concern | | |
| Arecaceae | *Caryota rumphiana* | Takipan | Least Concern | | |
| Arecaceae | *Adonidia merrillii* | Manila Palm | Near Threatened | | |
| Moraceae | *Ficus ulmifolia* | Is-is | Vulnerable | | Endemic |
| Meliaceae | *Swietenia macrophylla* | Mahogany | Vulnerable | | |
| Moraceae | *Ficus benjamina* | Benjamin's Fig | | | Endemic |
| Moraceae | *Ficus pseudopalma* | Niyog-niyogan | | | Endemic |

2.1.4.2.2 Terrestrial Fauna

In total there are 9 birds species **Table 2-17** which are endemic and include White-eared Brown dove (*Phapitreron leucotis*), Lemon-throated Leaf-warbler (*Phylloscopus cebuensis*), Philippine Pygmy Woodpecker (*Dendrocopos maculatus),* Red-keeled Flowerpecker (*Dicaeum australe* ) and Philippine Coucal (*Cinnyris jugularis*) to name a few. For mammals, one species was listed as endemic, the Musky Fruit Bat (*Ptenochirus jagori*). Two reptiles on the other hand were listed, the Northern water snake (*Rhabdophis spilogaster)* and the Northern Philippine Cobra (*Naja philippinensis*).

**Table 2-17: List of Endemic Fauna Species**

| Groups | Family Name | Scientific Name | Common Name |
|---|---|---|---|
| Birds | Columbidae | *Phapitreron leucotis* | White-eared Brown dove |
| Birds | Sylviidae | *Phylloscopus cebuensis* | Lemon-throated Leaf-warbler |
| Birds | Picidae | *Dendrocopos maculatus* | Philippine Pygmy Woodpecker |
| Birds | Dicaedae | *Dicaeum australe* | Red-keeled Flowerpecker |
| Birds | Cuculidae | *Cinnyris jugularis* | Philippine Coucal |
| Birds | Pittidae | *Erythropitta erythrogaster* | Red-Bellied Pitta |
| Birds | Psittacidae | *Loriculus philippensis* | Philippine Hanging Parrot |
| Birds | Columbidae | *Ducula poliocephala* | Pink-bellied Imperial-pigeon |
| Birds | Laniidae | *Lanius validirostris* | Mountain Shrike |
| Mammals | Pteropodidae | *Ptenochirus jagori* | Musky Fruit Bat |
| Reptiles | Colubridae | *Rhabdophis spilogaster* | Northern water snake |
| Reptiles | Elapidae | *Naja philippinensis* | Northern Philippine Cobra |

Threatened species are those species which are classified by both international and local institutions which have dwindling populations due to loss of habitat and environmental degradation. A total of three birds were listed by IUCN asThreatened species. The Ijima's Leaf-warbler (*Phyllocopus ijimae*) is listed as Vulnerable, while the Pink-bellied Imperial-Pegion (*Ducula poliocephala*) and Mountain Shrike (*Lanius validirostris*) are classified as Near threatened. As per DAO 2004-15, The Ijima's Leaf Warbler and Pink-bellied Imperial-Pegion are considered as both Vulnerable species. For reptiles, the Southeast Asian Box Turtle (*Cuora amboinensis*) and Northern Philippine Cobra (*Naja philippinensis*) are classified as Vulnerable and Near Threatened, respectively. **Table 2-18** shows the list of threatened species found in Metro Manila.

**Table 2-18: List of Threatened Species Found in Metro Manila.**

| Groups | Family Name | Scientific Name | Common Name | IUCN 2019 | DAO 2004-15 |
|---|---|---|---|---|---|
| Birds | Phylloscopidae | *Phylloscopus ijimae* | Ijima's Leaf-warbler | Vulnerable | Vulnerable |
| Birds | Columbidae | *Ducula poliocephala* | Pink-bellied Imperial-pigeon | Near threatened | Vulnerable |
| Birds | Laniidae | *Lanius validirostris* | Mountain Shrike | Near threatened | |
| Reptiles | Emydidae | *Cuora amboinensis* | Southeast Asian Box Turtle | Vulnerable | |
| Reptiles | Elapidae | *Naja philippinensis* | Northern Philippine Cobra | Near threatened | |

#### 2.1.4.3 Hindrance to Wildlife Access

Since majority of the construction and operation phases of the Project are conducted underground, there will be minimal impacts experienced by faunal groups. Faunal species on the depot area are already mostly domesticated and adjusted to urban setting, thus, the impacts on fauna are minimal

## 2.2 Water

### 2.2.1 Hydrology/Hydrogeology

This section presents the information on the baseline assessment of the hydrologic and/or hydrogeologic features of the project area. Secondary information for this portion was obtained from the Technical Component of the Feasibility Study for the Project prepared by AECOM in July 2018.

#### 2.2.1.1 Change in Drainage Morphology/ Inducement of Flooding

Makati City is prone to flooding because of its topographic and hydrological conditions. This is due to its low-level areas and the low gradient of the Pasig River, combined with the prevalence of heavy rainfalls associated with tropical cyclones. Open canals, reinforced concrete covered pipes (RCCP), and improved box culverts are provided to address flooding issues in the city. Domestic and industrial wastes are discharged into storm drains then flow to the nine streams and creeks that extend from Del Pan Street to San Jose, Guadalupe. The conversion of canals to improved box culverts and RCCPs occurred from 2009 to 2011. As of 2011, 419.24 km or 66% of the city's streets have improved box culvert systems, 208.54 km or 32.87% are lined with RCCP drainage, and 6.75 km or 1.06% continue to remain as open canals

Pasig River at the northern boundary of the study area is one of the major river systems through Metro Manila, draining westward to Manila Bay. Whilst Taguig River generally defines the eastern boundary of Makati City, which converge to north into Pasig River. The proposed alignment of Makati Subway generally traverses alongside the Pasig River and Taguig River approximately from the eastern portion of Poblacion, through Guadalupe, Cembo and West Rembo, to East Rembo. The alignments will underpass Balisampan Creek and San Jose Creek, connecting to Pasig River. Also the Station-Fire Station is located at the junction of Ayala Creek, Amorsolo Creek and Makati Diversion Channel, which these channels converge to Estero de Tripa de Gallina towards southwest of Makati City.

On theother hand, the MGB – Groundwater Availability Map of the Philippines 2004 describes the hydrogeology of the project area as consisting of rocks in which flow is dominantly intergranular of fairly extensive and productive aquifers with moderate to high permeability **(Figure 2-13)**. Well yields are mostly about 20 liters per second (L/s) but as high as 60 L/s in some sites having. Geologic formation in the area includes Pliocene, Pleistocene and Recent pyroclastics dominated by tuffs with ash and cinder deposits mostly at the aprons at volcanic centers.

The GTF is one of the groundwater systems of Metro-Manila. This groundwater system is considered as the main aquifer of the district. The groundwater is stored and transmitted by the openings and fractures in the tuffaceous rock of GTF. It is separated from the overlying material by a semi-permeable or semi-confining layer between 15m to 45m thick, and thus, the aquifer is confined and pressurized. However, over-pumping of groundwater reduced the piezometric head of the main aquifer to 50 – 60 m below mean sea level.

Unconfined aquifer also occurs in the earth materials above the confining layer, which mainly present at the area underlain by alluvial deposits and mainly recharged by infiltration of surface runoff. The water table of unconfined aquifer is believed to vary with rainfall, which the seasonal fluctuation may up to 6m. Since the confining tuffaceous strata is semi-permeable, it is believed that some "leakage" has taken place from the overlying unconfined aquifer to the main aquifer.

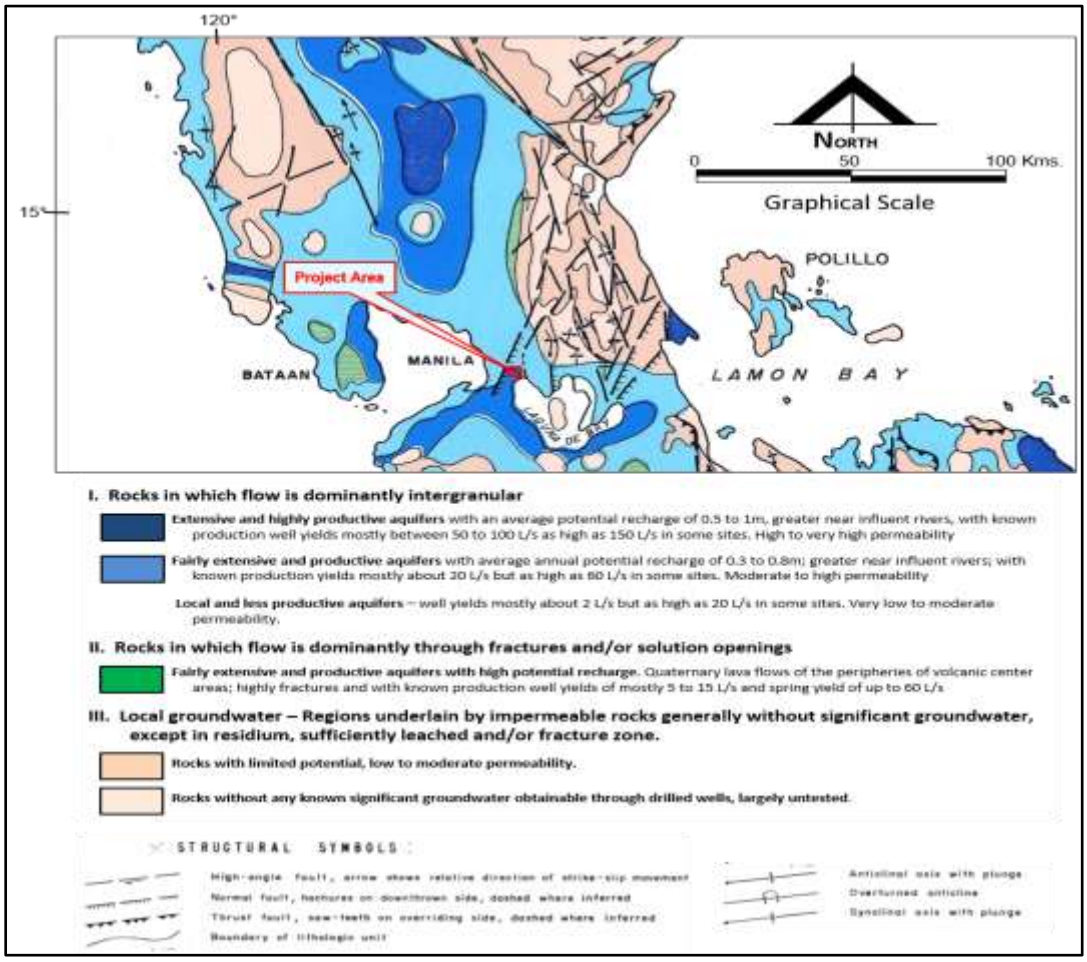



**Figure 2-13: Hydrogeologic Map**

Source: Extracted from 2004 Groundwater Availability Map of the Philippines (MGB)

2.2.1.1.1 Impact Assessment

Based on the relevant ground investigation data, the study area typically underlain by highly weathered locally moderately weathered weakly-cemented Guadalupe Tuff Formation (GTF), and overlain by a relatively thin layer of soil varying from 1 m to 14.5 m thick. However, GI records reveal that the alluvium gradually thickens up to 27m to further northwest of the proposed alignment.

Ground rupture hazard may arise during large earthquakes with the ground being displaced along the fault the cause the seismic event. It may occur suddenly during an earthquake, or gradually as an effect of fault creep progression. There is displacement on either side of a ground rupture: dip-slip faulting has surface ruptures that feature vertical offset, while strikeslip faulting has a lateral displacement. It is also possible to have a combination of horizontal and vertical slippage. Ground ruptures almost always follow pre-existing faults. Developments along identified or hidden fault zones are at risk of structural damage if old fault lines are reactivated.

The alluvial deposits along the Pasig River and creeks flowing into it may also extend to some depth if the present course of the River marks the position of a deeper, eroded palaeo-channel. Not only might this make tunneling conditions more difficult, embankment structures along the Pasig River that are founded on the alluvium may settle in the resulting subsidence trough generated by tunneling, and lower the overspill height of flood-protection walling.

Changes in the underground condition could occur as a result of the excavations. Underground openings such as subways will be subjected to differed loads of the surrounding earth/rock materials. Further, the reported shallow groundwater in the project area would also exert pressure that could

produce seepage (piping). Without adequate support during the construction and operation of the subway to resist these loads, displacement could occur and the resulting ground movement could lead to the collapse of the excavation and could potentially impact the structures near the excavation

2.2.1.1.2 Precautionary/ Mitigating Measures

Recommended Design Groundwater Level

According the hydrology set up in the study area, the tunnel alignment is bounded by Pasig River at northern side. The anticipated groundwater level for the proposed works is expected to be high. In addition, the existing groundwater as recorded in the available ground investigation data indicates the depth of water table varies from 2 m to 18 m below the ground surface. In view of limited GI information at current stages, a conservative approach by assuming the highest design groundwater table of 1m below existing ground level is recommended in the FS.

Proposed Additional Ground Investigation

Due to the limited existing geotechnical investigation information, there appears to be reasonable uncertainties as to the ground and hydro geological conditions identified in the existing available ground investigation data along the proposed subway alignment. The FS required that additional ground investigation and further studies are performed to further identify and confirm the geotechnical constraints in the later stage of the project.

The objectives of the proposed additional ground investigation using vertical drillholes are to obtain adequate geotechnical information for the detailed design in the later stage of the project. The proposed additional ground investigation plans are along the proposed subway alignment. The locations of the proposed drillholes should be further reviewed upon confirmation of the preferred alignment for more accurate assessment of the ground conditions. More ground investigation works should be proposed and undertaken during the detailed design stage within areas identified with problematic geological features.

Structural Design Main Elements

In accordance with the National Structural Code of the Philippines (NSCP, 2015), earthquake related site geology and hazard characteristics contain the following main elements and shall be adopted in the structural design:

a) Soil Profile Type: since the Makati Subway is constructed in weak rock of GTF and the stations are also founded on weak rock, soil profile type of "$S_C$ – Very dense soil and soft rock" is recommend. However, the design Excavation Lateral Support (ELS) of excavation works may require to adopt soil profile type $S_D$ or $S_E$ subject to the local soil profile.

b) Seismic Zone: the study area is located in Zone 4

c) Seismic Source Types: West Valley Fault was estimated to have slip rate of 5-7mm/year. It is appropriate to assume West Valley Fault to be seismic source Type A as earthquake event of Magnitude 7 or higher is expected in relation to the West Valley Fault.

d) Seismic Near-Source Factor and Seismic Response Coefficients: The near source factor shall be determined based on the actual distance of each structures from the West Valley Fault. The seismic response coefficients can be determined by the seismic zone and soil profile type.

Tunneling Scheme

Based on the Philippine Infradev Holdings, Inc. (2018) study, the tunnelling schemes/consideration recommended are:

- The majority of the proposed subway alignment is proposed to run under public road corridor to minimise impacts to the private land. As roads in Makati are very congested and to

construct the tunnels by open cut method will have significant impacts to the already very congested traffic.

- As TBMs remain below ground, their use can avoid many environmental issues and disruption to the existing at-grade traffic. As such, it is recommended that most of the subway tunnels to be constructed by using TBM tunnelling method except for tunnel section between Station 7 and Station 8 where non-congested urban areas are anticipated. Besides, due to the site constraints, the overrun tunnels emerging from Station 1 and Station 10 are envisaged to be constructed by mined tunnelling method.

- TBM construction method will impose less risk to nearby existing structure as this method will not impose significant settlement on ground surface. It is assumed that during excavation the TBM will provide full support to the face of the excavation so as to limit face (volume) losses. The permanent ground support will be in the form of an undrained precast reinforced concrete segmental lining. In order to further control ground settlement it is anticipated that the overcut annulus will be back-grouted as, or immediately after, the lining ring leaves the tail skin of the TBM.

- At cross passage locations, ground treatment will be carried out prior to the excavation works. This will either comprise TAM grouting, jet grouting or ground freezing, which are subjected to the encountered ground condition and site constraints. Ground freezing to strengthen the ground should be considered if jet grouting works are unable to be carried out from the ground surface. However, it should be further reviewed after more ground investigation data is available in the later stage of the project.

- The cut-and-cover tunnels and approach ramps are envisaged to be constructed by using conventional bottom-up construction method where multi-level temporary steel struts and a waling system shall be used to retain the ground water during excavation. The sheetpile wall/pipe pile wall/diaphragm wall will be installed to a depth that provides sufficient embedment. The excavation progresses in stages with struts and walings installed until the final excavation level is achieved. Backfilling and removal of struts shall be carried out in stages after completion of tunnel and ramp structure construction.

- Due to the site constraints, the overrun tunnels emerging from Station 1 and Station 10 are envisaged to be constructed by using forepoling and grouting techniques. For ground support, it is envisaged that horizontal pipe piles (sub-horizontal pipe piles) will be installed around the overrun tunnels to provide immediate tunnel support during incremental tunnel excavation. The temporary tunnel support will be in the form of horizontal pipe piles (subhorizontal pipe piles) and shotcrete lining. In terms of groundwater control, forward probing will be carried out to assess the groundwater inflow. If the inflow exceeds the specified criteria, advanced permeability grouting shall be conducted to ensure the groundwater inflow criteria are satisfied.

#### 2.2.1.2 Change in Stream, Lake Water Depth

There are 15 creeks and 1 river that serve as transportation system and drainage system for storm water in Makati City. These include:

- Pasig River;
- PNR Open Canal;
- Estero De Tripa De Gallina Creek;
- Maricaban Creek;
- Ayala Creek;
- Amorsolo Creek;
- San Lorenzo Creek;
- Makati Diversion Channel;
- Bankal (Lucban) Creek;
- Calatagan Creek;
- Sta. Clara Creek;

- Sanzibar Creek;
- Balisampan Creek;
- Taguig-Pateros Creek;
- San Jose Creek
- Pinos Creek

**Figure 2-14** presents water bodies traversed by the project site. Based on information from the Makati City government, the two main issues concerning the waterways in the city are pollution and the loss of creek and river easements. Waterways draining the city have low dissolved oxygen concentrations and elevated biological oxygen demand, which may most likely be attributed to untreated discharges of domestic and industrial wastes. Regular inspections done by the DENR-EMB also reveal that some of the creeks and river easements in the highly populated Metro Manila no longer exist and have been built upon.

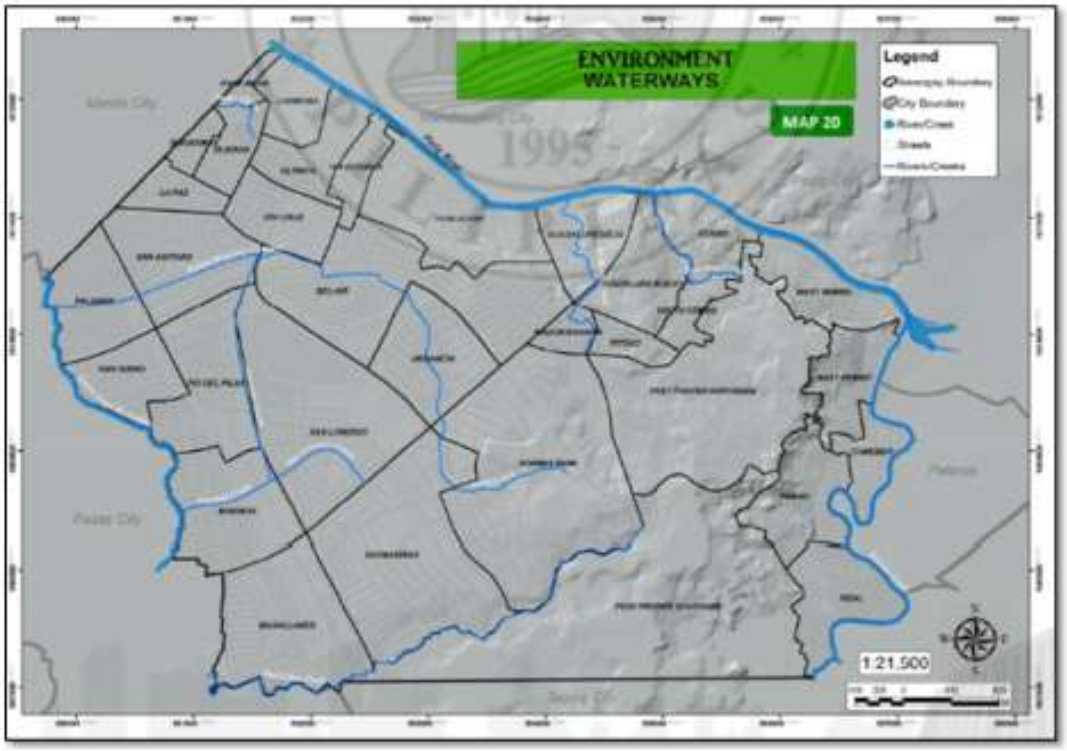



**Figure 2-14: Environment Waterways Map of Makati City**

The greater part of Makati City and its river system drains into the Pasig River System. The Pasig River is considered as a major river in Metro Manila, and is also considered as a tidal estuary because of the interchanging tidal flows brought by its connection to the Manila Bay and Laguna Lake. It has a length of approximately 27 km, an average width of 92 m, and an average depth of 1.3 m. Some portions of the river are 4.5 m deep, such as within the Guadalupe monitoring station of the Pasig River Rehabilitation Commission (PRRC). The average water volume of the Pasig River is 6.6 million $m^3$. During the low flow period from March to May, the river has a recorded flow rate of $12m^3$/sec. The discharge flow rate reaches an average of 275 $m^3$/sec during October and November (Water Quality Status of the Pasig River System). Pasig River at the northern boundary of the study area is one of the major river systems through Metro Manila, draining westward to Manila Bay. Whilst Taguig River generally defines the eastern boundary of Makati City, which converge to north into Pasig River.

Based on the Philippine Infradev Holdings, Inc. (2018) study, the proposed alignment of Makati Subway generally traverses alongside the Pasig River and Taguig River approximately from the eastern portion of Poblacion, through Guadalupe, Cembo and West Rembo, to East Rembo. The alignments will passunder Balisampan Creek and San Jose Creek, connecting to Pasig River. Also the Station-Fire Station is located at the junction of Ayala Creek, Amorsolo Creek and Makati

Diversion Channel, which these channels converge to Estero de Tripa de Gallina towards southwest of Makati City.

#### 2.2.1.3 Depletion of Water Resources / Competition in Water Use

The surrounding areas of the proposed project alignment are supplied with domestic and potable water by Manila Water Company, Inc. Establishments that retail bottled water provide an alternative supply of potable water to the area.

Based on the data collected from Local Water Utilities Administration (LWUA) by PIHI (2018) study, 166 groundwater extraction wells were registered in Makati City, 51 in Pasay City, 2 in Pateros and 94 in Taguig City. Approximately 180 out of 313 wells are in close proximity to the project site, with depths ranging from 91.5 m to 400 mbgs and flowrate capacity ranging from 2.2 L/s to 15.78 L/s.

Shallow groundwater extraction wells, not registered in LWUA, were also observed within the vicinity and are reportedly utilized mostly for domestic purposes only. However, one cannot ascertain the actual use of the extraction wells and no measures are present to prevent their use for drinking purposes.

Water supply needs of the Project during construction and operation will be sourced from the local water utility provider (Manila Water Company, Inc.) based on water demand/requirement of the Project to avoid competition in water use.

### 2.2.2 Water Quality

As per section 10 of DENR Administrative Order 15 series of 2017, the direct areas of impact of the water quality includes the tributaries of Pasig River. The indirect impact areas include the land area within 500 m radius from the project site.

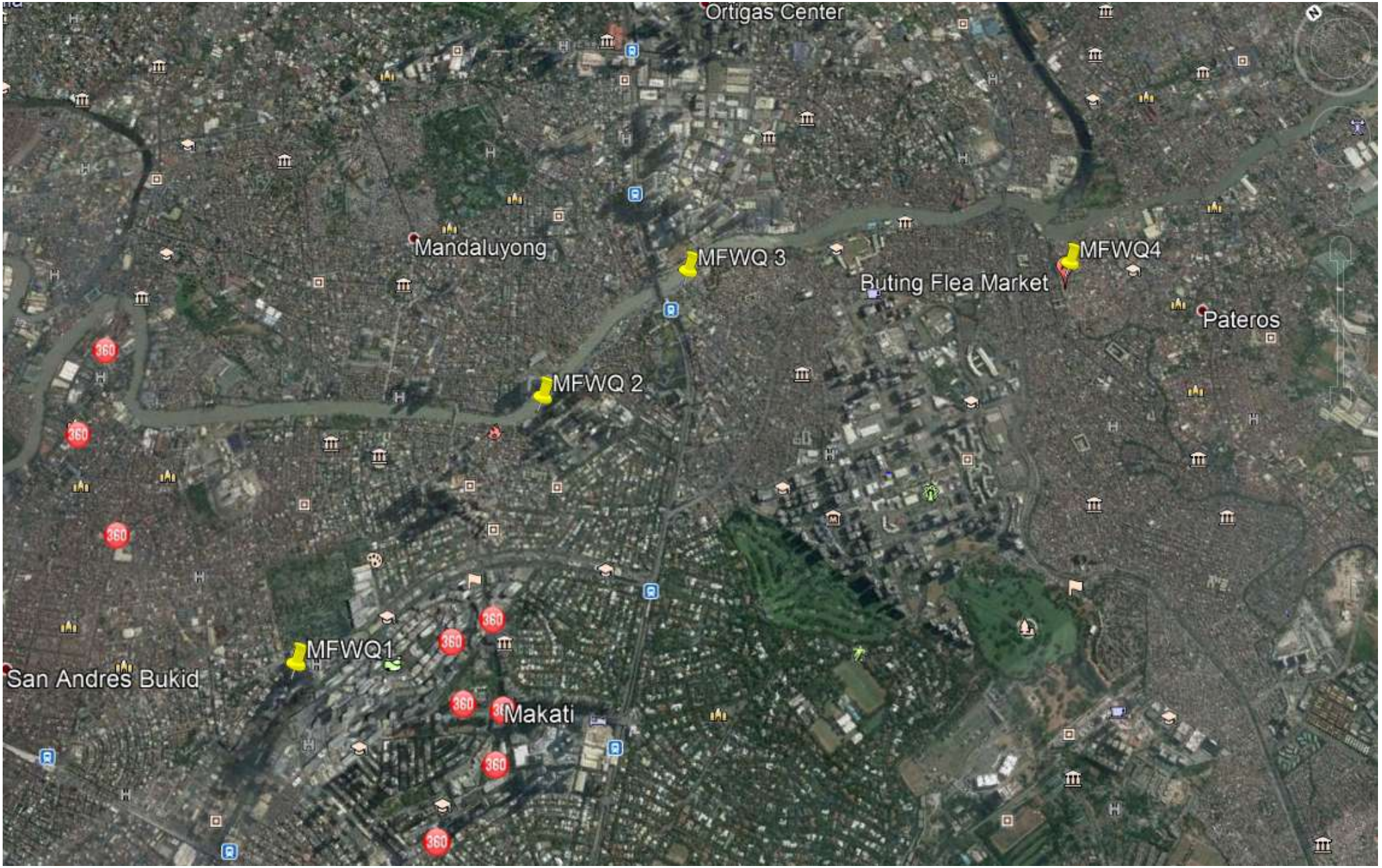
On June 21, 2019, LTI conducted water quality sampling, a multi-parameter water qualitychecker was used to measure *in-situ* parameters such as pH, temperature, dissolved oxygen (DO), conductivity, total dissolved solids and salinity. For the other parameters, grab sampling method was employed.**Table2-19** shows the sampling method usedfor water quality in the identified sampling stations (**Figure 2-15**).

Sampling was done using sterilized sample containers that were prepared by and obtained from the partner laboratory. For the sampling in surface water, one (1) sample was collected per station. A total of four (4) samples each from surface water.Each water samples were labeled properly for identification. The label included the name of the water body, sampling station, sampling number, date and time of sampling, and parameter for analysis.

**Table2-19: Methodology for Water Quality Sampling**

| Parameters | Methodology |
|---|---|
| Total Suspended Solids (TSS) | Grab sampling |
| Oil and Grease | Grab sampling |
| Biochemical Oxygen Demand (BOD) | Grab sampling |
| Oxygen Demand (COD) | Grab sampling |
| Fecal Coliform | Grab sampling |
| Dissolved Oxygen (DO) | Multi-parameter meter |
| Temperature | Multi-parameter meter |
| pH | Multi-parameter meter |

| | |
|---|---|
| Total Dissolved Solids (TDS) | Multi-parameter meter |
| Salinity | Multi-parameter meter |
| Conductivity | Multi-parameter meter |




Lichel Technologies, Inc.
Unit 1403 Prestige Tower Condominium
F. Ortigas, Jr. Road, Ortigas Center, Pasig City

FIGURE TITLE :

**Water Quality Sampling Stations**

FIGURE NO.:

**2-15**

LTI submitted the samples to EDLAV Environmental Testing Services in Los Banos, Laguna. Samples were analyzedfor various parametersand results presented in **Table 2-20.** LTI facilitated the transportation of samples along with the chain-of-custody recordand received and checked the results from the laboratories.

**Table 2-20: Methodology Used for Laboratory Analysis**

| Parameters | Methodology |
|---|---|
| Total Suspended Solids (TSS) | Gravimetric Method |
| Oil and Grease | Gravimetric Method |
| Biochemical Oxygen Demand ($BOD_5$) | 5-Day BOD Test |
| Chemical Oxygen Demand (COD) | Open Reflux Method |
| Fecal Coliform | Multiple Tube Fermentation |
| Metals | Various |

LTI developed a QA/QC procedure for the sampling activity. The equipment used for sampling was calibrated before every sampling event. It was rinsed at each station prior to the collection of samples. This was done by rinsing with water from the same source as the water being collected for the sample.Field data form and a chain of custody (**COC**) of samples were prepared for each sampling event or whenever samples were delivered to the laboratory. The COC included name of sampler, date of sampling, sample name, parameters for analysis, name of person who delivered the samples and name of person who received the samples. Sample contamination was prevented by observing the following precautions:

- Only laboratory-prepared sample containers were used;
- Only the recommended type of sample container for each parameter was used
- Sample containers were kept in a clean location.
- All sampling instrument were cleansed before and after using and as prescribed by the manufacturer.
- Samples were never left to stand in the sun for a long time.
- 6. Samples were delivered to the laboratory on the same day, which is less than the holding time of 24 hours.
- 7. During transportation of samples to the laboratory, it was stored in the proper temperature ($20^0$C) for preservation.

2.2.2.1 Degradation of Groundwater Quality

Based on a July 2018 report prepared by Philippine Infradev Holdings Inc. (INFRA, data collected for groundwater were obtained from Mines and Geoscience Bureau (MGB) and Local Water Utilities Administration (LWUA).The data identified that the site has extensive and productive aquifers with some sites having moderate to high permeability. Groundwater depths were recorded to be between 1.30 mbg to 18.00 mbg with a flow direction north towards Pasig River. Data was collected at LWUA and identified 166 groundwater extraction wells were registered in Makati City, 51 in Pasay City, 2 in Pateros and 94 in Taguig City. There is approximately 180 wells located near the Site with depths that range from 91.5 mbg to 400 mbg and flowrate of 2.2 L/s to 15.78 L/s.

There was no environmental testing done in the previous reports reviewed.

2.2.2.2 Degradation of Surface Water Quality

2.2.2.2.1 Location of Surface Water Sampling

There are four (4) sampling stations identified for surface water quality. Specific geographical coordinates of stations were obtained using GPS and the water quality in-situ measurements in each station were done using a water quality checker and collected water samples were analyzed through DENR-accredited laboratories. Based on DENR's DAO 2016-08, Pasig River was classified under Class C. Due to security reasons, the other corresponding wells and tributaries were unsampled and were not classified under DAO 2016-08. The description and location of the stations are presented in **Table 2-21,** while the DENR Water Quality Guidelines for surface water quality analysis are shown in **Table 2-22.**

**Table 2-21: Description of Surface WaterSampling Stations**

| Station | Intended Beneficial Use (DENR DAO 2016-08) | Geographical Coordinates | |
|---|---|---|---|
| | | Latitude | Longitude |
| MFWQ1 | Class C<br>1. Fishery Water for the propagation and growth of fish and other aquatic resources<br>2. Recreational Water Class II – For boating, fishing, or similar activities<br>3. For agriculture, irrigation, and livestock watering | 14°33'47" | 121°00'56" |
| MFWQ2 | | 14°34'03" | 121°02'25" |
| MFWQ3 | | 14°34'05" | 121°02'43" |
| MFWQ4 | | 14°31'45" | 121°00'18" |

**Table 2-22: Surface Water Sampling Parametersand DENR Water Quality Guidelines**

| Parameter | Unit | DENR Guidelines DAO 2016-8 for Class C |
|---|---|---|
| Total Suspended Solids (TSS) | mg/L | 80 |
| Oil and Grease | mg/L | 2 |
| Biochemical Oxygen Demand (BOD) | mg/L | 7 |
| Dissolved Oxygen (DO) | mg/L | 5.0 (minimum) |
| Temperature | °C | 25-31 (b) |
| pH | - | 6.5-9.0 |
| Chemical Oxygen Demand (COD) | mg/L | - |
| Total Dissolved Solids (TDS) | ppm | - |
| Salinity | ppb | - |
| Conductivity | µS/cm | - |

Notes:

(a) Samples shall be taken from 9:00 AM to 4:00 PM

(b)The natural background temperature as determined by EMB shall prevail if the temperature is lower or higher than the WQG; provided that the maximum increase is only up to 10 percent and that it will not cause any risk to human health and the environment.

2.2.2.2.2 Analysis of Primary Parameters

The results for the surface water sampling are presented in **Table 2-23**. The surface water bodies are classified by the Environmental Management Bureau of the DENR (EMB-DENR) as Class C freshwaters, which include fishery water, recreational water for boating, and/or industrial water for manufacturing processes. Thus, the results from the sampling were compared with the DENR Water Quality Guidelines for Class C freshwater, based on the DENR Administrative Order No. 2016-08 (**DAO 2016-08**) Standards.

**Table 2-23: Surface Water Sampling Results**

| Parameter | Unit | DENR Water Quality Guidelines (DAO 2016-08) for Class C | MFWQ1 | MFWQ2 | MFWQ3 | MFWQ4 |
|---|---|---|---|---|---|---|
| **Date** | mm/dd/yy | | 06/21/2019 | 06/21/2019 | 06/21/2019 | 06/21/2019 |
| **Time** | 24-hr | | 9:27 | 12:46 | 12:58 | 9:21 |
| **Temperature** | °C | 25-31 | 28.45 | 30.28 | 30.17 | 29.40 |
| **pH** | - | 6.5-9.0 | 6.64 | 7.12 | 7.32 | 7.11 |
| **TSS** | mg/L | 80 | 8 | 4 | 24 | 10 |
| **TDS** | Ppm | - | 331 | 545 | 398 | 335 |
| **Salinity** | Ppb | - | 0.32 | 0.53 | 0.38 | 0.32 |
| **Conductivity** | µS/cm | - | 663 | 1089 | 796 | 670 |
| **Oil & Grease** | mg/L | 2 | **6.9** | **8.6** | **10.2** | **4.0** |
| **Fecal Coliform** | MPN/100 mL | 200 | **$94 \times 10^7$** | **$35 \times 10^7$** | **$17 \times 10^7$** | **$24 \times 10^7$** |
| **DO** | mg/L | 5.0 (min) | **0.0** | **0.0** | **0.0** | **0.0** |
| **COD** | mg/L | - | 113 | 123 | 147 | 229 |
| **$BOD_5$** | mg/L | 7 | **76** | **35** | **63** | **62** |
| **Cadmium** | mg/L | 0.005 | <0.002 | <0.002 | <0.002 | <0.002 |
| **Chromium Hexavalent** | mg/L | 0.01 | **0.121** | **0.121** | **0.114** | **0.179** |
| **Copper** | mg/L | 0.02 | 0.0027 | <0.005 | 0.0123 | 0.0136 |
| **Lead** | mg/L | 0.05 | <0.005 | <.0.006 | <0.006 | <0.006 |
| **Mercury** | mg/L | 0.002 | 0.0019 | 0.0004 | 0.0004 | 0.0004 |

As shown **Figure 2-16** the recorded temperatures for stations MFWQ1, MFWQ2, MFWQ3 and MFWQ4 were 28.45°C, 30.28°C, 30.17°Cand 29.40°C, respectively. All surface watersampling stations had temperature values that are within the Water Quality Guidelines, 25-31°C.

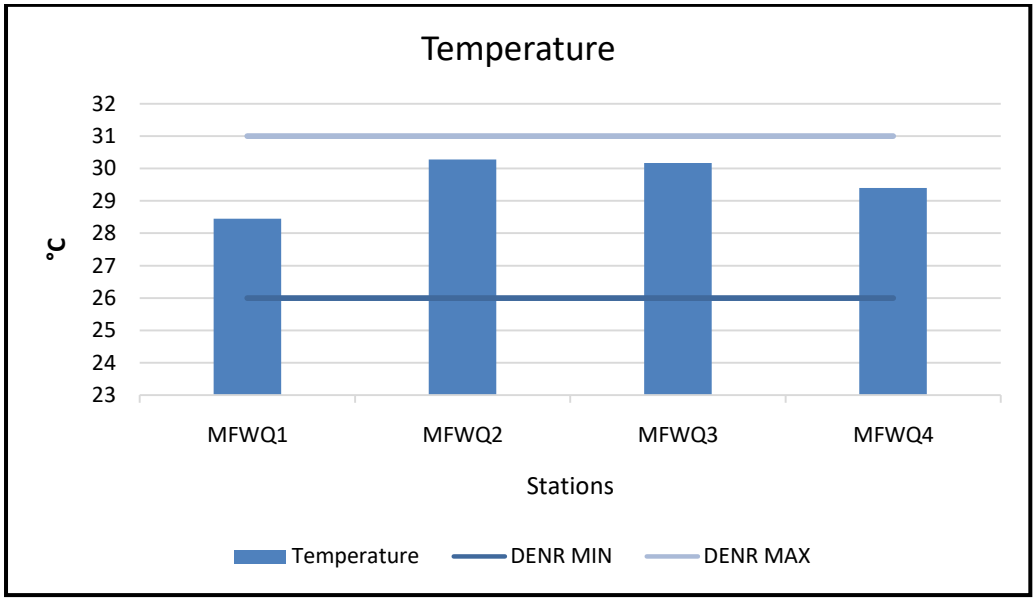



**Figure 2-16: Temperature (FW)**

The recorded pH values from the surface watersampling stations, MFWQ1, MFWQ2, MFWQ3 and MFWQ4 were 6.64, 7.12,7.32 and 7.11, respectively **(Figure 2-17)** All stations were within the guidelines.

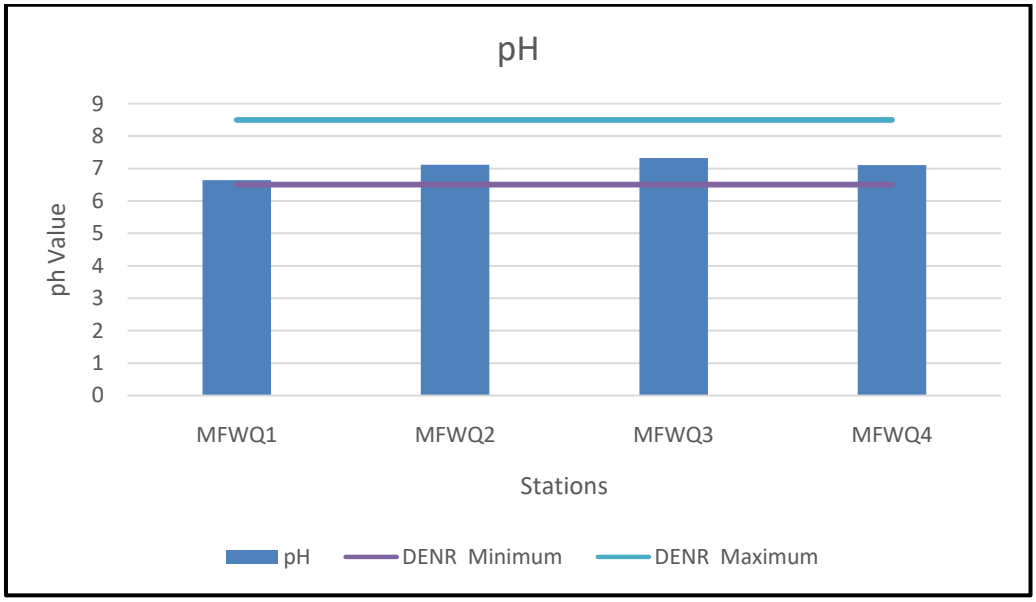



**Figure 2-17: pH (FW)**

The recorded TSS from the surface water bodies were 8 mg/L, 4 mg/L, 24 mg/L and 10 mg/L for sampling stations MFWQ1, MFWQ2, MFWQ3, and MFWQ4 **(Figure 2-18).**The results in **Figure 2-19** shows that TDS concentrations were331 mg/L, 545mg/L, 398 mg/Land 335mg/L for sampling stations MFWQ1, MFWQ2, MFWQ3, and MFWQ4, respectively. There is no DENR Water Quality Guidelines for TDS.

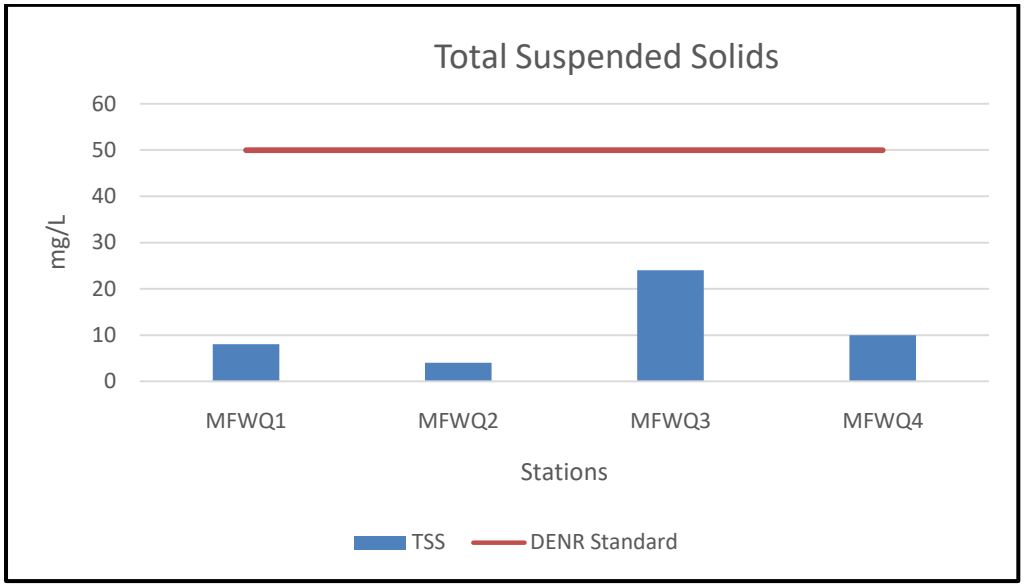



**Figure 2-18. Total Suspended Solids (FW)**

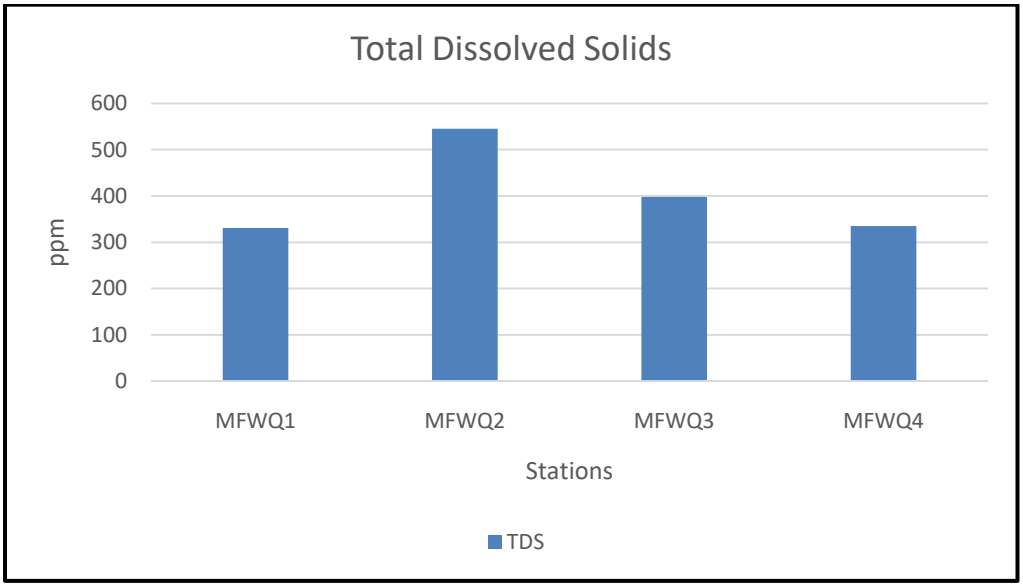



**Figure 2-19: Total Dissolved Solids (FW)**

The salinity of sampling stations MFWQ1, MFWQ2, MFWQ3 and MFWQ4 were recorded at0.32 ppb, 0.53 ppb, 0.38 ppb and 0.32 ppb, respectively.The conductivity of sampling stations MFWQ1, MFWQ2, MFWQ3 andMFWQ4 were 663µS/cm, 1089µS/cm, 796µS/cmand 670µS/cm, respectively.Salinity and conductivity are indicators of the electrical conductivity of water.**Figure 2-20** and **Figure 2-21** present the graphical results for the salinity and conductivity, respectively.There is no DENR Water Quality Guidelines for salinity and conductivity.

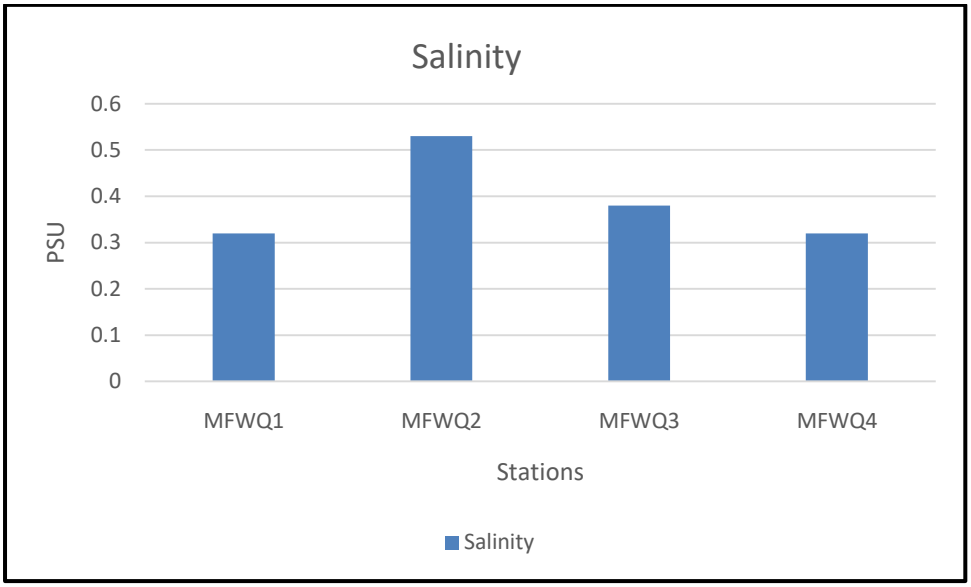



**Figure 2-20: Salinity (FW)**

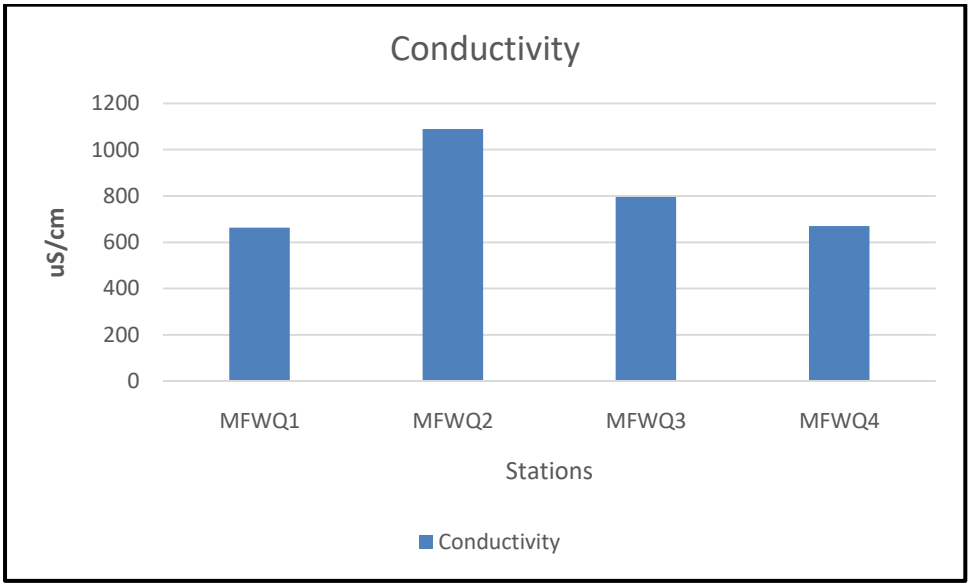



**Figure 2-21: Conductivity (FW)**

Oil and grease measurements for sampling stationsMFWQ1, MFWQ2, MFWQ3 and MFWQ4were 6.9 mg/L, 8.6 mg/L, 10.2 mg/L and 4 mg/L, respectively. The DENR Water Quality Guidelines for oil and grease as specified in DAO 2016-08 is 2 mg/L. All surface water sampling stations exceeded the DENRWater Quality Guidelines.**Figure 2-22** presents the graphical results for oil and grease.

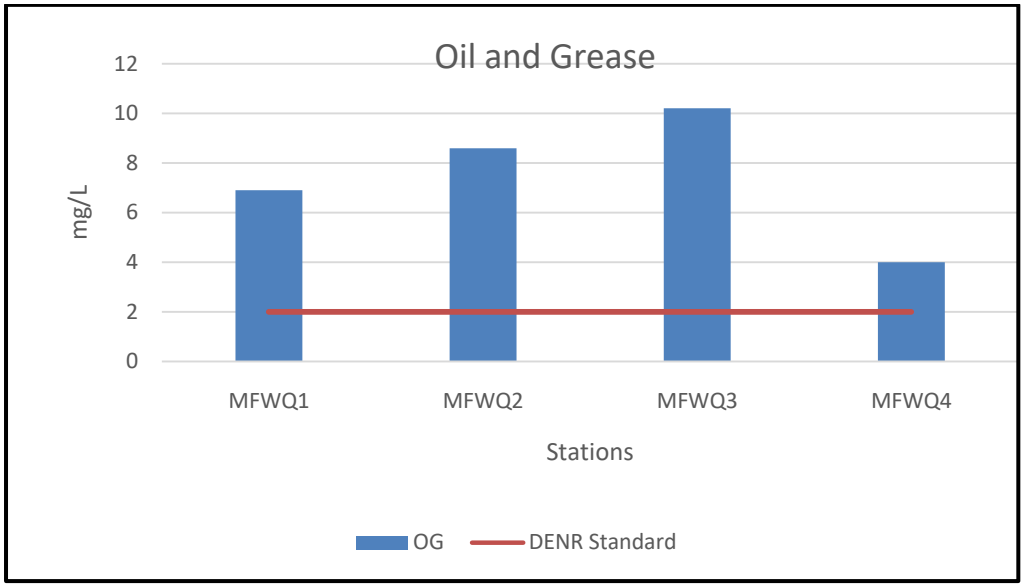



**Figure 2-22: Oil and Grease (FW)**

The DO for all sampling stations were 0.00 mg/L. The values for all stations were DENR Water Quality Guideline for DO which requires a minimum of 5.0 mg/L. The $BOD_5$ level of sampling stations MFWQ1, MFWQ2, MFWQ3 and MFWQ4 were 76 mg/L, 35 mg/L, 63 mg/L, and 62 mg/L, respectively. The BOD values for all stations exceeded with the DENR Water Quality Guidelines for Class C Fresh Waters of 7 mg/L. The low DO and high BOD can be attributed to the high amount of solid waste in the water. **Figure 2-23** and **Figure 2-24** present the graphical results for the DO and $BOD_5$, respectively.

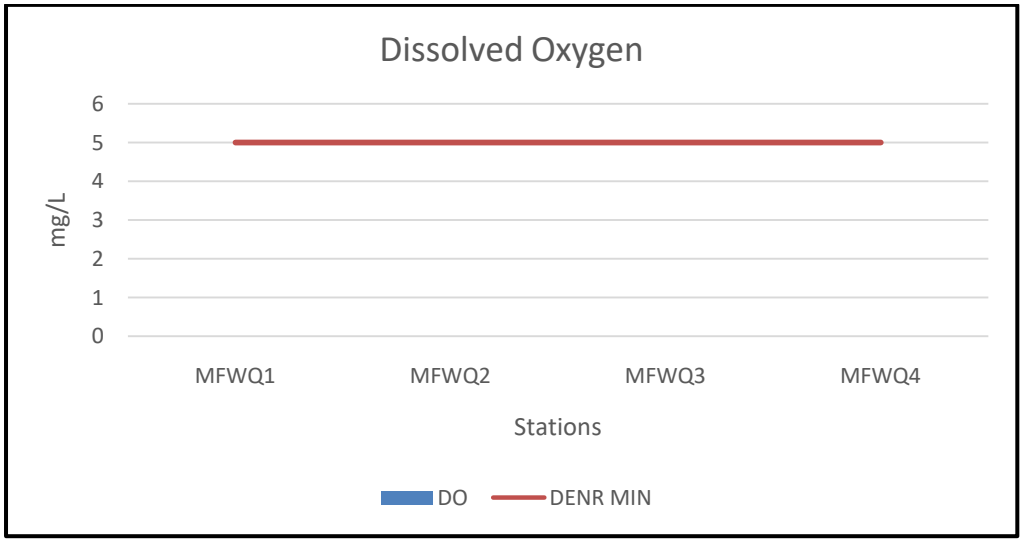



**Figure 2-23: Dissolved Oxygen (FW)**

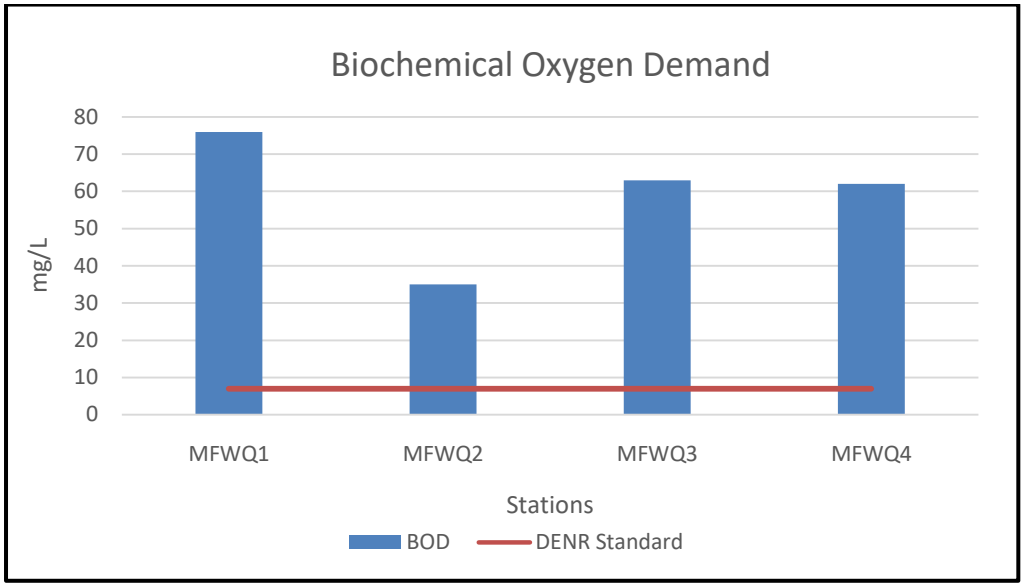



**Figure 2-24: Biochemical Oxygen Demand$_5$(FW)**

The COD of sampling stations MFWQ1, MFWQ2, MFWQ3 and MFWQ4 were 113 mg/L, 123 mg/L, 147 mg/L and, 229 mg/L, respectively. There is no DENR standard for COD under DAO 2016-08. **Figure 2-25** presents the graphical results for the COD.

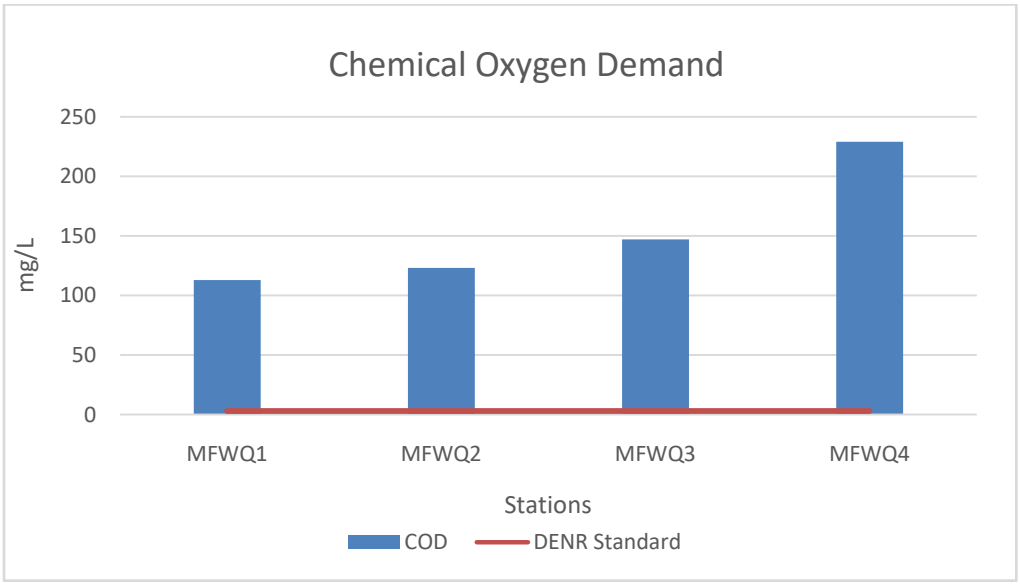



**Figure 2-25: Chemical Oxyen Demand (FW)**

Fecal coliform concentrations for sampling stations MFWQ1, MFWQ2, MFWQ3 and MFWQ4were recorded at 94 x $10^7$MPN/100 mL, 35 x $10^7$MPN/100 mL, 17 x $10^7$MPN/100 mL and 24 x $10^7$MPN/100 mL, respectively. The DENR Water Quality Guidelines for fecal coliform as specified in DAO 2016-08 is 200MPN/100 ML. All surface water sampling stations exceeded the DENR Water Quality Guidelines.**Figure 2-26** presents the graphical results for fecal coliform.

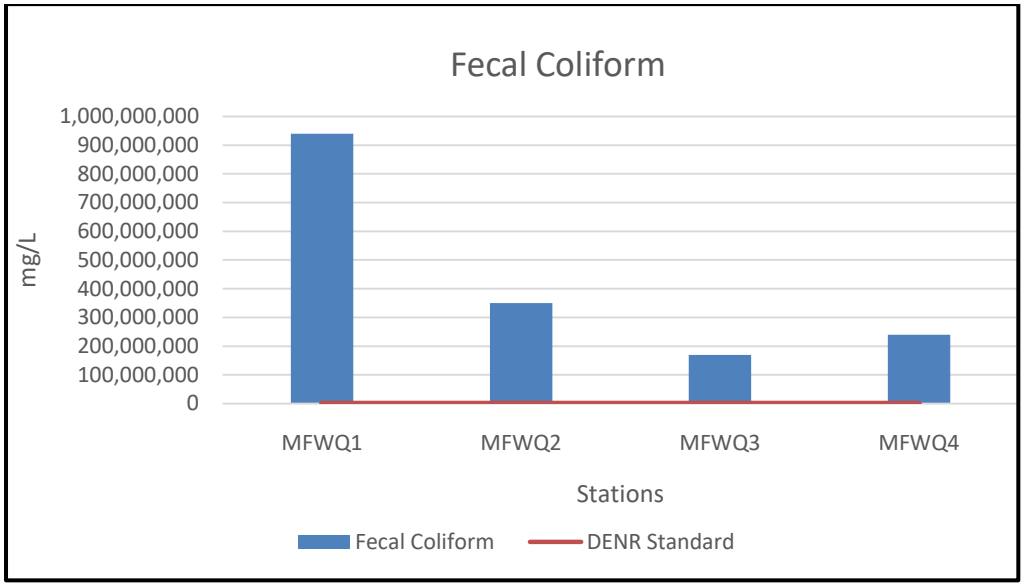



**Figure 2-26: Fecal Coliform (FW)**

2.2.2.2.3 Analysis of Secondary Parameters

As shown on **Figure 2-27**, the concentration of $Cr^{6+}$was detected to be above the DENR WQG of 0.01 mg/L in all the sampling stations with concentrations of 0.121 mg/L, 0.121 mg/L, 0.114 mg/L and 0.179 mg/L, respectively. The values of Cd, Pb, Hg and Cu, obtained from all sampling stations are compliant with the DENR Water Quality Guidelines for Class C Fresh Waters. The figure below shows a graphical representation of chromium hexavalent for the sampling stations.

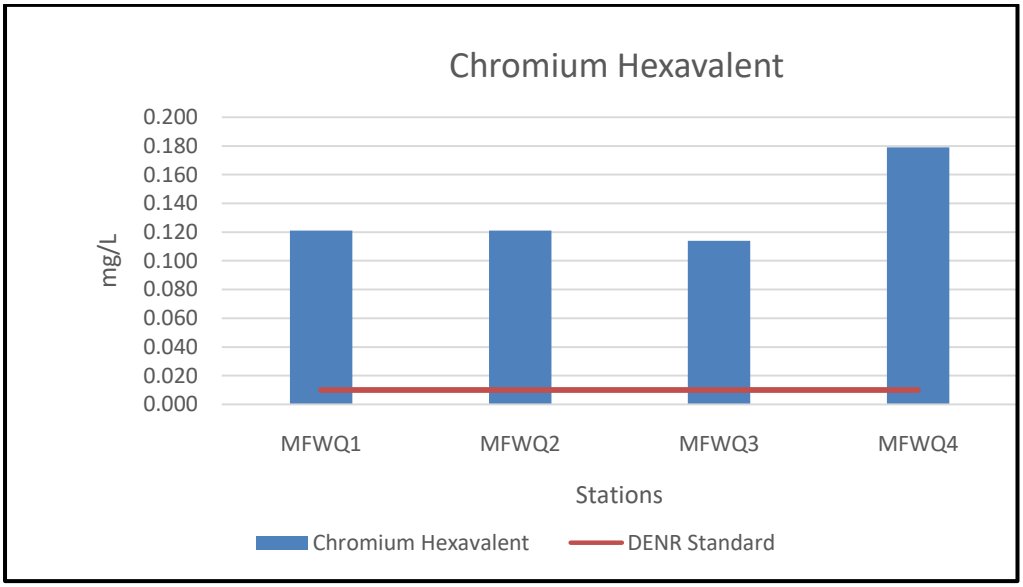



**Figure 2-27: Chromium Hexavalent (FW)**

2.2.2.2.4 Pasig River Water Quality

The Pasig River is classified as a Class C river by the DENR-EMB. Class C waters can be used as fishery water for the propagation and growth of fish and other aquatic resources, Recreational Water Class II (boating, etc.) and Industrial Water Supply Class I (for manufacturing processes after treatment). However, the river currently has poor water quality and is impacted by domestic wastes

(65% of total wastes), industrial wastes (30% of total wastes), and solid wastes (5% of total wastes). Water quality monitoring results of the PRRC in Guadalupe Viejo, Guadalupe Nuevo, the Guadalupe Ferry Station, and the Havana Bridge are all located within Makati City (**Table 2-24). Table 2-25** to **Table 2-28** shows low dissolved oxygen levels, and elevated concentrations of biological oxygen demand, oil and grease, surfactants, nitrates, phosphates, and total coliform in the Pasig River. Lead and cadmium concentrations that exceed the DENR-EMB Water Quality Guidelines for Class C waters have also been recorded occasionally in the river.

**Table 2-24: Pasig River Unified Monitoring System Monitoring Stations within Makati City**

| Monitoring Station | City/ Municipality | Coordinates | Site Description |
|---|---|---|---|
| Guadalupe Ferry Station | Makati City | 14.568 N 121.0459E | Station is along the docking area for transportation along the Pasig River. Green areas such as parks are within the vicinity. Across the river is Mandaluyong City where various industries ooperate, such as food manufacturing (RFM, Inc). |
| Guadalupe Nuevo Station | Makati City | 14.5677N 121.0471E | Station directly crosses the San Jose creek where residents and commercial business centers within Barangay Guadalupe Viejo discharge their waste water. The San Jose creek drains to the Pasig River. |
| Guadalupe Viejo Station | Makati City | 14.5675N 121.0402E | Station directly crosses the Balisampan creek where residents of Barangay Guadalupe Nuevo discharge their waste water. The Balisampan creek drains to the Pasig River. |
| Havana Bridge | Makati _ Manila City Boundary | 14.5941N 121.0260E | Station is part of the downstream portion of the Pasig River. It is also considered to be part of the Makati-Manila boundary. The majority of the station's vicinity is occupied by residential areas. |

**Table 2-25: Guadalupe Ferry Station 2015 Water Quality Monitoring Data**

| Parameters | Guadalupe Ferry Station | | | | DAO 2016-08 Water Quality Guideline (WQG) Class C |
|---|---|---|---|---|---|
| | 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter | |
| pH | 7.43 | 6.97 | 7.29 | 7.22 | 6.5-9.0 |
| Temperature ($^{O}$C) | 25.93 | 30.79 | 30.47 | 28.74 | 25-31 |
| Dissolved Oxygen (mg/L) | 4.87 | 0.64 | 5.16 | 4.30 | 5 (min) |
| Biological Oxygen Demand (Mg/L) | 27.50 | 40.33 | 25.67 | 22.00 | 7 (max) |
| Turbidity (NTU) | 48.33 | 43.77 | 40.12 | 61.60 | - |
| Total Suspended Solids (mg/L) | 27.00 | 3.33 | 17.00 | 15.67 | 80.00 |
| Oil and Grease (mg/L) | 2.70 | 43.27 | 0.97 | 22.63 | 3.00 |
| Surfactants (MBAS) | 2.00 | 5.72 | 0.21 | 0.83 | 1.50 |
| Nitrates (mg/L) | 22.25 | 3.60 | 3.50 | 3.27 | 7.00 |
| Phosphates (mg/L) | 3.75 | 4.60 | 6.66 | 6.28 | 0.50 |
| Total Coliform (MPN/100mL) | 1.00E+06 | 4.37E+08 | 4.83E+08 | 3.83E+05 | *200 Limit Fecal Coliform |
| Cadmium (mg/L) | ND | 0.21 | ND | ND | 0.005 |
| Chromium (mg/L) | ND | 0.067 | 0.08 | ND | - |
| Lead (mg/L) | 0.115 | ND | 0.08 | ND | 0.05 |
| Mercury (mg/L) | ND | ND | ND | ND | 0.002 |

**Table 2-26: Guadalupe Nuevo Station 2015 Water Quality Monitoring Data**

| Parameters | Guadalupe Nuevo Station | | | | DAO 2016-08 Water Quality Guideline (WQG) Class C |
|---|---|---|---|---|---|
| | 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter | |
| pH | 7.40 | 6.98 | 7.22 | 7.02 | 6.5-9.0 |
| Temperature ($^{O}$C) | 26.47 | 29.80 | 29.23 | 27.70 | 25-31 |
| Dissolved Oxygen (mg/L) | <1 | 0.51 | 1.34 | 1.25 | 5 (min) |
| Biological Oxygen Demand (Mg/L) | 137.50 | 116.00 | 94.00 | 91.33 | 7 (max) |
| Turbidity (NTU) | 138.33 | 134.33 | 96.57 | 85.11 | - |
| Total Suspended Solids (mg/L) | 52.50 | 51.67 | 48.00 | 53.00 | 80.00 |
| Oil and Grease (mg/L) | 25.00 | 43.17 | 10.57 | 14.20 | 3.00 |
| Surfactants (MBAS) | 12.50 | 3.60 | 7.97 | 3.16 | 1.50 |
| Nitrates (mg/L) | 8.80 | 40.40 | 10.00 | 10.67 | 7.00 |
| Phosphates (mg/L) | 23.00 | 23.08 | 27.47 | 20.70 | 0.50 |
| Total Coliform (MPN/100mL) | 1.00E+07 | 4.37E+08 | 6.50E+08 | 5.03E+09 | *200 Limit Fecal Coliform |
| Cadmium (mg/L) | ND | 0.018 | ND | | 0.005 |
| Chromium (mg/L) | 0.14 | 0.093 | 0.04 | 0.13 | - |
| Lead (mg/L) | 0.125 | ND | 0.09 | | 0.05 |
| Mercury (mg/L) | ND | ND | ND | 0.02 | 0.002 |

**Table 2-27: Guadalupe Viejo Station 2015 Water Quality Monitoring Data**

| Parameters | Guadalupe Viejo Station | | | | DAO 2016-08 Water Quality Guideline (WQG) Class C |
|---|---|---|---|---|---|
| | 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter | |
| pH | 6.97 | 6.98 | 7.30 | 7.08 | 6.5-9.0 |
| Temperature ($^{O}$C) | 26.83 | 9.80 | 29.81 | 28.13 | 25-31 |
| Dissolved Oxygen (mg/L) | <1 | 1.65 | 1.21 | 0.49 | 5 (min) |
| Biological Oxygen Demand (Mg/L) | 125.00 | 125.00 | 88.67 | 110.67 | 7 (max) |
| Turbidity (NTU) | 92.67 | 64.16 | 6.98 | 82.43 | - |
| Total Suspended Solids (mg/L) | 49.00 | 4.00 | 49.00 | 63.67 | 80.00 |
| Oil and Grease (mg/L) | 13.50 | 13.87 | 7.07 | 14.20 | 3.00 |
| Surfactants (MBAS) | 8.00 | 6.83 | 2.91 | 2.14 | 1.50 |
| Nitrates (mg/L) | 9.00 | 9.90 | 10.03 | 11.10 | 7.00 |
| Phosphates (mg/L) | 24.50 | 25.41 | 23.14 | 25.19 | 0.50 |
| Total Coliform (MPN/100mL) | 1.00E+07 | 2.87E+08 | 5.13E+08 | 3.90E+09 | *200 Limit Fecal Coliform |
| Cadmium (mg/L) | ND | 0.02 | ND | ND | 0.005 |
| Chromium (mg/L) | 0.03 | 0.096 | ND | 0.08 | - |
| Lead (mg/L) | 0.085 | ND | 0.08 | ND | 0.05 |
| Mercury (mg/L) | ND | ND | ND | ND | 0.002 |

**Table 2-28: Havana Bridge Station 2015 Water Quality Monitoring Data**

| Parameters | Havana Bridge | | | | DAO 2016-08 Water Quality Guideline (WQG) Class C |
|---|---|---|---|---|---|
| | 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter | |
| pH | 7.10 | 7.04 | 7.03 | 6.70 | 6.5-9.0 |
| Temperature ($^{O}$C) | 26.17 | 30.81 | 30.35 | 29.14 | 25-31 |
| Dissolved Oxygen (mg/L) | 0.17 | 1.65 | 1.77 | 1.50 | 5 (min) |
| Biological Oxygen Demand (Mg/L) | 120.00 | 113.33 | 71.33 | 78.00 | 7 (max) |
| Turbidity (NTU) | 83.33 | 111.77 | 71.26 | 47.19 | - |
| Total Suspended Solids (mg/L) | 55.00 | 49.33 | 53.00 | 55.00 | 80.00 |
| Oil and Grease (mg/L) | 10.00 | 14.93 | 8.93 | 11.20 | 3.00 |
| Surfactants (MBAS) | 2.00 | 6.71 | 7.53 | 7.40 | 1.50 |
| Nitrates (mg/L) | 9.05 | 9.57 | 9.87 | 10.33 | 7.00 |
| Phosphates (mg/L) | 20.00 | 20.21 | 24.16 | 25.85 | 0.50 |
| Total Coliform (MPN/100mL) | 1.00E+08 | 2.37E+08 | 4.65E+08 | 4.60E+07 | *200 Limit Fecal Coliform |
| Cadmium (mg/L) | ND | 0.28 | ND | ND | 0.005 |
| Chromium (mg/L) | 0.45 | 0.63 | 0.09 | 0.06 | - |
| Lead (mg/L) | 0.16 | ND | 0.11 | ND | 0.05 |
| Mercury (mg/L) | ND | ND | ND | 0.02 | 0.002 |

2.2.2.3 Impact Assessment and Mitigating Measures

The water quality monitoring was conducted in June 2019 where all water samples were gathered at all established stations and were analyzed. Oil and grease were detected at concentrations of 6.9 mg/L, 8.6 mg/L, 10.2 mg/L and 4.0 mg/L in all samples, MFWQ1 to MFWQ4 above the DENR Water Quality Guidelines of 2 mg/L. Fecal coliform was detected at concentrations of 94 x $10^7$ MPN/100 mL, 35 x $10^7$ MPN/100 mL, 17 x $10^7$ MPN/100 mL and 24 x $10^7$ MPN/100 mL in all samples, MFWQ1 to MFWQ4 above the DENR Water Quality Guidelines of 200 MPN/100 mL.

The DO reading of all monitoring stations was0.0 mg/L. Meanwhile, the $BOD_5$ level of monitoring stations MFWQ1, MFWQ2, MFWQ3 and MFWQ4 were 76 mg/L, 35 mg/L, 63 mg/L, and 62 mg/L, respectively. The BOD values for all stations are above the DENR Water Quality Guidelines for Class C Fresh Waters. The values for all stations were belowthe DENR Water Quality Guideline for DO which requires a minimum of 5.0 mg/L. Chromium Hexavalent was detected in all samples, MFWQ1 to MFWQ4, at concentrations of 0.121 mg/L, 0.121 mg/L, 0.114 mg/L and 0.179 mg/L, respectively, above the DENR Water Quality Guidelines of 0.01 mg/L.

The low DO reading and high concentration of OG, fecal coliform, BOD and $Cr^{6+}$ may be attributed the high amount of solid and liquid domestic waste. All other parameters tested were compliant with DENR WQG.In general; results showed that there are generally exceedances in all parameters to the DENR Guidelines and Standards (*in-situ* parameters except pH and temperature) in all sampling stations. The same is true for the heavy metal levels in all stations. These indicate the degraded quality of surface waters in the [project are.

During construction, heavy equipment will need fuel and lubricants for proper functioning. Waste from machineries such as oil and grease products may find their way to the rivers and ground water if not handled properly. These may pollute the rivers and creeks, block off photosynthesis and other plant processes, and may eventually affect the aquatic environment and organisms.

Given the above impacts, the following mitigating measures should be adopted:

- Spills of oil and greases in the equipment maintenance area must be avoided through proper housekeeping, regular inspection of working areas, proper maintenance and provision of waste containment area for filters and other consumables. Also, contractors should ensure that fuel and oil storage areas should be located 20 meters away from any watercourses and provided with inceptor traps so that accidental spills do not contaminate the site
- As generally the sources of wastes being discharged to the rivers are domestic, it is recommended that Makati City should implement a Solid Waste Management Program/Plan that will address the domestic solid wastes.
- Commercial establishments and industries should have the Waste Management Program/Plan to address the domestic wastes (solid wastes and liquid wastes).
- An operating, efficient and effective Sewage Treatment Plant should be established by the LGU.
- A Toxic and Hazardouw Waste Treatment and Disposal Facility should be established to take care of hospital wastes, service facitlities, and industrial wastes containing toxic and hazardous wastes.
- Wastes segregation and recycling should be strictly implemented by residents, commercial and industrial establishments.

#### 2.2.2.4 Water Quality Monitoring Plan

The water quality in the area should be fully monitored prior to and during construction of the subway system. This will determine whether water quality in the area will be affected by the construction activities. Major parameters such as oil and grease, BOD, COD, DO, pH, fecal/total coliform, TSS and heavy metals will be tested. Tested samples will be compared with DAO 2016-08 Water Quality Guidelines and General Effluent Standards. The detailed water quality monitoring plan was presented in **Section 6.**

### 2.2.3 Freshwater Ecology

As per DENR DAO 2017 – 15, water bodies presumed to be Direct impact Areas (DIA) would include portions of Pasig River, Ayala Creek, Amorsolo Creek, San Jose Creek, and Pinos Creek during construction, maintenance and operation, and de-commissioning of the project. Indirect Areas presumably would the downstream portions of Manila Bay and the upstream sites of Pasig River where backflow would occur especially during high tide.

Of the water bodies mentioned above as the presumed DIA of the project, only Pasig River was considered for Freshwater Ecology data gathering because all the 4 creeks mentioned above were almost dry.In Pasig River, five (5) sampling station, were designated as sampling stations based on the proposed locations of the stations along the Pasig River. The coordinate locations **(Table 2-29)** are map-pinpointed in **Figure 2-28.**

**Table 2-29: Description of Freshwater EcologySampling Stations**

| Station ID | Latitude | Longitude |
|---|---|---|
| Pasig 1 | 14.558624 | 121.068695 |
| Pasig 2 | 14.561865 | 121.062697 |
| Pasig 3 | 14.568265 | 121.040539 |
| Pasig 4 | 14.567503 | 121.038056 |
| Pasig 5 | 14.571895 | 121.028761 |

Sampling was done on each site taking into consideration accessibility and feasibility of employing our intended sampling procedures. Specific deviations in each site are here also indicated.

A. Plankton

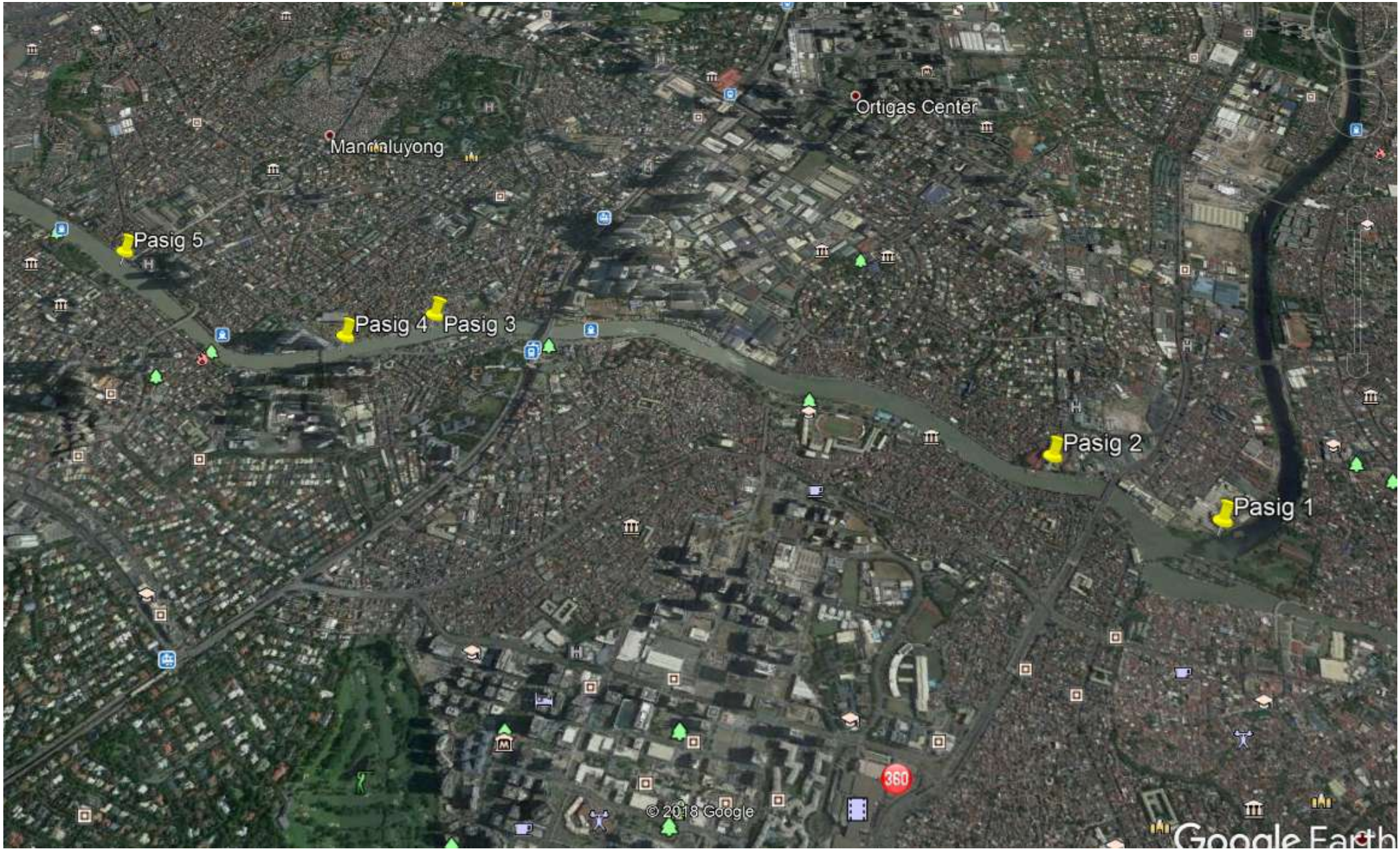
Zooplankton and phytoplankton samples were collected from the water column using a plankton net of 80 µm mesh size. Approximately 50 liters of water were collected, preferably from one side of the river Samples (approximately 50 ml) were immediately placed in plastic leak-proof containers and about 10 ml of 70% Ethanol added. In the laboratory, an additional 5 ml of 35% buffered formalin and 1 drop of concentrated rose Bengal solution added. Plankton identification and counts were determined in the laboratory. Each water sample was tapped with additional water to make 100 ml. From this 100 ml sample, a 1 ml sub-sample was taken after thorough mixing for plankton identification and counting.

B. Benthos

One Ekman Grab sample of 50 sq in of soft bottom was done per station. Samples were placed in plastic bags and transported to the lab in ice. In the lab, about 20 ml of 35% buffered formalin was added and mix with each sample. The sediment samples were run in a 0.5 mm sieve and examined for the presence of benthic organisms.

C. Fish Fauna

Fish sampling was not successfully done as: 1. The MMDA barge used was not appropriate for using an electro-fishing gear, and 2. the intermittent rains during sampling also prevented the use of the gear along the steep cemented banks of the river.




Lichel Technologies, Inc.
Unit 1403 Prestige Tower Condominium
F. Ortigas, Jr. Road, Ortigas Center, Pasig City

FIGURE TITLE :

**Freshwater Ecology Sampling Stations**

FIGURE NO.:

**2-29**

2.2.3.1 Threat to Existence and/or Loss Species of Important Local Habitat

A. Biota

The most visible organism in Pasig River are the patches of water hyacinth *(Eichornia cressipes)*. They can be so numerous as to be regarded as a nuisance for navigation, that the MMDA, usually make regular clean-up operation.

B. Plankton

Visually, the water in all the stations sampled were noticeably with greenish algae in the surface indicating a probable algal bloom in Pasig. The table below presents the plankton taxa collected in the stations.

**Table 2-30: Plankton Taxa Collected in the Identified Sampling stations**

| Plankton Species | Pasig 1 | Pasig 2 | Pasig 3 | Pasig 4 | Pasig 5 |
|---|---|---|---|---|---|
| Microcystis aeruginosa | 1,600 / ml | 1,900 / ml | 1600 / ml | 1,300 / ml | 1,000 / ml |
| Lyngbya | 35 / ml | 23 / ml | 27 / ml | 8 / ml | 5 / ml |
| copepod | | < 1/ml | | | |
| Paramecium | - | < 1 / ml | < 1 / ml | - | - |
| Nematode | | < 1 / ml | | | |

The results show the dominance of Microcystis in the waters of Pasig River. The density of Microcystis is apparently much lower that recorded blooms in Laguna de bay. So far, it cannot be known for now whether the high number of Microcystis reflects the density in Laguna de Bay, appearing circumstantial now as the above data shows a relatively higher density in Stations 1-3, receiving waters from Laguna de Bay through the Napindan channel. The paucity of other plankton taxa parallels that reported in the past (Lazo et al. 2009).

C. Benthic organisms

No organism was noted in all the sediment samples collected from the Grab sampling. Benthos may still be existent near the banks but are probably too few to be sampled.

D. Fishes

Fishes caught in Pasig River are generally regarded as incidental migrants coming from Laguna de Bay or the Marikina River. Most of these are also pollution tolerant.The following fish species have been reported from Pasig River **(Table 2-31)**

**Table 2-31: Reported Species in Pasig River**

| Fishes | Remarks |
|---|---|
| Oreochromis niloticus (cn tilapia) | One of the more common pollution-tolerant fish species; it is unsure if they could breed within the stretch of Pasig River |
| Pterygoplychthys pardalis (janitor fish) | Also pollution tolerant; breeding population may thrive in the upper stretches of Pasig River - bordering Napindan channel and Marikina River, |
| Pterygoplychthys disjunctivus (janitor fish) | |

| | |
|---|---|
| Gambusia affinis (mosquito fish) | Personally observe a few skimming the water surface in Station 1, near water hyacinth patches; pollution tolerant |
| Rasbora maculata (kataba) | Reported by Orozco & Zafaralla (2012) |
| Anabas testudineus (climbing perch) | |
| Chanos chanos (bangus) | usually as washout organisms after a storm that could destroy fishpens in Laguna de Bay |
| Hypophthalmichthys nobilis (bighead carp) | |

Addition of sediment load connotes an increase in nutrient load of the river. Increase in nutrient load usually leads to an increase in the chances of more algal blooms and the proliferation of water hyacinth, which in the time of sampling already exists. The former may lead to stronger unpleasant smell coming from the river and the latter would put a strain on the current clearing effort being done. Mitigation measures primarily would be to minimize area of earth moving and efficient collection of excess earth materials. The rainy season has just started when sampling was done in May. The algal (*Microcystis*) bloom, observed during the sampling may be just a spill-over of a dry-season event of which, river flow would be slower. In relation therefore to the construction phase, the sediment load during the dry/summer season may increase the possibility and severity of algal bloom and water hyacinth blooms within the stretch of Pasig River from Napindan to San Juan. During the rainy season, algal blooms may be reduced, due to the increase flushing of nutrient load going into Pasig River and out to Manila Bay. The effect of other pollutants to primary producers – oil/grease, plastics, etc – directly coming from construction activities is usually hard to pinpoint and may be negligible in a flowing-water environment like Pasig River.

The effect of pollutants to benthic organisms and fishes are probably minimal for the main reason that water quality of Pasig River have remained unfavorable for the survival, much less for the establishment and colonization, for aquatic organisms in the last few decades. The PRUMS report (Pasig River Unified Monitoring System,1$^{st}$ quarter 2019) indicated that DO, a water quality parameters that primarily indicate a favorable condition for fishes to live, fell below the minimum set under DAO-2016-08. Thus, whatever fish species caught in Pasig River, and there are so few of them to even be significant as a fishery resource, are not residents but probably just displaced fishes from their resident sites upstream (Laguna de Bay or Marikina River. All of these fishes are also pollution tolerant fishes. The only biological effect to such displaced species is to lessen their life-span in Pasig River.

As with the case of fishes, Pasig River has been known to be depauperate of snails and other benthic organisms. With light penetration barely half a meter deep, primary productivity is practically nil, and DO levels failing even in the surface, substratum conditions in Pasig are currently not favorable for benthos to survive. With this scenario, pollutant effect on benthic organism would not be of much concern.

#### 2.2.3.2 Threat to Abundance, Frequency and Distribution of Species

Drilling operation impacts on freshwater systems include: 1. siltation from ground disturbances, 2. oil and other machinery pollution, and 3. human pollution/disturbances.

As the construction sites for most of the station and the tunnels are quite near the Pasig River or near creeks that eventually end in the Pasig River, then the the higher and more likely the impact occur. Earth moving activities will always end in sediment load added to the river, especially during the rainy season. So far, Pasig River is already heavily silted and of the 21 parameters monitored by PRUMS in the first quarter of 2019, less than half passed the standards set in DAO 2016-08 for Class C waters. It is conceivable that during the construction phase – the situation will become worse.

Addition of sediment load may increase the chances of more algal blooms and the proliferation of water hyacinth. The former may lead to stronger unpleasant smell coming from the river and the latter would put a strain on the current clearing effort being done. Mitigation measures primarily would be to minimize area of earth moving and efficient collection of excess earth materials, and 3. Road-bank soil erosion prevention/minimization (use of biological or non-biological structures).

Heavy equipment need oil and gasoline. Spillage from leaks, equipment washing, etc. may reach the river water and cause pollution. The most effective prevention/mitigation strategy is imposition and implementation of rules on spillage.

Road workers will have excretory needs, of which the presence of a nearby river is usually seen as a convenient blessing. Fecal waste contributes towards biological pollution as well as profoundly reduces the aesthetic condition of rivers. Food-related waste, especially the non-biodegradable ones may also eventually reach the river waters. The effective strategy is prevention by the provision of "portalets" and other appropriate waste-disposal bins. This should be strictly monitored and should be subjected to regular clean-up.

## 2.3 Air

### 2.3.1 Meteorology

The climate at the Project site was described using the Climate Map of the Philippines while the meteorological conditions were described the following data:

- Climatological normals from PAGASA Synoptic Station, Science Garden, Quezon City (1981-2010) ;
- Climatological extremes from PAGASA Synoptic Station, Science Garden, Quezon City (as of 2018)
- Climatological normals from PAGASA Synoptic Station in South Harbor, Manila (1981-2010)
- Climatological extremes from PAGASA Synoptic Station in South Harbor, Manila (as of 2018)
- Climatological normals from PAGASA Synoptic Station at Ninoy Aquino International Airport (NAIA) in Pasay City (1981-2010)
- Climatological extremes from PAGASA Synoptic Station at NAIA in Pasay City (as of 2018)
- Map of tracks of tropical cyclones which crossed Metro Manila from 1948 to 2016 (PAGASA); and
- Typhoon Risk Map of the Philippines developed by Manila Observatory (2005)

Climate Change

The projected seasonal temperature increase, seasonal rainfall change and frequency of extreme events at the Project Site from 2006 to 2035 (centered in 2020) and from 2036 to 2065 (centered in 2050) under the medium-range scenario was determined using climate projections in National Capital Region (NCR) (PAGASA, 2011).

Greenhouse Gas Emissions (GHG).Transit projects generate GHG emissions during their construction, operations, and maintenance phases and can displace emissions by reducing personal vehicle emissions due to transit's "ridership effect"(FTA[2], 2017).GHG emission from construction, facility operation, and maintenance was estimated using Transit Greenhouse Gas Emissions Estimator v1.0 while GHG emissions from operation of railcar and displaced emissions were taken from the feasibility study (2018) of the Project.

[2] United States Federal Transit Administration (US FTA)

The Transit Greenhouse Gas Emissions Estimator: User v1.0, developed by FTA, is a spreadsheet tool that allows users to estimate the partial lifecycle GHG emissions generated from the construction, operations, and maintenance phases of projects across select transit modes. This GHG Estimator was used to estimate the amortized construction emission[3], annual maintenance emissions, and annual facility (stations and depot) operations emissions.

Annual GHG emission from railcar operations was taken from the feasibility study (2018) of the Project. The calculation approach used is shown below:

**General calculations for indirect emissions from consumption of purchased electricity**

$$Emission = Q \times EF$$

**where:**

| | | |
|---|---|---|
| Emission | = | Emissions (tonnes of $CO_2$-e) |
| Q | = | Quantity of electricity purchased (kWh) |
| EF | = | Scope 2 emission factor (Tonnes $CO_2$-e/kWh) |

Source: ***Section 2.3.1*** *of the National Greenhouse Accounts Factors – Australian Greenhouse Accounts*

Displaced emissions from reduction of vehicular traffic and potential fuel saved were also taken from the feasibility study. The calculation approach used is shown below:

**$CO_2$ from Road Transport and Tier 1 Emissions of $CH_4$ and $N_2O$**

$$Emission = \sum_a [Fuel_a \times EF_a]$$

**where:**

| | | |
|---|---|---|
| Emission | = | Emissions (kg) |
| $Fuel_a$ | = | fuel sold TJ) |
| $EF_a$ | = | emission factor (kg/TJ) |
| a | = | type of fuel (e.g. petrol, diesel, natural gas, LPG, etc.) |

Source: ***Equation 3.2.1*** *and* ***Equation 3.2.3*** *of the 2006 IPCC Guidelines on National Greenhouse Gas Inventories, Volume 2: Energy, Chapter 3: Mobile Combustion*

#### 2.3.1.1 Change in Local Climate

The climate of the Philippines is classified into four (Types I, II, III, and IV) based on the Modified Coronas' Climate Classification (**Figure 2-29)**

The Project site falls under the Type I climate, which is characterized by two pronounced season - dry from November to April and wet during the rest of the year. The maximum rain period is from June to September (PAGASA, 2007).

[3] Total construction related GHG emissions are amortized over a 50-year period, which corresponds to the minimum useful lifespan of facilities, per FTA Circular 5010.


**Figure 2-29: Climate Map of the Philippines Showing the Project Location**

Source: PAGASA, 2007

**Table 2-32: Climatological Normals at PAGASA Synoptic Station, Science Garden, Quezon City (1981-2010)**

| MONTH | RAINFALL | | TEMPERATURE | | | | | | VAPOR PRESS. (mbs) | RH (%) | MSLP (mbs) | WIND | | CLOUD AMT. (okta) | NO. OF DAYS W/ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AMOUNT (mm) | NO. OF RD | MAX (°C) | MIN (°C) | MEAN (°C) | DRY BULB (°C) | WET BULB (°C) | DEW POINT (°C) | | | | DIR (16pt) | SPD (mps) | | TSTM | LTNG |
| JAN | 18.5 | 4 | 30.6 | 20.8 | 25.7 | 25.3 | 22.2 | 20.9 | 24.6 | 76 | 1012 | N | 1 | 5 | 1 | 0 |
| FEB | 14.6 | 3 | 31.7 | 20.9 | 26.3 | 26 | 22.3 | 20.8 | 24.4 | 73 | 1012 | NE | 1 | 5 | 0 | 0 |
| MAR | 24.8 | 4 | 33.4 | 22.1 | 27.8 | 27.6 | 23.2 | 21.5 | 25.4 | 69 | 1011 | SE | 1 | 4 | 2 | 1 |
| APR | 40.4 | 5 | 35 | 23.7 | 29.4 | 29.2 | 24.4 | 22.7 | 27.2 | 67 | 1010 | SE | 1 | 4 | 4 | 2 |
| MAY | 186.7 | 10 | 34.7 | 24.7 | 29.7 | 29.3 | 25.3 | 23.9 | 29.5 | 72 | 1009 | S | 1 | 5 | 12 | 8 |
| JUN | 316.5 | 18 | 33.1 | 24.6 | 28.8 | 28.4 | 25.5 | 24.5 | 30.6 | 79 | 1008 | SW | 1 | 6 | 17 | 9 |
| JUL | 493.3 | 22 | 31.9 | 24.1 | 28 | 27.5 | 25.2 | 24.4 | 30.5 | 83 | 1008 | SW | 2 | 6 | 19 | 9 |
| AUG | 504.2 | 23 | 31.3 | 24.2 | 27.8 | 27.3 | 25.2 | 24.5 | 30.6 | 84 | 1007 | SW | 2 | 7 | 17 | 6 |
| SEP | 451.2 | 22 | 31.6 | 24 | 27.8 | 27.2 | 25.1 | 24.4 | 30.4 | 84 | 1011 | SW | 1 | 6 | 18 | 9 |
| OCT | 296.6 | 18 | 31.6 | 23.5 | 27.6 | 27 | 24.7 | 23.9 | 29.5 | 83 | 1009 | N | 1 | 6 | 11 | 6 |
| NOV | 148.8 | 14 | 31.4 | 22.7 | 27.1 | 26.5 | 24.1 | 23.2 | 28.4 | 82 | 1010 | N | 1 | 5 | 5 | 1 |
| DEC | 78.7 | 8 | 30.5 | 21.6 | 26 | 25.5 | 22.8 | 21.7 | 25.9 | 79 | 1012 | N | 1 | 5 | 1 | 0 |
| **ANNUAL** | **2574.4** | **153** | **32.2** | **23.1** | **27.7** | **27.2** | **24.2** | **23** | **28.1** | **78** | **1010** | **N** | **1** | **5** | **107** | **51** |

Source: Climate and Agrometeorology Division, PAGASA
Latitude: 14°38'41.35" N
Longitude: 121°02'40.45" E
Elevation: 43 m

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

**Table 2-33: Climatological Extremes at PAGASA-Synoptic Station, Science Garden , Quezon City (As of 2018)**

| MONTH | TEMPERATURE (°C) | | | | GREATEST DAILY RAINFALL (mm) | | STRONGEST WINDS (mps) | | | SEA LEVEL PRESSURES (mbs) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HIGH | DATE | LOW | DATE | AMOUNT | DATE | SPD | DIR | DATE | HIGH | DATE | LOW | DATE |
| JAN | 34.7 | 01-17-1998 | 15.5 | 01-27-1987 | 55.8 | 01-16-1988 | 24 | ESE | 01-17-1972 | 1021.4 | 01-21-2005 | 998.8 | 01-22-1989 |
| FEB | 35.6 | 02-24-1967 | 15.1 | 02-04-1987 | 61.7 | 02-22-2013 | 22 | SSE | 02-02-1992 | 1021.7 | 02-14-2017 | 1002.3 | 02-09-1985 |
| MAR | 36.8 | 03-26-1983 | 14.9 | 03-01-1963 | 65.0 | 03-31-2012 | 13 | S | 03-16-1992 | 1021.0 | 03-05-2005 | 997.8 | 03-28-1988 |
| APR | 38.0 | 04-25-1998 | 17.2 | 04-05-1963 | 64.8 | 04-21-2015 | 26 | SSE | 04-07-1992 | 1016.9<br>1016.9 | 04-05-1998<br>04-03-2017 | 1001.4 | 04-16-2007 |
| MAY | 38.5 | 05-14-1987 | 17.8 | 05-03-1962 | 166.0 | 05-20-1966 | 21 | N | 05-10-1992 | 1015.1 | 05-28-1986 | 992.4 | 05-17-1989 |
| JUNE | 38.0 | 06-02-1993 | 18.1 | 06-27-1961 | 334.5 | 06-07-1967 | 37 | SW | 06-25-1972 | 1014.9 | 06-07-1997 | 978.7 | 06-26-1993 |
| JULY | 36.2 | 07-20-1998 | 17.7 | 07-23-1961 | 246.4 | 07-07-2002 | 36 | NNW | 07-09-1977 | 1015.0 | 07-01-1979 | 989.2 | 07-15-1978 |
| AUG | 36.1 | 08-17-2017 | 17.8 | 08-23-1964 | 391.4 | 08-07-2012 | 32 | N | 08-22-2000 | 1015.3 | 08-23-2002 | 994.2 | 08-24-1978 |
| SEP | 35.6 | 09-10-2017 | 20.0 | 09-08-1964 | 455.0 | 09-26-2009 | 35 | NE | 09-28-2006 | 1016.0 | 09-28-1997 | 987.4 | 09-30-1995 |
| OCT | 35.4 | 10-09-2003 | 18.6 | 10-31-1967 | 209.3 | 10-18-1975 | 30 | SE | 10-11-1989 | 1016.0 | 10-25-1986 | 978.7 | 10-23-1988 |
| NOV | 35.0 | 11-01-2001 | 15.6 | 11-12-1962 | 169.9 | 11-20-1966 | 50 | NNW | 11-03-1995 | 1019.1 | 11-18-1979 | 980.6 | 11-03-1995 |
| DEC | 34.9 | 12-06-2018 | 15.1 | 12-13-1988 | 135.5 | 12-15-2015 | 22 | SE | 12-22-1997 | 1020.0 | 12-27-2001 | 998.1 | 12-02-2004 |
| **ANNUAL** | **38.5** | **05-14-1987** | **14.9** | **03-01-1963** | **455.0** | **09-26-2009** | **50** | **NNW** | **11-03-1995** | **1021.4** | **01-21-2005** | **978.7** | **06-26-1993<br>10-23-1988** |
| **Period of Record** | **1961 – 2018** | | | | **1961 - 2018** | | **1961 - 2018** | | | **1961 - 2018** | | | |

Source: Climate and Agrometeorology Division, PAGASA

Latitude: 14°38'41.35" N
Longitude: 121°02'40.45" E
Elevation: 43 m

**Table 2-34: Climatological Normals at PAGASA Port Area, Manila (1981-2010)**

| MONTH | RAINFALL | | TEMPERATURE | | | | | | VAPOR PRESS. (mbs) | RH (%) | MSLP (mbs) | WIND | | CLOUD AMT. (okta) | NO. OF DAYS W/ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AMOUNT (mm) | NO. OF RD | MAX (°C) | MIN (°C) | MEAN (°C) | DRY BULB (°C) | WET BULB (°C) | DEW POINT (°C) | | | | DIR (16pt) | SPD (mps) | | TSTM | LTNG |
| JAN | 17.3 | 4 | 29.6 | 23.8 | 26.7 | 26.7 | 22.9 | 21.4 | 25.3 | 72 | 1013 | N | 2 | 7 | 0 | 0 |
| FEB | 14.2 | 3 | 30.6 | 24.2 | 27.4 | 27.3 | 22.9 | 21.2 | 24.9 | 69 | 1012 | E | 3 | 6 | 0 | 0 |
| MAR | 15.8 | 3 | 32.1 | 25.3 | 28.7 | 28.5 | 23.7 | 21.9 | 26 | 67 | 1012 | SE | 3 | 6 | 0 | 1 |
| APR | 23.7 | 4 | 33.5 | 26.6 | 30.1 | 30 | 24.9 | 23.1 | 28 | 66 | 1010 | SE | 3 | 6 | 2 | 2 |
| MAY | 147.2 | 10 | 33.2 | 26.9 | 30 | 30 | 25.7 | 24.3 | 30 | 71 | 1009 | 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 | SW | 3 | 7 | 11 | 9 |
| JUL | 420.5 | 21 | 31.2 | 25.9 | 28.5 | 28.5 | 25.6 | 24.6 | 30.8 | 79 | 1008 | SW | 3 | 7 | 12 | 9 |
| AUG | 432.4 | 21 | 30.8 | 25.8 | 28.3 | 28.2 | 25.6 | 24.7 | 31 | 81 | 1007 | SW | 4 | 7 | 11 | 7 |
| SEP | 355.1 | 20 | 31 | 25.7 | 28.4 | 28.3 | 25.5 | 24.6 | 30.7 | 80 | 1008 | 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 | N | 3 | 7 | 3 | 1 |
| DEC | 67.4 | 7 | 29.8 | 24.2 | 27 | 27 | 23.4 | 22 | 26.3 | 74 | 1012 | N | 2 | 7 | 1 | 0 |
| **ANNUAL** | 2103.6 | 139 | 31.3 | 25.5 | 28.4 | 28.4 | 24.6 | 23.3 | 28.5 | 74 | 1010 | 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 2-35: Climatological Extremes at PAGASA Port Area, Manila (As of 2016)**

| MONTH | TEMPERATURE (°C) | | | | GREATEST DAILY RAINFALL (mm) | | STRONGEST WINDS (mps) | | | SEA LEVEL PRESSURES (mbs) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HIGH | DATE | LOW | DATE | AMOUNT | DATE | SPD | DIR | DATE | HIGH | DATE | LOW | DATE |
| JAN | 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 | 05-23-1922 |
| JUNE | 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 |
| JULY | 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 | 971.1 | 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** | 1885-2016 | | | | 1865-2016 | | 1948-2016 | | | 1885-2016 | | | |

Source: Climate and Agrometeorology Division, PAGASA

**Table 2-36: Climatological Normals at PAGASA-NAIA Station (1981-2010)**

| MONTH | RAINFALL | | TEMPERATURE | | | | | | VAPOR PRESS. (mbs) | RH (%) | MSLP (mbs) | WIND | | CLOUD AMT. (okta) | NO. OF DAYS W/ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AMOUNT (mm) | NO. OF RD | MAX (°C) | MIN (°C) | MEAN (°C) | DRY BULB (°C) | WET BULB (°C) | DEW POINT (°C) | | | | DIR (16pt) | SPD (mps) | | TSTM | LTNG |
| JAN | 6.8 | 2 | 30.2 | 22 | 26.1 | 26 | 22.6 | 21.2 | 25.1 | 75 | 1013.4 | E | 3 | 5 | 0 | 0 |
| FEB | 4.2 | 1 | 31 | 22.5 | 26.7 | 26.6 | 22.7 | 21.1 | 24.9 | 72 | 1013.2 | E | 3 | 4 | 0 | 0 |
| MAR | 4 | 1 | 32.5 | 23.6 | 28 | 27.9 | 23.4 | 21.7 | 25.7 | 68 | 1012.4 | E | 4 | 4 | 0 | 1 |
| APR | 16 | 1 | 34.1 | 25 | 29.5 | 29.4 | 24.5 | 22.7 | 27.4 | 67 | 1010.8 | ESE | 4 | 4 | 1 | 3 |
| MAY | 70.4 | 10 | 33.8 | 25.5 | 29.7 | 29.4 | 25.3 | 23.9 | 29.4 | 72 | 1009.3 | W | 3 | 5 | 5 | 12 |
| JUN | 265.2 | 14 | 32.5 | 25.1 | 28.8 | 28.5 | 25.3 | 24.2 | 30 | 77 | 1008.7 | W | 3 | 6 | 7 | 13 |
| JUL | 316.7 | 16 | 31.3 | 24.6 | 28 | 27.7 | 25.1 | 24.2 | 30.1 | 81 | 1008.4 | W | 3 | 6 | 8 | 13 |
| AUG | 418.4 | 19 | 30.8 | 24.6 | 27.7 | 27.4 | 25.1 | 24.3 | 30.3 | 83 | 1008 | W | 3 | 7 | 6 | 8 |
| SEP | 255.2 | 16 | 31 | 24.6 | 27.8 | 27.5 | 25.2 | 24.4 | 30.5 | 83 | 1008.8 | W | 2 | 6 | 8 | 11 |
| OCT | 283.4 | 14 | 31.1 | 24.3 | 27.7 | 27.5 | 24.8 | 23.8 | 29.4 | 80 | 1009.6 | E | 2 | 6 | 5 | 8 |
| NOV | 99 | 8 | 31.1 | 23.7 | 27.4 | 27.2 | 24.2 | 23.1 | 28.1 | 78 | 1010.8 | E | 2 | 5 | 1 | 3 |
| DEC | 28.6 | 3 | 30.2 | 22.7 | 26.5 | 26.3 | 23.1 | 21.9 | 26.1 | 76 | 1012.5 | E | 2 | 5 | 0 | 0 |
| **ANNUAL** | 1767.8 | 101 | 31.6 | 24 | 27.8 | 27.6 | 24.3 | 23 | 28.1 | 76 | 1010.5 | E | 3 | 5 | 41 | 72 |

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 2-37: Climatological Extremes at PAGASA-NAIA Station (as of 2018)**

| MONTH | TEMPERATURE (°C) | | | | GREATEST DAILY RAINFALL (mm) | | STRONGEST WINDS (mps) | | | SEA LEVEL PRESSURES (mbs) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HIGH | DATE | LOW | DATE | AMOUNT | DATE | SPD | DIR | DATE | HIGH | DATE | LOW | DATE |
| JAN | 35.8 | 01-07-1989 | 14.8 | 01-18-1961 | 55.3 | 01-03-1970 | 20 | ENE | 01-12-1986 | 1022.3 | 01-27-1987 | 1004.4 | 01-01-1950 |
| FEB | 35.1 | 02-21-1998 | 14.6 | 02-01-1962 | 20.5 | 02-18-2017 | 20 | E | 02-28-1988 | 1021.4 | 02-01-1998 | 1003.8 | 02-21-2001 |
| MAR | 36.5 | 03-30-1978 | 16.0 | 03-03-1963 | 36.0 | 03-07-2011 | 26 | E | 03-29-1992 | 1021.1 | 03-02-1987 | 1002.4 | 03-06-1999 |
| APR | 37.8 | 04-23-1948 | 18.7 | 04-01-1994 | 63.0 | 04-04-1992 | 22 | ESE | 04-06-1986 | 1019.9 | 04-23-1987 | 1002.8 | 04-21-2001 |
| MAY | 38.2 | 05-18-2014 | 19.1 | 05-11-1950 | 229.1 | 05-27-1960 | 31 | SW | 05-22-1976 | 1015.9 | 05-09-1957 | 992.2 | 05-17-1989 |
| JUNE | 38.0 | 06-02-1991 | 20.0 | 06-22-1954 | 353.8 | 06-01-1958 | 36 | S | 06-29-1964 | 1016.0 | 06-07-1997 | 974.6 | 06-29-1964 |
| JULY | 36.4 | 07-26-2016 | 18.3 | 07-28-1948 | 472.4 | 07-20-1972 | 36 | W | 07-08-1986 | 1014.9 | 07-07-1953 | 990.1 | 07-16-2014 |
| AUG | 36.5 | 08-15-2017 | 17.4 | 08-09-1949 | 401.8 | 08-10-1947 | 30 | WSW | 08-16-1984 | 1015.2 | 08-12-1958 | 992.8 | 08-24-1978 |
| SEP | 35.6 | 09-08-2017 | 19.1 | 09-15-1950 | 228.9 | 09-08-1963 | 40 | NNW | 09-28-2006 | 1016.2 | 09-18-2005 | 986.7 | 09-30-1995 |
| OCT | 36.0 | 10-24-1976 | 18.0 | 10-23-1981 | 274.5 | 10-09-1978 | 27 | W | 10-18-1985 | 1017.0 | 10-25-1986 | 977.9 | 10-14-1970 |
| NOV | 35.8 | 11-17-1972 | 17.2 | 11-26-1949 | 121.7 | 11-14-1977 | 56 | W | 11-19-1970 | 1019.4 | 11-03-1989 | 899.4 | 11-03-1995 |
| DEC | 34.2 | 12-29-1978 | 16.3 | 12-18-1955 | 125.5 | 12-15-2015 | 25 | NW | 12-30-1950 | 1020.9 | 12-08-1960 | 995.5 | 12-02-2004 |
| **ANNUAL** | 38.2 | 05-18-1969 | 14.6 | 02-01-1962 | 472.4 | 07-20-1972 | 56 | W | 11-19-1970 | 1022.3 | 01-27-1987 | 899.4 | 11-03-1995 |
| **Period of Record** | **1947 – 2018** | | | | **1949 - 2018** | | **1950 - 2018** | | | **1950 - 2018** | | | |

Source: Climate and Agrometeorology Division, PAGASA

2.3.1.1.1 Rainfall

**Figure 2-30** shows the monthly average rainfall at the three (3) synoptic stations of PAGASA in Metro Manila from 1981 to 2010 and the interpolated rainfall at the project site. For purposes of interpolation method using Palomino and Martin (1994), the point referred at the project site is at EDSA corner Dr. Jose Rizal Avenue.

Months with low rainfall are January, February, March and April. Rainfall starts to increase in May at 132.3 mm and appears to reach its peak in August at 450.8 mm. From September to December, monthly average rainfall appears to decrease at an average rate of 97.8 mm.

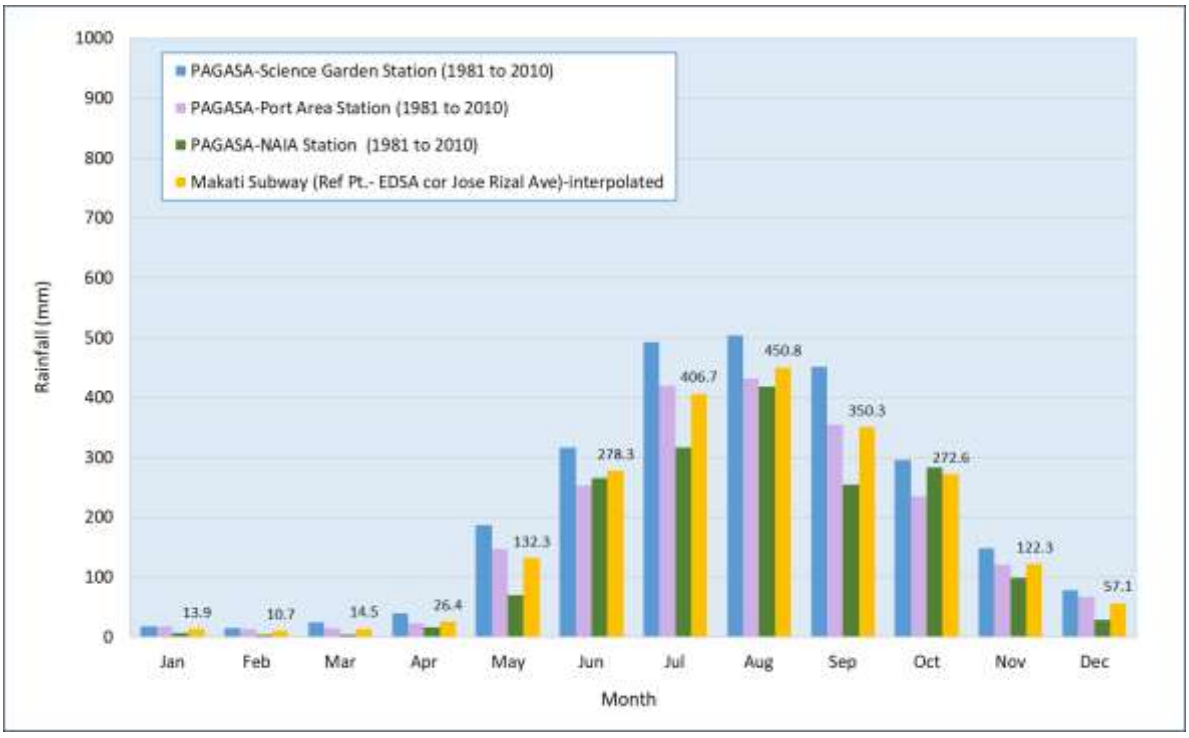



**Figure 2-30: Monthly Average Rainfall at the Project Site Based on Interpolation**

Extreme Recorded Rainfall Events

The greatest recorded rainfall at the three (3) synoptic stations in Metro Manila was 472.4 mm on July 20, 1972 (**Figure 2-31).** This occurred during the passage of Typhoon Rita (or Typhoon Gloring in the Philippines) in the Pacific. Although Typhoon Gloring did not cross the Philippines, its enormous circulation enhanced the southwest monsoon and brought prolonged rainfall in Luzon.

The second highest recorded rainfall in Metro Manila was on September 26, 2009 during passage of Tropical Storm Kesana (or Ondoy), which caused flooding in wide areas of Metropolitan Manila and other provinces of the northern Philippines.

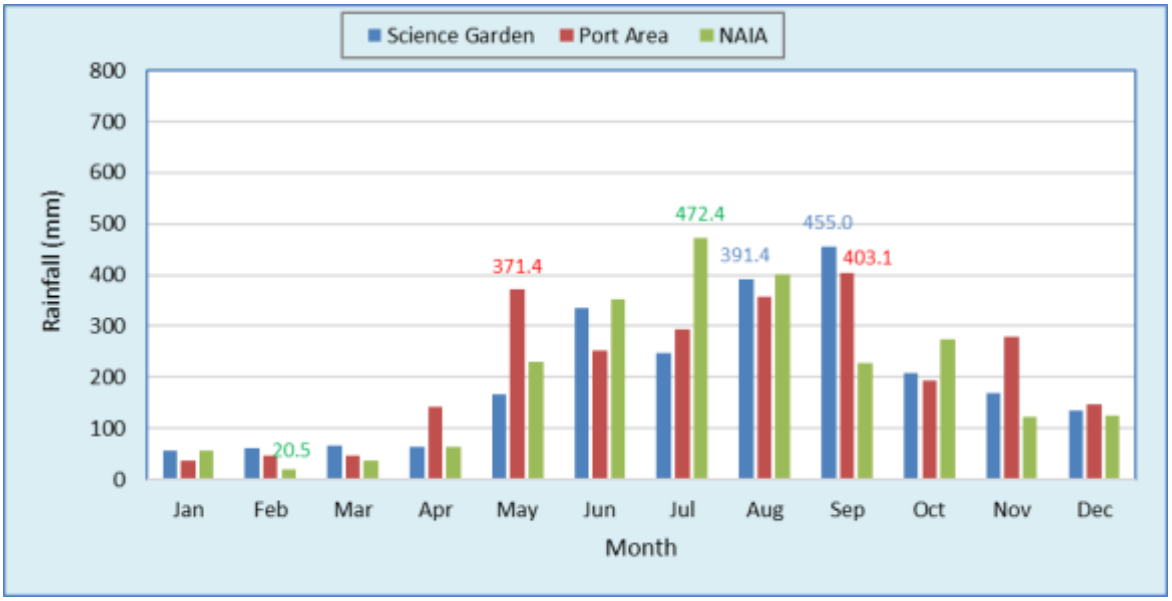



**Figure 2-31: Plot of Greatest Daily Rainfall Recorded per Month at PAGASA Synoptic Station, Science Garden, Quezon City (as of 2018)**

2.3.1.1.2 Ambient Air Temperature

**Figure 2-32** shows the plots of the monthly average and interpolated dry bulb temperatures. The interpolated dry bulb temperatures the project site follow closely those of PAGASA-NAIA Station, which is the closest synoptic station from the project site.

April appears to have the highest monthly average air temperature in Metro Manila followed by May and June. April and May are the transition months from northeast to southwest monsoon seasons.

Cold winds brought about by the northeast monsoon caused colder weather in December, January and February.

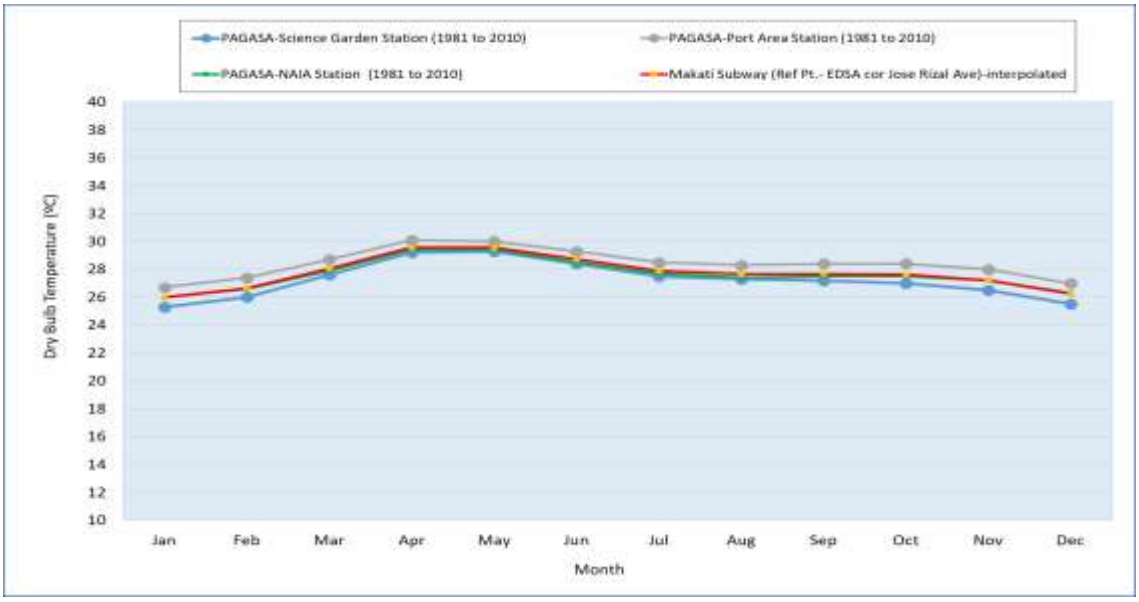


**Figure 2-32: Monthly Average Dry Bulb Temperatures at PAGASA's Synoptic Stations and theInterpolated Air Temperature at the Project Site**

Extreme Temperature Events

As of 2018, the highest recorded temperature was 38.6 °C at PAGASA-Port Area Station and the second highest at PAGASA-Science Garden at 38.5 °C (**Figure 2-33**). April, May and June are the months with the highest recorded air temperature.

The lowest recorded air temperature among the three (3) synoptic stations in Metro Manila was 14.5 °C at PAGASA-Port Area Station. The second highest was 14.6 °C at PAGASA-NAIA Station.

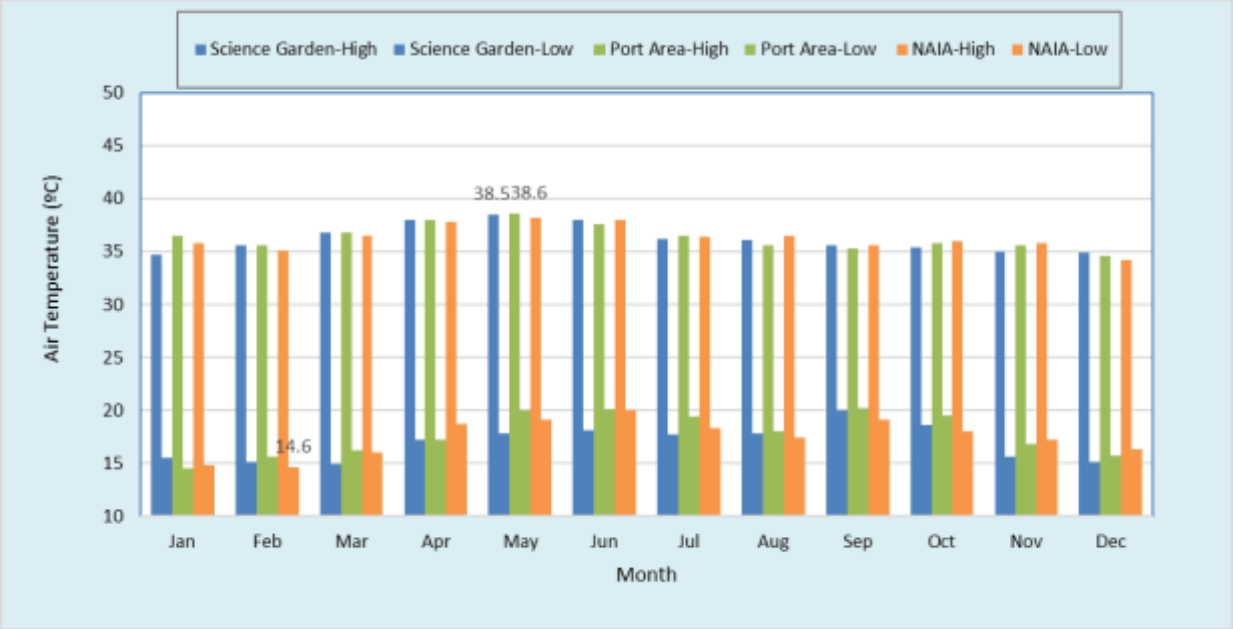



**Figure 2-33: Monthly Highest and Lowest Recorded Temperatures at Synoptic Stations in Metro Manila**

**Table 2-38** presents the monthly average wind speed and directions at the three (3) synoptic stations. Monthly average wind directions at PAGASA-NAIA Station differ from those of the other two (2) stations, particularly from May to September and from January to March.

Winds from PAGASA-NAIA Station are generally from the east and west directions while those at PAGASA-Science Garden and Port Area are from the northeast and southwest.

PAGASA-Port Area Station, however, has persistent southwest wind flows (average) in October, though at PAGASA-Science Garden and PAGASA-NAIA Station, monthly average wind directions are from the north and southwest, respectively.

**Table 2-38: Monthly Average Wind Speeds at PAGASA's Synoptic Station in Metro Manila**

| Month | PAGASA-Science Garden Station | | PAGASA-Port Area Station | | PAGASA-NAIA Station | |
|---|---|---|---|---|---|---|
| | Direction (16pt) | Speed (mps) | Direction (16pt) | Speed (mps) | Direction (16pt) | Speed (mps) |
| January | N | 1 | N | 2 | E | 3 |
| February | NE | 1 | E | 3 | E | 3 |
| March | SE | 1 | SE | 3 | E | 4 |
| April | SE | 1 | SE | 3 | ESE | 4 |

| Month | PAGASA-Science Garden Station | | PAGASA-Port Area Station | | PAGASA-NAIA Station | |
|---|---|---|---|---|---|---|
| | Direction (16pt) | Speed (mps) | Direction (16pt) | Speed (mps) | Direction (16pt) | Speed (mps) |
| May | S | 1 | SW | 3 | W | 3 |
| June | SW | 1 | SW | 3 | W | 3 |
| July | SW | 2 | SW | 3 | W | 3 |
| August | SW | 2 | SW | 4 | W | 3 |
| September | SW | 1 | SW | 3 | W | 2 |
| October | N | 1 | SW | 3 | E | 2 |
| November | N | 1 | N | 3 | E | 2 |
| December | N | 1 | N | 2 | E | 2 |

Extreme Recorded Winds

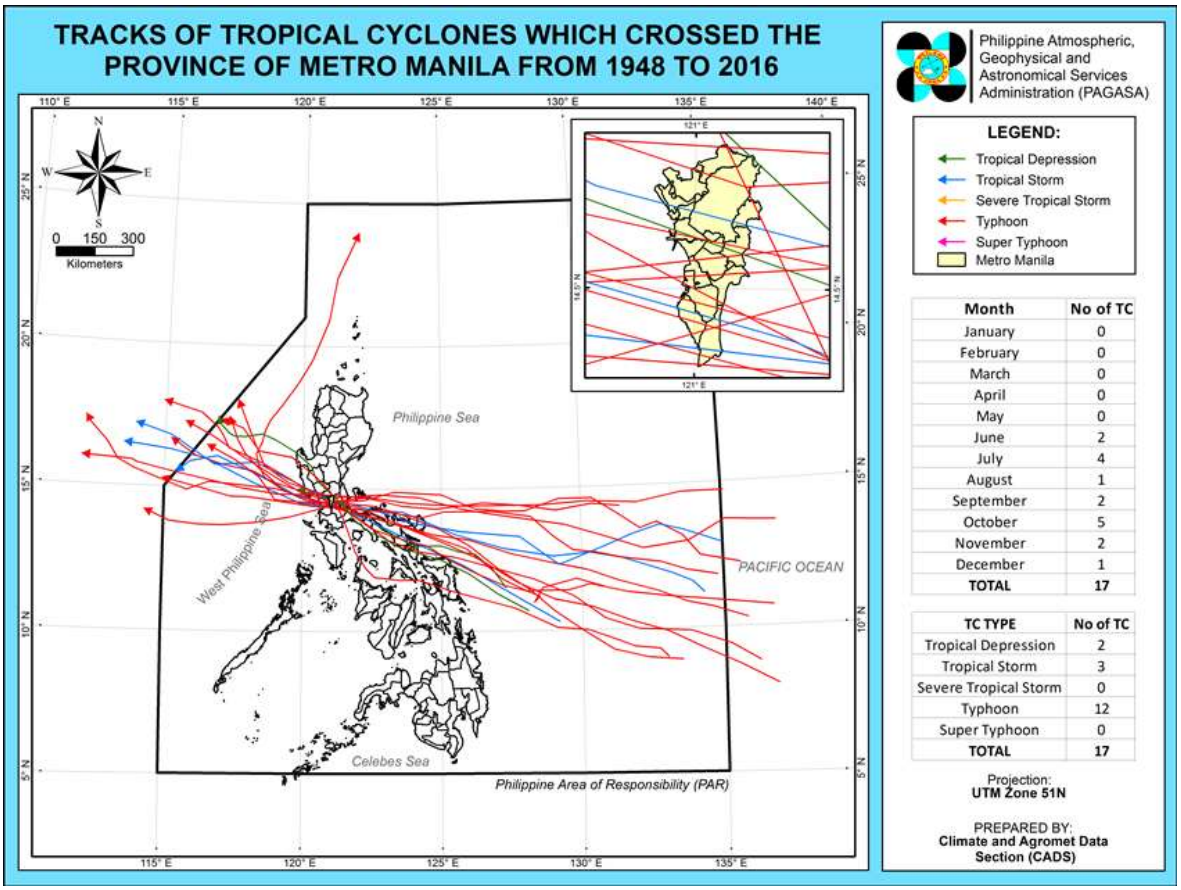
As of 2018, the strongest wind speed recorded at PAGASA's synoptic station in Metro Manila was 56 m/s. This was due to Typhoon Patsy or otherwise known in the Philippines as Typhoon Yoling. The second greatest wind speed was recorded at PAGASA-Science Garden Station at 50 m/s on November 3, 1995. This strong wind was brought by Typhoon Angela "also known as Typhoon Rosing" when it hit Metro Manila**(Table 2-39).**

**Table 2-39: Greatest Recorded Wind Speed at PAGASA's Synoptic Stations in Metro Manila**

| Station | Greatest Wind Speed (m/s) | Data of Occurrence | Period of Record |
|---|---|---|---|
| PAGASA-Science Garden Station | 50 | November 3, 1995 | 1961 to 2018 |
| PAGASA- Port Area Station | 56 | November 19, 1970 | 1948 to 2016 |
| PAGASA-NAIA Station | 56 | November 19, 1970 | 1950 to 2018 |

2.3.1.1.3 Cyclone Frequency

More tropical cyclones are entering the Philippine Area of Responsibility (PAR) than anywhere else in the world (PAGASA 2019). PAGASA determined an annual average of 20 tropical cyclones entering PAR, with about eight (8) or nine (9) of them crossing the Philippines. From 1948-2016 (period of 68 years), 17 tropical cyclones crossed Metro Manila (**Figure 2-34).**




| Month | No of TC |
|---|---|
| January | 0 |
| February | 0 |
| March | 0 |
| April | 0 |
| May | 0 |
| June | 2 |
| July | 4 |
| August | 1 |
| September | 2 |
| October | 5 |
| November | 2 |
| December | 1 |
| TOTAL | 17 |

| TC TYPE | No of TC |
|---|---|
| Tropical Depression | 2 |
| Tropical Storm | 3 |
| Severe Tropical Storm | 0 |
| Typhoon | 12 |
| Super Typhoon | 0 |
| TOTAL | 17 |

**Figure 2-34: Tracks of Tropical Cyclones which Crossed Metro Manila (1948-2016)**

Source: PAGASA

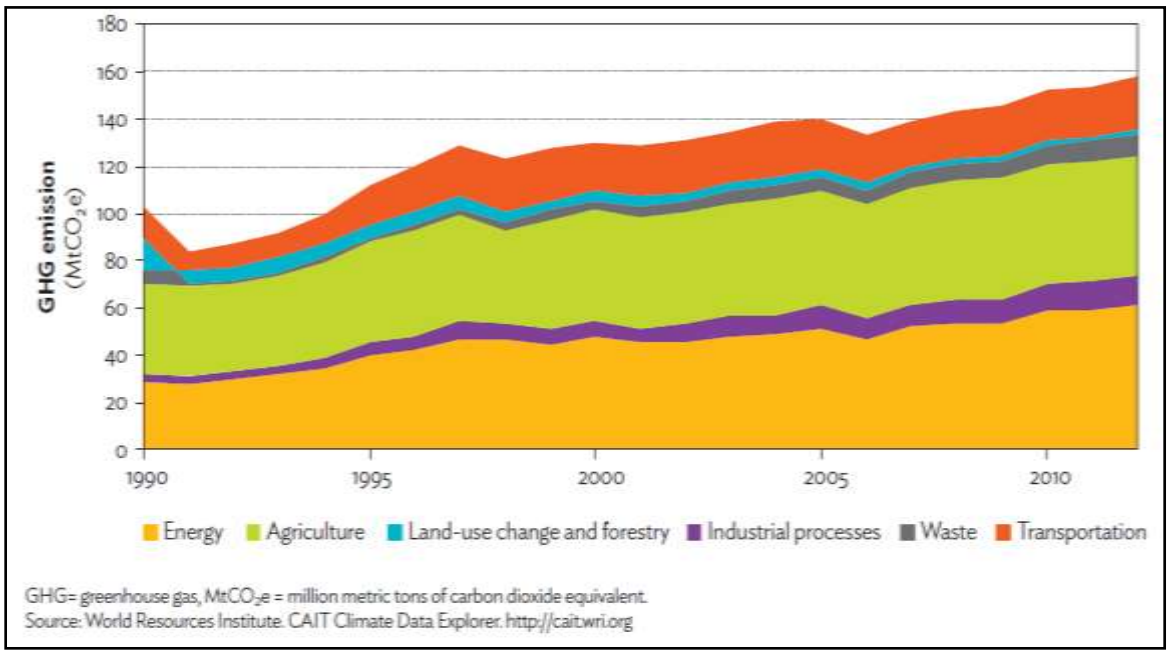
### 2.3.1.2 Greenhouse Gases

From 1990 to 2010, the Philippines' GHG emissions had been increasing at average of 3.25% annually. As of 2012, the Philippine GHG emission is approximately 157.6 million tons of $CO_2e$. Approximately 54% of this came from energy sector, followed by agriculture (33%), industrial processes (IP) (8%), and waste (7%) sector. Due to activities in the forest land subsector, the land-use change and forestry (LUCF) sector absorbed more emissions, approximately 1.64 $MtCO_2e$, than it releases. **Table 2-40** and **Figure 2-35** shows the increasing GHG emissions of the Philippines. **Figure 2-36** shows the Philippine's GHG emissions by sector and percent of the total emission in 2012.

**Table 2-40:GHG Emission of the Philippines, $MtCO_2e$, 1990-2010**

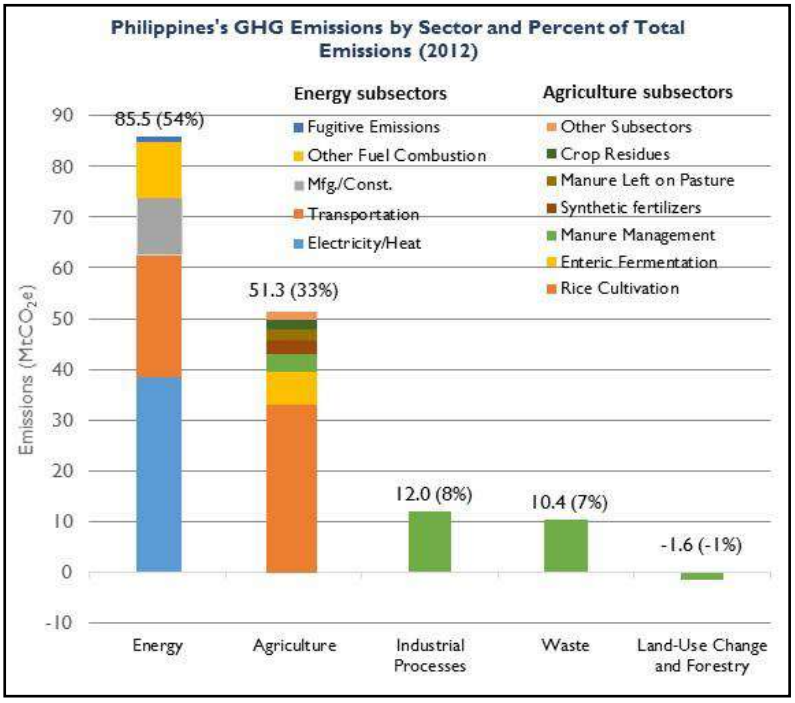
| | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|
| **GHG Emission ($MtCO_2e$)** | 96 | 125 | 140 | 146 | 159 |

Source: European Commission JRC/PBL, EDGAR




Source: ADB, 2017

**Figure 2-35: Philippine Greenhouse Gas Emission, 1990-2012**




Source: WRI CAIT 2.0, 2016, FAOSTAT, 2016

**Figure 2-36: PhilippinesGHG Emissions by Sector and Percent of Total Emissions**

2.3.1.3 Impact Assessment

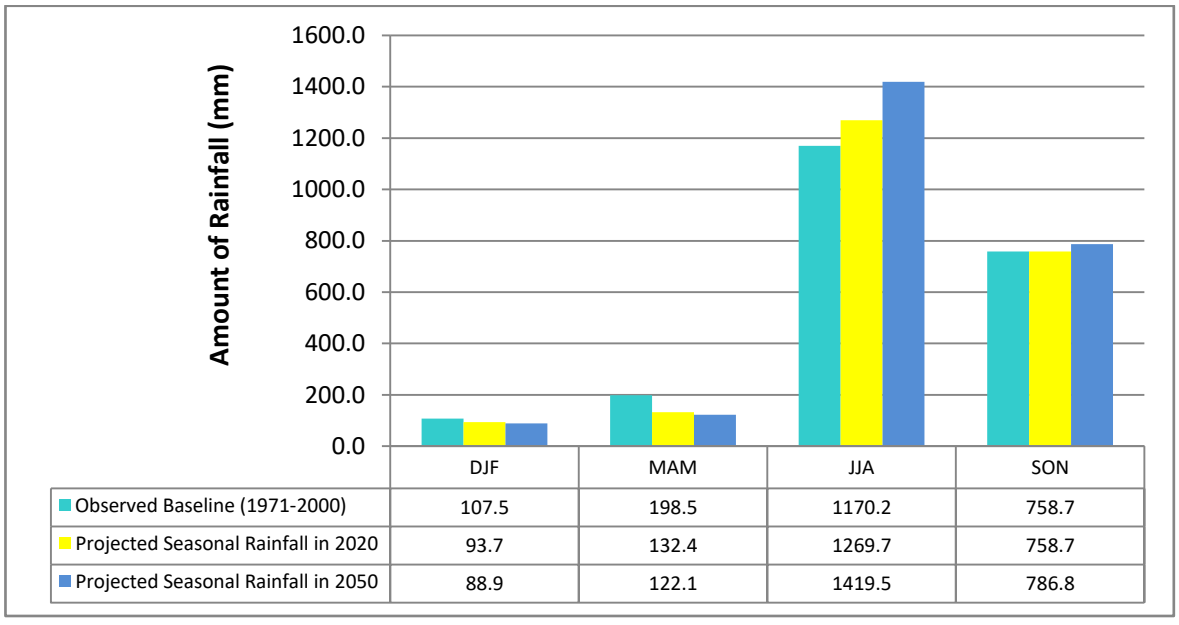
2.3.1.3.1 Local Climate Change

PAGASA (2011) projected the effect of climate change on the rainfall and temperature in Metro Manila for the periods 2006-2035 (centered at 2020) and 2036-2065 (centered at 2050) under medium-range emission scenario, as discussed below.

Projected Rainfall in 2020 and 2050

In 2020, PAGASA projected that Metro Manila will experience 12.8% decrease in rainfall amount from December to February. During these months, the amount of rainfall will decrease from 107.5 mm to 93.7 mm. Rainfall will also decrease from 198.5 mm to 132.4 mm, a 33.3% decrease in March to May. From June to August, Metro Manila will experience increase in rainfall of 8.5% from 1,170.2 mm to 1,269.7 mm. The amount of rainfall will remain at 758.7 mm from September to November.

For 2050, PAGASA projected that the amount of rainfall received by Metro Manila will continue to decrease to 88.9 mm (a 17.3% decrease from observed baseline of 107.5 mm) in December to February; and, to 122.1 mm (a 38.5% decrease from observed baseline of 198.5 mm) in March to May. During months of June to August, the rainfall will increase to 1,419.5 mm from an observed baseline of 1170.2 mm. A 3.7% increase in rainfall amount from 758.7 mm to 786.8 mm, will be experienced during months of September to November. **Figure 2-37** shows the projected amount of rainfall in Metro Manila in 2020 and 2050.




| | DJF | MAM | JJA | SON |
|---|---|---|---|---|
| Observed Baseline (1971-2000) | 107.5 | 198.5 | 1170.2 | 758.7 |
| Projected Seasonal Rainfall in 2020 | 93.7 | 132.4 | 1269.7 | 758.7 |
| Projected Seasonal Rainfall in 2050 | 88.9 | 122.1 | 1419.5 | 786.8 |

Note: DJF: Dec-Jan-Feb; MAM: Mar-Apr-May; JJA: Jun-Jul-Aug; SON: Sep-Oct-Nov

**Figure 2-37: Projected Amount of Rainfall in 2020 and 2050 in Metro Manila UnderMedium Range Emission Scenario**

Projected Extreme Rainfall Events

PAGASA projected that Metro Manila will experience a decrease on the number of rainy days from 7,476 (1971-2000) to 6,302 in 2020 (2006-2035) and to 6,220 in 2050 (2036-2065). On the other hand, more number of days with rainfall greater than 200 mm will be experienced in 2020 and 2050. From an observed baseline of 9 days, this will increase to 13 days in 2020 and to 17 days in 2050. **Figure 2-38** shows the projected number of dry days and number of days with rainfall greater than 100 mm for 2020 and 2050.

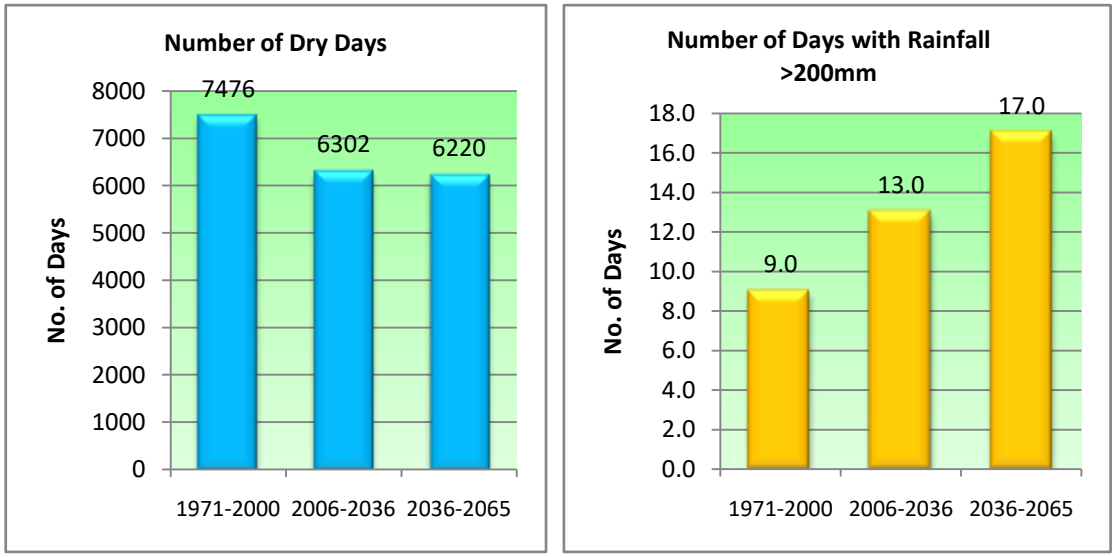
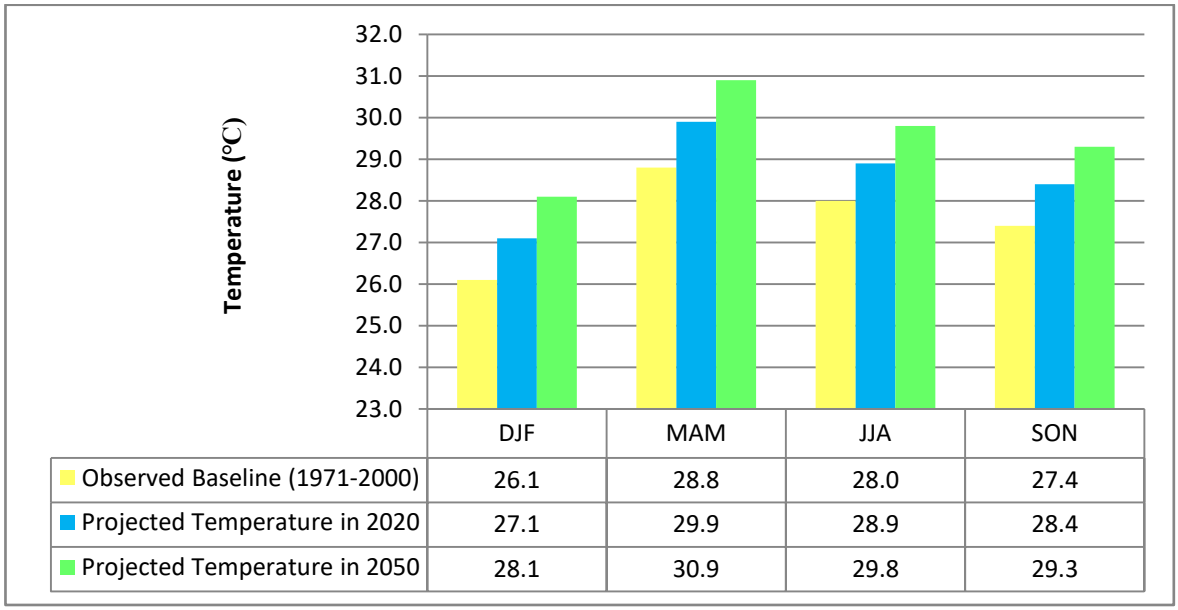



**Figure 2-38: Projected Number of Dry Days and Number of Days with Rainfall Greater Than 200 mm in 2020 and 2065 in Metro Manila Under Medium-range Emission Scenario**

Projected Temperature in 2020 and 2050

In 2020, PAGASA projected that ambient air temperature in Metro Manila will increase from 26.1 ºC to 27.1ºC in December to February and from 28.8 ºC to 29.9 ºC in March to May. From June to August, ambient air temperature will increase from 28.0 ºC to 28.9 ºC and in September to November, temperature will increase from 27.4 ºC to 28.4 ºC.

In 2050, PAGASA projected that ambient air temperature will further increase to 28.1 ºC in December to February, 30.9 ºC in March to May, 29.8 ºC in June to August and 29.3 ºC in September to November.**Figure 2-39** shows the projected air temperatures in 2020 and 2050 in Metro Manila.




| | DJF | MAM | JJA | SON |
|---|---|---|---|---|
| Observed Baseline (1971-2000) | 26.1 | 28.8 | 28.0 | 27.4 |
| Projected Temperature in 2020 | 27.1 | 29.9 | 28.9 | 28.4 |
| Projected Temperature in 2050 | 28.1 | 30.9 | 29.8 | 29.3 |

Note: DJF: Dec-Jan-Feb; MAM: Mar-Apr-May; JJA: Jun-Jul-Aug; SON: Sep-Oct-Nov

**Figure 2-39: Projected Cchange in Temperature in 2020 and 2050 in Metro Manila Under the Medium-range Emission Scenario**

Projected Extreme Temperature Events

PAGASA projected that Metro Manila will experience in increase number of days with ambient air temperature of greater than 35 °C in 2020 and 2050. In 2020, number of days with ambient air temperature greater than 35 °C will increase from 1,095 days to 1,984. This will further increase to 3,126 days in 2050**. Figure 2-40** shows the projected number of days in Metro Manila with temperature greater than 35 °C.

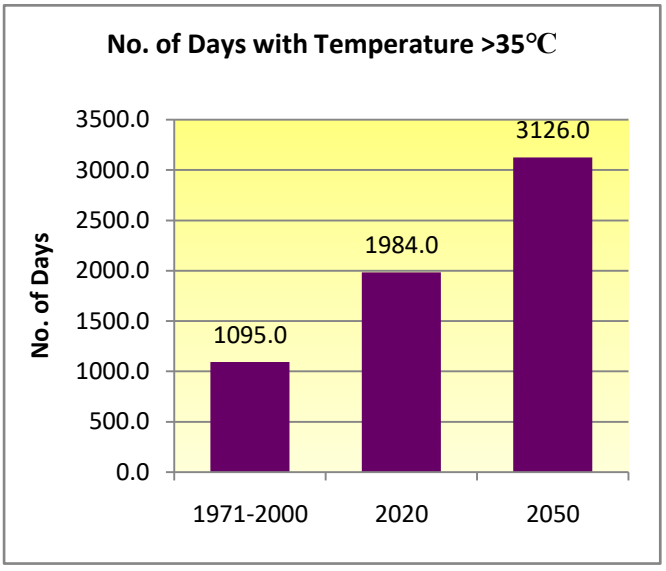



**Figure 2-40: Projected Number of Days GreaterThan 35 °C in Metro Manila**

Changes or variation in weather elements such as rainfall and temperature have consequences to the design, construction and alignment of railway track and infrastructure, maintenance and performance.

The projection of PAGASA showed that there will be increased in the amount of rainfall in Metro Manila during months of June to November and increase in the number of days with rainfall greater than 200 mm. This could induce stormwater flooding which may affect the subway infrastructures. Also, more frequent precipitation events may cause premature deterioration of concrete structures.

To mitigate the impacts of climate change in the project, drainage design will cater the average recurrence interval plus the effect of climate change to seasonal rainfall. The projected increase in temperature will be also incorporated in the rail design. Appropriate monitoring and inspection be conducted regularly to ensure that railway track, rail car and other facilities are in good condition.

To ensure safety of the workers, an occupational health and safety procedures manual will be prepared according to the requirements of Department of Labor and Employment (DOLE). Appropriate work-rest schedule for workers will be developed and implemented. Also, drinking water and rest area will be provided at/near workstations.

2.3.1.3.2 Contribution in Terms of Greenhouse Gas Emissions

The GHG emissions during the construction phase are associated with the extraction, transport, and production of the materials used in the construction of the facilities (e.g., asphalt, concrete, base stone, and steel) (upstream emissions), and the operation of construction vehicles and equipment (downstream emissions). As previously mentioned, the GHG emissions from Project construction were estimated using FTA GHG Emission Estimator v1.0. This tool amortized the total construction emissions over a 50-year period, which corresponds to the minimum useful lifespan of facilities[4]. Thus, the annual GHG emission from the Project construction is estimated to be 21, 935 metric tons of $CO_2e$ ($MTCO_2e$). Details of calculation are shown in **Annex 8** .

During operation phase, sources of GHG emissions include operation of stations, depot and rail car, and maintenance activities. GHG emissions from stations and depot operation including maintenance activities were also estimated using the FTA GHG Emission Estimator v1.0. The stations and depot operation, and maintenance activities will emit approximately 31,882 $MTCO_2e$ and 32 $MTCO_2e$, respectively. For railcar operation, approximately 104,000 MWh per year of power supply will be needed. This will emit approximately 51,780 metric tons of $CO_2e$ ($MTCO_2e$), as shown in **Table 2-41.**

**Table 2-41:Total Annual Scope 2 (Electricity Consumption) GHG Emissions by the Project**

| Total annual energy Consumption (MWh/Year) | Emission Factor[5] (Tonnes of $CO_2e$/kWh) | Total Annual GHG Emissions (Tonnes of $CO_2e$) |
|---|---|---|
| 104,000 | 0.0004979 | 51,781.60 |

Source: Philippine Infradev Holdings Inc., 2018

With the Project, it is expected that vehicular traffic in Makati City will be reduced. The projected displaced emissions from 2023 to 2048 due to reduction of vehicular are presented in **Table 2-42.** The average annual displaced emission is approximately 426,031 $MTCO_2e$.

[4] FTA Circular 5010.1D Chapter IV. 3.f.(2)(e).

[5] 1The World Bank (2009). Greenhouse gas emissions Inventory Management Plan for Internal *Business Operations*

**Table 2-42: Total Annual GHG Emissions Reduction by the Project Taking into Consideration the Annual GHG Emissions from Scope 2 Emissions**

| Design Year | CO2 Emissions (Tons/Year) | CH4 Emissions (Tons/Year) | N2O Emissions (Tons/Year) | Total Annual GHG Emissions Reduction (Tons of CO2-e) |
|---|---|---|---|---|
| 2023 | 1,445,411.38 | 77.00 | 88.51 | 1,419,240.00 |
| 2028 | 1,568,318.21 | 83.55 | 96.05 | 1,544,328.20 |
| 2033 | 1,703,032.85 | 90.72 | 104.31 | 1,681,433.78 |
| 2038 | 1,850,784.17 | 98.60 | 113.37 | 1,831,807.18 |
| 2043 | 2,012,731.66 | 107.23 | 123.31 | 1,996,628.66 |
| 2048 | 2,190,308.82 | 116.69 | 134.20 | 2,177,357.05 |

Source: Philippine Infradev Holdings Inc., 2018

Overall, the Project is expected to reduce 320,401 $MTCO_2e$ per year. This will reduce the emission contribution of the transportation sector 0.6% and the country's emission by 0.2% based on the 2012 GHG emission data of the Philippines. **Table 2-43** shows the annual GHG emission per Project Phase.

**Table 2-43: Annual GHG Emission per Project Phase**

| GHG Emission per Project Phase | Annual GHG Emission ($MTCO_2e$) |
|---|---|
| **Construction** | |
| Upstream | 21,171.00 |
| Downstream | 764.00 |
| **Operations** | |
| Stations and Depot | 31,882.00 |
| Railcar | 51,781.00 |
| **Maintenance** | 32.00 |
| **Displaced Emissions** | - 426,031.00 |
| **TOTAL ANNUAL GHG EMISSIONS** | **- 320,401.00** |

2.3.1.3.3 GHG Reduction Measures

GHG emissions of the project are significant during construction period only due to operation of heavy equipment and vehicles using diesel-engines. During operation, the project is expected to significantly offset GHG emissions due to reduction on use of motor vehicles by commuters.

Although significant GHG emissions of the project will occur only during construction period, it is recommended that mitigation measures related to the reduction or adaptation program on GHG emissions will be implemented. The following are the proposed mitigation programs related to GHG.

1) Prepare and implement a GHG emissions accounting program in accordance with international standards, such as those of the developed by the World Resources Institute (WRI) and the World Business Council on Sustainable Development (WBCSD). This protocol sets the global standard to measure, manage, and report greenhouse gas emissions.

   GHG emissions are reported according to the following scope.

- Scope 1 emissions – measure emissions that are directly owned and controlled sources. These include emissions from the exhaust stacks and vehicles owned by the proponent.
- Scope 2 emissions – measure emissions from purchase of electricity or acquired electricity, steam, heat, and cooling; and
- Scope 3 emissions – indirect emissions, such as extraction and production of purchase materials, transport-related activities in vehicles not owned or controlled by the proponent and electricity related activities (e.g., transmission and distribution losses) not covered in Scope 2 (source:www.ghgprotocol.com)

2) Minimize idling time by shutting equipment off when not in use or reducing the time of idling to not more than 3 minutes.
3) Use of use heavy equipment and trucks that are fuel efficient,
4) Optimize use of vehicles and heavy equipment,
5) Optimize lighting at workplaces, access roads, and inside the tunnel,
6) Optimal use of materials, i.e., recycling of steel, particularly those salvage during demolition works,
7) Maintain all construction equipment in accordance with the manufacturer's specification, and
8) Use of compact fluorescent bulbs and reduce consumption of electricity at workplaces;

2.3.2 Air Quality and Noise

Criteria for Assessment

**Table 2-44** shows the National Ambient Air Quality Guideline (NAAQG) and the National Ambient Air Quality Standards (NAAQS) for TSP, $PM_{10}$, $PM_{2.5}$, $SO_2$, and $NO_2$, as provided in the Philippine Clean Air Act (PCAA) and its implementing rules.

The NAAQG values are intended to serve as goals or objectives for the protection of health and/or public welfare. DAO 2000-81 (IRR of the PCAA) provides that that the NAAQG values shall be used for air quality management, such as evaluating deterioration or enhancement of air quality and on determining trends.

During construction and operation of the project, proponent shall ensure compliance with the NAAQS. The NAAQS are enforceable and must not be exceeded at the breathing zone. The NAAQS apply outside the project boundaries and at area sensitive receptors (ASRs) (e.g., households or residences).

**Table 2-44: NAAQS and NAAQG for $SO_2$, $NO_2$, TSP, $PM_{10}$and$PM_{2.5}$**

| Pollutant | NAAQS(1) | | NAAQGV(1) | |
|---|---|---|---|---|
| | Averaging Time | (µg/Nm$^3$) | Averaging Time | (µg/Nm$^3$) |
| Sulfur Dioxide ($SO_2$) | 60 min | 340 | 24 hours | 180 |
| Nitrogen Dioxide ($NO_2$) | 60 min | 260 | 24 hours | 150 |
| Total Suspended Particulates (TSP) | 60 min | 300 | 24 hours | 230 |
| | - | - | 1 year | 90 |
| Particulate Matter less than 10 microns ($PM_{10}$) | 60 min | 200 | 24 hours | 150 |
| | - | - | 1 year | 60 |
| Particulate Matter less than 2.5microns ($PM_{2.5}$) | 60 min | - | 24 hours | 50(2) |
| Notes: µg/Nm$^3$ – microgram per normal cubic meter<br>Source: (1) National Ambient Air Quality Guideline for Criteria Pollutants of the Philippine Clean Air Act of 1999 (DAO 2000-81); (2) DENR Administrative Order No. 2013-13 | | | | |

Locations of Monitoring Stations

Berkman Systems, Inc. (BSI) was commissioned by Lichel Technologies, Inc. (LTI) to conduct 1-hr and 24-hr ambient air quality sampling to determine the ambient concentration levels of TSP, $PM_{10}$, particulate matter equal to less than 2.5 µm (**$PM_{2.5}$**), sulfur dioxide (**$SO_2$**), and nitrogen Dioxide (**$NO_2$**) at five (5) sampling stations. **Table 2** shows the dates and times of monitoring. Details of monitoring are presented in **Table 2-45**.

**Table 2-45: Descriptions of Air Sampling Stations**

| Station | Location | GPS Coordinates | | Remarks |
|---|---|---|---|---|
| | | Latitude | Longitude | |
| ***A1*** | Along J.P. Rizal Ext. between 25th Ave. and Sampaguita St. | 14°32'58"N | 121°03'49"E | For 1-hour and 24-hour sampling |
| ***A2*** | Along Guadalupe Bliss Area | 14°33'58"N | 121°03'12"E | For 1-hour and 24-hour sampling |

| | | | | |
|---|---|---|---|---|
| ***A3*** | Between Camia & Estrella St. | 14°34'03"N | 121°02'20"E | For 1-hour and 24-hour sampling |
| ***A4*** | JP Rizal Ave cor. F. Zobel | 14°34'09"N | 121°01'37"E | For 1-hour and 24-hour sampling |
| ***A5*** | Near Junction of Ayala and Edsa | 14°33'03"N | 121°01'44"E | For 1-hour sampling |

**Table 2-46: Sampling Observations and Photo Documentations for 1-hr Monitoring**

| Station | Sampling Observations | Photo Documentations |
|---|---|---|
| ***A1***<br><br>Along J.P. Rizal Ext. between 25th Ave. & Sampaguita St.<br><br>July 04, 2019 / 0921H-1021H | The station was situated on concrete ground located in the corner of the J.P Rizal Ext. and Tanguile St. in front of a commercial building. Continuous passing of vehicles was observed during monitoring period.<br><br>Weather was fair with partly cloudy skies. No occurrence of rainfall was observed during sampling. Winds were blowing from the southeast at light air conditions. Average ambient air temperature was 32.9 ˚C. |  |
| ***A2***<br><br>Along Guadalupe Bliss Area<br><br>July 04, 2019 / 1052H-1152H | The station was situated on elevated ground located in the Rizal Riverwalk along Guadalupe Bliss Area. Continuous passing of vehicles and ongoing construction near the station were observed during monitoring period.<br><br>Weather was fair with partly cloudy skies. No occurrence of rainfall was observed during sampling. Winds were blowing from the southeast at light air conditions. Average ambient air temperature was 33.1 ˚C. |  |

| Station | Sampling Observations | Photo Documentations |
|---|---|---|
| ***A3***<br><br>Between Camia & Estrella St.<br><br>July 04, 2019 / 1225H-1325H | The station was situated on concrete ground located between Camia and Estrella St. along Rizal Riverwalk. Continuous passing of vehicles was observed during monitoring period.<br><br>Weather was fair with partly cloudy skies. No occurrence of rainfall was observed during sampling. Winds were blowing from the southeast at light air conditions. Average ambient air temperature was 33.5 ˚C. |  |
| ***A4***<br><br>JP Rizal Ave cor. F. Zobel<br><br>July 04, 2019 / 1400H-1500H | The station was situated on elevated concrete ground located along J.P Rizal Ave. corner Zobel St. several vehicles were parked near the station. Continuous passing of vehicles was observed during monitoring period.<br><br>Weather was fair with partly cloudy skies. No occurrence of rainfall was observed during sampling. Winds were blowing from the southeast at light air conditions. Average ambient air temperature was 33.6 ˚C. |  |
| ***A5***<br><br>Near Junction of Ayala & Edsa<br><br>July 04, 2019 / 1636H-1736H | The station was situated on concrete ground located in the corner of the Ayala Ave and EDSA in front of a Makati Garden Club. Continuous passing of vehicles was observed during monitoring period.<br><br>Weather was fair with mostly cloudy skies. No occurrence of rainfall was observed during sampling. Winds were blowing from the southeast at light air conditions. Average ambient air temperature was 32.1 ˚C. |  |


Lichel Technologies, Inc.
Unit 1403 Prestige Tower Condominium
F. Ortigas, Jr. Road, Ortigas Center, Pasig City

FIGURE TITLE :

**Air Quality Sampling Stations**

FIGURE NO.:

**2-41**

Methods of Air Sampling and Analysis

One-hour ambient air quality sampling was conducted at five (5) sampling stations while the 24-hr sampling was conducted only at four (4) sampling stations (Stations A1 to A5). High volume samplers were used to collect TSP and $PM_{10}$ samples while impingers were used to collect $NO_2$ and $SO_2$ samples. The method of sampling and analysis used per parameter are presented in Table 2-47: Methods of Ambient Air Sampling and Analysis

**Table 2-47: Methods of Ambient Air Sampling and Analysis**

| Parameters | Sampling Methodology / Analysis |
|---|---|
| Total Suspended Particulate (TSP) | High Volume Sampler - Gravimetric Method |
| Particulate Matter less than 10 microns ($PM_{10}$) | High Volume Sampler - Gravimetric Method |
| Particulate Matter less than 2.5 microns ($PM_{2.5}$) | High Volume Sampler - Gravimetric Method |
| Sulfur Dioxide ($SO_2$) | Impinger - Pararosaniline Method |
| Nitrogen Dioxide ($NO_2$) | Impinger – Griess-Saltzman Reaction |

*Reference: USEPA 40 CFR, Part 50*

The following presents the methodologies of sampling and analysis of particulates and gaseous air pollutants, as provided by BSI.

1) TSP

Sampling of TSP was carried out by using a high-volume sampler. Ambient air was drawn into a covered housing through a collecting medium of a pre-weighed glass microfiber filter paper at a controlled flow rate over the specified sampling period. The filter paper with retained particles was recovered after sampling and desiccated for 24 hours in the laboratory followed by accurate weighing (gravimetric method) using a calibrated mass balance. The net weight (mass gain) from the initial and final masses of the filter paper corresponds to the total amount of particulates collected. The concentration of TSP in ambient air was determined from the ratio of total mass of particulates collected and the total normal volume of air sampled (total volume of air sampled corrected to normal conditions of 25 °C and 760 mm Hg).

1) PM10

Sampling of $PM_{10}$ was carried out by using a high volume $PM_{10}$ sampler. Ambient air was drawn at a controlled flow rate into a specially-shaped cyclone inlet where the larger particulates are inertially separated from $PM_{10}$ size range. Each size fraction in the $PM_{10}$ size range is then collected on a pre-weighed glass microfiber filter over the specified sampling period. The filter paper with retained particles was recovered after sampling and desiccated for 24 hours in the laboratory followed by accurate weighing using a calibrated mass balance. The net weight (mass gain) from the initial and final masses of the filter paper corresponds to the amount of $PM_{10}$ collected. The concentration of $PM_{10}$ in ambient air was determined from the ratio of total mass of $PM_{10}$ collected and the total normal volume of air sampled.

2) PM2.5

Sampling of $PM_{2.5}$ was carried out by using a $PM_{2.5}$ Sampler. Ambient air was drawn at a controlled flow rate through a particle size separator where the suspended particulate matter in the $PM_{2.5}$ size range is separated for collection on a pre-weighed glass-fiber filter paper over the specified sampling period. After sampling, the filter paper with retained particles was recovered by

carefully removing the filter using a tweezer. The filter was folded in half so that the surfaces with particulate matter are in contact, placed in a filter jacket, then inside a box and transported to the laboratory. The filter was desiccated for 24 hours in the laboratory followed by accurate weighing using a calibrated analytical balance. The net weight (mass gain) from the initial and final masses of the filter paper corresponds to the amount of $PM_{2.5}$ collected. The concentration of $PM_{2.5}$ in ambient air was determined from the ratio of total mass of $PM_{2.5}$ collected and the total normal volume of air sampled.

3) Sulfur Dioxide

Sulfur dioxide in the ambient air was sampled using a handy gas sampler by aspirating air at a controlled flowrate into a solution of 0.04 M sodium tetrachloromercurate (TCM) through a glass midget impinger over the specified sampling period. The solution was then treated in the laboratory with formaldehyde and with a specially purified acid-bleached pararosaniline to form an intensely colored pararosaniline methyl sulfonic acid. The color intensity was measured spectrophotometrically at 548 nm and is directly related to the amount of $SO_2$ collected. $SO_2$ concentration was determined from the difference between the absorbance of the sample and blank, multiplied by the calibration factor, and divided by the total normal volume of air sampled.

4) Nitrogen Dioxide

Nitrogen dioxide in the ambient air was determined using Griess-Saltzman Reaction Method. Air was drawn using a handy gas sampler at a controlled flowrate into an azo dye forming reagent through a glass midget impinger over a specified sampling period. The absorption reaction produces a stable red-violet color. The color intensity was read by a spectrophotometer in a laboratory at 550 nm and is directly related to the amount of $NO_2$ collected. $NO_2$ concentration was determined from the difference between the absorbance of the sample and blank, multiplied by the calibration factor, and divided by the total normal volume of air sampled.

Observations During Sampling:

Meteorological observations such as wind speed and direction, cloud cover and other relevant parameters were also recorded during the duration of the sampling.

Impact Assessment

Impact assessment involved the determination of the type and number of equipment, which were provided by the proponent, and estimation of the emission rates of particulates (TSP, PM10, and PM2.5) and gaseous air pollutants (SO2 and NO2). Emission rates were estimated using the emission factors of the U.S.EPA and the NPI.

The emission factors that were used to estimate the air emissions of the non-point sources are discussed below.

1) Bulldozing

The emission factors for TSP, $PM_{10}$ and $PM_{2.5}$(in kg/hr) arising from bulldozing activities was based on AP-42 Emission factor (Table 11.9-2), as follows:

$$EF_{TSP(bulldozing)} = \frac{2.6s^{1.2}}{M^{1.3}} \qquad \textit{Equation 1}$$

$$EF_{PM10(bulldozing)} = 0.75x\frac{0.45\ s^{1.5}}{M^{1..4}} \qquad \textit{Equation 2}$$

$$EF_{PM2.5(bulldozing)} = 0.105 \times E_{TSP} = \frac{0.273\ s^{1.2}}{M^{1.3}} \qquad \text{Equation 3}$$

where, s, is the material silt content (%) and, M is the material moisture content (%).

2) Materials Handling

Emission factors for TSP, $PM_{10}$ and $PM_{2.5}$(in kg/ton) arising from movement of haul-trucks and front-end loaders/shovels for the unloading/loading of materials were estimated using Section 13.2.4 of AP-42, as follows.

$$EF_{Materials\ Handling} = k\ (0.0016)\ \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \qquad \text{Equation 4}$$

where U and M are the mean wind speed (m/s) and the material moisture content (%), respectively. The particle size multiplier, k, is 0.74 for TSP, 0.35 for $PM_{10}$ and 0.053 for $PM_{2.5}$.

3) Haul Trucks Along Unpaved Roads

Emission factors arising from operation of trucks (e.g., hauling of materials) along unpaved access roads (in lb/vehicle mile travelled) were obtained from Chapter 13.2 of AP-42, as follows:

$$EF_{UnpavedRoad} = k\left(\frac{s}{12}\right)^{a}\left(\frac{W}{3}\right)^{b} \qquad \text{Equation 5}$$

where k, a, and, b, are constants shown in**Table 2-48**.

**Table 2-48: Constants Used on Emission Factors for Unpaved Roads**

| Constant | Industrial Roads | | |
|---|---|---|---|
| | $PM_{30}$* | $PM_{10}$ | $PM_{2.5}$ |
| K (lb/VMT) | 4.9 | 1.5 | 0.15 |
| a | 0.7 | 0.9 | 0.9 |
| b | 0.45 | 0.45 | 0.45 |

**Assumed equivalent to total suspended particulate matter (TSP)*
*Source: Table 13.2.2-2 of AP-42*

The above equations and constants were converted to metric units using the conversion factor: 1 lb/VMT = 281.9 g/VKT.

The emission factor (Equation 5) was adjusted to account for the natural mitigation by rainfall using the formula,

$$E_{Funpaved(cor)} = EF_{unpaved}\left(\frac{365\text{-}P}{365}\right) \qquad \text{Equation 6}$$

where

- $EF_{unpaved(cor)}$= the annual size specific emission factor extrapolated for natural mitigation (lb/VMT), and
- P = number of days in a year with at least 0.254 mm (0.01 in) of rainfall

4) Haul Trucks Along Paved Roads

Emission factors arising from operation of trucks (e.g., hauling of materials) along paved roads (in lb/vehicle mile travelled) were obtained from Chapter 13.1 of AP-42, as follows:

$$EF_{PavedRoad}=k(sL)^{0.91}(W)^{1.02} \qquad \textit{Equation 7}$$

where k is the particle size multiplier; sL is the road surface silt loading ($g/m^2$); and W is the average weight (tons) of the vehicles of the road in**Table 2-49**.

**Table 2-49: Constants Used on Emission Factors for Paved Roads**

| Size Range | Particle Size Multiplier k (g/VKT) |
|---|---|
| $PM_{2.5}$ | 0.15 |
| $PM_{10}$ | 0.62 |
| $PM_{30}$* | 3.23 |

**PM-30 is sometimes termed "suspendable particulate" (SP) and is often used as a surrogate for TSP*

*Source: Table 13.2.1-1 of AP-42*

The emission factor (Equation 7) was adjusted to account for the natural mitigation by rainfall (daily basis) using the formula,

$$EF_{ext}= k\ (sL)^{0.91}(W)^{1.02}\left(1-\frac{P}{4N}\right) \qquad \textit{Equation 8}$$

where

- $EF_{ext}$= the annual or other long-term average emission factor in the same units as k,
- P = number of "wet" days with at least 0.254 mm (0.01 in) of precipitation during the averaging period, and
- N= number of days in the averaging period (e.g., 365 for annual)

5) Motor Vehicle Combustion

Tailpipeexhaust emissions from equipment and vehicles used for construction were estimated using emission factors prescribed in *NPI Emission Estimation Technique Manual for Mining V3.1 (January 2012)* and *Emission Estimation Technique Manual for Combustion Engine V3.0 (June 2008)*. For TSP, the emission factor was computed using particle size difference of 30% between TSP and $PM_{10}$. The emission factors for TSP, $PM_{10}$, $PM_{2.5}$, $NO_x$, $SO_x$ and CO are presented in **Table 2-50**.

**Table 2-50: TSP, $PM_{10}$ and $PM_{2.5}$ Emission Factors for Diesel Industrial Engines**

| Source | Emission Factor(EF) | | | | | | Unit | Source |
|---|---|---|---|---|---|---|---|---|
| | TSP* | $PM_{10}$ | $PM_{2.5}$ | $NO_x$ | $SO_x$ | CO | | |
| Excavator | 0.001144 | 0.00088 | 0.00081 | 0.012 | 0.0000075 | 0.003 | kg/kWh | NPI Emission Estimation Technique Manual for Combustion Engine V3.0. Table 32. June 2008 |
| Dozer | 0.000715 | 0.00055 | 0.00051 | 0.011 | 0.0000075 | 0.0047 | kg/kWh | NPI Emission Estimation Technique Manual for Combustion Engine V3.0. Table 28. June 2008 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Loader | 0.00143 | 0.0011 | 0.00099 | 0.012 | 0.0000075 | 0.0036 | kg/kWh | NPI Emission Estimation Technique Manual for Combustion Engine V3.0. Table 31. June 2008 |
| Crane | 0.001209 | 0.00093 | 0.00085 | 0.01 | 0.0000073 | 0.0029 | kg/kWh | NPI Emission Estimation Technique Manual for Combustion Engine V3.0. Table 27. June 2008 |
| Trenching machine | 2.34 | 1.8 | 1.7 | 23 | 0.017 | 6.8 | $kg/m^3$ | NPI Emission Estimation Technique Manual for Combustion Engine V3.0. Table 21. June 2008 |
| Haul trucks | 1.56 | 1.2 | 1.1 | 22 | 0.017 | 8.5 | $kg/m^3$ | NPI Emission Estimation Technique Manual for Combustion Engine V3.0. Table 22. June 2008 |

* Computed using particle size difference of 30% between TSP and $PM_{10}$

6) Compacting

The emission factors for TSP, $PM_{10}$ and $PM_{2.5}$ (in kg/hr) arising from compacting activities was based on AP-42 Emission factor (Table 11.9-2), as follows:

$$EF_{TSP(bulldozing)} = \frac{2.6s^{1.2}}{M^{1.3}} \qquad \textit{Equation 9}$$

$$EF_{PM10(bulldozing)} = 0.75x\frac{0.45\ s^{1.2}}{M^{1.3}} \qquad \textit{Equation 10}$$

$$EF_{PM2.5(bulldozing)} = 0.105\ x\ E_{TSP} = \frac{0.273\ s^{1.2}}{M^{1.3}} \qquad \textit{Equation 11}$$

where, s, is the material silt content (%) and, M is the material moisture content (%).

7) Concrete Batching Plant Operations

Emissions from the operation of concrete batching plant of the project were estimated. These include TSP, $PM_{10}$ and $PM_{2.5}$ emissions from aggregate and sand transfer, cement loading and unloading to elevated silo, weigh hopper loading and mixer loading.

TSP and $PM_{10}$ emissions were estimated using emission factors obtained from Section 11.12 *Concrete Batching* of AP-42 while for $PM_{2.5}$ emissions, a particle size multiplier from Table 2.4.1 was multiplied with $PM_{10}$ emissions.**Table 2-51** shows the emission factors of concrete batching plant operations.

**Table 2-51 Emission Factors of Concrete Batching Plant Operations**

| Operation/ Activity | TSP | $PM_{10}$ | $PM_{2.5}$ | Units |
|---|---|---|---|---|
| Aggregate transfer | 0.0035 | 0.0017 | 0.00026 | $kg/tons_{aggregate}$ |
| Sand transfer | 0.0011 | 0.00051 | 0.000077 | $kg/tons_{sand}$ |
| Pneumatic cement unloading to elevated silo (controlled) | 0.0005 | 0.00017 | 0.000026 | $kg/tons_{cement}$ |
| Weigh hopper loading | 0.0026 | 0.0013 | 0.00020 | $kg/tons_{aggregate\& sand}$ |
| Mixer loading (central mix) (controlled) | 0.0092 | 0.0028 | 0.00042 | $kg/tons_{cement}$ |

Source: Section 11.12 AP-42

2.3.2.1 Degradatation of Air Quality

2.3.2.1.1 Characterization of Ambient Air Quality

**Table 2-52** and **Table 2-53** show the measured one-hour average concentrations of particulate and gaseous air pollutants, respectively. TSP levels were from 62.3 to 129.5 µg/Nm$^3$and $PM_{10}$ from not detected level (< 1.7 µg/Nm$^3$) to 46.7 µg/Nm$^3$. $PM_{2.5}$ levels at all sampling stations were all not detected (less than 0.2 µg/Nm$^3$). In comparison with the ambient air quality standards, the ambient particulate air concentrations were less than the ambient standard set for TSP and $PM_{10}$ of 300 and 200 µg/Nm$^3$. There is no established one-hour ambient standard for $PM_{2.5}$.

For the gaseous air pollutants ($SO_2$ and $NO_2$), measured concentrations were from 0.33 to 1.67 µg/Nm$^3$ for $SO_2$ and 3.67 to 5.19 µg/Nm$^3$for $NO_2$. These levels were well within the ambient standard set at 180 and 150 µg/Nm$^3$ for $SO_2$ and $NO_2$, respectively.

Results of 24-hour air sampling show that ambient air qualities in the area in terms of TSP, PM10, and SO2 levels were in good condition at the time of monitoring (**Table 2-54** and **Table 2-55**). Under Annex A (Air Quality Indices) of DAO 2000-81, TSP levels (24-hour average) between 0 to 80, $PM_{10}$ from 0 to 54 µg/m$^3$ and SO2 from 0 to 0034 ppm (or 89 are µg/m$^3$) are classified as good condition.

Measured concentrations of TSP and $PM_{10}$ (24-hour average) on July 30 to July 4, 2019 were 26.58 to 96.34 and 23.61 to 39.11 µg/m$^3$, respectively. $SO_2$ levels were measured at 0.15 to 1.67 µg/Nm$^3$. $PM_{2.5}$ levels were from <0.01 to 0.36 µg/Nm$^3$ and were way below the ambient guideline value of 50 µg/Nm$^{3.}$ Sources of particulate and gaseous air pollutants at the time of monitoring were exhaust emissions of vehicles travelling along roads in vicinities of the sampling stations.

**Table 2-52:1-Hr Ambient Air Quality Monitoring Results of TSP, PM10 & PM2.5**

| Station | Location | Date/Time of Sampling | TSP | $PM_{10}$ | $PM_{2.5}$ |
|---|---|---|---|---|---|
| ***A1*** | Along J.P. Rizal Ext. between 25th Ave. and Sampaguita St. | July 04, 2019 / 0921H-1021H | 92.9 | < 1.7 | < 0.2 |
| ***A2*** | Along Guadalupe Bliss Area | July 04, 2019 / 1052H-1152H | 76.1 | 29.4 | < 0.2 |
| ***A3*** | Between Camia & Estrella St. | July 04, 2019 / 1225H-1325H | 62.3 | 29.4 | < 0.2 |
| ***A4*** | JP Rizal Ave cor. F. Zobel | July 04, 2019 / 1400H-1500H | 89.9 | 46.7 | < 0.2 |
| ***A5*** | Near Junction of Ayala and Edsa | July 04, 2019 / 1636H-1736H | 129.5 | 5.2 | < 0.2 |
| **DENR National Ambient Air Quality Standards for Source Specific Air Pollutants based on 60 minutes averaging time** | | | **300** | **200** | **none** |

*Note: For the non-detected values, the detection limit in µg was divided by the total normal volume of air sampled.*

**Table 2-53. 1-Hr Ambient Air Quality Monitoring Results of $SO_2$& $NO_2$**

| Station | Location | Date/Time of Sampling | $SO_2$ | $NO_2$ |
|---|---|---|---|---|
| ***A1*** | Along J.P. Rizal Ext. between 25th Ave. and Sampaguita St. | July 04, 2019 / 0921H-1021H | 11.1 | 4.0 |

| Station | Location | Date/Time of Sampling | $SO_2$ | $NO_2$ |
|---|---|---|---|---|
| ***A2*** | Along Guadalupe Bliss Area | July 04, 2019 / 1052H-1152H | 16.7 | 6.0 |
| ***A3*** | Between Camia & Estrella St. | July 04, 2019 / 1225H-1325H | 22.8 | 5.3 |
| ***A4*** | JP Rizal Ave cor. F. Zobel | July 04, 2019 / 1400H-1500H | 16.0 | 12.6 |
| ***A5*** | Near Junction of Ayala and Edsa | July 04, 2019 / 1636H-1736H | 15.4 | 34.2 |
| **DENR National Ambient Air Quality Standards for Source Specific Air Pollutants based on 60 minutes averaging time** | | | **340** | **260** |

**Table 2-54. 24-Hr Measured Ambient Air Concentrations of TSP, $PM_{10}$ and $PM_{2.5}$**

| Station | Location | Date / Time of Sampling | TSP | $PM_{10}$ | $PM_{2.5}$ |
|---|---|---|---|---|---|
| ***A24-1*** | Along J.P. Rizal Ext. between 25th Ave. and Sampaguita St. | June 30-July 01, 2019 / 1000H-1000H | 62.34 | 25.69 | 0.36 |
| ***A24-2*** | Along Guadalupe Bliss Area | July 01-02, 2019 / 1140H-1140H | 96.34 | 39.11 | < 0.01 |
| ***A24-3*** | Between Camia and Estrella St. | July 02-03, 2019 / 1240H-1240H | 26.58 | 23.61 | 0.26 |
| ***A24-4*** | J.P. Rizal Ave cor. F. Zobel | July 03-04, 2019 / 1500H-1500H | 71.40 | 26.34 | 0.13 |
| **DENR National Ambient Air Quality Guideline Values for Criteria Pollutants based on 24 hours averaging time** | | | **230** | **150** | **50** |

*Note: For the non-detected value, the detection limit in µg was divided by the total normal volume of air sampled.*

**Table 2-55: 24-Hr Measured Ambient Air Concentrations of $SO_2$, and $NO_2$**

| Station | Location | Date / Time of Sampling | $SO_2$ | $NO_2$ |
|---|---|---|---|---|
| ***A24-1*** | Along J.P. Rizal Ext. between 25th Ave. and Sampaguita St. | June 30-July 01, 2019 / 1000H-1000H | 0.39 | 5.19 |
| ***A24-2*** | Along Guadalupe Bliss Area | July 01-02, 2019 / 1140H-1140H | 0.33 | 4.72 |
| ***A24-3*** | Between Camia and Estrella St. | July 02-03, 2019 / 1240H-1240H | 0.15 | 3.67 |
| ***A24-4*** | J.P. Rizal Ave cor. F. Zobel | July 03-04, 2019 / 1500H-1500H | 1.67 | 4.74 |
| **DENR National Ambient Air Quality Guideline Values for Criteria Pollutants based on 24 hours averaging time** | | | **180** | **150** |

2.3.2.1.2 Predicted/Estimated Air Emissions

The construction of the project is expected to generate fugitive particulates and gaseous air pollutants. At the proposed depot area and stations, the general dust generating activities are a)

demolition and debris removal, b) site preparation, c) general construction works, and d) tunneling works. **Annex 9** presents the detailed emission estimates (assumptions, activities, and sample computations) of the particulate pollutants (TSP, $PM_{10}$ and $PM_{2.5}$) and NOX, SO2, and CO.

In summary, the construction of the project is estimated to generate 190.259 tons per year of TSP, 181.606 tons per year of $NO_X$, and 62.366 tons of $PM_{10}$ (

**Figure** 2-42). CO, $PM_{2.5}$ and $SO_2$were estimated at 50.778, 20.481, and 0.126 tons per year, respectively.

Particulate emissions are largely emitted during demolition and construction at the proposed depot area **(Figure 2-43**). Along the proposed route (Station 1 to Station 10), emissions due to combustion of fuel in vehicles, i.e., trucks and heavy equipment, used during construction works are the main sources of air emissions.

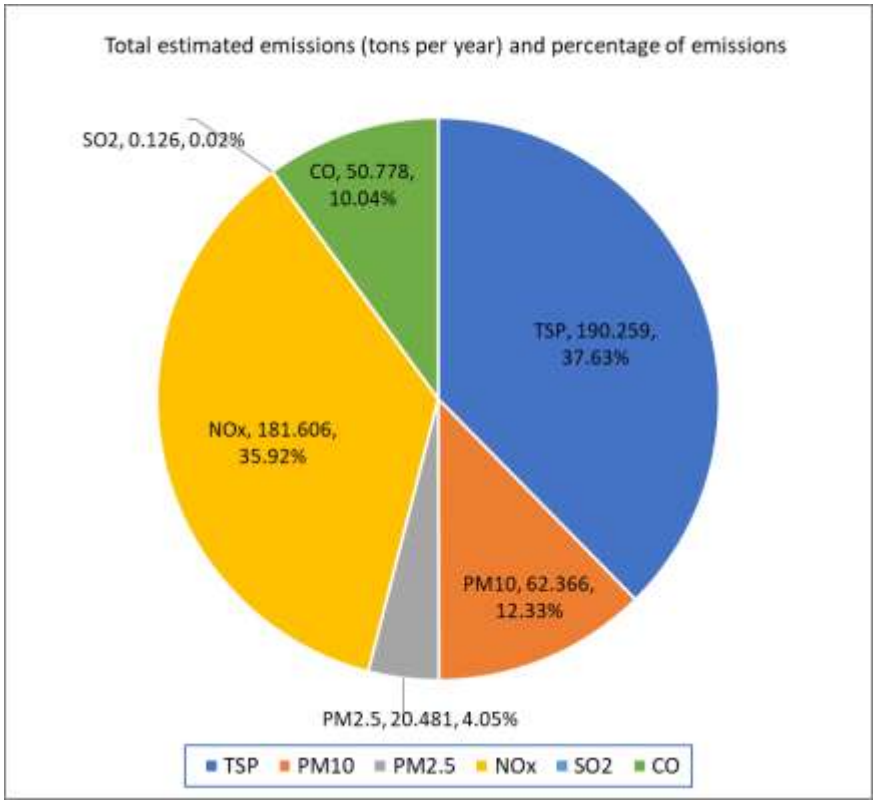
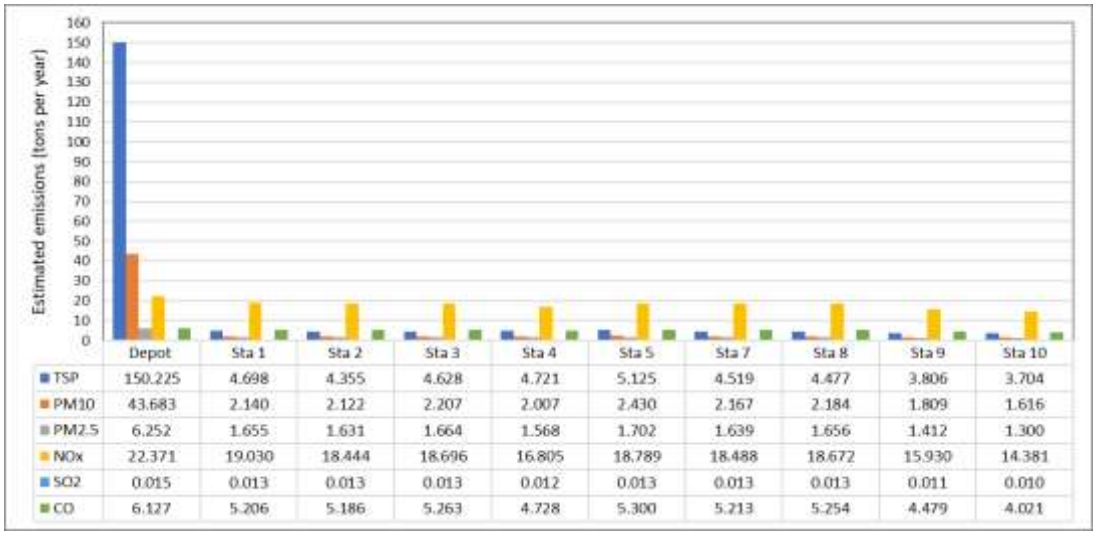



**Figure 2-42: Estimated Annual Emission Rates of TSP, $PM_{10}$, $PM_{2.5}$, $NO_X$, $SO_2$, and CO**




| | Depot | Sta 1 | Sta 2 | Sta 3 | Sta 4 | Sta 5 | Sta 7 | Sta 8 | Sta 9 | Sta 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| TSP | 150.225 | 4.698 | 4.355 | 4.628 | 4.721 | 5.125 | 4.519 | 4.477 | 3.806 | 3.704 |
| PM10 | 43.683 | 2.140 | 2.122 | 2.207 | 2.007 | 2.430 | 2.167 | 2.184 | 1.809 | 1.616 |
| PM2.5 | 6.252 | 1.655 | 1.631 | 1.664 | 1.568 | 1.702 | 1.639 | 1.656 | 1.412 | 1.300 |
| NOx | 22.371 | 19.030 | 18.444 | 18.696 | 16.805 | 18.789 | 18.488 | 18.672 | 15.930 | 14.381 |
| SO2 | 0.015 | 0.013 | 0.013 | 0.013 | 0.012 | 0.013 | 0.013 | 0.013 | 0.011 | 0.010 |
| CO | 6.127 | 5.206 | 5.186 | 5.263 | 4.728 | 5.300 | 5.213 | 5.254 | 4.479 | 4.021 |

**Figure 2-43: Estimated Annual Emission Rates of TSP, $PM_{10}$, $PM_{2.5}$, $NO_X$, $SO_2$, and CO Per Location/Activity**

2.3.2.1.3 Proposed Mitigation and Monitoring Program

a) Mitigating Measures

The implementing rules and regulations of the Philippine Clean Air Act (PCAA) of 1999 (or DAO 2000-81) specifies that reasonable measures shall be implemented to limit particulate emissions. As provided in DAO 2000-81, it is prohibited under DAO 2000-81 to emit fugitive particulates without taking reasonable precautions to prevent such emission. These sources include vehicular movement, transportation of materials, construction, demolition or wrecking or industry related activities such as loading, storing or “handling”. Hence, sources of fugitive emissions or particulates during construction works are subject to this provision.

Section 3(a), Rule XXV of DAO 2000-81) provides the following mitigation measures to control or limit emissions of fugitive particulates.

1) Use, where possible, of water or chemicals for control of dust from construction and quarrying or clearing of lands;
2) Application of water or suitable chemicals on roads, materials of stockpiles and other surface which create airborne dust problem; and
3) Installation and use of hood fans and fabric filters or any other suitable control devices to enclose and vent the handling of dusty materials. Adequate containment methods shall be employed during sandblasting or other similar operations.

Further, heavy equipment, trucks and other equipment that utilized diesel-engines shall also be regularly maintained to limit air emissions. Tailpipe emissions of motor vehicles used for the project shall also comply with the exhaust emission limits set in the implementing rules of the PCAA of 1999.

b) Environmental Compliance Monitoring

Section 1 (NAAQS), Rule XXVI of DAO 2000-81 (IRR of the PCAA) requres that air monitoring shall be done at the locations of highest expected concentration downwind of the emissions source. For this project, the expected highest dispersed air emissions are at households/residences in the vicinities of the proposed depot area. .

**RULE XXVI SOURCE SPECIFIC AMBIENT AIR QUALITY STANDARDS**

**Section 1. National Ambient Air Quality Standards**

For any industrial establishment or operation, the discharge of air pollutants that result in airborne concentrations in excess of the National Ambient Air Quality Standards shown in Table 3 shall not be permitted. Sampling shall be done at the location of highest expected concentration. Location shall be determined using dispersion modeling. Bureau-approved techniques shall be followed in developing sampling plans. For example, the Bureau's Air Quality Monitoring Manual specifies that sampling shall be done at an elevation of at least two (2) meters above the ground level, and shall be conducted either at the property line or at a downwind distance of five (5) to twenty (20) times the stack height, whichever is more stringent. However, the Bureau may approve the adoption of a different procedure in the choice of the location of the monitoring equipment depending upon the physical surrounding and other relevant factors in the area where the sampling is to be conducted.

It is highly recommended to conduct daily visual inspection of fugitive emissions at the project area during construction phase as results of ambient air monitoring using manual methods, i.e., high volume-gravimetric, will take time (takes few weeks to get the results. Hence,it may not be practical to establishing EQPLs and its corresponding action plan (alert, action, and limit).

In **Section 6,** the recommended air quality monitoring program is presented. It is also recommended to record the following during air sampling and/or fugitive dust monitoring.

a) Meteorological conditions/observations (wind speed, wind direction, air temperature, cloudiness, and rainfall); and

b) Sources of air emissions (project emissions and other sources of air emission in the area at the time of monitoring), including vehicles passing along the road.

2.3.2.2 Increase in Ambient Noise Level

Criteria for Assessment

The ambient noise standards were established by the then National Pollution Control Commission (NPCC) (now DENR) in 1978 and 1980. **Table 2-56** shows the Environmental Quality Standards for Noise in General Areas as specified in Table 1 of NPCC Memorandum Circular No. 002 series of 1980 (NPCC MC 1980-002).

**Table 2-56: Environmental Quality Standards for Noise in General Areas (NPCC MC 1980-002)**

| Category of Area | 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

For areas directly facing a public transportation route or an urban traffic artery, correction factors are indicated in the NPCC MC 1980-002.

Noise emissions may generate nuisance to noise sensitive receptors, such as residences and schools. Nuisance as defined in Article 694 of Republic Act No. 386 (Civil Code of the Philippines) is “any act, omission, establishment, business, condition of property, or anything else which annoys or offends the senses or injures or endangers the health and safety of others, or other effects as provided in Article 694. .

1) Injures or endangers the health or safety of others; or
2) Annoys or offends the senses; or
3) Shocks, defies or disregards decency or morality; or
4) Obstructs or interferes with the free passage of any public highway or street, or any body of water; or
5) Hinders or impairs the use of property.

As defined further in Article 695 of A 386, “nuisance is either public or private. A public nuisance affects a community or neighborhood or any considerable number of persons, although the extent of the annoyance, danger or damage upon individuals may be unequal. A private nuisance is one that is not included in the foregoing definition”

Noise Monitoring

Two (2) sets of baseline noise monitoring data are presented below. The first set is the noise data gathered in July 2018 and the second set on June 30 to July 4, 2019.

*July 2018 Noise Sampling*

During the feasibility stage of the project, noise level measurement was conducted to determine the existing noise levels at sensitive receptors in vicinities of the Project. Monitoring was conducted at 20 sampling stations on April 4, 2018 during daytime (0900H to 1800H) only **(Table 2-57**). On the descriptions of the locations of the sampling stations are presented in the report.

**Table 2-57: Location of Noise Sampling Stations and Date and Time of Monitoring**

| Station ID | Location |
|---|---|
| AN1 | Comembo, Brgy East Rembo |
| AN2 | Comembo, Brgy East Rembo |
| AN3 | 7th Ave. East Rembo |
| AN4 | East Rembo |
| AN5 | St. Francis Friendship Home Livelihood, West Rembo |
| AN6 | University of Makati |
| AN7 | Guadalupe Bliss (near condominiums) |
| AN8 | Guadalupe Bliss(near the river) |
| AN9 | Brgy. Poblacion cor Estrella |
| AN10 | Estrella |
| AN11 | F. Zobel St., Poblacion |
| AN12 | E. Zobel (near Makati City Hall) |
| AN13 | South Ave cor JP Rizal |
| AN14 | Trabaho |
| AN15 | Metropolitan Ave. |
| AN16 | Metropolitan Ave. (Near fire station) |
| AN17 | Paseo de Roxas |
| AN18 | Paseo de Roxas |
| AN19 | Ayala Station |
| AN20 | Ayala Station |
| Source: Philippine Infradev Holdings Inc., July 2018 | |

*June 30 to July 4, 2019*

Ambient noise monitoring was conducted at five (5) locations on June 30 to July 4, 2019 **(Table 2-58).** A Lutron sound level meter (SLM) (Model LM 8102) was used by BSI, Inc. to measure discrete sound levels at four (4) time periods for each station. The time periods are as follows:

- Morning - 5:00 A.M. to 9:00 A.M.
- Daytime – 9:00 A.M. to 6:00 P.M,
- Evening -6:00 P.M. to 10:00 P.M, and
- Nighttime - 10:00 P.M. to 5:00 A.M.

**Table 2-58: Locations of Noise Sampling Stations**

| Station | Location | GPS Coordinates | |
|---|---|---|---|
| | | Latitudes | Longitudes |
| N1 | Along J.P. Rizal Ext. between 25th Ave. and Sampaguita St. | 14°32'58"N | 121°03'49"E |
| N2 | Along Guadalupe Bliss Area | 14°33'58"N | 121°03'12"E |
| N3 | Between Camia & Estrella St. | 14°34'03"N | 121°02'20"E |
| N4 | JP Rizal Ave cor. F. Zobel | 14°34'09"N | 121°01'37"E |
| N5 | Near Junction of Ayala and Edsa | 14°33'03"N | 121°01'44"E |

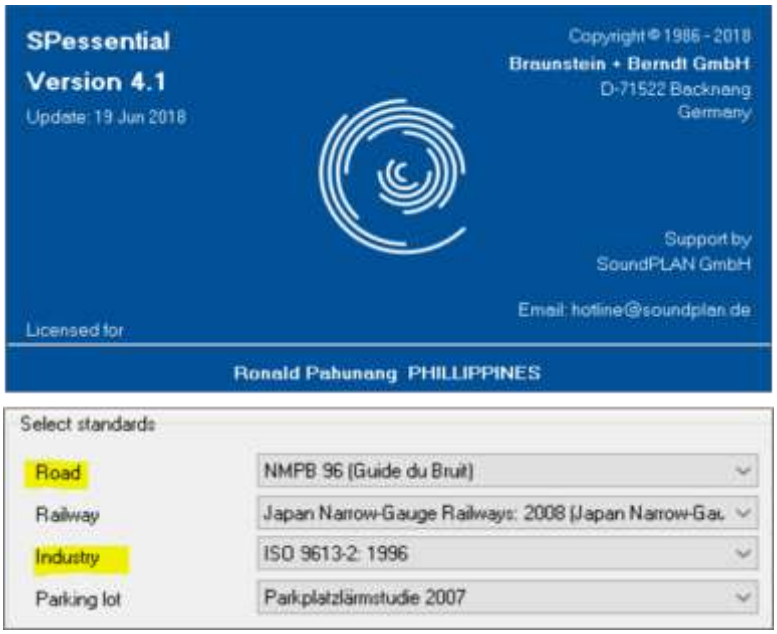
The procedure used in discrete noise monitoring followed that of Wilson (1989), in which at total of fifty (50) readings was recorded in order to increase the confidence limits of the data. Noise monitoring was done by recording in the data sheet the instantaneous noise reading that appeared in the noise meter display every ten (10) seconds until a total of fifty (50) readings was reached.

The procedure of Wilson (1989) was adopted in the monitoring as the time interval, duration of sampling, total data to be collected, and the method of analysis are not specified in NPCC (1978). As an example, NPCC (1978) provides that the median of the seven (7) maximum noise levels shall be compared with those of the ambient noise standards, however, it is not clear as to the total number of readings to be recorded and the duration of sampling.

Noise Modelling

*Noise Model*

SoundPlan noise model was used to determine the attenuated sound levels arising construction of the Project, particularly at the proposed depot area where large area will be developed for construction of buildings and related project facilities. SoundPlan is capable of modelling noise emissions from roads, railways, and industrial facilities.



SoundPlan implements ISO 9613-2 (*Acoustics – Attenuation of sound during propagation outdoors. Part 2: General Method of Calculation)* on modelling noise emissions from industrial facilities. ISO 9613-2 specifies an engineering method to calculate attenuation of sound as emitted outdoors from various types of sources, i.e., industrial noise sources and construction activities and other point (stationary or moving points sources). The following factors are included in ISO 9613-2.

- Directivity of the source (or the orientation of the source);
- geometrical divergence or travel of sound with distance,
- atmospheric absorption,
- ground effect,
- barrier, and
- miscellaneous sources, such as foliage of trees and shrubs, industrial sites, and clusters of houses or buildings.

*Technical Description of ISO 9613-2*

Sound pressure level, $L_{AT}$, in decibels, is defined in ISO 9613-2 by the equation,

$$L_{AT} = 10\log\left\{\left[(\gamma T)\int_0^T {\rho_A}^2(t)d_t\right]/{\rho_0}^2\right\} \quad dB$$

where

$\rho_A{}^{(t)}$ = the instantaneous A-weighted sound, in pascals;
$\rho_0$ = the reference sound pressure (= 20 x $10^{-6}$ Pa);
$T$ = specified time interval, in seconds

The A-frequency weighting is that specified of sound level in in IEC 651.

The equivalent continuous downwind octave-band sound pressure level, $L_{fT}$(DW), is defined by:

$$L_{ft}(DW) = 10log\left\{\left[(\gamma T)\int_0^T p_f^2(t)dt\right]/p_o^2\right\}dB$$

where $p_f$ *(t)* is the instantaneous octave-band sound pressure downwind, in pascals, and the subscript *f* represents a nominal midband frequency of an octave-band filter.

The equivalent continuous downwind octave-band sound pressure level at a receiver location, $L_{fT}$(DW), shall be calculated for each point source, and its image sources, and for the eight octave bands with nominal midband frequencies from 63 Hz to 8 kHz.

$$L_{fT}(DW) = L_W + D_c - A$$

Where:

$L_W$ is the octave-band sound power level, in decibels, produced by the point sound source relative to a reference sound power of one picowatt (1 pW);
$D_C$ is the directivity correction, in decibels, that describes the extent by which the equivalent continuous sound pressure level from the point sound source deviates in a specified

direction from the level of an omnidirectional point sound source producing sound power level $L_W$; $D_C$ equals the directivity index $D_I$ of the point sound source plus an index $D_\Omega$ that accounts for sound propagation into solid angles less than 4π steradians; for an omnidirectional point sound source radiating into free space, $D_C$ = 0 dB;

*A* is the octave-band attenuation, in decibels, that occurs during propagation from the point sound source to the receiver.

The attenuation term *A* is given by equation (4):

$$A = A_{div} + A_{atm} + A_{gr} + A_{bar} + A_{misc}$$

where

$A_{div}$ is the attenuation due to geometrical divergence;
$A_{atm}$ is the attenuation due to atmospheric absorption;
$A_{gr}$ is the attenuation due to the ground effect;
$A_{bar}$ is the attenuation due to a barrier; and
$A_{misc}$ is the attenuation due to miscellaneous other effects

General methods for calculating the first four termsare specified in this part of ISO 9613. Information on three contributions to the last term, $A_{misc}$ (the attenuation due to the propagation through foliage, industrial, sites and areas of houses) are provided in the annex of the specified method. .

The equivalent continuous A-weighted downwind sound pressure level shall be obtained by summing the contributing time-mean-square sound pressures for each point sound source, for each of their image sources, and for each octave band, as: :

$$L_{AT}(DW) = 10\log\left\{\sum_{i=1}^{n}\left[\sum_{j=1}^{8} 10^{0.1\left[L_{fT}(ij)+A_f(j)\right]}\right]\right\}$$

where

*n* is the number of contributions *i*(sources and paths);
*j* is an index indicating the eight standard octave-band midband frequencies from 63 Hz to 8kHz;
$A_f$ denotes the standard A-weighting (see IEC 651)

The long-term average A-weighted sound pressure level $L_{AT}$(LT) shall be calculated to

$$L_{AT}(LT) = L_{AT}(DW) - Cmet$$

where $C_{met}$ is the meteorological correction described in clause 8.

*Model Set-up*

Model set-up involved the following process:

a) Determination of the modelling domain or calculation area, which focused on the proposed depot area and immediate vicinities, and digitization of houses, buildings, and other structures within the modelling domain,
b) Processing of topographical data based from Shuttle Radar Topography Mission (SRTM) data;

c) Estimation of sound power levels and its location relative to the modelling domain

d) Processing of other input data, such as ground reflection, meteorology, calculation grid points, and receptors locations.

**Figure 2-44** to **Figure 2-46** shows the screenshots of the initial model set-up.


**Figure 2-44: Screenshot of Digitized Houses, Buildings, and other Structures within the Modelling Domain**

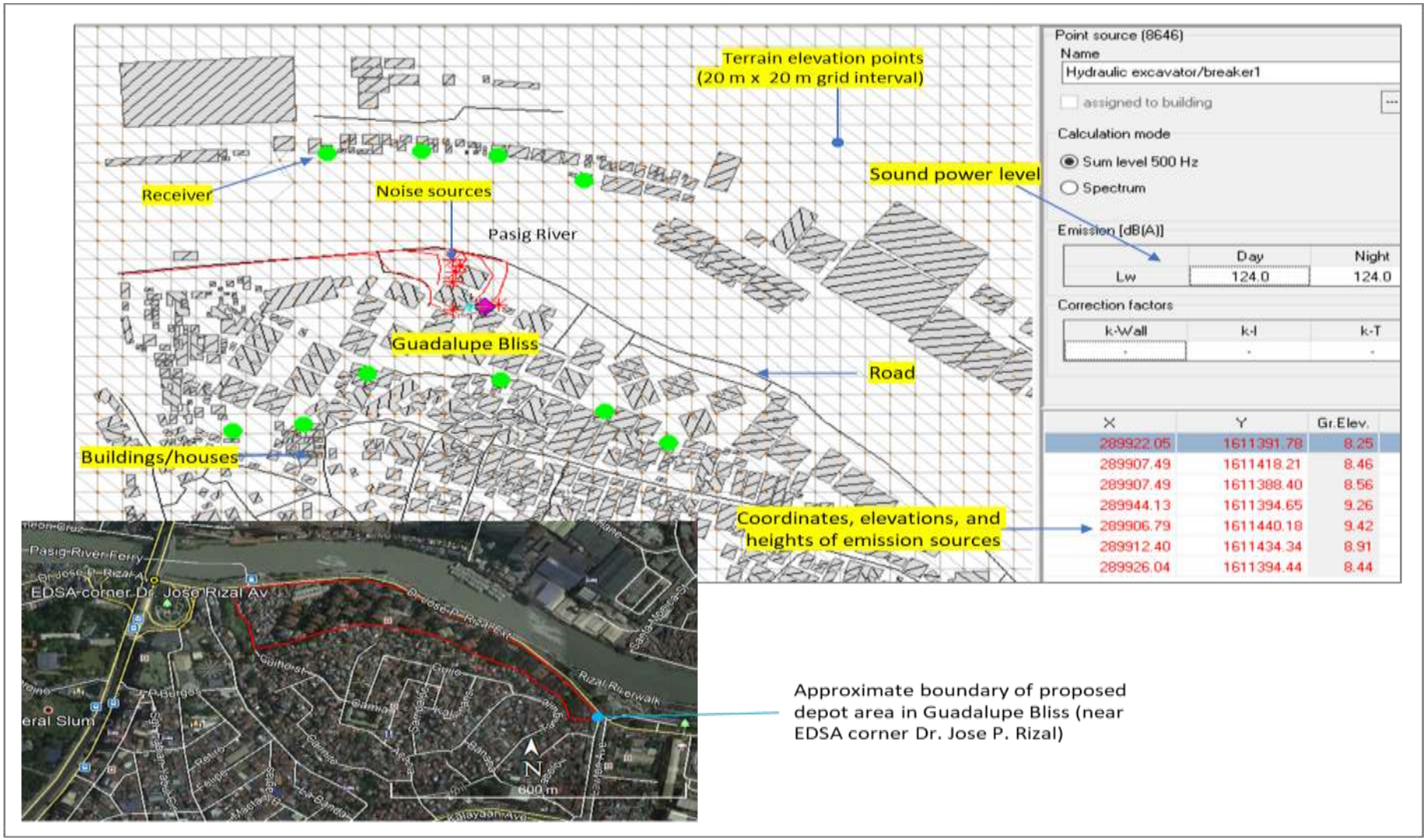



**Figure 2-45. Screenshot of Buildings, Roads, Topography, and Building Information in Soundplan**

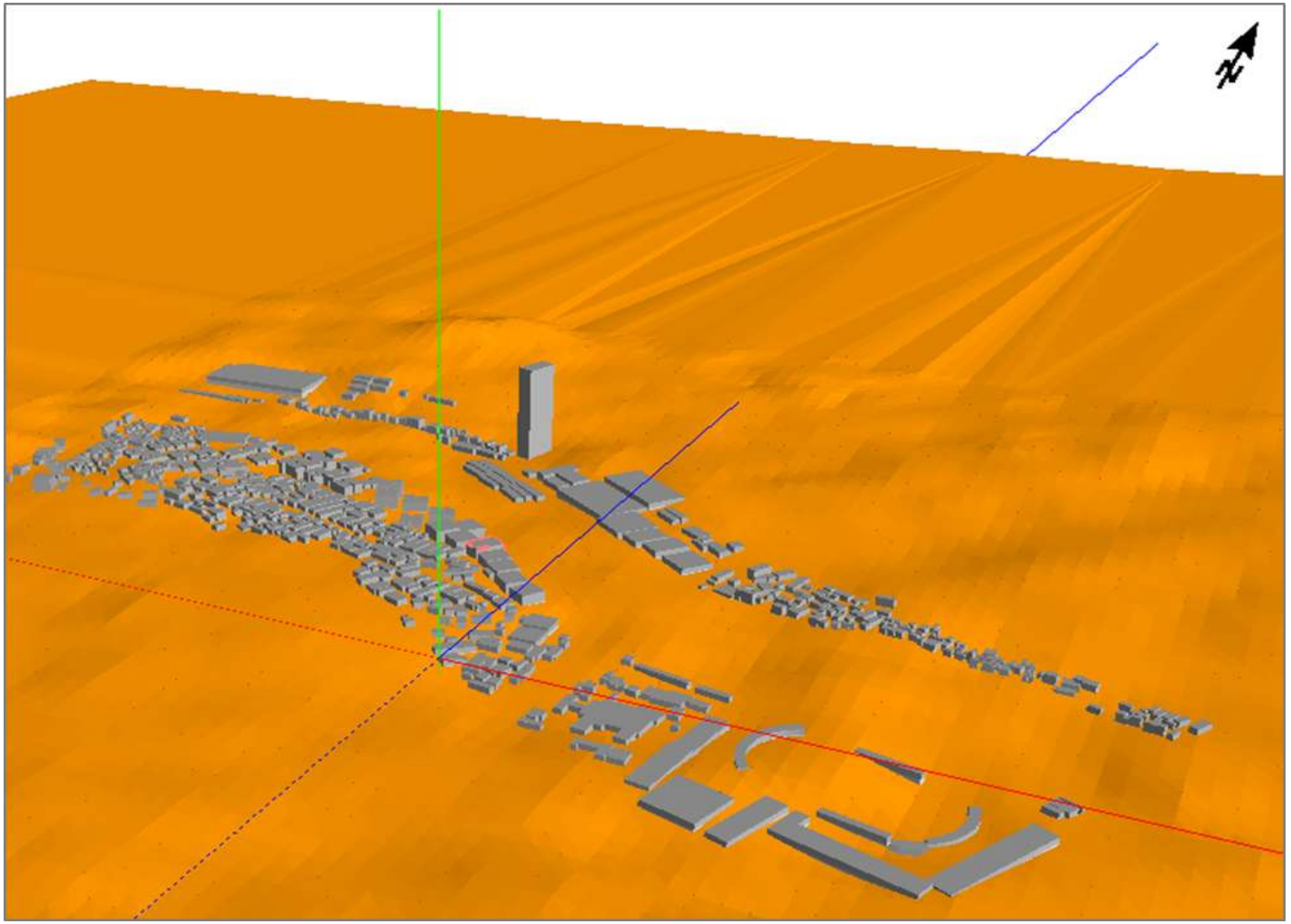


**Figure 2-46: Three-Dimensional View of Households, Buildings, and Structures within the Modelling Domain**

2.3.2.2.1 Background Ambient Noise Levels

**Table 2-59** shows the result of the noise level sampling conducted on April 4, 2018. The results show that ambient noise levels at 20 sampling stations were higher than the ambient daytime noise standards, even if a corrector factor of +10 dBA was included. The highest noise level (88.4 dBA) was recorded at Paseo de Roxas (Station AN17) while the lowest (75.8 dBA) was at Guadalupe Bliss(near the river) (Station AN8).

Sources of noise at the time of monitoring were generally from vehicles passing at the area.

**Table 2-59: Result of Noise Level Monitoring (April 4, 2018)**

| Station ID | Location | Area Category | Noise Level (dBA) | NPCC Noise Standards for Daytime (dBA)* |
|---|---|---|---|---|
| AN1 | Comembo, Brgy East Rembo | B | 77.5 | 65 |
| AN2 | Comembo, Brgy East Rembo | B | 79.2 | 65 |
| AN3 | 7th Ave. East Rembo | B | 80.6 | 65 |
| AN4 | East Rembo | B | 82.9 | 65 |
| AN5 | St. Francis Friendship Home Livelihood, West Rembo | AA | 77.5 | 50 |
| AN6 | University of Makati | AA | 81.8 | 50 |
| AN7 | Guadalupe Bliss (near condominiums) | B | 79.9 | 65/55** |
| AN8 | Guadalupe Bliss (near the river) | B | 75.8 | 65 |
| AN9 | Brgy. Poblacion cor Estrella | B | 81.7 | 65 |
| AN10 | Estrella | B | 83.0 | 65 |
| AN11 | F. Zobel St., Poblacion | B | 86.9 | 65 |
| AN12 | E. Zobel (near Makati City Hall) | B | 77.5 | 65 |
| AN13 | South Ave cor JP Rizal | B | 86.0 | 65 |
| AN14 | Trabaho | B | 76.7 | 65 |
| AN15 | Metropolitan Ave. | B | 87.6 | 65 |
| AN16 | Metropolitan Ave. (Near fire station) | B | 78.1 | 65 |
| AN17 | Paseo de Roxas | B | 88.4 | 65 |
| AN18 | Paseo de Roxas | B | 78.1 | 65 |
| AN19 | Ayala Station | B | 77.5 | 65 |
| AN20 | Ayala Station | B | 80.2 | 65 |

Source:Philippine Infradev Holdings Inc., July 2018
*Correction factors of +5 or +10 dBA ma apply at these areas (per NPCC 1980)
**Ambient noise standard for areas primarily used for residential purposes .

**Table** 2-60 shows the results of ambient noise monitoring conducted by BSI, Inc. Measured noise levels were from 59 to 75 dBA. The highest noise level (75 dBA) was measured at two locations (Station N24-2 and N24-3) in the evening and morning periods. “Rush hours” in Metro Manila are within the evening and nighttime periods. At nighttime, noise levels appear lower at three (3) stations (Station N24-1, N24-2, and N24-3), except at Station N2-4 in which noise levels were from 70 to 73 dBA – the highest of which occurred in the evening and nighttime at 73 dBA and the lowest in the morning at 70 dBA.

In comparison with the NPCC ambient noise standards, measured noise levels were higher than the noise standard, if no correction factor was applied at the noise standard per time period. If + 10dBA is added (correction factor for areas facing directly a 4 or more lanes), then some locations at varying time periods were within standard, as follows:

- N24-1 (Along J.P. Rizal Ext. between 25th Ave. and Sampaguita St) -daytime, evening, and nighttime;
- N24-2 (along Guadalupe Bliss Area) - morning, daytime, and nighttime;
- N24-3 (between Camia and Estrella St) – daytime and nighttime; and
- N24-4 (J.P. Rizal Ave cor. F. Zobel) – morning, daytime, and evening

Sources of noise at the time of monitoring were from passing vehicles, as presented in **Table 2-61**.

**Table 2-60.Results of Ambient Noise Level Monitoring on June 30 to July 4, 2019**

| Station | Location | Date / Time of Sampling | Period | Noise Level (dBA) | Noise Standard |
|---|---|---|---|---|---|
| ***N24-1*** | Along J.P. Rizal Ext. between 25th Ave. and Sampaguita St. | July 01, 2019 / 0600H-0610H | Morning | 72 | **60** |
| | | June 30, 2019 / 1030H-1040H | Daytime | 71 | **65** |
| | | June 30, 2019 / 1900H-1910H | Evening | 63 | **60** |
| | | June 30, 2019 / 2205H-2215H | Nighttime | 59 | **55** |
| ***N24-2*** | Along Guadalupe Bliss Area* | July 02, 2019 / 0550H-0600H | Morning | 68 | **60** |
| | | July 01, 2019 / 1301H-1311H | Daytime | 68 | **65** |
| | | July 01, 2019 / 1827H-1837H | Evening | **75** | **60** |
| | | July 01, 2019 / 2224H-2234H | Nighttime | 64 | **55** |
| ***N24-3*** | Between Camia and Estrella St. | July 03, 2019 / 0550H-0600H | Morning | **75** | **60** |
| | | July 02, 2019 / 1206H-1216H | Daytime | 71 | **65** |
| | | July 02, 2019 / 2018H-2028H | Evening | **75** | **60** |
| | | July 02, 2019 / 2212H-2222H | Nighttime | 65 | **55** |
| ***N24-4*** | J.P. Rizal Ave cor. F. Zobel | July 04, 2019 / 0714H-0724H | Morning | 70 | **60** |
| | | July 04, 2019 / 1200H-1210H | Daytime | 71 | **65** |
| | | July 03, 2019 / 2034H-2044H | Evening | 73 | **60** |

| Station | Location | Date / Time of Sampling | Period | Noise Level (dBA) | Noise Standard |
|---|---|---|---|---|---|
| | | July 03, 2019 / 2206H-2216H | Nighttime | 73 | **55** |

*[B] Class B – defined as a section or contiguous area which is primarily a commercial area.*
*Note: For areas directly facing a public transportation route, a correction factor is added to the applicable standard by: +10 dBA (if the area is facing a four-lane or wider road)*
**Sampling station was located on the other side of the road facing Guadalupe Bliss*

**Table 2-61.Primary Sources of Noise**

| Station | Location | Period | Sources of Noise |
|---|---|---|---|
| ***N24-1*** | Along J.P. Rizal Ext. between 25th Ave. and Sampaguita St. | Morning | Passing vehicles |
| | | Daytime | Continuous passing vehicles |
| | | Evening | |
| | | Nighttime | |
| ***N24-2*** | Along Guadalupe Bliss Area | Morning | Continuous passing vehicles |
| | | Daytime | Continuous passing vehicles, horn blowing and conversing people |
| | | Evening | Continuous passing vehicles, idling vehicle, horn blowing and conversing people |
| | | Nighttime | Continuous passing vehicles |
| ***N24-3*** | Between Camia and Estrella St. | Morning | Continuous passing vehicles and conversing people |
| | | Daytime | Continuous passing vehicles |
| | | Evening | Continuous passing vehicles and conversing people |
| | | Nighttime | Continuous passing vehicles |
| ***N24-4*** | J.P. Rizal Ave cor. F. Zobel | Morning | Continuous passing and idling of vehicle and conversing people |
| | | Daytime | Continuous passing vehicles, horn blowing and idling of vehicle and conversing people |
| | | Evening | Continuous passing vehicles and conversing people |
| | | Nighttime | Continuous passing vehicles |

2.3.2.2.2 Predicted Noise Levels

Noise modelling was performed using the ISO 9613-2 module of SoundPLAN. Noise modelling focused at the proposed depot area because of the expected high noise levels emanating from demolition works and other construction activities, i.e., tunneling, construction of buildings.

Demolition works assumed used of several heavy equipment, e.g., hydraulic breakers, including trucks to haul the debris.

**Figure 2-47** shows the list of equipment and the corresponding frequency spectrum, which were obtained from SoundPlan library. Note that frequency spectra were assumed equal for the daytime and nighttime. This assumed continuous operation of the heavy equipment within the 24-hour period.

Further, only daytime and nighttime periods corresponding to time periods established by the IFC and World Bank Group (EHS Guidelines on Noise Management) or from 7:00 A.M. to 10:00 P.M. and 10:00 P.M. to 7:00 A.M., respectively, were considered because the guideline (IFC WB Group) specifies equivalent noise levels similar to those required of the international standard (ISO 9613-2). Our local standards (NPCC 1978) specify median of seven (7) highest noise readings while ISO 9613-2 and the IFC World Bank Group specify equivalent noise levels ($L_{eq}$).

Two (2) modelling scenarios were performed for the study. The first scenario assumed an initial construction phase in which buildings near Pasig River at the proposed depot were the first to be demolished (please refer **Figure 2-45** and **Figure 2-48 ).** The second scenario assumed that construction works progressed or moved southward going near residences south of the proposed depot area (**Figure 2-51**).

Results depicted in **Figure 2-48** (initial construction phase at depot area) show that high noise levels (70.5 to 76 dBA) were simulated across Pasig River where residences/receptors (Receptors 1, 2, 3 and 4) are located. At receptors/residences south the proposed depot area (Receptor 5 to 10), relatively lower noise levels were simulated because of the blocking effects of the buildings between the equipment (noise sources) and the receptors. **Figure 2-49** shows that the Guadalupe Bliss buildings acted as noise barriers, though reflections of noise at walls of buildings contributed to increase of noise levels.

As construction/demolition works progressed southward of the proposed depot area, noise levels apparently increased at receptors close to the source (Receptors 5 to 10) (**Figure 2-51**). Across Pasig River, predicted noise levels slightly decreased due to increase in distance of the noise sources. **Figure 8** shows that if construction works will proceed at nighttime, then the whole area south of the proposed depot will experience high noise levels greater than 45 and 55 dBA for nighttime and daytime noise standards, respectively.

Assuming higher background nighttime noise level of 64 dBA at Guadalupe Bliss Area **(Table 2-60),** adding the predicted noise level of 90.8 dBA (Receptor 7) and 73.4 dBA (Receptor 6) in **Table 2-51** will result to significant increase of noise levels in the area equivalent or slightly higher than the predicted noise level.

Project settings | Editor | Emission table | Result table | Graphic plot

Industry

| Source name | Refe | Level | Frequency spectrum [dB(A)] | | | | | | | | | | | | | | | | | | | | | | | | | | | Corrections | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 | 800 | 1 | 1.3 | 1.6 | 2 | 2.5 | 3.2 | 4 | 5 | 6.3 | 8 | 10 | 12.5 | 16 | 20 | Cw | CI | CT |
| | | | Hz | Hz | Hz | Hz | Hz | Hz | Hz | Hz | Hz | Hz | Hz | Hz | Hz | kHz | kHz | kHz | kHz | kHz | kHz | kHz | kHz | kHz | kHz | kHz | kHz | kHz | kHz | dB( | dB( | dB( |
| Hydraulic exca | Lw/U | Day | 124 | | | | | | | | | | | | | | | | | | | | | | | | | | | - | - | - |
| | | Nig | 124 | | | | | | | | | | | | | | | | | | | | | | | | | | | - | - | - |
| Hydraulic exca | Lw/U | Day | 124 | | | | | | | | | | | | | | | | | | | | | | | | | | | - | - | - |
| | | Nig | 124 | | | | | | | | | | | | | | | | | | | | | | | | | | | - | - | - |
| Dozer | Lw/U | Day | 124 | - | 89 | 93 | 105 | 108 | 111 | 102 | 104 | 107 | 108 | 110 | 111 | 115 | 120 | 121 | 119 | 119 | 119 | 112 | 112 | 112 | 105 | 104 | - | - | - | - | - | - |
| | | Nig | 124 | - | 89 | 93 | 105 | 108 | 111 | 102 | 104 | 107 | 108 | 110 | 111 | 115 | 120 | 121 | 119 | 119 | 119 | 112 | 112 | 112 | 105 | 104 | - | - | - | - | - | - |
| Dozer2 | Lw/U | Day | 124 | - | 89 | 93 | 105 | 108 | 111 | 102 | 104 | 107 | 108 | 110 | 111 | 115 | 120 | 121 | 119 | 119 | 119 | 112 | 112 | 112 | 105 | 104 | - | - | - | - | - | - |
| | | Nig | 124 | - | 89 | 93 | 105 | 108 | 111 | 102 | 104 | 107 | 108 | 110 | 111 | 115 | 120 | 121 | 119 | 119 | 119 | 112 | 112 | 112 | 105 | 104 | - | - | - | - | - | - |
| Truck6 | Lw/U | Day | 79 | 41 | 44 | 48 | 58 | 59 | 59 | 59 | 61 | 61 | 62 | 65 | 68 | 67 | 69 | 71 | 70 | 68 | 69 | 66 | 63 | 62 | 61 | 57 | 52 | 50 | 47 | 43 | - | - | - |
| | | Nig | 79 | 41 | 44 | 48 | 58 | 59 | 59 | 59 | 61 | 61 | 62 | 65 | 68 | 67 | 69 | 71 | 70 | 68 | 69 | 66 | 63 | 62 | 61 | 57 | 52 | 50 | 47 | 43 | - | - | - |
| Truck7 | Lw/U | Day | 79 | 41 | 44 | 48 | 58 | 59 | 59 | 59 | 61 | 61 | 62 | 65 | 68 | 67 | 69 | 71 | 70 | 68 | 69 | 66 | 63 | 62 | 61 | 57 | 52 | 50 | 47 | 43 | - | - | - |
| | | Nig | 79 | 41 | 44 | 48 | 58 | 59 | 59 | 59 | 61 | 61 | 62 | 65 | 68 | 67 | 69 | 71 | 70 | 68 | 69 | 66 | 63 | 62 | 61 | 57 | 52 | 50 | 47 | 43 | - | - | - |
| Loader1 | Lw/U | Day | 116 | - | - | - | - | - | - | - | - | - | 116 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Nig | 116 | - | - | - | - | - | - | - | - | - | 116 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Loader2 | Lw/U | Day | 116 | - | - | - | - | - | - | - | - | - | 116 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Nig | 116 | - | - | - | - | - | - | - | - | - | 116 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Truck1 | Lw/U | Day | 79 | 41 | 44 | 48 | 58 | 59 | 59 | 59 | 61 | 61 | 62 | 65 | 68 | 67 | 69 | 71 | 70 | 68 | 69 | 66 | 63 | 62 | 61 | 57 | 52 | 50 | 47 | 43 | - | - | - |
| | | Nig | 79 | 41 | 44 | 48 | 58 | 59 | 59 | 59 | 61 | 61 | 62 | 65 | 68 | 67 | 69 | 71 | 70 | 68 | 69 | 66 | 63 | 62 | 61 | 57 | 52 | 50 | 47 | 43 | - | - | - |
| Truck2 | Lw/U | Day | 79 | 41 | 44 | 48 | 58 | 59 | 59 | 59 | 61 | 61 | 62 | 65 | 68 | 67 | 69 | 71 | 70 | 68 | 69 | 66 | 63 | 62 | 61 | 57 | 52 | 50 | 47 | 43 | - | - | - |
| | | Nig | 79 | 41 | 44 | 48 | 58 | 59 | 59 | 59 | 61 | 61 | 62 | 65 | 68 | 67 | 69 | 71 | 70 | 68 | 69 | 66 | 63 | 62 | 61 | 57 | 52 | 50 | 47 | 43 | - | - | - |
| Truck3 | Lw/U | Day | 79 | 41 | 44 | 48 | 58 | 59 | 59 | 59 | 61 | 61 | 62 | 65 | 68 | 67 | 69 | 71 | 70 | 68 | 69 | 66 | 63 | 62 | 61 | 57 | 52 | 50 | 47 | 43 | - | - | - |
| | | Nig | 79 | 41 | 44 | 48 | 58 | 59 | 59 | 59 | 61 | 61 | 62 | 65 | 68 | 67 | 69 | 71 | 70 | 68 | 69 | 66 | 63 | 62 | 61 | 57 | 52 | 50 | 47 | 43 | - | - | - |
| Truck4 | Lw/U | Day | 79 | 41 | 44 | 48 | 58 | 59 | 59 | 59 | 61 | 61 | 62 | 65 | 68 | 67 | 69 | 71 | 70 | 68 | 69 | 66 | 63 | 62 | 61 | 57 | 52 | 50 | 47 | 43 | - | - | - |
| | | Nig | 79 | 41 | 44 | 48 | 58 | 59 | 59 | 59 | 61 | 61 | 62 | 65 | 68 | 67 | 69 | 71 | 70 | 68 | 69 | 66 | 63 | 62 | 61 | 57 | 52 | 50 | 47 | 43 | - | - | - |
| Truck5 | Lw/U | Day | 79 | 41 | 44 | 48 | 58 | 59 | 59 | 59 | 61 | 61 | 62 | 65 | 68 | 67 | 69 | 71 | 70 | 68 | 69 | 66 | 63 | 62 | 61 | 57 | 52 | 50 | 47 | 43 | - | - | - |
| | | Nig | 79 | 41 | 44 | 48 | 58 | 59 | 59 | 59 | 61 | 61 | 62 | 65 | 68 | 67 | 69 | 71 | 70 | 68 | 69 | 66 | 63 | 62 | 61 | 57 | 52 | 50 | 47 | 43 | - | - | - |

**Figure 2-47: Sound Power Level/Spectrum of Noise Sources**

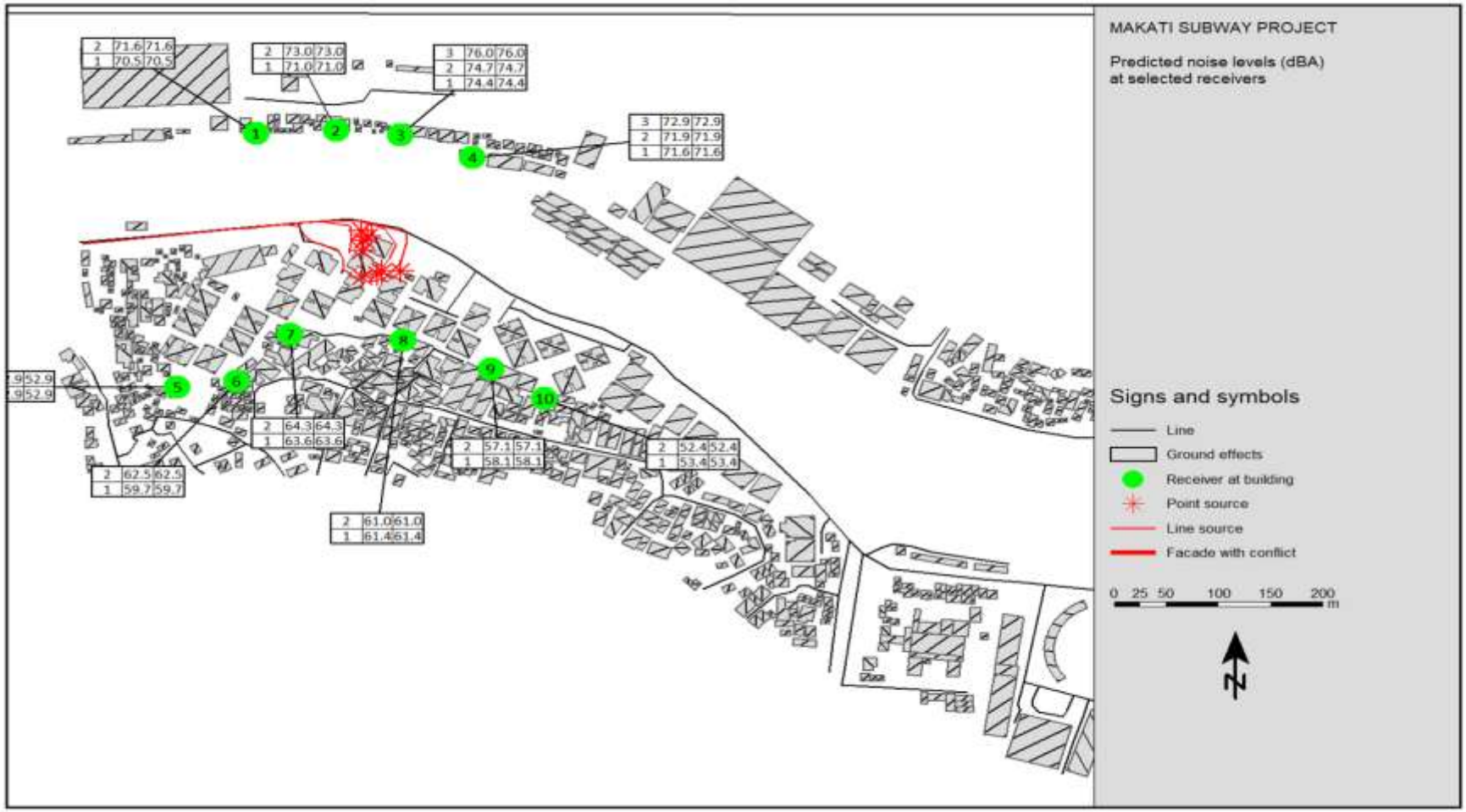



**Figure 2-48: Predicted Noise Levels at the Receiver Points (Initial Demolition Works)**

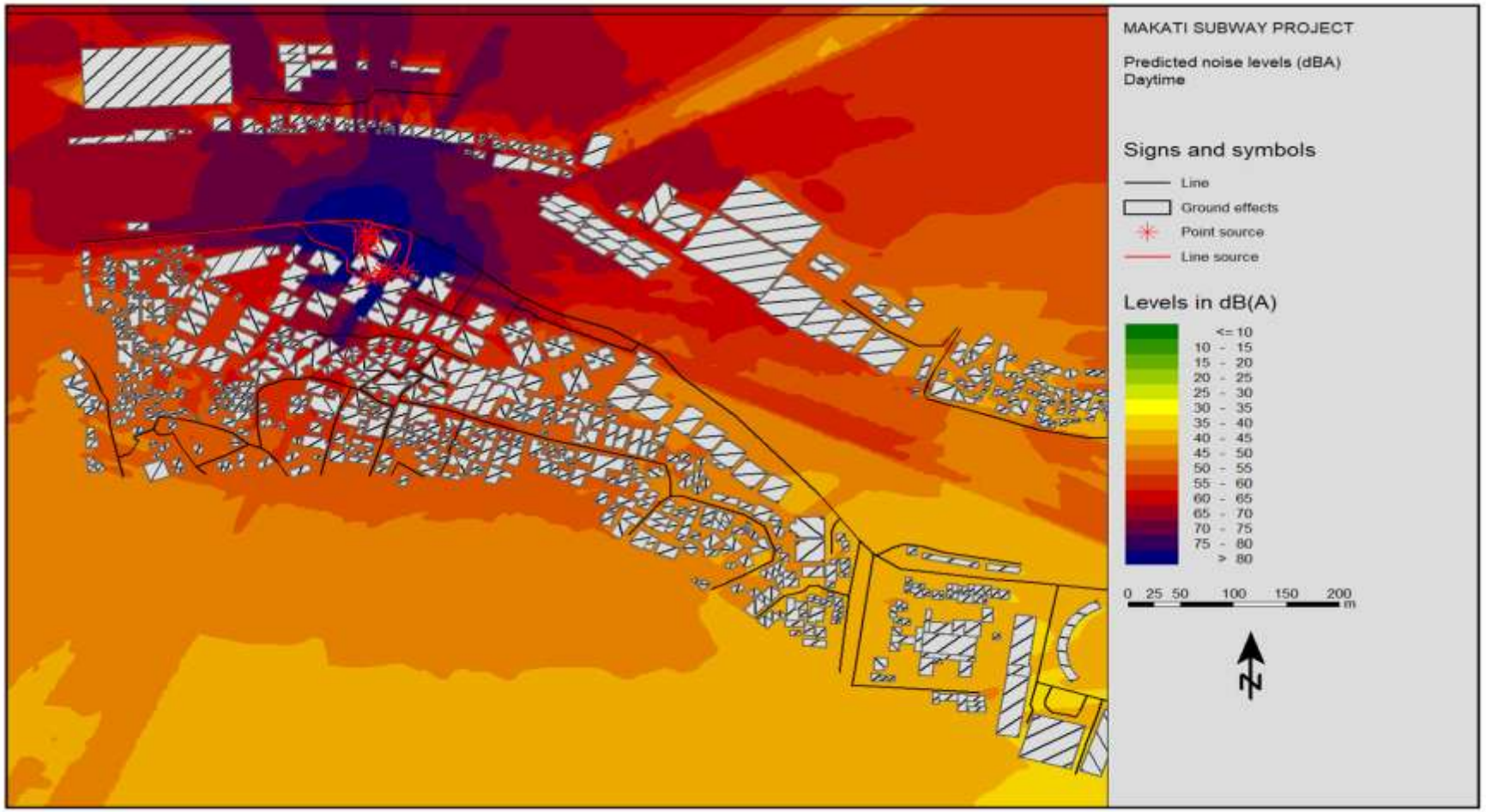



**Figure 2-49: Predicted Daytime Equivalent Noise Levels (Initial Demolition Works)**

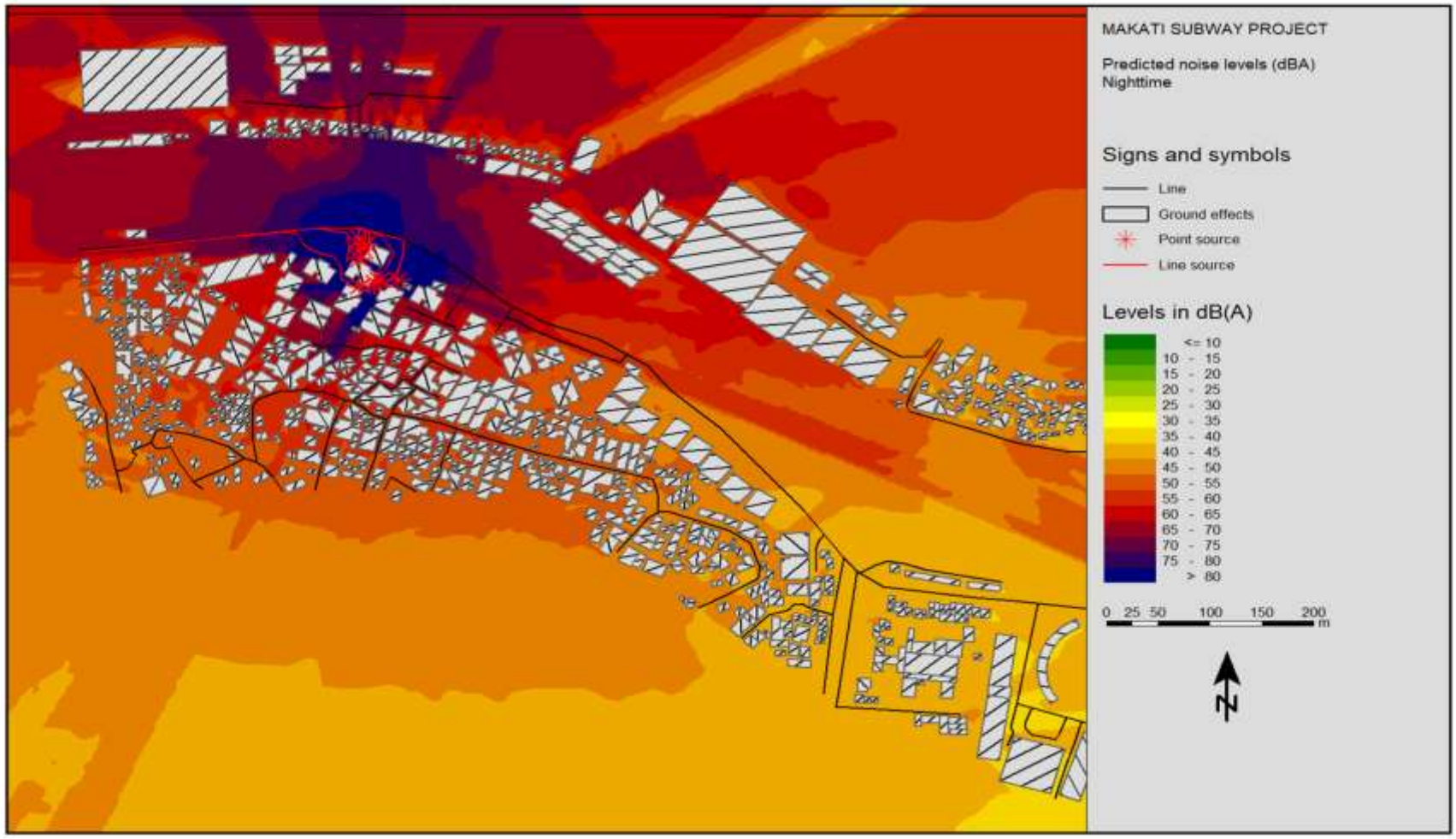



**Figure 2-50: Predicted Nighttime Equivalent Noise Levels (Initial Demolition Works)**

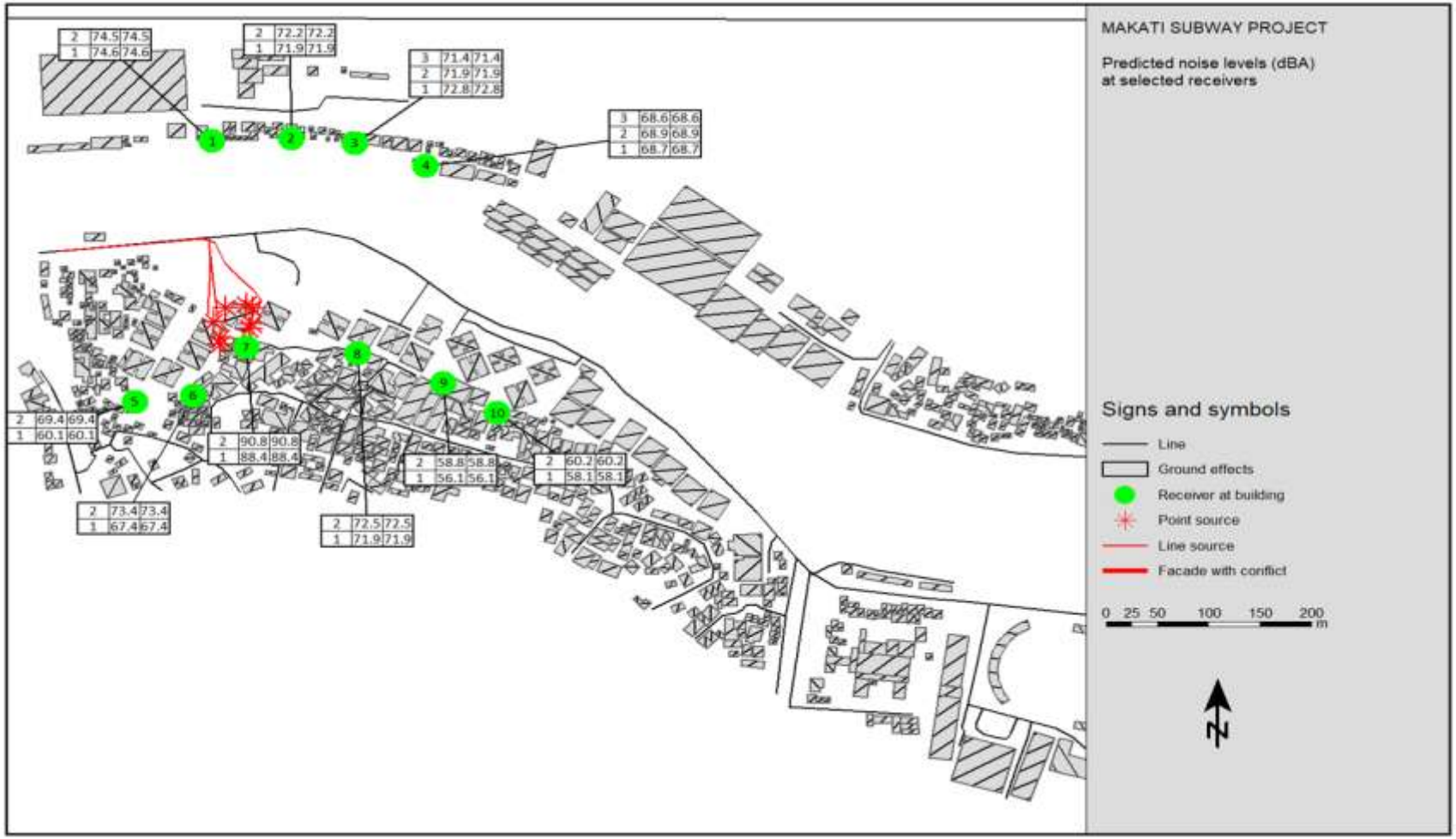



**Figure 2-51: Predicted Noise Levels at Selected Receiver Points (Subsequent Phase of Demolition Works)**

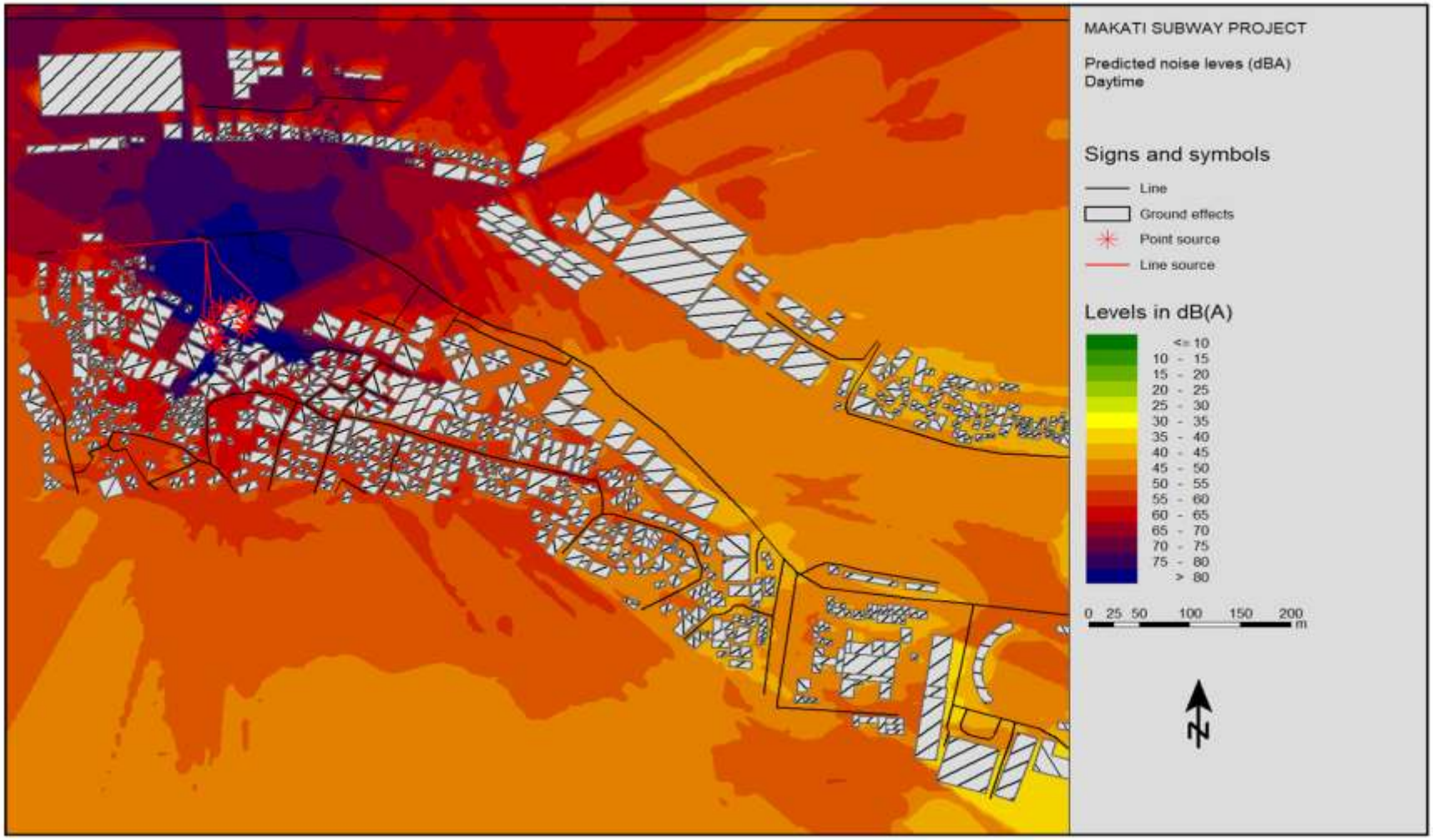



**Figure 2-52: Predicted Daytime Equivalent Noise Levels (Subsequent Phase of Demolition Works)**

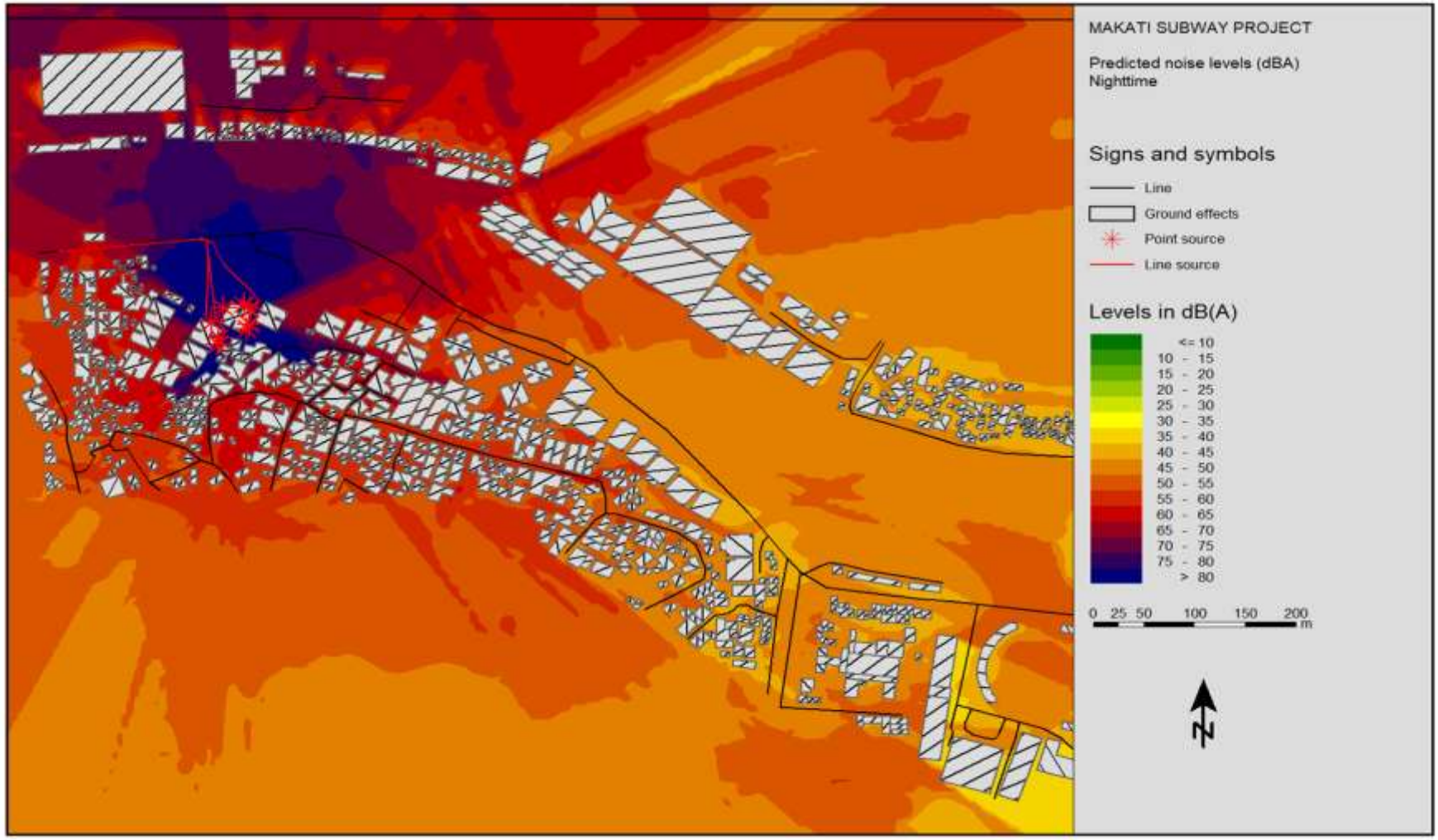



**Figure 2-53: Predicted Nighttime Equivalent Noise Levels (Subsequent Phase of Demolition Works**

#### 2.3.2.2.3 Mitigating Measures and Monitoring Program

Construction of the project is expected to generate high noise levels particularly at receptors near the proposed depot area. Mitigation measures should be implemented to avoid disturbance to nearby residents and other receptors in vicinities of the project. Mitigation measures should include the following:

1) Installation of effective or appropriate mufflers at tailpipes of mobile equipment and generator sets
2) Reduction on the number of operating equipment, particularly during nighttime and early morning/evening periods
3) Strictly impose speed limits at access roads and within the project area.
4) Provision partial or total enclosure of high noise sources, if practicable as possible.
5) Limit high noise generating activities, i.e., demolition work, during daytime

If construction during nighttime or early evening is necessary, residents and local government units (LGUs) who have jurisdiction of the area should be informed of the said activity. Consequently, adequate control measures, i.e., provision of partial or total enclosure of high noise sources, should be implemented to reduce nighttime noise levels. If possible, however, construction works, particularly demolition works should be conducted during daytime.

In any project activity, noise emissions from the project should not cause nuisance to residents and other receptors in vicinities of the project site. Nuisance as defined in Article 694 of Republic Act No. 386 (Civil Code of the Philippines) is “any act, omission, establishment, business, condition of property, or anything else whichannoys or offends the senses or injures or endangers the health and safety of others, or other effects as provided in Article 694.

## 2.4 People

### 2.4.1 Summary of Demographic Data

#### 2.4.1.1 Methodology

This section will present an assessment of the socio-economic impacts on the communities and the City at large, along the proposed alignment of the Makati Public Rail Transport System (the “Project”). The assessment is based on the People Module of the Technical Scoping Checklist agreed upon by the Environmental Management Bureau Central (EMB Central), the EIA Review Committee and Philippine Infradev Holdings, Inc., which is based on the guidelines set by PD 1586 Philippine Environmental Impact Statement System, DENR DAO 30-2003 Revised Procedural Manual, and DENR MC 005-14 Revised Guidelines for Coverage Screening and Standardized Requirements.

Others sections of this study have focused on the geophysical, biological, and environmental conditions that are present in the vicinity of the Project, this section will delve into the impact the Project may have on the population of the host communities, the livelihoods of those residing in the impact barangays, their access to basic services and how the people are able to meet their minimum basic needs. Measures, both mitigative: of possible negative impacts; and designed to enhance programs already in place, will be suggested for implementation subject to the Environmental Management Bureau’s (EMB) Assessment Review Process, of which this submission is part and parcel of, and the Proponent’s own assessment of feasibility for implementation.

A baseline profile of the fourteen impact barangays: Bel-Air, Cembo, Comembo, East Rembo, Guadalupe Nuevo, Guadalupe Viejo, Olympia, Poblacion, San Antonio, San Lorenzo, Santa, Cruz,

Urdaneta, Valenzuela and West Rembo in the host City of Makati, is presented, formed from a combination of primary and secondary data obtained through both quantitative and qualitative methods. To establish the baseline socioeconomic conditions, secondary and primary data needs were identified and gathered. The secondary information for the assessment was sourced from the following:

- Comprehensive Land Use Plan
- 10-Year Solid Waste Management Plan
- Philippine Statistics Authority
- National Competitiveness Council
- Department of Education
- Department of Health

Primary information was obtained through interviews and perceptions surveys. The perception survey was conducted to develop an appreciation of the communities perceived positive and negative impacts of the Project and to serve as an avenue for the host communities to provide their suggestions and recommendations to the project implementers. With the established baseline conditions, key socioeconomic impacts were identified, based on the following:

- Displacement of Settlers
- In-Migration
- Change in Lifestyle of Indigenous People
- Threat to Public Health
- Generation of Local Benefits from the Project
- Threat to Delivery of Basic Services
- Traffic Congestion

Once the impacts were identified, mitigating and enhancement measures were formulated and consulted to ensure appropriateness and effectiveness of the identified measures. These measures were included in the Social Development Plan (SDP) and the Information, Education and Communication (IEC) Plan Framework included as Section 5 in this report.

#### 2.4.1.2 Population Characteristics

Makati City has a total population of 582,602 distributed in its two districts and 33 barangays as of 2015. **Table 2-62** shows the population and population growth in the barangays covered by the Project. In general, there are approximately 14 barangays in Makati City covered by the Project. In terms of population, majority of the barangays (9 of 14 barangays) within the Project site has experienced an increase in population between 2010 and 2015. Barangays West Rembo is the most populous barangay with a population of 29,889 in 2015. In terms of population change, Barangay Poblacion registered the highest increase (2010 to 2015) at 3.26%. In contrast, Barangay Guadalupe Viejo registered the biggest decrease in population at 2.23%. These barangays account for the 42.89% of Makati City's total population (582,602) in 2015. The estimated ratio of population by sex in Makati City is 52.6% for female and 47.4% for male (City Population, 2015)

**Table 2-62. Population and Population Growth Rate of the Direct Impact Barangays**

| Barangay | 2010 Population | 2015 Population | Percent (%) Increase/ Decrease |
|---|---|---|---|
| Bel-Air | 18,280 | 23,685 | 2.28 |
| Cembo | 27,998 | 26,213 | -0.69 |
| Comembo | 14,433 | 16,818 | 1.42 |
| East Rembo | 26,433 | 28,114 | 0.6 |
| Guadalupe Nuevo | 18,271 | 18,341 | 0.04 |
| Guadalupe Viejo | 16,411 | 13,415 | -2.23 |
| Olympia | 21,270 | 20,251 | -0.5 |
| Poblacion | 17,120 | 25,393 | 3.26 |
| San Antonio | 11,443 | 16,840 | 3.2 |
| San Lorenzo | 10,006 | 12,995 | 2.3 |
| Santa Cruz | 7,440 | 7,207 | -0.32 |
| Urdaneta | 3,717 | 4,429 | 1.61 |
| Valenzuela | 7,261 | 6,310 | -1.51 |
| West Rembo | 28, 406 | 29,889 | 1.04 |

The land area of Makati is approximately 27.36 $km^2$, which comprise about 4.3% of the total land area of NCR. The City has an average population density of 21 persons per 1,000 $m^2$ as of 2015. **Table 2-63** shows the population density of the directly affected barangays in Makati City. Cembo has been recorded to have the highest gross population density at 60,960 persons/$km^2$ among the barangays covered by the project. On the other hand, Urdaneta has the lowest population density with only 5, 985 persons/ $km^2$ of land area.

**Table 2-63: Population and Population Growth Rate of the Direct Impact Barangays**

| Barangay | Land Area ( $km^2$) | 2015 Population | Gross Populaion Density (2015) |
|---|---|---|---|
| Bel-Air | 1.71 | 23,685 | 13,851 |
| Cembo | 0.43 | 26,213 | 60,960 |
| Comembo | 0.31 | 16,818 | 54,252 |
| East Rembo | 0.48 | 28,114 | 58,571 |
| Guadalupe Nuevo | 0.57 | 18,341 | 32,177 |
| Guadalupe Viejo | 0.54 | 13,415 | 24,843 |
| Olympia | 0.46 | 20,251 | 44,024 |
| Poblacion | 1.03 | 25,393 | 24,653 |
| San Antonio | 0.9 | 16,840 | 18,711 |
| San Lorenzo | 1.73 | 12,995 | 7,512 |
| Santa Cruz | 0.47 | 7,207 | 15,334 |
| Urdaneta | 0.74 | 4,429 | 5,985 |

| | | | |
|---|---|---|---|
| Valenzuela | 0.25 | 6,310 | 25,240 |
| West Rembo | 0.55 | 29,889 | 54,344 |

**Table 2-64** shows the estimated number of households in the covered barangays using Makati City's average household size in 2015 at 3.76. As shown in the result, West Rembo (7,949) has the highest estimated number of households while Urdaneta posted the least estimated number of households at 1, 178.

**Table 2-64: Estimated Number of Households**

| Barangay | 2015 Population | Estimated Number of Households |
|---|---|---|
| Bel-Air | 23,685 | 6,299 |
| Cembo | 26,213 | 6,972 |
| Comembo | 16,818 | 4,473 |
| East Rembo | 28,114 | 7,477 |
| Guadalupe Nuevo | 18,341 | 4,878 |
| Guadalupe Viejo | 13,415 | 3,568 |
| Olympia | 20,251 | 5,386 |
| Poblacion | 25,393 | 6,753 |
| San Antonio | 16,840 | 4,479 |
| San Lorenzo | 12,995 | 3,456 |
| Santa Cruz | 7,207 | 1,917 |
| Urdaneta | 4,429 | 1,178 |
| Valenzuela | 6,310 | 1,678 |
| West Rembo | 29,889 | 7,949 |

The estimated ratio of population by sex in Makati City is 52.6% for female and 47.4% for male (City Population, 2015). Thirteen barangays will be traversed by the 10km subway alignment including barangays Urdaneta, San Lorenzo, Santa Cruz, Olympia, Valenzuela, Poblacion, Guadalupe Viejo, Guadalupe Nuevo, Cembo, West and East Rembo, Comembo and Pembo. TODs will be located in five barangays, which include barangays Olympia, Poblacion, Guadalupe Viejo, Cembo and West Rembo. Barangays where the alignment will be situated account for 44.2% share of the total population in Makati City (PSA, 2015).About 41.7% of the city's population in 2015 resided in District I. District I accounts for the 61.8% of Makati's total land area.

### 2.4.2 Access to Basic Services

#### 2.4.2.1 Education

In 2000, Makati City's literacy rate is recorded at 98.93%, which is slightly higher than the NCR. The highest educational attainment completed by majority of the population in Makati is high school (as of 2007). About 33% of the total population of the city (or 162,899 individuals) took up high school, 72% of which graduated. College undergraduates comprise 15% of the total population while 21% are academic degree holders (as 2000). Less than 1% of the city's population is post-baccalaureate degree holders.

As of 2015, there are a total of 137 public and 250 private schools in Makati City (**Table 2-65**). There are also non-formal education programs such as computer schools that facilitate short-term courses and degrees, vocational and technological schools, food, special programs, home-making, business and commerce, and literacy programs. Makati City also offers special education (SPED) facilities in schools such as Pio del Pilar Elementary School, N. Yabut Elementary School, Gen. Pio Del Pilar National high school and Fort Bonifacio High School.

**Table 2-65: Number of Public Schools in Makati City**

| School Levels | Public | Private |
|---|---|---|
| Preschool only | 27 | 74 |
| Elementary only | 27 | 79 |
| Secondary only | 12 | 26 |
| Preschool and Elementary | 27 | 44 |
| Preschool, elementary and secondary | 37 | 2 |
| SPED | 6 | 2 |
| Higher Educational Institutions | 1 | 23 |
| Total | 137 | 250 |

During the academic year 2015-2016, the enrolment at the public elementary schools in Makati City are recorded at 52, 159 (DEPED, 2017). Of this, around 51.25% were male while 48.75% are female. In terms of public high school enrollment, records show that there are 31,763 students enrolled during the academic year 2015-2016. Among these, 50.32 % were male while 49.68 were female.

The tables below show the enrollment at the Elementary and Secondary level for School Year 2015-2016 in the covered barangays of the Project. DEPED records revealed that the most significant number of enrollees for both levels is found in Barangay West Rembo: Fort Bonifacio Elementary School at 11.30% and Fort Bonifacio High School at 31.94%.

**Table 2-66: Total Number of Enrollees at Public Elementary Schools**

| Barangay | School | Male | Female | Total Number of Enrollees | Percentage |
|---|---|---|---|---|---|
| Cembo | Cembo ES | 1312 | 1204 | 2516 | 9.43 |
| Comembo | Comembo Elementary School | 1224 | 1177 | 2401 | 9.00 |
| East Rembo | East Rembo ES | 1296 | 1186 | 2482 | 9.30 |
| East Rembo | Tibagan ES | 539 | 502 | 1041 | 3.90 |
| Guadalupe Nuevo | Nemesio I. Yabut ES | 840 | 758 | 1598 | 5.99 |
| Guadalupe Nuevo | San Jose ES | 662 | 615 | 1277 | 4.78 |
| Guadalupe Viejo | Guadalupe Viejo ES | 604 | 558 | 1162 | 4.35 |
| Olympia | Jose Magsaysay ES | 597 | 488 | 1085 | 4.06 |
| Olympia | Nicanor C. Garcia, Sr. ES | 544 | 563 | 1107 | 4.15 |
| Poblacion | Hen. Pio del Pilar ES I | 645 | 677 | 1322 | 4.95 |
| Poblacion | Hen. Pio del Pilar ES Main | 1397 | 1318 | 2715 | 10.17 |

| | | | | | |
|---|---|---|---|---|---|
| Poblacion | Makati ES | 558 | 549 | 1107 | 4.15 |
| San Antonio | San Antonio Village ES | 376 | 364 | 740 | 2.77 |
| Sta. Cruz | F. Benitez ES | 809 | 780 | 1589 | 5.95 |
| West Rembo | Fort Bonifacio ES | 1501 | 1444 | 2945 | 11.03 |
| West Rembo | West Rembo ES | 824 | 781 | 1605 | 6.01 |

**Table 2-67: Total Number of Enrollees at Public Secondary Schools**

| Barangay | Public Secondary Schools | Male | Female | Total Number of Enrollees | Percentage (%) |
|---|---|---|---|---|---|
| Comembo | Benigno "Ninoy" S. Aquino HS | 1153 | 1267 | 2420 | 9.97 |
| East Rembo | Fort Bonifacio HS - Tibagan HS Annex | 2475 | 2701 | 5176 | 21.32 |
| Poblacion | Makati High School | 1540 | 1533 | 3073 | 12.66 |
| Poblacion | Makati West HS (Makati Science HS) | 412 | 443 | 855 | 3.52 |
| Poblacion | Gen. Pio del Pilar NHS | 1402 | 1355 | 2757 | 11.36 |
| San Antonio | San Antonio NHS | 1120 | 1124 | 2244 | 9.24 |
| West Rembo | Fort Bonifacio HS | 4037 | 3718 | 7755 | 31.94 |

The implementation of the K to 12 program of the Department of Education in Makati started in 2014 covering the following key stages: Kindergarten to Grade 3, Grades 4 to 6, Grades 7 to 10 (Junior High School), andGrades 11 to 12 (Senior High School).

#### 2.4.2.2 Sanitation and Water Supply

The Manila Water Company, Inc. (MWCI) and Maynilad Water Services, Inc. (Maynilad) supplies potable water for residential, commercial, and industrial purposes in Makati City (City Government of Makati, 2013). Raw water, however, comes from the Angat-Ipo-La Mesa water system, an external source that begins in Norzagaray, Bulacan and supplies the whole of Metro Manila. Water supplied by the Manila Water company is treated at the Balara Treatment Plant while Maynilad treats its water at the La Mesa Dam.

In 2011, 97.50% of households in Makati were considered to have access to safe drinking water. Data from the Makati Health Department from 2009-2011, however, indicate a decrease in the total number of households served from 2010 to 2011.

**Table 2-68.Percentage of Households with Access to Safe Drinking Water**

| Year | Served | Unserved | Proportion of Households with access to safe drinking water (%) |
|---|---|---|---|
| 2009 | 99,549 | 2872 | 97.14 |
| 2010 | 100,393 | 1,930 | 98.02 |
| 2011 | 91,349 | 2,331 | 97.5 |

#### 2.4.2.3 Power

The Manila Electric Company (MERALCO), is the sole electric distributor in Metro Manila that provides electric power supply connections in all barangays of the city. MERALCO sourced its supply from the state-owned National Power Corporation (NPC). All barangays have access to electricity, and existing distribution lines and facilities are maintained to ensure reliable service.

#### 2.4.2.4 Telecommunication

A. Telephone

The Philippine Long Distance Telephone Co. (PLDT), Globe Telecom, Bayan Telecommunications (Bayantel) and Digitel Telecommunication Philippines, Inc. (DIGITEL), all provide telecommunication facilities. Cellular, radio facilities and other wireless communication services are provided by Smart Communications, Globe Telecom, and Sun Cellular.

B. Record Carriers

There are four international record carriers and stations in the city. These are the Eastern Telecommunications Philippines, Inc., Globe Telecom, Philippine Global Communications and Capitol Wireless, Inc. Postal services are provided primarily through four postal offices located at the central postal office in Sen. Gil Puyat Avenue, while three other postal offices are located in Districts I and II.

C. Radio, Television and Publication

There are five (5) FM radio stations, three (3) AM radio stations; two (2) cable operators and two (2) satellite television providers in Metro Manila servicing the City. There are also two (2) television stations and six (6) publishing houses based in the City. Existing telecommunication facilities meet the standards set by the HLURB and show that the City"s communication level is adequate.

#### 2.4.2.5 Transportation, Road Networks, and Traffic

Public utilities such as roads, bridges, and flyovers in the city have been concreted and meet established standards on structural design (City Government of Makati, 2013). Since 2010, all roads in 1,151 streets in District I, II, and villages have been completed. As of 2011, there are 38 bridges and six national flyovers which traverse Makati City, all of which are in good and passable conditions. Ancillary facilities such as sidewalks, streetlights, parking areas, waiting sheds, overpasses, underpasses, and road markings have also been provided for the safety of pedestrians.

The most common means of travel in the city is land-based (through jeepneys, UV Express and buses) and rail-based. Jeepneys and UV Express are taken mainly for local circulation, while buses, with exception of Fort Buses, are regional in service. Taxis and online vehicle requests through mobile applications commonly pass through Makati for the sub-urban commuters and residents. Rail-based transit (LRT 1, MRT 3, and PNR) serves Makati City, along Osmena Highway.

The Pasig River Ferry Service provides water-based transit that services Makati City in two stations: Valenzuela Station and Guadalupe Station. An informal boat system called *tawiran* is also used to cross the Pasig River to and from the adjacent city of Mandaluyong.

Makati City is generally accessible to the commercial airport in Metro Manila using the EDSA-Tramo route or the Skyway. Helicopters may also be an option in servicing air-based transit from most of the city's hotels to top companies for chartered services.

In terms of traffic, Makati is a known major generator of traffic in greater Manila, owing to its nature of being a central business district with a large residential population and predominantly service oriented economy. Based on 2011 estimates, Makati City generates 594,872 vehicle trips daily. This is equivalent to about 13% of the 4.5 million Metro Manila vehicle trips per day. The major destinations

of Makati City internal traffic reckoned from Barangay Poblacion are the Makati Central Business District and clusters of barangays in Northwest and Northeast. Approximately 11% of internal traffic crosses Epifanio delos Santos Avenue (EDSA), making this a major traffic issue considering that EDSA is a 10-lane highway with commuter rail line at the center.

#### 2.4.2.6 Protective Services

Protective services are also part of Makati City's priority to maintain peace and order among its residents. Departments, offices, and councils in charge of the law enforcements and protective services in Makati include the Makati police and fire departments, Makati City Jail, Makati Rescue, Makati Traffic Enforcement Unit, Public Safety Department, and Makati Disaster Risk Reduction and Management Council. Makati Rescue Services include Emergency Medical Services (EMS), response to fire incidents and vehicular accidents, K-9 services, paneling, patrol/posting services, and response to bomb threat incidents. The city has designated the Makati Rescue Team to manage and maintain immediate response. Response to emergency medical concerns had the most number of services rendered from 2006 to 2010. This increase was attributed to requests from different departments, barangays and other constituents of the city to transport non-emergency patients to and from the hospital.

#### 2.4.2.7 Social Welfare Services

According to the Makati City Profile (2012), programs implemented by the Makati Social Welfare Department include projects for the welfare of the child and youth, family and community, women, elderly and disabled, street children, juvenile delinquents, and victims of drug abuse. One social security program for the residents of Makati is the *PhilHealth ng Masa Program*. This program provides medical health insurance to indigent Makati residents. Day care centers and services are also provided per barangay in the city. Other programs include senior citizen center and benefit cards that gives discounts and privileges to the seniors, informal settlements reduction and management that provides subdivisions (called "Makati Home Ville" in Laguna and "Dreamland Ville" in Bulacan), where informal settlers are relocated. Additional facilities include the Rehabilitation Center, Women's Center, Social Development Center, and various sports and recreational facilities.

### 2.4.3 Health and Local Health Resources

#### 2.4.3.1 Local Health Resources

The City has several programs and projects intended for the residents. The focus is not only towards development of the City but also the improvement of the welfare of residents and people who primarily render services for the development of Makati. One of the programs of the City is the Makati Health Plus Program whereby residents are given color-coded cards that give them discounts on hospital bills and consultation fees. Availing of this program reduces the patients" burden of paying their hospital bills. The Makati Health Program Office is the overall in-charge of the program operations. The detailed number of residents in the barangays covered by the project and given by the mentioned program as of 2011 is summarized below.

**Table 2-69: Total Number of Residents covered by the Makati Health Plus Program**

| Barangay | Total | Percentage |
|---|---|---|
| Bel-Air | 1,156 | 1.24 |
| Cembo | 11,109 | 11.93 |
| Comembo | 6,641 | 7.13 |
| East Rembo | 9,288 | 9.97 |
| Guadalupe Nuevo | 10,054 | 10.80 |

| | | |
|---|---|---|
| Guadalupe Viejo | 5,996 | 6.44 |
| Olympia | 13,191 | 14.16 |
| Poblacion | 8,618 | 9.25 |
| San Antonio | 5,128 | 5.51 |
| San Lorenzo | 1,375 | 1.48 |
| Santa Cruz | 4,541 | 4.88 |
| Urdaneta | 729 | 0.78 |
| Valenzuela | 3,585 | 3.85 |
| West Rembo | 11,713 | 12.58 |

As shown in **Table 2-70**, the City's health figures are still at par with the standards. However, Infant and Child Mortality Rates significantly decreased this year as compared with 2015 and 2016 data.

**Table 2-70: Health Indicators, 2015-2017**

| Indicator | Rate per 1000 population/live births | | | DOH Standard |
|---|---|---|---|---|
| | 2015 | 2016 | 2017 | |
| Crude Birth Rate | 16.7 | 13.9 | 13.44 | - |
| Crude Death Rate | 5.6 | 5.7 | 5.14 | - |
| Infant Mortality Rate | 12.4 (Resident – 9.8 Non-resident-2.6) | 15.6 (Resident – 13.4 Non-resident-2.6) | 10.44 (Resident – 8.53 Non-resident-1.91) | 17.0 |
| Child Mortality Rate | 15.0 (Resident – 11.7 Non-resident-3.3) | 19.04 (Resident – 15.9 Non-resident-3.1) | 12.34 (Resident – 9.67 Non-resident-2.67) | 25.5 |
| Maternal Mortality Rate | 0.5 (Resident – 0.4 Non-resident-0.1) | 0.25 (Resident – 0.25 Non-resident-0) | 0.51 (Resident – 0.38 Non-resident-0.13) | 5/1,000 |

*Source: Makati Health Department*

Degenerative diseases are mostly in the top leading causes of mortality among residents. Heart Diseases remained the leading cause of mortality for all ages over the three-year period andclosely followed by Cancer and Pneumonia (**Table 2-71)**.

**Table 2-71: Leading Causes of Mortality For All Ages (2015-2017)**

| 2015 | 2016 | 2017 |
|---|---|---|
| 1. Heart Disease<br>2. Cancer<br>3. Pneumonia<br>4. Cerebrovascular Disease<br>5. Kidney Disease<br>6. Accident/ Injuries<br>7. Diabetes<br>8. Asthma/ COPD<br>9. Liver Disease<br>10. Dengue Hemorrhagic Fever | 1. Heart Disease<br>2. Pneumonia<br>3. Cancer<br>4. Cerebrovascular Disease<br>5. Accident/ injuries<br>6. Kidney Disease<br>7. Diabetes<br>8. Septicemia<br>9. Asthma/COPD<br>10. Liver Disease | 1. Heart Disease<br>2. Pneumonia<br>3. Cancer<br>4. Cerebrovascular Disease<br>5. Accident/ injuries<br>6. Kidney Disease<br>7. Septicemia<br>8. Asthma/COPD<br>9. Liver Disease<br>10. Fetoplacental Insufficiency |

*Source: Makati Health Department*

Upper Respiratory Tract Infection (URTI) and closely followed by Urinary Tract Infection (UTI) remained the leading causes of morbidity for all ages over the three-year period. Preventive measures, on this matter, need to be enhanced such as hygienic procedure, immunization and immunoprophylaxis, complementary and alternative therapies, among others **(Table 2-72)**

**Table 2-72: Leading Causes of Morbidity For All Ages (2015-2017)**

| 2015 | 2016 | 2017 |
|---|---|---|
| 1. Upper Respiratory Infection<br>2. Urinary Tract Infection<br>3. Myalgia<br>4. Arthritis<br>5. Wound<br>6. Acute Tonsillopharyngitis<br>7. Hypertension<br>8. Pneumonia<br>9. Soft and Skin Tissue Infection<br>10. Allergy | 1. Upper Respiratory Tract Infection<br>2. Urinary TractInfection<br>3. Arthritis<br>4. Myalgia<br>5. Hypertension<br>6. Soft and Skin Tissue Infection<br>7. Diabetes<br>8. Acute Tonsillopharyngitis<br>9. Pneumonia<br>10. Allergy | 1. Upper Respiratory Tract Infection<br>2. Urinary TractInfection<br>3. Arthritis<br>4. Myalgia<br>5. Wound<br>6. Hypertension<br>7. Dermatitis<br>8. Acute Tonsillopharyngitis<br>9. AcuteNasopharyngitis<br>10. Allergy |

***Source: Makati Health Department***

Included in Makati City Government's top priorities is to provide the citizens with good health services through regular preventive and curative programs, facilities, and health financial schemes. Health programs and services are provided in four departments of the Makati City Government including the Makati Health Department, Ospital ng Makati, Makati Veterinary Services Office, and Makati Health Program Office.

Makati City is also effective in implementing nutritional and health programs (Makati Health Plus Program) such as counseling, information and education campaigns, and hospital bills discounts in coordination with barangays and social development sectors. Veterinary services (rabies prevention and control, stray animal operations, and quality control of meat poultry and fishes), and provision of health personnel and facilities are other services offered by the city.
As of 2011, the city has two public and three private hospitals. The Ospital ng Makati (OSMAK) and the Makati Medical Center (MMC) are the only tertiary level hospitals in the city. In addition to hospitals, there are also 26 health centers distributed in different barangays and 173 medical clinics in the city (Makati City Profile, 2010; Makati, 2015).

### 2.4.4 Local Economy

Makati City is popularly known as the Central Business District hosting the headquarters of the biggest banks, commercial and business centers, and corporations in the Philippines. The establishments owned by Ayala houses headquarters of almost 40% of all companies listed in the top 1,000 corporations of the Philippines. Major commercial centers include Ayala Center (Glorietta I-V and Greenbelt I–V), South Gate Mall, Guadalupe Commercial Center, A Venue, Unimec, and Power Plant. Wet markets include Bangkal Market, Palanan Market, Pio del Pilar Market, Poblacion Market (city government-owned), Sacramento Market, and Tejeros Market in District I; and Comembo Market, Comembo Commercial Complex, Guadalupe Commercial Complex, and Kalayaan Talipapa in District II. The table below presents the predominant activities within the barangays covered by the project.

**Table 2-73: Economic Activities in the Covered Barangays**

| Barangay | Predominant Economic Activities |
|---|---|
| Bel-Air | Restaurants, banks, BPOs, real estates, veterinary clinics, beauty salons, travel agencies, furniture and antique stores, hotels, apartment/house rentals, printing shops, computer rentals, beauty parlors, gas stations, insurance companies, convenience stores, car dealers, drug companies, money changers, condominium, apartment and house rentals |
| Cembo | Sari-sari stores, Barber shops, Restaurant, Talipapa, and Computer rentals |
| Comembo | Sari-sari stores; Bakeries; Eatery; Grocery stores; Water refilling stations; Apartment / house rentals; Beauty parlors and spa; Barber shop; Medical, laboratory and dental clinics; Hardwares; Jeepney terminals, TODAs, bicycle and motor shops; Computer shops pawnshops; Aluminum and glass fabrication; Flea market |
| East Rembo | Talipapa; Sari-sari Stores; Tire & Auto Supplies; Bakery; Carinderia; Garments; Drug Stores; Video and Photo Shops; Computer Rentals; Barber Shops; Laundry Shop; and Beauty Parlors |
| Guadalupe Nuevo | Food establishments; Banks; Pawnshop, Bayad Centers, Money Remittance Center; Medical Clinics; Dental Clinics; Eye Clinics; Drug Stores; Beauty Parlors, Massage Spa; |
| Guadalupe Viejo | Sari-sari stores, Factories, Beauty parlors, Computer rentals, Funeral parlors, and Gas station |
| Olympia | Sari-sari stores, grocery stores, barber shops, beauty parlors, talipapas, banks, convenience stores, restaurants, pawnshops, drugstores, hardware. |
| Poblacion | Malls, hotels, condotels and inns, banks, schools, restaurants, night clubs & bars, drugstores, pawnshops, health and wellness spas, beauty salons, family and dental clinics, hardware stores, computer shops and internet cafes, convenience stores, bakeries, eateries, sari-sari stores and funeral parlors |
| San Antonio | Advertising, Apartelle, Auto repair shops, Banks, Beauty parlors, Constructions, Carinderias, restaurants, furniture shops, insurance firms, recruitment agencies, manufacturing companies, printing, real estate, sari-sari stores, security agencies, shipping companies, tailoring shops, training centers, wine/liquor stores |
| San Lorenzo | Banks, supermarkets, groceries, restaurants, bars, hotels, inns, tires and car repairshops, beauty parlors, computer shops, and printing shops |
| Santa Cruz | Sari-Sari stores, computer rentals, beauty parlors, restaurant, banks, merchandising, groceries, convenience stores, apartment/house rental, video rentals and manpower. |
| Urdaneta | Hotels, restaurants, offices spaces, banks, and condominiums |
| Valenzuela | Gasoline Station, Banks, Church, Law Office, Sari – Sari Store, Eatery/Restaurant/Fast-food, Services, Lessors, Enterprises, Foundation and Advertising |
| West Rembo | Sari-sari stores, turo-turo, burger stands, car wash, barber shops, beauty parlors, printing, funeral parlor, retail/wholesale stores, water station, hardware, and dental clinic |

The working age in Makati is 15-64 years old. The minimum daily wage rate in the city as of January 2018 is PhP 512.00, based on the summary of latest Wage Orders and Implementing Rules by the Regional Boards. About 72.3% of the working age population in Makati City was engaged in gainful occupation in 2015. A gainful worker is defined as a worker with at least 10 working hours per week for 6 months.

A. Tourism

Makati City boasts numerous hotels, historical and cultural sites, shopping centers, art galleries, restaurants and bars serving local and international gourmet food, and sports/recreational facilities. The city has 58 hotels, five of which are 5-star hotels (i.e. Mandarin Oriental, Dusit Hotel Nikko, Makati Shangri-la Hotel, Peninsula Hotel, and New World Hotel). There are also high-class tourist inns and apartelles in the city such as St. Illian's Inn Makati, El Cielito Tourist Inn, Sq. Resources, Ascott, Amorsolo Mansion Apartment and Suites, and Fraser Place Service Residences. There are also premier malls located in the city such as Greenbelt, Glorietta Malls, SM, Rustan's, among others. The city is also home to 50 foreign embassies, 43 consulates, and 17 international organizations. Museums in the city include the Ayala Museum and Museo ng Makati (Makati Museum). Makati has its own annual festivals, which regularly draw tourists such as Araw ng Makati, Balik Culi-Culi, Caracol, Filipino Heritage Festival, and Flores de Mayo.

B. Poverty Incidence

Poverty threshold is the minimum income required to meet the basic food and non-food needs such as clothing, fuel, light and water, housing, rental of occupied dwelling units, transportation and communication, health and education expenses, non-durable furnishing, household operations and personal care and effects. In Makati City (2018), no less than PhP 14,102, on average, was needed to meet both basic food and non-food needs of a family in a month.

### 2.4.5 Cultural Heritage Sites

The National Historical Commission of the Philippines has declared two cultural heritage sitesin Makati City. These include the Church and Monastery of Guadalupe and the Church of San Pedro Makati. Both sites are houses of worship and have Level II statuses which are recognized with historical markers. Both structures are located approximately 230 and 115 meters away from the nearest segment of the subway alignment.

The City of Makati has a planned heritage restoration of the city, named Makati Poblacion Heritage Conservation Project. The masterplan for the said restoration includes the redevelopment of Plaza Cristo Rey, Poblacion Park, JP Rizal, Museo Plaza, and DM Rivera Street. The Museo ng Makati is also a recognized cultural and arts facility of the city, and is also part of the planned heritage restoration. This museum serves as a repository of artifacts, treasures, and relics of the city's memoirs. It also serves as a venue for art exhibits, storytelling, and art workshops. The subway alignment, subway stations, and TODs do not encroach any of the cultural and arts facilities declared by Makati City, although the subway alignment will traverse Barangay Poblacion, the barangay of the aforementioned heritage restoration project.

### 2.4.6 Perception Survey

Socioeconomic information and perceptions on the Proposed Makati Public Rail Transport System Project was obtained through the conduct of a household survey in the identified direct impact barangays. The household surveys were performed on the fourteen direct impact barangays from the Makati City. Barangay health workers and other designated residents by the barangay officials were tapped to serve as enumerators, taking advantage of their superior knowledge of their own communities and neighbors. The survey was held in the month of May and June, 2019. A total of 657respondents from different zones/purok were interviewed on a face-to-face and one-to-one basis. Respondents were chosen in the following order of preference:

- Household head (who may be male or female but always a resident-household member who makes the major household decisions or is perceived to do so; the household head is usually the father but may also be the mother or the eldest child who is of majority age (18 years old);
- Spouse of the household head;
- Son or daughter who is at least 18 years old of the household head; or
- Other relative who is at least 18 years old of the household head.

Also, the sampling was only held during daylight hours in light of safety and security considerations. The sample size was determined with a margin of error of ± 5 with a confidence level of 99%.

Demographic Information

According to the survey results, there are more males (54 %) than females (46 %) respondents in the direct impact barangays **(Figure 2-54).** The highest percent share for males came from Barangay Poblacion (25.41%) and Barangay East Rembo for females (19.46 %). According to **Table 2-74**, among these 657 respondents, 14.31 % were from the ages 30-34 years old and 12.79% from ages 25-29 years old. The least significant number of respondents is found in the ages between, 15-19 years old (6.39%)

**Table 2-74: Age of the Respondents**

| Age | Frequency | Percentage |
|---|---|---|
| 15-19 | 42 | 6.39 |
| 20-24 | 51 | 7.76 |
| 25-29 | 84 | 12.79 |
| 30-34 | 94 | 14.31 |
| 35-39 | 66 | 10.05 |
| 40-44 | 57 | 8.68 |
| 45-49 | 68 | 10.35 |
| 50-54 | 62 | 9.44 |
| 55-59 | 78 | 11.87 |
| 60-64 | 55 | 8.37 |
| **Total** | **657** | **100** |

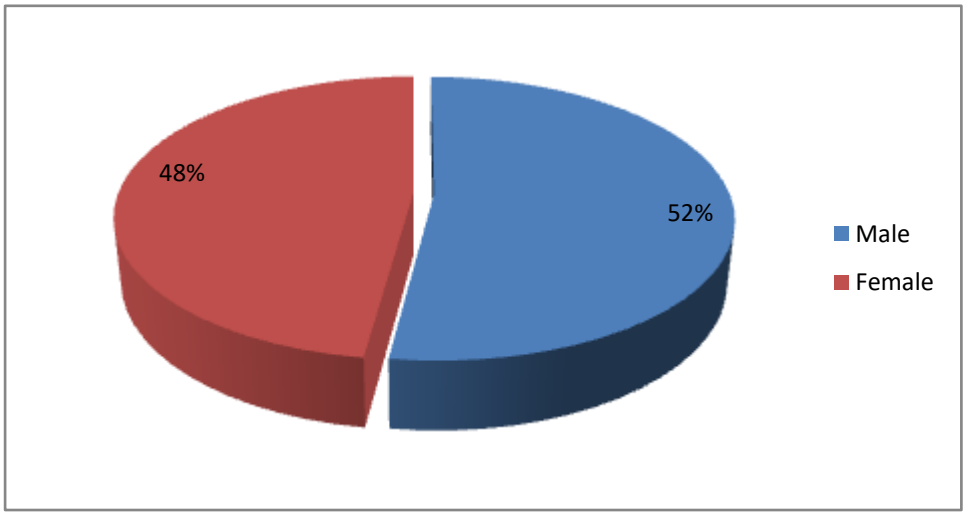



**Figure 2-54: Gender of the Respondents**

In terms of civil status, most of the respondents are married (78%) and 12 % were single. Respondents who are widow and separated are calculated both at 5% **(Figure 2-55).**

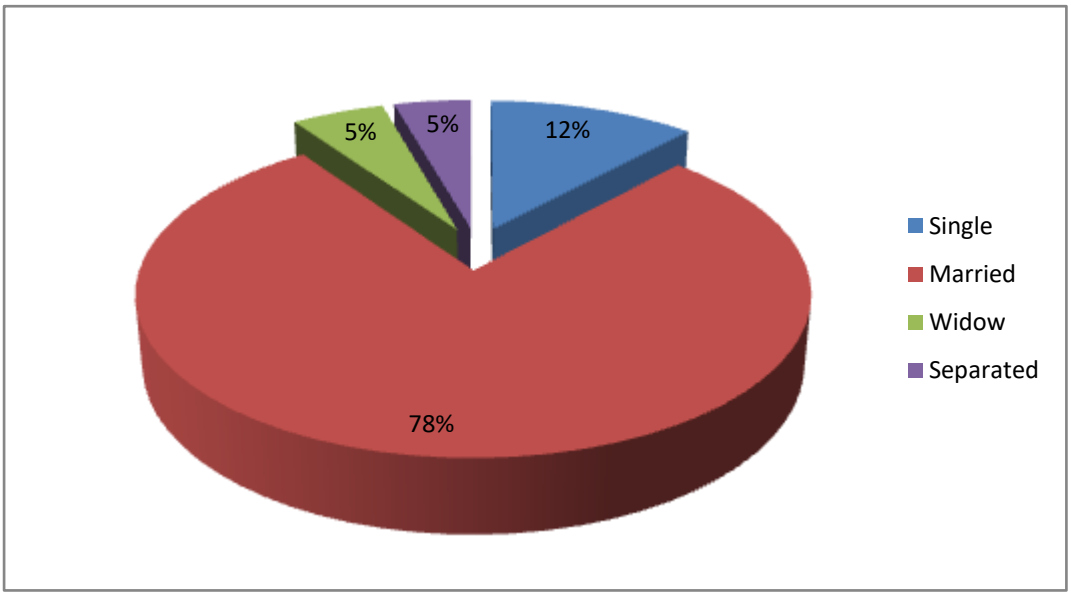



**Figure 2-55: Civil Status of the Respondents**

Highest educational attainment pertains to the highest level of education that an individual has completed. According to **Table 2-75**, many respondents are college graduates (42.16%) and college undergraduates (31.05 %). High school undergraduates and graduates are identified at 11.87 % and 14.92, respectively. Another noteworthy socio-cultural characteristic of a population is religion. In the surveyed area, most of the respondents are Roman Catholic (86.40%) while the remaining 14.7% belongs to other religious sectors (Baptist, Christian, Iglesia ni Cristo, and Islam). Moreover, 76% of the total numbers of respondents are Tagalog.

**Table 2-75. Highest Educational Attainment of the Respondents**

| Highest Educational Attainment | Frequency | Percentage |
|---|---|---|
| High school level | 78 | 11.87 |
| High school graduate | 98 | 14.92 |
| College level | 204 | 31.05 |
| College Graduate | 277 | 42.16 |
| **Total** | **657** | **100** |

Migration/Settlement History

**Table 2-76**shows the length of residency of the respondents. According to the survey, most of the residents have been in their respective barangays for 31 years or more (68.19 %). Thirty one percent (31%) of the total number of respondents have also found out to live outside of their current residences. The percentage of the detailed location of their previous residences is shown in **Figure 2-56.**

**Table 2-76. Length of Residency of the Respondents in their Respective Barangays**

| Years of Residency | Frequency | Percentage |
|---|---|---|
| 0-5 yrs | 24 | 3.65 |
| 6-10 yrs | 26 | 3.96 |

| | | |
|---|---|---|
| 11-15 yrs | 35 | 5.33 |
| 16-20 yrs | 21 | 3.20 |
| 21-25 yrs | 35 | 5.33 |
| 26-30 yrs | 68 | 10.35 |
| 31 yrs and above | 448 | 68.19 |
| **Total** | **657** | **100** |

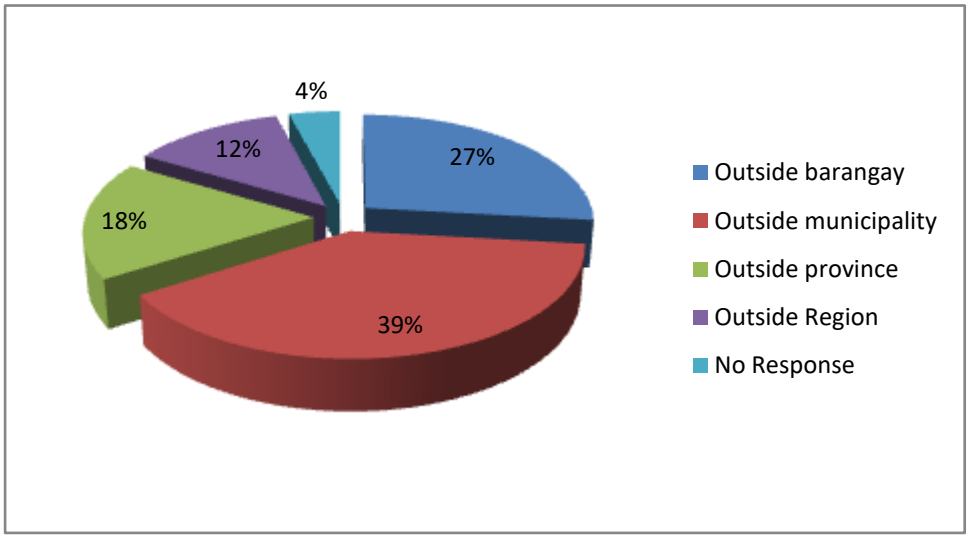



**Figure 2-56: Previous Residence of the Respondents**

Household Income

The predominant source of livelihood in the host communities includes regular employment (21.5%) from various companies and government institutions (**Table 2-77)**. Using the recorded declarations, most of the households under the study have an average monthly household income range of 5000 PHP- 9999 PHP (21.62%)**(Table:2-78).**Relatively, the male offspring and father of the surveyed households were both identified as the common household income earner at 23.14% and 22.37%, respectively (**Table 2-79**).

**Table 2-77: Sources of income of the household members**

| Source of Income | Frequency | Percentage |
|---|---|---|
| None | 58 | 8.8 |
| Regular Employment | 141 | 21.5 |
| Contractual Employment | 99 | 15.1 |
| Retail Sales / Online Shops | 121 | 18.4 |
| Family Business | 84 | 12.8 |
| Remittances | 42 | 6.4 |
| Others | 112 | 17.0 |
| **Total** | **657** | **100** |

**Table:2-78: Range of Average Household Income**

| Ave Household Monthly Income (PHP) | Frequency | Percentage |
|---|---|---|
| Below 1000 | 9 | 1.37 |
| 1000-4999 | 11 | 1.67 |
| 5000-9999 | 142 | 21.61 |
| 10000-14999 | 115 | 17.50 |
| 15000-19999 | 98 | 14.92 |
| 20000-24999 | 32 | 4.87 |
| 25000 and above | 42 | 6.39 |
| **Total** | **657** | **100** |

**Table 2-79: Common Household Income Earners**

| Household Earner | Frequency | Percentage |
|---|---|---|
| Father | 147 | 22.37 |
| Mother | 74 | 11.26 |
| Male Child/Children | 152 | 23.14 |
| Female Child/Children | 145 | 22.07 |
| Male Relative | 74 | 11.26 |
| Female Relative | 65 | 9.89 |
| **Total** | **657** | **100** |

Perception Survey

Primarily, respondents' knowledge on the proposed project was asked to further determine their perceptions. As revealed, majority of the respondents are knowledgeable on the proposed project (97%) than those who are not (3%). Majority of information known by the communities came from the massive IEC activities of the proponent (43.99%) (**Figure 2-57**)

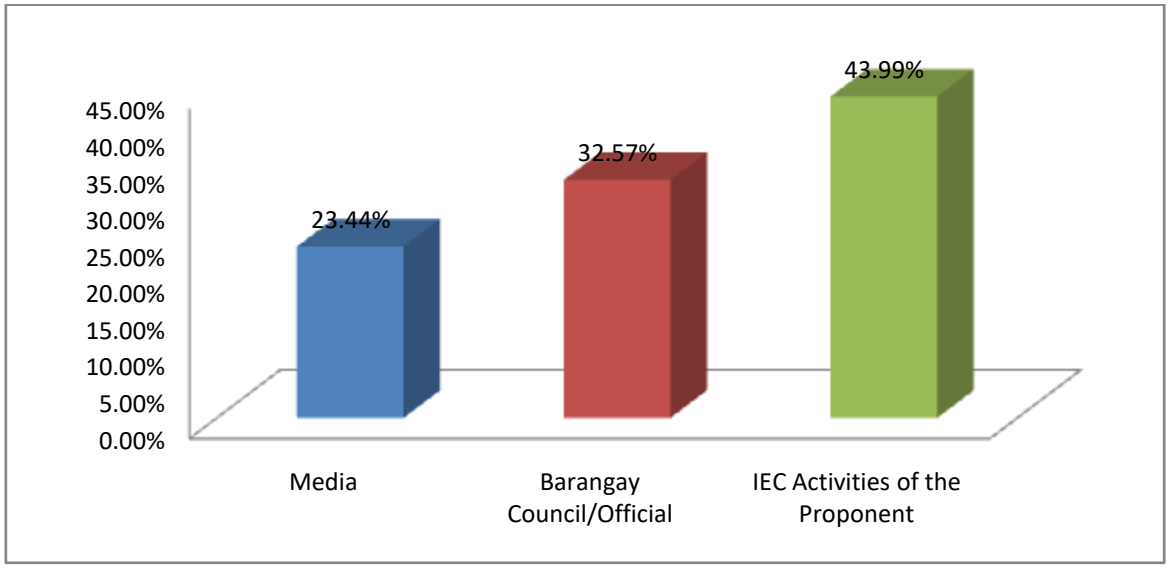


**Figure 2-57: Sources of Information**

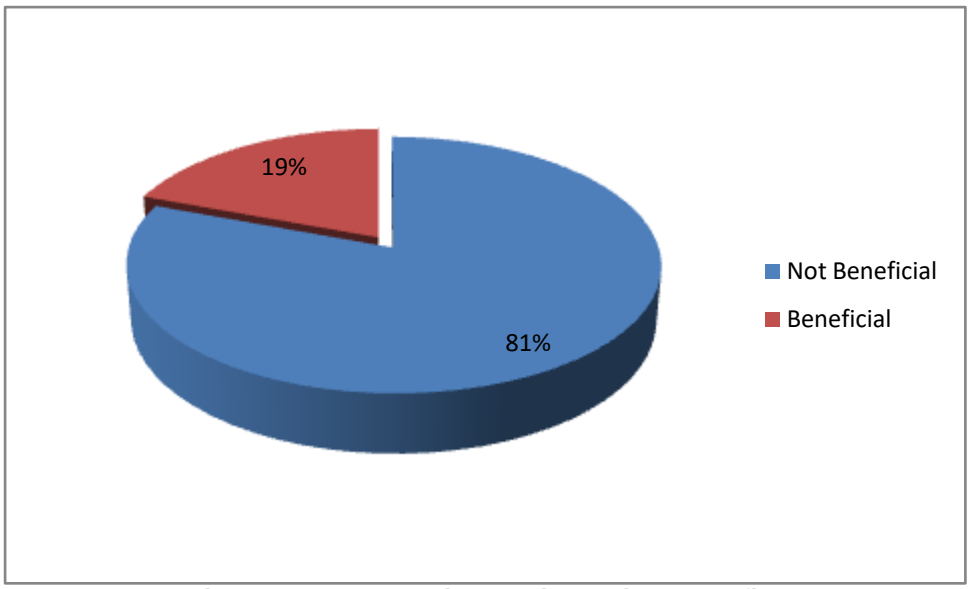



**Figure 2-58: Perception on the Project Benefits**

When asked with question, "What are the possible positive effects of the proposed project?" Respondents identified improved mobility (26.89%), better infrastructure (25.06%), and influx of tourists (19.81%) as the top three possible positive impacts of the proposed project **(Figure 2-59)**.

To complement, an average of 8 out of 10 has been calculated as the general level of acceptance with the project. On the other hand, the respondents have identified vehicular congestion and displacement of settlers as the pressing issues that this project has to address. These two has been also part of the common problems at the community and household level in addition to finances, peace and order, spaces, and waste management.

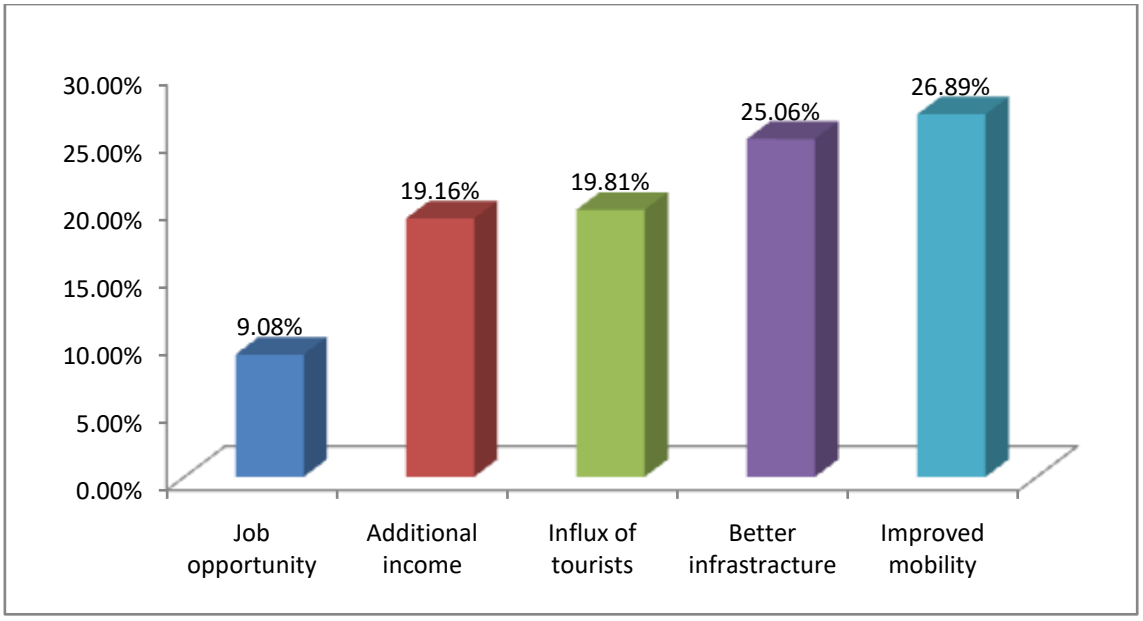



**Figure 2-59: Perceived Benefits of the Project**

### 2.4.7 Impact Assessment

#### 2.4.7.1 Displacement of Settlers and Properties

The Project will entail the construction of subway facilities, which might traverse several private properties and government-owned housing project based on the technical description of the Project. To this end, the Philippine Infradev Holdings, Inc. (IRC) will enter into negotiations with the concerned land/property owners once the final alignment of the Project has been established. IRC will negotiate the rightful compensation based on applicable laws and government procedures. IRC will establish a committee for this purpose whose main task will include the following:

- identification and inventory of affected properties/houses/lands
- identification of appropriate compensation (amount) and compensation scheme (type, frequency)
- establishment of grievance redress procedures
- establishment of compensation and grievance redress monitoring procedures

Essentially, a Resettlement Action Plan (RAP) must be prepared in order for the project affected households/residents to be entitled with a rightful and just compensation. In this document, a RAP Framework (attached as Annex 14) will serve as a guide or direction for the proponent's proper implementation.

#### 2.4.7.2 In-Migration

A temporary influx of workers can be expected during the construction phase of the Project. To ensure maximum benefit for the affected communities, it is recommended to IRC and to their contractors that labour and materials be sourced locally during construction. This would discourage the influx of migrant workers as well as increase project ownership of the affected communities

#### 2.4.7.3 Change in Lifestyle

During the construction phase, there will be significant changes in community operations within the project area. This will be brought by the interference of various foreign values and activities. On the other hand, mobility will be improved when the project has become operational. Fast phasing of daily living will be experienced by individuals who will access the project.

#### 2.4.7.4 Threat to Public Health

Construction-related accidents can occur due to improper work ethics, which may be a threat to the health and safety of workers and local residents. The workers and the local community also run the risk of exposure and spread of contagious/ infectious diseases due to unsanitary condition at the project site.

During the operation phase, there may be risk of accidents due to improper work ethics, which may threaten health and safety of workers and passengers at the stations and depot. An Occupational Health and Safety Management Plan will be implemented by the proponent during the operations stage. This will be aligned with the policy of the DOTr mandating the strict implementation of precautionary, safety and security measures to ensure safe, fast, efficient and reliable transportation services.

#### 2.4.7.5 Generation of Local Benefits from the Project

Construction activities of the Project present temporary employment for local skilled and unskilled workers. Downstream income generating possibilities could also be undertaken by enterprising residents such as provision of meals for the workers and staff in the absence of a canteen. Hiring information including minimum employment requirements for local hires will be provided to Makati City's Public Employment Service Office (PEOS) and the local barangay officials to ensure that local workers are given the chance to be employed by the Project. The Project will comply will all national labor laws and regulations. Employment for skilled personnel to operate and maintain the railway system will also be available. It is estimated that the subway operation will provide numerous employment for manning the stations, operations and maintenance of the subway and trains at the depot. The presence of the stations will also attract future commercial development around the area.

#### 2.4.7.6 Threat to Delivery of Basic Services

There will be inevitable disruption on existing utility structures and facilities such as flyovers, underpass roads, elevated and at grade railways, water pipes, sewage pipes, electric power distribution lines, telecommunication cables, etc. along the alignment during the construction.

Moreover, service utilities will not be disrupted once the subway is in operation. The power, water and other utilities requirements of the subway will be integrated into the service areas of the existing public utilities and would not deprive the public access to such utilities.

#### 2.4.7.7 Traffic Congestion

The construction of the Project will require temporary road and bridge closures at various sections of the project alignment which can exacerbate the already heavy traffic congestion in Makati City. In order to minimize potential traffic impacts associated with the construction of the Project, a Traffic Management Plan (TMP) should be prepared and strictly enforced during the construction period. The TMP will be discussed with the Makati City Government, Department of Public Works and Highways (DPWH), and the Metropolitan Manila Development Authority (MMDA), and residents and business owners located along affected roads and bridges. The following mitigation measures are also proposed to ease traffic congestion associated with the Project:

- Schedule the delivery of materials to avoid peak traffic hours as much as practicable

- Ensure that pedestrians and other vehicles will be able to safely access roads that will be used and affected during the construction phase of the Project; ·
- Provide appropriate road safety signages in the vicinity of the construction site; ·
- Schedule road and bridge closures in sections; and ·
- Coordinate with the Makati City Government to provide sufficient traffic enforcers to direct traffic and not allow vehicles to park on the side of the affected roads especially during peak hours to avoid blocking traffic.

# 3 IMPACTS MANAGEMENT PLAN

Prediction and evaluation of the potential impacts, issues and concerns of the project is based on the impact areas earlier delineated. Other impacts that are not covered in the discussion but may crop up during the scoping session shall be included in the succeeding study/assessment. The cost for the measures identified will be incorporated to the total project cost.

## 3.1 PRE-CONSTRUCTION PHASE

In this phase, impacts on the physical and biological aspect may be limited. Activities during this phase are limited acquisition of the necessary permits and right-of-way. This phase also includes the finalization of the subway design and finalization of plans including the resettlement plan for the project affected families/persons.

In this phase, significant impact includes resistance and/or apprehension of the project affected persons/families (PAPs) to the project. To mitigate this, there should be sufficient and meaningful dissemination of information to the PAPs on the proposed compensation scheme, relocation site and resettlement features. Coordination with the Local Government Unit should be conducted to ensure orderly implementation of the relocation/resettlement plan. Inventory of the affected families and properties must be finalized and the cost of compensation should be included in the project cost. Livelihood restoration in the relocation site whether in-city or outside of the city should be ensured. A grievance redress mechanism should be in place to assist should there be any questions on the relocation program.

For affected trees, inventory should be conducted in accordance with DENR policies and the proper replacement ratio/scheme should be observed. Tree cutting permit must be secured prior to construction.

## 3.2 CONSTRUCTION PHASE

### 3.2.1 Vegetation Clearing

A detailed inventory will need to be undertaken in order to ascertain the actual number of trees that will be cut as part of the construction activities of the Project. However, the potential impacts of the project to the removal of vegetation which will lead to habitat loss and/or reduction is expected to be very minimal and short term. The project site, given its location, past disturbances, and current development is already degraded and fragmented in terms of habitat condition. The vegetation in the project site consists mainly of fast-growing exotic species which are readily and commonly available in the surrounding areas of the project
site.

### 3.2.2 Change in Landform and Topogrophy

The earthwork activities (excavation, backfilling and stockpiling) involved during the construction of the stations, tunnel tubes and the Depot Area would entail alteration of the general land form and may entail impacts such as erosion, subsidence and soil runoff. To mitigate, proper sloping techniques must be used. Proper storage and maintenance of the spoil disposal areas must also be observed. The installation of a proper drainage system would also prevent soil runoff during construction.

Development of erosion control plan that will involve proper timing of construction activities, site protection, proper disposal of excavated materials and rehabilitation measures that address soil erosion resulting from construction as well as good operating procedures may be adopted by the contractor. Also, sediments must be contained within the construction site through sediment basins or other retention structures such as rock dikes, silt fences, siltation ponds and other measures.

These may be stipulated in the contract as well as the conditions that will ensure environmental integrity during construction and this will also become the contractor's and IRC's responsibility.

### 3.2.3 Contamination of Water Bodies

During construction, heavy equipment will need fuel and lubricants for proper functioning. Waste from machineries such as oil and grease products may find their way to the rivers and ground water if not handled properly. These may pollute the rivers and creeks, block off photosynthesis and other plant processes, and may eventually affect the aquatic environment and organisms.

Spills of oil and greases in the equipment maintenance area must be avoided through proper housekeeping, regular inspection of working areas, proper maintenance and provision of waste containment area for filters and other consumables. Also, contractors should ensure that fuel and oil storage areas should be located 20 meters away from any watercourses and provided with inceptor traps so that accidental spills do not contaminate the site

### 3.2.4 Noise Pollution

During construction, land-clearing, hauling of materials and spoils in and out the project area and other activities would generate noise in the host communities. Impacts are generally on the households near the construction site and communities along the stations, depot and staging area where construction and waste materials will be transported. The noise generators will be the heavy equipment's, such as bulldozers, pay loaders, rollers, dump trucks and other machineries.

To mitigate noise pollution during the construction, it is recommended that contractors may use properly maintained heavy equipment fitted with appropriate mufflers or silencers. Likewise, work schedule may be limited during daytime to avoid disturbance in the surrounding/nearest community operators must be properly oriented in the use of the machines and heavy equipment, avoid excessive pumping on the fuel and use of horn. Warning signs and speed limits in populated areas may be established.

### 3.2.5 Dust Generation

During construction, excavation of soil and transport of materials are perceived to generate dust. Significant impacts are more likely on the communities along the stations, depot, and staging area where materials will be hauled and transported. Activities such as clearing, hauling and stock piling of earth materials may raise the concentration of dust in the construction site. However, this condition is temporary during the land clearing and construction phase.

To mitigate the impacts on dust generation during construction phase, contractors should ensure that access roads and other dust generating areas would be frequently sprayed two (2) to three (3) times a week with water. It is also important to always observe speed limit of vehicles in dusty roads especially near to populated areas.

### 3.2.6 Increased in Domestic Wastes

Project workers will be brought to the project area. Temporary camps, motor pool, guard house and other important facility will be put in place near the construction areas. Hence, this could generate industrial and domestic wastes such as engine parts, tires, garbage, sewage and even human waste and other more.

The contractor and IRC should implement proper waste management. Installation of Material Recovery Facility (MRF) for waste segregation and compost pits may be provided in the construction and workers campsite/bunkhouses.

Waste storage facilities such as septic tanks or portable toilets may be installed on site during construction. The contractor should ensure that no untreated human wastes should be allowed to enter any water course where this will affect downstream water quality, aquatic environment, and human health. Change in aesthetic character of the area can be minimized by disposing of excavated materials as soon as possible to designated temporary dump sites. Likewise, the contractor must undergo proper clean up and abandonment of the site such as removal of temporary bunkhouses, stock yard and other unnecessary structures after completion of the construction activities.

### 3.2.7 Increase in Traffic

Due to the entry and exit of heavy equipment, hauling trucks and office vehicles, traffic may increase in the affected municipalities. To mitigate the impacts of increased traffic, road signs may be established to inform stakeholders of the incoming and outgoing traffic. Setting up of routes towards construction sites may be implemented so as not to further increase traffic at main roads. A traffic management plan prepared with the LGU should be implemented.

The construction of the Project will require temporary road and bridge closures at various sections of the project alignment which can exacerbate the already heavy traffic congestion in Makati City. In order to minimize potential traffic impacts associated with the construction of the Project, a Traffic Management Plan (TMP) should be prepared and strictly enforced during the construction period. The TMP will be discussed with the Makati City Government, Department of Public Works and Highways (DPWH), and the Metropolitan Manila Development Authority (MMDA), and residents and business owners located along affected roads and bridges. The following mitigation measures are also proposed to ease traffic congestion associated with the Project:

- Schedule the delivery of materials to avoid peak traffic hours as much as practicable;
- Ensure that pedestrians and other vehicles will be able to safely access roads that will be used and affected during the construction phase of the Project;
- Provide appropriate road safety signages in the vicinity of the construction site;
- Schedule road and bridge closures in sections; and
- Coordinate with the Makati City Government to provide sufficient traffic enforcers to direct traffic and not allow vehicles to park on the side of the affected roads especially during peak hours to avoid blocking traffic.

### 3.2.8 In-migration and Employment

During construction, influx of workers together with their families may be expected. These would create strain and stresses, competition and demand for local resources.

During construction qualified residents of host communities must be given priority in hiring, including senior citizens. This must be coordinated with the LGU's and Barangay officials to enhance community appreciation of the project and will provide employment and income to the residents especially to those affected families.

## 3.3 OPERATION PHASE

### 3.3.1 Domestic Waste Generation

With the operation of the subway, increase in solid and liquid waste is expected. Subway operations, passengers and concessionaire's activities are potential sources of solid and liquid waste. A Solid Waste Management Plan must be implemented during project operations to ensure management of solid waste. Materials recovery facilities should be established to handle solid waste while implementation of proper drainage and proper maintenance of septic system should be done for liquid wastes.

### 3.3.2 Wastewater Management

The operation of the subway will generate stormwater runoff and sanitary wastewater streams. It is recommended that these two wastewater streams are separated to reduce the volume of wastewater requiring treatment. Stormwater runoff from the site will be collected by an onsite drainage system. If deemed necessary, collected stormwater will be treated prior to discharge to nearby creeks. Effluent from the subway stations and various establishments in the TODs will be treated as required to ensure compliance with the DENR Administrative Order 2016-08 General Effluent Standards prior to discharge to public sewers or surface waters.

### 3.3.3 Geologic Hazards

According to the hazard assessment report of PHILVOCS on the alignment of the project all, all sites may be affected by strong ground shaking. Areas within stations 4, 8, and 9 s all identified as highly susceptible to ground rupture and liquefaction hazards. These hazards can be mitigated by following the mitigation measures provided in the National building Code and the Structural Code of the Philippines.

### 3.3.4 Contamination of Land and Water from Accidental Spills and Chemical Leaks

The operation of the train depot would entail the storage and handling of substances that might pose contamination risk to soil and water. Proper labelling, storage and disposal of these substance should be observed to avoid contamination of soil and water bodies.

**Table 3-1: Environmental Management Plan**

| Project Phase / Environmental Aspect | Environmental Component Likely to be Affected | Potential Impact | Options for Prevention for Mitigation or Enhancement | Responsible |
|---|---|---|---|---|
| **I. PRE-CONSTRUCTION PHASE** | | | | |
| 1. Acquisition of Right of Way | Land/ People | loss of land and crops ownership<br><br>Damage to Properties | - avert negative perception of people through IEC<br><br>- Resettlement Action Plan (RAP) must be finalized for equitable compensation and acquisition scheme of affected families and properties<br>- The project affected households will still experience the privileges of being Makatizens after the project implementation. | IRC-Environmen Unit/PCO Community Rela |
| **II. CONSTRUCTION PHASE** | | | | |
| 1. Site Preparation -Vegetation Clearing, Grubbing, and stripping | Terrestrial Ecology/ Biota and Riparian Zone | - Vegetation loss<br><br>- Removal of economically and ecologically important species<br><br>- Habitat fragmentation | - Avoid unnecessary cutting of vegetation<br><br>- Inventory of biota and riparian zone as basis for species and volume replacement<br><br>- Compensate through planting indigenous tree species suitable in the area<br><br>- Implement watershed Management Plan | IRC -En Unit/PCO |
| 2. Earthworks (Soil excavation; stockpiling; hauling of raw materials to construction site; Grading and road construction) | Slope and Topography<br><br>Underground Condition | - change in topography<br><br>- Underground openings will be subjected to differed loads of the surrounding earth/rock materials.<br><br>- seepage (piping) of underground openings. | - - Optimized project footprint to minimize landdisturbance<br><br>- The excavation works will have temporary support for the maintain stability.<br><br>-Use engineering and vegetative measures<br><br>- Limit construction activities during dry season<br><br>-adequate positioning of stockpile areas away from river/creek.<br><br>- road-bank soil erosion prevention/minimization (use of biological or | IRC -En Unit/PCO |
| | Soil/ Pedology | - increased soil erosion | | |
| | Aquatic Flora and Fauna<br><br>Biota and Riparian Area | Destruction or disturbance of aquatic life due to works in rivers.<br><br>Degradation of aquatic habitat, species decline | | |

| Project Phase / Environmental Aspect | Environmental Component Likely to be Affected | Potential Impact | Options for Prevention for Mitigation or Enhancement | Responsible |
|---|---|---|---|---|
| | | | $NO_x$ emissions | |
| | Noise | Noise pollution | Use of mufflers and exhaust silencers<br><br>Periodic inspection and maintenance of equipment<br><br>Construction works should be done during daytime only | |
| 3. Use of Vehicles and Heavy Equipment | Water Quality | Oil and grease leaks from heavy equipment and vehicles | Periodic inspection and maintenance of equipment<br><br>Spillage should be avoided by having proper storage facilities and handling for any equipment that will need fuel and lubricants<br><br>Provide inceptor traps in case of accidental spills<br><br>Waste oils must be properly stored in drums or storage unit and then properly disposed off through a third-party disposal. | IRC-Environmen Unit/PCO |
| | Air Quality | Increase in $SO_x$ and $NO_x$ concentrations from vehicle emission | - designation of motor pool with complete facilities<br><br>-equipment should always be in good running condition | IRC-Environmen Unit/PCO |
| 4. Construction of Structures | People | Employment Opportunities<br>Temporary increase of illness to workers due to increase of Pollutants. | Priority of hiring of qualified laborer are given to the residents in the area | IRC-Community Relations |
| | | | Provision of temporary housing and sanitary | IRC-Community |

| Project Phase / Environmental Aspect | Environmental Component Likely to be Affected | Potential Impact | Options for Prevention for Mitigation or Enhancement | Responsible |
|---|---|---|---|---|
| | | | trucks and heavy equipment.<br><br>Coordinate with LGUs | |
| | | Temporary disruption of income sources/ livelihood for those who will be displaced/ relocated | Provision of livelihood training, livelihood assistance and subsistence allowance for displaced families | IRC-Community Relations |
| | | Permanent and temporary dislocation of households and loss/destruction of properties, trees, and crops. | Implementation of mutually acceptable compensation scheme<br><br>Implementation of an IEC program | IRC-Community Relations |
| | | Temporary disruption of access to institutional and basic services for those who will be displaced/ relocated | Ensure provision of institutional facilities (health center, barangay hall, school, churches) at relocation site | IRC-Community Relations |
| **III. OPERATION PHASE** | | | | |
| 1. Subway Operations | Air Quality | Increase in particulate matter in station | Regular air quality monitoring<br><br>Noise barriers & planting trees/vegetation on stations and strategic locations. | IRC-Environmen Unit/PCO |
| | | Increase in vehicle concentration along stations | Regular air quality monitoring | |
| | Water Quality | Change in water quality due to feeds and excrements in Aqua culture | Regular water quality monitoring<br><br>Any generated wastewater should be properly stored in drums or storage units and then disposed off through a third-party disposal | |
| | People | Employment opportunities | Prioritization of host communities in employment | IRC Communit |
| | | Increased source of livelihood for locals | Assistance to LGUs in formulation and implementation of alternative sources of livelihood | |
| Host communities | People | Monetary and non-monetary benefits to host communities | Proper utilization of resources. | IRC C Relations |

| Project Phase / Environmental Aspect | Environmental Component Likely to be Affected | Potential Impact | Options for Prevention for Mitigation or Enhancement | Responsible |
|---|---|---|---|---|
| | | disposal | Proper storage facilities and handling for any equipment that will need fuel and lubricants<br><br>Provide inceptor traps in case of accidental spills<br><br>Waste oils must be properly stored in drums or storage unit and then properly disposed off through a third-party disposal | |
| 3. Use of vehicles for mobility i maintenance and operations | Air Quality | Change in TSP, $SO_x$, and $NO_x$ levels in air | | |
| **IV. Project Abandonment** | | | | |
| Dismantling/ removal of facilities such as camps, storage yards, workshop areas and motor pool | Land and water quality | Land and water pollution | allocate certain percentage of the construction cost for clean-up after construction<br><br>- salvage materials that are usable which can be used by the local workers or residence | IRC-Environmer Unit/PCO |

# 4 ENVIRONMENTAL RISK ASSESSMENT

## 4.1 Natural Hazard Assessment

### 4.1.1 Fault Related/Seismic Hazards

The fault related/seismic hazards that could impact the project area are intense ground shaking resulting from ground acceleration, ground rupture and liquefaction.

Potential Earthquake Generators

Based on historical and instrumental data, five active faults have been identified to be the locus of major earthquakes and have significantly impacted Metro Manila (Daligdig and Besana, 1993). These are the Valley Fault System (VFS), the Philippine Fault Zone (PFZ), the Lubang-Verde Island Passage Fault, the Casiguran Fault, and the Manila Trench (**Figure 4-1**).

The VFS is a system of two curvilinear NE-trending dextral faults, the West Valleyand East Valley Faults, which transects the easternlong axis of Metropolitan Manila. Records indicate the last movements of the VFS took placein 19 August 1658 for the West Valley Fault and 01 February 1771 forthe East Valley Fault, that generated Ms 5.7 and Ms 5.0,respectively.

Far south of the project site, the Lubang-Verde Island Passage Fault traverses through the Mindoro Strait located between Batangas and Mindoro Island. This sinistralstrike-slip fault transforms to a transpressional fault as it cuts through the southern section of the Manila Trench (MGB, 2010). A notable seismicity along this fault took place in 08 April 1942, having generated an earthquake measuring Ms 7.5.

The Infanta Segment of the 1,200-km sinistral Philippine Fault traces the Pacific coastline of Luzon Island from Infanta to Lucena City in the province of Quezon. It had a notable activity on 18 July 1880, which generated an earthquake that measured Ms 7.6. Another segment of the Philippine Fault with more recent activity is the Digdig Segment which is the source of the Ms 7.8 earthquake that caused widespread destruction throughout central and northern Luzon on July 16, 1990.

The Casiguran Earthquakeof August 02, 1968 is one of the destructive earthquakes experienced in the Philippines (PHIVOLCS). The earthquake of Ms 7.3 and an intensity of VIII in the Rossi-Forel Intensity Scale rocked the town of Casiguran, Aurora. Two hundred seventy (270) persons were killed and 261 were injured as a result of the earthquake. A six-storey building in Binondo, (Ruby Tower) Manila collapsed instantly during the quake while several major buildings near Binondo and Escolta area in Manila sustained varying levels of structural damages. The cost of property damage was several million dollars. Extensive landslides and large fissures were observed in the mountainous part of the epicentral area. Tsunami was also observed and recorded as far as observation in tide gauge station in Japan.

The Manila Trench is the crustal manifestation of the subduction of the West Philippine Sea beneath the Philippine Mobile Belt. It loosely follows the configuration of the western coast of Luzon island, following a N-S strike between 14-16° N latitude, and bends to a SE direction between 12.5-14° N latitude. Notable seismicity attributed to these segments of the Manila Trench were recorded on 25 April 1972 (12.5-14° N) and 07 December 1677 (14-16° N) that generated earthquakes measuring Ms 7.2 and 7.3, respectively.

The Laguna-Banahaw Fault is a linear structure that can be traced along the base of the Caliraya Plateau which sits on the eastern edge of Laguna de Bay. This strike-slip fault is believed to have caused the Ms 7.5 earthquake that occurred on 20 August 1937

On 03 June 1863, a strong, Ms 6.5 earthquake destroyed Manila Cathedral, the Ayuntamiento (city hall), the Governor's Palace (all three located at the time on Plaza Mayor, now Plaza de Roma) and much of the city. Records indicated that this event originated from somewhere near Sangley Point in

Manila Bay. The movement is believed to be strike-slip, although no surficial evidence of an active fault that traverses this area has been observed to date.

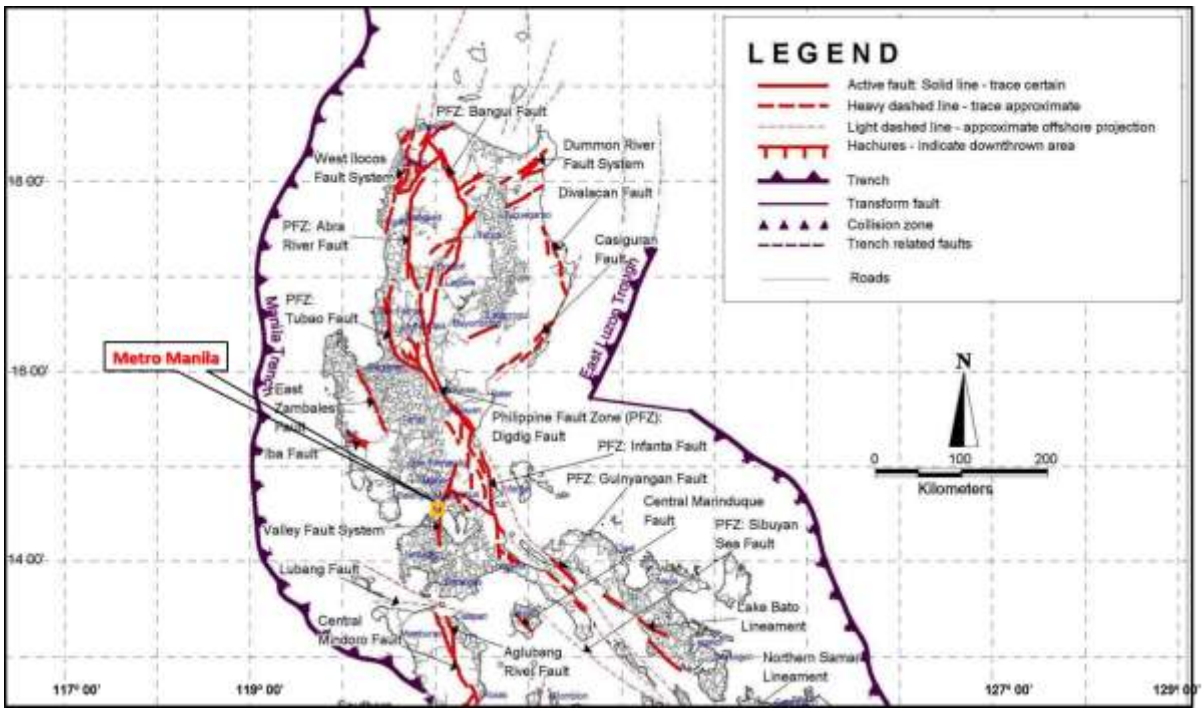



**Figure 4-1: Earthquake Generators which Significantly Impacted Metro Manila.**

(Reference Map: PHIVOLCS, Distribution of active faults and trenches in the Philippines.)

A. Ground Acceleration

In general, the intensity of ground shaking is magnitude-dependent and gradually decreases with distance from the source. Differences in ground conditions, however, may cause deviations from this expected norm, particularly in areas underlain by recent alluvium.

Ground shaking hazard assessment is done to identify the potential effects of seismic movement over a particular area by determining the characteristic response of the ground during an event. One method, the Deterministic Seismic Hazard Assessment (DSHA), uses data from known seismic sources to simulate ground motion during discrete, single-valued events. DSHA, however, does not factor in the probability of occurrence of an earthquake of a certain magnitude occurring at a specific area over a given finite period of time, nor the uncertainties in the values needed to compute ground motion characteristics.

A formula developed by Fukushima and Tanaka in 1990 computes for seismic responseexpressed as peak ground acceleration (PGA) in a specific site using maximum crediblemagnitude that can be generated by an earthquake source (i.e. active fault), the seismicgenerator's distance from the site, and the attenuation of the substrate in that area. Thepotential earthquake generators around the project site, the estimated perpendicular (orshortest) distance between the seismic generator and the project site (based on the medianlocation of the proposed sites), and the maximum credible earthquake (MCE) (JICA-MMDA, PHIVOLCS,2004) are presented in **Table 4-1**. This table contains scenario parameters of thefaults and trenches previously discussed which includes possible seismic sources notcurrently classified under the active faults list of PHIVOLCS. Thus, the Laguna-Banahaw Faultand the inferred Manila Bay source of the Ms 6.5 03 June 1863 event are also assessed.

The average PGA value is calculated from the resulting mean of peak acceleration divided by the acceleration due to gravity constant. In general, the average PGA in an area decreases the farther away from the earthquake source, given the same magnitude.

Seismic waves propagate differently across various substrate compositions, resulting in attenuation of ground acceleration. Investigations of acceleration attenuation in strong-motion stations in Japan recognized a divergence of observed measurements from predicted peak horizontal accelerations. By classifying the ground condition and segregating the data, the attenuation or amplification factor was estimated. The four general types of ground conditions used in the Japanese study are Rock, Hard Soil, Medium Soil and Soft Soil (Fukushima & Tanaka, 1990). The three soil types are described as follows (Earthquake Engineering Committee, the Japanese Society of Civil Engineers, 1988):

1. Hard Soil: ground before the Tertiary period or thickness of diluvial deposit above bedrock is less than 10 m;
2. Medium Soil: thickness of diluvial deposit above bedrock is greater than 10 m, or thickness of alluvial deposit above bedrock is less than 10 m, or thickness of alluvial deposit is less than 25 m and thickness of soft deposit is less than 5 m; and
3. Soft Soil: other soft ground such as reclaimed land.

**Table 4-1: Scenario Earthquakes for Ground Shaking Hazard Assessment.**

(Source: 2018 FS)

| Seismic Source | Distance(km) | | | Maximum Credible Earthquake (Magnitude) |
|---|---|---|---|---|
| | Western | Central | Eastern | |
| West Valley Fault (central)* | 5 | 2.5 | 0 | 7.2 |
| Manila Bay source (1863 Earthquake)* | 12 | 14 | 16 | 6.5 |
| East Valley Fault* | 19 | 18.5 | 18 | 6.3 |
| Laguna–Banahaw Fault | 50 | 47.5 | 45 | 7.5 |
| Lubang – Verde Island Passage Fault* | 99 | 99 | 99.5 | 7.7 |
| Philippine Fault (InfantaSegment)* | 63.5 | 61 | 59 | 7.6 |
| Philippine Fault (DigdigSegment)* | 121 | 121.5 | 122 | 7.9 |
| Manila Trench (14-16°N)* | 190 | 190.5 | 191 | 7.9 |
| Manila Trench (12.5-14°N)* | 202 | 204.5 | 206.5 | 7.9 |

**Classified as active by PHIVOLCS*

**Table 4-2** shows the computed peak ground acceleration values and ground shakingattenuations on different ground conditions in the western (Sta. Cruz, Olympia, Tejeros),central (Poblacion, Guadalupe Viejo, Guadalupe Nuevo) and eastern (West Rembo, EastRembo) zones of Makati City, based on the formula of Fukushima and Tanaka (1990) and theinformation provided. The values indicate that the strongest shaking can becaused by a Ms 7.2 earthquake from the central segment of the West Valley Fault, withaverage peak ground accelerations ranging from 0.52 to 0.64 g (5.1 to 6.3 m/s2). The proposedsubway will be bored through tuff rock, so less intense shaking ranging from 0.31 to 0.38 g(3.0 to 3.7 m/s2) may be recorded in this layer. However, for the overlying soft soil layers, higher acceleration values of 0.72 to 0.88 g (7.1 to 8.6 m/s2) may be recorded. Of the threezones, the east has the strongest ground shaking values, since it is transected by the West Valley Fault.

**Table 4-2: Computed Peak Ground Acceleration Values in Makati City for Various Seismic Sources**

(Source: 2018 FS)

| Seismic Source | Western District | | | Central District | | | Eastern District | | |
|---|---|---|---|---|---|---|---|---|---|
| | Average (g) | Soft Soil | Rock (g) | Average (g) | Soft Soil | Rock (g) | Average (g) | Soft Soil | Rock (g) |
| West Valley Fault | 0.52 | 0.72 | 0.31 | 0.57 | 0.8 | 0.34 | 0.64 | 0.88 | 0.38 |
| Manila Bay source (1863 Earthquake)* | 0.32 | 0.44 | 0.19 | 0.29 | 0.41 | 0.18 | 0.27 | 0.37 | 0.16 |
| East Valley Fault* | 0.22 | 0.3 | 0.13 | 0.22 | 0.31 | 0.13 | 0.22 | 0.31 | 0.13 |
| Laguna-Banahaw Fault | 0.19 | 0.26 | 0.11 | 0.2 | 0.27 | 0.12 | 0.21 | 0.29 | 0.12 |
| Lubang – Verde Island Passage | 0.09 | 0.13 | 0.06 | 0.09 | 0.13 | 0.06 | 0.09 | 0.13 | 0.06 |
| Philippine Fault | 0.15 | 0.21 | 0.09 | 0.16 | 0.22 | 0.1 | 0.17 | 0.23 | 0.1 |
| Philippine Fault | 0.08 | 0.11 | 0.05 | 0.08 | 0.11 | 0.05 | 0.08 | 0.11 | 0.05 |
| ManilaTrench | 0.03 | 0.05 | 0.02 | 0.03 | 0.05 | 0.02 | 0.03 | 0.05 | 0.02 |
| ManilaTrench | 0.03 | 0.04 | 0.02 | 0.03 | 0.04 | 0.02 | 0.03 | 0.04 | 0.02 |

**Classified as active by PHILVOLCS*

Moderate to strong ground shaking may also be anticipated from scenario earthquakes originating from the Manila Bay source of the 1863 earthquake, the East Valley Fault, and the Infanta Segment of the Philippine Fault.

Deterministic ground shaking hazard assessment was also previously conducted as part of the multi-agency Risk Analysis Project (or READY Project) composed of PHIVOLCS, MGB, NAMRIA, PAGASA, the National Disaster Risk Reduction and Management Council (NDRMMC) and the Department of National Defense (DND). A ground shaking hazard map for an event scenario of a Ms 7.2 earthquake along the West Valley Fault was generated **(Figure 4-2).** The map shows possibility of shaking with a PHIVOLCS Earthquake Intensity Scale (PEIS) rating of High 8 in the western and eastern zones of Makati City, and a rating of Low 8 for the central zone. Both are considered to have Very Destructive impacts, with equivalent PGAs of 0.34 to 0.65 g (3.3 to 6.4 $m/s^2$) for the Low 8 rating and 0.65 to 1.24 (6.4 to 12.2 $m/s^2$) for the High 8 rating. The difference in intensity is attributed to the type of underlying geology in the zones: the western and eastern zones are largely underlain by soft Quaternary Alluvium, while the central zone is underlain by tuff rock of the Guadalupe Formation.

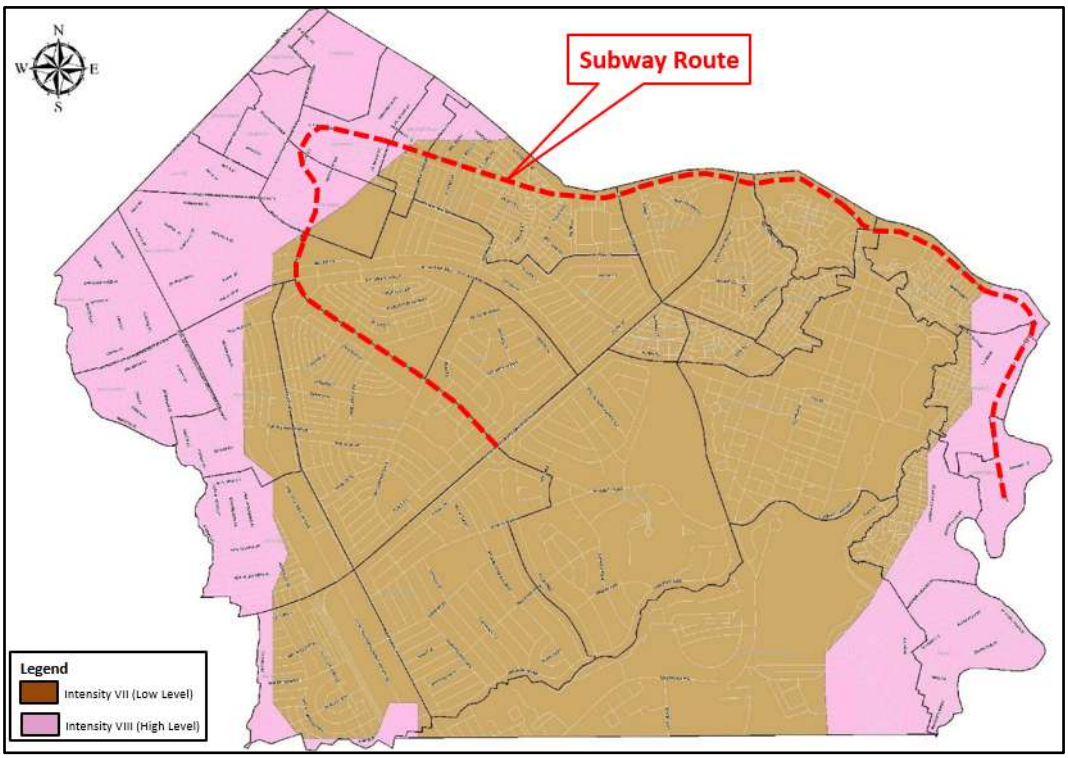



**Figure 4-2: Ground Shaking Hazard of Makati City for a Ms 7.2 Earthquake along**

As previously mentioned, DSHA does not factor in the probability of occurrence of an earthquake. To remedy this, the Probabilistic Seismic Hazard Assessment (PSHA) was developed to incorporate a temporal aspect with the inclusion of occurrence probabilities of seismic events. In addition, the PSHA also allows for uncertainties in size, location and recurrence rates of earthquakes (Anbazhagan, 2007).

Probabilistic seismic hazard maps typically show the critical level of earthquake ground motion (i.e. peak acceleration) in a specific area for a given probability of exceedance (or inversely, the return period). It is useful in setting design thresholds for structures within their expected useable life. The peak acceleration is determined essentially the same way as in the DSHA.

Thenhaus and others (1994) performed a probabilistic estimate of peak ground acceleration levels across the Philippines based on a hypothetical earthquake with Ms 8.2 and with 10 percent probability of exceedance in 50 years for both rock and soft soil conditions. Based on these maps, Metropolitan Manila in general can anticipate PGAs of about 0.22 g (2.2 $m/s^2$) in rock foundation to 0.60 g (5.9 $m/s^2$) in soft soil foundation, within 475 years (**Figure 4-3).**

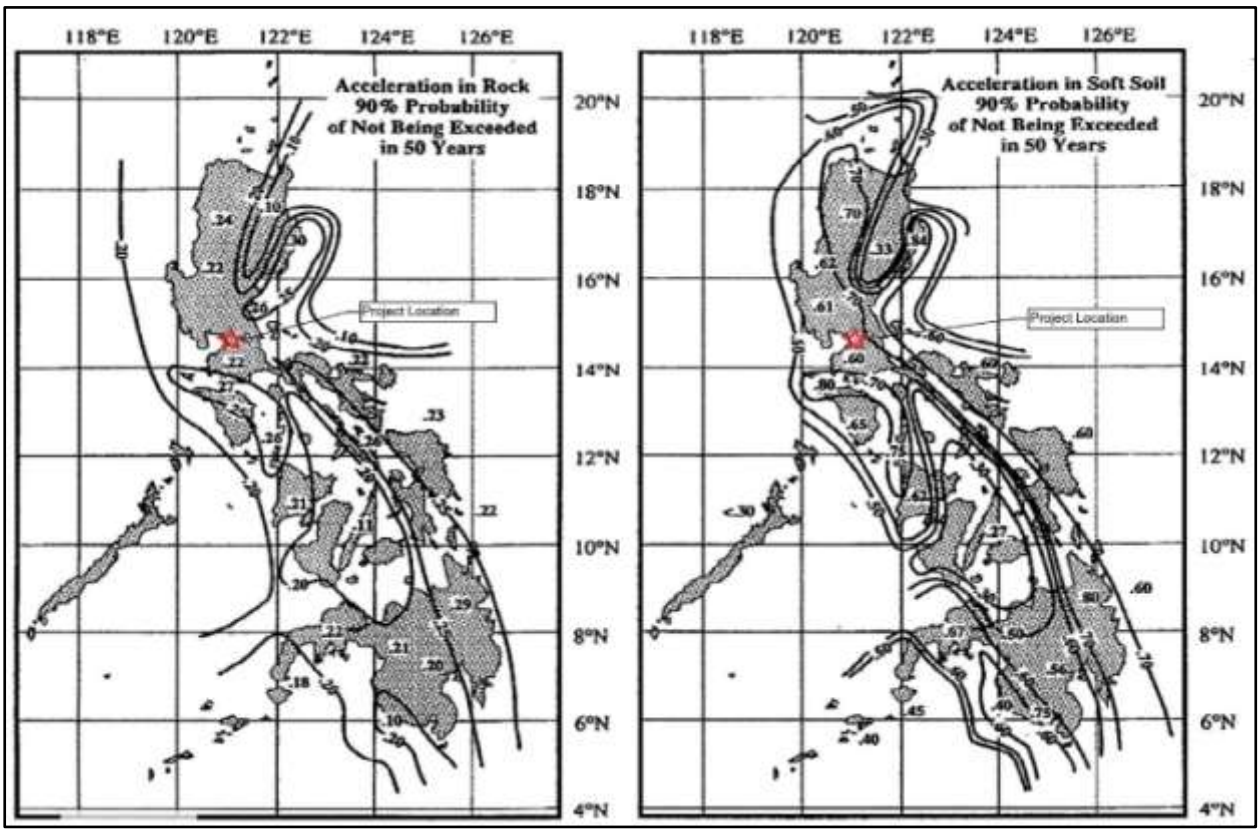



**Figure 4-3: 475-year Probabilistic Seismic Hazard Maps of the Philippines**

(Source: Thenhaus et al., 1994 as referenced in the 2018 FS)

If the PGAs obtained thru DSHA were compared with those from the PSHA, the maximum values computed under rock conditions (0.31 to 0.38 g) are higher than the 0.22 g 475-year return period shaking in for the Metropolitan Manlia area. Likewise, the maximum values computed under soft soil conditions (0.72 to 0.88 g) are higher than the 0.60 g 475-year return period shaking. Since stronger earthquakes are rarer than weaker ones, this suggests that the probability of an earthquake occurring that will generate shaking that will not exceed the PSHA values is higher than 90% within 50 years. The last known movement of the West Valley Fault was around 360 years ago (with a magnitude of 5.7). A stronger event may be due within the next couple of generations.

In accordance with the provisions of the National Structural Code of the Philippines (NSCP, 2015), which PHIVOLCS recommends to mitigate ground shaking hazard, earthquake related site geology and hazard characteristics contain the following main elements and shall be adopted in the structural design:

a) Soil Profile Type: since the Makati Subway is constructed in weak rock of GTF and the stations are also founded on weak rock, soil profile type of “SC – Very dense soil and soft rock” is recommend (according to Table 208-2, NSCP 2015). However, the design earth lateral support (ELS) of excavation works may require adopting soil profile type SD or SE subject to the local soil profile.

b) Seismic Zone: the study area is located in Zone 4 (Figure 208-1, NSCP 2015).

c) Seismic Source Types: West Valley Fault was estimated to have slip rate of 5-7mm/year(Rimando and Kneupfer, 2006). It is appropriate to assume West Valley Fault to be seismicsource Type A (Table 208-4, NSCP 2015) as earthquake event of Magnitude 7 or higheris expected in relation to the West Valley Fault.

d) Seismic Near-Source Factor and Seismic Response Coefficients: The near source factorshall be determined based on the actual distance of each structures from the West ValleyFault. The seismic response coefficients can be determined by the seismic zone and soilprofile type.

B. Ground Rupture

Ground or surface rupture occurs when movement on a fault breaks through to the surface. Rupture may occur suddenly during an earthquake or slowly in the form of fault creep. There is displacement on either side of a ground rupture: dip-slip faulting has surface ruptures that feature vertical offset, while strikeslip faulting has a lateral displacement. It is also possible to have a combination of horizontal and vertical slippage. Fault rupture almost always follows pre-existing faults. The length of ground rupture and the width of the zone of deformation generally increase with the magnitude and type of earthquake. A ground rupture is rarely confined to a simple narrow and distinct line and the zone of deformation could be as wide as 100 m (Punongbayan et al., as cited in PHIVOLCS, 2001). Developments along identified or hidden fault zones are at risk of structural damage if old fault lines are reactivated.

Ground ruptures formed by seismic events occur usually along pre-existing fault traces, and that movement conditions of newer earthquakes are almost similar to previous events. The WVF is the nearest active fault to the Project, cutting along the eastern margin of Metropolitan Manila (and a portion of the proposed alignment in East Rembo). From the official PHIVOLCS trace of the West Valley Fault (**Error! Reference source not found.),** it can be seen that the fault cuts through arangays West Rembo, East Rembo, Comembo, Pembo, Rizal and Post Proper Southside in the eastern district of the city. An approximate 3.63 km segment of the West Valley Fault traverses these six barangays of Makati City (**Error! Reference source not found.**). The proposed eastern lignment of the subway in this area intersects somewhere near the junctions of J. P. Rizal Extension and P. Urduja and P. Zamora Streets. The subway alignment will then generally follow J. P. Rizal Extension southward (which closely parallel to the trace of the West Valley Fault) and makes a curve towards the Ospital ng Makati in Pembo/Comembo, where it will just be around 150 m east of the fault. Any displacement of the tunnel may severely affect the subway operation.

**Table 4-3: City Barangay Affected by Ground Rupture of the WVF.**

(Source: Makati City Atlas as referenced in the 2018 FS)

| Barangay | Approximate Length of Fault Zone (km) |
|---|---|
| West Rembo | 0.31 |
| East Rembo | 1.07 |
| Comembo | 0.16 |
| Pembo | 0.82 |
| Rizal | 0.83 |
| Post Proper Southside | 0.44 |
| **Total** | **3.63** |

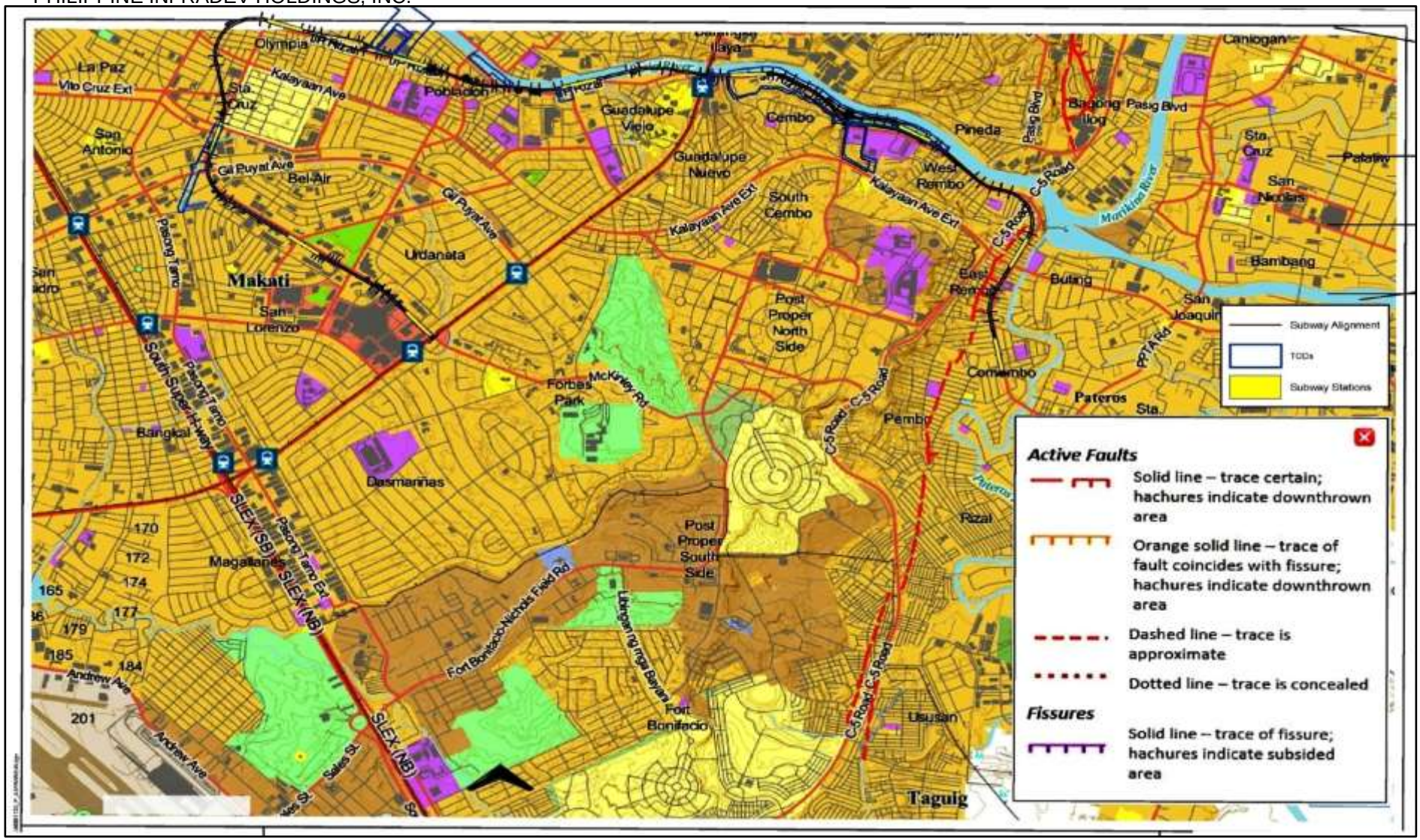



**Figure 4-4: Trace of the West Valley Fault (WVF) in Makati City**

(Source: PHIVOLCS FaultFinder as referenced in the 2018 FS)

A ground rupture hazard assessment by PHIVOLCS considered the locations of 10 subway stations as safe based on their distances to nearest known active WVF. PHIVOLCS recommends a buffer zone, or Zone of Avoidance against ground rupture hazard of at least 5 m on both sides of the active fault or from its zone of deformation.

The Makati City Government currently partially enforces a 10-m easement (5 m on both sides) building policy along the trace of the WVF. It also plans the eventual removal or demolition of public buildings it owns that are on the fault easement, as well as the condemnation of private buildings that are situated along the WVF.

C. Liquefaction and Liquefaction-Induced Lateral Spreading

Liquefaction refers to the process whereby water-saturated, cohesionless soil substantially loses strength and stiffness in response to an applied stress, usually earthquake shaking causing it to behave like a liquid. Liquefaction-induced lateral spreading occurs on mild slopes of less of 0.3 to 5% underlain by loose sands and a shallow water table (Bartlett and Youd, 1992).

From the PHIVOLCS liquefaction hazard map as shown in **Figure 4-5** the potential for liquefaction in Makati City ranges from low to none in areas underlain by the Guadalupe Formation (e.g. central districts), and moderate to high in areas underlain by Quaternary Alluvium on the western and eastern districts and adjacent to Pasig River. The areas with high liquefaction hazard include Barangays Kasilawan, Carmona, Singkamas, Tejeros, La Paz, San Antonio, Palanan and San Isidro, as well as portions of Barangays Valenzuela, Olympia and Poblacion that are close to the Pasig River. In the eastern part of the city, areas along the banks of Pateros River such as in Barangays East Rembo, Comembo and Pembo, moderate to high liquefaction hazard.

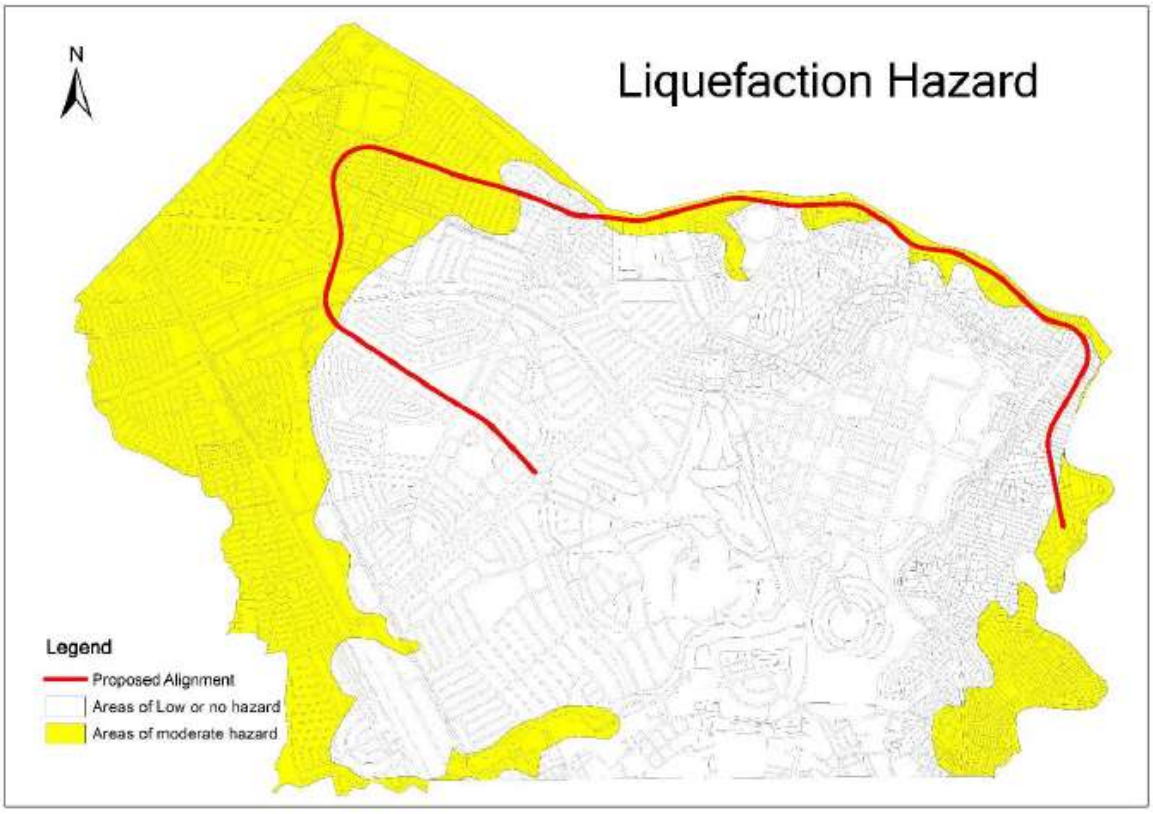



**Figure 4-5: Liquefaction Hazard Map of Makati City**

Liquefaction hazard assessment by PHIVOLCS indicated that of the 10 subway stations, Station 4 at the junction of J.P. Rizal Avenue and Sacramento Street in Barangay Olympia and Station, Station 8

along J.P. Rizal Extension near Gen. Arellano Street in Barangay West Rembo and Station 9 along J.P. Rizal Extension between 4th Avenue and Kalayaan Avenue in Barangay East Rembo are highly susceptible to liquefaction.

The proposed alignment is mainly located within area of low or no liquefaction hazard, while the portion of the alignment underlain by alluvium is classified as moderate to high liquefactionhazard. Considering that the proposed tunnel is constructed in weak rock and the stations arefounded on weak rock, the liquefaction hazard to the proposed subway is low. However, liquefaction hazard shall be considered during construction phase as liquefaction may affectthe ELS of the excavation. Furthermore, existence of liquefiable soils, quick and highly sensitive clays, etc. will increase the possibility of soil profile type to be SF, which requires site-specific evaluation for seismic design.

Borehole data from geotechnical reports gathered from the City Government indicate thepresence of about 5-15 m-thick unconsolidated sediments overlying harder tuff or sandstonerock in the western and eastern districts; the sediment layer is thinner to less than 5m in thecentral districts. The upper 4 m of the substrate in the western and eastern districts commonly yielded SPT N-values that are less than 15, while the same is true for the upper 2 m of thesubstrate in the central districts. Experimental studies have shown that SPT N-values of lessthan 15 tend to have greater values of cyclic stress ratio of design earthquake (Ri) comparedto cyclic stress ratio required for liquefaction (Rf), resulting to a factor of safety that is less than 1. This may suggest that about 4 m of substrate materials are liquefiable in the western andeastern districts, while about 2 m of the upper soil profile has a potential for liquefaction in thecentral districts. However, considering well-sorted sand or silt are rarely recorded in theborehole logs, the potential for liquefaction may be low.

#### 4.1.1.1.1 Landslide

Landslides or slope failure includes any or combination of the following: falls (rock or debris), slides (topple, rotational or planar), avalanches (rock or debris), flows, creep, solifluction and complex.Slope failure which produces mass movements is caused by a number of factors relating to the physical properties of the material and the subsequent history of crustal movements, erosion, and weathering processes. Landslides typically occur in hilly or mountainous areas, and usually follow periods of intense rainfall or ground shaking events (as in earthquakes).

Although most of the city is considered as built-up area, there are moderately steep slopes that can still be observed as small outcrops with unprotected slope faces which make these prone to landslides or rock fall.

The proposed subway is mainly located below ground surface; only the entrances of stations are located on ground level. Based on the slope gradient and elevation, the topography of the study area is predominantly gentle, only the eastern barangays, including West Rembo, East Rembo, Pembo and Post Proper Southside, along the general trace of the West Valley Fault zone consist of relative steep terrain and are prone to landslide. Therefore, landslide hazard to the proposed alignment is considered to be minimal.

#### 4.1.1.1.2 Volcanic Hazard

Volcanic processes prior, during and succeeding eruptions give rise to numerous volcanic hazards that can have different types and magnitudes of impacts on people and property. Commonly known volcanic hazards such as lava flows, pyroclastic flows, lahars, ground rumbling, ashfalls, and volcanic landslides typically affect areas immediately surrounding active volcanoes where these originate. In less frequent instances, the effects of a volcanic eruption may reach great distances, especially if the eruption is powerfully explosive, and physical conditions are optimal for widespread dispersion.

It should be noted, however, that volcanic hazards are not limited to the deposition of volcanic material. Metropolitan Manila has also been affected by strong ground shaking resulting from the explosive eruption of faraway active volcanoes. Taal Volcano, with its frequent Plinian activity, has been known to occasionally cause strong ground shaking in Manila. In the 18th century alone, three separate eruption events of Taal Volcano, in 1716, 1749 and 1754, shook the city and caused

significant damage to property (Masó, 1910). There is a high probability that future eruptions of Taal Volcano may similarly affect Metropolitan Manila. **Error! Reference source not found.** lists the three ctive volcanoes which may affect the Metropolitan Manila, their estimated distance from central Makati City, and the potential hazards they pose.

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**Table 4-4: Active Volcanoes which may Affect Metro Manila**

(Source: 2018, FS)

| Volcano | Distance (km) and Direction from the Project Site | Occurrence of Last Activity | Possible Hazards to Site |
|---|---|---|---|
| Taal Volcano | 61 (to the south) | 18 August 1749 | Ground rumbling, volcanic shock, volcanic earthquake |
| Mt. Bamahaw | 74 (to the southeast | Circa 1843 | Ashfall |
| Mt. Pinatubo | 98 (to the northwest) | 15 June 1991 | Ashfall |

a. Flooding

Based on Project NOAH (Nationwide Operational Assessment of Hazards) flood hazard maps (**Error! eference source not found.**), the western parts of Makati City are more prone to widespread flooding, compared to the central and eastern portions. Thismay be due to the lower elevations and wider flood basin in that area compared to the lattertwo.

The central portion of the city is dissected by rivers and creeks that drain into the Pasig Riveror to areas of lower elevation, usually to the west. Only the areas adjacent to these rivershave higher susceptibility to flooding; no widespread inundation is expected even during100-year events.

The relatively narrow area (and thus, flood basin) of the eastern portion of Makati City alsocontributes to the lower flooding susceptibility in the area compared to the western part ofthe city. Here, flooding hazard is concentrated along the banks of the Pateros River. A morewidespread inundation of the floodplain may be expected during 100-year events.

The Project NOAH flood hazard maps generally correlate with the 200-year flood hazard map generated by the Greater Metro Manila Area (GMMA) READY Project **Error! Reference source not ound.**), as well as results of a Flo-2D simulation of Makati City for Typhoon Ondoy (**Error! Reference**

**source not found.**) which triggered widespread flooding across the metropolis. Flo-2D is a dynamic flood routing model that simulates channel flow, unconfined overland flow and street flow. Based on the Flo-2D model, flood depths within the Pasig River channel vary from 0.15 to 2 m at the western part, to 3 m and higher at the eastern part where the junction with Marikina River is located. At the banks of the river however, the simulation shows maximum flood heights of 2 m at the western part and 3 m at the eastern part. Along the Pateros River channel and its banks (at the southeastern border of Makati City), simulated flood depths range from 0.15 to 2 m. As a whole, the Flo-2D model shows that flood occurrence during a Typhoon Ondoy-like event is generally restricted to creeks and rivers and immediate vicinities, except in the western part of the City wherein sheet floods ranging from 0.15 to 3 m cover a much larger extent.

With respect to the proposed subway, some segments at the western portion of the alignment are found in areas having simulated flood depths of 0.15 to 1 m. At some central segments along the bank of Pasig River particularly those intersecting creeks that drain into the main channel, up to 3 m-deep floods were modelled. Eastern portions of the proposed track located near Pateros River have generally low susceptibility to flooding during a Typhoon Ondoy-like event.

Being of lower elevation compared to ground level, tunnels may be flooded when surface waters, such as during extreme storm rain events (as what happened in some tunnels in Makati City during Typhoon Ondoy in 2009), descend and collect in the tunnel space. However, the threat of tunnel flooding is greatest from the ingress of groundwater. Many tunnels are built below the water table, so groundwater naturally flows toward the tunnel. It is quite common for tunneling projects to be hindered or slowed down by groundwater problems. In some cases, complete inundation of tunnels resulted from uncontrolled entry of groundwater.

A significant portion of the proposed subway alignment lies along the bank of Pasig River, the largest river in Metropolitan Manila, so it must be expected that the water table in this area is shallower compared to those located far from bodies of water. Several creeks and small rivers are also expected to be intersected by the proposed subway alignment. During construction, huge amounts of groundwater may enter the tunnel, especially in these segments close to rivers. However, even with the installation of an impermeable lining to prevent the seepage of groundwater, huge amounts of water may still enter the tunnel during operations, so additional control measures such as dewatering pumps must be employed

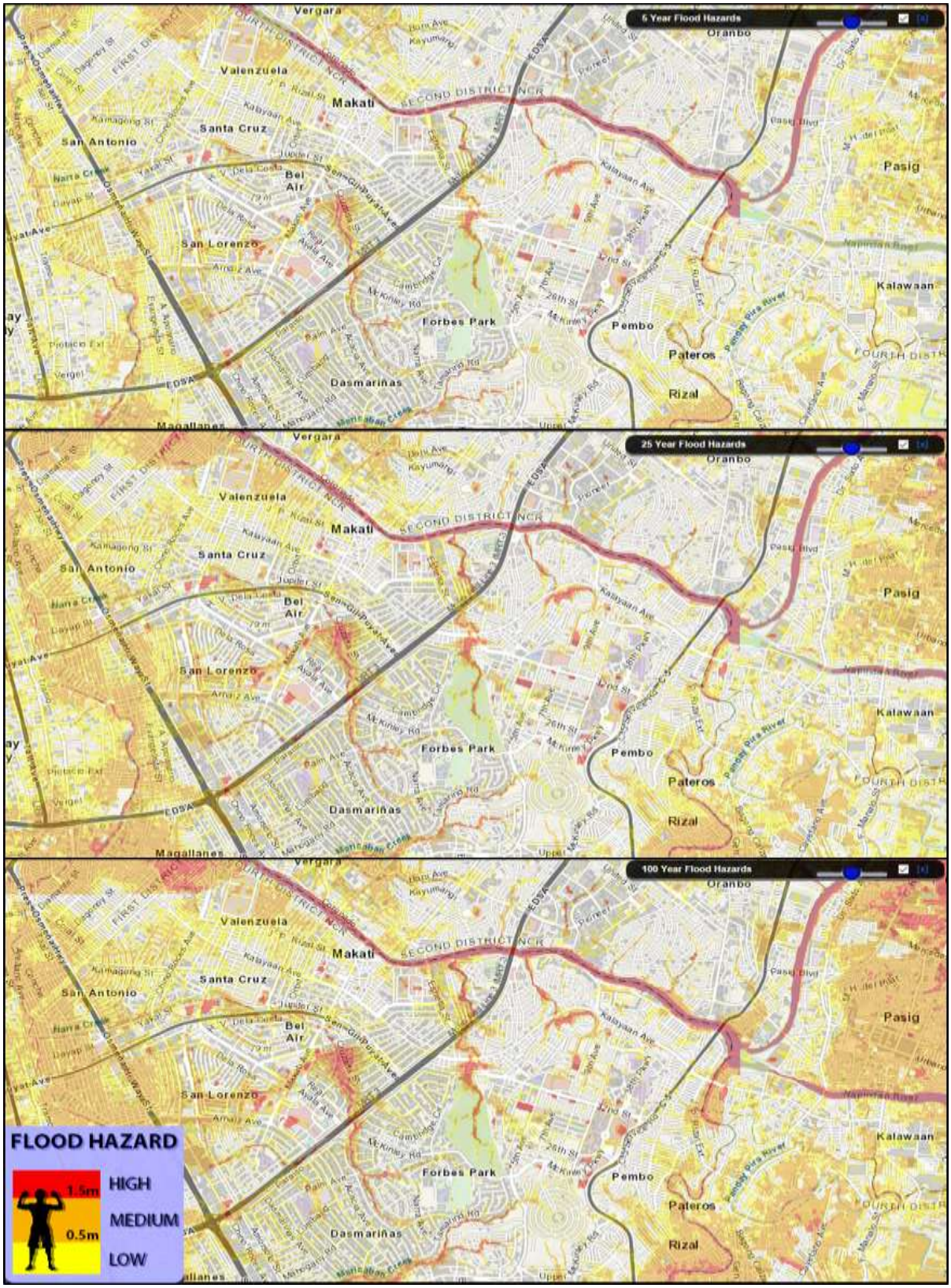


**Figure 4-6: 5-, 10- and 100-Year Flood Hazard Map of Makati City**

(Source: Project Noah as referenced in 2018 FS)

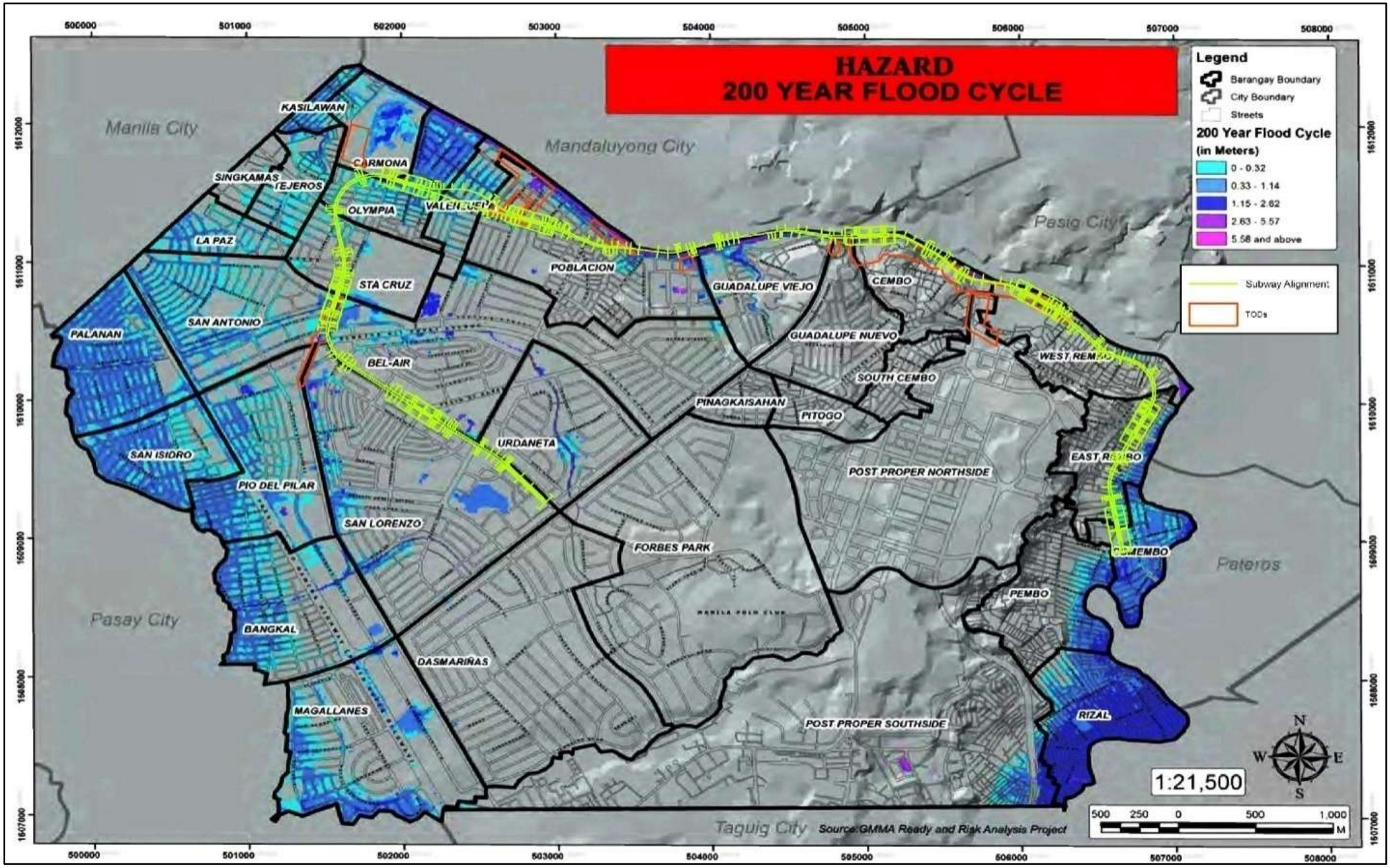


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FIGURE TITLE :

**200-Year Flood Hazard Map of Makati City**

FIGURE NO.:

**4-7**

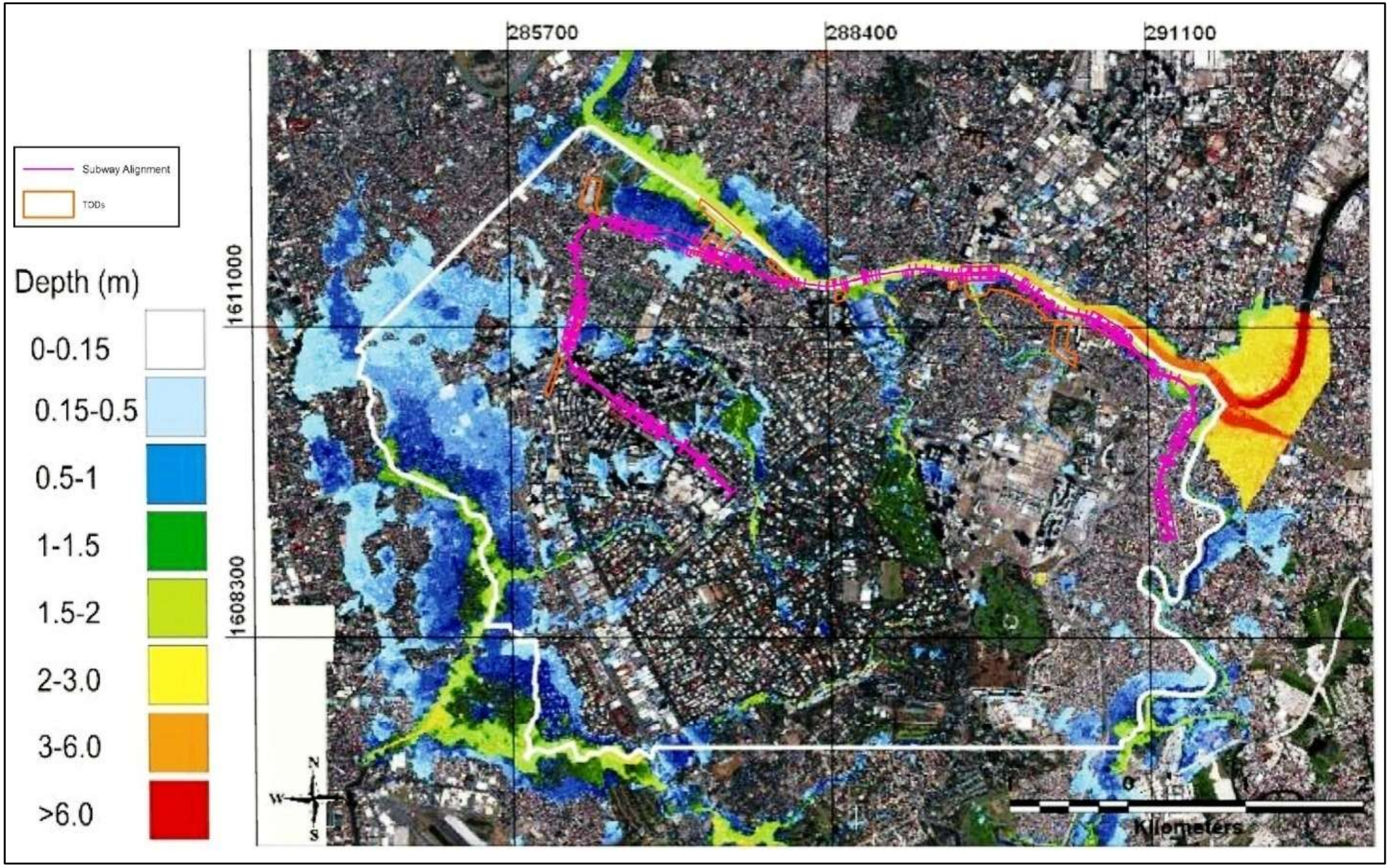


FIGURE TITLE :

**Flo-2D Flood Simulation Map of Makati City**

FIGURE NO.:

**4-8**

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4.1.1.2 Impact Assessment

**Table 4-5** summarizes the key impacts as well as recommende mitigating measeres for the discussed potential geohazards.

**Table 4-5: Summary of Potential Geohazards and Recommended Mitigative Measures.**

| Geohazard | Potential Risk | Causative Factors | Impact | Mitigations Applied/Recommended |
|---|---|---|---|---|
| *Seismic Hazards* | | | | |
| Ground Acceleration<br><br>(intense ground shaking) | High | Earthquake | Structure deformation or failure | Site specific ground conditions and PGA should be given particular consideration in the final design of the infrastructures and facilities. The project should also adhere to design guidelines of the National Building Code (NBC) and the National Structural Code of the Philippines.<br><br>Visual inspection and assessment of the infrastructures after major earthquakes. Minor damaged structure should be repaired immediately. |
| Ground Rupture | Moderate to high near the junctions of J. P. Rizal Extension and P. Urduja and P. Zamora Streets;<br><br>Low to moderate | Earthquake | Structure deformation (cracking of structure) | Modification of engineering design should be considered as the need arises brought about by the changes in the nature and geotechnical properties of lithology as they are uncovered during the detailed geotechnical drilling and during the excavation.<br><br>PHIVOLCS recommends a buffer zone or Zone of Avoidance of at least 5 m on both sides of the active fault |

| Geohazard | Potential Risk | Causative Factors | Impact | Mitigations Applied/Recommended |
|---|---|---|---|---|
| | elsewhere. | | | The Makati City Government currently partially enforces a 10-m easement (5 m on both sides) building policy along the trace of the WVF.<br><br>Visual inspection of the infrastructures after major earthquakes. Minor damaged structure should be repaired immediately. |
| Liquefaction / Liquefaction-induced lateral spreading | Moderate to high in loose sandsand a shallow water table<br><br>Low in bedrock | Earthquake | Excessive settlement, structure deformation | Engineering consideration such as appropriately designed foundations (e.g. deep piles) or suitable in situ ground improvements such as excavation and/or compaction, in-situ ground densification (e.g. vibroflotation).<br><br>Visual inspection and assessment of the infrastructures after major earthquakes .Minor damaged structure should be repaired immediately. |
| Mass movement (landslide) | Low; topography of the study is predominantly gentle | Earthquake; excessive rainfall | Damage or burial of structures in zone of debris accumulation | No mitigations required; changes in underground condition from excavations that could cause mass movement. The excavation works will have temporary support for the to maintain stability. The cut-and-cover tunnel will be designed to withstand the permanent loads including all worst case combination of applied loading and effect without causing distress during the design life of the tunnels. |

| Geohazard | Potential Risk | Causative Factors | Impact | Mitigations Applied/Recommended |
|---|---|---|---|---|
| Volcanic ashfall (2mm size particle) | Low | Explosive volcanic eruption of Taal with prevailing wind blowing to the northwest | Accumulation of ash of roofs. | Low impact given the remoteness of the active volcano.<br><br>Immediate washing of accumulated ashes on roofs (depot area).<br><br>Equipment should be covered when there is an impending ash fall, and the ash should be removed before normal operations. |
| Volcanic quakes (ground shaking) | Low | Explosive volcanic eruption of Taal | Structure deformation or failure | Volcanic quake is expected to be of lesser magnitude compared with tectonic earthquakes; project will be designed to withstand MCE. |
| Flooding - inundation | Low at the western portion of the alignment; Moderate to High along the alignment located beside Pasig River | Heavy prolonged rainfall, | Flooding of tunnels<br><br>. | Adequate dewatering pumps along the subway |
| Piping (groundwater seepage) | Moderate to high | Internal erosion of the foundation; flooding | Collapse of excavation during construction; weakening of foundation during operation | Adequate support during the construction and operation of the subway to resist piping<br><br>Adequate dewatering pumps along the subway |

## 4.2 Physical and Chemical Risk

### 4.2.1 Description of Possible Major Accident Scenarios

a) Construction related accidents

During construction, all personnel assigned at the project site may be subject to accidents if health and safety management plans are not properly carried out. Examples of accidents are as follows:

- Collapse of scaffolding
- Falling of construction materials while being lifted by a crane boom
- Personnel being run over by heavy equipment
- Accidental fall of workers from elevated location or in open pits
- Injury from construction debris and materials
- Collapse of underground tunnel/ pit

b) Toxic chemicals

The chemicals to be used and wastes to be generated from maintenance activities at the depot like solvent-based cleaning chemicals, grease and used oil are classified as hazardous. Accidental release or spillage into the environment may soil contamination, air pollution and surface water pollution.

c) Fire

Fire normally occurs during summer season due to excessive heat. It can also occur due to accidents, equipment failure or faulty electrical systems. Fire may result to damage of property and/or loss of human life.

d) Rail System Failure

This includes failure of rail equipment particularly rail track, signaling/ communication systems and rolling stock. Failure of these devices due to natural hazards (flood, earthquake, volcanic eruption and the like), natural wear and tear of rail parts, or other forms of accidents may result to derailment.

### 4.2.2 Information Relating to the Safety Management System for the Establishment

The company will formulate if non-existent, and implement the following protocols during the construction and operational phases to ensure that the operation of its proposed project is hazard-free as possible and the factors leading to an accident are minimized:

- Emergency Response Procedures Manual
- Road Transport Safety Management System Manual
- Material Safety Data Sheet Database
- Accident Reports and Procedures

These protocols are to be used to prevent accidents and fatalities during emergency cases and in handling hazardous materials on-site.

## 4.3 Emergency Response Policy and Generic Guidelines

### 4.3.1 Objectives

The primary objective is to ensure the protection and preservation of life, property and environment in the event of disasters such as floods, typhoons, earthquakes, tsunamis, volcanic eruptions, flashflood and man-made disasters such as land, air and sea disasters through the effective and efficient execution of the Emergency Response Plan.

### 4.3.2 Concept

On May 27, 2010, Republic Act No. 10121, otherwise known as the Philippine Disaster Risk Reduction and Management Act of 2010 was approved. This enabling law is a broad regulatory cum institutional development framework encompassing all aspect of disaster risk reduction and Management.

The Local Government code mandates every Punong Barangay [Section 389 (b) (6)]; Municipal Mayor [Section 444 (b) (viii)] and Governor [Section 465 (b) (viii)] to carry out emergency measures during and aftermath of a man-made and natural disaster or calamity.

The IRC will adhere to the said law and shall coordinate with the Disaster Risk Reduction Council in the Area during and aftermath a calamity in the Project area.

### 4.3.3 Preparedness

Pre-disaster actions and measures shall be undertaken to avert or minimize loss of lives and properties, such as, but not limited to, staffing, training, planning, equipping, stockpiling, hazard identification and public information and education initiatives.

- Plans - contingency plans, fire and earthquake plans, etc
- Information - personnel awareness, information dissemination thru corporate communications, office memoranda, coordination with the local disaster coordinating councils, etc.
- Resources - available response units, capabilities, equipment, manpower, location, contact nos. and persons, etc
- Education & Training - training of executives, management staff, organic personnel, etc.

### 4.3.4 Organization

Although the IRC will have an internal procedure in handling disasters and emergency, the Department of Interior and Local Government exercises the delegated power of general supervision and at the minimum, this power is translated or must be understood in several interrelated dimension; supporting capacity, development, oversight, administrative power hierarchy with reference to inter local relations, community empowerment and local autonomy.

# 5 SOCIAL DEVELOPMENT FRAMEWORK AND IEC FRAMEWORK

## 5.1 Social Development Plan Framework

### 5.1.1 Background/ Rationale

The Social Development Plan Framework (SDPF) will address the issues and concerns and impacts identified during the consultations and discussions with the affected Barangays. It will incorporate the proposed interventions based on needs of various stakeholders of the project.

As part of its social responsibility, the proponent will aim to provide basic social services and empower the stakeholders, especially the affected residents as partners for sustainable development.

It will also strive to develop strategies that will alleviate poverty and improve the standard of living of communities through socio-economic programs and projects that will harness affected residents' productivity to the fullest, strengthen their self-reliance values and enhance their dignity as members of civil society.

### 5.1.2 5.1.2 Basic Features of the SDP

The SDP framework is based on the sustainable development and self-reliance approaches. Its goal is to empower communities and stakeholders to undertake sustainable development efforts even after the decommissioning of the project.

The full benefits of the project should be able to trickle down to the most disadvantaged and vulnerable sectors of affected communities. The participation of these vulnerable sectors (youth, women, elderly, persons with disability, fishermen, farmers, small traders and enterprise owners, etc.) as "partners" of development activities in the affected Barangays should be ensured from planning, implementation to evaluation of identified projects.

The SDP should be able to complement the existing Municipal/Provincial Development Plans and consider their basic priorities identified by the LGUs, and more importantly, the project impact and stakeholders' concerns and issues

## 5.2 Information, Education and Communication Framework

### 5.2.1 Background/Rationale

The Information, Educational Communication (IEC) Plan Framework is an important tool in establishing harmonious relationship between the IRC and project stakeholders. It opens the line of an open interaction that will critically identify issues and concerns on the part of project stakeholders and a responsive mitigation measures to be developed by both project IRC and project stakeholders. The IEC plan goes beyond the objective of providing information or conducting dissemination activities. It focuses on providing on-going interaction between the IRC and stakeholders during the construction, operation and decommissioning phases. It provides information on the milestones and progress of development and issues during implementation stages. More meaningfully, IEC program will inculcate value formation by making the community and residents aware of their roles as project stakeholders. When the IEC program is conducted effectively, it is a significant confidence and trust-building tool for both the project stakeholders and the project IRC.

**Table 5-1.Social Development Plan Framework**

| | CONCERN | Responsible Community Member / Beneficiary | Government Agency/ Non-government Agency and Services | IRC | Indicative Timeline | Source of Fund |
|---|---|---|---|---|---|---|
| **1.** | **Gender Responsive Livelihood / Employment (Men, Women, Youth & elderly)** | | | | | |
| | Skills training | -Qualified Project Affected Men, Women, Youth & Elderly<br>- Affected Residents | • LGU- Planning and Development Coordinator<br>• CSWD<br>• TESDA | Community Relations | • Pre-construction<br>• Construction | LGU – IRA/ IRC |
| | Employment Opportunities and Livelihood for Vendors | -All residents of Makati City in a legal working-age | • LGU- Planning and Development Coordinator<br>• DOLE<br>• DTI | Community Relations | • Construction<br>• Operation | LGU – IRA/ IRC |
| **2.** | **Health and Safety** | | | | | |
| | Safety for the future employees (accidents and exposures)<br><br>Safety of the project affected residents ( environmental health) | -Barangay Kagawad for Health<br>-Project Affected Community | • LGU City Health Office<br>• CDRRMO<br>• Barangay Disaster Management | Community Relations | • Pre-construction<br>• Construction<br>• Operation | LGU – IRA/ IRC |
| **3.** | **Environment and Sanitation** | | | | | |
| | Generation of solid and liquid waste wastes | -Barangay Kagawad for Environment<br>-Project Affected Community | • City Health Office | Community Relations | • Pre-construction<br>• Construction<br>• Operation | LGU – IRA/ IRC |

| | | | | | | |
|---|---|---|---|---|---|---|
| **4.** | **Peace and Order** | | | | | |
| | Entry of migrant workers | -Barangay Kagawad for Peace and order<br>-Project Affected Community | • LGU<br>• PNP | Community Relations<br><br>Security Office | • Pre-construction<br>• Construction<br>• Operation | LGU – IRA/ IRC |
| | Traffic congestion | - Residents within the proposed alignment | • MMDA<br>• City Traffic Management Office<br>• PNP | Community Relations | • Construction | LGU – IRA/ IRC |
| **5.** | **Relocation Concerns** | | | | | |
| | Livlihood and access to services in the relocation site | - Affected Residents<br>- Barangay Kagawad for social welfare. | • CSWD<br>• TESDA<br>• DepEd | Community Relations | • Pre-construction<br>• Construction | LGU – IRA/ IRC |

### 5.2.2 Goals and Objectives

The IEC plan will seek to reach a broad-based population of various project stakeholders and sectoral groups that will be directly or indirectly affected by the project. It promotes a better understanding of the issues and concerns of the project stakeholders and the IRC, for the resolution of the issues and concerns through acceptable planned mitigation measures.
Specific Objectives:

- To provide better appreciation of the project goals and objectives, project description and components, identified impacts and corresponding social concerns and issues on the part of the project stakeholders, mitigation measures and project benefits
- To clarify misinformation and vague ideas about the project to reduce negative reactions as well as informed-decision among project stakeholders.
- To establish trust and confidence between stakeholders and the project IRC to pursue pro-active approaches and strategies to mitigate potential impacts and to enjoy an equitable distribution of the benefits of the project.

**Table 5-2: IEC Plan Framework**

| Target Sector Identified as Needing Project IEC | Major Topics of Concern in Relation to Project | IEC Scheme/Strategy/Methods | Information Medium | Indicative Timelines and Frequency | Indicative Cost |
|---|---|---|---|---|---|
| a. Residents of Affected Barangays | 1. Project description and status<br>2. Objective of EIA study/EIA Findings<br>3. Issues and concerns about the project<br>4. Building Trust and confidence<br>5. Rights and responsibilities of stakeholders/pro-active response to project operations: Monitoring/creation of MMTs | • Community assemblies<br>• Group discussions<br>• Interpersonal/CO approach<br>• Deployment of Staff for continuing dissemination of information/organization of information/gatekeepers and peer facilitators | • Invitation letters<br>• Primer about the project<br>• Study tours to sites with good practice<br>• Hand-outs on MMT creation, task and responsibilities<br>• Flyers/Billboards/Public Information Brochure | • Pre-construction<br>• Pre-construction<br>• Construction Phase (monthly)<br>• Operation Phase (monthly)<br>• Decommissioning Phase (quarterly) | • Php 100,000 |
| b. LGU: Regional, City, and Barangay Units | 1. Project description and status<br>2. Project Impact<br>3. Objective of EIA Study/EIA Findings<br>4. Issues and concerns about the project<br>5. Mitigation measures<br>6. Building Trust and Confidence that mitigation measures will be undertaken<br>7. Rights and responsibilities of stakeholders/pro-active response to irrigation operations: Monitoring/creation of MMTs | • group methods<br>• group workshops<br>• group discussion<br>• Interpersonal/ CO approach<br>• one-on-one meetings<br>• group workshop/ discussion | • Invitation Letters<br>• One-on-one meetings<br>• Primer about the project and EIA study<br>• Study tours to sites with good practice<br>• Flyers/Billboards/Public Information Brochure<br>• Hand-outs on MMT and IA creation, task and responsibilities | • Pre-construction<br>• During and after EIA Study<br>• Pre-construction<br>• Construction Phase (monthly)<br>• Operation Phase (monthly)<br>• Decommissioning Phase (quarterly) | • Php 100,000 |

| Target Sector Identified as Needing Project IEC | Major Topics of Concern in Relation to Project | IEC Scheme/Strategy/Methods | Information Medium | Indicative Timelines and Frequency | Indicative Cost |
|---|---|---|---|---|---|
| c. Sectoral Groups (NGOs, POs, Homeowners Association) | 1. Project description and status<br>2. Project Impact<br>3. Objective of EIA Study/<br>4. EIA Findings<br>5. Concerns about the project's potential negative impact<br>6. Project benefits (community assistance, training, enterprise development, livelihood and employment, etc.<br>7. Rights and responsibilities of stakeholders/pro-active response to project operations: Monitoring/creation of MMTs | • Group methods<br>• Community Consultations/ assemblies<br>• Group Discussion | • Invitation Letters<br>• One-on-one meetings<br>• Primer about the project and EIA study<br>• Study tours to sites with good practice<br>• Hand-outs on MMT creation, task and responsibilities | • Pre-construction<br>• Pre-construction<br>• Construction Phase (monthly)<br>• Operation Phase (monthly)<br>• Decommissioning Phase (quarterly) | • Php 100,000 |
| d. Concerned agencies (DOTr,NHA, DPWH, HLURB, DENR, DSWD, DepEd, etc.) | 1. Project Description and Status<br>2. Project Impact<br>3. Issues and Concerns about the project<br>4. Mitigation Measures<br>5. Rights and responsibilities of stakeholders/pro-active response to project operations: Monitoring/creation of MMTs | • Community assembly<br>• Group workshop/ discussion<br>• Group workshop/ discussion<br>• group workshop/ discussion | • One-on-one meetings<br>• Primer about the project and objectives of EIA<br>• Group discussion<br>• SDP presentation<br>• Study tours to sites with good practice<br>• Hand-outs on MMT creation, task and responsibilities<br>• Flyers/Billboards/Public Information Brochure | • Pre-construction<br>• Construction Phase (monthly)<br>• Operation Phase (monthly)<br>• Decommissioning Phase (quarterly)<br>• | • Php 100,000 |

# 6 ENVIRONMENTAL COMPLIANCE MONITORING

This Environmental Monitoring Plan (EMoP) has been formulated to:

- Validate the changes in the various environmental media as predicted in the impact assessment.
- Provide early warning information of unacceptable environmental conditions
- Monitor the Project's Compliance with the conditions set in the Environmental Compliance Certificate (ECC)
- Monitor specific parameters identified
- Provide a basis for timely decision-making and effective planning and management of environmental measures through the monitoring of actual Project impacts.

The EMoP will also be the basis of the Multi-Partite Monitoring Team that will eventually be formed once the ECC for the Project is issued.

## 6.1 Self-Monitoring Plan

Design, review and construction supervision by an independent consultant is highly recommended to ensure QA/QC during construction. The sources of construction material should be regularly sampled and tested for their suitability as construction material (e.g. grain size analysis, natural moisture content, consolidation test). It is recommended that compaction tests, either by neutron density meter or by sand cone testing, be conducted every third lift of the embankment.

### 6.1.1 Soil Quality

Soil quality monitoring will be undertaken semi-annually for the duration of the construction phase. Physico-chemical characteristics of the soil shall be monitored for changes. This aims to immediately identify any changes in soil profile during construction phase and to apply appropriate remedial measures.

### 6.1.2 Air Quality and Noise

During construction, air quality monitoring will be undertaken to monitor concentrations of TSP (using High Volume Sampler) at the sampling stations established including additional stations at the boundary of the construction site. Likewise, noise monitoring will be undertaken at the periphery of the site and at sensitive receptors (e.g. schools and residential areas). The primary aim of the noise monitoring during the construction period is to respect sleeping and resting periods of residents near the construction site.

### 6.1.3 Water

During construction, surface water quality monitoring will be undertaken at the selected sampling stations on a quarterly basis.

### 6.1.4 People

The socio-economic monitoring will consist of monitoring the influx of workers during construction period and local employment for the operational phase. The distribution of benefits will also be monitored annually during the operational phase of the Project.

**Table 6-1: Matrix of Environmental Monitoring Plan**

| Project Phase / Environmental Aspect | Potential Impact per Envtl Sector | Parameters to be monitored | Sampling and Measurement Plan | | | Lead Person | Annual Estimated Cost | EQPL | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Method | Frequency | Location | | | Alert* | Action |
| **I. PRE-CONSTRUCTION PHASE** | | | | | | | | | |
| 1. Acquisition of Right of Way | Land/People | # of complaints | Consultations and Interviews | Semi Annual | Host communities | Community Relations | P20,000 per consultation = P40,000 | 1 complaint | 2 Complai |
| **II. CONSTRUCTION PHASE** | | | | | | | | | |
| Environmental Aspect #1: Site Preparation (Clearing, Grubbing, Stripping) | Geologic Hazards: Landslides and slope failures | Cracks in slopes | Visual inspection/ absence or presence | Monthly | Construction areas | Site Construction Safety | P20,000.00/yr | Presence of cracks/loose soils | - |
| | Terrestrial Ecology: Removal of vegetation on construction areas | # of individuals | Species Inventory | Semi-annual | Construction Sites | Environment Unit | P150,000/ yr | 5% increase from inventory | 10% increase fro |
| | Terrestrial Ecology: Temporary disturbance of terrestrial fauna | Species Richness of Fauna | Visual Observation and Listings | Semi-annual | Critical habitats and/or forest areas | Environment Unit | P 150,000.00 | Baseline levels -15% decrease in species richness for two consecutive monitoring period richness | Baseline levels - decrease in spec richness for two consecutive mor period |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Air Quality and Noise: Potential increase in Total Suspended Particulate (TSP), and Noise Levels within and around the Project site. | TSP,<br>Noise | TSP = High Volume /Gravimetric<br>Noise = Noise Meter | Quarterly | Air Quality Sampling Stations | Contractor | P10,000 | TSP 250 µg/Ncm | | | | TSP 275 µg/Ncm | | | | |
| | | | | | | | | Cat | D | ME | N | Cat | D | | | |
| | | | | | | | | A | 50 | 45 | 40 | A | 53 | | | |
| Environmental Aspect #2:<br>Earthworks generation and exposure of loose soil | Geologic Hazards: Landslides and slope failures | Cracks in slopes | Visual inspection/ absence or presence | Monthly | Construction areas | Contractor | 20,000.00/ yr | Presence of cracks/loose soils | | | | - | | | | |
| | Water Quality: increased sedimentation and siltation of rivers | DO<br>Oil and Grease<br>Heavy Metals<br>Fecal/ total coliform<br>pH<br>TSS<br>BOD | Grab Sampling | Quarterly | Downstream of civil works activities | IRC, Contractor | P80,000.00/yr | 70 mg/L | | | | 75 mg/ | | | | |
| | Water Quality: Water contamination from solid and liquid wastes | DO<br>Oil and Grease<br>Heavy Metals<br>Fecal/ total coliform<br>pH<br>TSS<br>BOD | Grab Sampling/ In-situ | Quarterly, except Heavy Metals monthly | Downstream of civil works activities | Contractor | P160,000.00/ yr | 5.5 mg/L<br>7 | | | | 5.3 mg/<br>7 | | | | |
| | Potential increase in Total Suspended Particulate (TSP) and Noise | TSP,<br>Noise | TSP = High Volume /Gravimetric<br>Noise = Noise Meter | Quarterly | Monitoring stations for quarterly monitoring to be located at the | IRC, Contractor | P40,000/yr | TSP 250 µg/Ncm | | | | TSP 275 µg | | | | |
| | | | | | | | | Cat | D | ME | N | Cat | D | | | |
| | | | | | | | | A | 50 | 45 | 40 | A | 53 | | | |
| | Health and Safety: Increased accidents to people in communities | # of accidents | Audit health and safety | Continuous | Construction areas | Administrative and Finance Division- Administrative Section | P10,000.00/ yr | 1% increase in accidents | | | | 2% increase in a | | | | |
| Environmental Aspect #3:<br>Actual Construction of | Geologic Hazards: Landslides and slope failures | Cracks in slopes | Visual inspection/ absence or presence | Monthly | Construction areas | Engineering and Operations Division: | 20,000.00/ yr | Presence of cracks/loose soils | | | | - | | | | |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | A | 50 | 45 | 40 | A | 53 | 4 | | | |
| Ambient Air | Release particulates and gaseous air pollutants | Ambient TSP, PM10, NO2, and SO2, | ● High Volume/ gravimetric | Quarterly Monthly or as frequent as necessary | Receptors or ASR's downwind of prevailing winds at the time of monitoring | Project proponent | PhP120,000 per sampling | • EQPLs may not be applicable as laboratory results are known few days or weeks after air sampling<br>• Recommend daily visual inspection of fugitive dust emissions and meteorological monitoring (please see next item below)<br>• Air sampling using High Volume/Gravimetric is intended to check compliance with the NAAQS | | | | NAAQS (in µg/Nm<br>● TSP = 300<br>● $PM_{10}$ = 200<br>● $NO_2$ = 260<br>● $SO_2$=340 | | | | | |
| Ambient air | Release of fugitive dusts | Ambient TSP/ Fugitive particulates | Visual inspection and meteorolo-gical monitoring | Daily during operation during dry condition | Sources of air emissions at the project site | Project proponent and contractor | Part of Environmental Officer's scope | Fugitive dust is generated within project area at wind speed of < 5.4 m/s (relatively calm to light wind condition)<br><br>Note: Wind speed of 5.4 m/s is within Beaufort Scale 3 – leaves and small twigs constantly moving, light flags extended) | | | | Fugitive dust is ger close to residential speed > 5.4 m/s (moderate to strong<br><br>Note: Wind speed within Beaufort Sca leaves and small tw constantly moving, | | | | | |

## 6.2 Multi-Sectoral Monitoring Framework

Stakeholder engagement and public participation were incorporated in the Philippine Environmental Impact Statement System (PEISS) in response to the growing awareness of environmental impacts associated with development projects. The PEISS necessitates public participation not only during the review process but more importantly after the issuance of the Environmental Compliance Certificate (ECC). This is implemented through the creation of a Multi-Partite Monitoring Team (MMT), which aims to encourage public participation and greater stakeholders' vigilance and provide appropriate check and balance mechanisms in the monitoring of project implementation. The composition, functions and responsibilities of the MMT shall be in accordance with the provisions of the Procedural Manual for DAO 03-30. Likewise, the operation and sampling protocol shall be in consonance with the applicable rules and regulations.

The functions of MMT are as follows:

1. Monitor project compliance with the conditions stipulated in the ECC and the EMP;
2. Validate IRC's conduct of self-monitoring;
3. Receive complaints; gather relevant information to facilitate determination of validity of complaints or concerns about the project and timely transmit to the IRC and EMB the recommended measures to address the complaint;
4. Prepare, integrate and disseminate simplified monitoring reports to community stakeholders; and
5. Make regular and timely submission of MMT Report based on EMB-prescribed format.

Members of the MMT shall include the following but not limited to:

1. Mayor
2. Barangay Chairman
3. Representative from National Government Agency (DoTr, MMDA, DPWH)
4. NGO representative
5. DENR DENRO

## 6.3 Environmental Guarantee and Monitoring Fund

### 6.3.1 Environmental Guarantee Fund

The amount for the allocation of an Environmental Guarantee Fund (EGF) shall be determined based on negotiations between IRC and EMB. Once costs are negotiated, the EGF will be established through a MOA and shall be used exclusively for the following purposes:

1. Immediate rehabilitation of areas affected by damages in the environment and the resulting deterioration of environmental quality as a direct consequence of project construction, operation and abandonment;
2. Just compensation of parties and communities affected by the negative impacts of the project;
3. Conduct of scientific or research studies related to the project that will aid in the prevention or rehabilitation of accidents and/or environmental damages; and

4. Contingency clean-up activities, environmental enhancement measures, damage prevention programs and social equity measures (e.g. livelihood, social development programs) including the continuing necessary IEC and capability building activities related to the project.

If costs from the EGF are insufficient to cover compensable claims, additional costs may be covered by the IRC. Whenever the EGF is below 50% of agreed level, it will be replenished by the IRC. The amount may be changed at the course of Project Operations.

### 6.3.2 Environmental Monitoring Fund

The EMF shall be exclusively utilized to cover all costs attendant to the operation of the MMT and shall be disbursed in accordance with the guidelines stipulated in the approved MMT Manual of Operations (MOO). The EMF shall be co-managed and co-administered by MMT Secretariat in accordance with the MOO and AWFP. A proposed Monitoring Fund of Php 100,000 is set for the activities of the MMT.

# 7 ABANDONMENT/DECOMMISSIONING REHABILITATION POLICIES AND GENERIC GUIDELINES

Abandonment shall cover the temporary structures used during pre-construction and construction phases such as storage yards, camp house, and temporary staging areas.

In case abandonment is imperative due to force majeure or any other reasons, the structures, equipment and other related facilities may be used for other applications. Otherwise, the removal of structures, equipment and machineries from the existing site will be done to minimize possible threats to the surrounding environment.

An abandonment plan shall be formulated with consideration of the following:

- Advice and properly compensate affected employees; separation fees or compensation fees will be provided to any displaced employees;
- Machines / Equipment dismantled will be sold to interested parties;
- Removal of Solid, Liquid and Hazardous Wastes within the site through a DENR-certified Waste Transporter/ Treater; and
- Clean up and possible remediation of the site, if future evaluations and testing suggest such activity is applicable.

# 8 INSTITUTIONAL PLAN FOR EMP IMPLEMENTATION

## 8.1 Designation of Pollution Control Officer

Current DENR guidelines provide for the appointment of Pollution Control Officer (PCO) to oversee the EMP of the company. The position should be senior and the PCO should be technically qualified to oversee the implementation of the environmental management program.

The environmental commitments of the IRC will be thoroughly documented in the Environmental Compliance Certificate (ECC). These environmental commitments will be the minimum basis for monitoring activities by any interested party on the environmental performance of the company.

The IRC, through its Contractor shall hire a full-time Pollution Control Officer (PCO) who will also serve as the Health, Safety and Environmental Officer. The PCO will be accredited by the DENR and shall be required to attend regular PCO training to be accustomed with the environmental regulations pertaining to the project, especially those pertaining to the air and water quality. More importantly, the PCO will be thoroughly acquainted with the environmental management and monitoring plan of the project.

## 8.2 Compliance Reporting

As part of the duties of the PCO, regular reporting of compliance to DENR standards and other regulatory agencies shall be undertaken. The general schedule of reporting is indicated in the environmental monitoring plan.

## 8.3 Health and Safety

The IRC shall subscribe to an active program of pursuing a healthy, safe and environment-friendly operation. It shall push for the adoption of industrial hygiene programs to ensure that a work environment shall be consistent with internationally accepted norms of industrial operations. Loss controls program, allied to the pursuit of the safety program, shall also be implemented and overseen by the PCO. In each section and shift, a safety officer shall be designated, and, together with the PCO, shall undergo health and safety training programs available from the Safety Organization of the Philippines.

Following the Company's guidelines on health and safety, it shall be made known and clear to Contractors and all employees during construction and operations. Strict compliance with these guidelines shall form part of the employees' code of conduct; sanctions and will be imposed upon violators. Safety evaluation within the Project site shall be conducted with the aim of continuously improving safety conditions.

The continuous availability of medical attention for sicknesses and medical emergencies and the provisions for first aid and emergency transport shall be made available at the Project construction site and may be shared with the nearby community.

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**Annex 1: Proof of Authority over the Project Site**

**Annex 2: IEC Documentation**

**Annex 3: Public Scoping Documentation**

**Annex 4: Public Hearing Documentation**

**Annex 5: Summary of Available Ground Investigation Data**

**Annex 6: Inferred Geological Longitudinal Sections**

**Annex 7: SPT N-Values for Residual Soil**

**Annex 8: Detailed GHG Calculation**

**Annex 9: Detailed Emission Estimates**

**Annex 10: Configuration Description of Construction Machinery and Equipment**

**Annex 11: Air and Noise Quality Laboratory Results**

**Annex 12: Water Quality Laboratory Result**

**Annex 13: Sample Household Questionnaire**

**Annex 14: Resettlement Action Plan Framework**

**Annex 15: PHIVOLCS Hazard Assessment**

**Annex 16: Technical Scoping Checklist**

**Annex 17: Project Environmental Monitoring and Audit Prioritization Scheme (PEMAPS)**

**Annex 18: Accountability Statements of Preparers**

**Annex 19: Accountability Statements of Proponent**